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Geophysical Survey Report for Groundwater Development in Gwoza West of Gwoza Local Government Area, Borno State, Northeastern Nigeria

[1]**Ali, S. D.**, [2]**Bello, S.**, [3]**Major, B. I.** & [4]**Fambia, A.**
[1,3&4]*Department Physics, Umar Ibn Ibrahim El-kanami College Education Science and Technology Bama, Borno State Nigeria*
[2]*Department of Physics, College of Education Waka Biu, Borno State Nigeria.*

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Corresponding Author:
Ali, S. D.

Abstract

A geophysical Survey employing Schlumberger electrode configuration using vertical electrical Sounding (VES) Method was carried out around Gwozawest and environs within the basement complex of northeastern Nigeria using an ABEM SAS 300C terrameter with view to exploring Groundwater potential in the study area. The vertical electrical Sounding (VES) data were acquired from 16 locations within the study area. The apparent resistivity values obtained in the field were plotted on log-log graph sheets against stations spacing and then the curves of each VES smoothened. The computer software IXID was used for the interpretation of the data. All of the VES data indicates 3 – 4 layers earth models and the curves types were of the H, KH, and A types. The first layer is the top soil with an average thickness of 0.9 and average resistivity of 443Ωm. The second layer is the weathered basement with average thickness of 11m and average resistivity of 51Ωm. The third layer is the fractured basement with an average of thickness of 6m and average resistivity of 563Ωm. The forth layer is the fresh basement which have average resistivity of 4277Ωm. The forth layer is the fresh basement which have average resistivity of 4277Ωm. The possible areas for groundwater development in the study area are VES 1 at Fadagwe Christian with thickness of 6m, VES 3 with thickness 15m, VES 6 with thickness 6m at Fadagwe Wanzam, VES 9 at Lokodisa with thickness 24m and VES 10 at Gileri thickness15m respectively. The research indicated that about 50% 0f the study area has good water potential.

Background to the Study

Locating a best and suitable point for productive borehole for groundwater exploration at Gwoza west in Gwoza Local Government area, Borno State, is very important, because water is an essential Commodity to mankind. It is found everywhere in the earth's ecosystem, however, the only naturally occurring inorganic liquid and is only Chemical compound that occurs in normal conditions as solid, liquid and gas. The area where water fills the space is called the saturated zone and the top of this zone is the water table Allele, (2017).

Despite effort by successive Government on the provision of portable water, a large number of Nigeria population, do not have access to portable water of adequate quality and quantity. Gwozawest in Gwoza local Government area is therefore not an exception as greater part of the population consisting mostly of Women and Children have to trek several kilometers in such of water. To cope with the need of an increasing population of the area and to ensure sustainable development, there is need for an elaborated groundwater supply policy. Prospecting for steady and reliable water supply from subsurface or groundwater will rescue the area from acute shortage of water. Based on the above reasons, the researcher decided to choose their area to conduct geophysical survey for good ground water potential zone, determine the thickness and depth to aquifer in the study area.

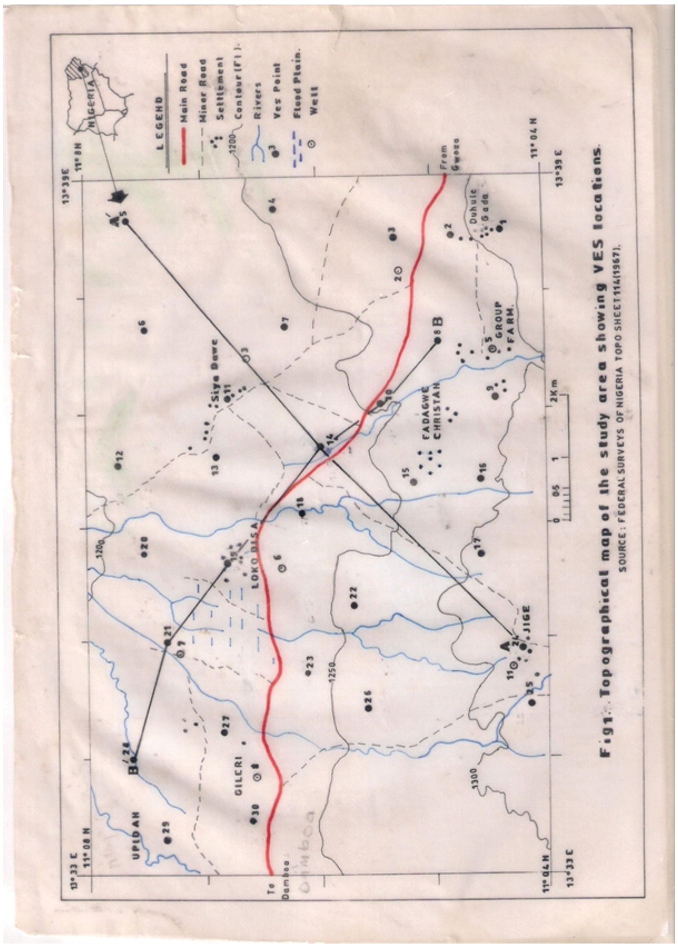
Groundwater is characterized by certain numbers of parameters which are determined by geophysical methods such as electrical resistivity methods, seismic methods, magnetic methods, gravity methods etc. But for the purpose of this research work, the application of electrical resistivity methods was employed for data acquisition with accuracy and precision. The depth sounding or vertical electrical sounding was used to delineate vertical variation and this method is known as Schlumberger configuration. Groundwater can be found almost everywhere, which may be deep or shallow and may rise and fall depending on many factors, such as heavy rain or melting snow may cause the water table to rise or extended period of dry season may cause the water table to fall.

Groundwater is stored in, and moves slowly through layers of soil, sand and rocks called aquifers. Aquifers typically consist of gravel, sand, sandstone or fractured rock. Aquifers are also known as underground reservoirs otherwise called underground flood and the water that reaches this chamber is usually much cleaner than the water or reservoirs at the earth surface. Aquifers could be confined or unconfined. Confined aquifers are sandwiched between rock layers that are either effectively impermeable or have very low permeability. However, a combination of the two can occur and that aquifer is called Leaky or semi confined aquifer.

Location and Geology of the Study Area

The study area is located along Damboa road in Gwoza Local Government area of Borno State which is about five kilometers away from the town. It is part of Gwoza Local Government area of Borno State of sheet 114 on scale of 1; 50,000. It lies between Longitude $13^0$33'E to $13^0$39' and Latitude $11^0$04'N to $11^0$08'N, (fig1).

Fig. 1



Geologically, the area is underlain by a series of metamorphic and igneous rocks believed to be pre-Cambrian age basement complex, (Islam and Baba, 2010). The area is underlain by older granites intruded into a Migmatites-gneiss quartzite complex considered as country rock. Nigeria and thus comprises of mandara hills which disappeared beneath the thick deposit of the Chad Basin, (Mohammed, *et al* 2021). The oldest member of the basement complex is believed to be older met sediments, which are now represented by migatite and granite-gneiss, (Carter *et al*, 1963). During the Proterozoic times, several sedimentation episodes took place. These rocks together with underlying met sediments were later folded at the advent of Pan-Africa Orogeny with the subsequent emplacement of the older granites occurring as Batholiths, bosses and stocks comprises the Mandara hills in Gwoza area and beyond, (Mohammed, *et al.*2021).

Gwoza area is underlain by rocks of the pre-Cambrian Basement complex of Northeastern Nigeria. The most abundant rock type in the Mandara hills is the medium coarse grained granite Myolonite occupies a narrow zone that trend generally N-S within the coarse grained granites, (Baba *et al*, 2010). Aplites are commonly found as dikes at the borders of Batholiths and as contemporaneous veins. Pegmatites which are widespread in the area occurs either as veins type or dyke like structure, and consist essentially of quartz and feldspars (Islam et al, 2010). Details of the geology of the Gwoza area can be found in (Carter, 1963); MC Curry, 1976. The cataclastic biotite granites and mylonites outcrop mainly in Liga, Limankara, Takaskala and Ngoshe Sama. These sheared rocks believed to have been emplaced synchronously with a faulting episode towards the closure of the Pan-Africa Orogeny (Okwong, ital. 2012).

The area has high intensity of rainfall thereby subjecting it to weathering conditions appropriate for the removal and subsequent deposition of the sediments which with time act as a sites for groundwater storage. In addition to the above, fault zones and joints, which are abundant in the study area contribute to the groundwater storage capacity of the rocks, thus acting as aquifers (Adamu, *et al* 2015).

Material and Methods

The electrical resistivity method of all the surface geophysical methods, has been applied widely in groundwater exploration studies (Todd, 1980), because it can clarify the subsurface structure, delineate groundwater zone, estimate the thickness of overburden and also the thickness of weathered/fractured zones with reasonable accuracy (Zohdyital., 1974). Based on this reasons, the electrical resistivity methods were employed for research work.

Schlumberger array, involving four electrodes spacing with two current electrodes widely spaced outside and two potential electrodes closely spaced within them along a line was used for this survey. The maximum current electrode spacing AB/2 =100m was used. A tetrameter SAS 300C was used to measure and record the resistance of the subsurface.

The resistance values obtained in the field was used to multiply with the geometric factor, which gives the required apparent resistivity values. The software IXID was used for the interpretation to obtain the geoelectric parameters. A global positioning system (GPS) was used to locate the coordinate of each VES point. Apparent resistivity values are plotted against the half- current spacing AB/2 on Log – Log scale.

Results and Discussion

A total of sixteen VES points were sounded at Fadagwe Christian, Fadagwe Wanzam, Lokodisa and Gileri areas of Gwoza west area of Borno State (figure 2). Four VES points were sounded in each of these locations. The first step in the interpretation of the resistivity sounding survey is to classify the observed apparent resistivity curves into types. This classification is primarily made on the basis of the shapes of the curves, but at the same time it is related to the geological situation in the subsurface. The shapes of a VES curve depend on the number of layers in the subsurface and thickness of each layer. The interpretation is classified into qualitative and quantitative interpretation.

Qualitative Interpretation

The qualitative interpretation of sounding data involves, the study of the type of curves obtained in the study area and classify the curves into types. The function of resistivity and thickness of layers as well as electrode configuration determines the form of curves obtained by sounding over horizontal stratified medium.

Based on the research conducted, the ground is composed of three to four layers of resistivity's $ƒ_1$,$ƒ_2$,$ƒ_3$ and $ƒ_4$ and thickness h_1, h_2, h_3 and h_4 respectively.

Thirteen of the curves obtained are H-type which have higher resistivity ($ƒ_1$) than $ƒ_2$ but $ƒ_3$ is higher than $ƒ_2$, ($ƒ_1 > ƒ_2 < ƒ_3$) for three layers model and ($ƒ_1 > ƒ_2 < ƒ_3 < ƒ_4$) for four layers model. That is the resistivity falls to minimum then increases again due to intermediate layer that is better conductor than the top and bottom layers, (figure 3). Two of the A-type curves with resistivity $ƒ_1 < ƒ_2 < ƒ_3$ for three layer curves and $ƒ_1 < ƒ_2 < ƒ_3 > ƒ_4$ for four layers curves which shows that apparent resistivity generally increases continuously with increasing electrode separation indicating that the true resistivity's increases with depth from layer to layer (figure 4). One of the KH-type of curves having resistivity $ƒ_1 < ƒ_2 > ƒ_3 < ƒ_4$ which indicates that the resistivity $ƒ_1$ is less than $ƒ_2$, and $ƒ_2$ is greater than $ƒ_3$ also $ƒ_4$ is greater than $ƒ_3$ (figure 5).

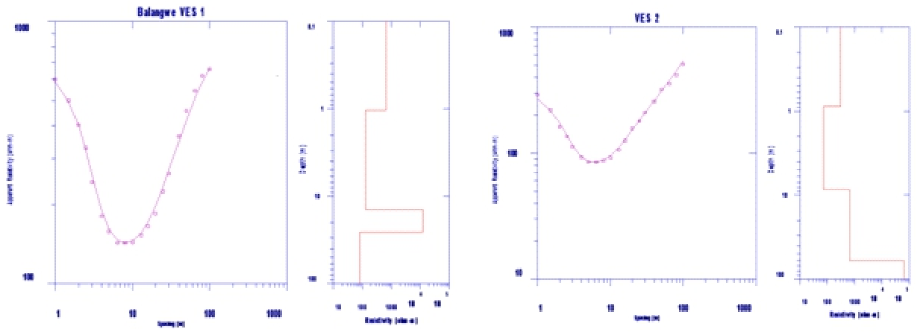


Fig. 1: Some of the H-type Curves.

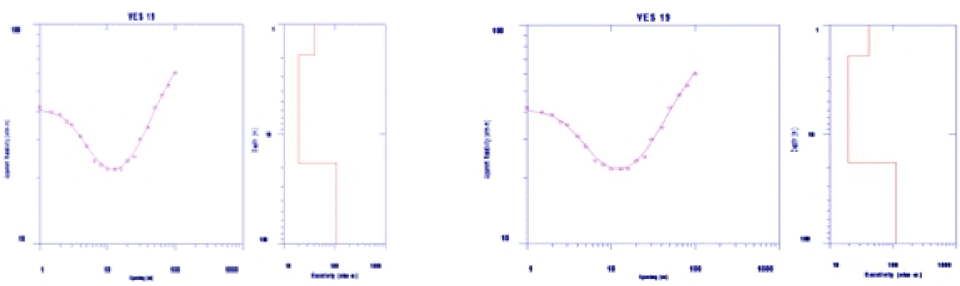


Fig. 2: H- type curves. Cont

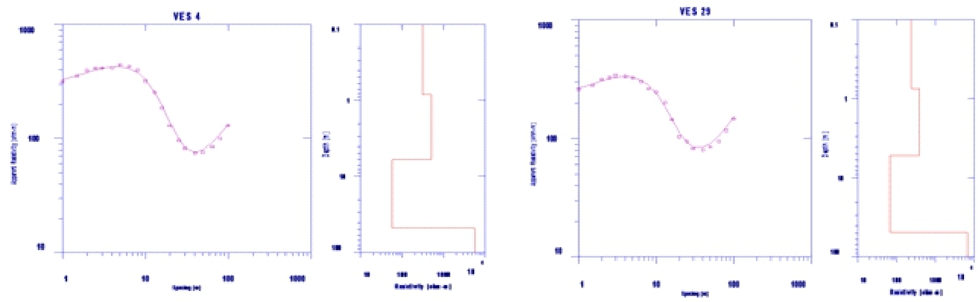


Fig 3: KH type of curves

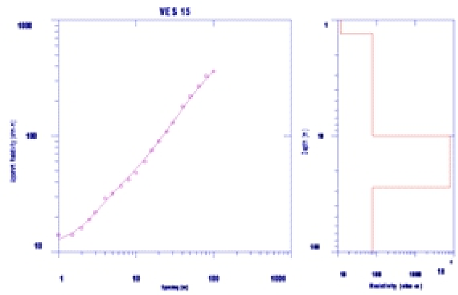


Fig. 4: A- type of curve

Quantitative Interpretation

The VES curves were also interpreted qualitatively though from a purely theoretical view point to delineate the subsurface succession of the geoelectric layers in the study area. By studying the curves type of H, A, and KH-types which was identified based on the use of IXID Computer Software (table 1).

Table 1: Summary of Results

S/No.	VES Locations & Curve types	Layers	Resistivity (Ohm-m)	Thickness (m)	Depth (m)	Lithology
1.	1	1	654	1	1	Top soil
	H	2	129	13	14	weathered base.
		3	86	11	26	Fractured base.
		4	1273	-	-	fresh basement
2.	2	1	313	1	1	Top soil
	H	2	73	8	9	W. basement
		3	648	52	61	Weathered base.
		4	64167	-	-	Fresh basement
3.	3	1	140	1	1	Top soil
	H	2	44	14	15	Weathered base.
		3	27	9	24	highly w. base.
		4	4347	-	-	Fresh basement
4	4	1	308	1	1	Top soil
	KH	2	511	5	6	Clayey soil (dry)
		3	58	42	48	Fractures base.
		4	5734	-	-	Fresh basement
5	6	1	20	1	1	Top soil
	H	2	17	7	8	Weathered base.
		3	69	37	45	highly w. base.
		4	6870	-	-	Fresh basement
6	7	1	553	1	1	Top soil
	H	2	89	3	4	Weathered base.
		3	48	42	46	Highly w. base.
		4	4725	-	-	Fresh basement
7	8	1	85	1	1	Top soil
	H	2	17	12	20	Weathered base.
		3	300	-	-	Fresh basement
8	9	1	1706	1	1	Top soil
	H	2	110	8	9	Weathered base.
		3	230	14	22	highly w. base.
		4	1095	-	-	Fresh basemen
9	11	1	199	1	1	Top soil
	H	2	18	2	8	Weathered base.
		3	268	22	31	highly w. base.
		4	53	-	-	Fresh weathered
10	12	1	73	1	1	Top soil
	H	2	16	21	22	Weathered base.
		3	1568	-	-	Fresh basement
11	13	1	108	1	1	Top soil
	H	2	14	6	7	Weathered base.
		3	29	45	52	highly Weathered
		4	79	-	-	Fresh basement
12	14	1	103	2	2	Top soil
	H	2	20	22	24	Weathered base.
		3	1951	-	-	Fresh basement
13	15	1	12	1	1	Top soil
	A	2	79	9	10	Weathered base.
		3	78	18	28	Weathered base.
		4	7841	-	-	Fresh basement
14	17	1	53	1	1	Top soil
	H	2	35	3	4	Weathered base.
		3	396	5	9	
		4	1901	-	-	Fresh basement
15	18	1	66	1	1	Top soil
	H	2	30	5	6	Weathered base..
		3	75	12	17	Weathered base.
		4	120	-	-	Fresh basement
16	29	1	246	1	1	Top soil
	KH	2	384	4	5	Weathered base.
		3	68	44	47	Fractures base.
		4	6767	-	-	Fresh basement

Conclusion

The information's gathered from the interpretations reveals that resistivity values obtained in most of the locations are favorable overburden thickness greater than 8 m shows the possibility for groundwater occurrence. Extreme high and infinite resistivity values may probably be indicative of fresh basement.

Based on the electrical resistivity conducted in the study area, groundwater potential zones have been delineated at a depth ranging between 9 m to 50 m. The study reveals that; about 50% of the study area has good groundwater potential recommended for borehole drilling. This research has provided information on the depth to the groundwater and the thickness of the aquifer unit in the study area. This information is going to be relevant to the development of an effective water scheme for the area and possible beyond other areas underlain by the formation.

It also helped in the identification and understanding of aquifer dimensions especially the thickness of weathered basement, depth to bedrock and fractured zones which required for locating points with high potential for groundwater occurrence. This work would reduce the occurrence of borehole failure or traditional method of obtaining groundwater. This work will also act as guide for future studies.

Recommendations

The electrical resistivity method has helped in the identification and better understanding of aquifer dimensions. Result from this study shows that electrical resistivity methods within its scope are suitable for estimating thickness of weathered basement and fractured zones. It is therefore suggested that geo-physical methods along other geological information should form an integral part of groundwater exploration programs. Hence, we recommend that a detailed pre-drilling geophysical investigation be carried out particularly in basement areas of Nigeria. This is because it will prevent the common occurrence of borehole failure and wastage.

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