INTEGRATED GEOPHYSICAL METHODS FOR POST FOUNDATION STUDIES, PHASE ONE, FACULTY OF SOCIAL SCIENCES AND HUMANITIES, FEDERAL UNIVERSITY OYE EKITI, EKITI STATE.

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CERTIFICATION

I hereby certify that ABIOYE OLAJUMOKE MARY, with Matric no:GPY/11/0291 carried out this research work under my supervision in the Department of Geophysics, Faculty of Science, Federal University, Oye Ekiti, Ekiti State, Nigeria.

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MR. A.O FAJANA

DEDICATION

This project is dedicated to God Almighty for his protection, direction, and wisdom he gave to me during this research work and also to my parent ELDER AND DEACONESS A.I ABIOYE for their support financially, materially, and encouragement. I pray that God bless u more in Jesus name.

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Finally, I express my profound gratitude to all those that has contributed in one way or the other to this study and my academic pursuit generally but too numerous to mention.

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ABSTRACT

A combined geophysical method involving very low electromagnetic method, magnetics and electrical resistivity methods were used in delineating the causes of crack in the building at Faculty of Social Science and Humanities Oye Ekiti, Ekiti,State.

Five (5) VLF-EM traverses were established in both east-west direction and also north-south direction were occupied in the building and Twenty-one (21) VES studies were also occupied around the building.

The VLF-EM helped in the identification of conductive zone that have high peak ,positive filtered, pseudo section and 2-D VLF-EM models and lineament map that were interpreted in terms of structures, lithology, and thickness in the distressed building. The electrical resistivity help us in generating geoelectric section profiles, and also some maps on the study area.

The interpretation shows that there is high conductive zone which the value ranges from 11.5-102ohms-m, 19.7-115ohms-m and 17.7-281ohms-m respectively and the thickness ranges from 0.3-2.1m, 2.7-2.8m and 1.0-21.3m respectively. Also the depth to bedrock value ranges from 1.0-21.3m respectively

Also from the geoelectric section three layers were delineated in the study area which include the topsoil, weathered layer and fresh basement. The VES curve types obtained were A,H,K and Q curves respectively in the study area.

It is concluded that the possible causes of the crack in the foundation study area is due to the presence of clayey material at the distressed building.

CHAPTER ONE

1.1 INTRODUCTION

Maton and Templeton (1973) defined engineering geophysics as an intermediary discipline between engineering geology and soil mechanisms. It involves the application of geophysical methods to civil engineering projects. It is also used in initial site investigation to determine subsurface ground conditions prior to excavation and construction work. Engineering geophysics therefore gives detail information on the degree of competence of the subsoil in foundation engineering.

Building failure occurs when the building losses is ability to perform its intended (design) function. Hence, building failure can be categorized into two board groups which are of physical or (structural failures) which result into the loss of certain characteristics like strength and also performance failures which means a reduction in functions below an established acceptable limit. (Douglas and Ransom, 2007).

Also, buildings with different structures are designed to support certain loads without deforming excessively whereby the loads are the weights of people and objects, the weight of rain and snow and the pressure of wind (called *live loads* and the *dead load*) of the building itself. With buildings of a few floors, strength generally accompanies sufficient rigidity, and the design is mainly that of a roof that will keep the weather out while spanning large open spaces. With tall buildings of many floors, the roof is a minor matter, and the support of the weight of the building itself is the main consideration. Like long bridges, tall buildings are subject to catastrophic collapse.

The causes of building failure can be classified under most of these general headings to facilitate analysis. These headings are:

- Bad Design
- Faulty Construction
- Foundation Failure
- Extraordinary Loads
- Unexpected Failure Modes

- Bad design does not mean only errors of computation, but a failure to take into account the loads the structure will be called upon to carry, erroneous theories, reliance on inaccurate data, ignorance of the effects of repeated or impulsive stresses, and improper choice of materials or misunderstanding of their properties. The engineer is responsible for these failures, which are created at the drawing board.
- Faulty construction has been the most important cause of structural failure. The engineer is also at fault here, if inspection has been lax. This includes the use of salty sand to make concrete, the substitution of inferior steel for that specified, bad riveting or even improper tightening torque of nuts, excessive use of the drift pin to make holes line up, bad welds, and other practices well known to the construction worker.
- Even an excellently designed and constructed structure will not stand on a bad foundation which is also one of the causes of foundation failure. Although the structure will carry its loads, the earth beneath it may not. The Leaning Tower of Pisa is a famous example of bad foundations, but there are many others. The displacements due to bad foundations

may alter the stress distribution significantly. This was such a problem with railway bridges in America that statically-determinate trusses were greatly preferred, since they were not subject to this danger.

- Extraordinary loads are often natural, such as repeated heavy snowfalls, or the shaking of an earthquake, or the winds of a hurricane. A building that is intended to stand for some years should be able to meet these challenges. A flimsy flexible structure may avoid destruction in an earthquake, while a solid masonry building would be destroyed. Earthquakes may cause foundation problems when moist filled land liquefies.
- Unexpected failure modes are the most complex of the reasons for collapse, and we have recently had a good example. Any new type of structure is subject to unexpected failure, until its properties are well understood. Suspension bridges seemed the answer to bridging large gaps. Everything was supported by a strong cable in tension, a reliable and understood member. However, sad experience showed that the bridge deck was capable of galloping and twisting without restraint from the supporting cables. Ellet's bridge at Wheeling collapsed in the 1840's, and the Tacoma Narrows bridge in the 1940's, from this cause.

In this study combination method of Electrical resistivity (VES), magnetic method and also VLF-EM were used to map subsurface sequence delineation, causes of crack and also depth to bedrock determination in the distressed building.

1.2 location of the study Area

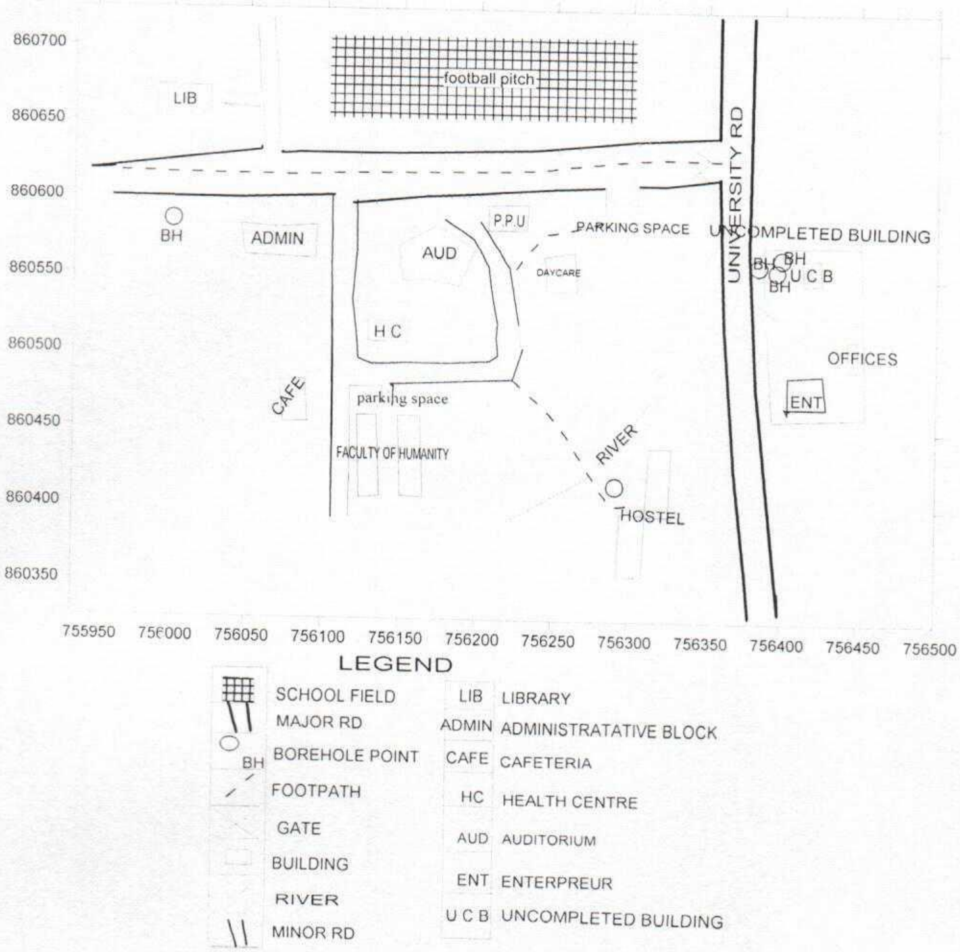


Fig1: Basemap showing the study area

1.3 AIMS AND OBJECTIVE OF THE STUDY

The aim is to determine the causes of fracture on the distressed building with the following objectives:

- To delineate subsurface sequence.
- To determine the depth to bedrock.
- To study the degree of fracture.

1.4 Physiographic Setting

1.4.1 Location and accessibility of the study area

The study area lies within longitude 0756183N-0756114N and latitude 0860396E-0860486E. The study area is easily accessible and some are not easily accessible due to bushes around the premises of the study area.

1.4.2 Vegetation

The type of vegetation in the study area is forest, scrubs and also there are bushes around the study area.

1.4.3 Topography, climate and drainage

Topographically, there is no hill in the area due to these it was easily accessible with footpath way and also with network connection around the study area.

With respect to climate, the climatic condition in theses area is the same thing with all the south western, Nigeria. And also the drainage pattern in the study area is mostly trellis drainage pattern controlled by structures.

1.5 REVIEW OF PREVIOUS WORK

Many researchers have been carried out studies of post foundation studies and its advantage over the stability of the structures. Availability of this post foundation has been made possible with the aid of different geophysical methods based on the local geologic setting, cost and maintenance of equipment, and also accuracy in interpretation. Different geophysical methods that can be use for these post foundation studies are Magnetic method, Gravity method, Seismic survey, Electromagnetic method, Electrical method among many others. Combination effect of Electromagnetic (VLF-EM), and Electrical resistivity (VES) methods were used in the study area.

M.O AFOMOLA, K.A.N ADIAT, G.M OLAYANJU and B.D AKO carried out a geophysical investigation in detecting the causes of crack on a building at FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, NIGERIA using integrated geophysical methods for post foundation studies at oba-nla quarters and they were able to came out with their result in detecting the causes of crack in the building foundation which was successful.

Also, Ogungbemi Oluwaseun.S, Badmus Ganiyu.O, Idowu Kayode. A, carried out a geoelectric and electromagnetic methods for post foundation studies in a typical basement terrain and they were able to came out with a successful result.

Oyedele, K.F and Okoh, C, carried out subsoil investigation using integrated methods at Lagos, Nigeria and they came out with good and accurate result.

Further more, OMOSUYI et al. (2007), conducted the combination of electromagnetic profiling and geoelectric sounding method to locate fissured zones at AFUNBIOWO near AKURE, South Western Nigeria.

CHAPTER TWO

MATERIAL AND METHODOLOGY

2.0 BASIC METHOD USED FOR THE STUDY

Very low frequency electromagnetic method (VLF-EM), and Electrical resistivity (VES) method were used in carrying out the geophysical survey in post foundation studies for detecting the causes of building failure in the study area.

The VLF-EM method has been used in many site investigations for delineation of fault, fracture and also causes of building failure in some basement complex. It is also relevant in depth to basement estimation and basement fracture delineation (overburden thickness).

2.1 VERY LOW FREQUENCY ELECTROMAGNETIC METHOD

2.1.1 GENERAL BACKGROUND THEORY OF VLF-EM

This method makes use of the response of the ground to the propagation of electromagnetic fields, which composed of an alternating electric intensity and magnetizing force. The primary electromagnetic field may be generated by passing alternating current through a coil made up of many turns of wire or through a large loop of wire. The response of the ground is the generation of secondary electromagnetic fields and the resultant field may be detected by the alternating current that they induced to flow in a receiver coil by the process of electromagnetic induction.

In the presence of a conducting body, the magnetic component of the electromagnetic field penetrating the ground induces alternating current, or eddy currents generating their own secondary electromagnetic field which travels to the receiver. The receiver will then responds to the resultant of the arriving primary and secondary fields so that the responds differs in both phase and amplitude from the response to the primary field alone. The difference between the transmitter and receiver electromagnetic fields revel the presence of the conductor and provide information o its geometry and electrical properties.

Electromagnetic method does not require contact with the ground, therefore the speed with which electromagnetic can be made is much greater than the electrical method. Electromagnetic can be used from aircraft and ships as well as boreholes. It is lightweight and portable, it is good for investigating groundwater, measurement can be collected rapidly with a minimum number of field personnel, taking at walking pace and the result of the method is accurate.

But despite all these advantages, the electromagnetic method are best used as a reconnaissance tool for investigating building failure in a basement complex not a detail compare to the electrical resistivity method as it serves many times as reconnaissance survey to locate depth to bedrock.(Palacky *et al, 1991*).

2.1.2 COMMON TYPE OF ELECTROMAGNETIC EQUIPMENT

- The Geonic EM-16 VLF equipment, the horizontal loop EM and EM 34-3 are most commonly used electromagnetic system. The VLF equipment consists of a receiver and thus requires only one operator.
- The Geonics EM 34-3 is a portable instrument operated by two workers, one operator camping the transmitter and the other carrying the receiver.
- The Airborne technique is widely used because of its speed and cost effectiveness.

2.1.3 ADVANTAGES OF VERY LOW FREQUENCY METHOD

1. Very low frequency equipment is very fast and generally portable.

2. It is very cheap and affordable instrument for building failure investigation.
3. One or two operator is needed for the field work.
4. Very low frequency is very effective for locating zone of high electrical conductivity.

Very low frequency devices can be used to measure the electric component by using a grounded dipole up to 5m long made up of a piece of wire connected to the ground at each end.

2.1.4 DISADVANTAGES OF VERY LOW FREQUENCY METHOD

Repeatability of measurement is sometimes difficult along the same profile when surveyed on different occasions as the transmitter with the strongest signal may be different each time. Thus survey parameters are difficult to keep constant.

Another setback of very low frequency system is that the method is totally dependent on there being an appropriate transmitter operational. There are occasions when transmitters are off-air and no source signal from a transmitter with an appropriate azimuth to the target is available. Sometimes a given transmitter can be switched off while an operator is in mid-survey. There is nothing within the control of that operator that can be done to rectify the situation unless another transmitter is available with a suitable azimuth and the instrument being used has the appropriate aerial.

The measurement of very low frequency can be adversely affected by topography, and so some sort of topographic correction may have to be applied before a target anomaly becomes obvious. The effect of this topographic can be removed by the application of an appropriate filter.

2.2 ELECRICAL RESISTIVITY METHOD

Electrical methods were developed in the early 1900s but have become very much more widely used since the 1970s, due commonly to the availability of computers to process and analyze the data. These techniques are used extensively in the search of building failure and environmental studies. The most useful techniques in engineering studies is electrical resistivity method which help in locating sub-surface cavities, faults, and fissures, permafrost, mineshafts etc and also in archeology for mapping out the area extent of remnants of buried foundation of ancient buildings amongst many other applications, electrical resistivity are also used extensively.

In general, it is able to map different stratigraphic units in a geologic section as long as the units have a resistively contrast. Often this is connected to rock porosity and also relevant to depth to bedrock determination, structural mapping, determination of the nature of the superficial deposits and lots more (olorunfemi and okhue, 1992).

Electrical resistivity is part of geophysical techniques that has great advantage in investigating post foundation as it utilizes a direct, commutated or low frequency alternating current source of E.M.F to know the content of the earth. The current is introduced from the transmitter into the ground by means of a pair of electrodes and the resulting potential distribution on the ground is measured by means of another pair of electrodes connected to a receiver voltmeter.

2.2.1 BACKGROUND THEORIES OF ELECTRICAL RESISTIVITY SURVEY

Electrical resistivity is defined as the resistance between opposite faces of a unit cube with cross sectional area and unit length. The resistivity R (Ω) is directly proportional to the length of the cube (L) and is inversely proportional to its cross sectional area, the Electrical Resistivity can depict as p, mathematically it can be expressed according to (Todd, 1959) as;

2.2.2 ELECTRODE CONFIGURATION

The value of the apparent resistivity depends on the geometry of the electrode array used, as different by the geometric factor K. There are three main type of electrode configuration, two of which are named after their originators-Frank Wenner (1912) and Conrad Schlumberger and arrange of sub types such as Dipole-dipole array, pole-dipole array etc.

2.2.3 CLASSIFICATION OF ELECRODE CONFIGURATION

There are two main types of electrical resistivity methods; one is for depth sounding that is to determine the vertical variation of resistivity which is known as Vertical Electrical Sounding (VES). The other is for horizontal traversing that is the horizontal variation of resistivity which is known as Constant separation Traversing (CST) which is also called electrical resistivity traversing (ERT), which is used to determine the lateral variation of resistivity. The current and potential electrodes are maintained at a fixed separation and progressively moved along the profile. Many configuration of electrodes have been designed (Habberjam, 1979), but wenner and schlumberger array configuration are commonly used today.

2.2.4 VERTICAL ELECTRICAL SOUNDING

It is used to measure vertical variation in electrical properties beneath the earth surface with respect to fixed center array. It is done by increasing the electrode spacing linearly about a central position whose vertical resistivity variation is sought.

Resistivity measurements are made at each expansion and multiply by the respective geometric factor (k) to give the resistivity. The depth of investigation is dependent on the electrode spacing. It can be used to map depth to bedrock and also to delineate aquifer.

Array type used include; wenner, schlumberger, dipole-dipole and pole-dipole array. Results are also presented as depth sounding curves.

Werner array configuration

The four electrodes A, M, N, and B are equally spaces along a straight line. The distance between adjacent electrodes is called 'spacing'. So AM =MN=NB=1/3 AB =a

Pa= 2 π a V / I

The Werner array is widely used in the western Hemisphere. This array is sensitive to horizontal variations.

Schlumberger Arrangement

This array is the most widely used in the electrical prospecting. Four electrodes are placed along a straight line in the same order AMNB, but with AB≥5 MN.

In this type of arrangement, the current electrodes are always on the move with potential electrode moved occasionally. The formula for the apparent resistivity value for two current electrodes is given thus;

$$\rho_a = 2\pi \frac{\Delta V}{I}\left[\frac{1}{r_1} - \frac{1}{r_2} - \frac{1}{r_3} + \frac{1}{r_4}\right]^{-1}$$

2.2.5 MERITS OF VERTICAL ELECTRICAL SOUNDING (VES)

1. It aid in geological map provision.
2. It is used to determine the depth to bedrock.
3. It is used in determine electrical resistivity tomography.
4. The equipment is very light, portable and not expensive.

2.2.6 LIMITATIONS OF VERTICAL ELECTRICAL SOUNDING (VES)

The electrical resistivity method is mostly used in site investigation where the geology is simple and subsurface layers are horizontal. The practical difficulty of dragging the electrodes and wire on the field is also a disadvantage of the method. (Telford et al, 1976). Hence this method is particularly not suitable for oil prospecting (Telford et al, 1976). Other limitations encountered in this method arise from field operations are stated below:

- Poor electrical contact particularly at the current electrode position. This could be due to a very dry ground surface.
- Lateral in homogeneity in the upper layer of the Earth can degrade the quality of resistivity sounding curves (Zohdy, 1980). This sensitivity to minor variations in near surface conduction can be described in electronic parlance as low signal to noise ratio or high noise level (Telford et al, 1976).
- Some errors will be introduced into interpretation results of depths sounding curves if the assumed horizontal electrical interfaces are in reality steeply dipping (Olorunfemi and Mesida, 1987).

2.3 GEOLOGY OF THE STUDY

2.3.1 GENERAL GEOLOGY OF NIGERIA

Nigeria is a country in the Africa continent; the Africa continent is a product of the breakup of Arica plate from the south western American plate. Nigeria is bounded by the Atlantic Ocean to the south, by the republic of Benin to the west, by the Niger Republic to the North, the republic of Chad, the Republic of Chad to the North and the Republic of Cameroon to the East. The country lies between latitude 4-14 degree and longitude 3-14 degree and it is located in the western part of African continent. Hence the geologic frame work of Nigeria is genetically related to the global process and episodes that affected the African continent (Rahaman et al, 1988).

Geologically, about half of the total area of Nigeria is covered by igneous and metamorphic rocks of which about 80% of it is of Precambrian age and the remaining 20% are younger intrusions and volcanic lava. These crystalline rocks are collectively called Basement complex (the basement complex is made up of Precambrian rocks and the younger granite of Jurassic age); the remaining half are made of sedimentary rocks of any region are found crystalline rocks to have been extensively altered by heat, such heated rocks (constitute the basement complex) lies below the oldest sedimentary rock. It forms part of the African crystalline shield and consist of West African Craton, which occurs predominantly in the West, and the Craton that occur in the East (van Breeman, 1984). The rocks evolve through four major orogenic events and radiometric data that have been used to delineate four major orogenic belts in the Precambrian of African.

They include:

1. The Liberian Orogeny rock emplaced about 2500-2800Ma.
2. The Eburnean Orogeny rock emplaced about 2200-1800Ma.
3. The Kiberian Orogeny rock emplaced about 1300-900Ma.
4. The Pan African Orogeny rock emplaced about 600-150Ma.

   Out of all these Orogenic belts, Pan African is the most recent and the most wide spread (even most significant) in Nigeria, since it is only part of a vast area in Africa that experience a major thermostectonic upheaval that occur about 600-180M years ago emplacing rocks of this age (Rahaman, 1976).

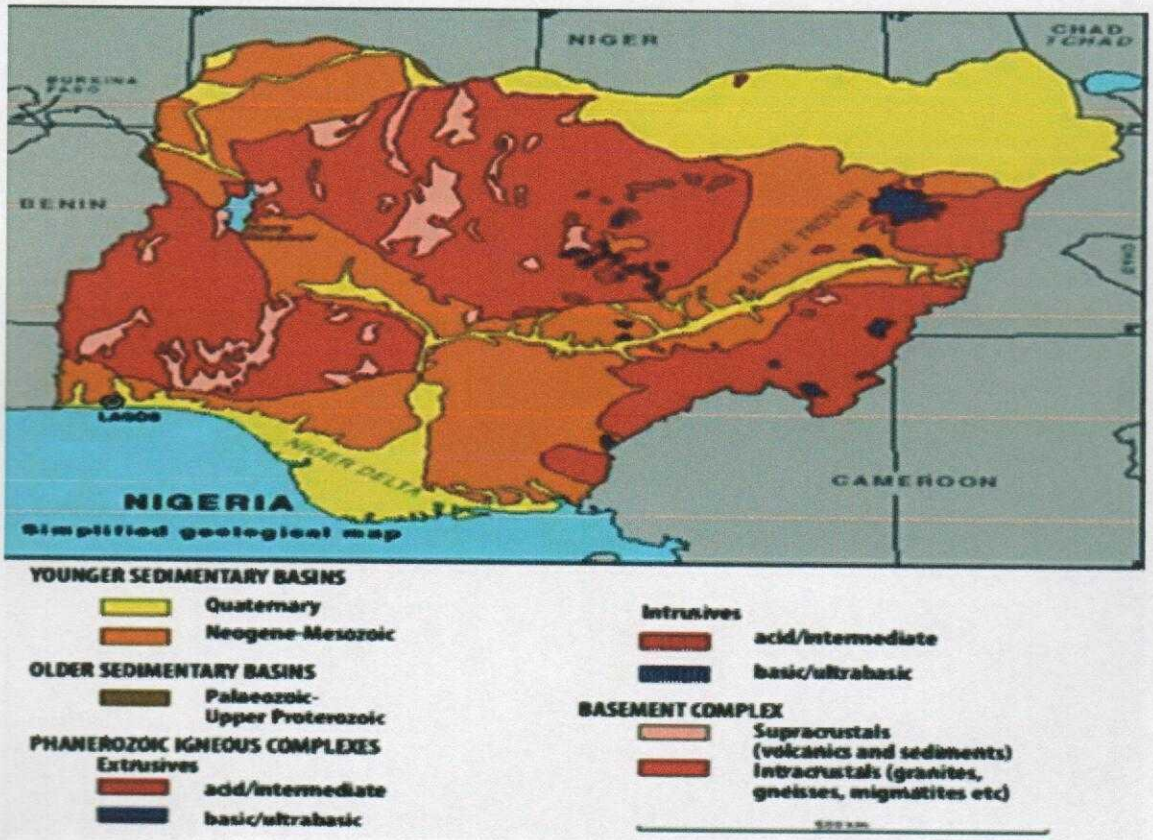


Figure 2: Regional Map of Nigeria (after Ajibade 1979)

2.3.2 GEOLOGY OF EKITI STATE

Geologically, Ekiti state is underlain by metamorphic rocks of the Precambrian basement complex, the great majority of which are very ancient in age.

These basement complex rocks show great variations in grain size and in mineral composition. The rocks are quartz gneisses and schist's containing essentially of quartz with small amounts of white micaceous minerals.

In grain size and structure, the rock varies from very coarse grained pegmatite to medium grained gneisses. The rocks are strongly foliated and they occur as outcrops especially in Efon Alaaye and ikere Ekiti areas (Smyth and Montgomery).

2.3.3 GEOLOGY OF OYE EKITI

Oye Ekiti area of Ekiti state, falls within the basement complex south-western part of Nigeria.

Geologically the rock present there are biotite, granite, charlokite, granite genesis and migmatite. The identification of the rock involved their characteristics features. The minor rocks are well exposed, while some just traverse below the surface and also the drainage pattern in these area are majorly trellis drainage pattern controlled by structures.

2.3.4 GEOLOGY OF THE STUDY AREA (permanent site federal university Oye Ekiti phase one faculty of social-science and humanities)

The study area is within the south western part at Oye Ekiti, the study area has really been develop with lecture rooms, cafeteria and health center which is underlain by migmatite, migmatite gneiss, granite, granite gneiss and also charlokite whereby most of the outcrop in the area have been metamorphosed i.e. the rock produced structurally and mineralogical changes in any type of rock in response to physical and chemical condition different from those under which the rocks originally formed.

CHAPTER THREE

3.0 MATERIAL AND METHOD

3.1 FIELD PROCEDURE USED IN ELECTROMAGNETIC (Very low frequency (VLF)) METHOD

The first commercially available ground VLF instrument was made in 1964by Ronka (Paterson and Ronka 1971) with others being manufactured within the following few years. Geonics EM-16 has been the most widely used instrument, its resistivity mapping mode is also very well used in the EM16R configuration. Other instruments have been useful in recent time such as WADI from ABEM, OMNI IV, the VLF-3, and VLF-4 from scintrex.

A worldwide network of high power VLF station has been established, the sites are arranged so that at least two stations can be detected anywhere over the earth's surface.

Very low frequency measurement can be made from air, but only ground-based system will be considered in this work and Abem wadi is employed for the instrumentation of the survey. And also for the purpose of this work, five (5) traverses were established within the survey area and the profile technique was employed for the VLF-EM using a station separation of 5m along the pre cut traverse. VLF method has remained an excellent, cheap and rapid tool for reconnaissance mapping of conductive mineralization bodies and also mapping of depth to bedrock of a building.

3.1.1 FILTERING AND INTERPRETATION OF VERY LOW FREQUENCY (VLF)

VLF tilt angle are being interpreted qualitatively. The point where tilt angle crossed over from being positive to negative is usually interpreted as being immediately above the top of conductor causing the anomaly. In profile, this crossover is usually quite clear, when plotted spatially in map form, however, the locus of all zero points (a line joining the cross-over points from each profile) is not as easy to recognize. These problem has been resolved by the used of filter, such as that device by Frazer 1969, which shift the tilt-angle data by 90 degree so that crossover points become peaks.

The filter (which is applied in other to eliminate errors and enhance interpretation of data) uses four consecutive data points, where the data have been acquired at a regular interval and can be applied very simply using a hand calculator or spreadsheet. The sum of the first and second data is subtracted from the sum of the third and fourth values and plotted at the midpoint between the second and third tilt angle stations.

$F_1 = [(M_3+M_4) - (M_1+M_2)]$

Where: F_1 is the Fraser filter value

M_1, M_2, M_3, M_4 are Electromagnetic data and the subscripts are the station positions.

The filter attenuated long spatial wavelengths is help to overcome some respect of topographic effects, overburden effects, possibility of metallic conductors and also to reduce the slow temporal variations signal strength of the transmitter. The filtered real data transform every genuine inflection points of the real anomaly to positive peaks while reverse crossovers become negative peaks.

The real and filter real data are then doubled plotted against the stations and the interpretation is based on the highest peak of the profile, which enabled qualitative identification of the top of linear fractures as points of coincident of crossovers and positive peaks of the real and filtered real anomaly curves. The real and imaginary component of the electromagnetic data is used to determine the conductivity and formation thickness.

Summarily, the characteristics of the measured tilt curve can give the following information:

- The slope of the tilt curve near the inflection point is a qualitative measure of the depth to the top of the conductor.
- The location of conductor is directly below the inflection point, where the tilt angle changes sign.
- The asymmetry of the profile gives a rough indication of the dip of the conducting sheet. However, after the consideration of the profile, the peak zone of the positive filter real anomalies are considered as points for further investigation for building failure investigation because they often correspond to zone with high conductivity which characterizes fault structures or clayey anomalies (Alvin *et al, 1997*).

3.2 FIELD PROCEDURE USED IN ELECTRICAL RESISTIVITY METHOD

The vertical electrical sounding was used in measuring vertical variation of ground resistivity. The electrodes are placed in a straight line and the inter-electrode spacing is gradually increased about a fixed centre. For the purpose of this work twenty-one (21) VES were generated on three (3) traverses which are used to determine the overburden thickness, isopach of the topsoil and resistivity of basement rocks in the subsurface. The following precautionary measure was adhered to while using this method which include;

- We ensured that the current and potential electrode was fully in contact with the natural ground
- We ensured proper connection of inter connecting reel cables to the terrameter.

3.2.1 INTERPRETATION OF DATA

Vertical electrical sounding could be interpreted either qualitatively or quantitatively.

Qualitatively Interpretation of VES

The qualitative interpretation of VES data involves the visual inspection of curve types.

Quantitatively Interpretation of VES

In quantitative interpretation of VES data, the aim is to determine the number of layers represented by the curve individual layer resistivity and the thickness. The procedures for the quantitative interpretation are as follow;

- Curve matching: Using the available albums of theoretical curves computed for mathematical model with two, three or four layers.
- Partial curve matching (auxiliary point method): The auxiliary point method is an empirical method by which a multi-layer problem is progressively reduced by simple two or more cases.
- Direct interpretation: Interpretation of VES curve in terms of layer thickness and resistivity is carried out with the aid of computer programs and without an initial approximation of the geo-electric section.

In partial curve matching adopted in this project report, each sounding curve was superimposed on the master curve and with the axes are kept parallel moved around until a fit was obtained as many point as possible. The point of interjection of the master curve was marked on field curve tracing paper as X1. The coordinate X1 on the log-log graph paper gave P1 and h1 the resistivity and the thickness of the first layer. The value K of the master curve, which fitted the first segment of the field curve, is noted as K1. This is the reflection co-efficient at the interface between the first and second layer.

The auxiliary curve and the reflection co-efficient value of K1 was drawn on the field curve in broken lines with the axis kept parallel, the next segment of the field curves was fitted to a two layer master curve of best fit. When the best fit was obtained, the point of intersection of the master curve marked as X2. The coordinates of X2 on the log-log graph gave the replacement resistivity and thickness of the third layer. The actual resistivity and thickness of the second layer was calculated using this relationship.

P1=k1p1 and h2=h1Dn/Dr1

Where Dn/Dr1 is the depth index read off the auxiliary curve by placing X 1 at the origin of the auxiliary curves and tracing X2 parallel to the auxiliaries bordering it. For the four layers, the last segment of the curve was fitted to the master curves and X3 marked as done previously, K3 and h3r are read off. The actual layer resistivity is calculated using X2 and X3 as done previously thus H3=h2rDn/Dr2.

3.3 FIELD INSTRUMENTS ON VLF-EM METHOD

Albem wadi , topographical map, Global positioning system (GPS), compass clinometers, meter rule, field note, graph sheet, pencil, ruler, and cutlass.

3.4 FIELD INSTRUMENT ON ELECTRICAL RESISTIVIY METHOD

R-50 resistivity meter, and its accessories like the connecting cables and crocodile clip, four reels of long cables, four electrodes, measuring tapes, hammers, a global positioning system (GPS), topographical map, field note, pencil, ruler, and cutlass.

CHAPTER FOUR

4.1 RESULT AND INTERPRETATION

Five (5) traverses on VLF profiling which is of three (3) N-S and two (2)E-W were surveyed in the study area with 5.0m interval spacing and length ranges from 5m to 105m.

During the survey exercise the used of R-50 resistivity meter, magnetometer and also VLF-EM instrument were used in obtaining the data from the field.

The real and imaginary data obtained were recorded from the field. The filter real and filtered imaginary values were calculated. The real component and filtered real component values were plotted against the station numbers to give the VLF anomaly graph for each of the traverse interpretation of the VLF anomaly graph.

Interpretation of the VLF anomaly graph for the investigation of post foundation studies is based mostly on qualitative and inflection point of filter imaginary values and filter real values which are more diagnostic of linear features. High positive filtered real anomaly indicated sites with high electromagnetic anomaly which was suspected to the weathered zone that can act as causes of crack and were further probed by Electrical Resistivity (VES) method and magnetic method for detailed survey.

These same process of qualitative interpretation was adopted for the remaining profiles and pseudo sections. Based on the point of VLF-EM profiles the points of interest marked as conductive zones were among the points that were further investigated using the vertical electrical sounding (VES). The interpretation of these result are discussed below in the various traverses:

4.1.1 TRAVERSE 1

Traverse 1covers a distance of 80m. The Raw real component ranges from 1 to 17, the highest positive value of the raw real component is 17.0, while that of the filter real values obtained ranges from -1 to 5 and the highest positive value of the filtered real is 5.0. The profile shows peak in both positive and negative regions, but the more prominent positive filtered real value is considered. Hence, three conductive zones are considered for further geophysical investigation based on it high positive filtered peak value.

And also looking at the conductive zone from magnetic euler deconvolution and its in line with the fracture and also the point of reflection looking at the geo-electric section is also inline and it is assuming to be clay and main looking at the building the clayey material is affecting the building due to the low resistivity and the 2nd layer is also thick which can affect the building, the 1st layer is thin to absorb the foundation and the 2nd layer is low resistive which is likely to be clay can trend the foundation capacity.

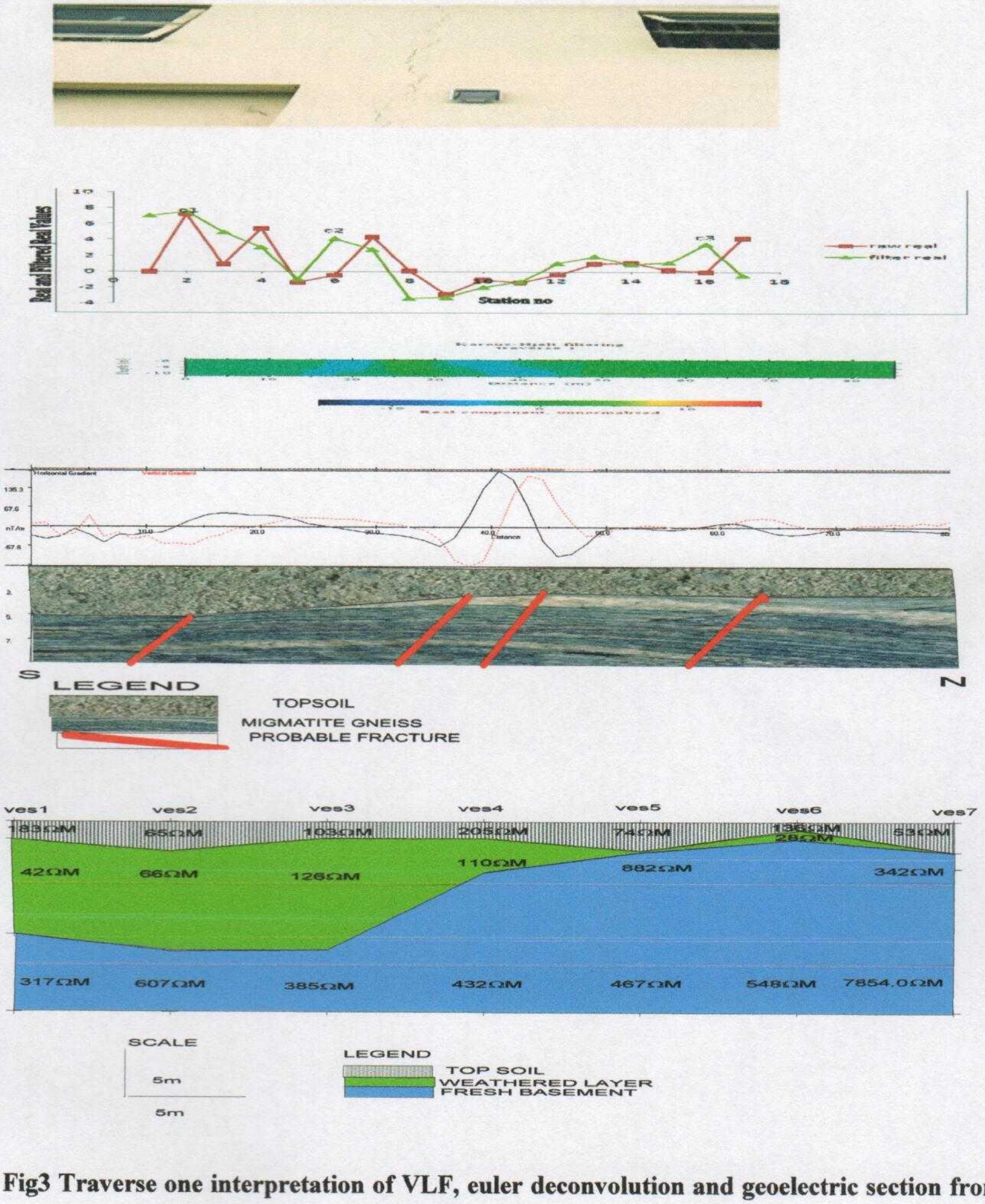


Fig3 Traverse one interpretation of VLF, euler deconvolution and geoelectric section from ves 1-7

4.1.2 TRAVERSE 2

Traverse 2 covers a distance of 110m. The Raw real component ranges from 0 to 110, the highest positive value of the raw real component is 110.0, while that of the filter real values obtained ranges from 23 to 110 and the highest positive value of the filtered real is 110. The profile shows peak in both positive and negative regions, but the more prominent positive filtered real value is considered. Hence, two conductive zones are considered for further geophysical investigation based on it high positive filtered peak value.

And also looking at the conductive zone from magnetic euler deconvolution and its in line with the fracture and also the point of reflection looking at the geo-electric section is also inline and it is assuming to be clay and main looking at the this clayey material is affecting the building due to the low resistivity and the 2^{nd} layer is also thick which can affect the building, the 1^{st} layer is thin to absorb the foundation and the 2^{nd} layer is low resistive which is likely to be clay can trend the foundation capacity.

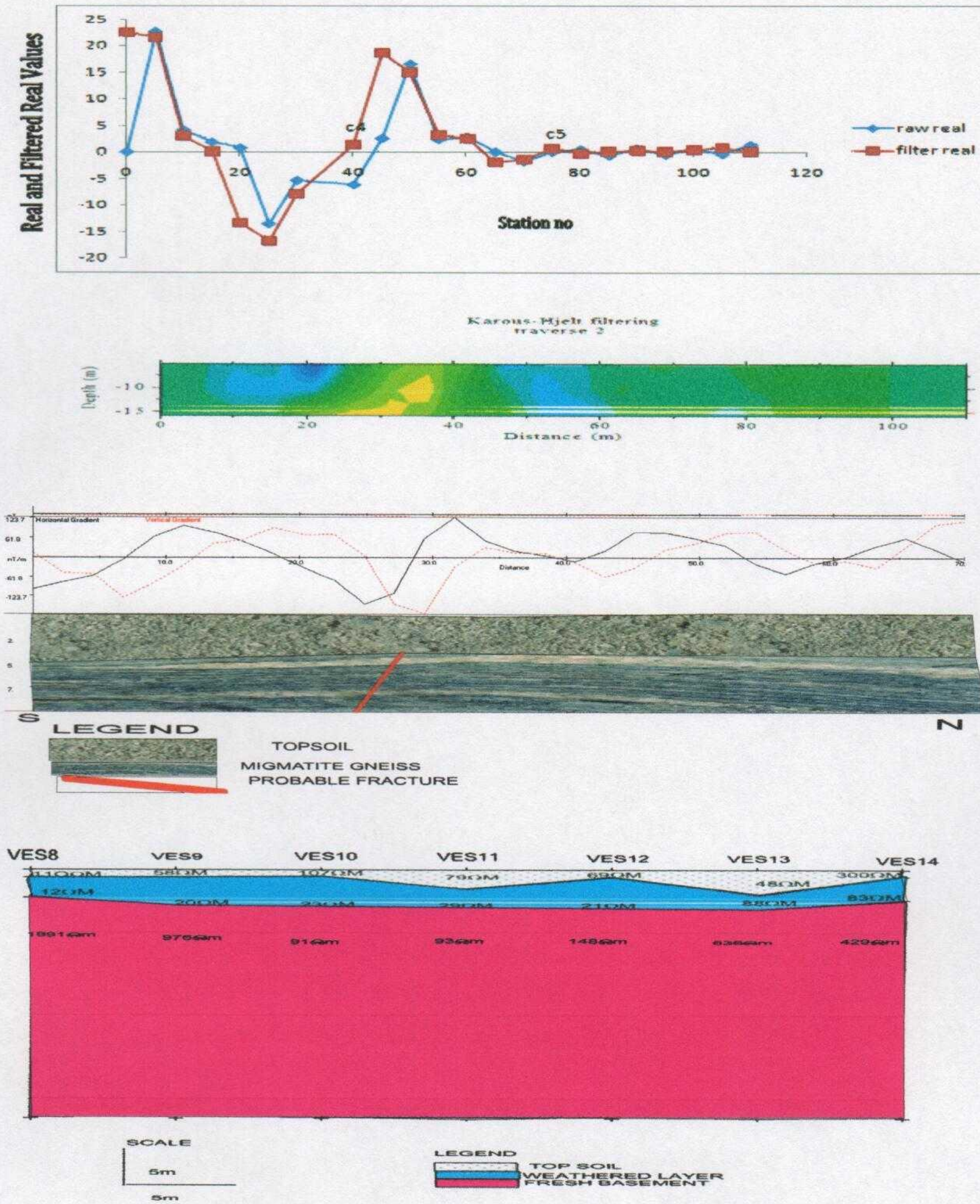


Fig4 Traverse two interpretation of VLF, euler deconvolution and geoelectric section from ves 8-14

4.1.3 TRAVERSE 3

Traverse 3 covers a distance of 145m. The Raw real component ranges from 0 to 140, the highest positive value of the raw real component is 140.0, while that of the filter real values obtained ranges from 15 to 145 and the highest positive value of the filtered real is 145.0. The profile shows peak in both positive and negative regions, but the more prominent positive filtered real value is considered. Hence, One conductive zones are considered for further geophysical investigation based on its high positive filtered peak value.

And also looking at the conductive zone from magnetic euler deconvolution and its in line with the fracture and also the point of reflection looking at the geo-electric section is also inline and it is assuming to be clay and main looking at the this clayey material is affecting the building due to the low resistivity and the 2nd layer is also thick which can affect the building, the 1st layer is thin to absorb the foundation and the 2nd layer is low resistive which is likely to be clay can trend the foundation capacity.

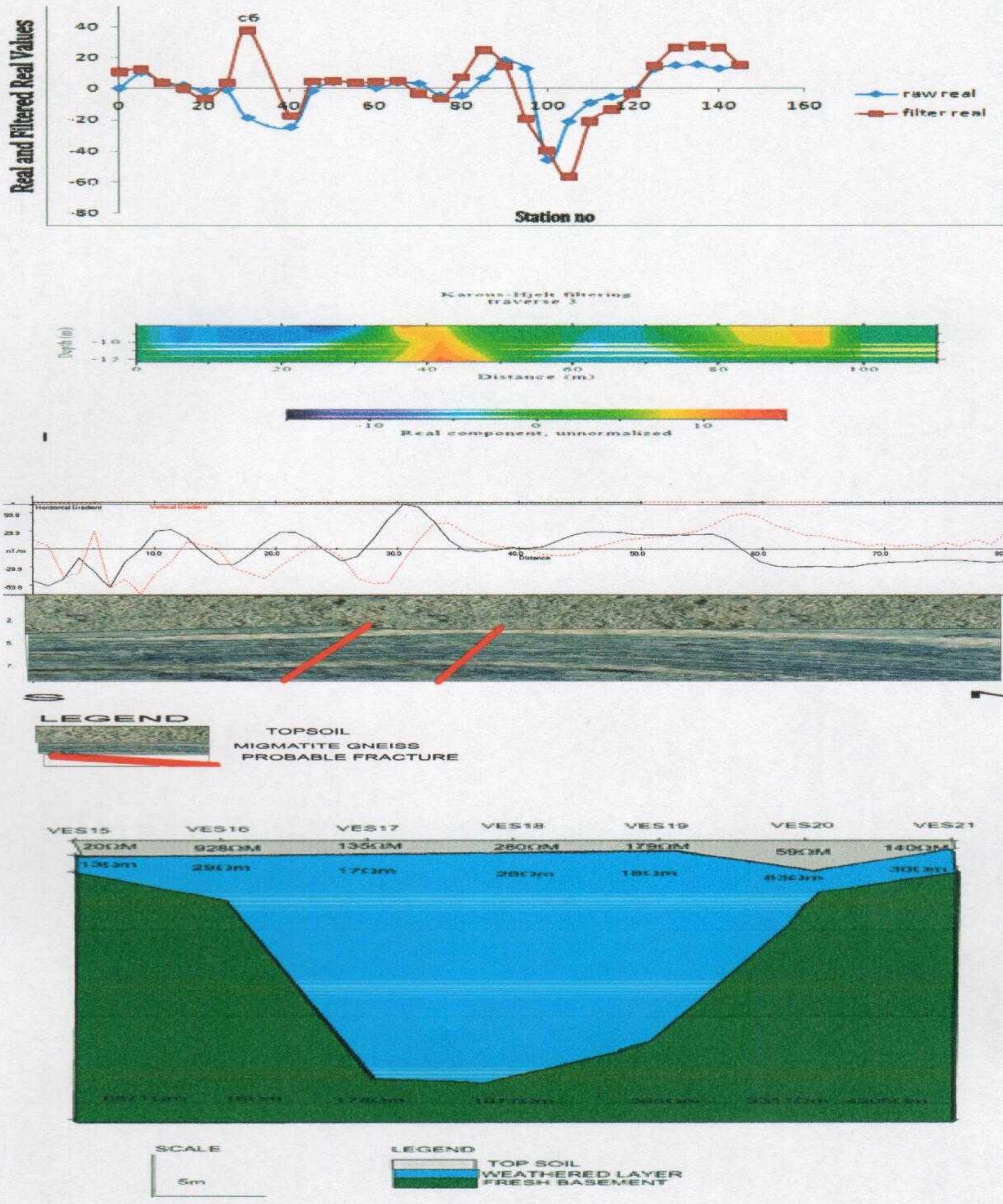
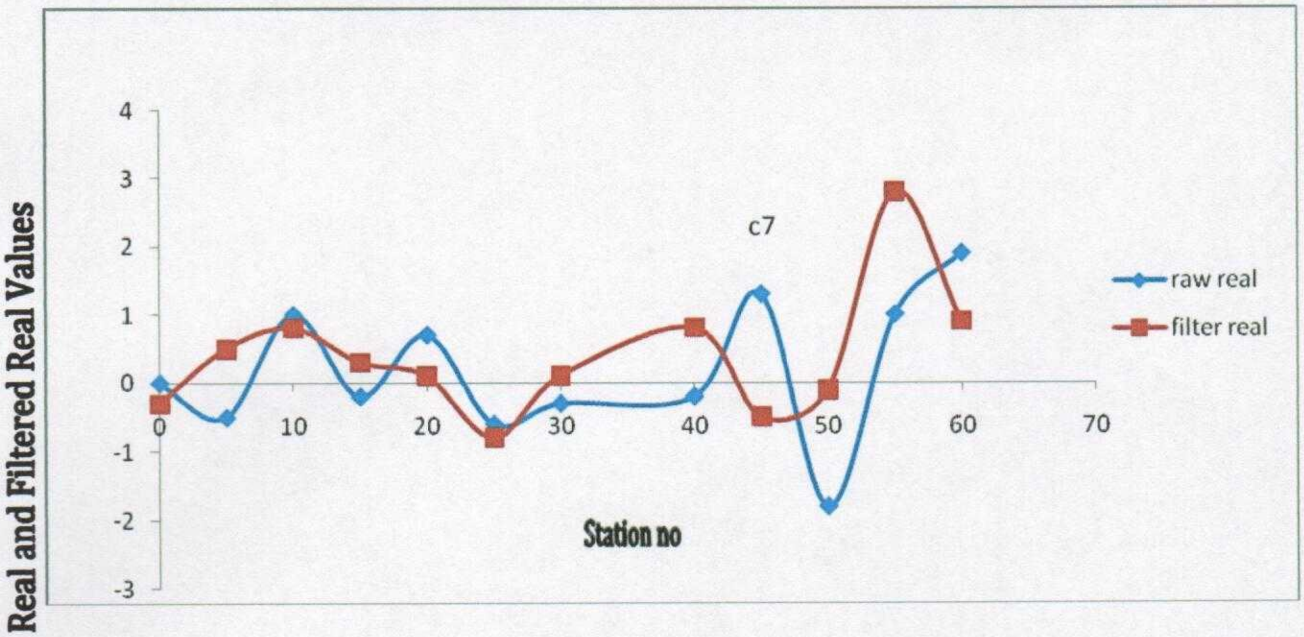


Fig4 Traverse three interpretation of VLF, euler deconvolution and geoelectric section from ves 15-21

4.1.4 TRAVERSE 4

Traverse 4 covers a distance of 65m. The Raw real component ranges from 0 to 65, the highest positive value of the raw real component is 65.0, while that of the filter real values obtained ranges from -0 to 65 and the highest positive value of the filtered real is 65.0. The profile shows peak in both positive and negative regions, but the more prominent positive filtered real value is considered. Hence, One conductive zones are considered for further geophysical investigation based on it high positive filtered peak value.



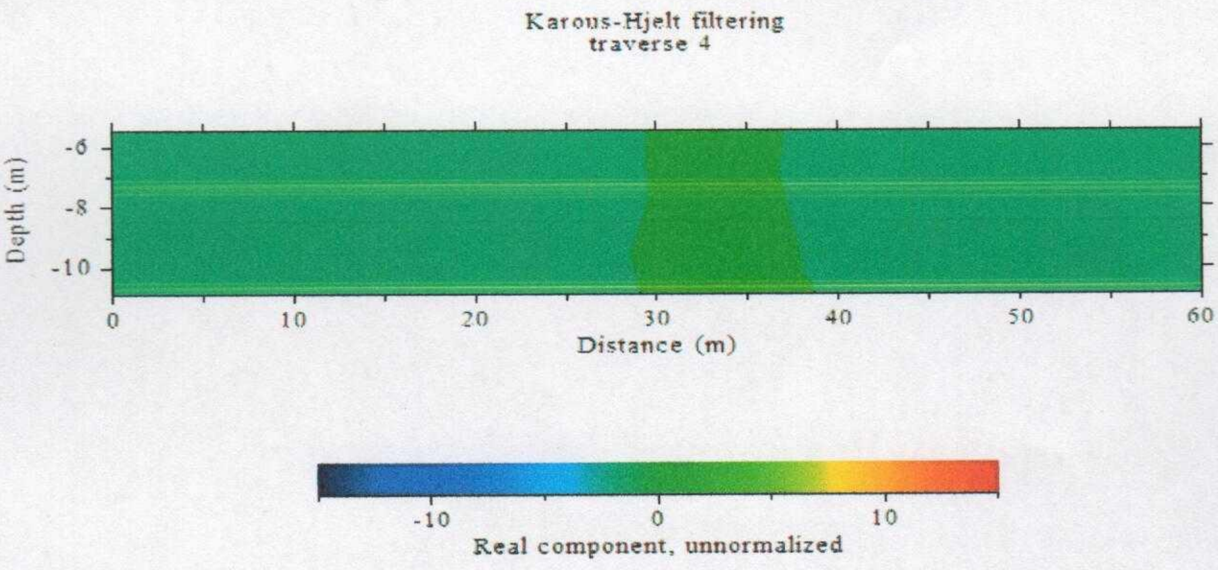


Fig6 Traverse four interpretation of VLF

4.1.5 TRAVERSE 5

Traverse 5 covers a distance of 85m. The Raw real component ranges from 0 to 80, the highest positive value of the raw real component is 80.0, while that of the filter real values obtained ranges from -0 to 85 and the highest positive value of the filtered real is 85.0. The profile shows peak in both positive and negative regions, but the more prominent positive filtered real value is considered. Hence, One conductive zones are considered for further geophysical investigation based on it high positive filtered peak value.

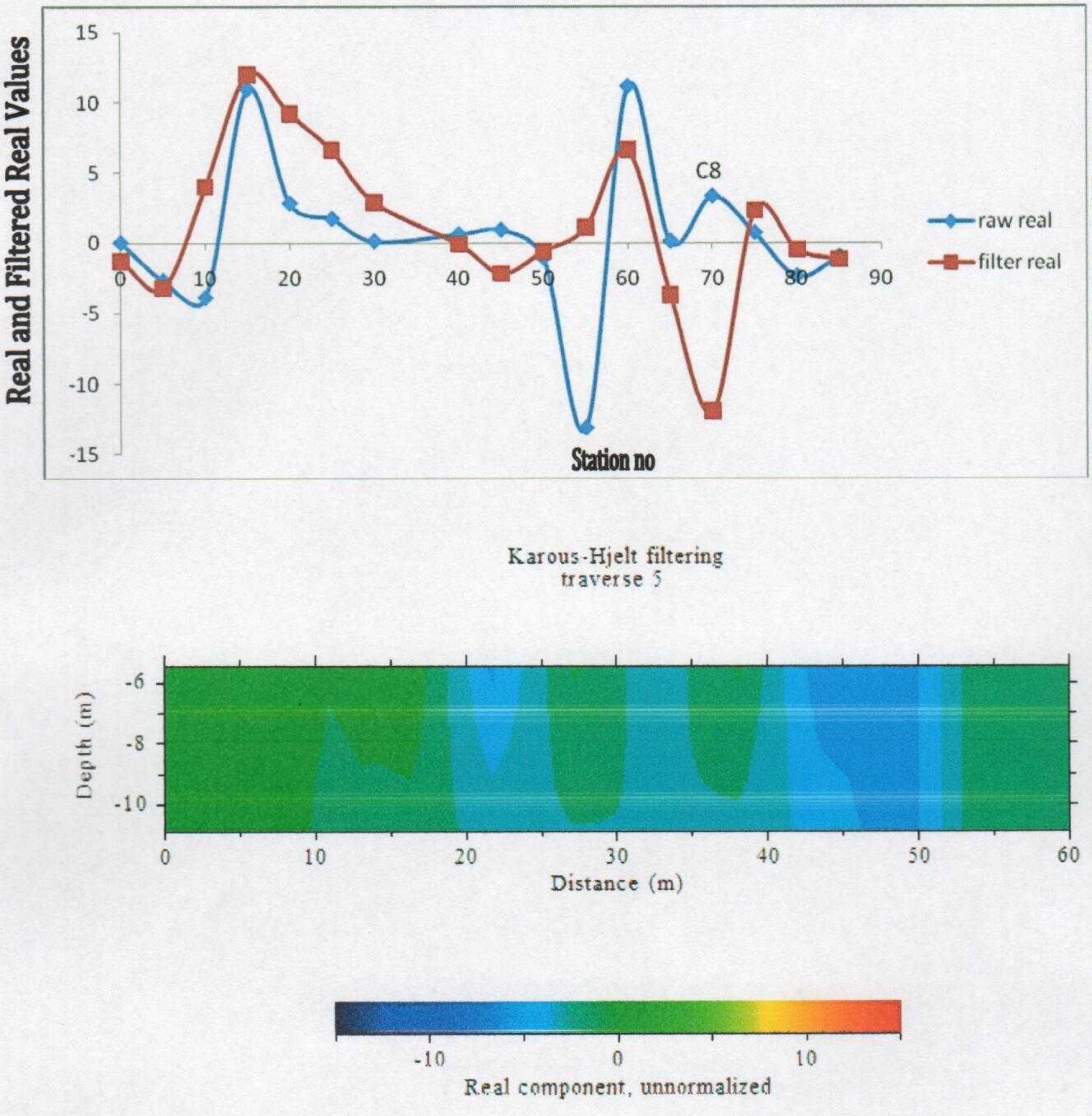


Fig7 Traverse five interpretation of VLF

After proper investigation of all electromagnetic VLF field data considering particularly the filtered real values and points of VLF anomaly has been located, Vertical Electrical Sounding were carried out in the same location at 5m intervals to suspected the causes of crack in the building. Three out of Five traverses were survey with VES and Twenty One (21) VES were carried out from Three traverses.

The details of the obtained results, and interpretation are presented below.

4.2 RESULT AND INTERPRETATION OF VERTICAL ELECTRICAL SOUNDING (VES)

Twenty One (21) Vertical Electrical Sounding, were carried out with the aid of R-50 resistivity meter, the result obtained in form of resistance were converted to apparent resistivity by multiplying the resistance value with appropriate Geometric Factors.

The values obtained were then plotted against the current electrode spacing (AB/2) on the log-log graph and the field curve obtained were then obtained were then interpreted using the curve matching method. The data obtained were inputted into the computer for analysis using the Winresist software for further processing.

The computer iteration smoothern the values to filter out the errors and the noise observed, this makes the adjusted or connected apparent resistivity values slightly different from the original observed values. The geoelectrical parameters were obtained from the value of resistivity and thickness gotten from the computer iterated result and the result obtained reveals three geo-electric layers in each of the traverses.

4.2.1 CURVE INTERPRETATIONS

This interpretation is based on the resistivity values of each layer, thickness of each layer and their respective K-factor using qualitative and quantitative interpretation of VES curve obtained from the study area.

Location of Ves	Layers	Resistivity (Ωm)	Layer interface (m)	Depth to interface (m)	Curve Types	Geological Implication
1	1 2 3	183.4 42.2 315.6	1.4 7.5	1.4 8.9	H	Top soil weathered layered fresh basement
2	1 2 3	64.6 66.1 607.1	2.4 7.7	2.4 10.1	A	Top soil weathered layered fresh basement
3	1 2 3	102.8 126.4 385.2	1.3 8.9	1.3 10.1	A	Top soil weathered layered fresh basement
4	1 2 3	204.7 109.9 432.3	1.3 2.8	1.3 4.0	H	Top soil weathered layered fresh basement
5	1 2 3	74.3 882.1 465.6	2.4 5.9	2.4 8.3	K	Top soil weathered layered fresh basement
6	1 2 3	136.2 27.7 548.4	0.5 0.9	0.5 1.4	H	Top soil weathered layered fresh basement
7	1 2 3	52.6 341.9 7854	2.4 1.3	2.4 3.7	A	Top soil weathered layered fresh basement
8	1 2 3	1109.7 11.5 1890.9	0.8 2.0	0.8 2.8	H	Top soil weathered layered fresh basement
9	1 2 3	58.2 19.7 976.3	0.8 3.2	0.8 3.9	H	Top soil weathered layered fresh basement
10	1 2 3	107.3 23.1 91.4	0.7 1.6	0.7 2.3	H	Top soil weathered layered fresh basement
11	1 2 3	78.7 29.1 92.6	2.7 1.3	2.7 2.0	H	Top soil weathered layered fresh basement

12	1 2 3	78.7 29.1 92.6	0.7 1.5	0.7 2.2	H	Top soil weathered layered fresh basement
13	1 2 3	47.6 88.1 635.5	2.5 1.7	2.5 4.1	H	Top soil weathered layered fresh basement
14	1 2 3	299.8 83.0 428.9	0.7 2.3	0.7 3.0	H	Top soil weathered layered fresh basement
15	1 2 3	20.3 13.0 6870.5	1.3 1.5	1.3 2.8	H	Top soil weathered layered fresh basement
16	1 2 3	927.5 29.4 17.7	0.4 4.4	0.4 4.8	Q	Top soil weathered layered fresh basement
17	1 2 3	134.8 17.0 177.6	1.2 20.1	1.2 21.3	H	Top soil weathered layered fresh basement
18	1 2 3	279.6 28.2 1877.0	1.0 20.7	1.0 21.6	H	Top soil weathered layered fresh basement
19	1 2 3	179.3 18.1 394.9	1.0 16.7	1.0 17.7	H	Top soil weathered layered fresh basement
20	1 2 3	59.2 82.6 3310.5	3.0 1.4	3.0 4.4	H	Top soil weathered layered fresh basement
21	1 2 3	140.2 29.5 4306.1	0.7 1.4	0.7 2.3	H	Top soil weathered layered fresh basement

TABLE 1: CURVE INTERPRETATION

RESISTIVITY SOUNDING CURVES

The resistivity sounding curves of 21 VES stations obtained from the surveyed area are 3-layers curve of H, A, K and Q. the curves were characterized according to their signatures, which mirror the layer of the subsurface.

The 2-Dimensional view of the geoelectric parameters (resistivity and depth) obtained from the inversion of the electrical sounding data are presented as geo-electric sections.

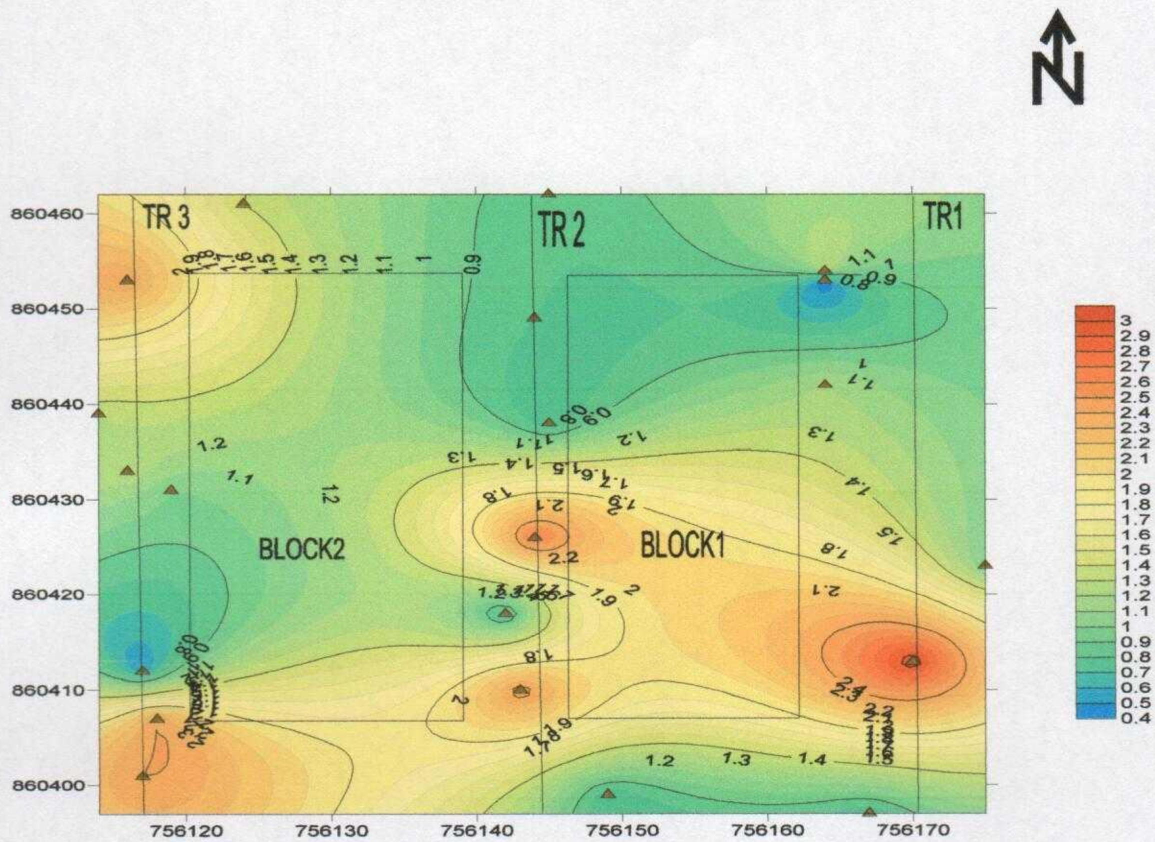
These geoelectric sections taking along three traverses (fig3-5) attempt to correlate the geoelectric sequence across the study area.

Three subsurface geologic layers were delineated in the study area. These include the topsoil, weathered layer and fresh basement with resistivity value ranging from48 Ωm-300 Ωm, 19.7 Ωm-910 Ωm, 430 Ωm-1891 Ωm respctively and the thicknesses ranging from 0.1-2.4m. depth to the depths to the bedrock are generally less than 4m.

4.3 GEOELECTRIC CHARACTERISTICS

4.3.1 Topsoil layer resistivity map

Figure 8 shows that the topsoil layer resistivity contour map of the study area. It is an attempt to study the layer resistivity trend at a shallow depth. The resistivity of the topsoilvaries from 48 Ωm -300 Ωm while the thickness varies from 0.1-2.4m. in the vicinity of the distressed building the top soil resistivity varies from 42.2-101 Ωm. zones within the topsoil where the resistivity values are less than 300 Ωm are considered geotechnical incompetent to carry large engineering structures (adesida and omosuyi, 2005).



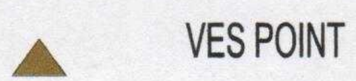


Fig 8: Isorestivity Map Of Top Soil

4.3.2 Layer resistivity map

Layer resistivity map of the study area at depth of 5m is shown in the figure 9. The map shows a trend varying from 50-180 Ωm. around the distressed buildings the resistivity ranges from 48-300 Ωm, typically clayey materials. Therefore at this depth, the north-south part of the study area in which the distressed buildings were located is still geotechnical incompetent.

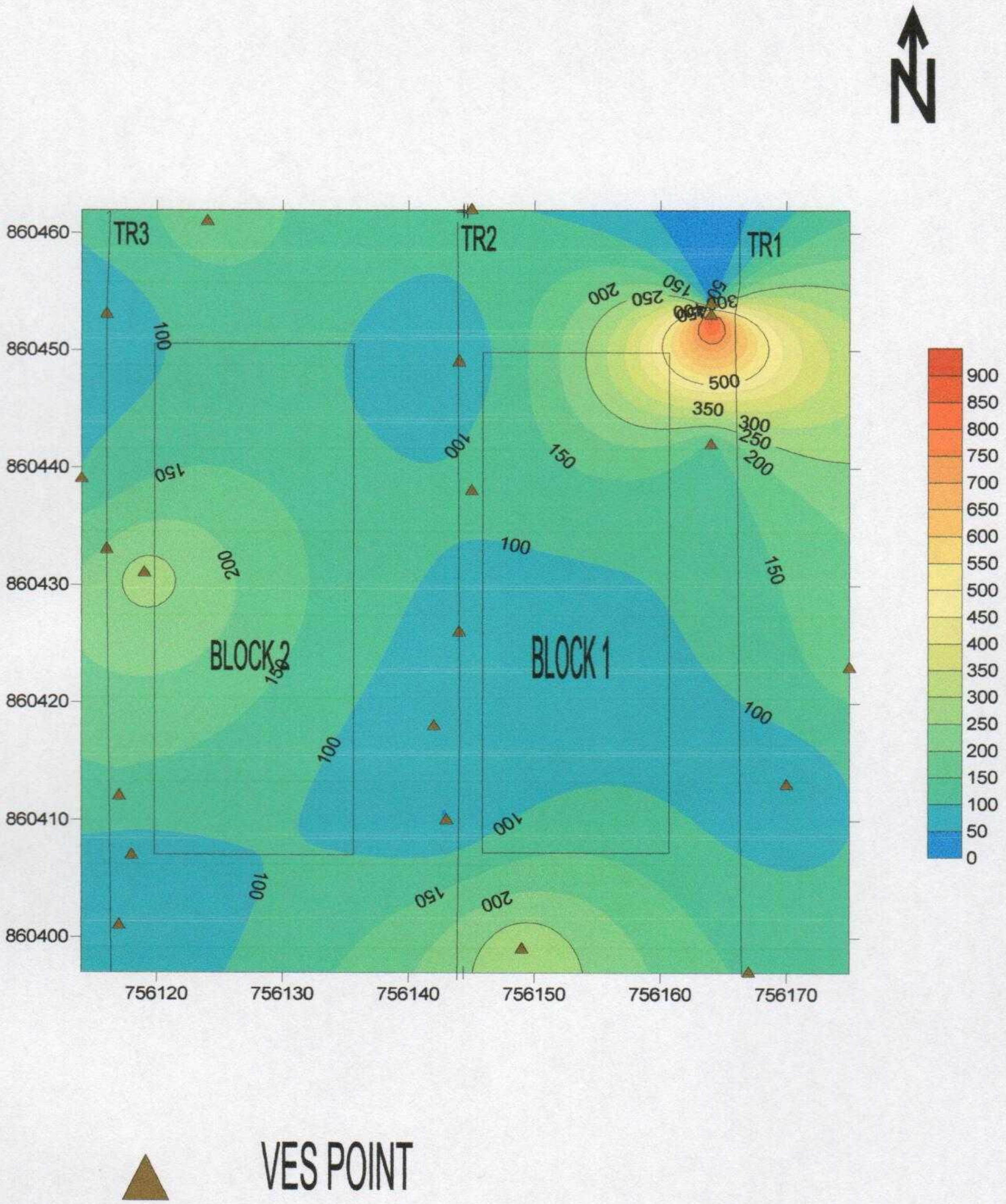


Fig 9: Layer restivity map of the topsoil

4.3.3 Isopach map of overburden

Depth to bedrock beneath all VES stations were plotted and contoured. The overburden thickness map figure 10 shows the depth to bedrock varies from 1.4-10.1m in the study area. The maps shows areas with thin overburden and areas with thick overburden. The overburden thickness is very thin and the only area that is good for foundation varies from 17-22m which is the only place that is good to place the building foundation.

Areas with thick overburden are considered to be incompetent, most especially when it is composed of geotechnical weak overburden materials.

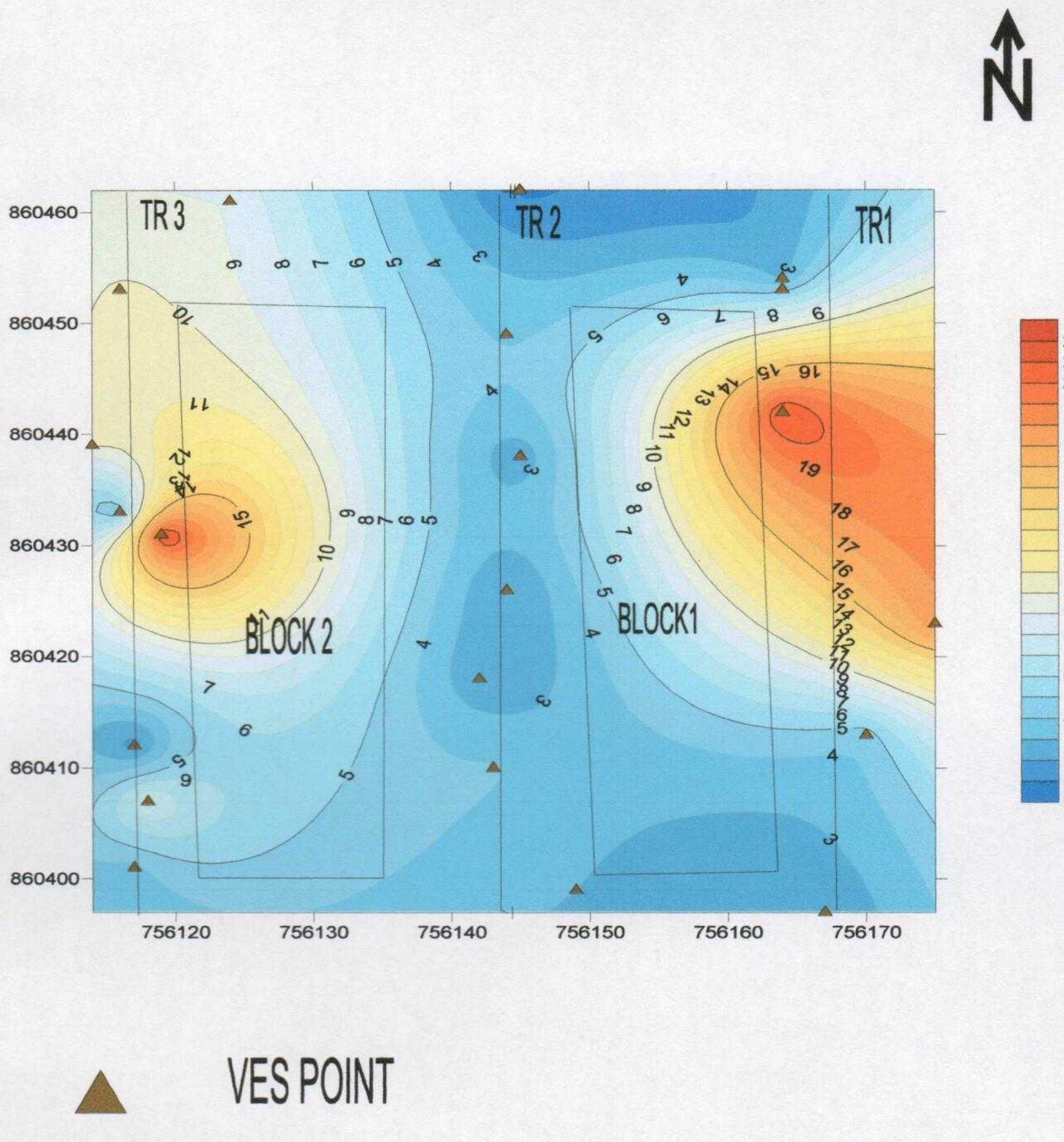


Fig 10: Isopach map of overburden thickness

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Geophysical investigations were carried out within the Faculty of Social Science and Humanities federal university Oye Ekiti in order to unravel the possible causes of failure of building in the area. The geophysical survey involves the use of vey low frequency electromagnetic method (VLF-EM), and the Vertical electrical sounding (VES).

Five traverses were established for the VLF-EM survey with an inter traverse separation distance of 5m. The profiling technique was adopted along the traverses and the results were presented as profiles, 2d models and pseudo section.

Anomaly responses which may due to conductive clayey material and weathered basement/ fracture zones were identified. From the resistivity of the weathered layer beneath the topsoil in which the foundation is seated was found to be a clayey materials. The geo-electric parameters obtained from the VES data interpretation were used to generate the geo-electric section of the study area, isoresistivity maps, overburden thickness map of the bedrock and also isopach map of depth to bedrock.

5.2 RECOMMENDATION

The Very Low Frequency electromagnetic method (VLF-EM) and the vertical electrical sounding (VES) appear to be a valuable tool for post foundation studies.

In order to avert future geophysical problem in the faculty, the services of the geophysicist should be engaged for pre-foundation studies, which will act as a guild for the civil engineers before and during construction.

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Olayinka A.L. and Olorunfemi M.O. 1992. "Determination of geoelectrical characteristics in Okene area and implications for borehole siting". Journal of mining and geology.

Olorunfemi and Okhue 1992 used electrical restivity to map different staratigraphy unit in a geological section.

Palacky et al 1991 "Using electromagnetic method as a reconnaissance survey to locate depth to bedrock in a basement complex.

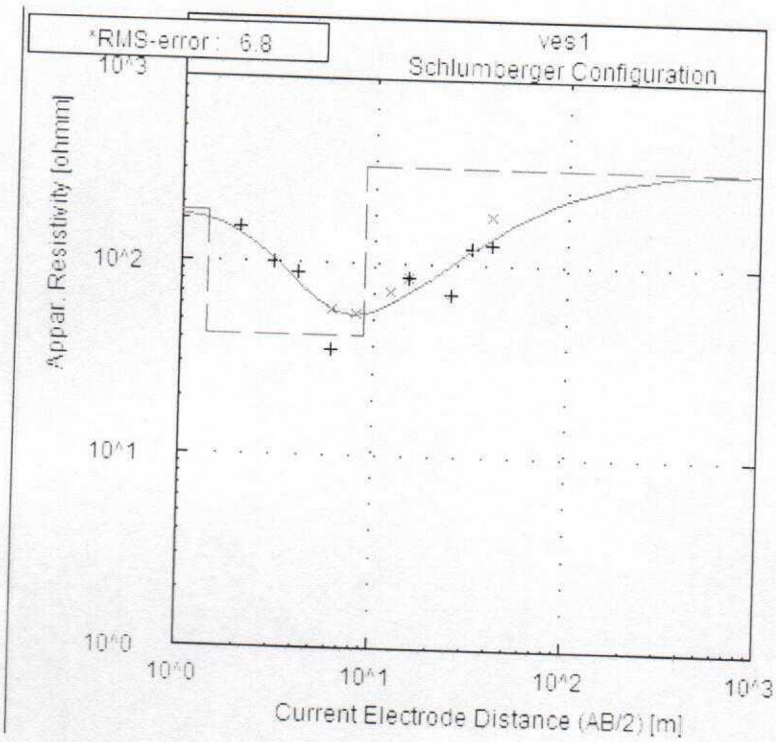
Telford 1976 discuss the limitation of vertical electrical sounding.

Telford M.A. 1988 VLF mapping geological structure.

APPENDIX

VERTICAL ELECTRICAL SOUNDING (VES) PLOTS

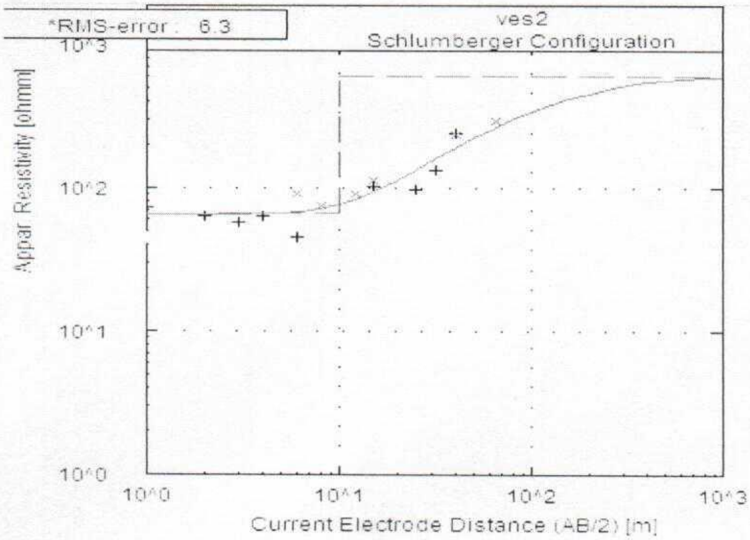
VES 1



No	Res	Thick	Depth
1	183.4	1.4	1.4
2	42.2	7.5	8.9
3	315.6	-.-	-.-

* RMS on smoothed data

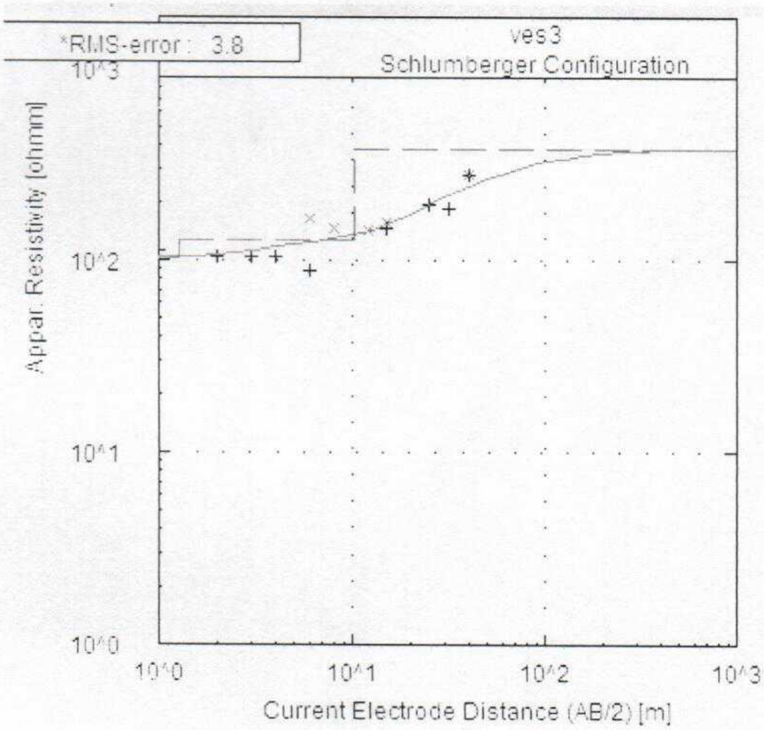
VES 2



No	Res	Thick	Depth
1	64.6	2.4	2.4
2	66.1	7.7	10.1
3	607.1	-.-	-.-

* RMS on smoothed data

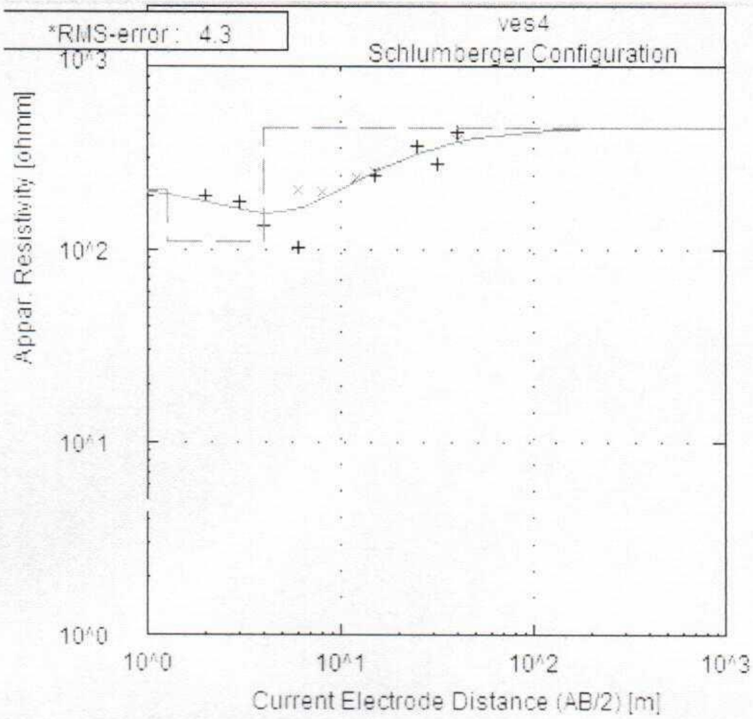
VES 3



No	Res	Thick	Depth
1	102.8	1.3	1.3
2	126.4	8.9	10.1
3	385.2	-.-	-.-

* RMS on smoothed data

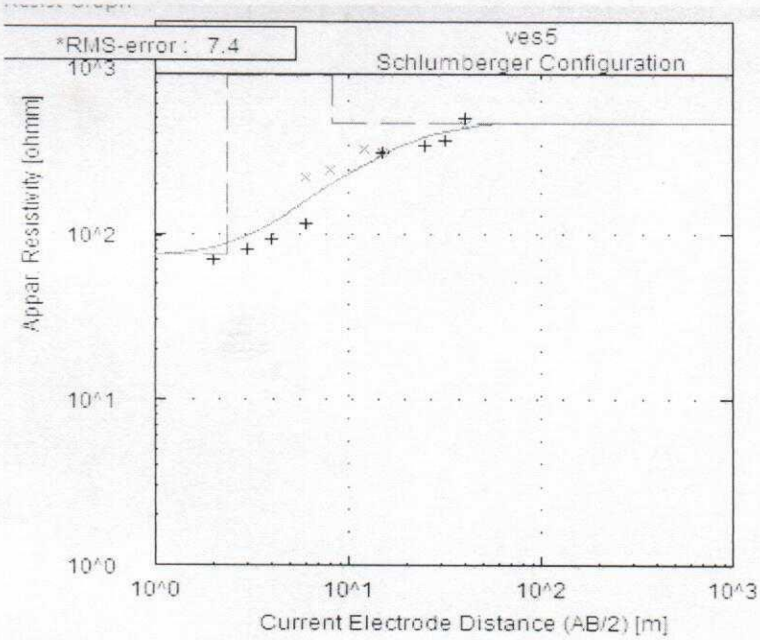
VES4



No	Res	Thick	Depth
1	204.7	1.3	1.3
2	109.9	2.8	4.0
3	432.3	-.-	-.-

* RMS on smoothed data

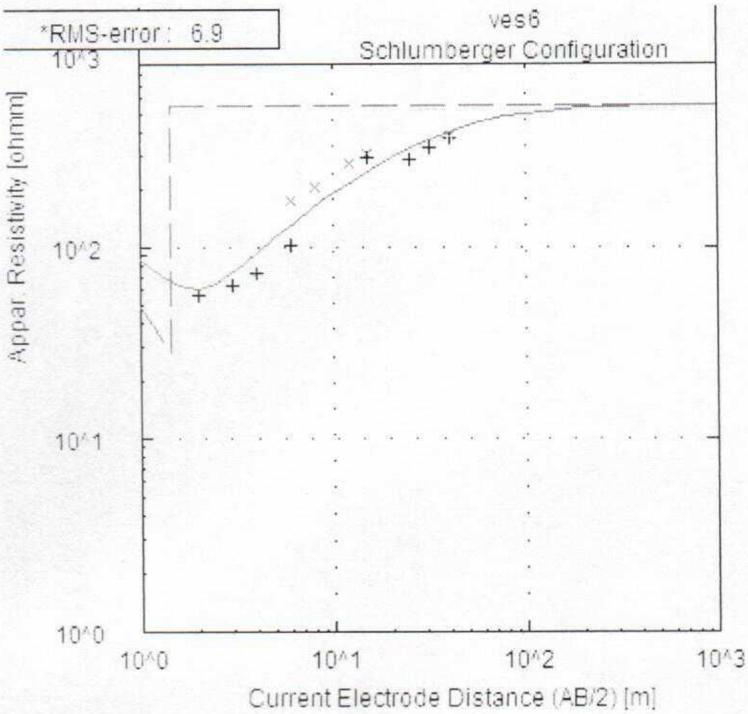
VES 5



No	Res	Thick	Depth
1	74.3	2.4	2.4
2	882.1	5.9	8.3
3	465.6	-.-	-.-

* RMS on smoothed data

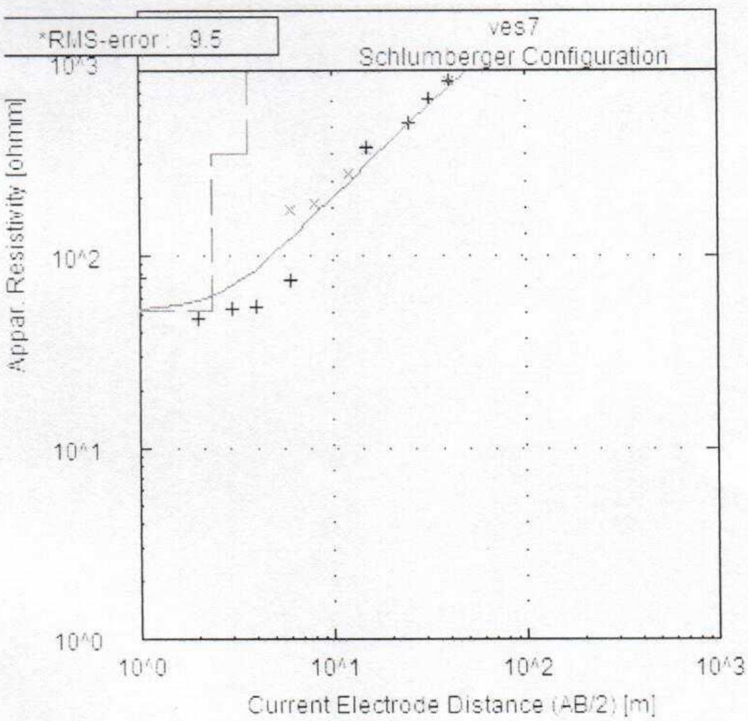
VES 6



No	Res	Thick	Depth
1	136.2	0.5	0.5
2	27.7	0.9	1.4
3	548.4	-.-	-.-

* RMS on smoothed data

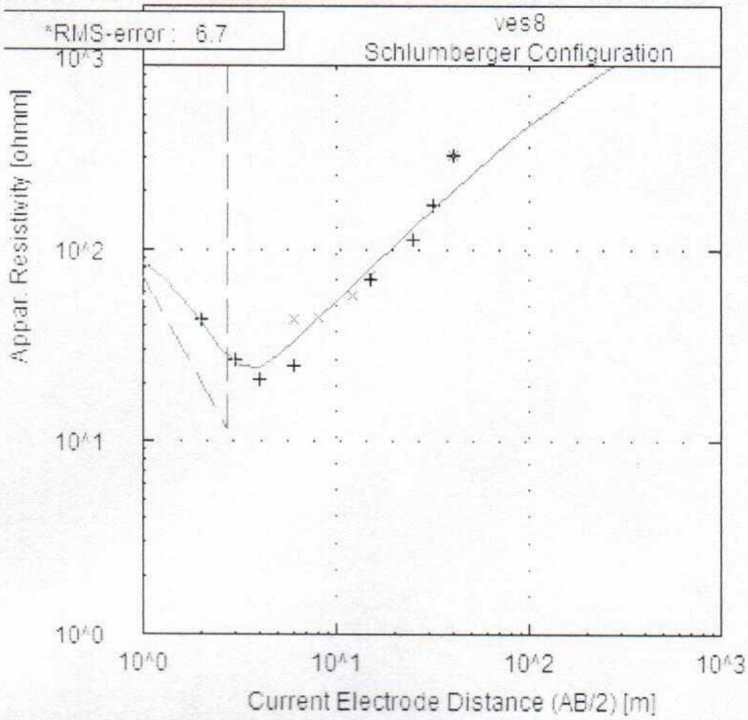
VES 7



No	Res	Thick	Depth
1	52.6	2.4	2.4
2	341.9	1.3	3.7
3	7854.0	-.-	-.-

* RMS on smoothed data

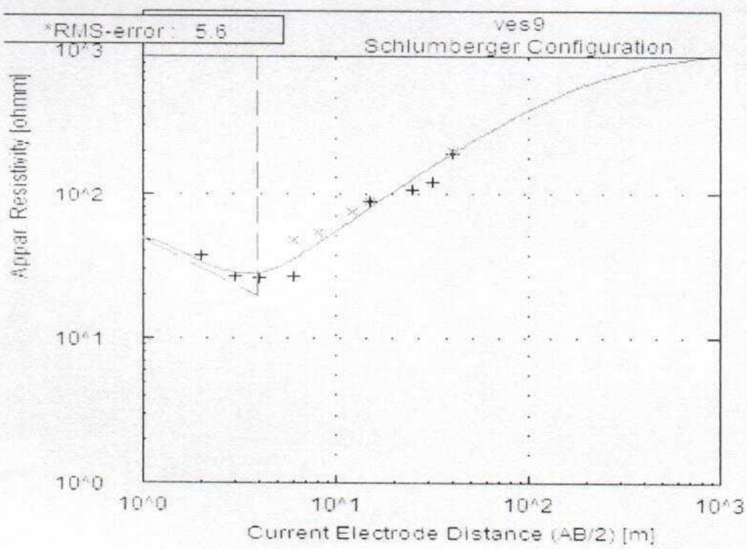
VES 8



No	Res	Thick	Depth
1	109.7	0.8	0.8
2	11.5	2.0	2.8
3	1890.9	-.-	-.-

* RMS on smoothed data

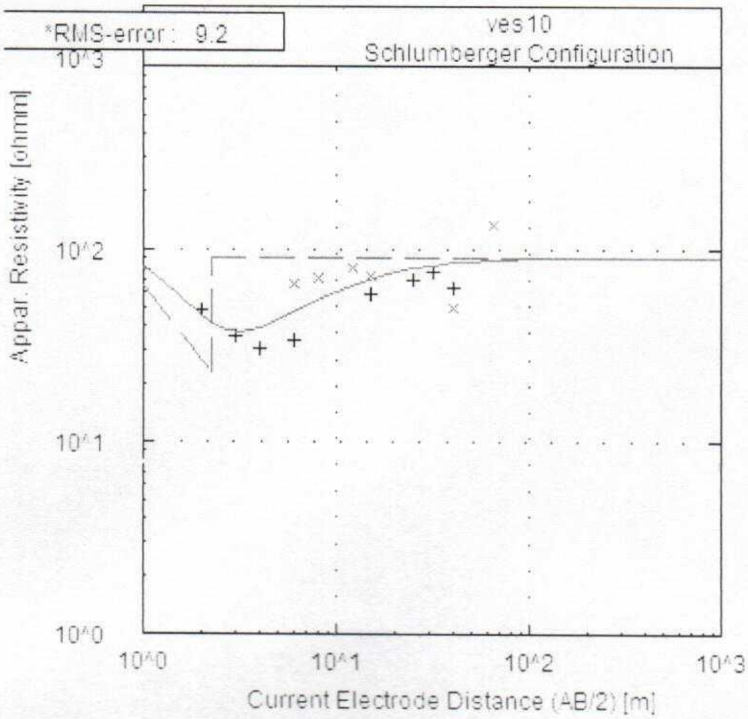
VES 9



No	Res	Thick	Depth
1	58.2	0.8	0.8
2	19.7	3.2	3.9
3	976.3	-.-	-.-

* RMS on smoothed data

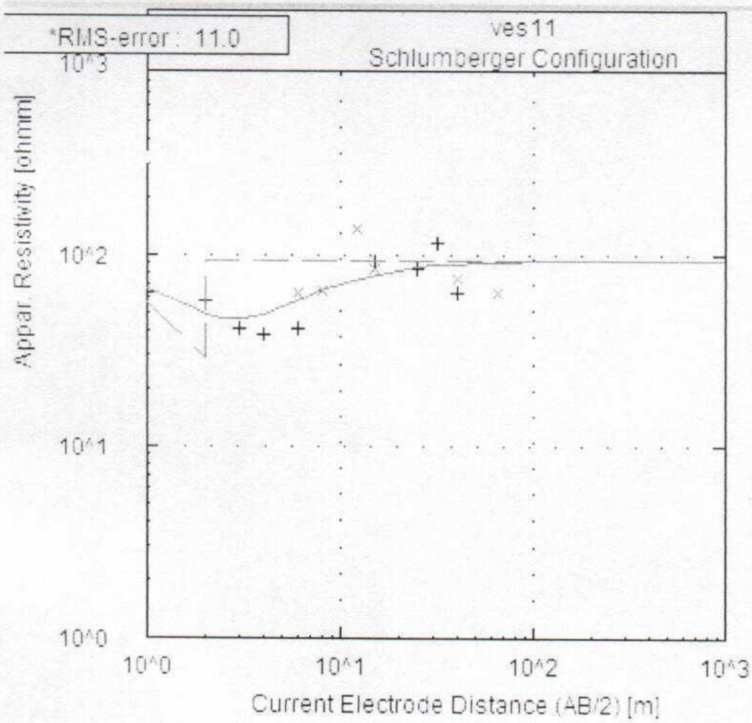
VES 10



No	Res	Thick	Depth
1	107.3	0.7	0.7
2	23.1	1.6	2.3
3	91.4	-.-	-.-

* RMS on smoothed data

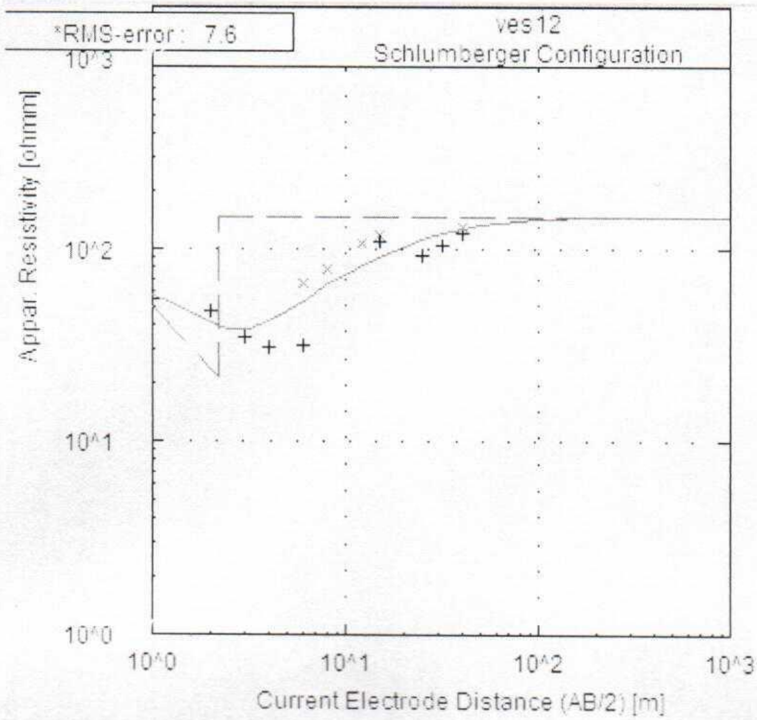
VES 11



No	Res	Thick	Depth
1	78.7	0.7	0.7
2	29.1	1.3	2.0
3	92.6	-.-	-.-

* RMS on smoothed data

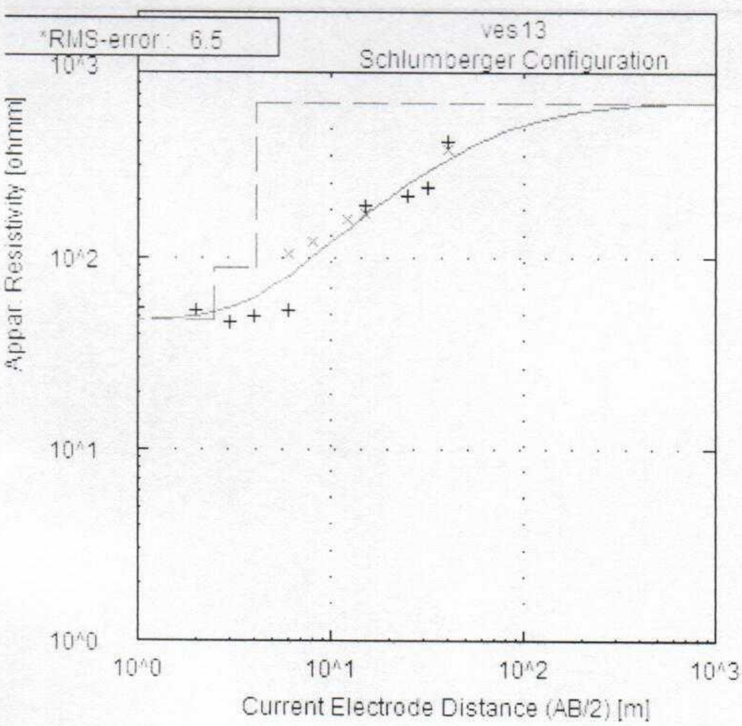
VES 12



No	Res	Thick	Depth
1	68.8	0.7	0.7
2	21.4	1.5	2.2
3	148.4	-.-	-.-

* RMS on smoothed data

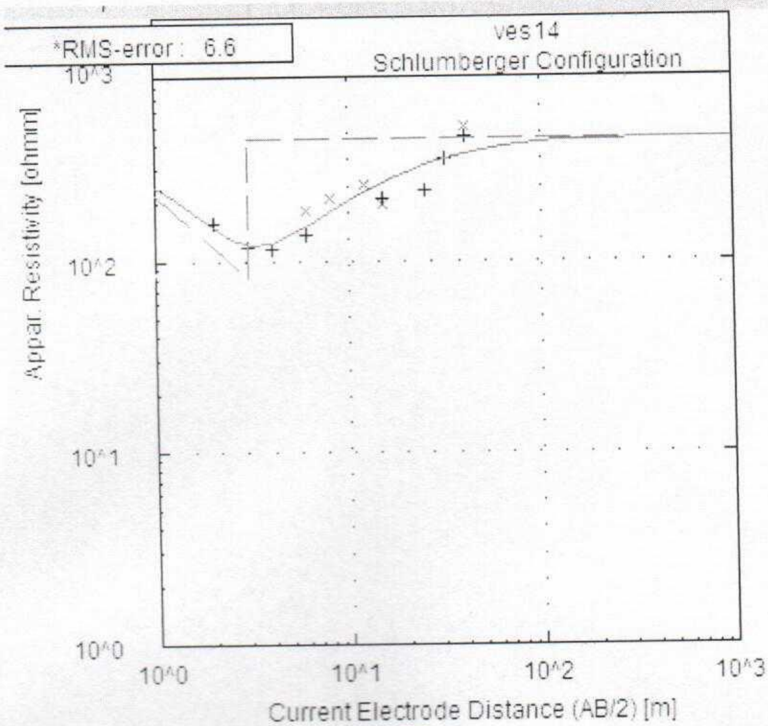
VES 13



No	Res	Thick	Depth
1	47.6	2.5	2.5
2	88.1	1.7	4.1
3	635.5	-.-	-.-

* RMS on smoothed data

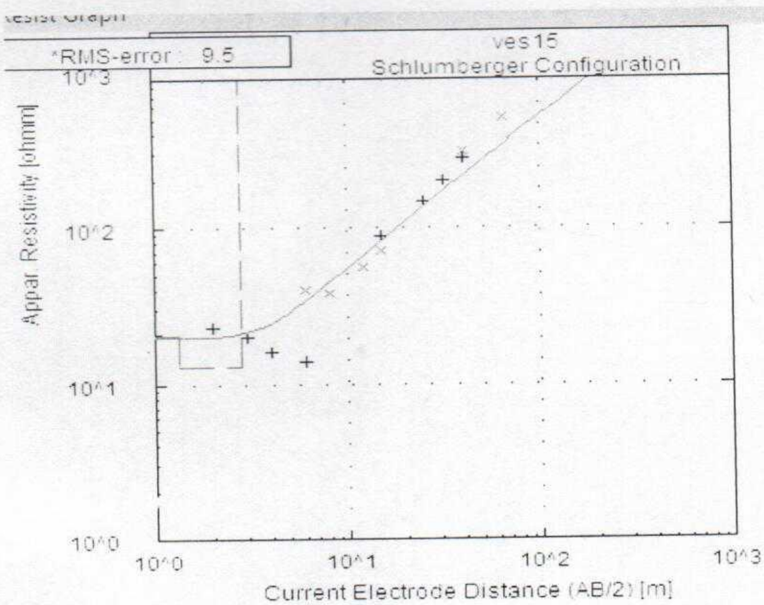
VES 14



No	Res	Thick	Depth
1	299.8	0.7	0.7
2	83.0	2.3	3.0
3	428.9	-.-	-.-

* RMS on smoothed data

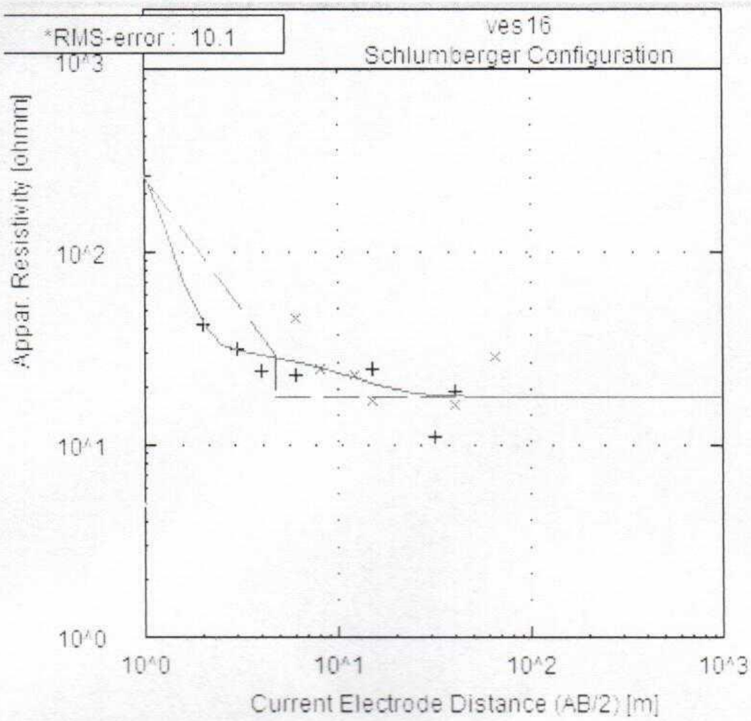
VES 15



No	Res	Thick	Depth
1	20.3	1.3	1.3
2	13.1	1.5	2.8
3	6870.5	-.-	-.-

* RMS on smoothed data

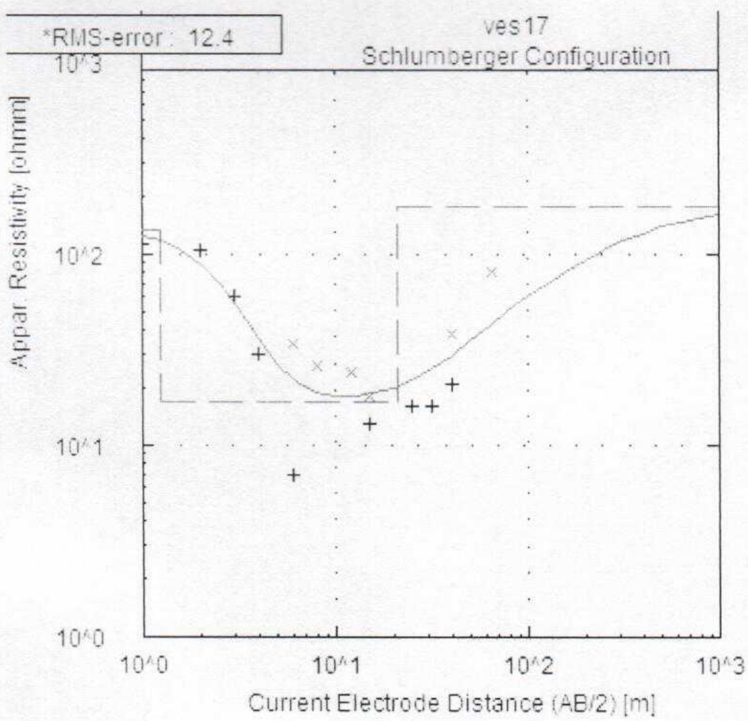
VES 16



No	Res	Thick	Depth
1	927.5	0.4	0.4
2	29.4	4.4	4.8
3	17.7	-.-	-.-

* RMS on smoothed data

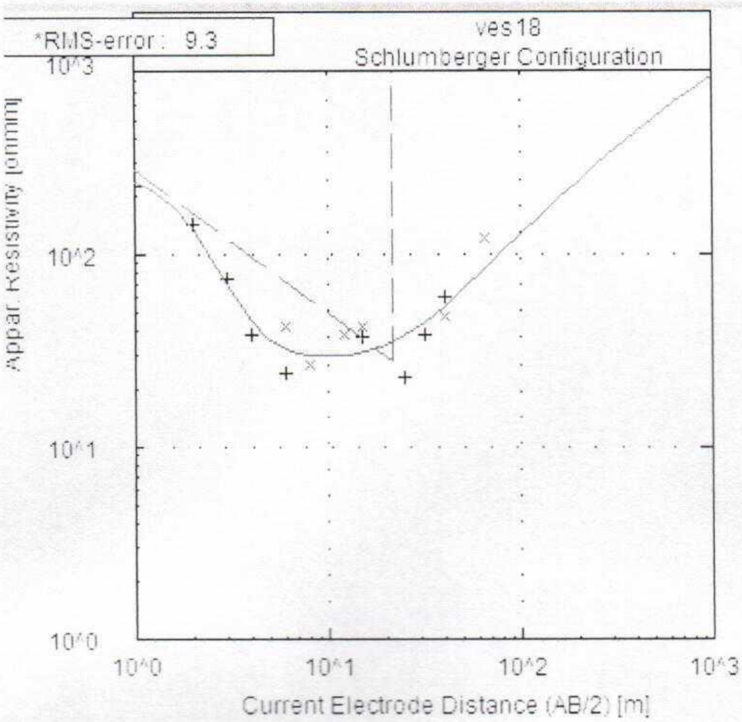
VES 17



No	Res	Thick	Depth
1	134.8	1.2	1.2
2	17.0	20.1	21.3
3	177.6	-.-	-.-

* RMS on smoothed data

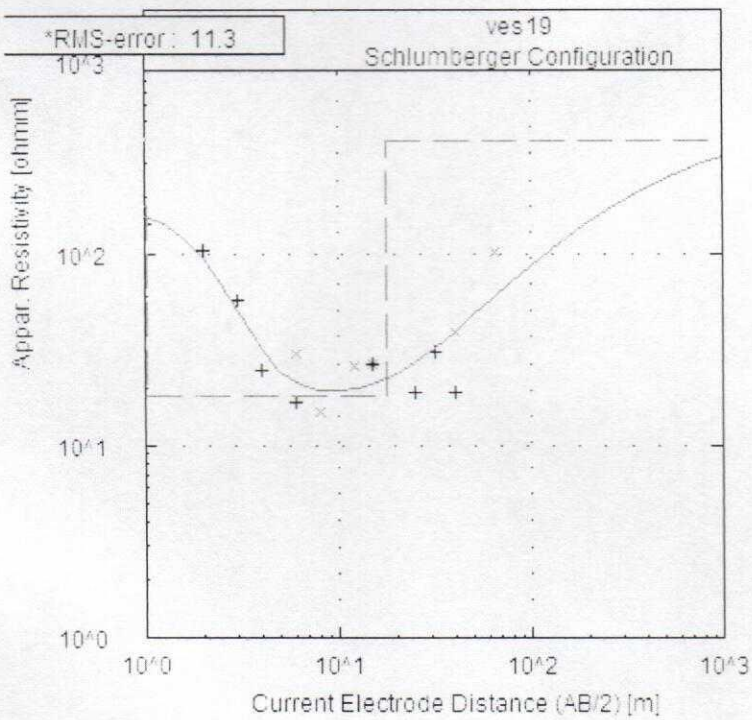
VES 18



No	Res	Thick	Depth
1	279.6	1.0	1.0
2	28.2	20.7	21.6
3	1877.0	-.-	-.-

* RMS on smoothed data

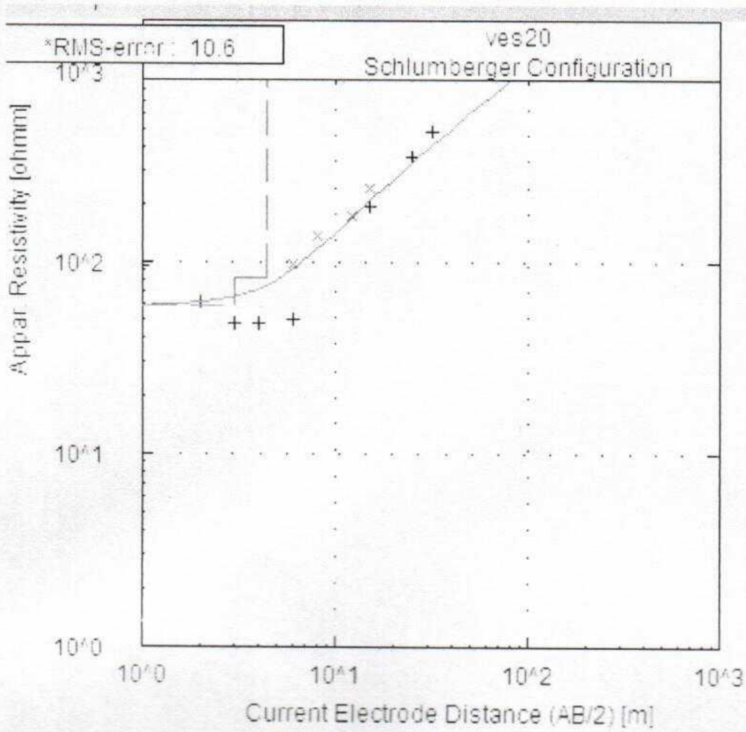
VES 19



No	Res	Thick	Depth
1	179.3	1.0	1.0
2	18.1	16.7	17.7
3	394.9	-.-	-.-

* RMS on smoothed data

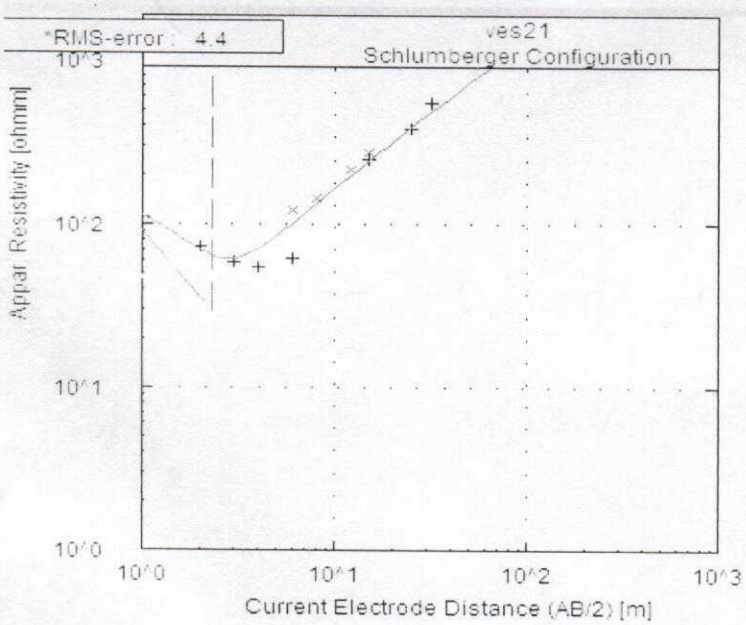
VES 20



No	Res	Thick	Depth
1	59.2	3.0	3.0
2	82.6	1.4	4.4
3	3310.5	-.-	-.-

* RMS on smoothed data

VES 21



No	Res	Thick	Depth
1	140.2	0.7	0.7
2	29.5	1.6	2.3
3	4306.1	-.-	-.-

* RMS on smoothed data

Fig 11:Back image of the distressed building (block 1).

Fig 11: Front image of the distresses building (block 1).