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Evaluation of ground water resource in Akamkpa area, Cross river state, Nigeria

Theophilus O. Arong, Avwenagha E. Oghenero

Department of Geology, University of Port Harcourt, East-West Road, Choba, Port Harcourt, Rivers State, Nigeria

ABSTRACT

A combined analysis of lineament length and density from radar imagery and surface resistivity data were used to assess the hydrogeologic conditions in Akamkpa Area, Cross River State. Twenty vertical electrical soundings (VES) were carried out in the area using maximum current electrode spacing of 600m (AB/2=300M), employing schlumberger electrode configuration. The data were interpreted using conventional partial curve-matching method to obtained initial parameters, which were used in a computer programme (REX 2 DINV) to obtain final parameters. The interpretation showed a geological setting with three to six Geoelectric layers occurring more in the area. The first layer has apparent resistivity range of 53.2Ωm-4492.4Ωm, the second layer has apparent resistivity range between 63.3Ωm-8389.9Ωm. The third layer has apparent resistivity values of 406.0Ωm-3623.0Ωm, the fourth layer has apparent resistivity values between 42.5Ωm-6969.0Ωm, and the fifth layer has resistivity range of 75.0Ωm-34999.0Ωm. The result shows that the second, third, and fourth Geoelectric layers constitute the aquiferous unit depending on location in the area. Correlation of the sounding curves with Lithologic data from nearby borehole showed that the major Lithologic units penetrates weathered laterite, shallow saturated layer of weathered basement, and a fresh basement. Interpretations of radar imagery were done by identifying the lineaments, their number, total length, and total area. This revealed that the area is intensely fractured. The fractures trending in the N-S, NE-SW, and NW-SE directions. The total lineament length of the area is calculated to be 3010.10Km with the frequency of the lineament decreasing in the southwest direction.

Key words: Groundwater, Akamkpa, Lineament, Resistivity, Resource, Isoresistivity.

INTRODUCTION

Akamkpa area is part of Oban Massif basement complex, southern Nigeria. The inhabitants of this area reside in scattered hamlets, villages, and small towns. There are mostly farmers; water demand in the area is mainly for domestic and agricultural uses. Majority of the people depend on shallow dug wells and streams which are mostly seasonal. The streams are also generally remote, polluted, and hazardous. Most of the natural resources in the Cross River State occur in Akamkpa Local Government Area. Presently, there exist oil palm and rubber plantations, quarries, and holiday resorts. There is also a game reserve manage by the World Wildlife Fund (WWF) and funded by the United Nation in the area. These existing facilities and the need to provide portable water to rural dwellers, therefore, form important factors for the development of water resources within the area. The works aims at using geophysics and radar imageries in Akamkpa to delineate aquiferous zones so that productive boreholes can be drilled in the area.

LOCATION OF STUDY AREA

The study area is Akamkpa Local Government Area, is located roughly between longitudes $8^0 12^1$E to $9^0 00^1$E and latitudes $5^0 00^1$N to $5^0 48^1$N in Cross River State, Nigeria (Fig 1).

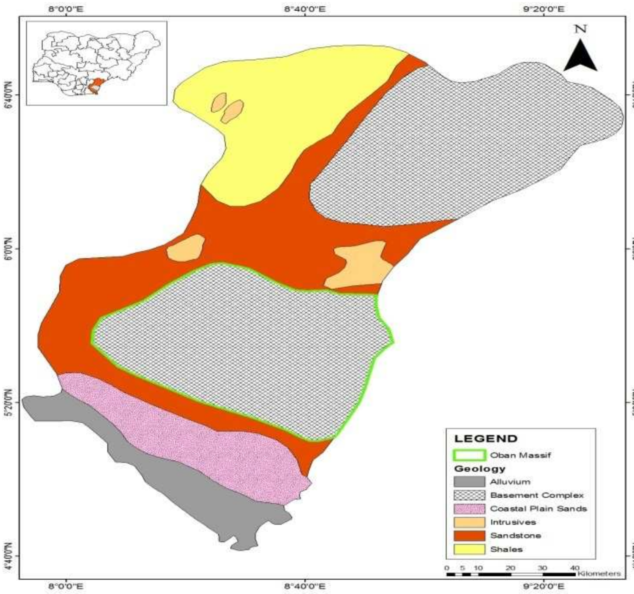


Fig 1: Geologic map of cross river state showing study area

GEOLOGY OFE STUDY AREA

Akamkpa Local Government Area is part of the Precambrian Oban Massif, which is overlaid by cretaceous-Tertiary sediments of Calabar Flank. The metamorphic rock units in this area are: phylites, schists, gneisses, and amphibolites. These rocks are intruded by pegmatites, granites, granodiorites, diorites, tonalites, Monzonites, and dolerites (Ekwueme, 1990). Associated with the rocks are charnokites which occur as enclaves in gneisses and granodiorites (Fig2)

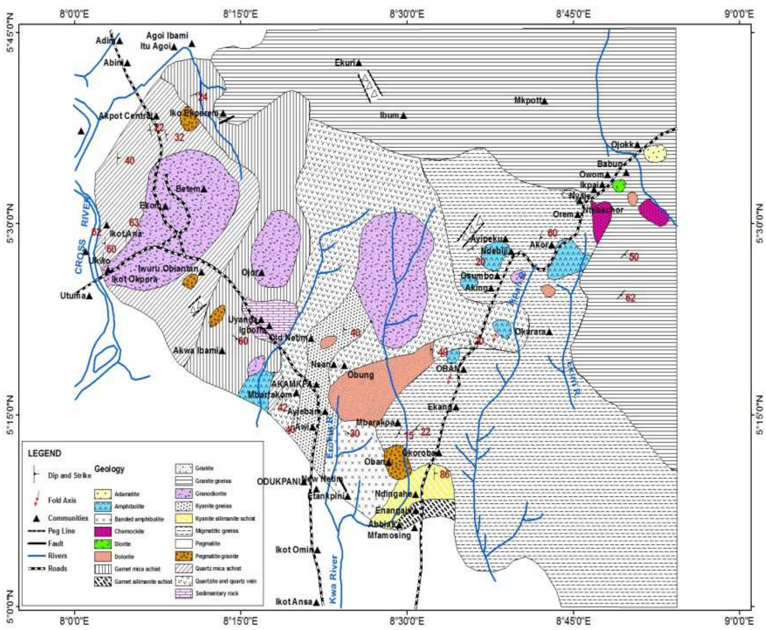


Fig 2: Geologic map of Oban Massif

These rocks record three phase of tectonothermal events which have affected the Nigerian basement with the most resent being the Pan-African Orogeny dating about 600±150 Ma ago. The main results of the deformation include fractures, faults, folds, and dykes trending N-S, NE-SW, and NW-SE directions. Similar trends characterised major lineaments revealed by remote sensing and aeromagnetic interpretation (Fig.3).

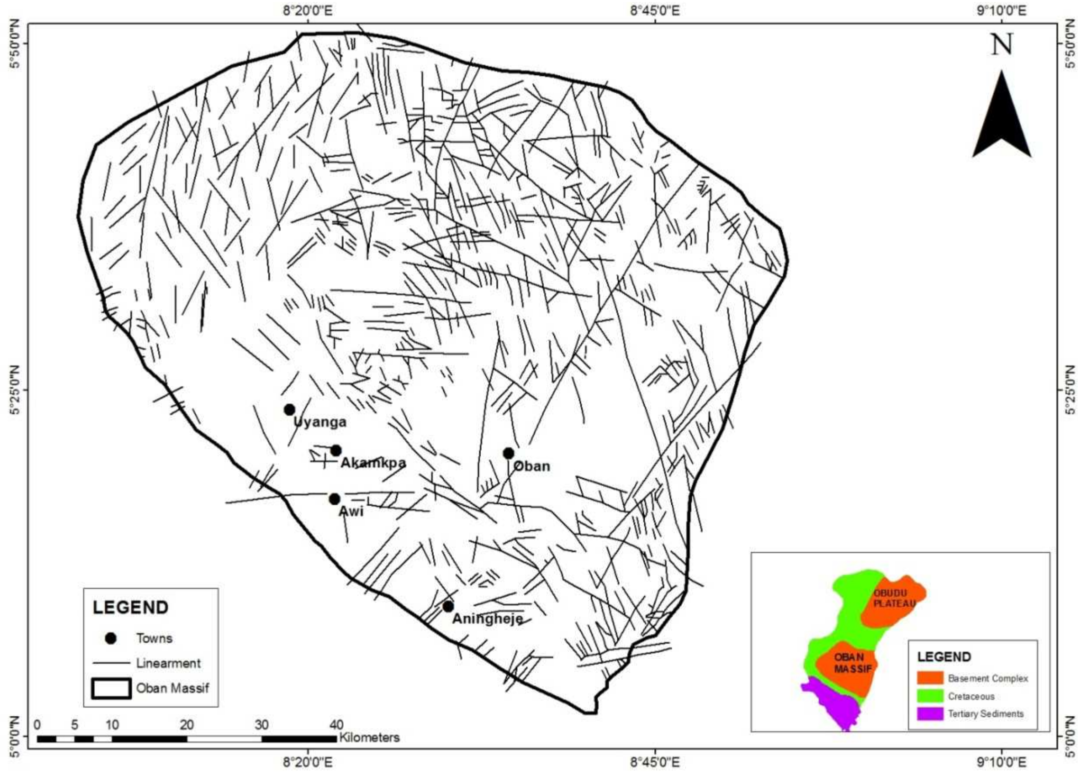


Fig 3: Lineament map of Oban Massif

MATERIALS AND METHODS

Vertical electric sounding (VES) was carried out in the study area. The survey was conducted using schlumberger electrode configuration (Fig.4) with current electrode spacing ranging from 1-600M (AB/2, 0.5-300M). This was sufficient to delineate the major rock boundaries to the fresh rocks. The distance between potential electrodes was increased at intervals of 0.25-10.00M in order to maintain a measurable potential difference across the current electrodes.

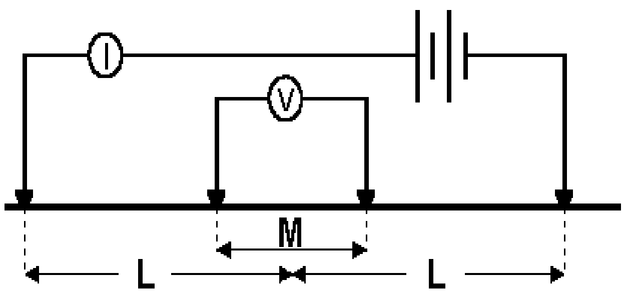


Fig.4 schematic illustration of schlumberger electrode configuration
M=potential electrode separation, L=current electrode spacing.

Geotrone-SSR-MP-ATS resistivity metre and the complete accessories were used for data acquisition. Also the Global Positioning System (GPS) Garmin 72H was used to take the coordinates and elevations of sounding locations as shown in table 1.

Table1: coordinates/elevations of sounding locations in the study area

LOCATION NAME	S/NO	LATITUDE	LONGITUDE	ELEVA-TION(m)
Oban Sec. Sch. Oban	1	O5°18'868"	008°34'827"	132·87
Aningheje	2	05°08'275"	008°30'831"	77·87
Abiatti	3	05°06'302"	008°30'993"	98·18
Mfamosing	4	05°06'650"	008°31'542"	97·54
COE-Akamkpa	5	05°15'436"	008°21'178"	98·06
Prim.Sch.Mbarakom	6	05°16'044"	008°20'136"	137·87
Uyangha Model Sch.	7	05°22'866"	008°15'373"	96·78
Akwa Ibami	8	05°20'759"	008°14'860"	113·96
Igofia Camp	9	05°21'165"	008°17'679"	93·69
Okomita	10	05°19'837"	008°19'837"	109·24
GSS-Akamkpa	11	05°18'736"	008°20'875"	111·03
A Prim.Sch,Akamkpa	12	05°18'419"	008°21'469"	124·96
Ojor 1	13	05°25'080"	008°16'290"	119·00
Ojor 2	14	05°25'040"	008°16'280"	120·00
Old Netim	15	05°21'145"	008°21'809"	116·70
New Ekuri	16	05°43'365"	008°23'370"	204·00
Obung	17	05°21'016"	008°23'463"	164.00
Orem	18	05°30'321"	008°45'205"	170.00
Old Ndebije	19	04°57'321"	008°21'199"	143.00
New Ndebije	20	04°57'421"	008°21'208"	163.00

The resistivity metre was capable of measuring current and potential difference and displaying their ratio as the measured resistance. A total of 20 stations were sounded as shown in the station location map (Fig.5).

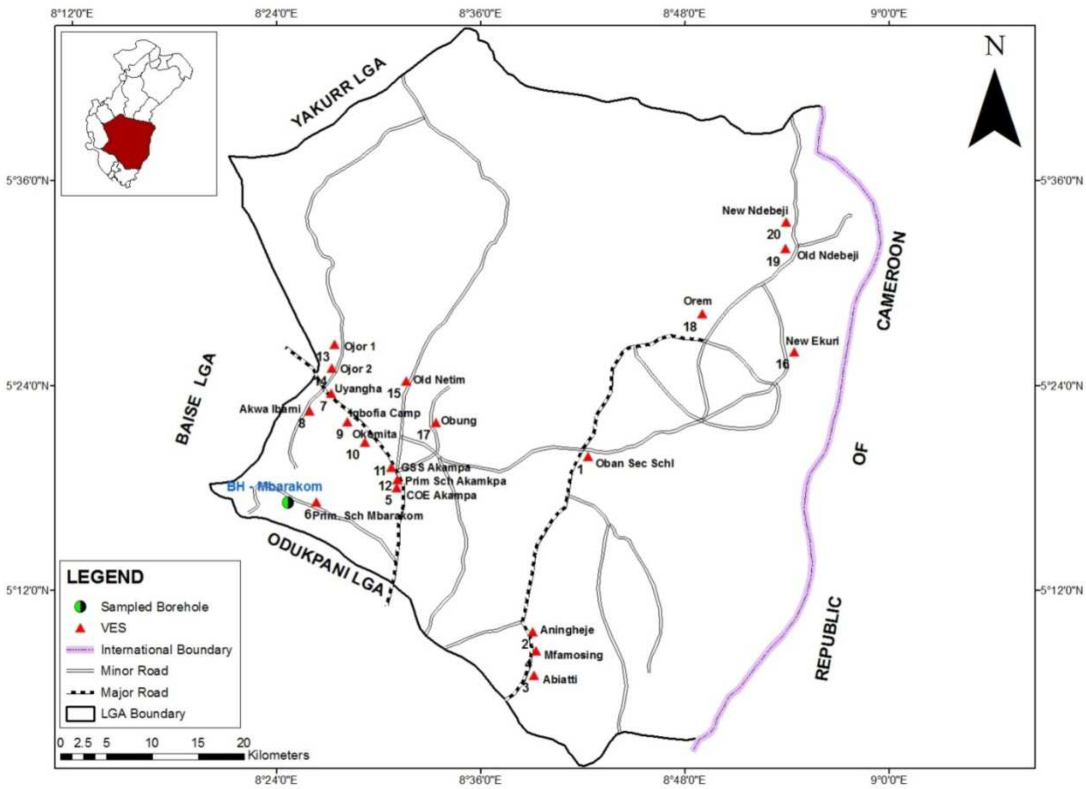


Fig. 5: Station location map of study area

COMPUTATION OF APPARENT RESISTIVITY: Resistivity data are generally interpreted using the modelling process. The field data were multiplied by the geometric factor (K) to compute the apparent resistivity values. The apparent resistivity values were plotted against half the current electrode spacing (AB/2) on bi-log graphs. Quantitative analysis of the field curves was made by partial curve matching of the field curves with relevant schlumberger master curves and auxiliary point diagram was drawn according to Zohdy (1965), Zohdy et al (1994). The resistivity values and thicknesses obtained were fed into computer inversion software REX2 DINV as initial model parameters to obtain optimized results, and the curves shown in (Fig. 6a-6h) were produced. The results of the interpretation were checked against the Lithologic log of a well drilled close to a VES site (Mbarakom) and the agreement was good. DETERMINATION OF LINEAMENT DENSITY: Lineament identification was carried out by the interpretation of radar imagery covering Oban Massif on a scale of 1:100,000. A total of 961 lineament were identified. This include 2000.50km in basement area and 1009.60km stradding the basement sediment contacts. Most of the lineaments derived from the radar images had lengths ranging from 1-5km. On the basis of this interpretation a lineament length density map of the area Was produced (Fig 7). Lineament length density was dertermine using the equarion; $LD = \sum_{i=1}^{n} L/_A$

Where LD= Lineament length density (km^{-1}),L= Total length of all lineaments, and A=Area being considered (km^2)

RESULTS

After analysis of raw field data generated from vertical electric sounding (VES) and data generated from radar imagery, the results are presented as follows;

APPARENT RESISTIVITY DATA: Apparent resistivity data for the twenty (20) sounding stations were computed and their results presented in table 2a-2d

Table 2a: Apparent Resistivity data for VES 1-3 in study area

VES STATION	AB/2(m)	MN/2(m)	VES1 ρ_a (Ω-m)	VES2 ρ_a (Ω-m)	VES3 ρ_a (Ω-m)
1	1·0	0·25	4698·293	2896·006	3993·690
2	1·5	0·25	5934·553	2327·212	4118·592
3	2·0	0·25	6291·703	1776·985	4459·434
4	3·0	0·25	5156·133	1502·931	9264·827
5	4·0	0·50	4622·842	1164·927	4576·746
6	4·0	0·25	5046·965	1324·171	4775·276
7	5·0	0·50	4992·895	1081·074	3745·847
8	6·0	0·50	5123·020	1042·579	4326·933
9	8·0	0·50	4235·060	1103·480	3533·700
10	10·0	1·00	3942·878	1128·927	2799·537
11	10·0	0·50	4354·589	1173·746	2796·222
12	15·0	1·00	4098·254	1197·770	4554·651
13	200	1·00	4085·695	1210·110	2958·416
14	300	1·00	4217·258	1059·211	1936·015
15	400	2·50	3536·934	1470·336	652·629
16	400	1·00	4045·067	1054·260	697·775
17	500	2·50	3640·763	1498·742	580·823
18	6000	2·50	3102·993	1915·659	616·191
19	80·0	2·50	2719·919	2222·874	625·414
20	100·0	10·00	2394·683	1916·104	797·590
21	100·0	2·50	3375·697	3005·601	586·288
22	150·0	10·00	4193·619	1531·145	1238·082
23	200·0	—	—	—	—
24	250·0	—	—	—	—

Table 2b: Apparent Resistivity data for VES 4-9 in study area

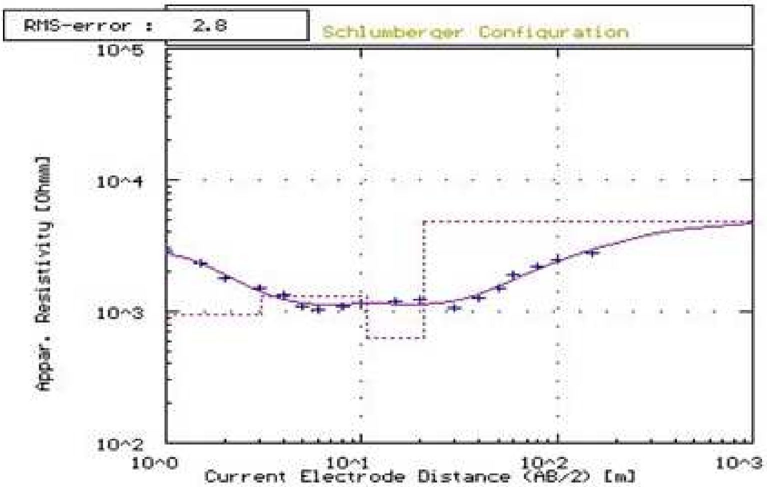
VES4 ρ_a(Ω-m)	VES5 ρ_a (Ω-m)	VES6 ρ_a (Ω-m)	VES7 ρ_a (Ω-m)	VES8 ρ_a (Ω-m)	VES9 ρ_a (Ω-m)
352·381	3035·122	858·579	909·781	1029·754	696·410
406·702	2903·078	967·257	870·043	727·816	574·721
432·403	2724·195	878·116	898·977	629·474	516·365
467·173	2440·208	795·495	946·559	4469·652	509·922
516·487	2116·192	690·890	1127·134	650·382	567·378
508·100	2149·819	765·892	1036·482	575·512	587·358
526·852	1960·010	691·093	1244·758	759·091	633·283
528·986	1808·692	736·202	1334·233	875·648	709·902
554·204	1703·198	658·338	1547·167	920·128	799·584
596·976	1784·955	791·863	1669·505	1052·809	838·197
585·108	1857·367	768·929	1676·649	994·230	846·426
623·904	1263·222	807·677	1767·467	1227·279	784·219
712·552	1723·644	798·186	1909·963	1138·968	743·965
806·182	1830·238	917·689	1973·589	938·154	665·560
919·066	1791·991	902·180	2349·562	931·594	663·009
807·154	1622·645	893·629	2274·819	894·684	578·168
807·264	1258·466	921·343	2522·230	1009·945	649·064
741·719	1258·962	551·479	2303·205	944·831	704·570

632·609	1541·601	981·154	1672·944	767·084	841·976
582·179	2410·656	1103·540	1428·720	1292·741	815·765
563·809	2114·876	1088·775	1757·728	1288·984	788·462
566·878	3760·059	1460·859	1957·747	1066·445	5593·86

Table 2c: Apparent resistivity data for VES 10-15 in study area

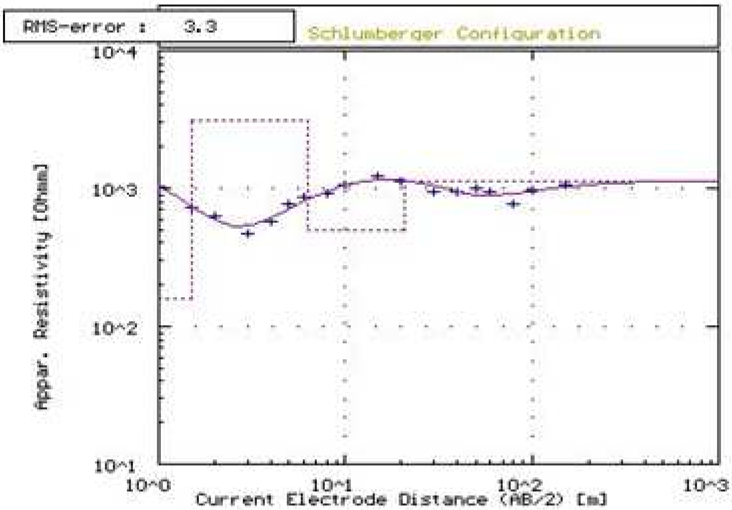
VES10 ρ_a(Ω-m)	VES11 ρ_a(Ω-m)	VES12 ρ_a(Ω-m)	VES13 ρ_a(Ω-m)	VES14 ρ_a(Ω-m)	VES15 ρ_a(Ω-m)
1532·813	232·964	389·977	1738·963	933·447	560·000
1466·685	262·380	365·206	1956·212	1162·260	850·000
1404·940	292·901	346·763	2336·445	1043·582	1221·000
1443·064	342·556	312·030	2801·036	1257·197	1468·000
1624·439	380·445	288·841	2721·900	1154·651	187·073
1483·191	356·731	332·424	2784·170	1381·368	—
1667·765	520·554	302·899	2706·903	1233·040	2007·860
1796·886	556·155	331·980	2711·389	1235·068	2240·240
2041·617	515·942	341·588	2799·676	1385·875	2306·230
2187·684	632·330	426·083	2703·111	1610·668	2415·510
2301·748	476·273	395·413	3059·383	1469·610	—
2855·506	739·077	349·602	2825·651	1979·472	2611·660
3086·316	762·745	279·584	2827·065	2412·794	3102·410
3707·115	746·035	297·794	3410·918	2821·129	3707·410
3818·367	878·434	363·087	3537·733	2392·306	3948·770
4467·796	646·521	362·963	3513·325	2850·149	—
5028·508	1131·173	367·618	3817·382	2572·188	4361·50
5262·810	944·312	300·938	4122·770	2628·898	4441·000
6061·418	1102·130	472·456	4622·513	2655·504	4572·40
5871·313	887·432	180·849	4125·016	3154·439	5328·040
6624·783	520·806	610·108	4293·789	2728·941	5328·040
3783·495	1486·935	720·910	4869·047	4568·769	—
VES16 ρ_a(Ω-m)	**VES17 ρ_a(Ω-m)**	**VES18 ρ_a(Ω-m)**	**VES19 ρ_a(Ω-m)**	**VES20 ρ_a(Ω-m)**	
2605·081	1309·690	606·775	171·406	824·321	
3142·365	1546·536	674·114	176·845	650·181	
3165·701	1457·650	707·911	174·276	475·540	
3328·481	1380·729	756·007	156·547	490·069	
2952·513	1507·859	724·482	129·403	465·329	
—	1297·650	766·011	142·973	459·370	
2302·926	1440·237	702·120	140·467	508·690	
1864·081	1506·231	673·325	138·933	488·856	
1656·964	1315·511	773·948	199·845	600·615	
1325·527	1419·470	730·193	241·959	615·470	
—	1611·656	673·737	243·049	653·168	
978·374	1902·407	672·981	325·416	790·562	
775·450	2197·405	566·741	507·399	824·436	
740·000	2148·774	499·724	823·599	942·023	
744·385	2061·533	456·940	1229·397	120·3317	
—	1972·772	502·029	1209·115	1093·436	
753·934	2041·002	480·940	1211·865	1366·722	
776·498	2272·472	498·206	1579·155	1514·537	
972·838	2048·371	557·755	1839·192	1815·538	
—	1578·004	581·600	2485·385	1331·313	
1206·796	2226·349	579·022	2643·094	1686·890	
1445·164	2462·976	694·236	37080·351	1582·407	
1839·492	2462·976	1035·596	5025·351	1876·413	
2377·139	3393·840	819·445	—	—	
2990·324	—	—	—	—	

GEOELECTRIC (VES) CURVES: The different layers and their apparent resistivity and thicknesses, inferred from partial curve matching were fed into a computer base programme REX2 DINV to obtain the model layer curves for the VES ran in the study area. The curves are of the type; AHA, AKH, AK, HK, AKQ, QHA, A, and QHKH. Some of the curves are presented in figs 6a-6h.



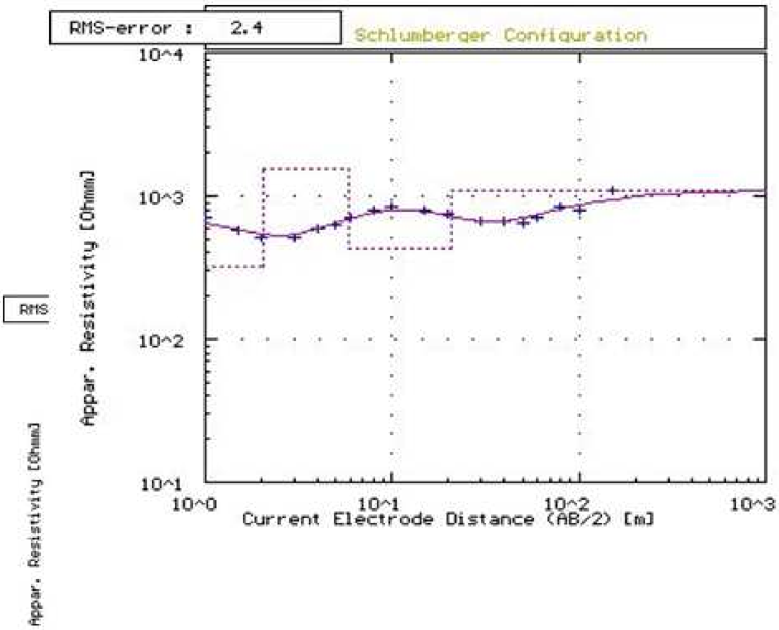
No	Res	Thick	Depth
1	3186.1	0.9	0.9
2	935.9	2.2	3.1
3	1283.6	7.5	10.6
4	634.4	10.4	21.0
5	4810.1	-.-	-.-

Fig 6a: Typical QHA curve type in study area



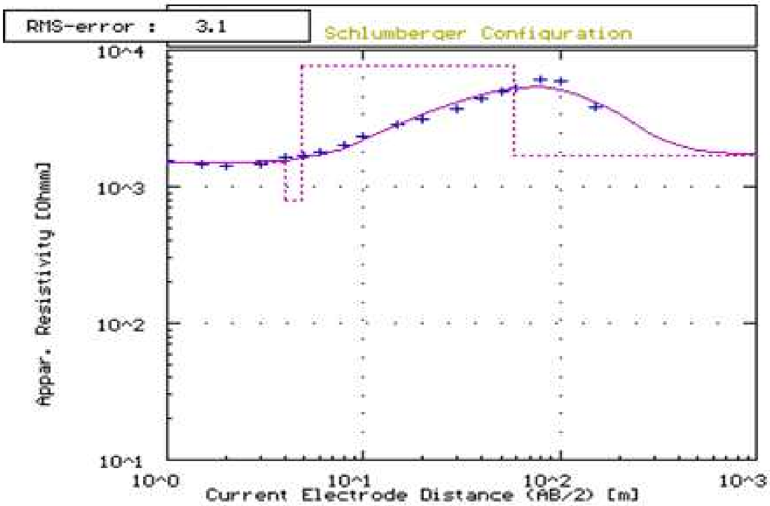
No	Res	Thick	Depth
1	1362.8	0.7	0.7
2	161.3	0.8	1.5
3	3102.5	4.7	6.2
4	496.0	14.7	20.9
5	1136.7	-.-	-.-

Fig 6b: Typical QHKH curve type in study area



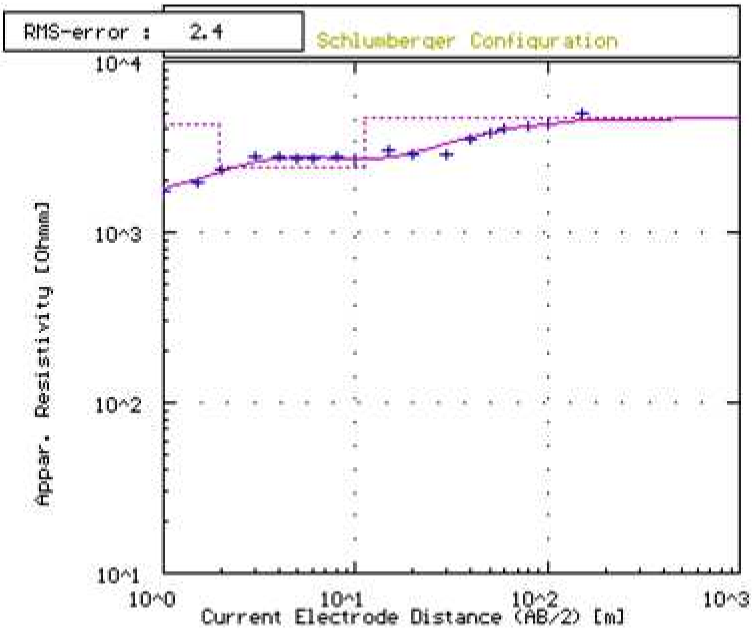
No	Res	Thick	Depth
1	703.7	0.8	0.8
2	316.3	1.2	2.0
3	1570.4	3.9	5.9
4	425.5	14.8	20.7
5	1085.3	-.-	-.-

6c: Typical AK curve type in study area



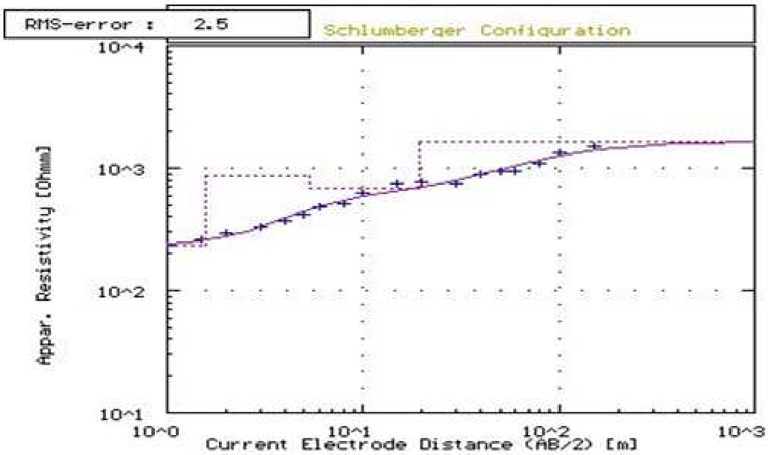
No	Res	Thick	Depth
1	1491.1	4.0	4.0
2	800.1	0.9	4.9
3	7608.5	53.6	58.5
4	1697.9	-.-	-.-

Fig 6d: Typical HK curve type in study area



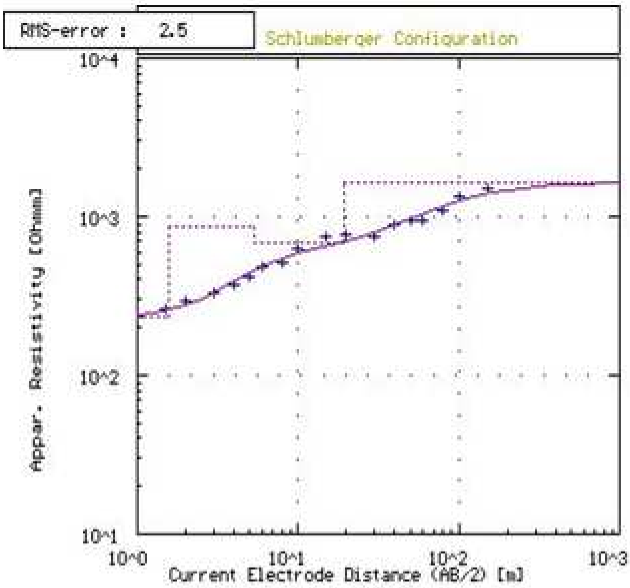
No	Res	Thick	Depth
1	1591.5	0.8	0.8
2	4321.9	1.1	1.9
3	2393.0	9.3	11.2
4	4646.6	-.-	-.-

Fig 6e: Typical AKQ curve type in study area



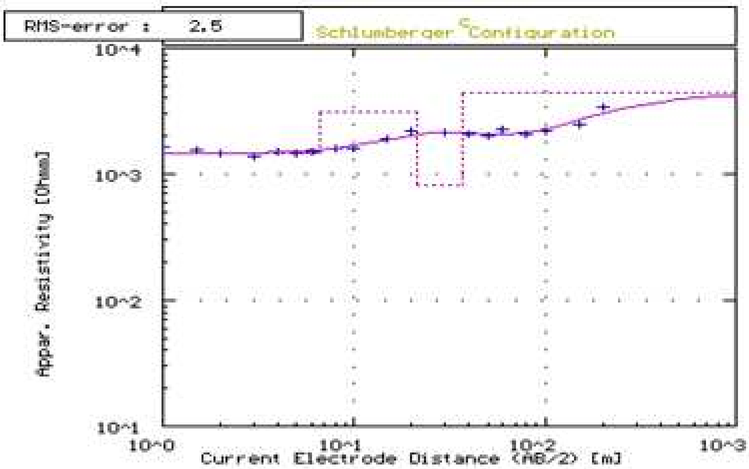
No	Res	Thick	Depth
1	230.2	1.6	1.6
2	887.6	3.7	5.3
3	693.4	14.0	19.2
4	1636.4	-.-	-.-

Fig 6f: Typical A curve type in study area



No	Res	Thick	Depth
1	230.2	1.6	1.6
2	867.6	3.7	5.3
3	683.4	14.0	19.2
4	1636.4	-.-	-.-

Fig 6g: Typical AHA curve type in study area



No	Res	Thick	Depth
1	1467.1	6.6	6.6
2	3091.2	14.7	21.4
3	807.8	15.6	37.0
4	4364.1	-.-	-.-

Fig 6h: Typical AKH curve type in study area

Isoresistivity depth slice maps

The values of apparent resistivity, longitudes, latitudes, and half current electrode spacing (AB/2=2, 5, 10, 20, 50m) of all the sounding stations were fed into a computer base programme SUFER 6 to obtain 2-D isoresistivity depth slide maps(Fig. 7a-7f).

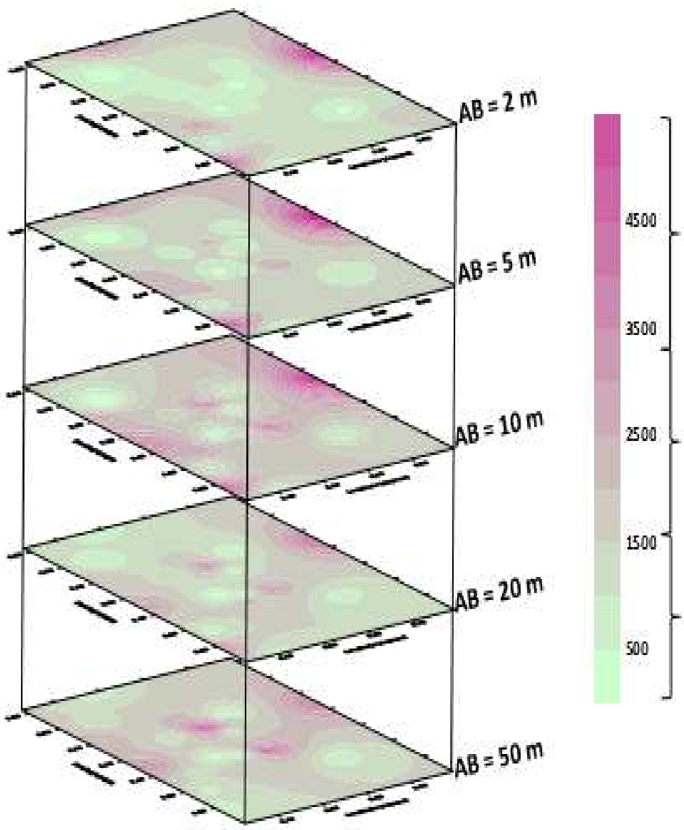


Fig 7a:3D view of isoresistivity depth slice map

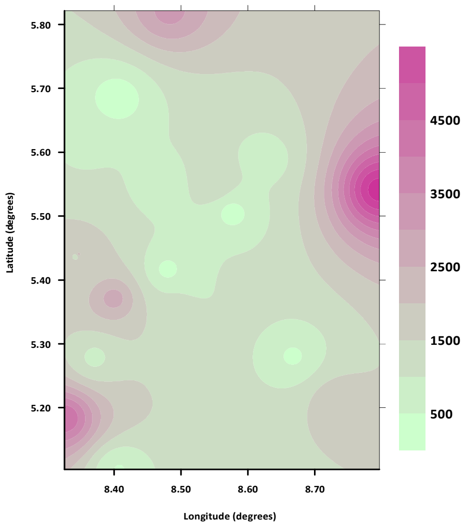


Fig 7b: Isoresistivity depth slice map at 2m

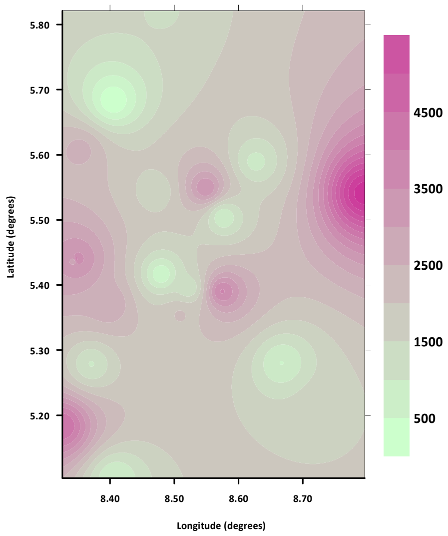


Fig 7c: Isoresistivity depth slice map at 5m

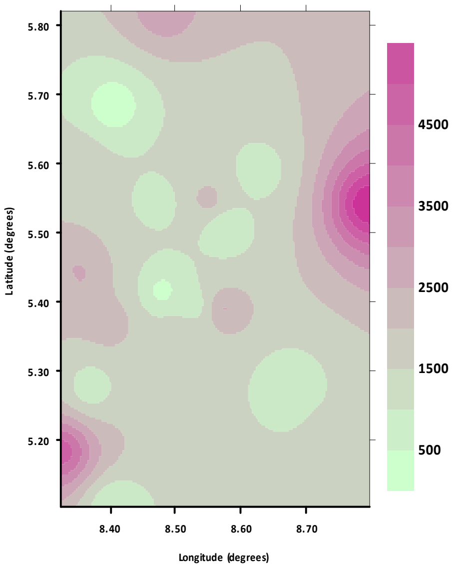


Fig 7d: Isoresistivity depth slice map at 10m

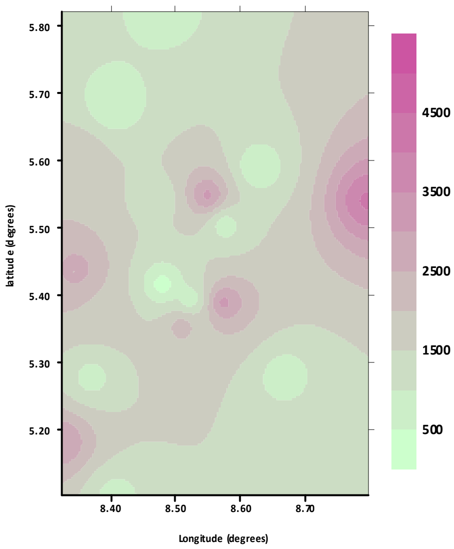


Fig 7e: Isoresistivity depth slice map at 20m

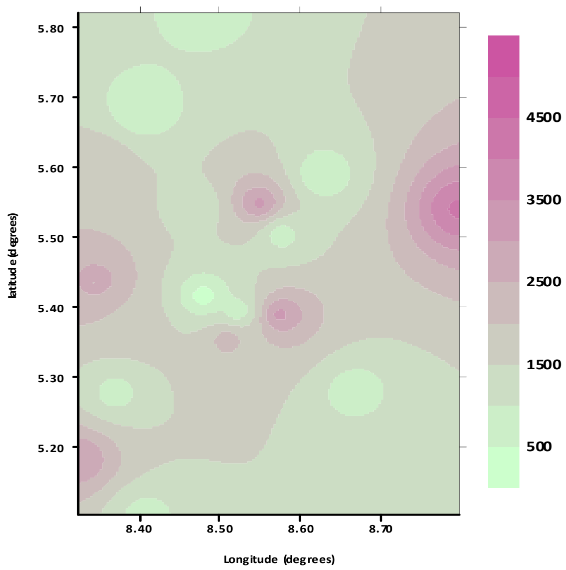


Fig 7f: Isoresistivity depth slice map at 50m

LINEAMENT LENGTH DENSITY MAP: After interpretation of radar imagery of Oban Massif basement complex, a lineament length density map of the area was produced as shown in (8)

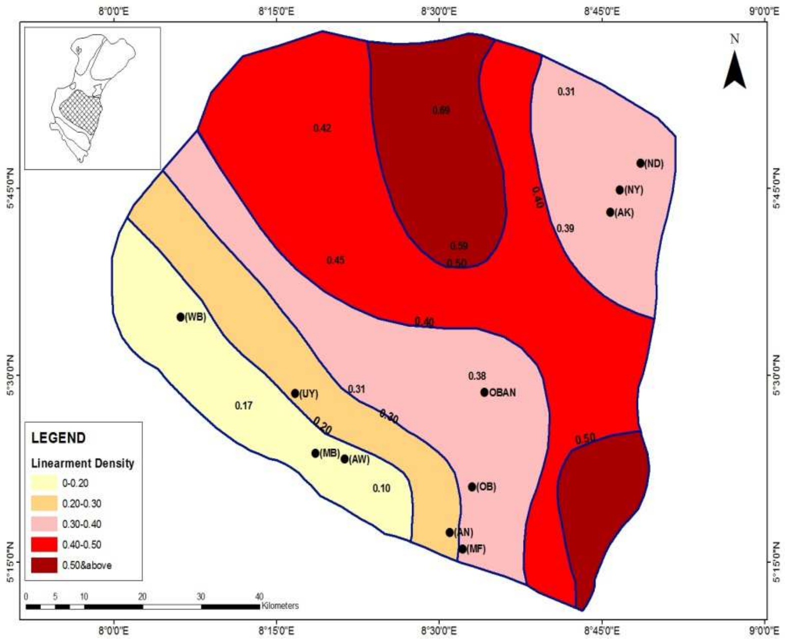


Fig 8: Lineament length density map of study area

DISCUSSION

Three layer Subsurface profile : The profile are of the type QHA, the first layer is laterite (sandy, gravelly, and clayey), with thickness of 1.4-9.2m. The second layer is weathered basement ,43.8m thick, and the third layer is fresh basement.

Four layer Subsurface profile : The profiles are of the types ; AK,Q, AK, AHA, QHA, and A. The first layer is laterite (gravelly, clayey, and sandy), 1.0-4.0m thick. The second layer is decomposed basement (gravelly and sandy), 0.9-7.6m thick, third layer is fractured basement, 13.7-63.4m, and the Fourth layer is fresh basement.

Five layer Subsurface profile : The profiles are of the types ; QHKH, QHA, HK, and AK. The first layer is silty Clay, (o.8-1.0m), second layer is laterite (1.2-2.2m), third layer is decomposed basement, 3.2-7.5m thick, Fourth layer is fractured basement, 10.4-14.8m in thickness, and the fifth layer is fresh basement

Six layer Subsurface profile : The six layer curve is QHA type The first layer is gravely laterite (0.6m), the second layer is sandy laterite (1.0m), third layer silty laterite (7.5m), fourth layer is highly fractured basement (10.8m), fifth is slightly fractured basement (22.1m) and the sixth layer is fresh crystalline basement.

GEOELECTRIC SECTIONS: The geoelectric sections of the study area were created to indicate the various geoelectric layers within the subsurface with their characteristic resistivity measurement of the study area were also interpreted and represented in fig 9.

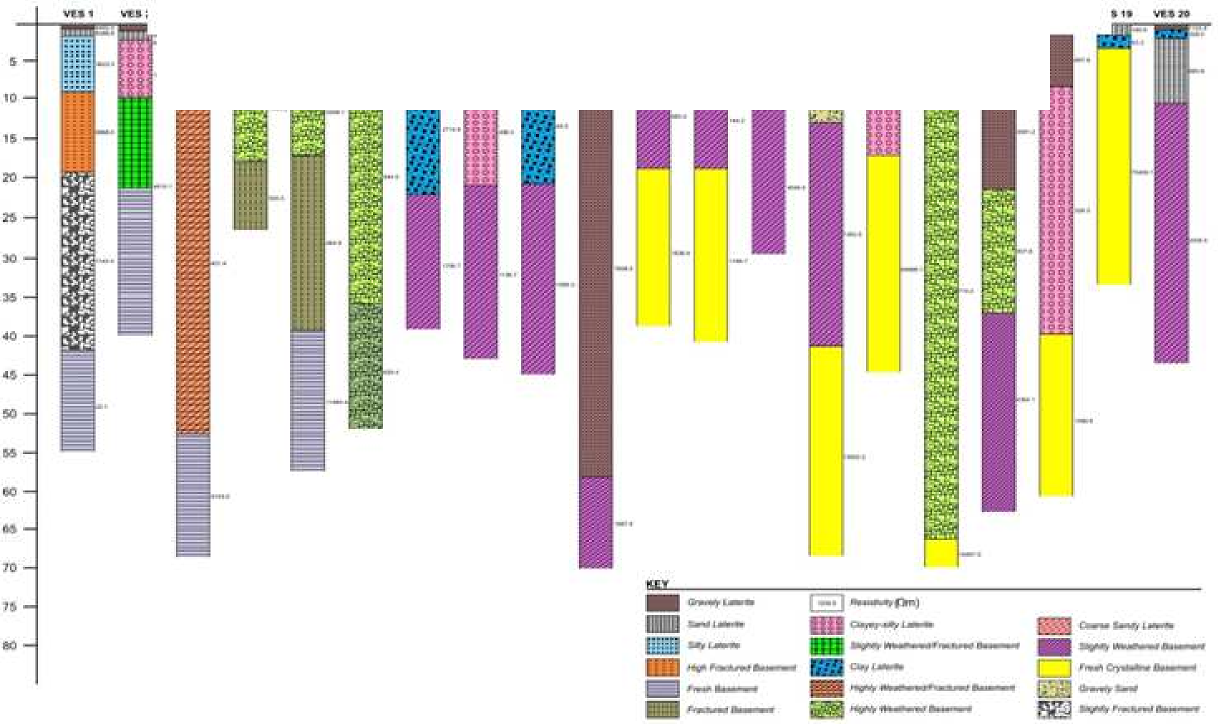


Fig. 9 Geoelectric Sections of Study Area

ISORESISTIVITY DEPTH SLICE MAP: Interpretation of isoresistivity depth slice map shows that the resistivity values of the study area at the same depth varies from one location to another. This variation in resistivity is due to change in rock type, weathering characteristics and fluid content.

LINEAMENT LENGTH DENSITY MAP: Analysis of the lineament length density map showed that the lineament density decreases southwest-wards from a high of 0.69 to a low of 0.17. The variation of lineament density could be attributed to the different stress patterns. Edet et al (1994) showed that lineament density increases with decrease in the overburden ratio. It can therefore be inferred that the areas north and southeast of the study area (high lineament density: > 0.40) represent outcropping rocks and areas of low lineament density :< 0.40 (southeast of study area) indicates buried. Both areas, however, can give a guide to groundwater potential of the area.

ESTIMATION OF AQUIFER HYDRAULIC CONDUCTIVITY ANDTRANSMISIVITY:
Niwas and Singhal (1981) established an analytical relationship between aquifer transmissivity and transverse resistance on one hand and between transmissivity and aquifer longitudinal conductance on the other hand.

The relationship is given as:

$$Tr = K\sigma T = \frac{KS}{\sigma} = Kh$$

Where T_r = Aquifer transmissivity,σ =Electric conductivity,T=Transverse resistance of water bearing formations, S= Longitudinal conductance of water bearing formations, and,h= Aquifer thickness

Transverse resistance (T) and longitudinal conductance (S) are called Dar Zarrouk parameters, which have been shown to be powerful interpretational aids in groundwater surveys (Zohdy et al, 1974). Since Dar Zarrouk parameters, T and S are directly proportional to aquifer property of transmissivity, apart from defining the aquifer geometry, aquifer transmissivity and storativity can be inferred on the basis of total transverse unit Resistance, T and Total Longitudinal unit Conductance values. This fact has been established by (Zohdy 1974, Onuoha and Mbazi, 1989). This means that higher values of T, or S, suggests higher Transmissivity. It has been shown by Niwas and Singhal (1981) that in areas where the geologic setting and water quality do not vary greatly, the product of Kρ remains fairly constant which not the situation in the study area. Table 3 bellow shows Dar Zarrouk parameters of the study area. Generally the study area has low values of Dar-Zarrouk parameters, but the relatively high values of Dar-Zarrouk parameter in study area indicate presence of aquifers.

Table 3: Dar Zarrouk parameters of study area

VES STAT-ION	ρ_a (Ω-m)	THICK NESS(m)	DEPT (m)	ELEVA TION(m)	TRANS. RES. (Ωm^{-2})	LONG. COND. (S)	ELEC. COND. (Sm^{-1})
1	1142.4	22.1	41.9	132·87	25247.0	0.01934	0.000875
2	634.4	10.4	21.0	77·87	6547.7	0.01639	0.00157
3	410.4	43.8	53.0	98·18	17975.5	0.10672	0.00244
4	1040.2	13.7	18.6	97·54	14354.7	0.01317	0.0009614
5	464.8	21.7	39.5	98·06	10086.1	0.04668	0.002151
6	844.9	31.9	35.7	137·87	26952.3	0.03775	0.00118
7	2714.8	16.8	22.1	96·78	45608.6	0.00618	0.000368
8	496.0	14.7	20.9	113·96	7291.2	0.02637	0.002016
9	425.5	14.8	20.7	93·69	6297.4	0.03478	0.00225
10	ND	ND	ND	109·24	ND	ND	ND
11	ND	ND	ND	111·03	ND	ND	ND
12	144.2	12.8	19.2	124·96	1845.7	0.08876	0.00693
13	ND	ND	ND	119·00	ND	ND	ND
14	1362.5	28.0	41.1	120·00	38150.0	0.02055	0.000734
15	406.0	13.4	17.3	116·70	5440.4	0.03300	0.00246
16	710.0	63.4	66.2	204·00	45014.0	0.08929	0.00141
17	807.6	15.6	37.0	164.00	12598.5	0.0193	0.00123
18	329.3	31.0	39.8	170.00	10208.3	0.O941	0.00303
19	ND	ND	ND	143.00	ND	ND	ND
20	ND	ND	ND	163.00	ND	ND	ND

•ND means not determined

CONCLUSION

An integrated method of study combining geological and geophysical (aero-structural and surface resistivity) have been employed in the study of the hydrogeology of Akamkpa Area. After careful interpretation of the data, it is noticed that six (6) locations; Okomita, Old Ndebije, Government Secondary School Akamkpa, Ojor1, Model High School Uyangha, out of the twenty (20) location sounded do not have aquiferous units and therefore groundwater abstraction through borehole development is not possible in these locations. The interpretation of the data shows a complex geological setting with three to six geoelectric layers. However,the 4-layer case is more abundant in the area. The thicknesses of the different geoelectric layers vary from place to place due to differences in elevation, rock type and weathering characteristics. Though interpretation of vertical electric sounding data show a multiple layer setting up to six geoelectric layer, lithologic log from a borehole drilled close to one of the vertical electric sounding stations (Mbarakom) show that the study area is made up of predominantly three (3) layers. These layers are; overburden, composed of laterite that are gravelly, clayey, silty and occasionally sandy. The second layer is the weathered basement, Whereas, the third layer is fresh basement. The thickness of the overburden varies from 0.4m-43.8m with an average thickness of 15m. The thickness of the weathered basement varies from 14m-75m with an average of 45m, the third layer which is the fresh basement is at a depth ≥70m.

The depth to water has also been seen to vary from place to place from resistivity data in the study area. Depth to water is between 19-70m with an average of 50m.

Interpretation of resistivity data and model generated from this set of data show that the apparent resistivity of the area vary from place to place. The first geoelectric layer has apparent resistivity varying from 53.2-4492.4 Ωm. The values of apparent resistivity in some location are high due to the fact that the locations are gravelly, sandy and very dry. The second Geoelectric layer has apparent resistivity between 63.3Ωm-8389.5Ωm with an average value 2100.765Ωm. Again, apparent resistivity values of this layer in some locations vary because of the presence of gravels, sand and dryness of the layer. Apparent resistivity of the third geoelectric layer is between 406Ωm-3623Ωm with an average of 1470Ωm. The layer constitutes part or the aquifer in some locations in the study area. The fourth layer has apparent resistivity values ranging from 42.5-6968Ωm with an average 2817Ωm. Again this layer constitutes part of the aquifer in some locations in the study area. The fifth geoelectric layer which is the fresh basement has resistivity values between 75-34999Ωm with an average of 6453Ωm.

Analyses of the isoresistivity depth slice maps at different depth have shown that, the apparent resistivity of the earth material at the some depths varies from place to place. Interpretation of radar imagery shows that the study area is intensely fractured. The fractures trending in the N-S, NE-SW, and NW-SE directions.

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