EXPLORATION OF GROUNDWATER WITHIN THE MARIAM BABANGIDA GIRLS SCIENCE SECONDARY SCHOOL MINNA NORTHCENTRAL NIGERIA USING SCHLUMBERGER VERTICAL ELECTRICAL SOUNDING TECHNIQUES

Momoh O.L., Amadi, A.N., Abdulfatai I.A., Omananyi, Y.A., Onoduku, U.S. & Onah M.
Department of Geology,
School of Natural and Applied Sciences,
Federal University of Technology, Minna,
P.M.B. 65, Minna, Niger State, Nigeria.
Email: momohodapo@yahoo.com
Mobile Phone No: +234-706-759-6900,

Abstract
A Geoelectrical investigation adopting Schlumberger vertical electrical sounding (VES) have been carried out to explore for groundwater within the premises of Mariam Babangida Girls Science Secondary School, Bosso, Minna, Niger State. This is with a view to resolve the problem of acute water shortages experienced by the staff and students of the institution. The area lies within the basement rock complex of North Central Nigeria with biotite granite and muscovite granite constituting the main lithological units. The survey was carried out using ABEM SAS 300C Terrameter along five (5) established traverses with 40m maximum electrode separation. The VES data were analyzed and interpreted through curve matching and the use of Resist software to obtain the geoelectric parameters. These were used in constructing the 1D geoelectric sections and the isopach map. The geoelectric sections revealed the presence of four geo-electric layers namely the top soil, the weathered layer, the partly weathered/fractured bedrock and the resistive bedrock. The contoured depth to bedrock contour map reveals a significant linear feature delineated by the VES as fractures beneath T2V7, T2V8 and T3V9 and is filled with clayey substratum except T3V9 that are characterized by clayey sand materials. T3V9 is therefore recommended for drilling and groundwater development to a depth of about 30m. However, the groundwater potential of the study area is generally very low.

Keywords: Exploration, Groundwater, Schlumberger Ves, Minna

Introduction
The study area is located within the premises of Mariam Babangida Girls Science Secondary School (MBGSSS) Minna Niger State, northcentral Nigeria. It is bounded by latitude $9^0$39'23''N to $9^0$39'27''N and longitude $6^0$31'15''E to $6^0$31'19''E. It falls within the guinea savannah belt. Productive boreholes within the area as obtained in other parts of the Basement Complex of Nigeria are normally located within the porous and permeable weathered basement and fracture column of the basement lithology (Satpathy and Kanungo, 1976; Olorunfemi and Fasuyi, 1993; Momoh and Olasehinde, 2010). The area has two distinct seasons, the wet (May to October) and prolong dry (November to March) with annual rainfall varying between 1270mm and 1524mm (Iloeje, 1981).The relative humidity is generally low except at the peak of the rainy season while the diurnal temperature ranges from 35 to 24ºC. The need to explore for groundwater becomes necessary in view of the fact that the available surface water is inadequate and not portable. For any successful development of groundwater scheme to be completed, the geoelectrical characteristics of the subsurface geologic/geoelectric sequences have to be properly understood. The weathered layer is known all over the world to have the capability of accumulating groundwater to appreciable level due to its significant high porosity and permeability (Palacky and Kadekaru, 1979 and Olorunfemi, 1990). Research has equally shown that high groundwater yield in the basement terrain is normally obtained in areas where relatively thick overburden overlies fractured column (Olorunniwo and Olorunfemi, 1987, Olorunfemi and Fasuyi, 1993). The ability of electrical resistivity method in delineating the different subsurface geoelectric configurations, the aquiferous unit together with their geoelectric/geologic characteristics and

subsurface linear structures cannot be over emphasized (Awni et al, 2004; Adiat et al, 2009). This will ultimately help in resolving the lateral and vertical limitation of basement aquifers observed by Satpathy and Kanugo, 1976.

The available statistics shows that the population of the school community is well above 1,000. The school equally operates boarding system and at present lack effective functional water supply system. This has resulted in students searching for water from the neighboring communities that depend on shallow hand dug well. Hence, the search for groundwater within the school premises becomes very necessary. This study is meant to create awareness on the productive aquifer so as to guide both the government and the school authorities involved in groundwater development on the possible areas and depth that boreholes could be drilled for potable and sustainable water supply within school communities.

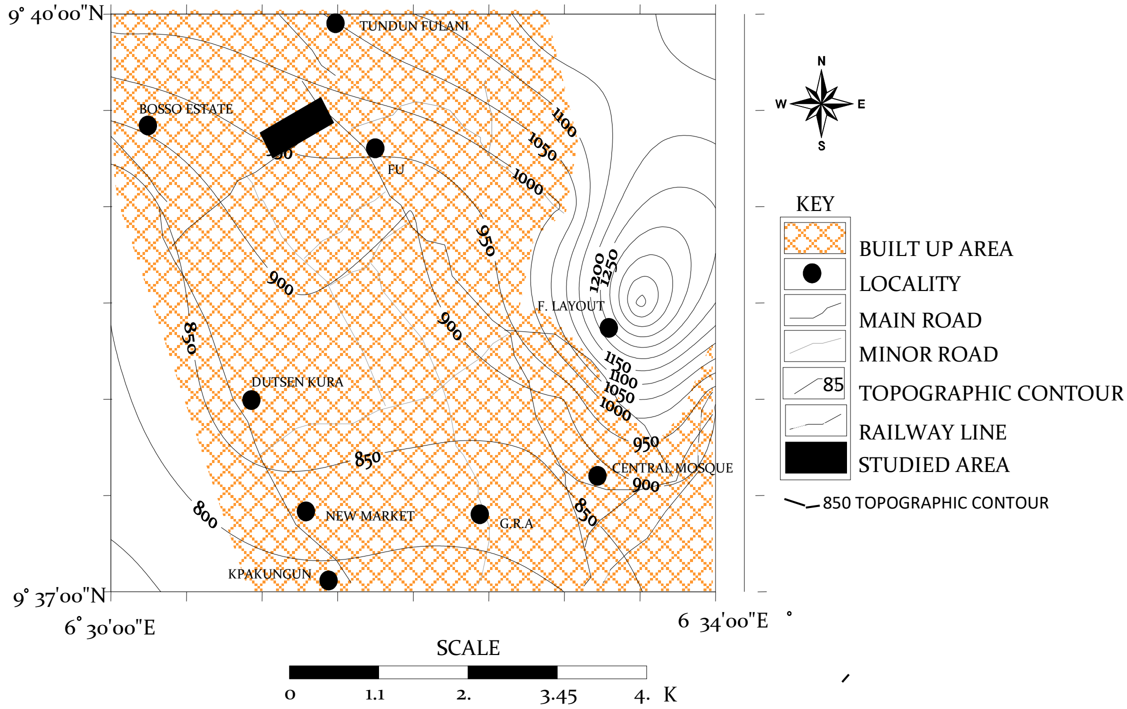

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Fig. 1.0: Topographic Map Showing parts of Minna and the Location of the Study Area

Geology and Geomorphology of the Study Area

The study area and environ is underlain by rocks of the Precambrian Basement lithologies of Pan-African age with biotite granite and muscovite granite constituting the major lithological units. The biotite granite underlies the study area and cover over 80% of the surrounding environment (Fig. 2). It consists of quartz, microcline, plagioclase and biotite. The northeastern part of the surrounding environment to the studied area has granite that is rich in muscovite and is characterized by light coloured minerals (Shekwolo, 1995).

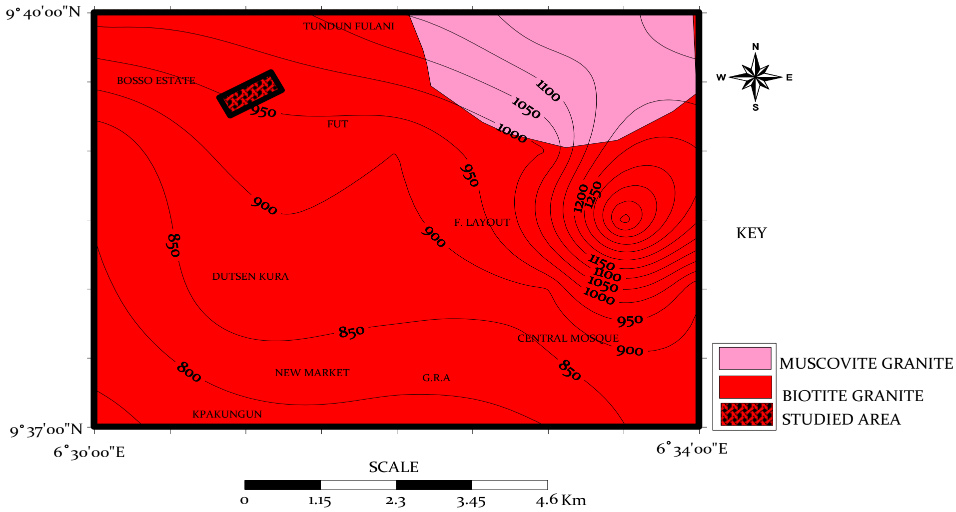

Fig. 2: Geological Map of the Study Area

Joints and fracture constitutes the major structural elements and are trending in NE – SW and NW – SE directions (Fig. 4). Although the joint density is very low, the few recognized have direct bearing with the delineated fractured column. The MBGSSS is characterized by plain to gently slope topography toward the south. The surrounding environment are generally plain.

Field Investigation

A total of twenty (20) VES data were acquired along five (5) uniformly established geophysical traverses with inter-traverse and station distances of 50 and 25m respectively (Fig. 3). The traverses were designed to perpendicularly cut across the dominant WNW-ESE joint directions (Fig. 4). The VES data were collected using ABEM SAS 300C Terrameter with electrodes separation of 1 to 40 m to probe the successive depth. Plots of the apparent resistivities obtained at each sounding location against electrode spacing were made to obtain the resistivity sounding curves. The resulting sounding curves were interpreted through partial curve matching using 2-layer master curves and the corresponding auxiliary curves. The obtained geoelectric parameters (layer resistivities and thicknesses) were used as the starting model for 1-D forward modeling involving the RESIST software. The curves were then compared with the computer generated curves for the purpose of obtaining a good fit (>97.5% correlation). The final geoelectrical parameters were then used in constructing the geoelectric sections and depth to bedrock map. The joint directions were statistically analysed as presented in table1 to obtain the dominant trend shown in Figure 4.

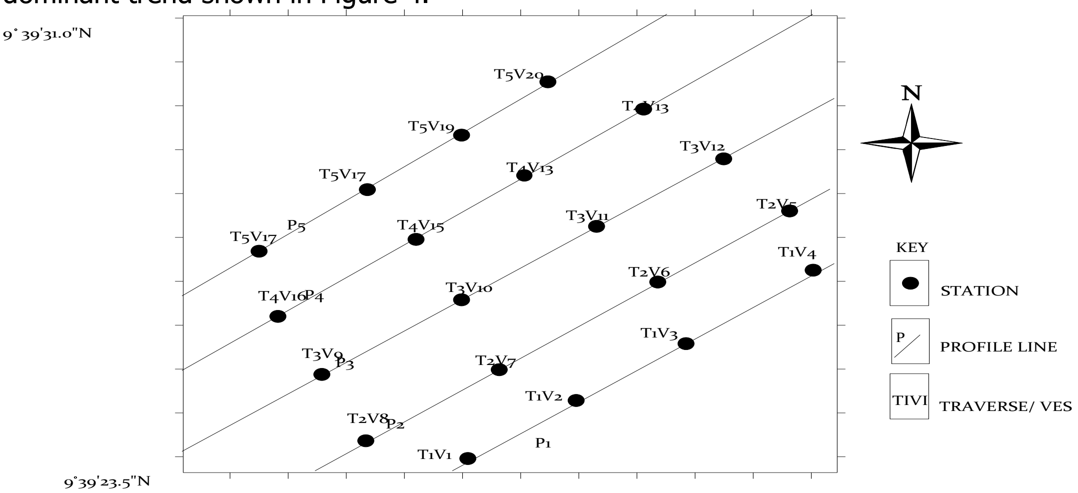

Fig. 3: The VES Data Acquisition Map in the Study Area

Results and Discussion

The dominant trends of the joints in the study area are NNE – SSW and WNW – ESE (Table 1 and Fig. 4) and have direct bearing with the delineated fractured column typifies by HA type curves and shown by the contour depth to bedrock map (Fig. 6). Hence, the rosette diagram could be of value in searching for groundwater in the study area. The relief map shows that the surface water flow from the relatively highland in the eastern and northern part to the gently slope and plain area where the present study is located (Fig. 5). The contour isopach map shows a discontinuous contour in the southern to south-east part of the study area possibly revealing a linear feature denoted by letter F in the diagram (Fig. 6). The Schlumberger VES delineates fracture beneath T2V7, T2V8 and T3V9 within the vicinity of the suspected linear feature.

Table 1: Joint Directions used in Plotting the Rosette Diagram in the Study Area

JOINT DIRECTIONS	FREQUENCY F1	JOINT DIRECTIONS	FREQUENCY F2	TOTAL=F1+F2	%=$\frac{F1+F2}{TOTAL}\times\frac{100}{1}$
000-030	13	181-210	29	42	26.1
031-060	0	211-240	8	8	5
061-090	8	241-270	7	15	9
091-120	21	271-300	21	42	26.1
121-150	23	301-330	5	28	17.3
151-180	20	331-360	6	26	16.14

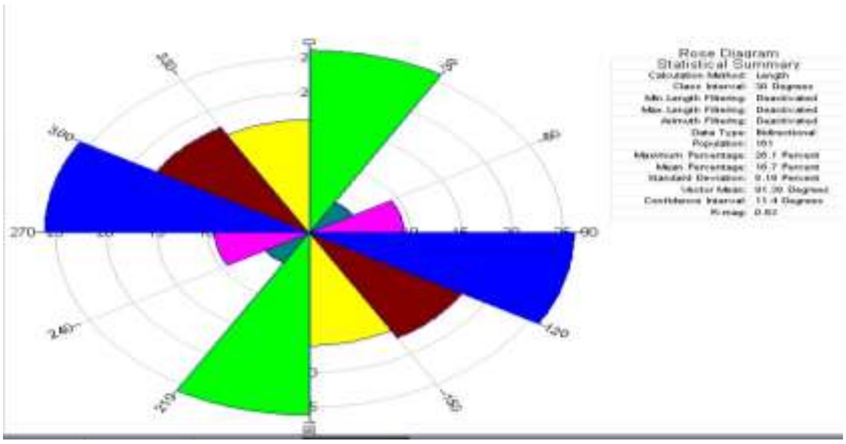

Fig. 4: The Rosette Diagram of the Study Area

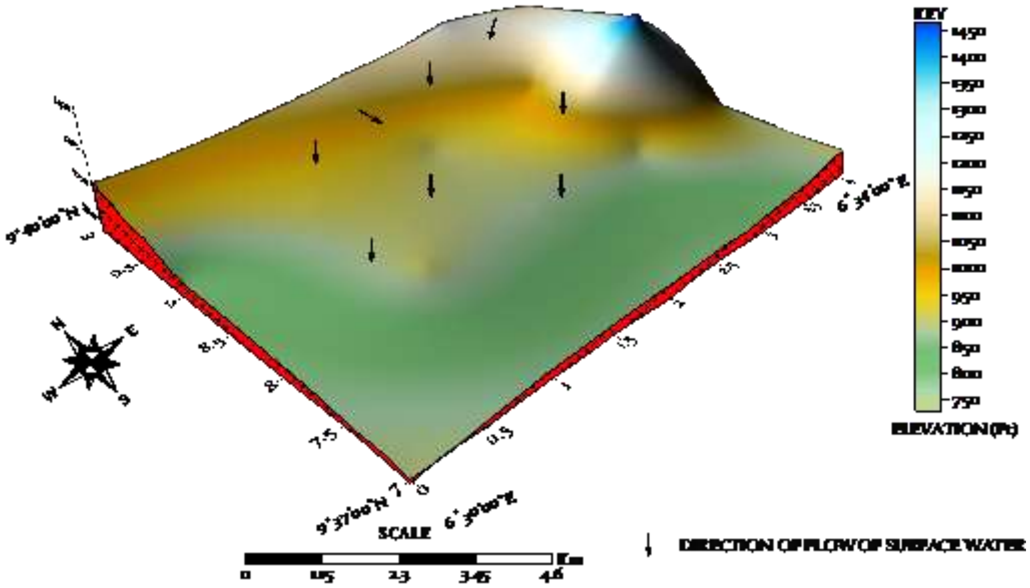

Fig. 5: Relief Map and Surface Water Flow Direction in the Study Area

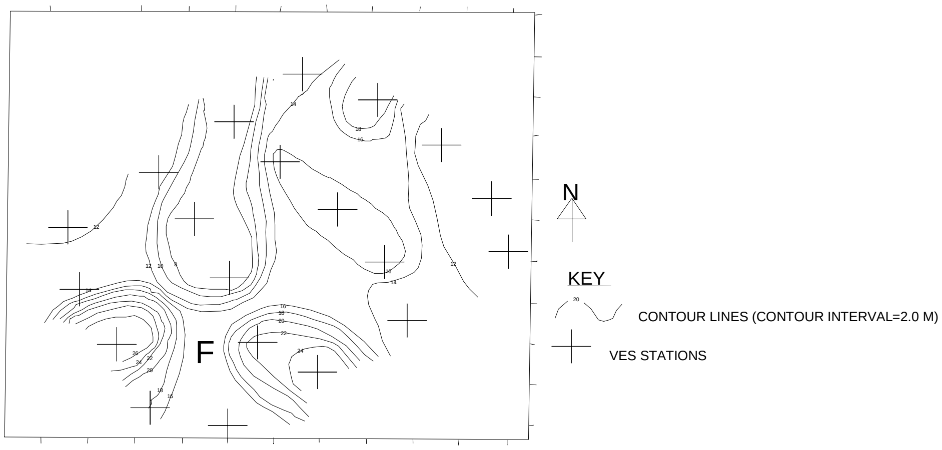

FIG. 6: DEPTH TO BEDROCK CONTOUR MAP OF THE STUDY AREA

Table 2: Geoelectric Parameters Obtained Beneath Traverse 1

S/N	VES NO_	Resistivity (Ωm) // Depth (m)	Type Curve
1	T_1VES $_1$	284 / 60 / 417 // 2.8 / 12.2	H
2	T_1VES $_2$	94 / 258 / 906 / 3185 // 5.8 / 8 / 12.1	AA
3	T_1VES $_3$	83 / 401 / 421/ 620 // 1.7 / 4.2 / 7.9	AA
4	T_1VES $_4$	101 / 29 / 31 / 594 // 1 / 3.9 / 6.4	HA

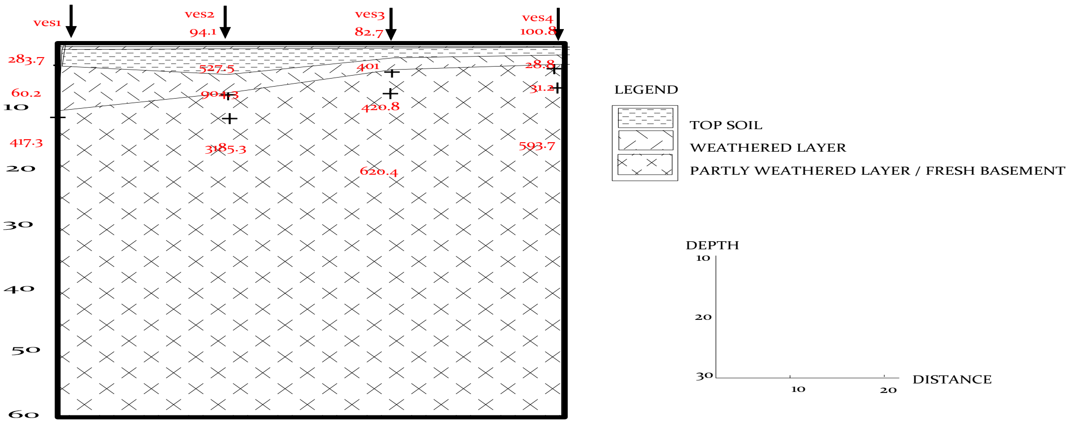

Fig. 7: Geoelectric Section Showing Subsurface Sequences Beneath Traverse1

The geoelectric sections delineate four main geoelectric/geologic sequences below the subsurface of the study area. These includes the top soil, the weathered layer, the partly weathered/fractured layer and the resistive bedrock.

Table 3: Geoelectric Parameters Obtained Beneath Traverse 2

S/N	VES NO_	Resistivity (Ωm) // Depth (m)	Type Curve
1	T_2VES_5	178 / 19 / 39 / 1363 // 1.3 / 2.7 / 6	HA
2	T_2VES_6	21 / 57 / 136 / 591 // 2.9 / 5.6 / 9.5	AA
3	T_2VES_7	84 / 21 / 99 / 702 // 1.1 / 4.9 / 17. 4	HA
4	T_2VES_8	225 / 33 / 75 / 612 // 1.9 / 6.5 / 9.6	HA

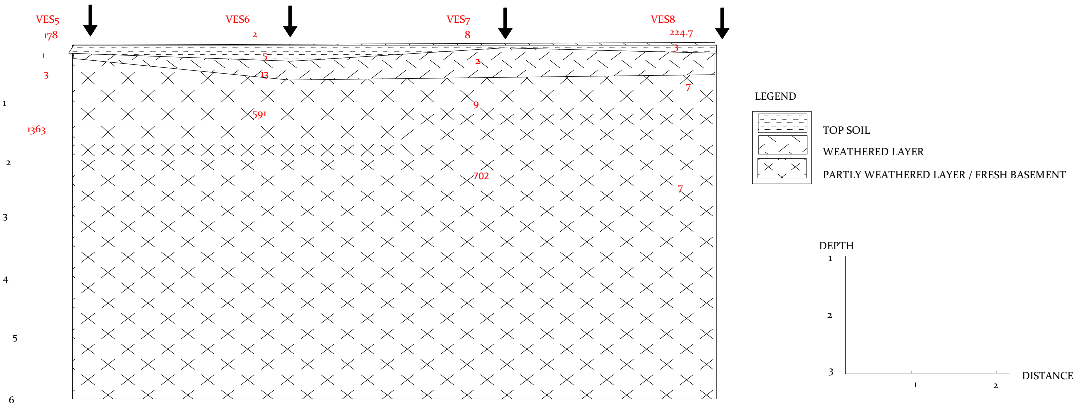

Fig. 8: Geoelectric Section Showing Subsurface Sequences Beneath Traverse 2

Table 4: Geoelectric Parameters Obtained Beneath Traverse 3

S/N	VES NO_	Resistivity (Ωm) // Depth (m)	Type Curve
1	T_3VES_9	146 / 23 / 167 / 244 // 0.6 / 5.9 / 21	HA
2	T_3VES_{10}	536 / 195 / 2308 // 0.7 / 6.7	H
3	T_3VES_{11}	31 / 181 / 474 // 5.1 / 11.2	A
4	T_3VES_{12}	80 / 9 / 222 / 1386 // 0.8/ 3.1 / 6.8	HA

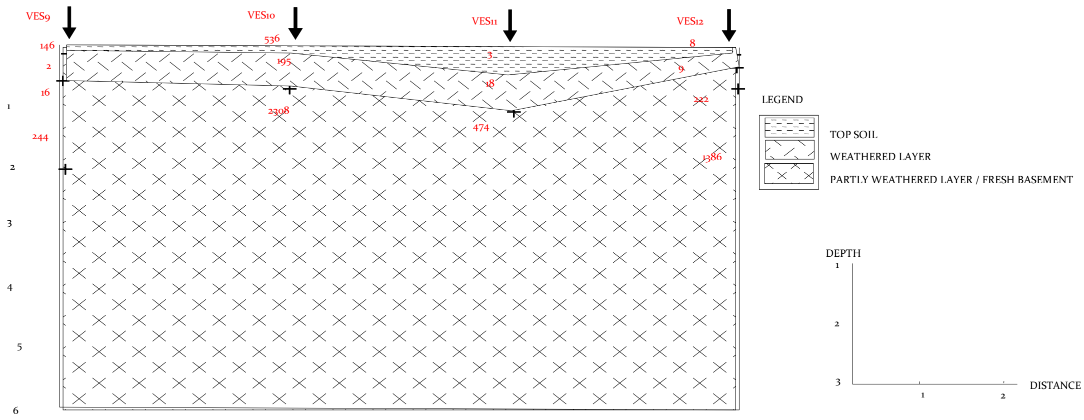

Fig. 9: Geoelectric Section Showing Subsurface Sequences Beneath Traverse 3

The top soil is characterized by clay, sandy clay, clayey sand and sands with the exception of VES 10 beneath traverse 3 where lateritic soil was encountered. The resistivities and thicknesses of this layer vary from 21 to 536Ωm and 0.6m to 5.0m respectively. The weathered layer resistivity ranges between 9Ωm and 401Ωm while the thickness varies from 2.7m to 11.2m. The partly weathered/fractured bedrock has resistivity greater than 349Ωm with thicknesses ranging between 6.0m and 21.0m. The geoelectric sections show that the overburden is generally shallow to moderately thick. The VES delineated fracture column that is equally shown by the contour depth to bedrock map as subsurface linear structural feature beneath T2V7, T2V8 and T3V9 and are filled with clayey substratum as characterized by resistivity values of generally below 100 Ωm except T3V9 that are characterized by clayey sand materials with 167 Ωm resistivity value. T3V9 is therefore recommended for drilling to a depth of about 30m. Hence, the groundwater potential of the study area is generally very low.

Table 5: Geoelectric Parameters Obtained Beneath Traverse 4

S/N	VES NO_	Resistivity (Ωm) // Depth (m)	Type Curve
1	T_4VES_{13}	198 / 54 / 20 / 349 // 3.7 / 5.4 /10.9	QH
2	T_4VES_{14}	363 / 191 / 613 / 1309 // 1.3 / 3.7 / 12	HA
3	T_4VES_{15}	260 / 32 / 1318 // 0.9 / 4.4	H
4	T_4VES_{16}	389 / 67 / 145 / 639 // 1.1 / 3.9 / 7.4	HA

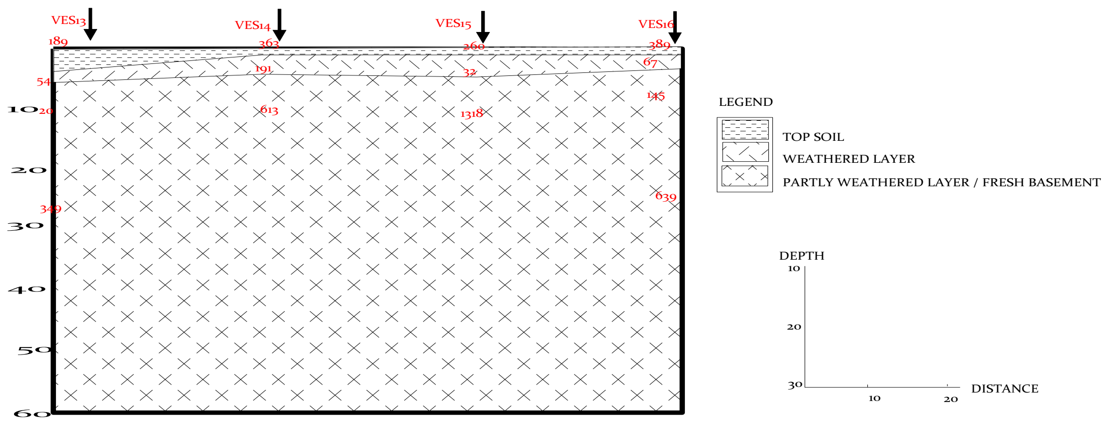

Fig.10: Geoelectric Section Showing Subsurface Sequences Beneath Traverse 4

Table 6: Geoelectric Parameters Obtained Beneath Traverse 5

S/N	VES NO_	Resistivity (Ωm) // Depth (m)	Type Curve
1	T_5VES_{17}	65 / 149 / 1015 // 2.4 / 6.5	H
2	T_5VES_{18}	148 / 64 / 1869 // 2.3 / 6.4	H

3	T_5VES_{19}	94 / 25 / 1045 / 0.9 / 3.5	H
4	T_5VES_{20}	168 / 64 / 539 / 2096 // 1.2 / 3.4 / 8	HA

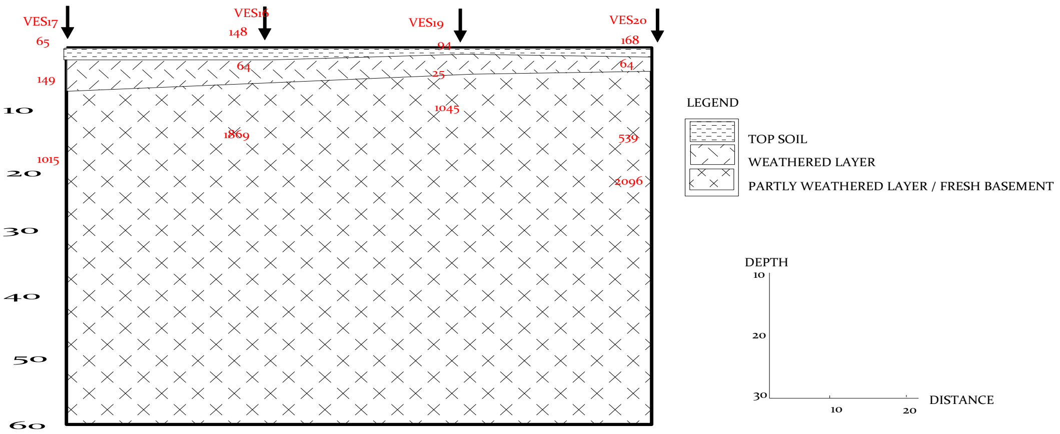

Fig. 11: Geoelectric Section Showing Subsurface Sequences Beneath Traverse 5

Recommendations and Conclusions

The exploration of groundwater at MBGSS, Minna, Niger State, Nigeria has been made using Schlumberger vertical electrical sounding (VES) techniques. The objective of the survey is to understudy the geoelectrical characteristics of the area and recommend a suitable point for drilling and groundwater development with the hope of solving the persistent water scarcity of the school community. The survey delineates four geoelectric sequences including the topsoil, the weathered layer, the partly weathered/fractured basement and the fresh bedrock. The contour depths to bedrock map reveal a significant linear feature delineated by the VES as fractures beneath T2V7, T2V8 and T3V9 and are filled with clayey substratum except T3V9 that are characterized clayey sand materials. T3V9 is therefore recommended for drilling to a depth of about 30m. Hence, the groundwater potential of the study area is generally very low.

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