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HYDRO-GEOELECTRICAL STUDY IN JALINGO METROPOLIS AND ENVIRONS OF TARABA STATE, NE NIGERIA.

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ABSTRACT

Eighteen Schlumberger Vertical Electrical Soundings (VES) of maximum electrode spread AB/2 of 100 meter, conducted in Jalingo and its environs of Taraba State have been interpreted. The area falls within Latitudes 8° 50'- 8° 58' N and Longitudes 11° 18'-11° 26' E. From the study, 72% of the VES data indicate a three electro-stratigraphic earth model. The first layer is the topsoil and has an average thickness of 1.0 meter, and an average resistivity value of 451 ohm.m. The second layer, which is weathered/fractured basement, has an average thickness of about 12.5 meters and a mean resistivity value of 300 ohm.m. The third layer, which could represent the fresh basement, has a mean resistivity value of 2811 ohm.m.

Based on the resistivity survey, six boreholes of depth between 15-50 meters were drilled in the study area. The resistivity values range between 100-300 ohm.m. The aquifer was identified in the weathered/fractured basement. The water table of the boreholes drilled varied from 3 to 12 m. A relatively moderate mean transmissivity (T) value of 39 m^2/day, an average hydraulic conductivity (k) value of 0.1 m/day, and an average pH value of 6.82 were also obtained.

KEYWORD: Geology and hydrogeology of Jalingo and environs and interpretation of resistivity data.

INTRODUCTION

The need for groundwater resources to meet up adequate domestic demands in local communities and residents in Jalingo metropolis of Taraba State called for pre-drilling geophysical surveying. Jalingo town and its environs belong to the undifferentiated basement complex rocks of northeastern Nigeria. The Mineralogical compositions are mainly of granite, gneiss, migmatite and pegmatite associations. The aquifer system of such rock types is highly restricted in the weathered and/or fractured basement rocks. Geophysical study is therefore essential before drilling activities takes place in the study area.

Eighteen Vertical Electrical Soundings (VES) were carried out having maximum electrode spacing AB/2 of 100 meters. The study area covers Jalingo and metropolis and its environs comprising (Yelwa, Bashin, Wuro Voto Sanyang, GRA, Hospital, Kagen, Veterinary, Department, Market, Karkaye and Yugang). The results obtained from the hydrogeoelectrical study of Jalingo and its environs will no doubt be a contribution to the better understanding of the aquifer systems in the study area.

GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

Jalingo and its environs are characterized with a tropical climate marked by a dry and rainy seasons. The dry season begins from late November to March, and is characterized by Harmattan wind blowing from the Sahara Desert. The Southwest wind blows across the Atlantic to the hinterland from March to November. This wind with moisture brings rain most parts of Nigeria including the study area. The highest temperature in the area is 53° C and the lowest 16°C. The rainfall of this area is about 980 mm per annum.

Jalingo is located in a region characterized by high and low lands. The peak of the highland from the watershed of River Lamurde takes its source from the northeastern part of the study area, while River Pantinapu takes its source from the River Benue (Fig.1). The highest elevations of about 800ft were found in the eastern part (Sunyang) and the southeastern (yugang) of the study area (fig.1). The study area lies within the basement complex rocks of the Precambrian and Upper Paleozoic age. The rocks consist of the Undifferentiated Basement, Older Granite, Undifferentiated Metasediment, and Alluvium (Fig.2).

The Undifferentiated basement complex

They are found in the southwestern part of the study area. They have undergone weathering and laterization, which lead to unconsolidated laterite, silty-sand clay and gravel. The Undifferentiated basement complex consists

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TABLE 1. SUMMARY OF RESULTS OBTAINED FROM THE COMPUTER OUTPUT OF THE EIGHTEEN (18) VES IN THE STUDY AREA.

Locat.	Thickness of layers (m)				Resistivity of Layers (ohm.m)					Resistance (ohm)				Conductivity (Siemen)				Fitting Error %
	H1	H2	H3	H4	ρ 1	ρ2	ρ3	ρ4	ρ5	R1	R2	R3	R4	σ1	σ 2	σ3	σ4	
VES1	0.72	2.77	21.67	21.47	5.57	22.20	3.32	21.00	40.65	3.99	61.48	71.08	450.96	0.129	0.125	0.527	1.022	6.82
VES2	0.62	27.64	-	-	8.06	9.77	215.96	-	-	5.02	270.16	-	-	0.077	2.828	-	-	12.18
VES3	0.29	4.29	22.67	-	438.31	1872.9	449.20	2681.0	-	129.00	8033.80	10182.0	-	0.001	0.002	0.050	-	6.71
VES4	2.28	13.15	-	-	110.70	16.31	5546.80	-	-	252.73	214.55	-	-	0.021	0.806	-	-	9.98
VES5	1.89	25.03	-	-	1104.6	188.60	1026.14	-	-	2087.8	4720.90	-	-	0.002	0.133	-	-	5.24
VES6	1.86	4.76	-	-	565.12	66.35	2303.04	-	-	1049.4	315.60	-	-	0.003	0.072	-	-	11.35
VES7	1.46	9.68	-	-	647.62	121.88	8631.80	-	-	944.09	1179.90	-	-	0.002	0.079	-	-	10.42
VES8	1.18	5.28	-	-	673.71	56.94	719.20	-	-	792.64	300.78	-	-	0.002	0.093	-	-	12.32
VES9	0.28	1.92	0.10	-	304.22	585.50	196.51	108.60	573.30	84.85	1125.72	19.84	1899.1	0.001	0.003	0.001	0.161	13.15
VES10	0.33	2.03	13.73	17.49	192.53	472.60	94.28	261.27	677.97	66.44	961.36	1294.80	7501.2	0.002	0.004	0.146	0.110	3.77
VES11	0.80	2.43	31.03	28.71	537.15	203.50	18.38	3720.2	-	431.69	495.11	570.27	-	0.001	0.012	1.688	-	8.48
VES12	1.49	14.85	-	-	476.20	173.87	7585.01	-	-	710.03	2582.20	-	-	0.003	0.085	-	-	10.00
VES13	0.34	7.10	-	-	467.12	193.79	2068.15	-	-	156.53	1375.20	-	-	0.001	0.037	-	-	3.03
VES14	0.89	11.58	-	-	379.63	155.36	2916.47	-	-	337.90	1798.30	-	-	0.002	0.075	-	-	6.65
VES15	1.71	7.50	-	-	25.30	11.68	2088.68	-	-	43.17	87.[illegible]9	-	-	0.067	0.642	-	-	12.25
VES16	0.63	33.80	-	-	13.96	299.79	3021.87	-	-	8.78	9833.20	-	-	0.045	0.109	-	-	9.38
VES17	0.61	26.89	-	-	1849.7	791.78	8710.06	-	-	1123.4	2128.75	-	-	0.000	0.034	-	-	4.02
VES18	0.73	20.12	-	-	423.97	172.47	5013.82	-	-	309.56	3471.03	-	-	0.002	0.117	-	-	4.49
Mean Value	1.01	12.27	17.27	22.56	451.31	300.85	2810.48	1358.4	430.65	474.28	2164.20	2327.60	3283.8	0.020	0.292	0.482	0.431	8.35

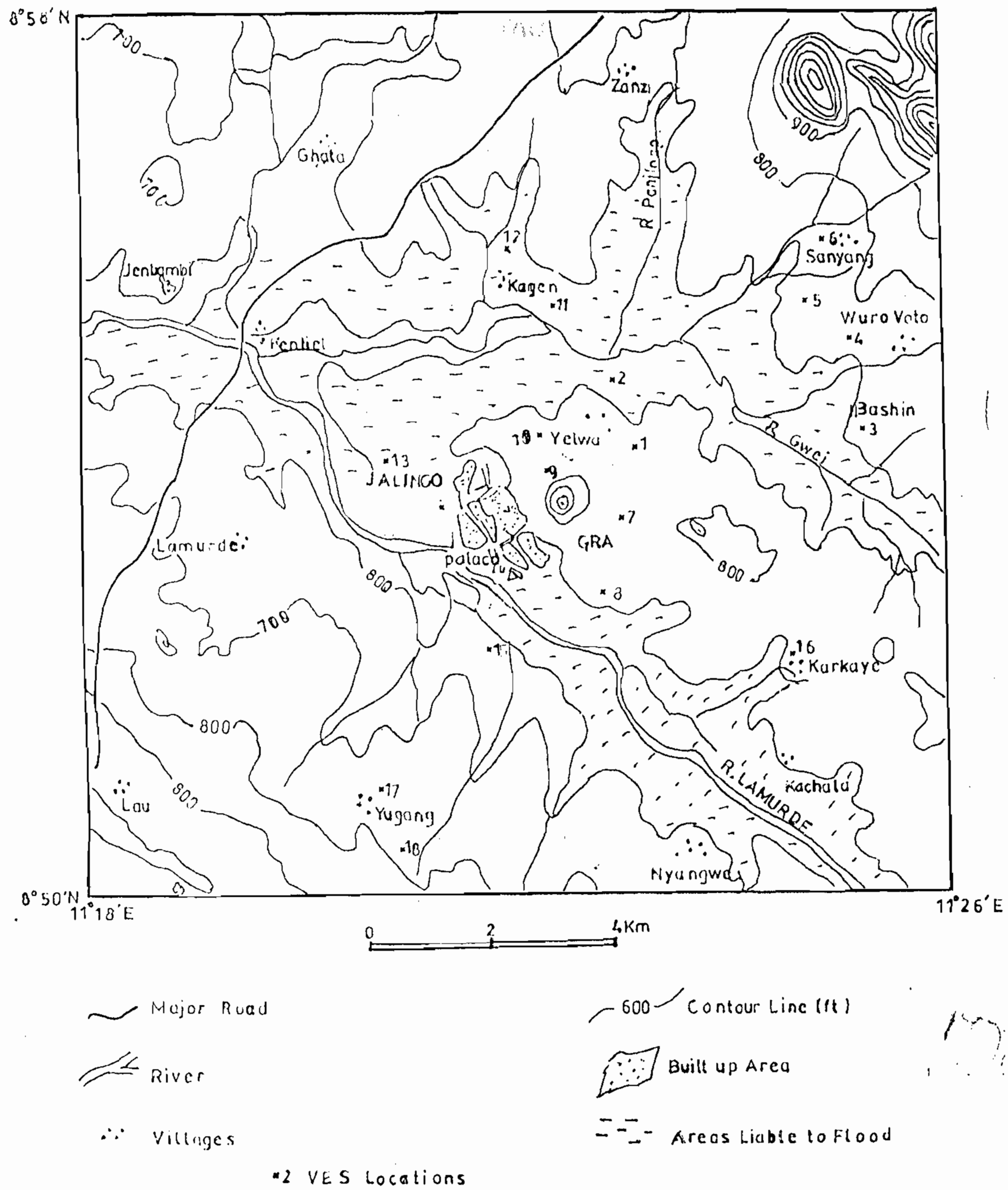

FIG. 1. TOPOGRAPHIC MAP OF THE STUDY AREA (AFTER NGS,1970)

mainly granite, gneiss, quartzite, gabbros, diorite and migmatitic rocks (Carter 1963). Qaurtzites are commonly found inter-beded with biotite-gneiss or migmatite. They are often feldspatic containing highly kaolinised plagioclase and occasional microcline in finely granular quartz matrix.

The Older Granite

They are found in the northern part of Jalingo town (fig.2), and are mainly pegmatite, prophyritic-granite, granodiorites and biotite. The older granite is coarse to very grained with large white or pink prismatic phenerocrysts, and this largely determine the colour and texture of the rocks.

The Undifferentiated Metasediment

These rocks have been metamorphosed at least two tectonic metamorphic cycles and largely migmatites and granite gneiss.

The Alluvium deposits are derived from the weathered up hill basement rocks, transported and deposited along the riverbanks in the study area (Fig.2). They consist mainly of fine and/or medium grained sand and clay.

Hydrogeology

Groundwater estimation in an area

requires accurate data of aquifer parameters such as water level, hydraulic conductivity, storage coefficient and transmissivity (Uma et al. 1989). The major sources of surface water in the area are from rainfall, and there are seasonal Rivers Lamurde and Gwei (Fig.1). These rivers have their peak discharge in the months of August and September, and they very dry in the months of January and February. Aquifer unit in the study area is mainly from the weathered/fractured basement is dependent to perennial supplies from boreholes. Poor infiltration of surface water flow during rainy season resulting into shallow water table conditions because these rocks are mainly low permeability in the study area. Water samples were collected and analyzed, and the results obtained are present in Table 2.

DATA COLLECTION AND INTERPRETATION

Eighteen Schlumberger Vertical Electrical Soundings (VES) were carried out using an ABEM Terrameter 300C and current of 12-volt Universal DC/AC converter that was pulsed with frequency of 5Hz. The data used for this work was obtained from Taraba State Rural Water Supply and Environmental Sanitation Agency (WES) who acquired originally in October 1993 for the rural water project in Taraba State. The apparent resistivity obtained from the field was plotted on a log-log graph paper and show the presence of three or four layer model. The curve types found in the study area are of A, QH, H and HK. These types of curves are typical in the

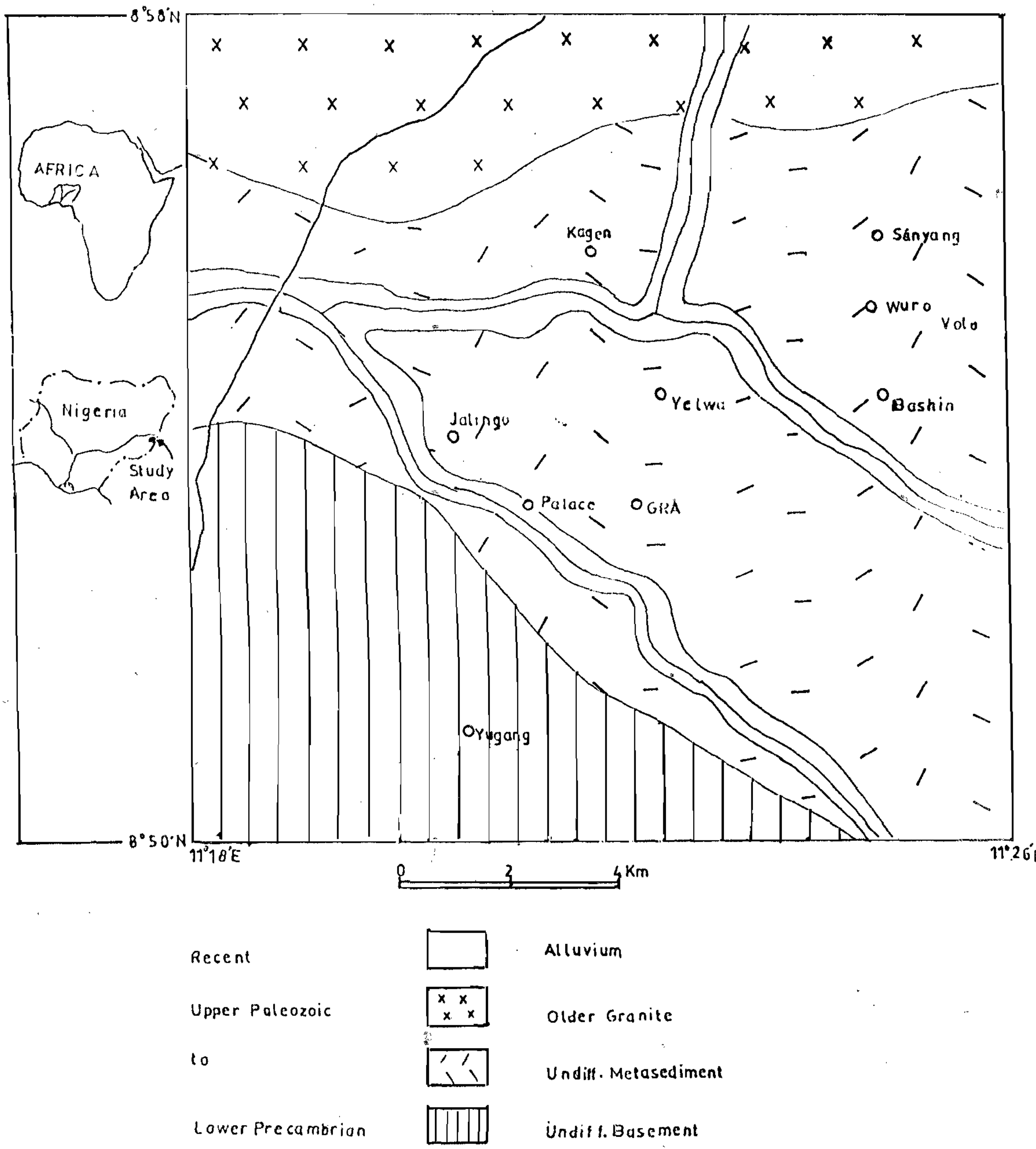

FIG. 2. GEOLOGIC MAP OF THE STUDY AREA (AFTER GEOLOGICAL SURVEY OF NIGERIA, 1994 EDITION)

TABLE 2. HYDRAULIC PROPERTIES OF WATER SAMPLES IN THE STUDY AREA.

Borehole Locations	Water Table (m)	Total Depth of Borehole (m)	Hydraulic conductivity (m/day)	Transmissivity (m^2/day)	pH
Yelwa (BH1)	11.00	50	1.12×10^{-1}	60.05	7.6
Bashin (BH2)	7.50	40	9.50×10^{-2}	19.00	5.8
Wuro Veto (BH3)	12.00	35	0.80×10^{-2}	36.75	6.0
GRA (BH4)	4.05	25	9.70×10^{-2}	24.45	6.8
Karkaya (BH5)	3.00	15	8.50×10^{-2}	46.20	7.5
Yugang (BH6)	5.27	21	1.21×10^{-2}	45.98	7.2
Mean	7.14	31	1.01×10^{-2}	38.70	6.82

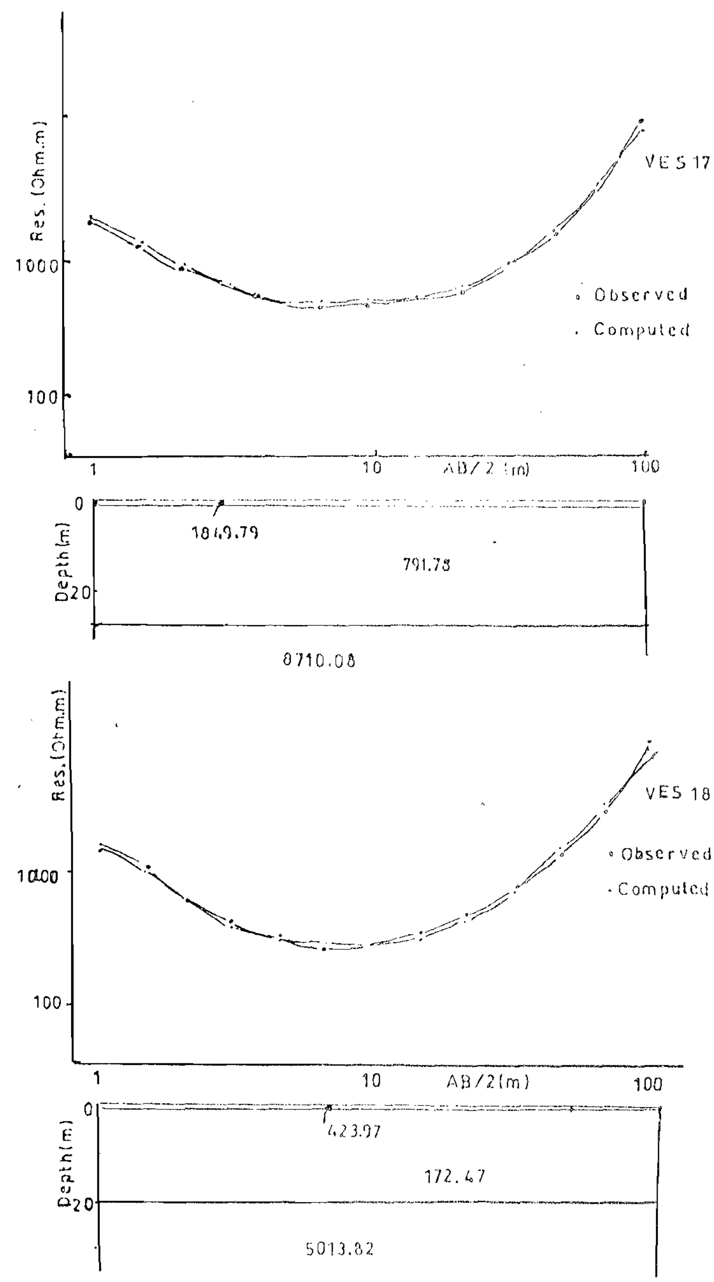

FIG. 3. EXAMPLES OF COMPUTER INTERPRETATION FOR VES17 AND VES 18.

basement complex area and can generally be interpreted as topsoil, saprolite and bedrock. The initial interpretation of the VES data was carried out using normal conventional partial curve matching technique utilizing a two layer master curve and auxiliary diagram. The resistivities and thicknesses of the eighteen vertical electrical sounding (VES) were used as initial input to a computer program (RESIST.FOR), which is based on optimization techniques. Details of the model parameters and the mathematical formulae used can readily be found in Mbonu et al. (1991), Nur et al. (2001). During the interpretation borehole information was also incorporated and the layered earth models from the vertical electrical sounding interpretation were kept as simple as possible. The results obtained from the computer modeling are presented in table 1 while figure 3 shows examples of two vertical electrical sounding (VES) and their interpretation.

DISCUSSION OF THE RESULTS

Isoresistivity maps are mainly used for qualitative geoelectrical interpretation. Depths to the current penetration into the ground among other things depend on the electrode spacing. The results from this study have been useful in the determination of the topsoil, weathered/fractured basement rocks in Jalingo metropolis and its environs. To understand better the situation in the study area, isoresistivity values corresponding to AB/2=10 and AB/2=50 meters were contoured as shown in figures 4a and 4b. In figure 4a, there are two major anomalies found. The first is located in the east of the study area (VES3), the highest resistivity value obtained was 1200 ohm.m. The second anomaly was found in the southwest of the study area (Yugang), the resistivity value recorded here is 900 ohm.m. The major part of the study area the resistivity values range between 100 ohm.m. to 200 ohm.m. The low

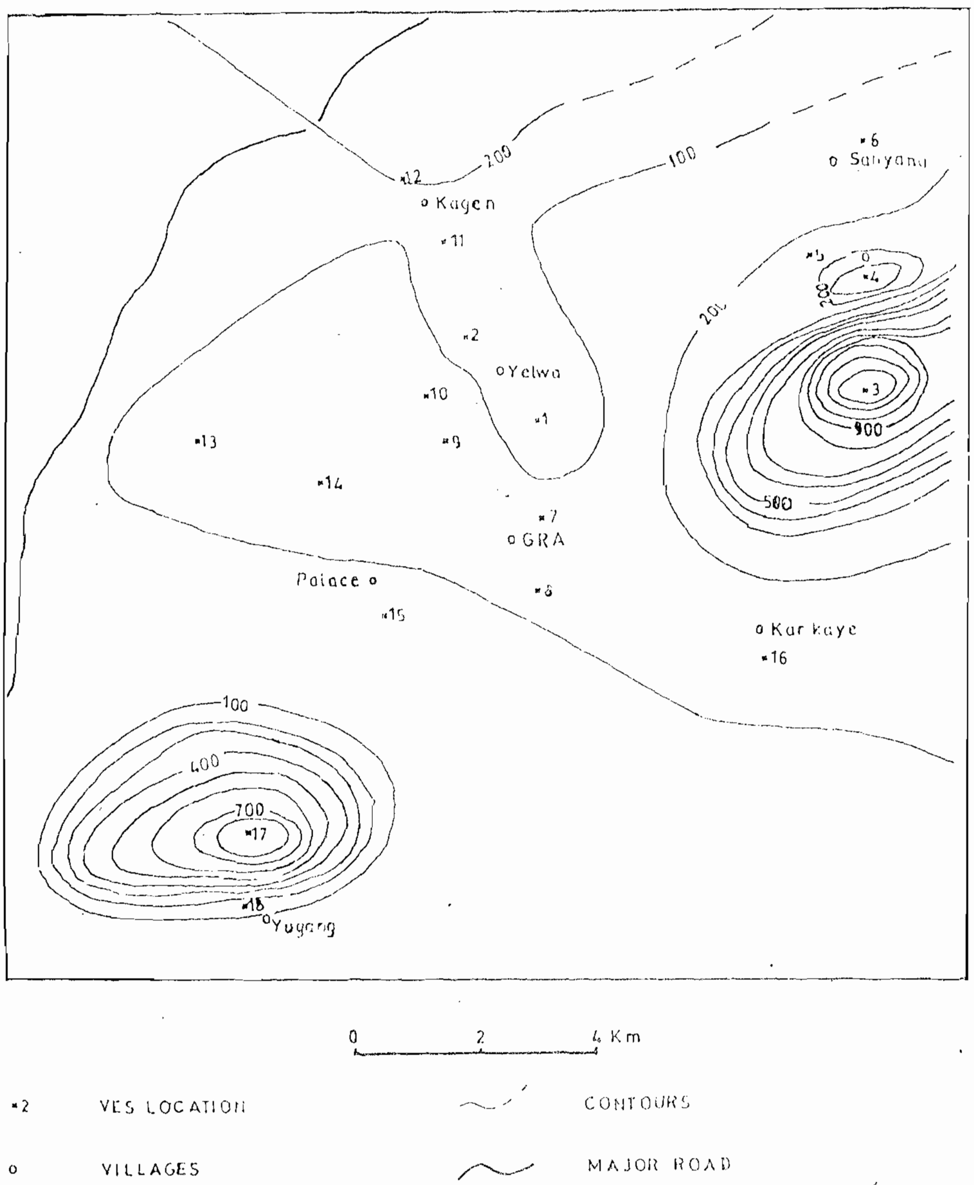

FIG.4a. ISO-RESISTIVITY MAP FOR AB/2 =10 M (CONTOUR INT. 100 OHM.M)

resistivity values represent the top 3 meters corresponding the clay/top soil in the study area.
Figure 4b, there are three anomalies at the depth of about sixteen meters. The first anomaly of NE-SW direction is located in the northeast (Wuro Veto) of the study area and the resistivity values decreases from 800 ohm.m. to 100 ohm.m. This anomaly has a length of about 5 km. The second anomaly has a nearly N-S direction and it is located at Yelwa area. The resistivity values of the anomaly decrease from 800 ohm.m. to 100 ohm.m. Third anomaly, the resistivity values increases from 400 ohm.m. to 1400 ohm.m. it is located in the southwest of the study area (north of Yugang). Since there are no vertical electrical soundings (VES) in the southeast and southwest of the study area, it was necessary to extrapolate the contour lines of the resistivity values.
The following three groups of electro-stratigraphic earth models were obtained from the analysis of the resistivity data in the study area (table1).

a) The first group, VES1, VES9 and VES10 there are five distinct earth model. The first layer has an average resistivity value of 167 ohm.m. and an average thickness of 0.4 meters. The second layer has an average resistivity value of 360 ohm.m. and an average thickness 2.2 meters. The third layer has an average resistivity value of 98 ohm.m. and an average thickness of 12 meters. The fourth layer has an average resistivity value of 130 ohm.m.

and an average thickness of 23 m. The fifth layer has an average resistivity value of 430 ohm.m.

b) The second group, VES3 and VES11 there are four-layer earth model. First layer has an average resistivity value of 488 ohm.m. and an average thickness of 0.6 m. The second layer has an average resistivity of 1038 ohm.m. and an average thickness of 3.4 m. the third layer has an average resistivity value of 234 ohm.m. and an a average thickness of 26.9 m. The forth layer has an average resistivity of 3201 ohm.m.

c) Thirteen soundings, which makeup about 72% vertical electrical sounding (VES) conducted, show a three electro-stratiphic earth models. The first layer has an average resistivity value of 519 ohm.m. and an average thickness of 1.2 m. The second layer has an average resistivity value of 174 ohm.m. and an average thickness of 16 meters. The third layer has resistivity value of 3833 ohm.m.

The results obtained from the resistivity data interpretation (table1) assisted in the delineation of the thicknesses of the topsoil and the

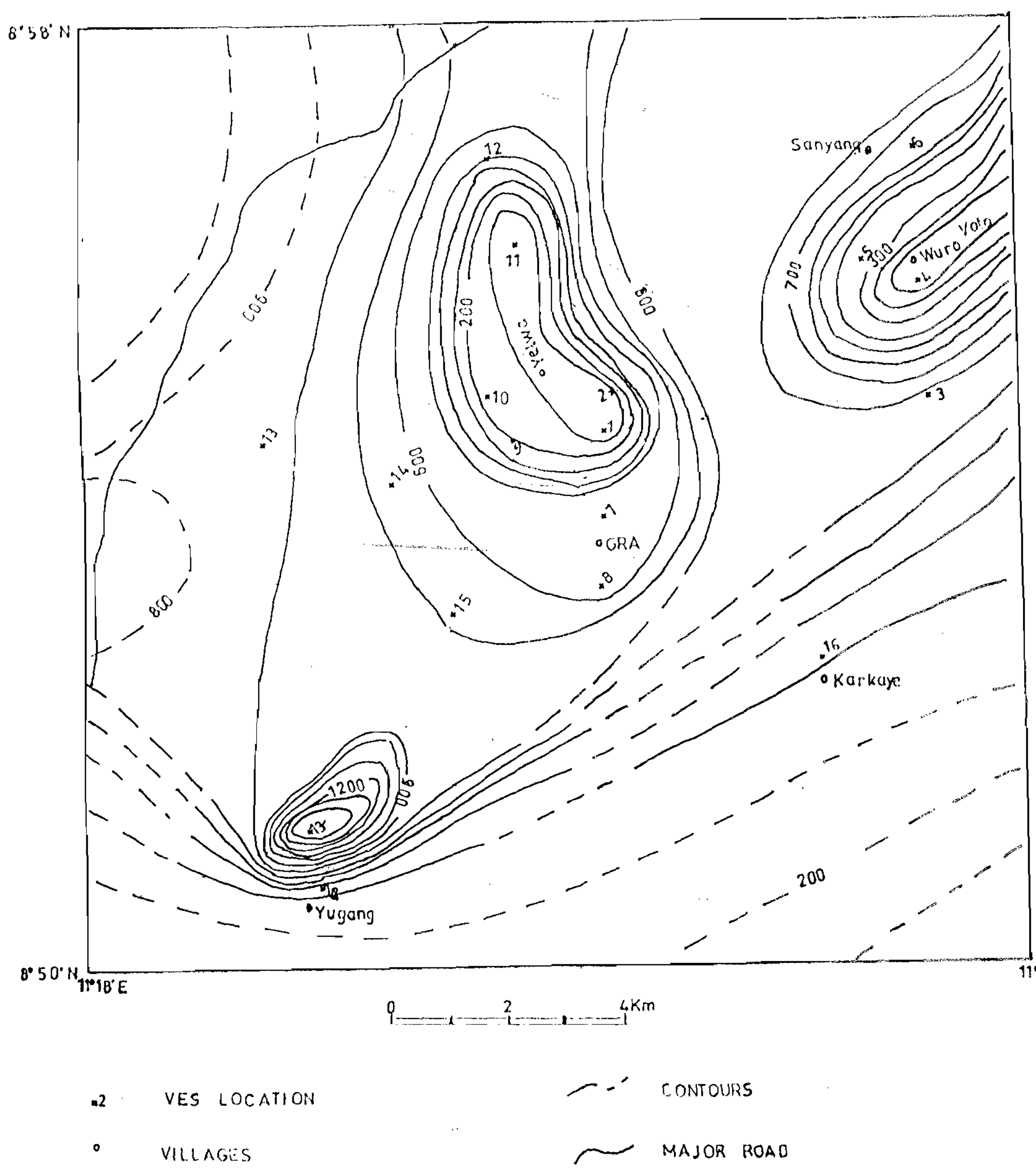

FIG.4b. ISO-RESISTIVITY MAP FOR AB/2 =50 M (CONTOUR INT. 100 OHM.M)

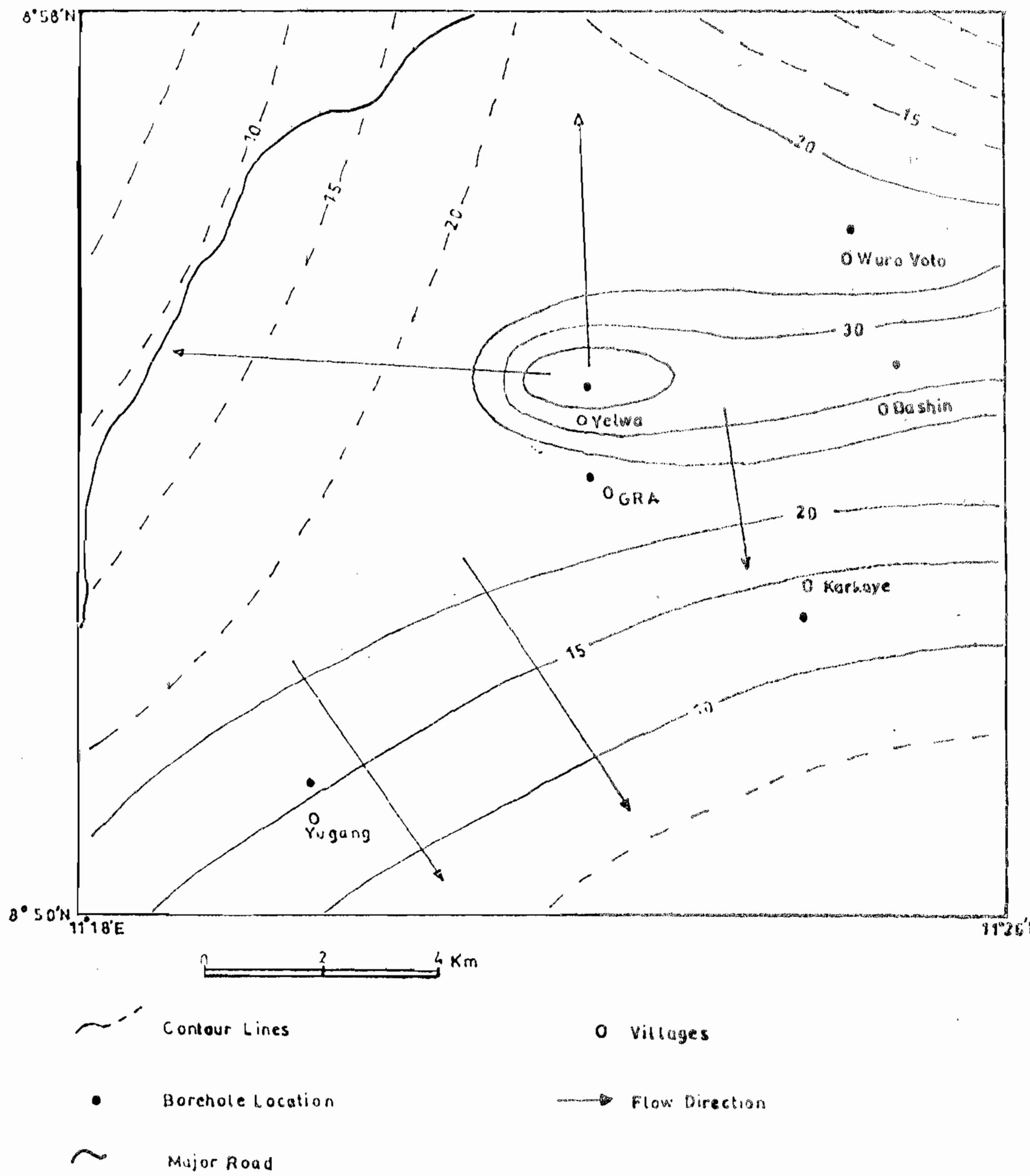

FIG.5. CONTOUR MAP OF HYDRAULIC HEAD VALUES OF SIX BOREHOLES IN THE STUDY AREA

weathered and fractured rocks, which in turn was used for the location of the drilled Boreholes in the study area. The aquifer unit was identified in the weathered/fractured basement of the study area, and has an average water table of 7.1 m (Table 2).

The hydraulic properties determined from statistical methods indicate a mean hydraulic conductivity (k) value of 0.1 m/day and a mean transmissivity (T) of 39 m^2 /day (table2). Comparisons made to the hydraulic conductivity (k) to Todd, 1980 and transmissivity (T) Gheoge, 1978 classifications, and it was found that the present results of k and T are relatively moderate.

Most of the water tested indicates pH value ranging from 5.8 to 7.2, which correspond to natural to slightly acidic water. According Obiefuna et.al., (1997), the fractured aquifer has low to moderate hydraulic conductivity and transmissivity values which give rise to low and moderate yield and specific capacities in boreholes tapping such aquifer system.

The hydraulic head map in figure 5, there is only one major hydraulic head identified in the middle of the study area (Yelwa). The flow direction is towards almost to all the directions. Most of northwest of the study area there are no borehole data available and as such available data was extrapolated in the entire area of study.

CONCLUSSION

Eighteen Schlumberger vertical electrical soundings (VES) were carried out in Jalingo and its environs of Taraba State. In the study area, 72% of the VES shows a three electro-stratigraphic earth model. Resistivity values less than 300 ohm.m. was obtained, and most of these are considered to a water bearing zones and therefore were targets for the drilling operations.

Six boreholes of mean depth of 31 meters were drilled in the study area. Water sample analysis indicates that a mean hydraulic conductivity value of 1.0 m/day, a mean transmissivity value of 39 m^2/day and an average pH value of 6.8 were also obtained. These values indicate that the water quality in the study area is good for human as well as industrial uses.

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