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ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 5, Issue 3, pp. 153-159, March, 2014

RESEARCH ARTICLE

HYDROGEOPHYSICAL STUDY OF THE GROUNDWATER POTENTIAL OF ACHIEVERS UNIVERSITY OWO, SOUTHWESTERN NIGERIA

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ARTICLE INFO

Article History:
Received 13th December, 2013
Received in revised form
10th January, 2014
Accepted 12th February, 2014
Published online 25th March, 2014

Key words:
Lithologic variation,
Overburden thickness,
Groundwater potential and challenges.

ABSTRACT

Hydrogeophysical study of the permanent site of Achievers University Owo was conducted to investigate its groundwater potential and challenges. Vertical electrical sounding method was employed and Schlumberger configuration was adopted. Sixteen points were sounded along five different traverses across the main campus (Figure 1). Five different subsurface lithologic units were established namely; lateritic topsoil, sand, quartzite, weathered/fractured basement and, basement. The curve types range between simple K, H to complex KHA, HKH and KHK. The topsoil, sand and weathered basement materials are characterised with relatively low resistivity values while the quartzite ridge materials are characterized with high resistivity values. The average resistivity and thickness values for the topsoil are 180Ωm and 2m respectively. Sand was encountered in seven locations with average resistivity and thickness values of 102Ωm and 13m respectively. Quartzite was encountered in eleven locations with average resistivity and thickness values of 422Ωm and 8m respectively. Weathered/fractured basement was encountered in fifteen locations with average resistivity and thickness values of 114Ωm and 11m respectively. Basement is relatively deep in the study area, it was encountered in seven locations and the average resistivity and depth values to the top of basement are 4000Ωm, and 22m respectively. Overburden thickness was established in six locations with an average value of 20m. The combination of overburden materials with the fractured basement constitutes aquiferous units within the study area though the sand and weathered basement units are largely responsible for the groundwater potential. The groundwater potential of the area is moderate. The loose/unconsolidated nature of the quartzite unit will pose a challenge during drilling and completion.

INTRODUCTION

Achievers University Owo is one of the private Universities in the Southwestern part of Nigeria and is noted for its humble beginning and steady growth from inception. The lack of social amenities such as pipe bone water and good accessible road are parts of the initial constraints to be overcome. The community depends on rainwater, surface water and groundwater for its water supplies. The University took off from its mini campus with a relatively few number of staff and students and the existing infrastructures in place were just enough for the take off. However, with increasing population and attendant infrastructural requirement, the university has moved to its main campus where progressive infrastructural development is ongoing. The university has spent fortunes in purchasing water to ensure that the daily demand for portable water on the campus is met; hence, the need for a sustainable water supply network on the campus cannot be overemphasized. The university is located on a quartzite ridge in a complex basement terrain where occurrence of groundwater in recoverable quantity as well as its circulation is controlled by geological factors. (Olorunfemi and Fasuyi (1993) upheld that most often, the occurrence of groundwater in the Basement Complex terrain is localized and confined to weathered/fractured zones. However, groundwater exploration in the basement aquifers posed a serious challenge resulting from complexity of rocks and minerals and their attendant heterogeneous grain size distribution. Olayinka and Olorunfemi (1992) emphasized the need to conduct a surface geophysical survey such as Vertical Electrical Resistivity Sounding in identifying the localized aquiferous zones before siting boreholes. Among the various geophysical methods of groundwater investigation, the Electrical Resistivity Method has the widest adoption in groundwater exploration. It is useful in locating areas of maximum aquifer thickness and serves as a good predictive tool for estimation of borehole depth. Electrical resistivity method has been used extensively in groundwater investigation especially in the basement complex terrains (Grant and West, 1965, Olorunfemi and Olorunniwo, 1985. Olorunfemi, 1990. Olorunfemi and Olayinka, 1992). The method is commonly used in getting detailed information about hydrogeological settings for groundwater. This study therefore aims at assessing the groundwater potential of the

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area with attention on the delineation of the fracture system, overburden thickness and lithological variation across the terrain.

Location and Geology of the Study Area

The study area is Achievers University Main Campus (Figure 1 and 2), at Km 1, Idasen/Ute road, Owo in South Western Nigeria. It lies between longitudes $5^0$35'19"E and $5^0$35'28"E and latitudes $7^0$10'14"N and $7^0$10'5"N. (Figure 1).

Figure 1. Location Map

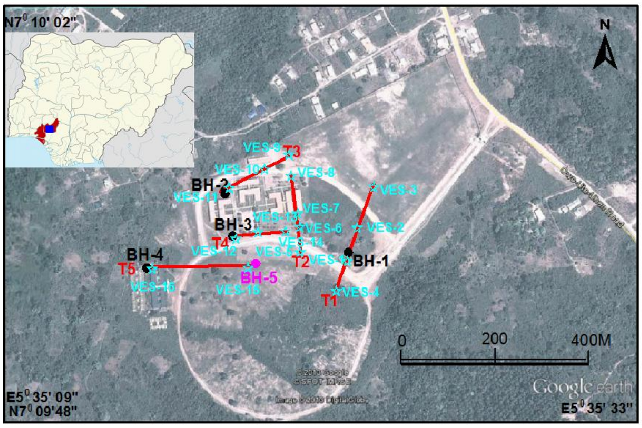

Figure 2. Base Map of the Study area

The terrain in the study area is moderately undulating, with topographic elevation ranging from 200m to 360m above sea level. The area is situated within the tropical rain forest region, with a climate characterized by dry and wet seasons. Annual rainfall ranges between 100 and 1500 mm, with average wet days of about 100. The annual temperature varies between 18^0C to 34^0C. The study area lies within the basement complex of south-western Nigeria and is characterized by migmatite gneiss and pelitic schist with quartzite layers (Figure 3). The local geological mapping of the study area revealed that the area is underlain mainly by quartzite. The overburden is relatively thick within the study area ranging from 9m to 34m.
The study area occurs within the basement complex of south-western Nigeria and it is Precambrian in age. Rahaman (1976) classified the rocks into five major groups which include the following Migmatite-Gneiss Complex, Meta-igneous rocks, Charnockitic rocks, Older granites and Unmetamorphosed dolerite dykes. The basement complex rocks are poor aquifers as they are characterized by low porosity and negligible permeability, resulting from their crystalline nature, thus availability of groundwater resource in such areas can only be attributed to the development of secondary porosity and permeability resulting from weathering and fracturing.

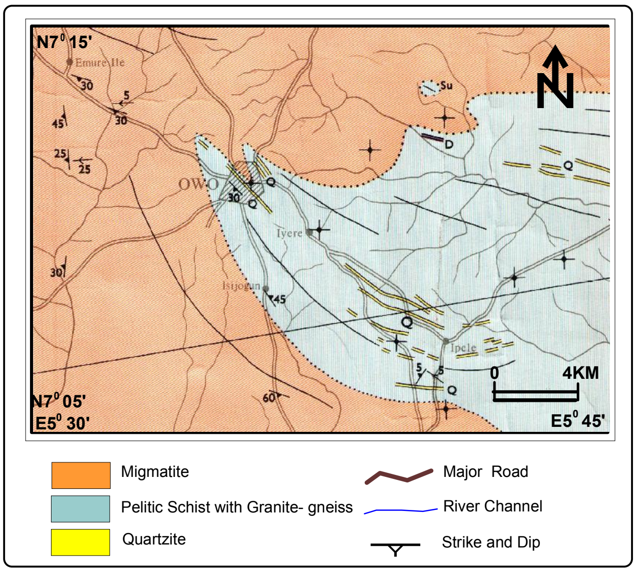

Figure 3. Geology Map Of The Study area

Methodology, Data Acquisition and Interpretation

The geophysical resistivity data was acquired with the R-50 d.c. resistivity meter which contain both the transmitter unit, through which current enters the ground and the receiver unit, through which the resultant potential difference is recorded. Other materials include: two metallic current and two potential electrodes, two black coloured connecting cable for current and two blue coloured cable for potential electrodes, two reels of calibrated rope, hammer for driving the electrodes in the ground, compass for finding the orientation of the traverses, cutlass for cutting traverses and data sheet for recording the field data. The Schlumberger array was adopted. The electrode spread of AB/2 was varied from 1 to a maximum of 150 m. The expected depth of investigation was (D) = 0.125 L, where L = AB/2 and AB the current electrode separation. Sounding resistivity against AB/2 or half the spread length on a bi-log paper.

Ground resistance (R) measurements were recorded with the R–50 d.c resistivity meter. The electrical resistances obtained were multiplied by the corresponding geometric factor (k) for each electrode separation to obtain the apparent resistivity (r = kR) in ohm-meter. The models obtained from the calculations above were used for computer iteration to obtain the true resisitivity and thickness of the layers. Computer-generated curves were compared with corresponding field curves by using a computer program "Resist" version 1.0. The software was further used for both computer iteration and modeling. Computer iteration of between 1 - 29 were carried out to reduce errors to a desired limit and to improve the goodness of fit. Areas where the overburden thickness was greater than 25m and are of low clay content (resistivity above 100 Ω-m) were considered zones of high groundwater potential while those within 10 and 25 m are zones of medium groundwater potential and less than 10 m are of low groundwater potential.

RESULTS AND DISCUSSION

In all, a total of 16 VES locations across 5 traverses were spread over the study area (Figure 3). The processed data were interpreted, resulting curve types were assessed, existing subsurface lithologic units were established, and the geoelectric properties of the various subsurface layers were used in delineating the aquiferous units in the study area. The results are presented in the form of table (Table 1), geoelectric curves (Figure 4) and sections (Figure 5). Five different subsurface lithologic sequences were established namely; lateritic topsoil, sand, quartzite, weathered/fractured basement and, basement. The curve types ranges between simple K, H to complex KHA, HKH and KHK. The topsoil, sand and weathered basement materials are characterised with relatively low resistivity values while the quartzite ridge materials are typified with high resistivity values.

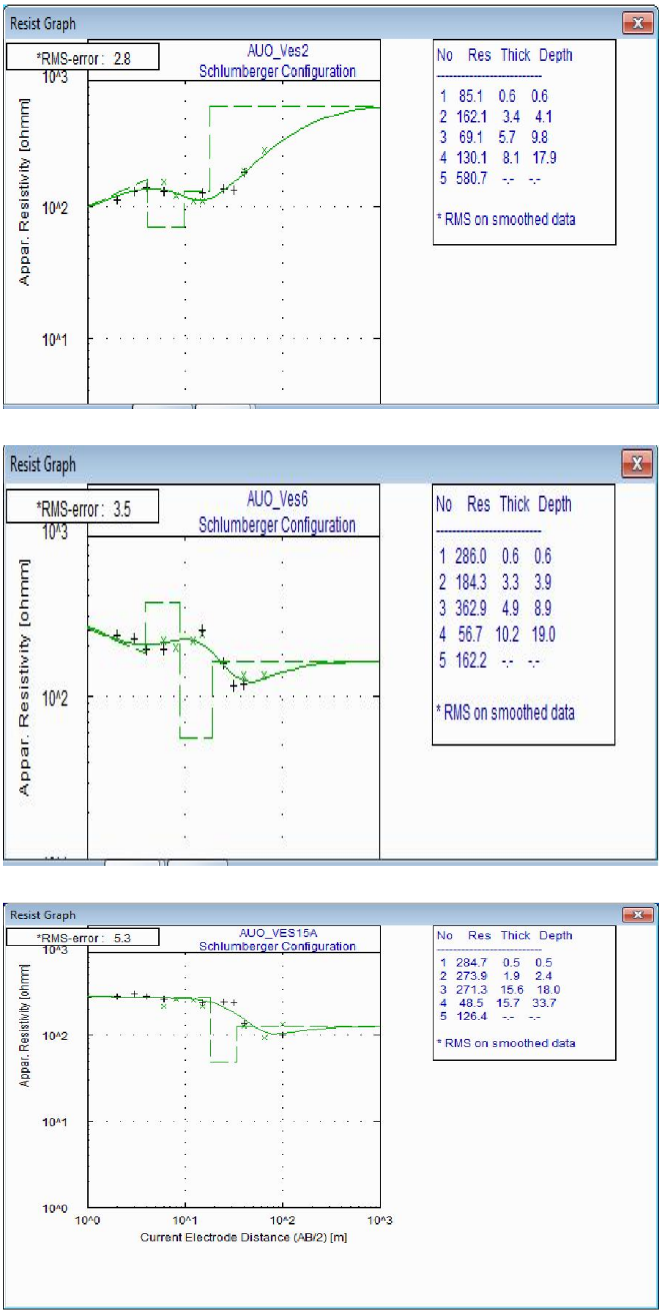

Figure 4a. Geoelectric curves of the study area

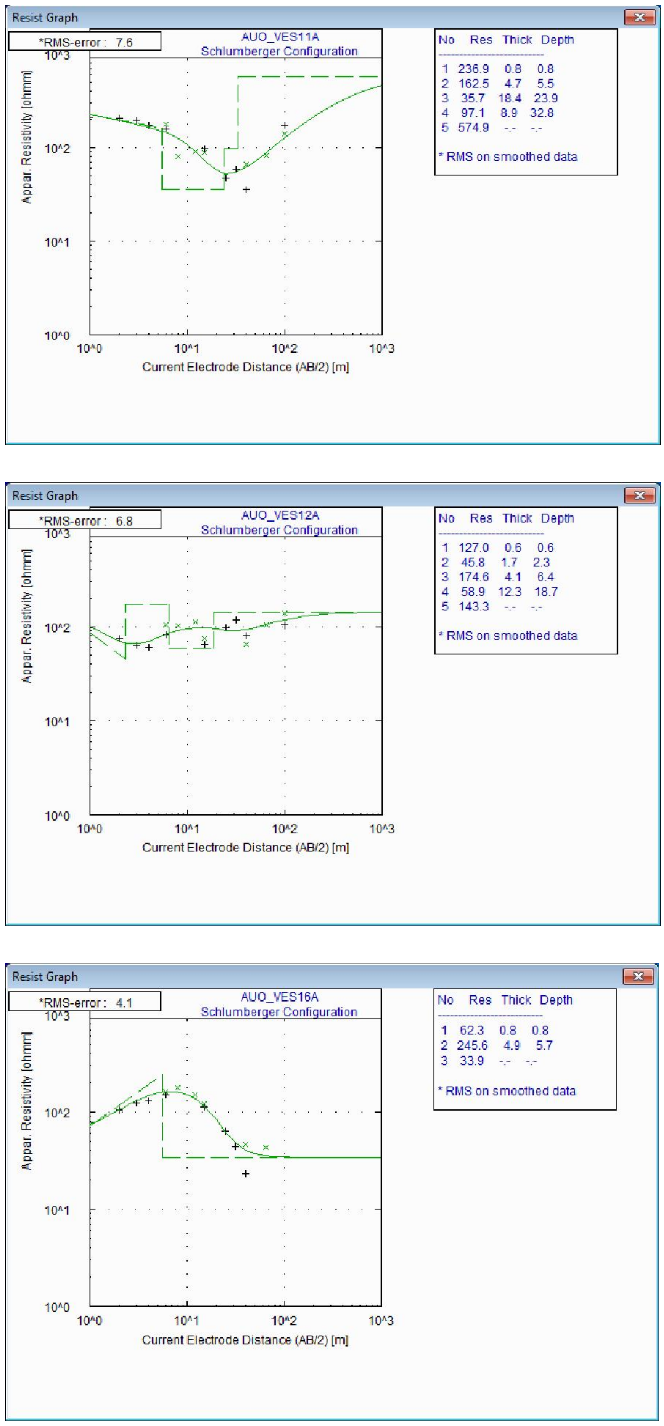

Figure 4b. Geoelectric curves of the study area

According to Olorunfemi and Olorunniwo (1985), Idornigie and Olorunfemi (1992), Olayinka and Olorunfemi (1992), curve types can be classified into four distinct classes as follows: Class 1 type curve, represents a subsurface condition in which there is an increase in resistivity values from the topsoil to the basement rock, example is the A-type curve. In class 2 curve types, the upper horizons when not leached are usually clayey and of low resistivity. Immediately underlying this usually low resistivity, high porosity, low specific yield and low permeability aquiferous zone is the fresh basement. This classic architecture of the profile produces an H-type curve signature. Curve types of class 3 are typical of a succession of relatively low and high resistivity layers. The K type is found where a highly resistive lateritic layer underlies low resistivity clayey topsoil and weathered zone in turn underlies the former. Or it may result from where the basement, fractured at depth, underlies the topsoil. In the curve type in class 4, the succession of the subsurface layers starts with a highly resistive topsoil followed by a more conductive horizon and then another less conductive layer underlies the latter example is the HKH-type curve.

A summary of the results of interpretation, on which the following findings were hinged, is shown in Table 1.

the weathered/fractured basement are, 114Ωm and 11m respectively thus indicating that the material composition is largely clay, sandy clay and clayey sand or high degree of fracture and/or water saturation. It is of infinite thickness where it is the last observable layer.

Basement

The basement is the fresh bedrock and is the last layer. It is relatively deep in the study area, it was encountered in seven locations and the average resistivity and depth values to the

Table 1. Correlation Table

VES POINT		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CURVE TYPE		K	KHA	KH	KHA	K	HKH	KH	H	KHA	K	H	KHK	HK	K	H	K
LITHOLOGY	DEPTH (M)																
	TOP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOP SOIL	BASE	3	4	5	3	1	4	1	6	1	2	6	2	1	4	2	1
	THICKNESS	3	4	5	3	1	4	1	6	1	2	6	2	1	4	2	1
	Ωm	317	162	135	386	31	286	165	272	72	17	237	127	339	318	285	62
	TOP	3	4	5	-	-	-	1	-	1	-	6	-	1	-	-	-
SAND	BASE	5	10	18	-	-	-	8	-	26	-	33	-	11	-	-	-
	THICKNESS	2	6	13	-	-	-	7	-	25	-	27	-	10	-	-	-
	Ωm	154	69	81	-	-	-	118	-	95	-	97	-	102	-	-	-
	TOP	5	-	-	-	1	4	8	6	-	2	-	2	11	4	2	1
QUARTZITE	BASE	10	-	-	-	14	9	18	10	-	7	-	6	26	9	18	6
	THICKNESS	5	-	-	-	13	5	10	4	-	5	-	4	15	5	16	5
	Ωm	793	-	-	-	392	363	548	230	-	291	-	175	373	964	271	246
WEATHERED	TOP	10	10	18	3	14	9	18	10	26	7	-	6	26	9	18	6
/FRACTURED	BASE	-	18	-	9	-	19	-	23	-	-	-	19	-	-	34	-
BASEMENT	THICKNESS	-	8	-	6	-	10	-	13	-	-	-	13	-	-	16	-
	Ωm	56	130	105	187	55	57	94	77	196	36	-	59	47	527	49	34
	TOP	-	18	-	9		19	-	23	-	-	33	19	-	-	34	-
BASEMENT	Ωm	-	581	-	8708		162	-	139	-	-	575	143	-	-	126	-

top of basement are, 4000Ωm, and 22m respectively. The resistivity values are so high because of its crystalline nature.

Geoelectric Units

The geoelectric sections (Figures 5) show the variations of resistivity and thickness values of layers within the depth penetrated in the study area at the indicated VES stations. The traverses were taken along the N-S and W-E directions. Generally, the traverses revealed five subsurface layers: top-soil, sand, Quartzite, weathered/fractured basement and the presumed fresh basement.

Topsoil

The topsoil thickness is relatively thin along these traverses. The average resistivity and thickness values for the topsoil are 180Ωm and 2m respectively, which indicated that the predominant composition of the topsoil is lateritic clay, sandy clay and clayey sand.

Sand

Sand was encountered in seven locations and the average resistivity and thickness values for the sand are, 102Ωm and 13m respectively.

Quartzite

Quartzite was encountered in eleven locations and the average resistivity and thickness values for the quartzite are, 422Ωm and 8m respectively.

Weathered layer/fractured layer

Weathered/fractured basement was encountered in fifteen locations and the average resistivity and thickness values for

Overburden

The overburden in assumed to include all materials above the presumably fresh basement. The depth to the bedrock varies from 9.0 to 34.0m and the average depth to the bedrock is 22m (Table 1 and Figure 5). Overburden thickness was established in six locations and the average thickness value is 20m. Generally, areas with thick overburden and low percentage of clay in which intergranular flow is dominant are known to have high groundwater potential particularly in basement complex terrain (Okhue and Olorunfemi, 1991). However, resistivity values between 3 and 60 Ωm are typical of clay which may be constantly saturated but poorly permeable to the interstitial formation water for abstraction.

Evaluation of Groundwater Potential

Given the average resistivity values and thicknesses of the sand, weathered/fractured layers and the overburden thickness, (Table 1 and Figure 5), the study area is prolific. The combination of overburden materials with the fractured basement constitutes aquiferous units within the study area although the sand and weathered/fractured basement units are largely responsible for the groundwater potential. Observed thickness and nature of the weathered layer are important parameters in the groundwater potential evaluation of a basement complex terrain (Clerk, 1985; Bala and Ike, 2001). Horizon is regarded as a significant water-bearing layer (Bala and Ike 2001) if significantly thick and the resistivity parameters suggest saturated conditions. An average thickness

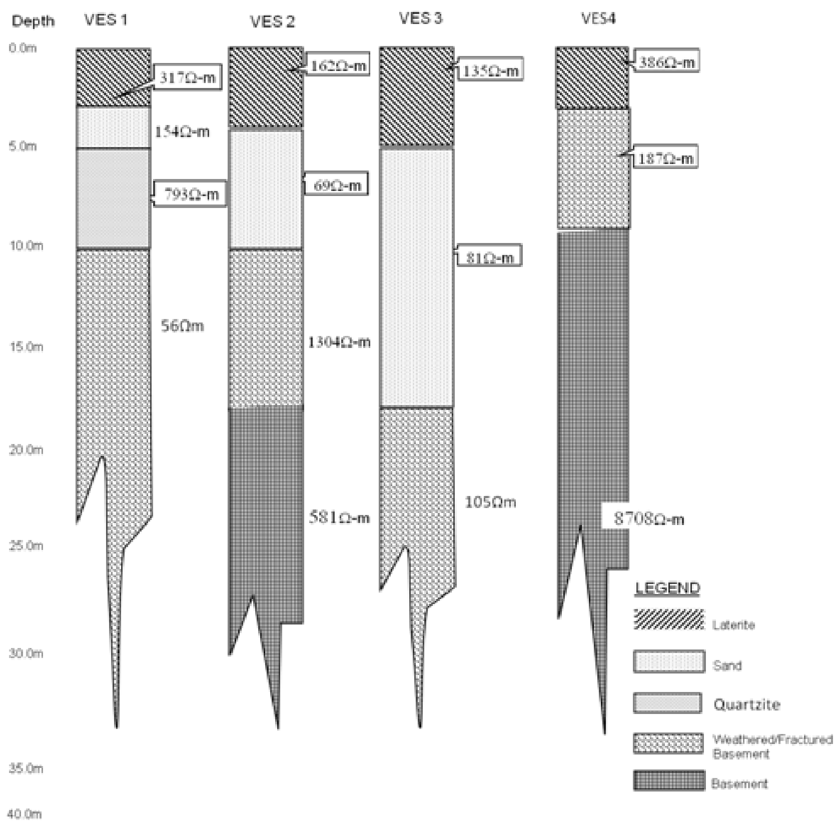

Figure 5A. Geoelectric Section of VES; 1, 2, 3, and 4

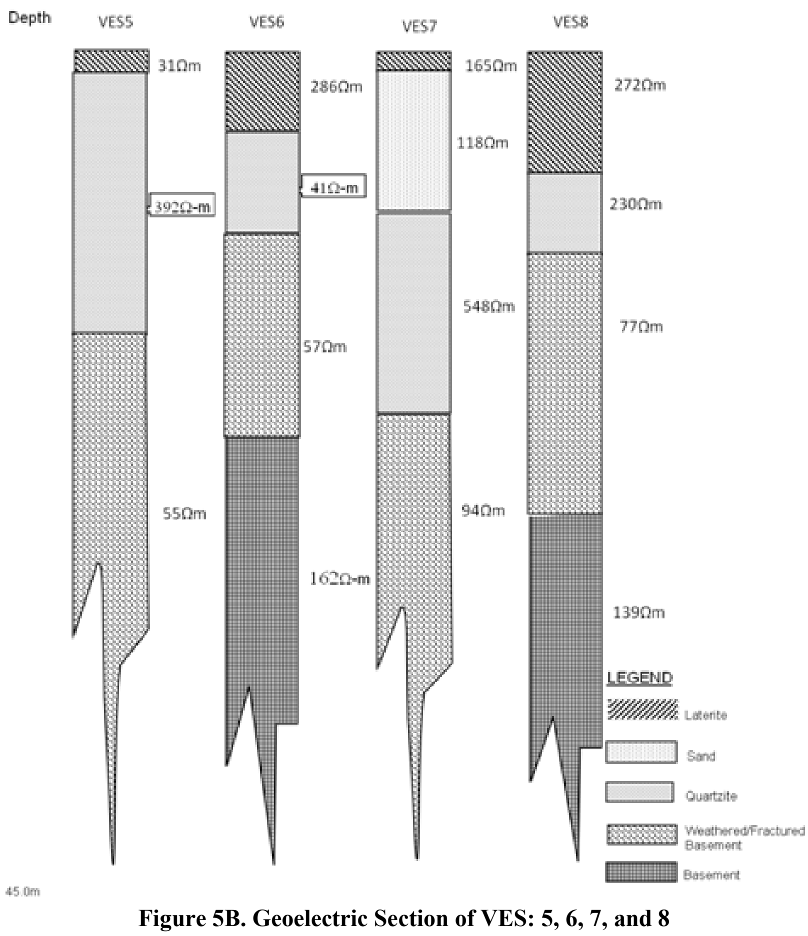

Figure 5B. Geoelectric Section of VES: 5, 6, 7, and 8

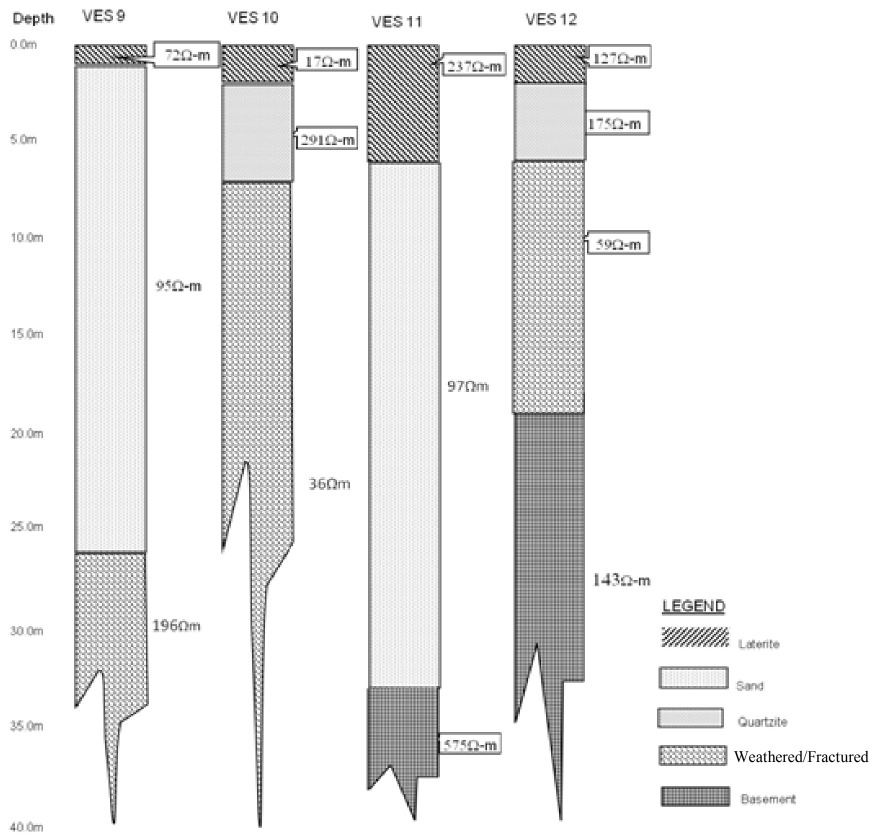

Figure 5C. Geoelectric Section of VES: 9, 10, 11, and 12

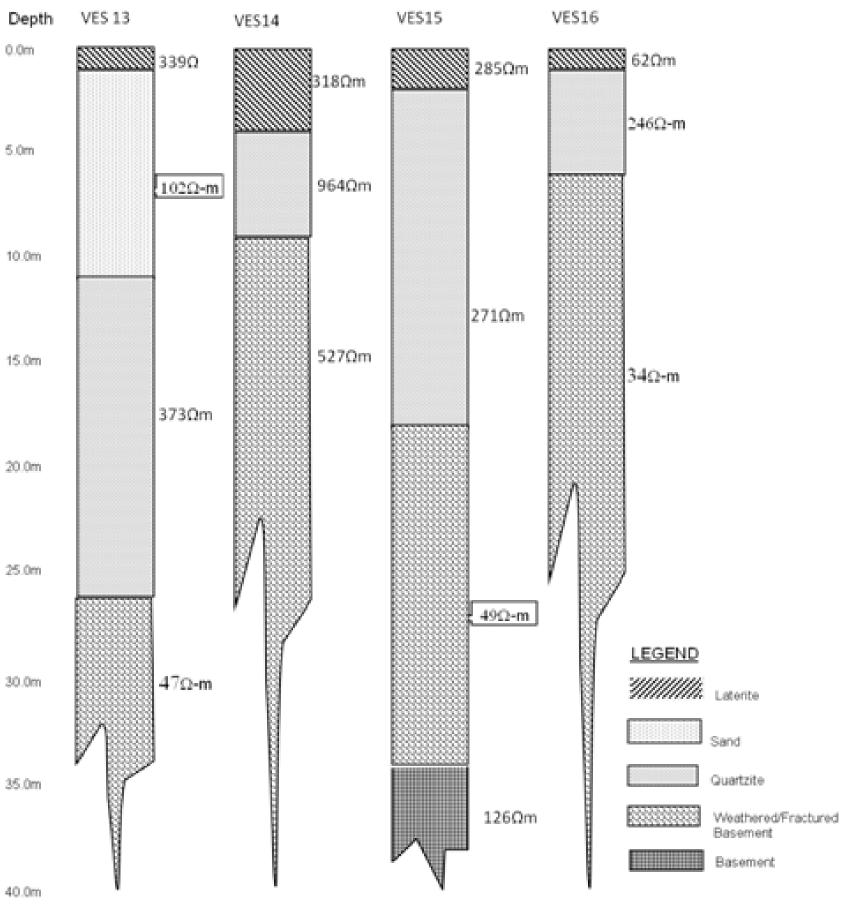

Figure 5D. Geoelectric Section of VES: 13, 14, 15, and 16

value of 12m and resisitivity of 108Ωm of aquiferous unit and of low clay content is suggestive of a medium/moderate groundwater potential.

Conclusions

In this study, the groundwater potential of Achievers University main campus, Owo, southwestern Nigeria was evaluated using 16 Schlumberger vertical electrical soundings (VES). The curve types ranges between simple K, H to complex KHA, HKH and KHK. The computer assisted sounding interpretation revealed five different subsurface lithologic sequences namely; lateritic topsoil, sand, quartzite, weathered/fractured basement and, basement. The topsoil, sand and weathered basement materials are characterised with relatively low resistivity values while the quartzite ridge and basement materials are typified with high resistivity values. The combination of overburden materials with the fractured basement constitutes aquiferous units within the study area although the sand and weathered basement units are largely responsible for the groundwater potential. The yield of the weathered basement material is dependent on the amount of the clay content. The higher the clay content, the lower the groundwater yield. The topsoil has limited hydrologic significance. The groundwater potential rating of the area is considered moderate. The loose/unconsolidated nature of the quartzite unit will pose a challenge during drilling and completion. Existing number of boreholes, storage facilities and reticulation network are inadequate for the ever-growing population of the university. There is need for proper completion of borehole(s) and expansion of storage and reticulation facilities. An average depth of 40m to 50m is recommended for boreholes in this area.

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