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*Full Length Research Paper*

# Hydrogeophysical investigation of groundwater resources in Amai Kingdom Ndokwa land area of Delta State

**Oseji, Julius Otutu**

Department of Physics, Delta State University, Abraka, Delta State, Nigeria. Email: oseji2002@yahoo.com

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**Resistivity measurements were carried out in six locations within Amai kingdom in Ndokwa land area of Delta State. Vertical electrical sounding method of schlumberger array was employed in carrying out the field investigation. Data obtained from the field were plotted on a log-log graph with electrode spacing (AB/2) on the x-axis and the apparent resistivity ($\ell_a$) on the y-axis. The field curves were curve-matched to obtain the resistivities and thickness of the layers. The results obtained from the partial curve matching were improved upon by employing a computer iteration method. The various layers obtained from the iteration were grouped together into geologic depth intervals called geoelectric section. The driller's log from Amai Umuekum was used to correlate the geoelectric section and was found to be consistent. With the knowledge of the local geology, the result obtained revealed that the first and second layers are clay formations with an average thickness of about 7m while an appreciable and sustainable water supply could be obtained in the fourth layer at an average depth of 30m within the medium grained sand formation in Amai Kingdom.**

**Key words:** Amai Kingdom, vertical electrical sounding, drillers log, local geology, groundwater, medium-grained sand and clay formation.

## INTRODUCTION

Water is not only essential to man but a basic necessity in life; it is foremost needed by man to quench his thirst used domestically in our homes for washing, bathing and cooking. Water is also used for agricultural activities like irrigation, animal husbandry and serves as recreation spots such as swimming pools. Due to these and many more important uses of water man tends to migrate from places of inadequate water supply to places where water can easily be obtained such as streams, rivers and lakes. These sources of water are classified as surface water. Water can also be obtained from other sources other than the surface; it could be obtained under the earth crust and this is called groundwater (Shanker, 1994).

Groundwater is found underground in the cracks and spaces in the soil, sand and rock and originates from rain, melted snow, sleet and hail that soak into the ground. The water moves down into the ground due to the effect of gravity passing between particles of soil, sand and gravel or rock until it reaches a depth where the ground is filled or saturated with water. The top of this saturation zone is called the water table. Below this water table is an underground layer of water-bearing permeable rock or unconsolidated materials such as gravel, sand or silt from which groundwater can be usefully extracted and is called an aquifer. Aquifer therefore is a geological formation, group of formations or part of a formation that contains sufficient saturated permeable materials capable of yielding significant quantities of water to springs and wells. (Etu- Efeotor *et al*., 1989; Ako and Osondu, 1985)

This work was carried out to establish a baseline geophysical data using the schlumberger arrangement (vertical electrical sounding) and the lithology of the study area. The vertical electrical sounding method was chosen for this study because the instrumentation is simple: field logistics are easy and straight forward and the analysis of data is less tedious and economical (Zohdy *et al*., 1974; Zohdy *et al*., 1993; Keller and Fristhcnecht, 1996).

The resistivity method has been used successfully in investigation of groundwater potential. Oseji *et al*. (2005) used the method to investigate the aquifer characteristics and groundwater potential in kwale. Okolie *et al*. (2005) used the method to investigate the source of river Ethiope in Ukwuani local Government area of Delta State. Oseji *et al*. (2006) also used the method to determine the groundwater potential in Obiaruku and Environs. The resistivity of water may vary from 0.20 ohm-m to over 100.00 ohm-m depending on its ionic concentration and the amount of dissolved solids (Nowruoozi *et al*., 1999). Resistivity of natural water without clay varies from 1.00 ohm-m to 1000 ohm-m while that of clay only varies from 1.0 ohm-m to 120 ohm-m (Zohdy *et al*., 1993).

### Purpose and scope of study

This project is limited to field acquisition of geophysical data using the Schlumberger arrangement of the vertical electrical sounding to assess the groundwater potential, determine near surface geologic formation, locate the aquiferous region and the thickness of the aquifer within Amai Kingdom and hence determine the depth boreholes could be drilled for significant and appreciable quantity of water.

### Geology of Amai Kingdom

Amai Kingdom is within the Niger-Delta basin. The geology of the Niger Delta has been explained in Reijers, 1996; Short and Stauble, 1967; Nedeco, 1961; Bernard and Trent, 1994. In these studies, the three major depositional environments typical of most deltaic environment that is the marine, mixed and continental deposits observed in the Niger-Delta gave rise to three vertical subsurface units in descending order of sedimentation. These are the Benin formation, the Agbada formation and the Akata formation. However, in Amai Kingdom, the topmost layer of the soil contains humus content. The area receives rainfall of about seven months per year. Below the humus soil is a massive bed of lateritic soil which increases downward from the topsoil. It is dark brown and after a further depth it became reddish brown. This massive bed of lateritic soil is a feature of Benin formation.

## MATERIALS AND METHODS

### Location of the study area

Amai is a rural community located in Ukwuani local government area of Delta state. It is in the southern part of Nigeria known as the Niger-Delta region and lies within latitude 5.96° to 6.04° and longitude 6.48° to 6.59° (Figure 1). Amai has two major roads which are tarred, they are; the Obiaruku-Amai road and the Amai-Ogume road with some network of roads that are not tarred. Amai is also home to the Novena University. The occupation of her settlers is mainly farming.

### Data acquisition

In the schlumberger array method, four electrodes were used and measurement of apparent resistivity were made by increasing the distance between the current electrodes while the potential electrode separation remain constant, such that the distance "L" within the electrodes is 5 times greater or equal to the separation distance between the potential electrodes "M". It is used to study the variations of resistivity with depth. It should be noted that for large values of "L" it may be necessary to increase "M" in order to maintain a measurable potential (Figure 2).

### Field equipments

The field equipments are the equipments and tools used in carrying out the field work and these includes the following: terrameter, cables/wires, and electrodes, measuring tape, cutlass, car battery, sledge hammer, clips, umbrella and the Global Positioning System (GPS)

### Field procedures

The location and geology of the area were noted and

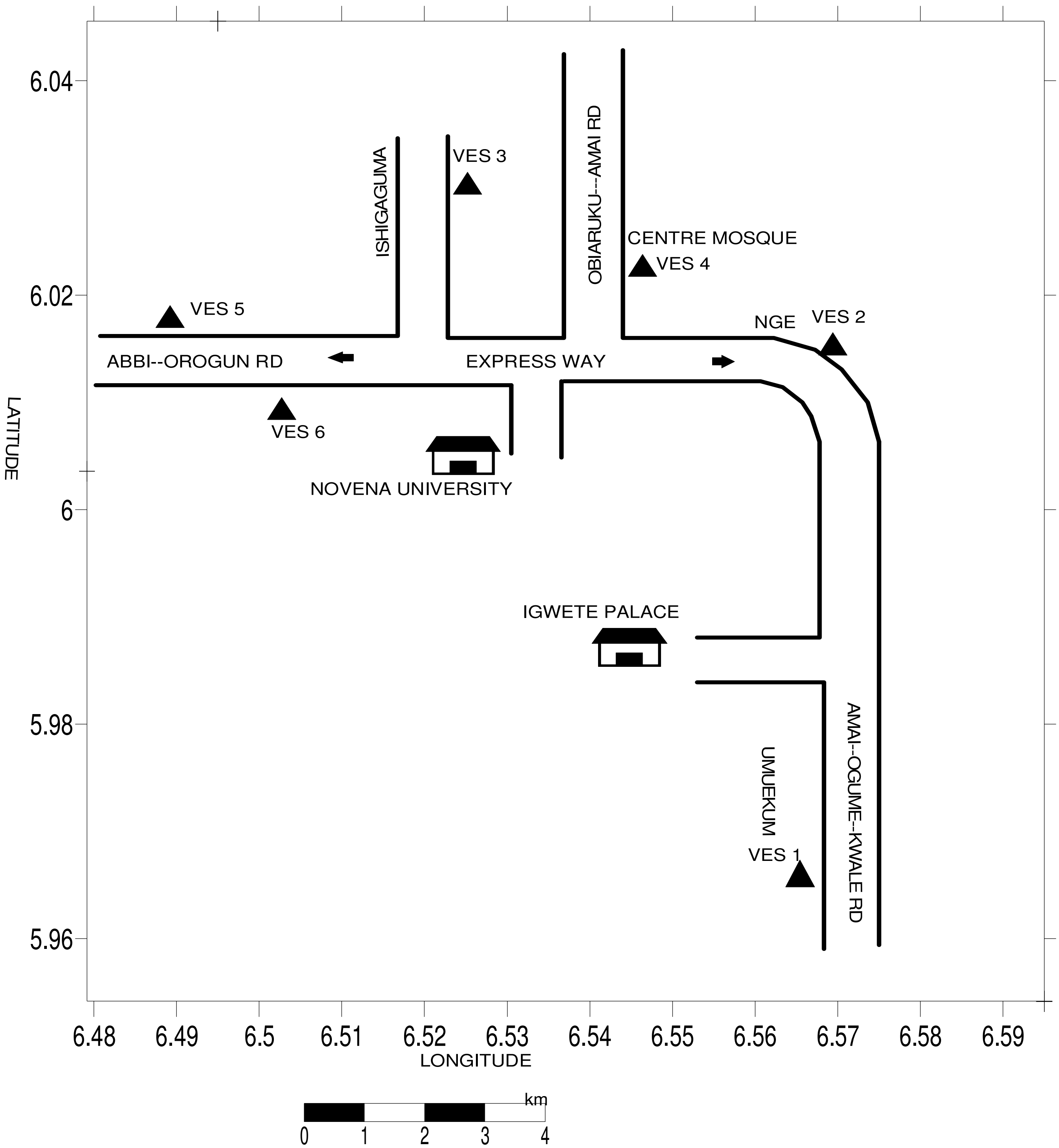


**Figure 1.** Map of the study Amai Kingdom.

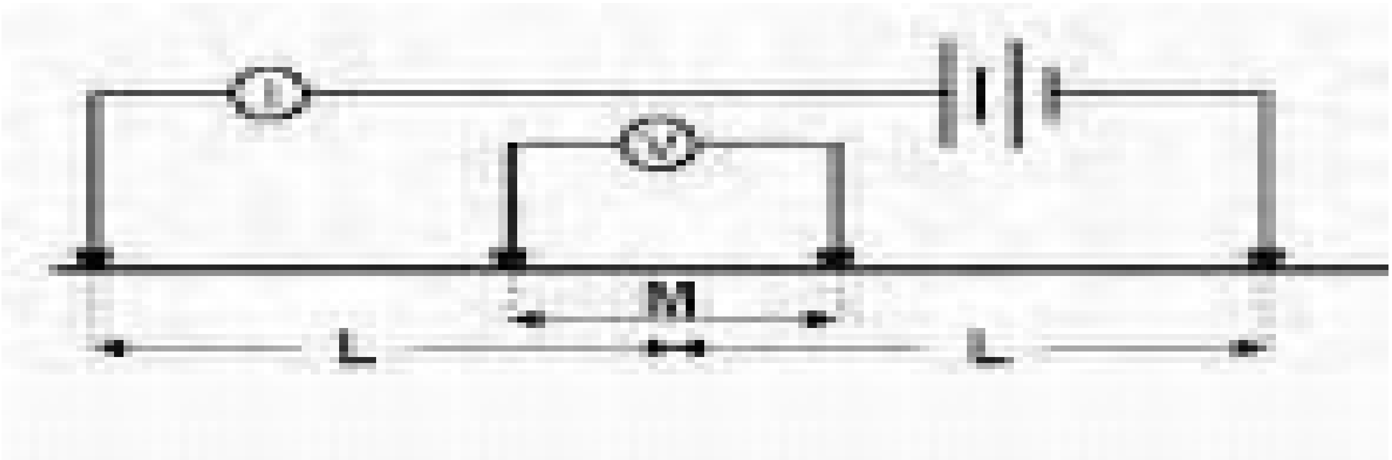


**Figure 2.** Schlumberger array model.

then a map of the study area was sketched out. The vertical electrical sounding technique using the schlumberger array method was used in the field.

A spot was marked out as the base station where the terrameter and the battery were placed to serve as the centre of the array and the reference point is marked using an electrode. Two current electrodes were placed 1m away from the terrameter at opposite sides of the terrameter, the same thing was done with the potential electrodes but these are placed at 0.5m away from the terrameter. The electrodes were driven fast into the ground with the help of a sledge hammer. The cables/wires were connected from the terrameter to the electrodes and clipped to the electrodes in order to make sure that the wire is in contact with the electrode while reading is taken.

The terrameter was switched on and current passed from the terrameter through the electrodes into the ground. The current and voltage readings were recorded after which the terrameter was switched off in order to avoid electric shock while handling the electrodes and cable wires. The current electrode distance was increased to 2m then the same procedures were repeated at 2m, 3m, 4m and 6m.

The procedures were repeated at specified current electrode spacing while the potential electrode separations were increased after every four current electrodes spacing. When suitable quantities of data were recorded, the array was disconnected and the equipments were moved to another VES point.

## RESULTS

### Presentation of data

The data obtained from the electrical resistivity survey were plotted on a log – log graph paper with the electrode separation AB/2 on the abscissa and apparent resistivity as the ordinate. During the process of curve matching, the axis of the sound curve were kept parallel with the master curves until best fit of the curve is obtained. The curve is matched segment by segment starting from the left to the right.

The intersection of the axis point of the best fit curve is marked (+) on the field curve and the value is read and drawn out with dotted lines from the corresponding auxiliary curve. The depth index “DI” is read from the vertical axis to the auxiliary curves at the cross point marked. Thereafter, the resistivity and thickness of the layer were calculated from the various parameters of the curves.

Six (6) VES were taken in six locations in Amai kingdom in Ndokwa land area of Delta. The VES locations are as follows;

UmuekumAmai……………………………………VES 1
Nge Amai……… …………………………………VES 2
Ishikaguma
Amai……………………………………………………VES 3
Amai Umuosele within the central Mosque Area….VES 4
Along Ogume Road Amai….. ……………………VES 5

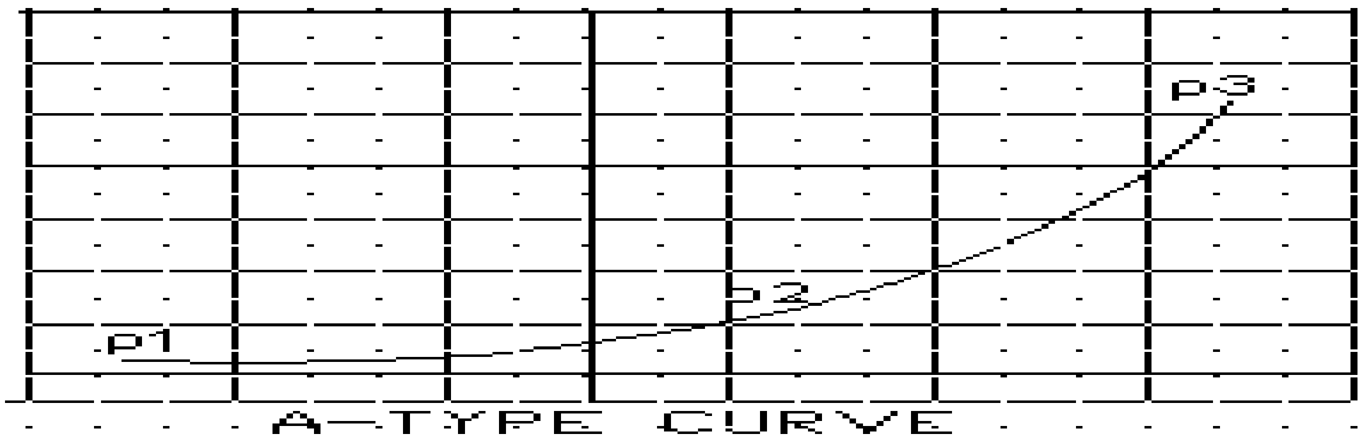


**Figure 3** Description of A-type curve.

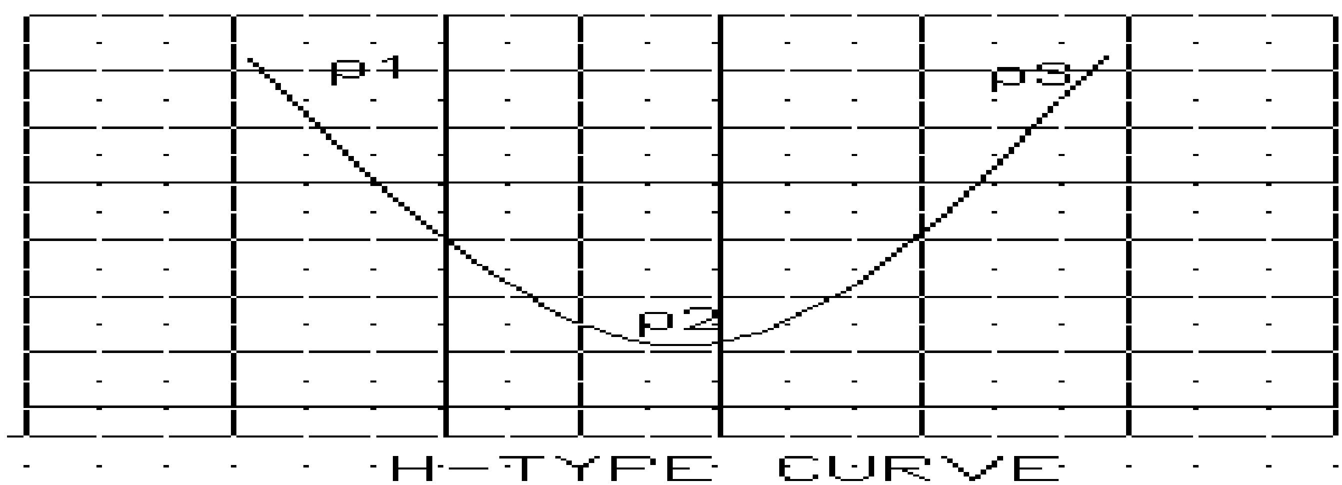


**Figure 4.** Description of H-Type curve.

Along Abbi/Orogun Road……………………………VES 6

## Interpretation

The qualitative interpretations involve the classification of the resistivity field curves into different curve types. Field curves in vertical electrical sounding (VES) are classified into four major types namely; the A – type curve (Figure 3), the H – type curve (Figure 4), the Q – type curve (Figure 5) and the K – type curve(Figure 6).

The A type curve shows some change of gradient but the apparent resistivity generally increases continually with increased electrode spacing.

The H type curve decreases to a minimum and then increases such that the intermediate layer has lower resistivity with depth.

The Q type curve exhibits the opposite effect, it decreases continually which implies that there is a decrease of resistivity with depth.

The K type curve shows the opposite of the H type curve.

The results were interpreted using the partial curve matching to obtain the thickness and the resistivity of the

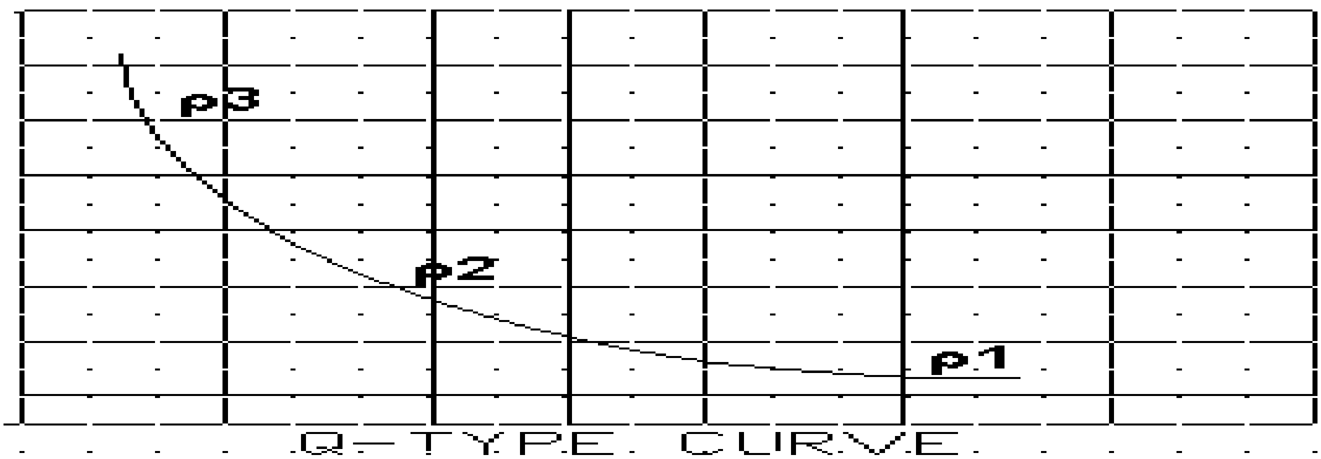


**Figure 5.** Description of Q-type curve.

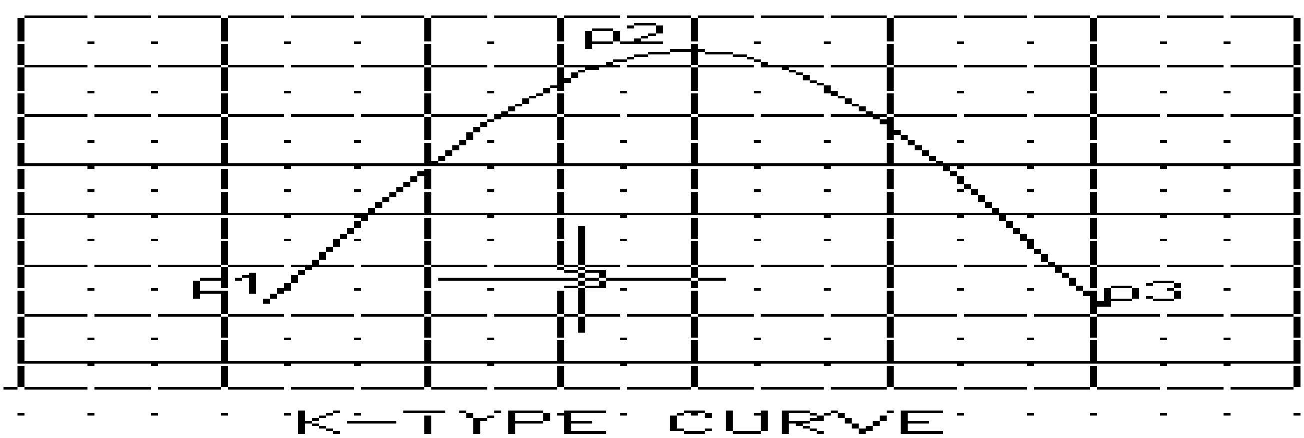


**Figure 6.** Description of K-type curve

layers (Zohdy *et al.*, 1974). This method involves a comparison of the measure field curve with a set of theoretically derived curves called master and auxiliary curves. The resistivity and thickness obtained from the partial curve matching were improved upon by employing an automatic iterative computer program to obtain the layers parameter (resistivity, thickness and depth).

The numerous layers that were generated by the computer were grouped into relevant geologic depth intervals called geoelectric sections (Figure 7). The type of curves (Selemo *et al.*, 1995), the resistivity of the sediments (Oyedele, 2001) and the knowledge of the local geology were used as guides in the interpretation and analysis of the geoelectric parameters in terms of probable, portable and sustainable water supply.

## DISCUSSION

VES 1 is an H-type curve with the first layer as clayey sand that varies in depth from 1.1m to 3m, the second and third layers are fine-grained sand varying in depth from 3m to 33m, the fourth layer is medium-grained sand which varies from 33m to 45m. It has one aquifer at an

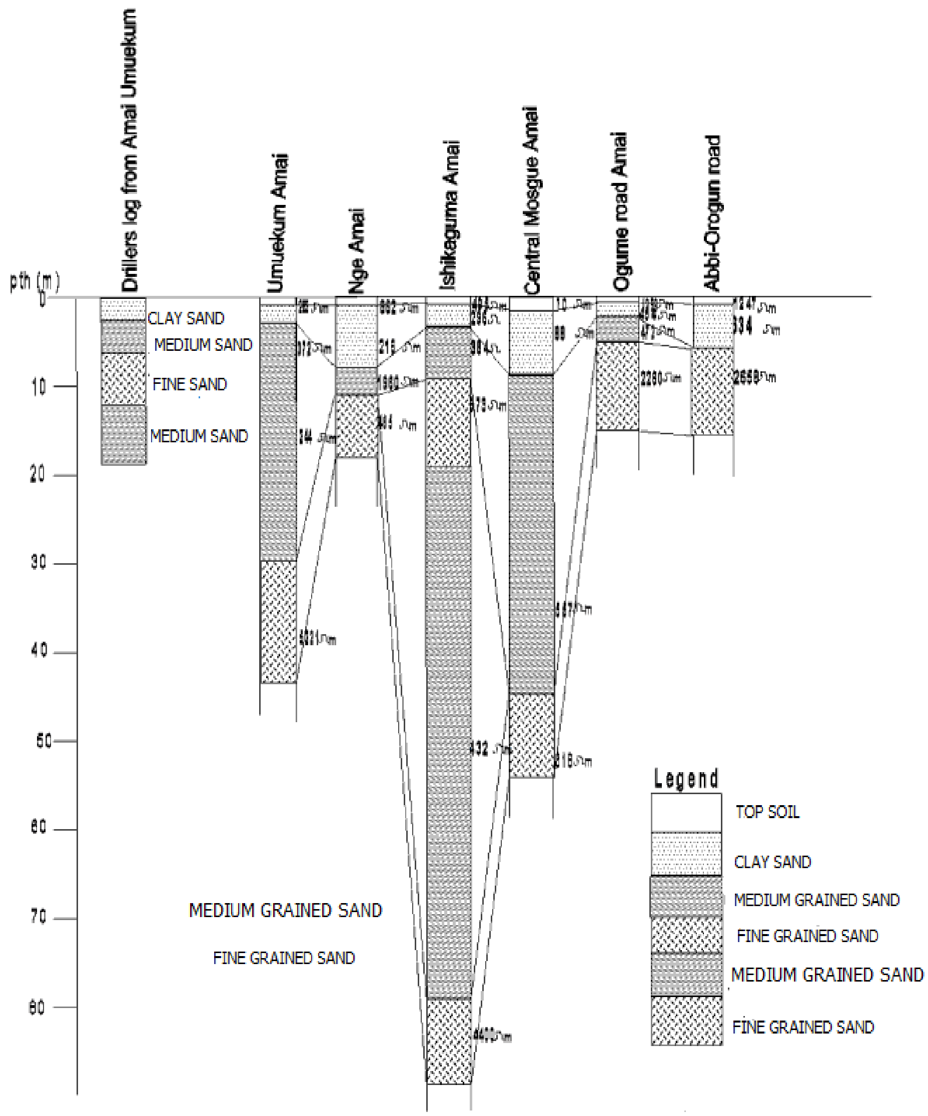


**Figure 7.** Geoelectric section of Amai Kingdom.

average depth of 30m and a thickness of about 27m

VES 2 is an H-type curve with the first and second layer as clayey sand whose depth is from 1.0m to 8m, the third layer is fine-grained sand whose depth is from 8m to 11m and the fourth layer is medium-grained sand with a depth of about 11m to about 20m.

VES 3 is an A-type curve with the first and second layers as of clayey content and varies in depth from 1.1m to 5m, the third layer is medium-grained with a depth of about 5m to 20m, the fourth layer is very fine-grained sand which ranges in depth from 20m to about 78m, the fifth layer is medium-grained sand with a depth from 78m to 88m.

VES 4 is also an A-type curve and has its first and second layers as clayey sand with a depth from 2.6m to 12m, the third layer is fine-grained sand with a depth from

12m to 48m which is not an encouraging formation for groundwater development, the aquifer is the medium-grained formation in the fourth layer and ranged from 48m to 58m.

VES 5 is an H-type curve and has its first and second layer as clay deposit at a depth of between 0.5m to 3m, the third layer is fine-grained sand with a depth from 3m to 5m, the fourth layer ranges from 5m to 17m and it is of medium-grained sand content.

VES 6 is an H-type curve, the first and second layer is clayey sand and it ranged from 0.9m to 5m while the third layer is medium-grained sand and it is from 5m to 20m.

## Conclusion

From the aforementioned analysis, the first and second layers in Amai Kingdom are generally clay formation with a thickness of between 5m – 10m. Although Amai Ishikaguma has two shallow aquifers within the third and the fifth layers while along Amai/Ezionum road the aquifer is in the third layer at a depth of between 5m – 20m, appreciable quantity of water could be obtained at an average depth of 30m in the fourth layer within the medium grained sand in Amai Kingdom. It is therefore saving to conclude that the aquifer in Amai kingdom is semi-confined since there was no confining bed such as clay formation after the aquiferous unit.

## RECOMMENDATION

In the light of the aforementioned studies, boreholes should be drilled to a minimum depth of 30m in the fourth layer (medium grained sand) for an appreciable and sustainable quantity of water in Amai kingdom.

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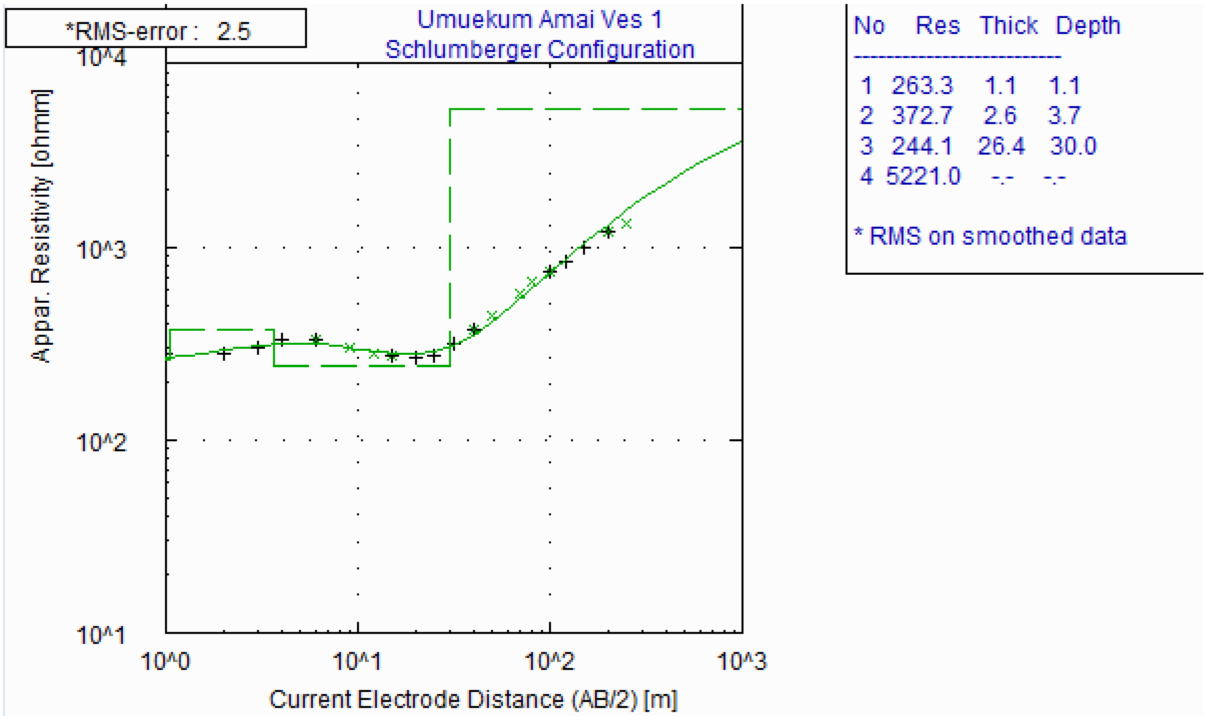
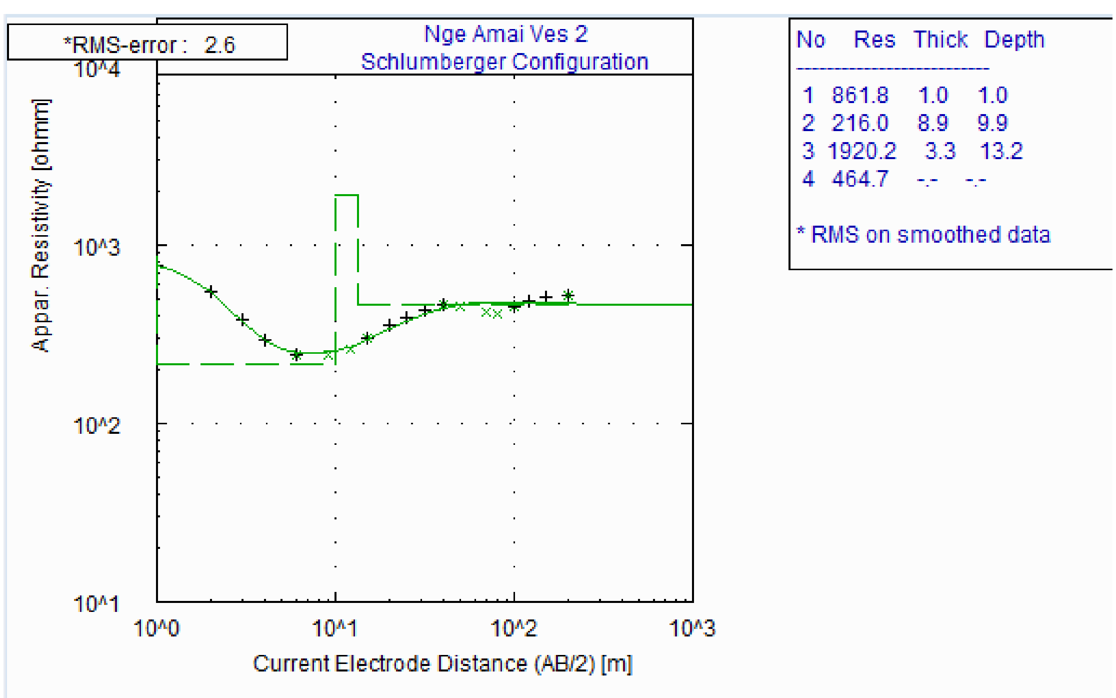
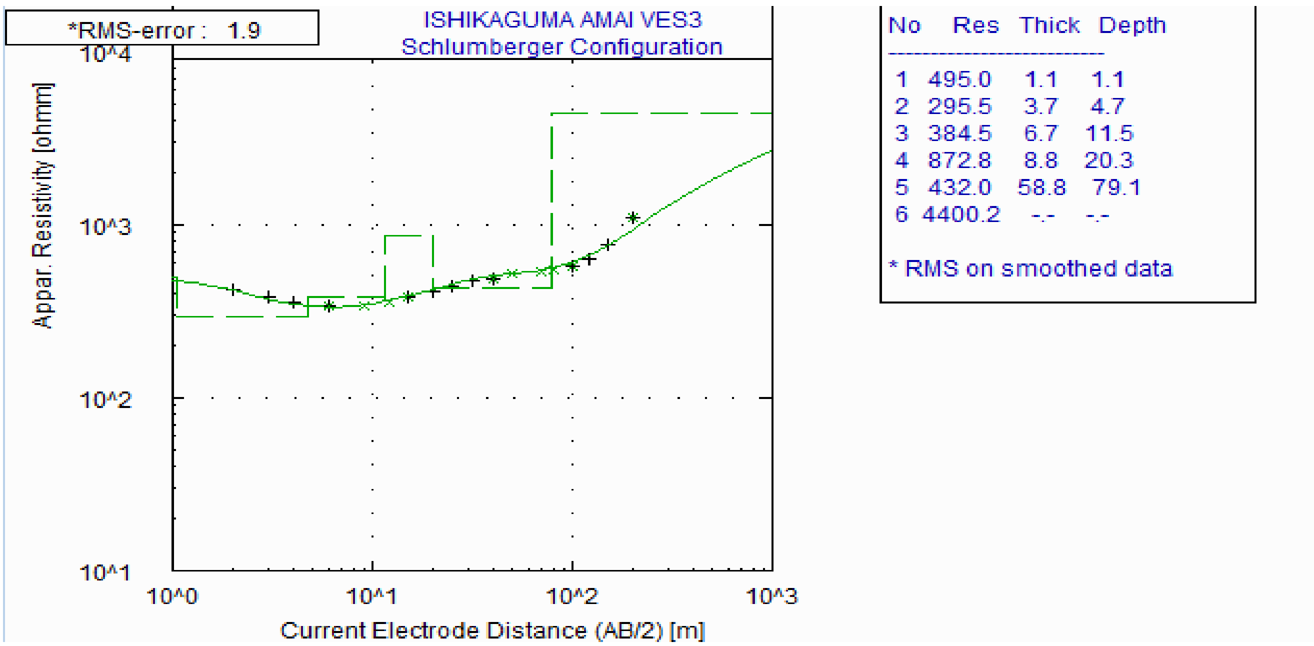
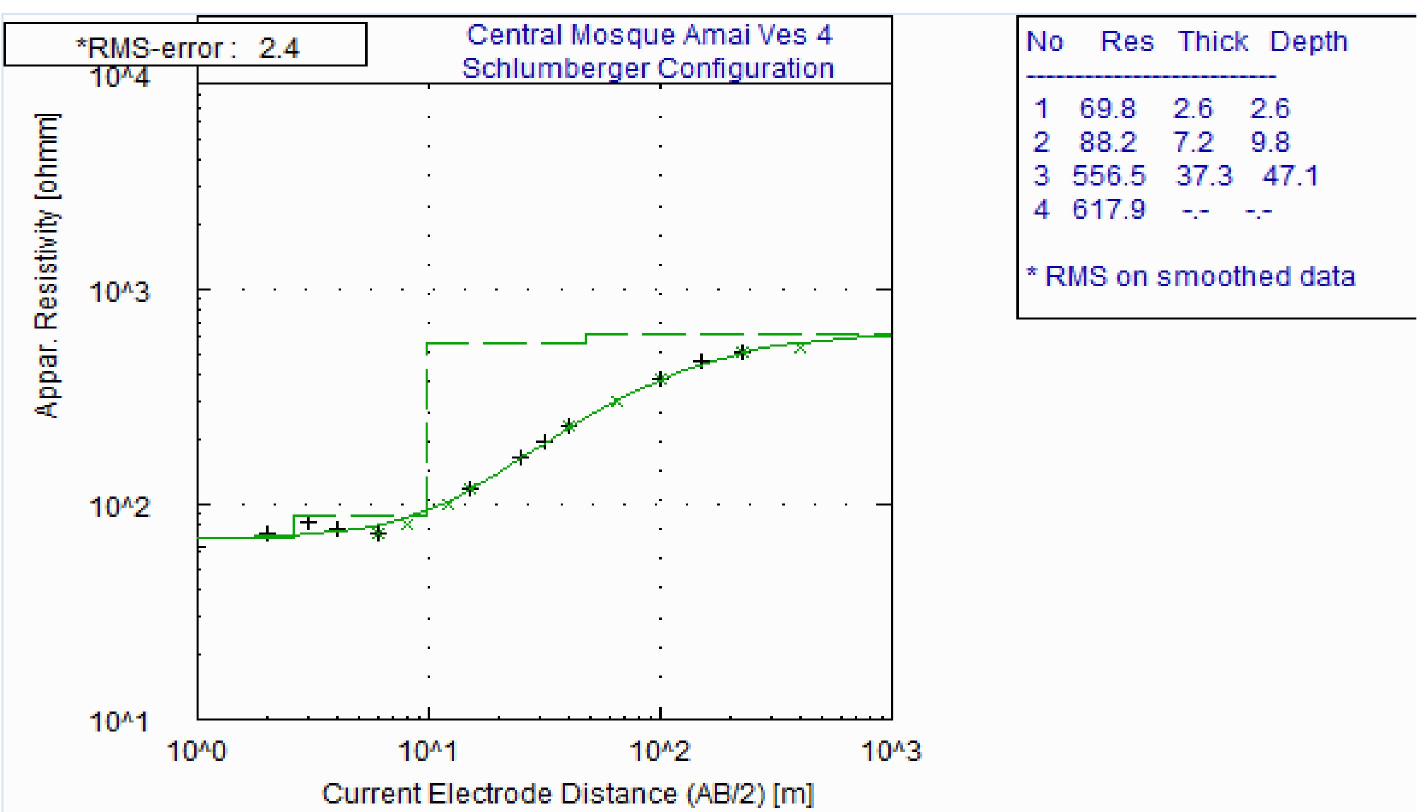
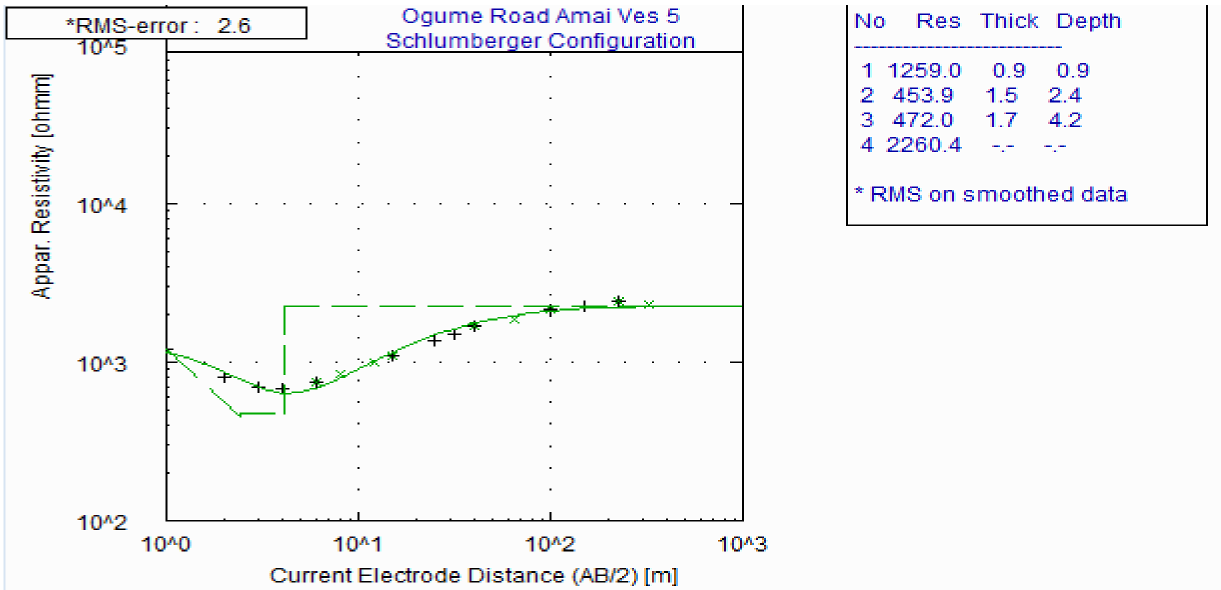
## APPENDIX

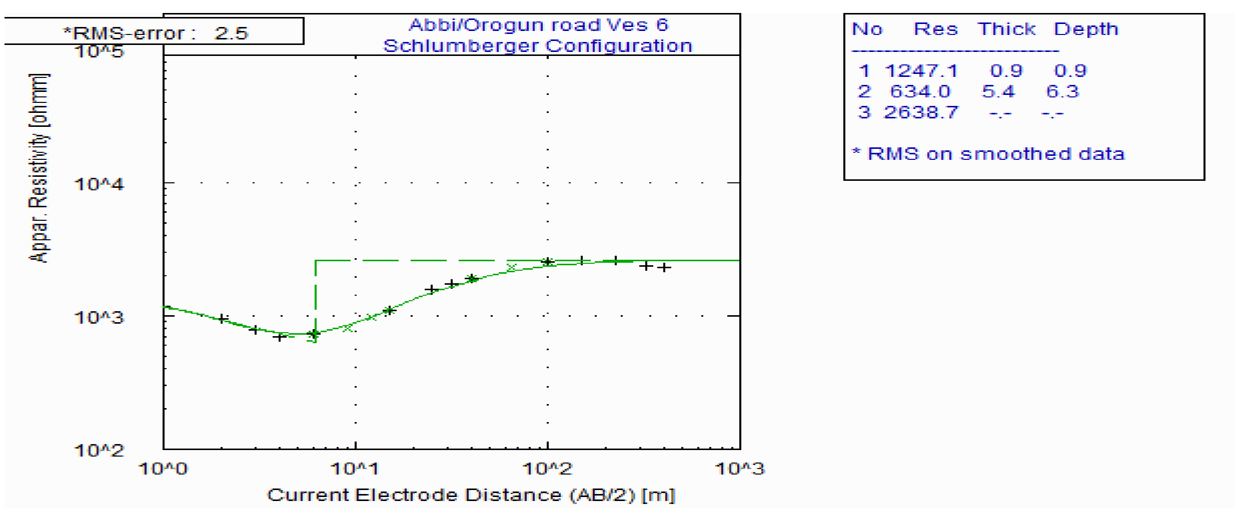

*RMS-error : 2.5
Umuekum Amai Ves 1
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^4
10^3
10^2
10^1
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 263.3 1.1 1.1
2 372.7 2.6 3.7
3 244.1 26.4 30.0
4 5221.0 -.- -.-
* RMS on smoothed data


*RMS-error : 2.6
Nge Amai Ves 2
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^4
10^3
10^2
10^1
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 861.8 1.0 1.0
2 216.0 8.9 9.9
3 1920.2 3.3 13.2
4 464.7 -.- -.-
* RMS on smoothed data


*RMS-error : 1.9
ISHIKAGUMA AMAI VES3
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^4
10^3
10^2
10^1
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 495.0 1.1 1.1
2 295.5 3.7 4.7
3 384.5 6.7 11.5
4 872.8 8.8 20.3
5 432.0 58.8 79.1
6 4400.2 -.- -.-
* RMS on smoothed data


*RMS-error : 2.4
Central Mosque Amai Ves 4
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^4
10^3
10^2
10^1
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 69.8 2.6 2.6
2 88.2 7.2 9.8
3 556.5 37.3 47.1
4 617.9 -.- -.-
* RMS on smoothed data


*RMS-error : 2.6
Ogume Road Amai Ves 5
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^5
10^4
10^3
10^2
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 1259.0 0.9 0.9
2 453.9 1.5 2.4
3 472.0 1.7 4.2
4 2260.4 -.- -.-
* RMS on smoothed data


*RMS-error : 2.5
Abbi/Orogun road Ves 6
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^5
10^4
10^3
10^2
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]
No Res Thick Depth
1 1247.1 0.9 0.9
2 634.0 5.4 6.3
3 2638.7 -.- -.-
* RMS on smoothed data