HYDRO-GEOELECTRICAL STUDY OF ZING AND ENVIRONS, TARABA STATE, NORTHEAST NIGERIA

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Abstract: The study examined Hydro-geo-electrical/geological conditions of the area with the view of delineating potential areas for groundwater development. The resistivity method was employed and twenty one (21) vertical electrical sounding (VES) were conducted with spread of AB/2 = 100 m using the ABEM-SAS 300C Terrameter. The data obtained were interpreted by a computer iteration process using a software (INTERPEX). The resistivity values for this area range from 14.27 to 8772.82 Ωm while the thickness ranges from 0.137 to 30.0 m. Resistivity values corresponding to AB/2=10 and AB/2=50 m were taken and contoured. The profile of AA¹ and BB¹ were drawn and presented. The finding indicates that the area is generally underlain by three to four lithology units which include top lateritic soil, weathered/fractured basement, and the fresh basement. Based on the result obtained, the fractured /weathered basement makes up the aquiferous zone within the study area; hence the ground water potentials of the area have been inferred from these weak zones. Vertical electrical sounding points 7, 8, 10, 19 and 21 are considered to have the highest water bearing potentials within the study area and are therefore recommended for citing of boreholes.

Keywords: Resistivity, Schlumberger array, iso-resistivity, geo-electric section, weathered basement

Introduction

The research was conducted in Zing Local Government Area, of Taraba state which lies between latitudes 8°48'N and 9°00'N and longitudes 11°30'E and 11°48'E with a total area of 8671 km2 The area lies within the savanna grassland belt (Ogidiolu 2000). It has two distinct seasons-the rainy and dry seasons. The onset of the rains is in April; with low amount but increases gradually to a maximum in August while the dry season set in by November and ends by April.

Zing and Environs falls within the basement complex of northeast Nigeria where groundwater occurrence is hosted within zones of weathering and fracturing which often are not continuous in vertical and lateral extent (Jeff, 2006). Most often the occurrence of groundwater in basement complex terrain is localized and confined to weathered/fractured zones (Adiate *et al*., 2009; Ariyo *et al*., 2009; Mbiimbe *et al*., 2010, Nur and Ayuni. 2004 & 2011).

The electrical resistivity method is usually preferable because of the resistivity contrasts obtained when the groundwater zone is reached. This study therefore seeks to delineate groundwater potential zones in Zing metropolis and environs using geoelectrical analysis of vertical electrical sounding.

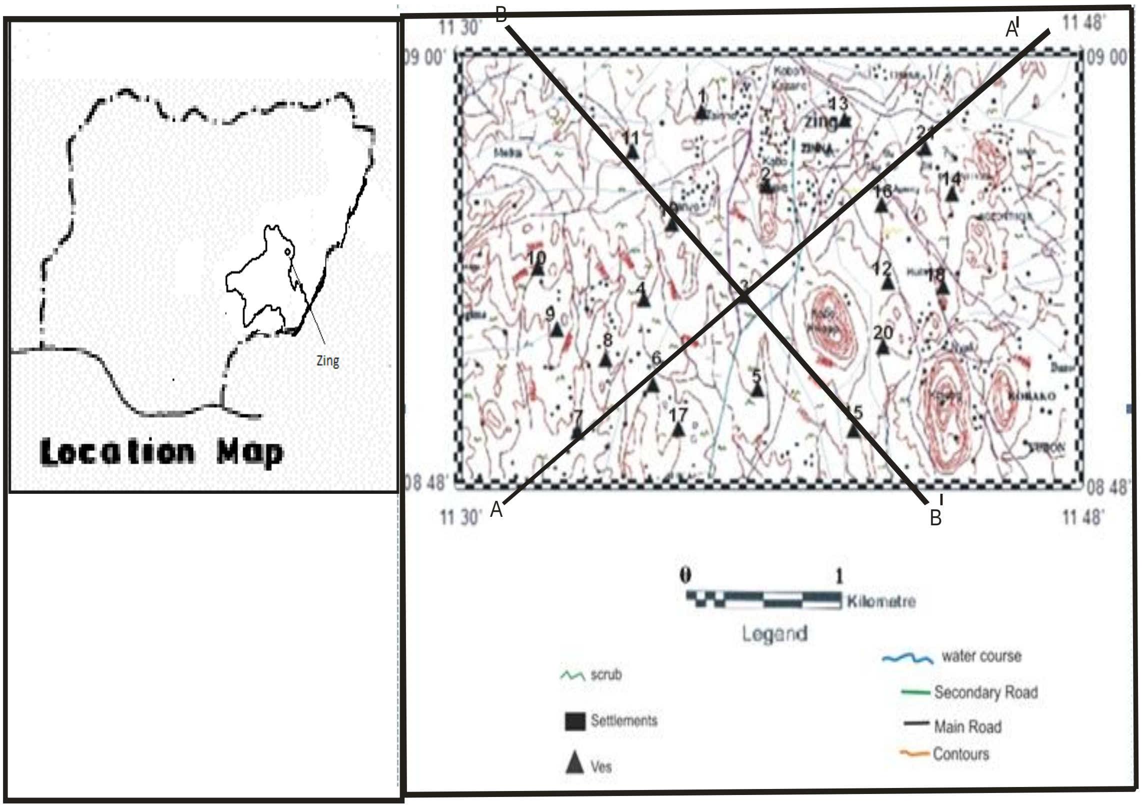

Fig. 1: Topographic map of the study area showing VES points

The study areas is basically a Basement complex terrain and falls within the North-Eastern craton of Nigeria (Carter *et al*., 1963). These rocks are granitic in nature, which are metamorphosed, weathered and fractured in parts and places. Outcrops of these rocks are seen at the surrounding areas. Existing well records shows that immediate environment have shallow localized and restricted aquifers, which are seasonal.

Data acquisition/analysis

Twenty one (21) Vertical Electrical Sounding (VES) were conducted and the result interpreted qualitatively and quantitatively. Apparent resistivity obtained from the field were plotted against half of the current electrode spacing AB/2 on a log-log paper and a two layer curve was fitted to the early point on the graph and the resistivity and thickness z_1 of the upper layer was determined while z_1 were combined into a single equivalent layer of resistivity (ρ) and thickness (z_e). Based on this preliminary interpretation, estimate of resistivity and thickness of various geo–electric layers were obtained. These were later used as starting models for a computer programmed (INTERPEX).

Results and Discussion

Vertical Electrical Sounding data obtained in Zing and Environment were interpreted and processed. From the interpretation, three to four subsurface layers were identified within the study area and presented in (Table 1) .Curves types are made up of H, A and a combination of KA.

The mean resistivity value for layers one is 343.11 Ωm with a corresponding thickness of 1.31 m, while average value for layers two was found to be 108.7 Ωm with a mean thickness of 11.7 m. The third layer which is fresh basement has a mean resistivity value of 1310.5 Ωm, thickness of 12.35, and transverse resistance of 833.4 Ωm² and a mean longitudinal conductance of 0.183 Siemen, respectively.

Table 1: Result obtained from the computer analysis of the twenty one VES points

S/N	VES NO.	CURVE TYPES	Resistivity of layers (Ωm)				Thickness of Layer (m)			$\frac{AB}{2}$ =	$\frac{AB}{2}$ =	Transverse Resistance (Ωm²)			Longitudinal Conductance (Siemens)			Fitting error (%)
	1-21	H,K,Q&A	ρ_1	ρ_2	ρ_3	ρ_4	h_1	h_2	h_3			T_1	T_2	T_3	S_1	S_2	S_3	
1	VES 1	KA	97.39	208.0	67.48	500.3	0.916	3.98	12.35	130	170	89.23	829.1	833.4	0.00941	0.0191	0.183	4.88
2	VES 2	H	87.16	66.13	325.6	-	1.09	1.52	-	65	160	95.53	762.3	-	0.0125	0.174	-	4.46
3	VES 3	H	178.7	97.10	257.5	-	1.82	6.96	-	70	120	326.1	676.3	-	0.0102	0.0717	-	3.67
4	VES 4	H	730.2	47.68	323.7	-	1.07	10.19	-	65	120	744.4	486.1	-	0.00140	0.213	-	7.01
5	VES5	H	378.9	304.2	1004.7	-	1.02	13.60	-	500	1100	388.9	4138.3	-	0.00271	0.0447	-	6.10
6	VES6	A	81.03	522.8	1619.7	-	0.137	13.48	-	410	1000	11.13	7051.0	-	0.00170	0.0258	-	8.61
7	VES7	H	557.4	41.12	361.7	-	1.27	19.14	-	50	85	711.1	787.0	-	0.00229	0.465	-	687
8	VES8	H	23.26	49.02	155.07	-	1.79	28.70	-	55	8`5	417.8	1407.2	-				10.88
9	VES9	H	281.9	26.40	562.0	-	1.52	8.17	-	28	85	430.3	215.8	-	0.00541	0.3096	-	13.34
10	VES10	H	321.7	34.57	501.6	-	1.36	19.08	-	34	125	438.4	659.8	-	0.00424	0.331	-	6.11
11	VES11	H	475.8	47.24	535.9	-	0.917	15.65	-	40	125	438.4	659.8	-	0.00424	0.552	-	11.76
12	VES12	H	640.0	70.58	856.6	-	0.611	11.51	-	74	225	391.5	812.7	-	9.559× 10.4	0.163	-	4.93
13	VES 13	H	188.9	19.89	2638.2	-	2.23	0.918	-	145	550	421.7	18.27	-	0.0018	0.0461	-	4.57
14	VES14	H	371.0	14.27	289.2	-	0.0660	7.60	-	18	90	244.9	108.5	-	0.00178	0.533	-	6.77
15	VES15	H	231.6	26.86	1793.6	-	1.38	6.18	-	54	160	320.1	166.2	-	0.00597	0.230	-	13.43
16	VES16	H	515.3	100.7	2069.2	-	1.06	6.15	-	150	620	549.4	620.6	-	0.00207	0.0611	-	12.44
17	VES17	H	436.1	22.59	8772.88	-	1.76	12.09	-	34	85	768.7	273.2	-	0.00404	0.535	-	7.19
18	VES18	A	14.9	282.3	7070.8	-	2.33	6.60	-	210	460	348.9	1863.9	-	0.0155	0.0233	-	4.33
19	VES19									210	340							6.69
20	VES20	H	515.9	117.7	245.2	-	1.48	6016	-	160	280	7672	72052	-	0.00288	0.0523	-	6.29
21	VES21	H	367.8	26.44	2658.1	-	1.66	30.10	-	30	48	613.1	796.0	-	0.0045	1.13	-	13.05
	Average		343.11	108.7	1310.489	500.3	1.31	11.7	12.35	120.6	287.3	432.94	1147.8	833.4	0.4605	0.258	0.183	40.16714

The subsurface is composed of three layers of resistivity and thickness h_1, h_2 and h_3, and the geo-electric section is described according to the relation between resistivity's and thicknesses (h_1, h_2, and h_3).

The Iso-Resistivity maps are obtained from sounding curves given electrode spacing common to all the sounding points for AB/2 = 10 m (Fig. 2) and AB/2 = 50 m (Fig. 3) in the study area. The points of equal resistivity values were contoured. This is a qualitative interpretation that represents the variation in the electrical properties of the study area.

From Fig. 2, four distinctive anomalies are observed. The first anomaly which is located at Danvo of the study area and trend in the North-West direction has resistivity in the range of 100 to 200 Ωm. The Second anomaly covers Zinna and Koba Bdako trend in North-East direction and has lower resistivity values of 50 to 100 Ωm indicating loose materials.

The third anomaly which is located at the eastern corner of the study area trend north – east, resistivity values here are in the range of 100 to 200 Ωm. The fourth anomaly lies at the southern portion of the study area with a maximum resistivity value of 500 Ωm.

The resistivity variation in the contour map of AB/2=10 m show high variation in the southern part with values ranging from 400 to 500 Ωm indicating top lateritic soil. The north and northeast has resistivity values ranging from 50 to 200 Ωm which are relatively low and indicate loose soil with clayey materials.

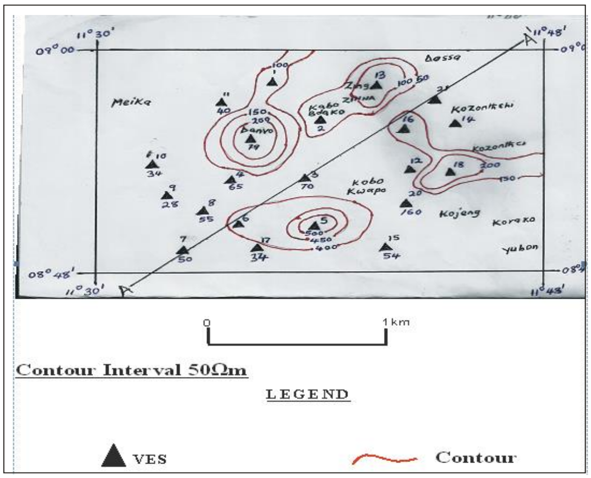

Fig. 2: Iso-resistivity map of AB/2 = 10 m

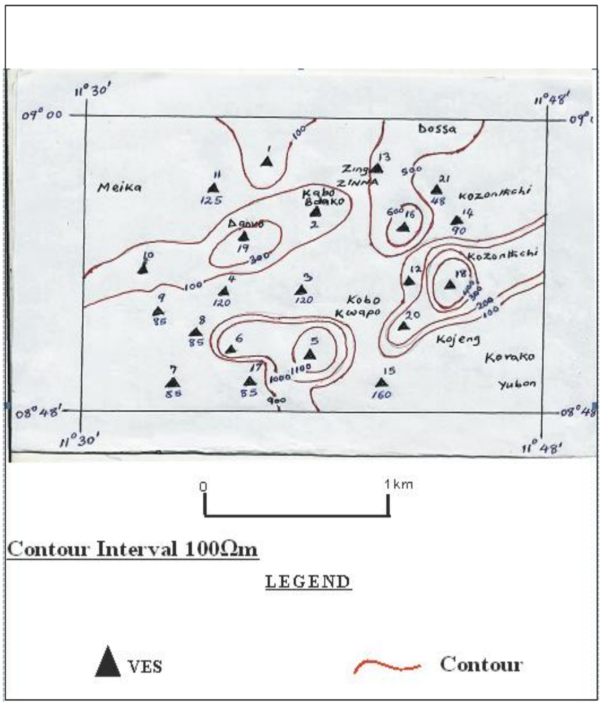

Fig. 3: Iso-resistivity map of AB/2 = 50 m

From Fig. 3 resistivity values corresponding to AB/2 = 50 m were taken and contoured. The figure exhibit four anomalous zones. The first anomaly covers places like Kabo Bdako and Danwo. Resistivity values here are from 100 to 300 Ωm. This anomaly trends in the northeast direction.

The second and third anomalies are located at the northeastern part of the study area. The anomalies here are in the range of 500 to 600 Ωm at places like Zing and Dossa.

The third anomaly covers Kozonthchi and Kojong and trend in the east – west direction. Resistivity values here are in the range of 100 to 400 Ωm.

The forth anomaly is situated at the southern part of the study area and has high resistivity values in the range of 1000 to 1100 Ωm which is an indication of fresh basement.

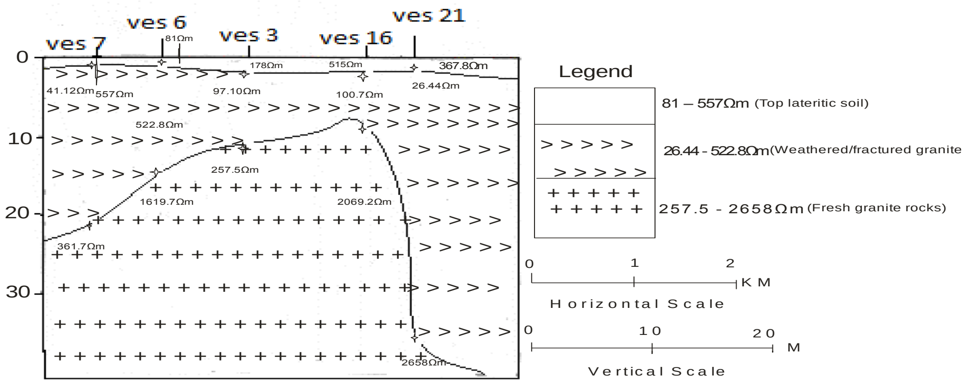

Fig. 4: Geo-electric section along profile AA' (VES 7, 6,3,16 and 21

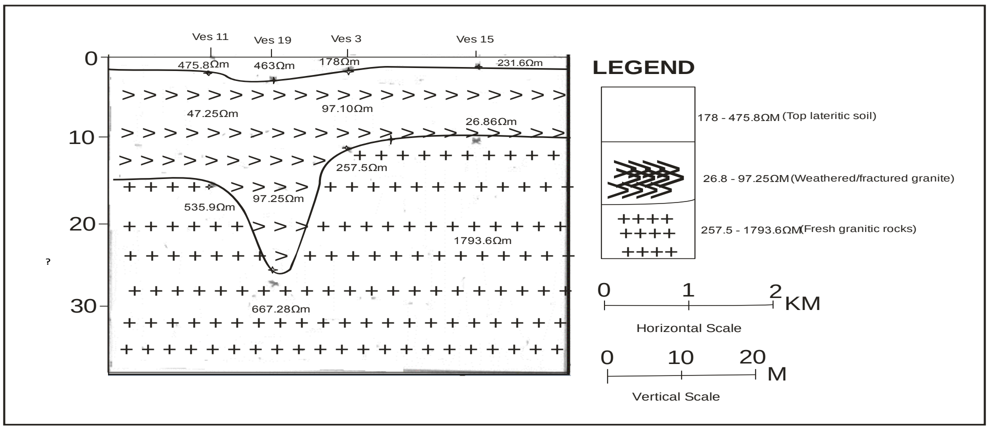

Fig. 5: Geo-electric section along profile BB[1] (VES: 11, 19, 3 & 15)

The geo-electrical section along profile AA' cuts through Vertical Electrical Sounding points (VES) 7, 6, 3, 16 and 21 and shows 3 layers. The first layer which is top lateritic soil and has its resistivity value of 557.4 Ωm at VES 7 and low resistivity of 81.03 Ωm at VES 6. The second layer is made up of weathered /fractured basement with low resistivity value of 26.44 Ωm at VES 21 and highest resistivity value of 522.8 Ωm at VES 6. The third layer is inferred to be the fresh basement and with a highest resistivity value of 2658.1 Ωm at VES 21 and lowest resistivity value of 361.7 Ωm at VES 7. From Fig. 4, VES 21 second layer could be said to be the aquiferous zone. This is consistent with the results of previous studies conducted within the same geologic environment by Uti *et al.* (2018).

The geo-electric section along profile BB^1 cut across VES points 11, 19, 3 and 15. The section indicates three electro-stratigraphic sequences representing top lateritic soil, weathered/fracture basement and fresh basement respectively, which is typical of a basement terrain (Mohammed *et al.*, 2007).

The figure indicates resistivity values ranging from 175.7 ohm-meters to 475.8 ohm-meters with a corresponding thickness of 0.92 to 2.79 m for the first layer. The thicknesses for the first layers are less than the value of 24 m established by Mohammed *et al.* (2007). The second layer which represents the weathered/fractured granite has resistivity that range from 26.66 ohm meters to 97.25 ohm meters with thickness of 6.96 m for VES 3, 15.6 m for VES 11, 6.18 m for VES 15 and 27.85 m for VES 19. This agrees with the findings of Onsachi *et al.* (2016) where the average thickness of aquifer was established at 7 to 30 m. The aquifer here is shallow except for VES 19 which has an appreciable thickness of alluvium/weathered granite. The survey revealed that within the surveyed points obtained from the geoelectric sections, VES 19 and 21 has the highest water bearing potentials and is consequently recommended for borehole drilling.

Conclusion

Electrical resistivity method using Vertical Electrical Sounding technique was adopted in all the twenty one (21) locations in Zing and Environment by applying the Schlumberger configuration with electrode spacing AB/2 = 100 m with a view to understand the subsurface geological settings that could guide the successful exploration of groundwater. Analysis of the interpreted results revealed the nature and composition of the sub-surface. This includes top lateritic soil, weathered/fractured basement, and fresh basement. The weathered/fractured basement serves as the aquiferous zone (water bearing zone).

Based on the qualitative interpretation of the Vertical Electrical Sounding (VES) data, VES 2, 4, 5, 7, 8, 10, 11, 12, 17, 19 and VES 21 are suitable for boreholes with appreciable thickness of weathered and fractured basement. This fractured structure enhances groundwater permeability and storage (Ayuni *et al.*, 2017). In conclusion this implies that 52% out of the total Vertical Electrical Sounding (VES) locations are good for drilling borehole.

Conflict of Interest

Authors declare that there are no conflicts of interest.

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