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HYDROGEOLOGIC INVESTIGATION OF HOUSING ESTATE OGBOMOSO, SOUTHWESTERN NIGERIA

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ABSTRACT

High numbers of immigrants in Ogbomoso Township has aided rapid development at Housing Estate Ogbomoso. This development has called for geophysical survey that was carried out in order to know the areas that are good for groundwater prospects in the study area. Housing Estate Ogbomoso lies on a Precambrian Basement which was known to have little or no water present beneath the subsurface except there are presence of highly weathered zones and fractured basement. The objective of this research is to investigate on the promising areas for groundwater prospects within the study area. Vertical Electrical Sounding (VES) geophysical method was used to delineate Oyo State Housing Estate, Ogbomoso North, Southwestern Nigeria between longitude N 08^0 $09'$ $48.5''$ and N 08^0 $09'$ $48.5''$ and latitude E 004^0 $14'$ $41.1''$ and E 004^0 $14'$ $32.9''$ Southwestern Nigeria for hydro geological prospect area. A total of fourteen VES stations were established on the study area of $45,000m^2$ using Schlumberger configuration with electrode spacing of 100m. Three lithological sections were inferred from the study area. These are; the top soil, clayed/sandy clay horizons and fractured/fresh basement. Average depth to basement of the study area was estimated as 14.2 m, areas with relatively thick overburden that overlies fractured or weathered basement have been identified as areas that are suitable for groundwater prospects whereas areas with thin overburden and fresh basement have been delineated as low groundwater potential zones. Conclusively, VES 11 is the only area with fractured basement within the study area and is the most promising area for groundwater exploration.

Keywords: Vertical Electrical Sounding, Groundwater, Housing Estate, Basement.

INTRODUCTION

The population explosion experiencing in Ogbomoso North Local Government of Oyo State Southwestern part of Nigeria because of the civil servants in the town developing their own houses has made the housing estate to be experiencing structural development thus there is urgent need to delineate the study area for groundwater development. Aquifer zones often characterized by relatively low resistivity values in the basement complex terrains are either fractures such as joints and faults or the weathered basement (Du-Preez and Barbar 1965; Olayinka and Olorunfemi, 1992; Olorunfemi and Olorunniwo, 1985).

The basement complex rocks in their unaltered stage lack porosity and permeability and are thus very poor aquifers. Their ability to store and transmit groundwater effectively depends on secondary structures such as joints and faults. According to Olorunfemi and Olorunniwo (1985), the highest groundwater yields are found in areas where thick overburden overlies fractured zones. In order to ensure maximum and perennial yield, boreholes are best sited in areas where the regolith could be maximally penetrated.

Geophysical methods are often used in site investigation to determine depths to the basement and map subsurface characterization prio to excavation and construction (Adagunodo, 2011). Nwankwo et al. (2004) and Omosuyi (2010) have used Electrical Sounding to determine depth to basement. The resistivity method has its origin in the 1920's due to the work of Schlumberger brothers. For the next 60 years, for quantitative interpretation, conventional sounding surveys (Koefoed, 1979) were normally used. In this method, the centre points of the electrode array remain fixed, but the spacing between the electrodes is increased to obtain more information about the deeper section of the subsurface (Alagbe, 2005; Ayantunji, 2005). The method is suitable for engineering and hydro geological investigations.

This study aimed at providing detailed geophysical signatures for groundwater detection in the study area with a view to developing it for domestic and commercial purposes.

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THE STUDY AREA

The study area is located Northwest of Ogbomoso, between longitude N 08^0 09′ 48.5″ and N 08^0 09′ 48.5″ and latitude E 004^0 14′ 41.1″ and E 004^0 14′ 32.9″ Southwestern Nigeria.

Regionally the area under investigation is concealed with the Southwestern Nigeria basement complex composing migmatite-gness complex, metaigneous rock such as pehtic schist, quartzite, amphibolites, charnokitic rocks, older granite and unmetamorphorsed dolerite dykes. The rock sequence consists of basically weathered quartzite older granite.

The basement complex rocks of Nigeria are made up of heterogeneous assemblages and have been variedly classified by Jones and Hockey (1964) and Rahaman (1976) among others.

It is classified into three major rock units of ancient gneiss-migmatite series; the meta-sedimentary and the older granite with gneiss-migmatite suite as the most widely spread.

However, all the aforementioned rock units are well represented in Ogbomoso area.

The basement complex rock in their unaltered forms is generally characterized by low porosity values usually less than one percent and permeability values that are almost negligible (Rahaman, 1976). The groundwater potential of such area is therefore dependent on the following factors; the presence of large fractures, joins or brecciate zones within the rock. The extent of weathered overburden and degree or amount of precipitation recharging the aquifer, by far most significant factor in the groundwater capacities of an area underlain by crystalline rock is the depth of weathering.

The absolute depth of weathering has implications on the zone of saturation because groundwater is known to fill the regolith from phreastic surface down to the bedrock.

Generally Ogbomoso is located in southwest Precambrian basement complex of Nigeria, predominantly composed of:

(i) Older granite: comprising of rocks varying in composition from granites and pottassic syenite- older granites were first distinguished from the younger tin-bearing alkalic granite by Falconer (1911). Older granites include rocks like synites pegmatites quartz monzoneites and adamelites. Graniticoradiontic are most common, in older granite and found in Iseyin area. Rahaman (1976) recognized the late kinematics and post kinematics and equated them to the main and late phase of granites, Jones and Hockey (1964), respectively. This can be found in Okeho, Iseyin, Ajawa, Ikoyi and Ogbomoso area.

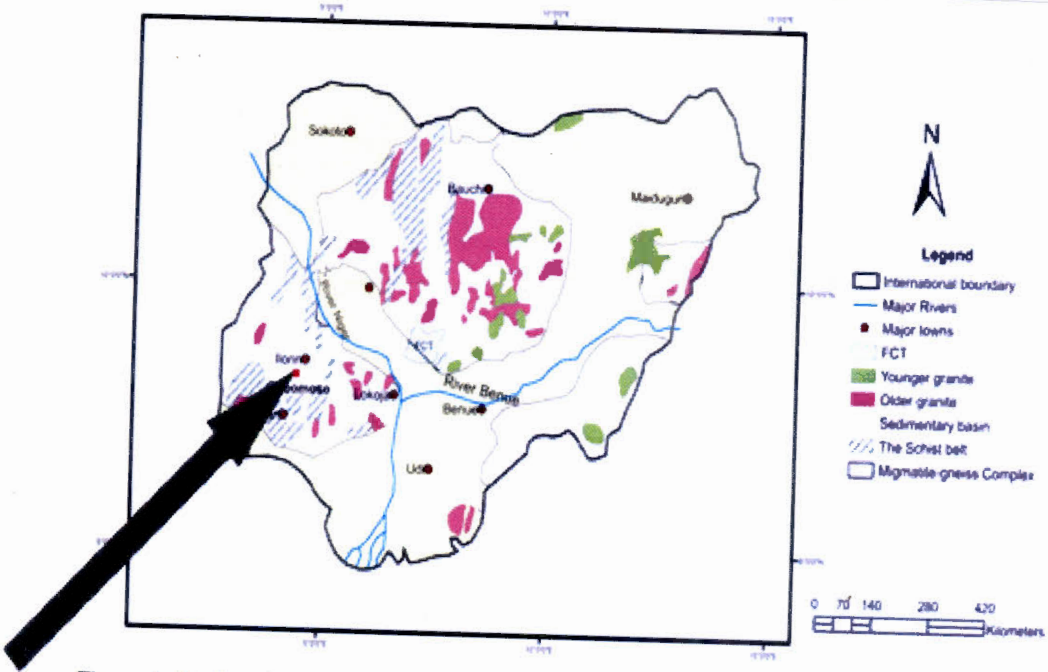
(ii) Migmatite gneiss complex: which comprises biotite horn blende, gneiss, quartzite and quartzschist and small lenses of calcsilate rocks. In general the outcrops are poorly grown but few good out crops occur around Ibadan and Iseyin (Rahaman 1976). Similar occurrence has been found at Ife, Kuta and Iyanu.

(iii) Unmetamorphosed Dolerite Dykes: they occur as tabular, unmetamorphosed bodies crosscutting the foliation in the host rocks and are regarded as youngest member of the basement complex. In some cases the dykes are stepped and there is exact correspondence of opposite walls. The general trend of all Dykes observed by Jones and Hockey (1964) and Rahaman (1976) is NE-SW and ENE-WSW.

The rock is generally black and fine grained; in some cases a pale green colour of olivine may be observed in the hand specimen. The rock is composed largely of augite and plagioclase of andesine.

(i) Charnockitic Rocks: Charnockitic rocks occur in West of Ibadan as dyke-like bodies scattered over a wide area. Jones and Hockey (1964) described two main areas of diorite or charnockitic rocks have three major mode of occurrence commonly in core of aureole of granite bodies especially prophyritic, biotite, hornblende granites. Example of this occured in North of Akure, west of Egusi and South of Otta. They occur as discrete individual bodies in gnesis complex such as the occurrence at Lagun, Iwo, Osuntedo and some part of Ola.

Slightly magnetized to unmagnetized para-schists and metaigneous rocks: comprising schists, quartzite amphibolites, talcose rocks and metaconglomerates, marble and cale-silicate rocks.



STUDY AREA Figure 1: Regional geological map of Nigeria (Modified after Ajibade et al, 1988)

MATERIALS AND METHOD

The equipment used for data acquisition was R50 Resistivity meter.

A total of 14 Vertical Electrical Soundings (VES) stations were occupied along the East-West and West-East directions of the study area. The Schlumberger array with maximum electrode spacing AB was 200m. For each movement of current electrode positions the product of the resistance measured and the corresponding value of the geometric factor (K) gave the measured ground apparent resistivity.

The data were processed by partial curve matching and computer iteration with WinGlink. The results from the partial curve matching (on WinGLink software), that is, the layer resistivity and the corresponding depths to the various layers were input into a computer iterating software WinResist to check the RMS-error. Because the RMS-error must be as reduced as possible. The final VES data generated from WinResist were represented as curves in fig.3.1 -3.14.

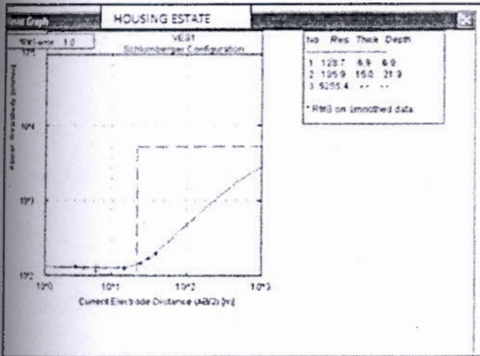


Figure 3.1 layer model interpretation for VES 1

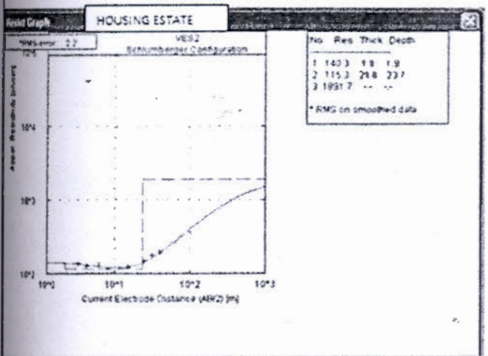


Figure 3.2 layer model interpretation for VES 2

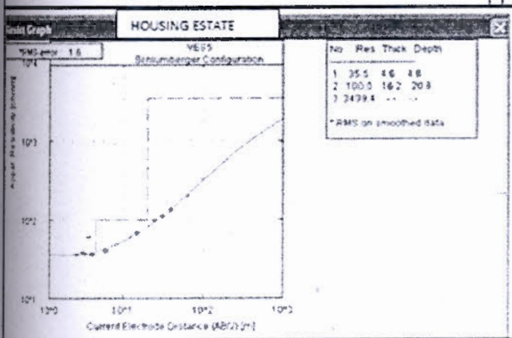


Figure 3.5 layer model interpretation for VES 5

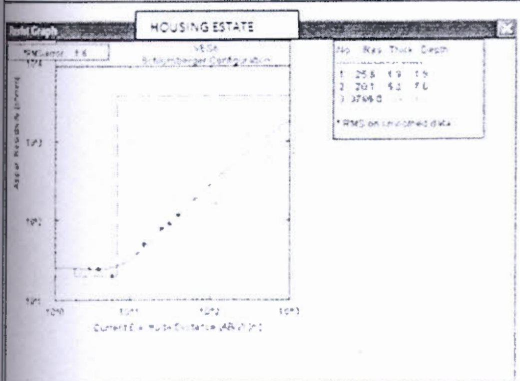


Figure 3.6 layer model interpretation for VES 6

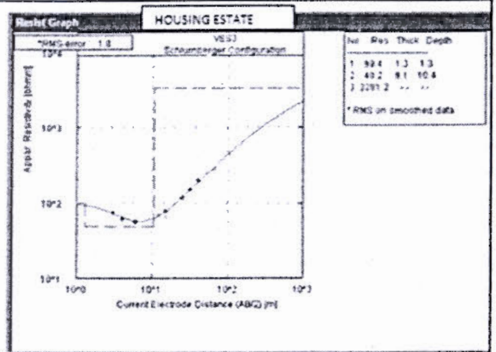


Figure 3.3 layer model interpretation for VES 3

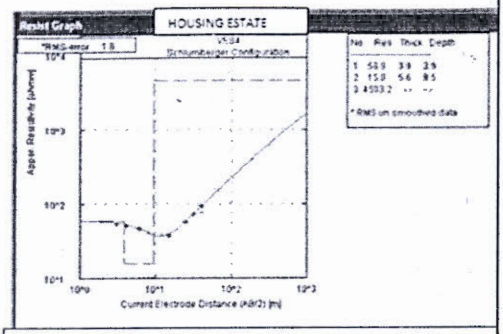


Figure 3.4 layer model interpretation for VES 4

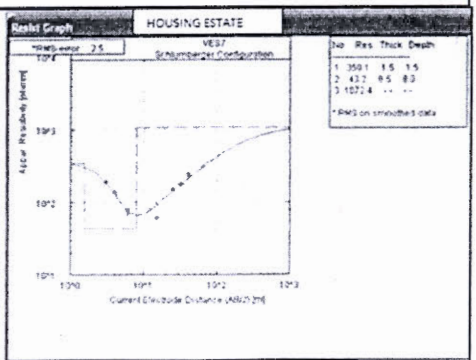


Figure 3.7 layer model interpretation for VES 7

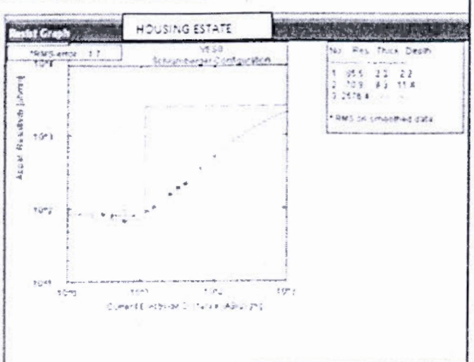


Figure 3.8 layer model interpretation for VES 8

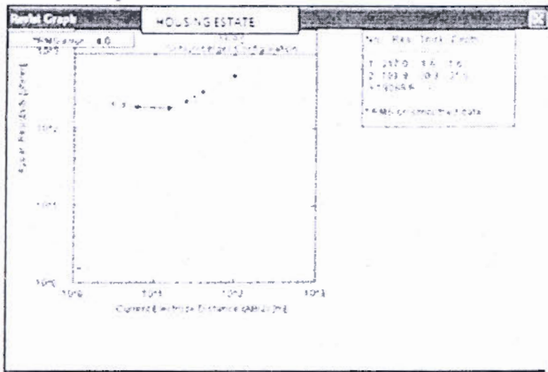


Figure 3.9 layer model interpretation for VES 9

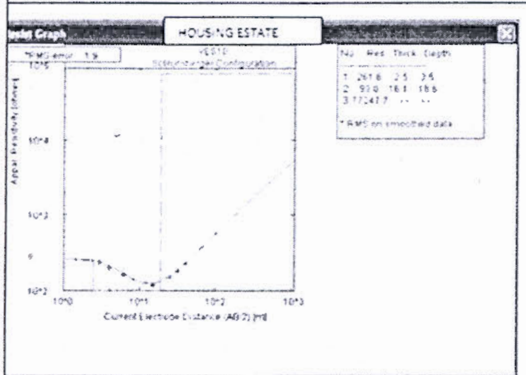


Figure 3.10 layer interpretation for VES 10

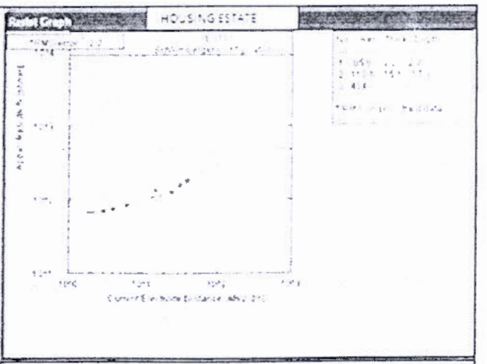


Figure 3.11 layer model interpretation for VES 11

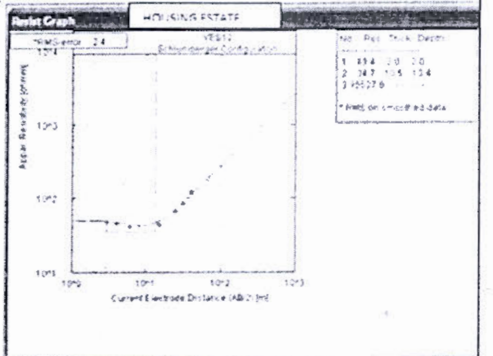


Figure 3.12 layer model interpretation for VES 12

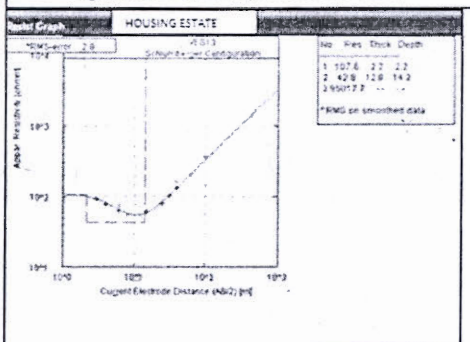


Figure 3.13 layer model interpretation for VES 13

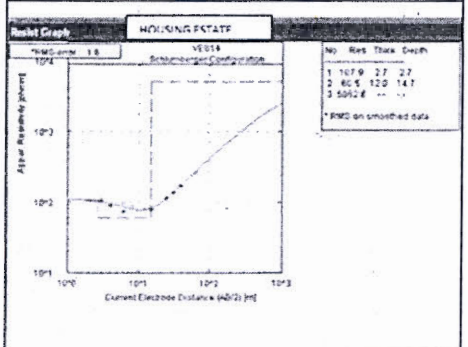


Figure 3.14 layer model interpretation for VES 14

RESULTS AND DISCUSSIONS

The results are presented in table 1. Three lithological sections were inferred. These are top soil, clayed horizon and fractured/fresh basement. The thicknesses of these horizons vary from 1.3m to 6.9m and 7.0m to 92.0m for the top soil and clayed horizon respectively. The resistivity values ranges from 25Ωm to 261.6Ωm for top soil, 15.8Ωm to 518.3Ωm for clayed zone and 484.0Ωm to 95527.8Ωm for fractured/ fresh basement. The topsoil is of average thickness of 3.02m, weak/weathered rock of average thickness of 11.18m and fresh bedrock, of infinite depth. Thus, the average depth to the basement (overburden thickness) is 14.2m. The sections are shown in figure 4.1 and 4.2.

The topsoil is made up of sandy clay, saturated clay and silt, clayed, hard, partially saturated sands and gravels. These dominated the last four VES stations; VES4-VES7 towards the Western side of the delineated area. Layer resistivity and thickness values range respectively from 25.8Ωm to 5255.4Ωm and 1.3m to 23.7m (profile A–A'), 34.7Ωm to 95527.8Ωm and 2.2m to 18.6m (profile B–B'), figure 4.1 and 4.2.

The topsoil is underlained by the second layer of saturated inorganic clay or silt clayed sand, shale and dry clay in the Eastern region of the investigated area. This layer has resistivity values ranging from 15.8Ωm to 518.3Ωm with mean value of 267Ωm and thickness values from 7.0m to 23.7m with an average of 15.35m. With respect to the geology of the area it is seen as a weak zone in most stations.

The last layer which forms the bedrock is fractured in VES 11.The bedrock resistivity value is 484Ωm.8Ωm. Study shows that the resistivity value of fresh bedrock often exceeds 1000Ωm, beside, where it is fractured/sheared and saturated with fresh water, the resistivity often reduces below 1000Ωm (Olayinka and Olorunfemi, 1992). The geophysical signature at VES 11 depicts fracture. Thus VES 11 is having very low resistivity value at the basement depth of 17.3m which depicts fracture zone for groundwater exploration or borehole development.

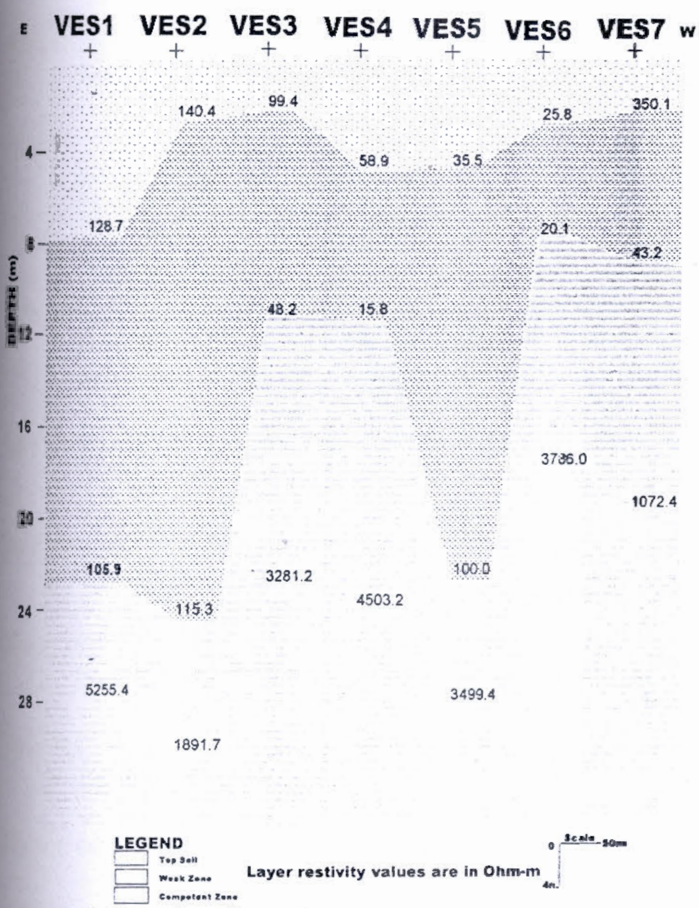


Figure 4.1 Geo-electric section along profile 1.

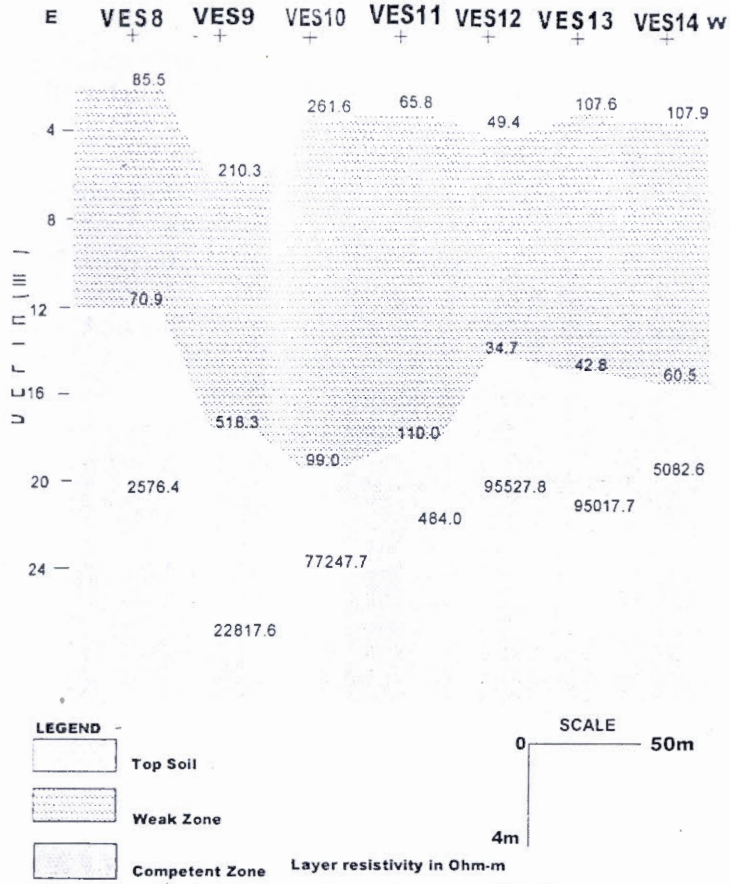


Figure 4.2 Geo-electric section along profile 2.

Table 1: Summary of the formation layer thickness

Location	Layer 1		Layer 2		Layer 3	
	h1 (m)	ρ1 (Ωm)	h2 (m)	ρ2 (Ωm)	h3 (m)	ρ3 (Ωm)
VES 1	6.9	128.7	15.0	105.9	--	5255.4
VES 2	1.9	140.4	21.8	115.3	--	1891.7
VES 3	1.3	99.4	9.1	48.2	--	3281.2
VES 4	3.9	58.9	5.6	15.8	--	4503.2
VES 5	4.6	35.5	16.2	100.0	--	3499.4
VES 6	1.9	25.8	5.0	20.1	--	3786.0
VES 7	1.5	350.1	6.5	43.2	--	1072.4
VES 8	2.2	85.5	9.3	70.9	--	2576.4
VES 9	2.3	44.9	8.97	518.3	--	22818
VES 10	2.5	261.6	16.1	99.0	--	77248
VES 11	2.2	65.8	15.1	110.0	--	484.0
VES 12	3.0	49.4	10.5	34.7	--	95528
VES 13	2.2	107.6	12.0	42.8	--	95018
VES 14	2.7	107.9	12.0	60.5	--	5082.6

CONCLUSION

The geophysical delineation of Oyo state Housing Estate, Ogbomoso Southwestern part of Nigeria has revealed three geophysical units. The thickness and resistivity values of each layer and depths to the basement (overburden thickness), and resistivity values of the aquifer have been identified. The top soil was found to be of average thickness of 3.02m, the weathered rock of average thickness of 11.18m and fresh basement of infinite depth. The average depth to the basement in the area is 14.2m. Areas where relatively thick overburden overlies fractured or weathered basement have been identified as having the highest potentials for groundwater. Whereas areas with either thick overburden or weathered and or fractured basement are delineated as having medium potentials for groundwater while areas with thin overburden and high resistivity values which correspond to fresh basement have been delineated as low groundwater potential zones. These results show that VES 11 is fractured with aquifer potential for groundwater exploration.

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