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Groundwater prospecting and Aquifer Delineation using Vertical Electrical Sounding (VES) method in the Basement complex terrain of Kumbotso Local Government Area of Kano State Nigeria

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Abstract: *A total of twenty seven (27) vertical electrical soundings (VES) where carried out on the basement complex area of Kumbotso Local Government Area of Kano with a spread of 40m-45m adopted. The results obtained revealed three to four geo-electric layers of the subsurface. The third weathered basement and a forth fractured basement rock constitutes the Aquiferous water bearing layers with resistivity ranges from 6Ωm - 265Ωm respectively with average thickness of 19m and 15m respectively. The result shows the weathered regolith to be thicker than the fractured bedrock layer; average depth range of boreholes in the area is between 30m-35m while the average static water levels in dug wells is 8.3m. It is highly recommended that a spread of between 75-85m be used in the future and also the use of EM method to locate deep fractures as important in maximizing the borehole yield.*

Keywords*: Vertical Electrical Sounding, Weathered regolith, fractured bedrock, Geoelectric, Borehole failure, Schlumberger array, Kumbotso, Kano State*

I. Introduction

In recent years, attention has moved to the exploration of groundwater most especially in the rural communities of the developing countries of the world. This is because the surface water sources that is being used by these rural dwellers is constantly being expose to pollution and contamination because of lack of protection from contaminant and pollutant. Large sum of money is being committed to the drilling of boreholes by individual companies, international organizations, Federal Government, State Government, Local Government, donor agencies and charity organizations of the recent Millennium Development Goal (MDGs).

A major problem associated with the drilling of boreholes most especially in the Basement terrain is the high failure rate. Wright (1992) shows that the response of water withdrawal by the aquifer of basement terrain is in a discontinuous manner which is mainly due to the presence of barrier boundaries in the fracture system and the low permeability of the regolith layer gives rise to the high failure rate and wide range of boreholes yield for these aquifers. In order to reduce this failure rate, there is the need for the use of the proper and best Geophysical techniques. Beeson and Jones (1988) carried out resistivity and conductivity in relation to the lithology and weathering of the basement rock in part of Kano State, also Hazel et al (1988) shows that the pink feldspar Granite in Kano State is an important aquifer which are fractured and contain less Kaolin with good yield and they demarcated 3, 4 and 5 layers for Kano; these consist of a lateritic ironstone layer of resistivity of 5000 Ωm and a weathered layer whose resistivity lies between 30 Ωm to 270 Ωm.

Auwalu and Abubakar (2012) discovered a four layer sequence for Rimin Gado and Tofa Local Government Areas; thus has a top lateritic sandy layer, silty sand or sandy clay zone, a weathered basement (clay sand), a fractured basement and a fresh basement. The weathered and fractured zones has resistivity ranging from 9 Ωm -1640 Ωm and a thickness that varies between 1.66m-28m.

Abubakar and Auwalu (2012) conducted a survey for the basement complex rocks of the Dawakin Tofa Local Government Area of Kano State; they delineated the fractured and weathered regolith zone as the aquiferous zone with resistivity of between 7.3 Ωm and 772 Ωm with an average 178 Ωm and average depth of 14.33m.

Bala et al (2011) shows that the regolith constitutes the dominant aquifer in the Kano area and the mineralogical composition, texture and structure of the parent bedrock control the water yielding ability of the regolith aquifer.

This research work carried out subsurface investigation using the vertical electrical sounding method in order to delineate the various layers present and to map out the zones of hydrogeological interest and of high Groundwater potentials in the basement complex terrain of Kumbotso Local Government Area of Kano State, Nigeria.

Description of Study Area

Kumbotso Local Government Area of Kano State is located between latitude $11^0$53'17″N and longitude $8^0$30'10″E on an elevation of 450m above sea level. It is a metropolitan Local Government Area with a landmass of about 158km^2. According to the national population commission, a population of 294, 391 people with an annual growth rate of 4.06% were recorded in the 2006 population census in the area of study. The Local Government Area shares boundaries with Dala, Gwale, Tarauni and Ungogo Local Government Areas to the north, to the east lays Dawakin kudu and Warawa Local Government Area. Madobi Local Government Area is Southward of Kumbotso while Tofa and Rimin Gado Local Government Area located west of Kumbotso.

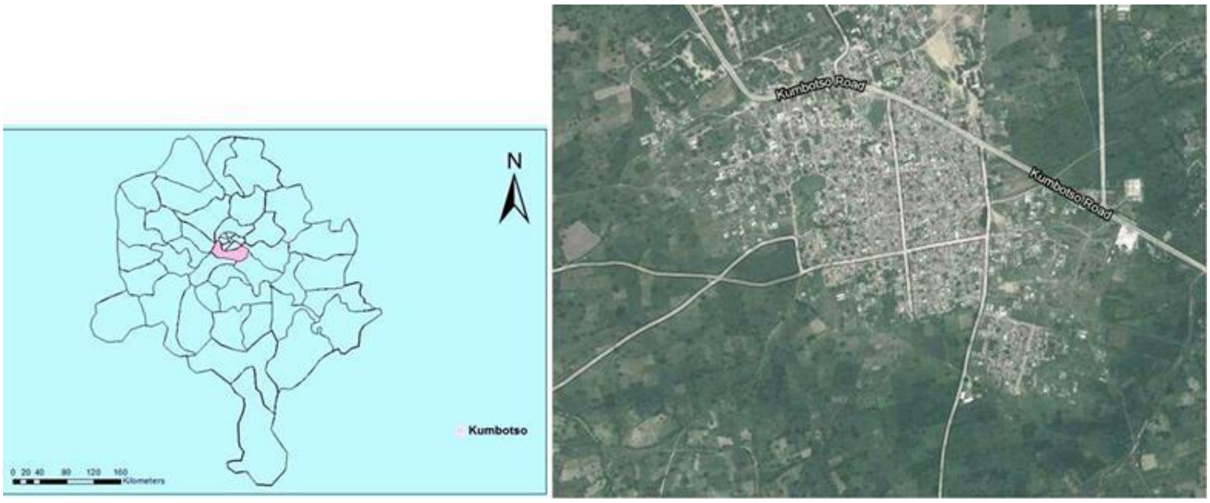


Figure 1: Map of Kano State and satellite Image map showing the study area

Geology of the Study Area

The Geology of the basement complex of Nigeria comprises of migmatite of high metamorphism and gneisses which are formed from the metamorphism (high grade) and granitization of Birrimian sedimentary rocks. The upper proterozoic younger metasediment of low grade were folded along with the migmatite and gneisses during the pan African Orogeny. Mc Cury (1989) reported the intrusion of the Older Granite series during the pan African Orogeny, while Hazell et al (1988) reported the occurrence of Younger Granite series. Falconer (1911) shows that they are so called because they are Jurassic in age. Present in the area of study also are the younger dykes, flows and volcanic. KNARDA (1989) identifies the different varieties of granites in the area. However the younger metasediments and migmatite gneiss rocks are grouped to form the migmatite gneiss complex (figure 2).

II. Method of Study

A total of 27 sounding were taken in the area, using of the Schlumberger array at spread of between 40m-45m using Terrameter SAS 300C model. Table 1 below summarizes VES data and Geoelectric layers from sounding curves generated from the study area. The curves generated from partial matching techniques were interpreted using the 1XID computer interpretation software (Fig 3a, 3b, 3c, 3d). The maps of the thickness of the Aquiferous layers are produced. Also, the static water level of dug wells was measured which serves as a guide.

Results and Discussion

The interpretation of the curves generated from field data reveal a three to four layer sequence based on the behavior of the electric current and resistivity values recorded at different depth of penetration. The top layer which is made up of laterite sand layer has a resistivity value ranging between 22 Ωm -995 Ωm with an average thickness of 5.4m. The second layer has resistivity of between 18Ωm -398Ωm with an average thickness of 9 m; this is made up of sandy clay. A third layer of weathered basement layer (regolith) has a resistivity ranging from 6 Ωm -265 Ωm with an average thickness of 19m.The fourth layer is a fractured basement layer with resistivity ranging from 38 Ωm -297 Ωm with an average thickness of 15m. Static water level measured in dug wells within the area of study ranges from 3m-22m with a mean value of 8.3m, table 1 contain the result of the survey.

Figure 3a, 3b,3c, 3d shows the different curves generated. The weathered and fractured basement layers are those with low ranges of resistivity and are the most promising zones with high ground water potentials.

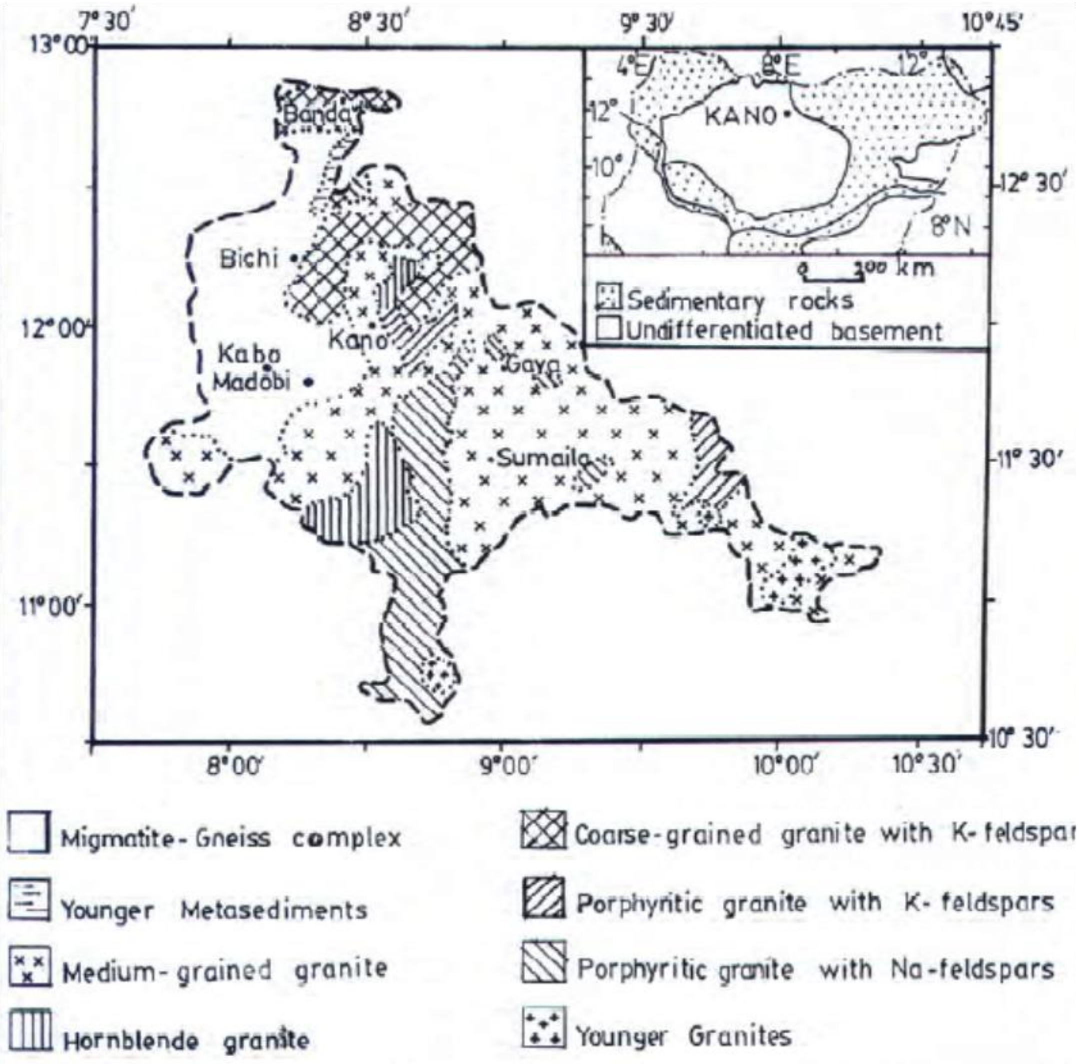
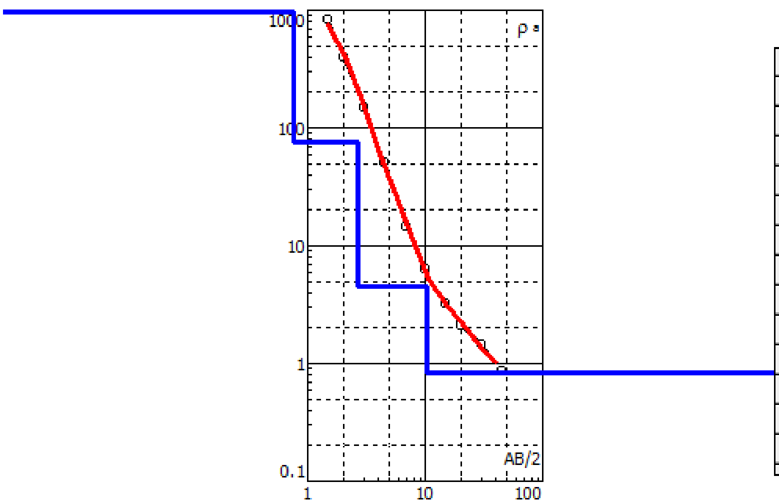
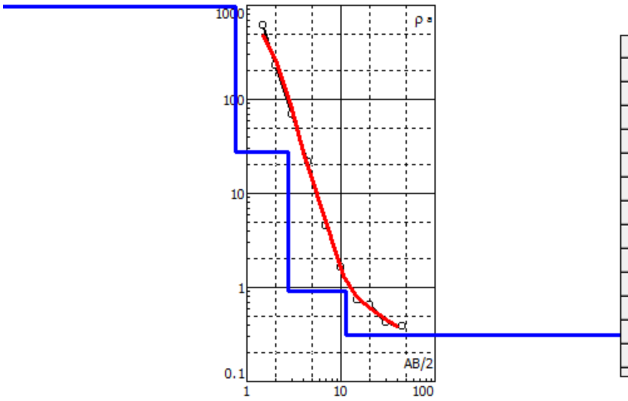


Figure2: Geological Map of Kano and Jigawa States including of the area of Study. (Modified from Bala et al., 2011)



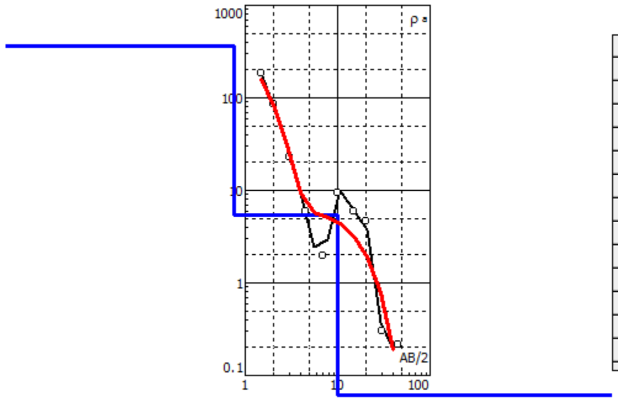
N	ρ	h	d	Alt
1	1600	0.75	0.75	-0.75
2	75.5	1.96	2.71	-2.708
3	4.52	7.72	10.4	-10.43
4	0.83			

Figure 3(a)



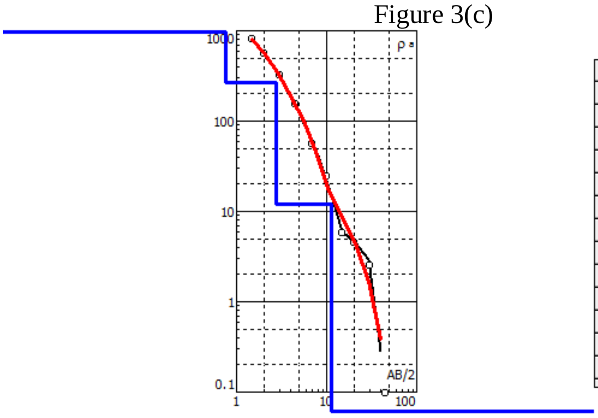
N	ρ	h	d	Alt
1	1067	0.75	0.75	-0.75
2	27.6	2	2.75	-2.748
3	0.901	8.52	11.3	-11.27
4	0.314			

Figure 3(b)



N	ρ	h	d	Alt
1	361	0.75	0.75	-0.75
2	5.48	9.27	10	-10.02
3	0.005			

Figure 3(c)



N	ρ	h	d	Alt
1	1365	0.753	0.753	-0.7533
2	264	2.01	2.77	-2.767
3	12.1	8.71	11.5	-11.48
4	0.0258			

Figure 3(d)

Figures 3a, 3b, 3c and 3d: shows the different types of Curves generated in the area

III. Conclusion

The results obtained revealed two important Geo-electric layers of good ground water potentials made up of the weathered regolith layer and the fractured basement rocks; these two constitute the aquifers in the basement complex area of Kumbotso Local Government Area of study. The recommended drilling depth ranges between 30m-45 meters. The vertical electrical sounding method has proved useful and indispensable tool in the area of groundwater prospecting.

IV. Recommendation

It is, however, recommended that a spread of 70m-80m and the use of more sophisticated and effective geophysical techniques such electromagnetic method of geophysical investigation of ground water be adopted in the future as can assist in detecting deeply buried fracture with high groundwater potentials.

Table 1: Summary of VES data and Geoelectric layers from sounding curves from the study area

Station		**COORDINATE**		**LATERITE SAND LAYER**		**SANDY CLAY LAYER**		**WEATHERED BASEMENT LAYER**		**FRACTURED BASEMENT LAYER**	
	LOCATION	**(N)**	**(E)**	**(Ωm)**	**(m)**	**(Ωm)**	**(m)**	**(Ωm)**	**(m)**	**(Ωm)**	**(m)**
1	Shagari Quarters	11 ° 57'62”	8°32'53”	134-319	5	55-88	3	38-42	15	63-155	15
2	Hawan Dawaki	11°55' 99”	8°31'82”	203-225	3	107-180	35	62-76	15	108-121	15
3	Hawan Dawaki	11°55'64”	8°30'58”	155-211	5	54-85	5	117-201	157	171-259	20
4	Mariri	11°56' 93”	8°36'56”	313-456	6	121-191	14	21-56	15	-	-
5	Bechi	11°55'39”	8°30'16”	212-402	5	212-300	6	245-257	5	263-297	15
6	Rinjin wanzamai	11°54'52”	8°29'40”	263-995	5	55-83	6	57-106	20	-	-
7	Coca cola Challawa	11°53'26”	8°28'70”	110-118	5	35-96	10	43-60	25	-	-
8	Challawa	11°54'52”	8°26'79”	112-211	5	38-68	5.5	18-82	25	-	-
9	Sabuwar Gandu	11°56'22”	8°37'14”	61-272	5	46-56	6	6-75	20	-	-
10	Gaida	11°55'13”	8°28'62”	107-133	5	137-188	12	255-329	20	-	-
11	Rinjin wanzamai	11°55'53”	8°30'44”	417-409	5	67-208	10	91-238	20	-	-
12	Danbare	11°57'42”	8°25'53”	68-91	4	13-24	6	22-46	25	-	-
13	Mariri	11°57'38”	8°37'48”	256-407	4	287-398	12	95-108	5	28-50	15
14	Hawan Dawaki	11°55'51”	8°30'34”	108-401	7	56-81	13	70-126	15	-	-
15	Danladi Nasidi	11°56'15”	8°37'44”	221-239	10	19-265	5	60-211	20	-	-
16	Giwarite Sharada	11°55'22”	8°34'14”	84-210	5	65-83	6	51-70	20	-	-
17	Zara School	11°55'74”	8°35'94”	82-93	7	102-118	8	96-149	20	-	-
18	Gadama village	11°54'32”	8°29'22								
19	Janguza	11°58'21”	8°24'61”	22-68	7	28-36	15	33-50	23	-	-
20	Mariri	11°57'32”	8°37'41”	73-85	5	125-137	13	92-121	20	-	-
21	Zawaciki	11°55'16”	8°27'98”	104-119	5	85-101	10	54-77	25	-	-
22	Danbare	11°57'64”	8°25'45”	27-240	5	55-67	8	40-90	20	-	-
23	Dorawar Na Abba	11°56'56”	8°31'67”	416-701	7	197-313	18	112-168	10	73-98	25
24	Farawa	11°57'01”	8°36'28”	204-233	5	151-196	6	46-70	9	38-44	16
25	Challawa	11°55'	8°30'	330-354	5	136-293	10	114-219	20	-	-
26	Hawan Dawaki	11°56'56”	8°31'67”	104-302	5	75-88	12	68-100	20	-	-
27	Bechi	11°55'20”	8°30'01”	217-312	7	158-191	8	203-265	20	-	-

Resistivity (Ωm), Thickness (m), Longitude (E), Latitude (N

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