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Electrical Investigation of Groundwater Characteristics and Capability of Tantalite Area of Ijero-Ekiti Town

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Abstract
Geoelectric measurements using the vertical Electrical Sounding(VES) method were carried out around Tantalite exploration field, ijero Local Government, Ekiti State, Nigeria, using the OHMEGA terrameter. The objectives of the study were to investigate the aquifer characteristics and groundwater potential of the subsurface formations. Ten profiles were carried out using the schlumberger array configuration. The data was interpreted using the conventional curve matching and computer iteration methods. Results showed that four major curve types were identified, namely: A, H, K and KH. The top layer has resistivity value ranging from 55.0 to 623.9 ohm-m showing that it consists of clayey sand and sandy clay, with maximum layer thickness of 1.3 m. The resistivity of the second layer which is the weathered zone ranges from 22.3 to 4161.5 ohm-m while the thickness vary between 1.6 to 11.9 m. VES station 8 is the only fourth layer region. The third layer VES 8 constitutes the weathered layer which has resistivity from 187.0 to 3542.7 ohm-m while its layer thickness is 5.7 m. VES stations 10, 9, 8, 7 and 4 are the locations recommended for deep sitting, because they have highest thickness of both weathered zone and fractured zone respectively which are good for groundwater storage
Keywords: Aquiferous Zones, Electrical Measurement, Fractured Zone, Groundwater Potential, Weathered Zone

I Introduction

Groundwater has greater quality than surface water. The average amount of water used domestically each day by every person is about 190 litres (Hamill and Bell, 1986). It can be recorded that surface water resources account for less than 2 percent of the world's fresh water. The fresh water available however is unevenly distributed while the sources that available have been contaminated or polluted. (Hamill and Bell, 1986). Groundwater accounts for about 98 percent of the world's fresh water and is fairly evenly distributed throughout the world. It provides a reasonable constant supply which is not completely susceptible to drying up under natural condition unlike surface water (World water balance and water resources of the earth UNECO Copyright 1978).
The ijero area and its environs are aquiferous zones. The yielding capacity of wells drilled within such rock is usually very great. Thus, a total of 10 VES soundings were made throughout the area Ijero environment South West of Nigeria. Water resources of the study area are threatened by increasing population trend which increases water demand and the stress of water use for various activities. Also, it's due to the increasing number of students in the school of health technology. The progressive population growth has led to several shortage of portable drinking water for the area which poses a great challenge to the people living in the environment.
Several scientists had used electrical resistivities to delineate different subsurface geoelectrical layers, aquifer unit and their characteristics, the subsurface structure and its influence on the general hydro geological condition. (Dan-Hassan and Olorunfemi, 1991; Olorunfemi and Okhue, 1992; Olayinka 1990; Ojo et al. 1990; Omosunyi, Ojo, and Olorunfemi 2007; Ojelabi et al 2002). They found out that electrical resistivity was a suitable method to determine the depth to bedrock and nature of superficial deposit and structural mapping and also, in the groundwater investigation and determination of structural trends.
The present investigation is aimed at producing the data which could serve as a basis for more detail groundwater exploitation activities in the environment. The results show a geophysical survey data containing basic information necessary for sitting better yield borehole for people of the area and serve as basis for more detail geophysical and geotechnical studies in the area as well as provide other geophysical parameters for carrying out geotechnical pursuit.
The interpretation of the field data was by the qualitative processes of plotting resistivity field curve to ensure data reliability. The observed field data are fed into the computer, while theoretical resistivity models are generated by means of appropriate computer program that yield a set of layer parameters, using a 9- point digital linear filter (Koefoed, 1979). Automatic iterative interpretation, following the main ideas of zohdy (1989) was employed in the final selection of layer parameters.

II MATERIALS AND METHODOLOGY

To perform a vertical sounding, measurements are taken by increasing electrode apertures, maintaining the sounding point(Osella et al 2002; Joshua et al 2011). Location fixing and topographical heightening of the sampling points was achieved by means of twelve channel global positioning system (GPS) set- the 'GARMIN GPS 12' (Alile, 2008). When the ratio of the distance between the current electrodes to that between the potential electrodes becomes too large, the potential electrodes must also be displaced outwards otherwise the potential difference becomes too small to be measured with sufficient accuracy (Koefoed, 1979). One of the major advantages this method has over other methods is that only the current electrodes need to be shifted to new position for most readings while potential electrodes are kept constant for up to three readings (Reinhard, 1974).

III Materials and Method

The basic equipment for this study is the OHMEGA Terrameter SAS 9(Signal Averaging System) 300B which displays apparent resistivity values digitally as computed from ohm's law. It is powered by a 12.5V DC power source. Other accessories to the terrameter includes the booster , four metal electrodes, cables for current and potential electrodes, hammers(3) , measuring tapes, walking phones (walkie -talkie) for very long spread.

IV Field Location

Ijero, a city in Sub-Sahara Africa and central Ekiti state with several settlements, is not only large in area but also fairly populated. With a population of 222,000 people as it was shown with 2007 population census, Ijero Ekiti is the second largest town in the whole of Ekiti state (EKSBIR, 2010). The study area within the south western part of the Nigerian Precambrian basement complex and within latitude $7^{o}42.061^{1}$N and longitude $5^{o}17.009^{'}$E (Figure 3.3). The plains are the most extensive landform system in the area, with the elevation ranging between 1218 and 1469m above sea level with an average elevation of 1343m above elevation that is the hydraulic gradient.

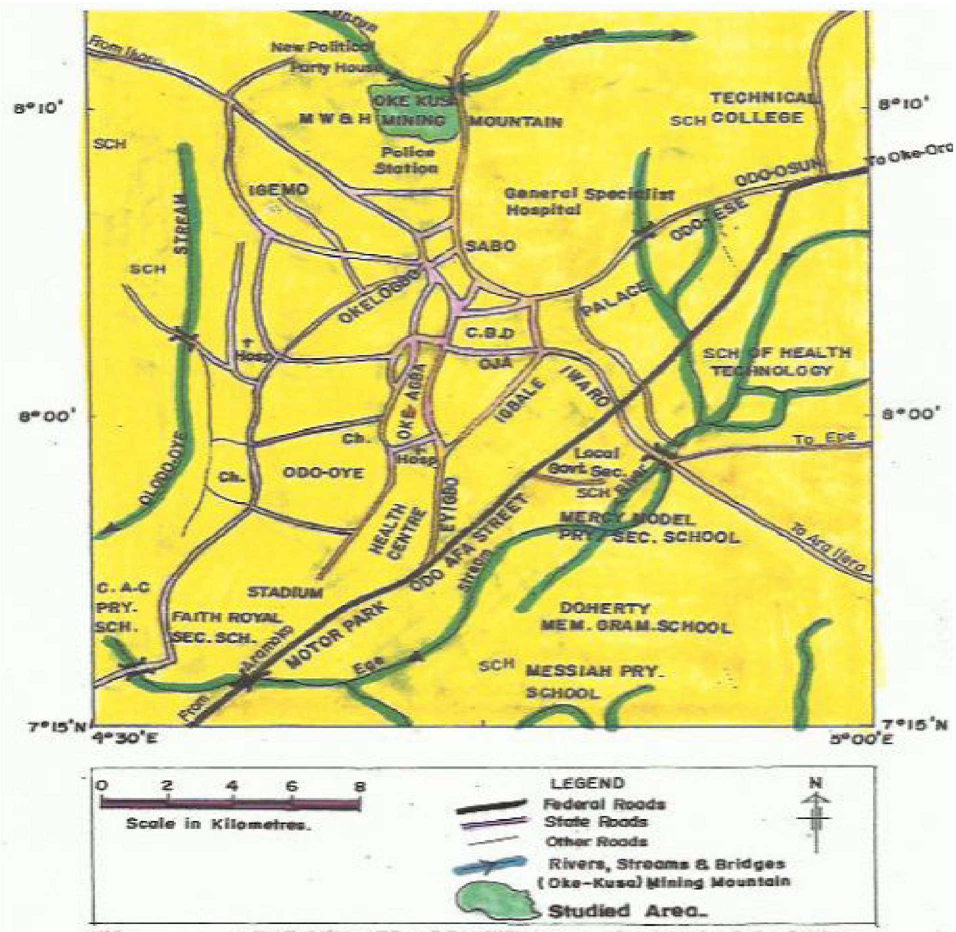

FIG. : THE STUDIED AREA WITHIN IJERO TOWNSHIP SHOWING VERTICAL ELECTRICAL SOUNDINGS LOCATION.

SOURCE : Local Government Secretariat, Ijero-Ekiti, Ekiti State / Dept. of Geography & Planning Science, Carto. Unit, Ekiti State Uni. EKSU, Ado-Ekiti.

V Results

Table 4 showed that VES 1,3, 10 are type k , VES 2, 6, 9 are type A, VES 4 ,5 ,7 are H type and VES 8 is type KH since $\rho_1<\rho_2>\rho_3<\rho_4$. The apparent resistivity curve shows that the curves A, K, H are dominant over the entire area except in VES 8. The dominance of the curve shows that a homogenous subsurface succession and in most sounding curve the same layer were found.

Table 1: The position latitude, longitude and elevation of the studied area

S/N	VES Stations	Position latitude	Position longitude	Elevation (ft)
1	VES 01	$07^0 49.244^1$N	$005^0 03.916^1$E	1715ft
2	VES 02	$07^O 49.291^1$N	$005^0 03.906^1$E	1701ft
3	VES 03	$07^0 49.254^1$N	$005^0 03.890^1$E	1543ft
4	VES 04	$07^0 48.510^1$N	$005^0 04.370^1$E	1547ft
5	VES 05	$07^0 48.509^1$N	$005^0 04.350^1$E	1543ft
6	VES 06	$07^0 48.508^1$N	$005^0 04.320^1$E	1540ft
7	VES 07	$07^0 49.844^1$N	$005^0 03.389^1$E	1840ft
8	VES 08	$07^0 49.820^1$N	$005^0 03.399^1$E	1806ft
9	VES 09	$07^0 49.796^1$N	$005^0 03.411^1$E	1806ft
10	VES 10	$07^0 49.186^1$N	$005^0 04.009^1$E	1698ft

Table 2a: Apparent Resistivity values for VES 1 to 5

		APPARENT RESISTIVITY (ohm-m)				
CURRENT ELECTRODE [AB/2] (km)	POTENTIAL ELECTRODE [MN/2] (km)	VES1`	VES 2	VES 3	VES 4	VES 5
1.0	0.5	528.64	239.54	389.16	568.78	141.84
1.3	0.5	634.16	352.56	419.46	344.88	121.59
1.8	0.5	765.29	451.66	525.84	324.89	116.44
2.4	0.5	924.35	522.76	611.04	239.74	132.58
3.2	0.5	1189.30	601.87	784.50	225.94	167.883
3.2	1.0	1443.75	597.81	751.62	211.56	162.802
4.2	1.0	1814.37	908.39	914.90	213.92	210.49
5.5	1.0	1847.19	835.83	1010.90	219.64	261.92
7.5	1.0	2169.75	928.69	992.00	256.898	348.03
10	1.0	2523.93	1003.04	1010.58	312.58	424.54
13	1.0	2348.62	1126.81	1121.53	362.85	514.85
13	2.0	2011.24	993.96	1187.04	412.10	530.02
18	2.0	1915.14	1133.50	1171.20	580.57	655.97
24	2.0	1684.69	1141.10	1118.63	673.88	677.02
32	2.0	1471.64	1225.70	1042.24	849.18	790.70
42	2.0				923.38	1004.93
55	2.0				996.53	1207.70
75	2.0				1044.1	1422.90
100	2.0				1756.2	1474.40

Table 2b: Apparent Resistivity values for VES 5 to 10

		APPARENT RESISTIVITY (ohm-m)				
CURRENT ELECTRODE [AB/2] (km)	POTENTIAL ELECTRODE [MN/2] (km)	VES 6	VES 7	VES 8	VES 9	VES 10
1.0	0.5	58.52	179.17	128.84	123.43	199.56
1.3	0.5	74.13	184.82	134.61	131.40	173.39
1.8	0.5	96.81	174.37	157.38	140.38	128.92
2.4	0.5	118.40	146.88	186.60	144.24	78.73
3.2	0.5	143.09	116.51	219.97	143.34	52.34
3.2	1.0	145.83	130.59	234.34	156.71	57.27
4.2	1.0	171.14	112.59	265.95	146.97	46.00
5.5	1.0	213.67	105.18	281.44	149.11	40.58
7.5	1.0	252.56	115.60	290.49	170.37	24.19
10	1.0	299.82	142.56	311.64	207.14	44.93
13	1.0	363.90	164.85	324.85	252.65	62.81
13	2.0	369.33	163.41	329.55	216.48	66.86
18	2.0	447.87	211.22	350.10	316.93	107.90
24	2.0	472.16	252.75	377.55	403.61	163.18
32	2.0	523.13	296.65	440.93	532.26	180.09
42	2.0	610.98	348.75	586.37	752.39	244.67
55	2.0	740.28	439.18	789.39	883.59	
75	2.0	909.432	597.31	1023.81	1181.38	
100	2.0	1149.36	621.11	1293.82	1589.01	

Table 3: Summary of Layer Thickness of Resistivity

Stations	Layer	Resistivity(ohm-m)	Thickness(m)	Depth(m)	RMS-Error
1	1	432.4	0.8	0.8	3.9
	2	4161.5	5.0	5.8	
	3	1072.1	---	----	
2	1	228.2	0.7	0.7	2.9
	2	1290.7	---	---	
3	1	286.1	0.7	0.7	2.3
	2	1435.3	4.9	5.6	
	3	931.2	---	---	
4	1	623.9	0.7	0.7	3.5
	2	155.3	3.6	4.3	
	3	1549.7	----	---	
5	1	136.2	0.6	0.6	3.3
	2	104.8	1.6	2.1	
	3	1722.1	---	----	
6	1	55.0	1.0	1.0	3.0
	2	509.9	11.9	6.9	
	3	1369.0	----	---	
7	1	194.8	1.3	1.3	3.0
	2	81.7	5.6	6.9	
	3	1187.4	----	---	
8	1	101.2	0.8	0.8	2,8
	2	360.9	6.0	6.8	
	3	187.0	5.7	12.5	
	4	2549.3	---	---	
9	1	130.5	1.0	1.0	2.7
	2	144.4	6.0	7.0	
	3	3542.7	----	---	
10	1	220.1	1.0	1.0	5.9
	2	22.3	3.7	4.7	
	3	1769.6	---	---	

Table 4: Classification of VES curves

Town	Location	VES Number	Curve Type
Ijero-Ekiti	Ijero	1	K
	Close to	2	A
	School of	3	K
	Health	4	H
	Technology,	5	H
	Ijero	6	A
	Local	7	H
	Government	8	KH
	Ikoro- ijero Road	9	A
	Ijero	10	K

Table 5. The distribution of layer thickness / depth of bedrock weathered layer thickness

VES Stations	Thickness of 1st Layer (m)	Thickness of 2nd Layer (m)	Thickness of 3rd Layer (m)	Depth of Bedrock(m) Overburden Thickness	Thicknessof Weathered Layer (m)	Resistivity of Weathered Layer (ohm-m)
1	0.8	5.0	-	5.8	5.0	4161.5
2	0.7	-	-	0.7	0.7	228.2
3	0.7	4.9	-	5.6	4.9	1435.3
4	0.7	3.6	-	4.3	3.6	155.3
5	0.6	1.6	-	2.1	1.6	104.8
6	1.0	11.9	-	12.8	11.9	509.9
7	1.3	5.6	-	6.9	5.6	81.7
8	0.8	6.0	5.7	12.5	5.7	187.0
9	1.0	6.0	-	7.0	6.0	144.4
10	1.0	3.7	-	4.7	3.7	22.3

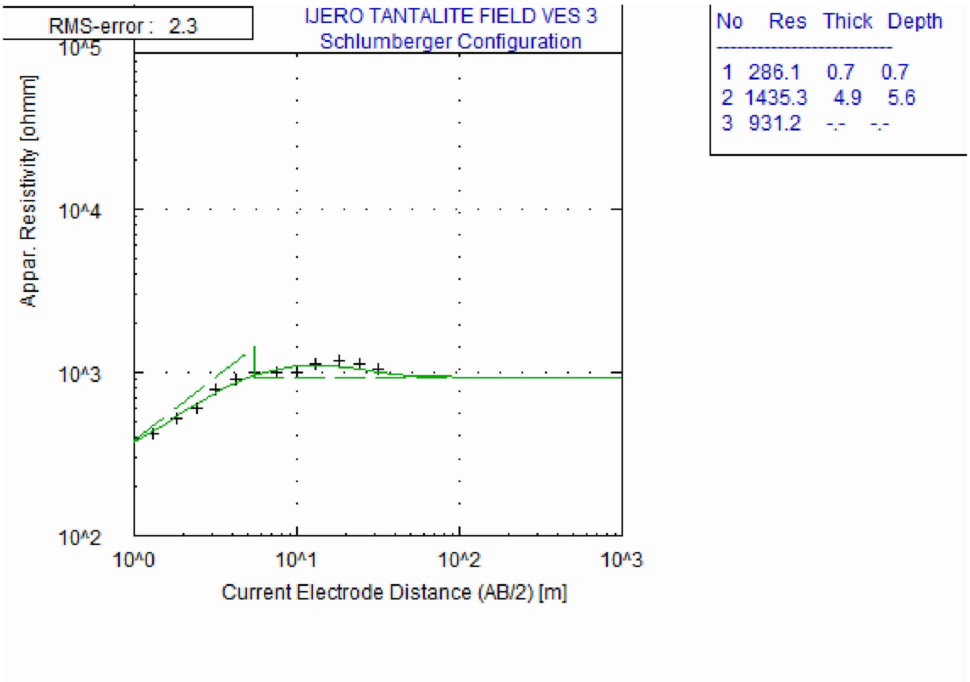

Figure1: The typical K-type curve

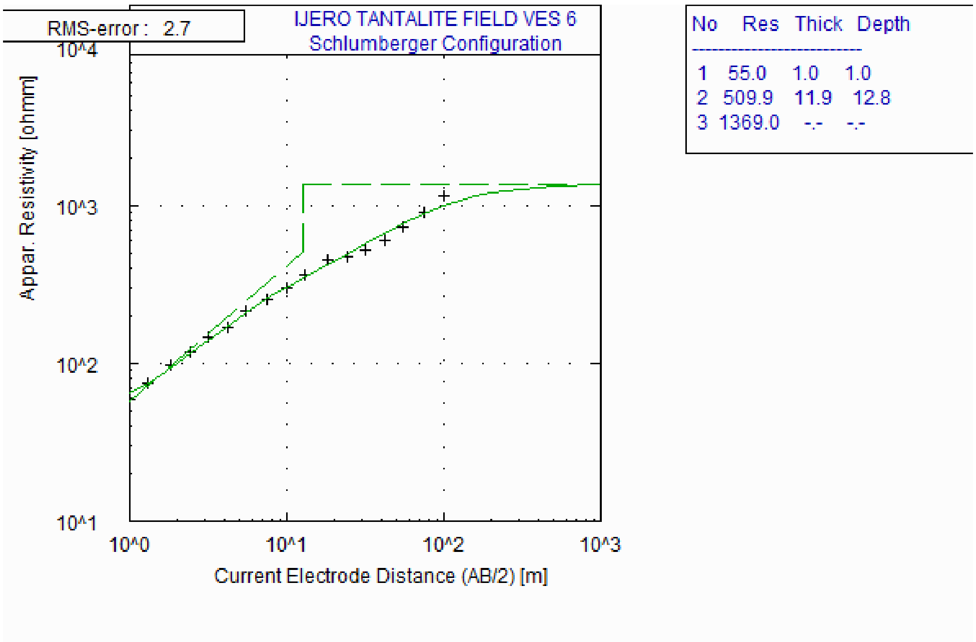

Figure 2: The typical A-type curve

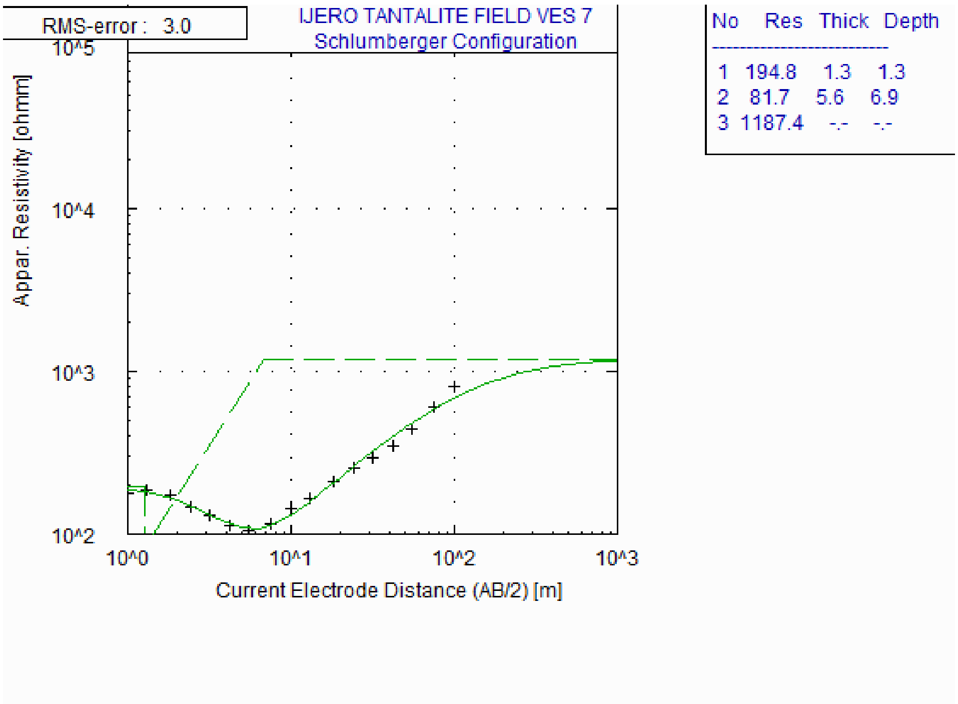

Figure 3: The typical H-type curve

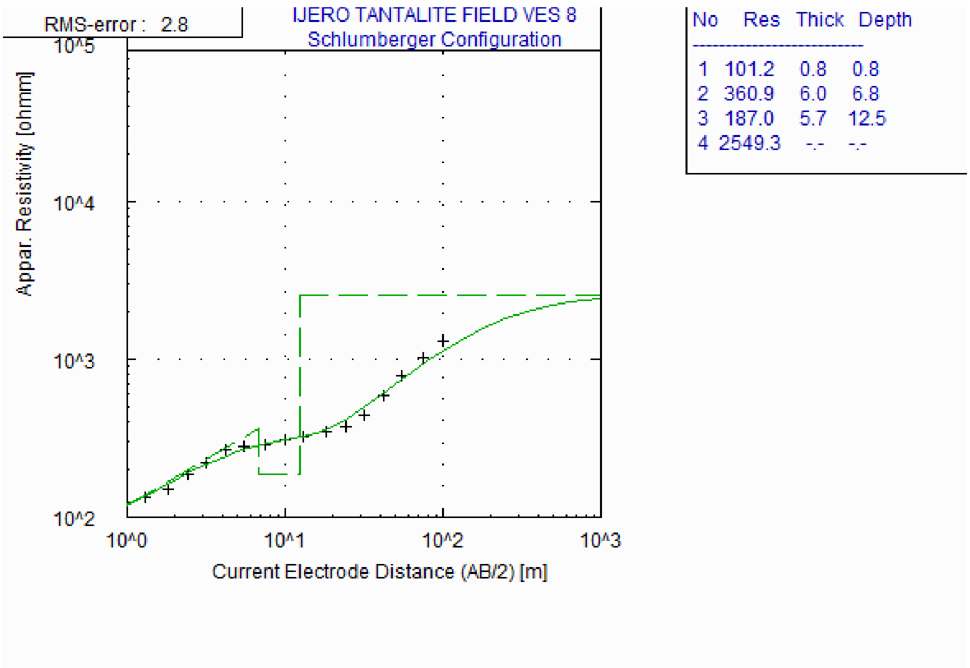

Figure 4: The typical KH-type curve

VI Overburden Layer

The thickness of the overburden is an important hydrogeologic consideration in groundwater development in the basement terrain. The reason for this is that water gets into the saturated zone through the overburden, the thickness of the overburden ranges from 0.7m to 12.8m in the studied area. The degree of decomposition caused the variation in the overburden thickness.

VII Weathered Layer

The weathered zone thickness shows the thickness of the weathered layer beneath with VES 6 having the highest thickness of about 11.9m and VES 2 having the lowest thickness of about 0.7m. Thus the thickness of weathered layer of this study area is high enough for ground water accumulation and therefore recommended for sinking borehole.

VIII Conclusion

The result of a quantitative interpretation of the VES data obtained in a geophysical survey over a part of ijero Local Government Area, Near School of Health Technology, ijero, Ekiti state. The interpreted result obtained from the study area shows the sequence and relationships between the subsurface lithologies. The layers with the lowest resistivity have been identified as the aquiferous zone. VES 2, 4, 5, 7, 8, 9 and 10 are the locations that are recommended for groundwater because they have lowest resistivity compared with the rest which is good for ground water storage.

VES 10 is highly recommended as priority location for sitting a borehole because it has the lowest resistivity of weathered layer and its overburden thickness which is good for subsurface water accommodation. The location will be good for maximum groundwater development.

IX Recommendation

The present study investigated the geo-electrical attributes of a basement complex terrain in Ijero with a scientific bias for low lying areas and a groundwater potential evaluation to be made. There is a need to understand the structural setting in order to know the groundwater flow pattern. Although, it is appreciated that locations with thick overburden and high weathering depth offer bright potential for groundwater occurrence. Also , geochemical study of the groundwater of the environment is recommended due to the heavy presence of Tantalite. Therefore to ascertain that the water is safe for drinking further treatment is needed.

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