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

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ABSTRACT

Twenty-eight Schlumberger Vertical Electrical Soundings (VES) with maximum current electrode spread (AB/2) of 215 meter, conducted in Takum and its environs of Taraba State have been interpreted. The area falls within Latitudes 7°15'-7° 27' N and Longitudes 10° 00'-10° 15' E. From the study, 42% of the VES data indicate a three-layer geoelectric earth model, while the remaining 58% of the VES indicate four layer models. The first layer has an average thickness of 1.25 m, and an average resistivity value of 1716 ohm-m. The second layer has an average thickness of about 8.31 m and a mean resistivity value of 646 ohm-m. The third layer has an average thickness of 17.37 m and an average resistivity of 3187 ohm-m. The forth layer has a mean resistivity value of 6886 ohm-m.

Based on the resistivity survey, five boreholes of depth between 69 and 99 m were drilled in the study area. The water table of the boreholes drilled varied from 1.3 to 5.1 m. A relatively moderate mean transmissivity (T) value of 29 m^2/day, and an average hydraulic conductivity (k) value of 0.494 m/day, and pH value of 6.98 were also obtained.

INTRODUCTION

The need for the development of groundwater resources to meet up adequate domestic demands in local communities and residents in Takum and its environs of Taraba State called for pre-drilling geophysical survey. Alluvial deposits cover the major part in the east of the study area. The aquifer system of such rock types is the weathered and/or fractured basement rocks. Geo-electrical investigation is therefore essential before drilling activities take place in the study area.
Twenty-eight Vertical Electrical Soundings (VES) were carried out having maximum electrode spacing (AB/2) of 215 m. The study area covers Takum, Kuruku, Bika Babba, Ekas and a Military Base at about 4km Southwest of Takum town. The results obtained from the hydrogeoelectrical study of Takum and its environs will no doubt be a contribution to a better understanding of the aquifer systems in the study area.

CLIMATE, GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

Takum and its environs fall within a tropical climate marked by 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 moisture Laden wind brings rain to most parts of Nigeria including the study area. Takum is located in a region characterized by high and low lands. (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, Undifferentiated Metasediment, and Alluvium (Fig.2).
The undifferentiated basement rocks are found in the northern part of Takum. They have undergone weathering and laterization, which lead to unconsolidated laterite, silty-sand clay and gravel. The Undifferentiated basement complex consists mainly of diorite, granodiorite, and migmatitic rocks (Carter et al.1963). Qaurtzites are also commonly found inter-beded with biotite-gneiss or migmatite. They are often feldspar containing highly kaolinised plagioclase and occasional microcline in finely granular quartz matrix.
The Undifferentiated Metasediment rocks have been metamorphosed into migmatites and granite gneiss. They are found in the western part of the study area. The Alluvium deposits are derived from the weathered up hill basement rocks, transported and deposited along the riverbanks at the eastern part of the study area (Fig.2). They consist mainly of fine and/or medium grained sand and clay.

Hydrogeology

Groundwater evaluation 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 these are seasonal. The rivers have their peak discharge in the months of August and September, and they are dry in the months of January and February. Aquifer unit in the study area is mainly the weathered/fractured basement. Poor infiltration of surface water during rainy season results in shallow water table conditions because these rocks have low permeability.

DATA COLLECTION AND INTERPRETATION

Twenty-eight 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 raw data for this work was collected out by China Geo-Engineering Corporation (CGC Nigeria Ltd) in 1994. The apparent resistivity data obtained from the field were plotted on log-log graph paper. The curves are of three or four layer type. The curve types found in the study area are of A, QH, H and HK. These type curves are typical of the basement complex area and can generally be interpreted as topsoil, saprolite and basement bedrock. The initial interpretation of the VES data was carried out using partial curve matching technique with two layer master curves and auxiliary diagram. The resistivities and thicknesses of the twenty-eight vertical electrical sounding (VES) were used as initial input into 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 and Ayuni (2004) and Nur et al. (2001). During the interpretation, borehole information were also incorporated and the layered earth

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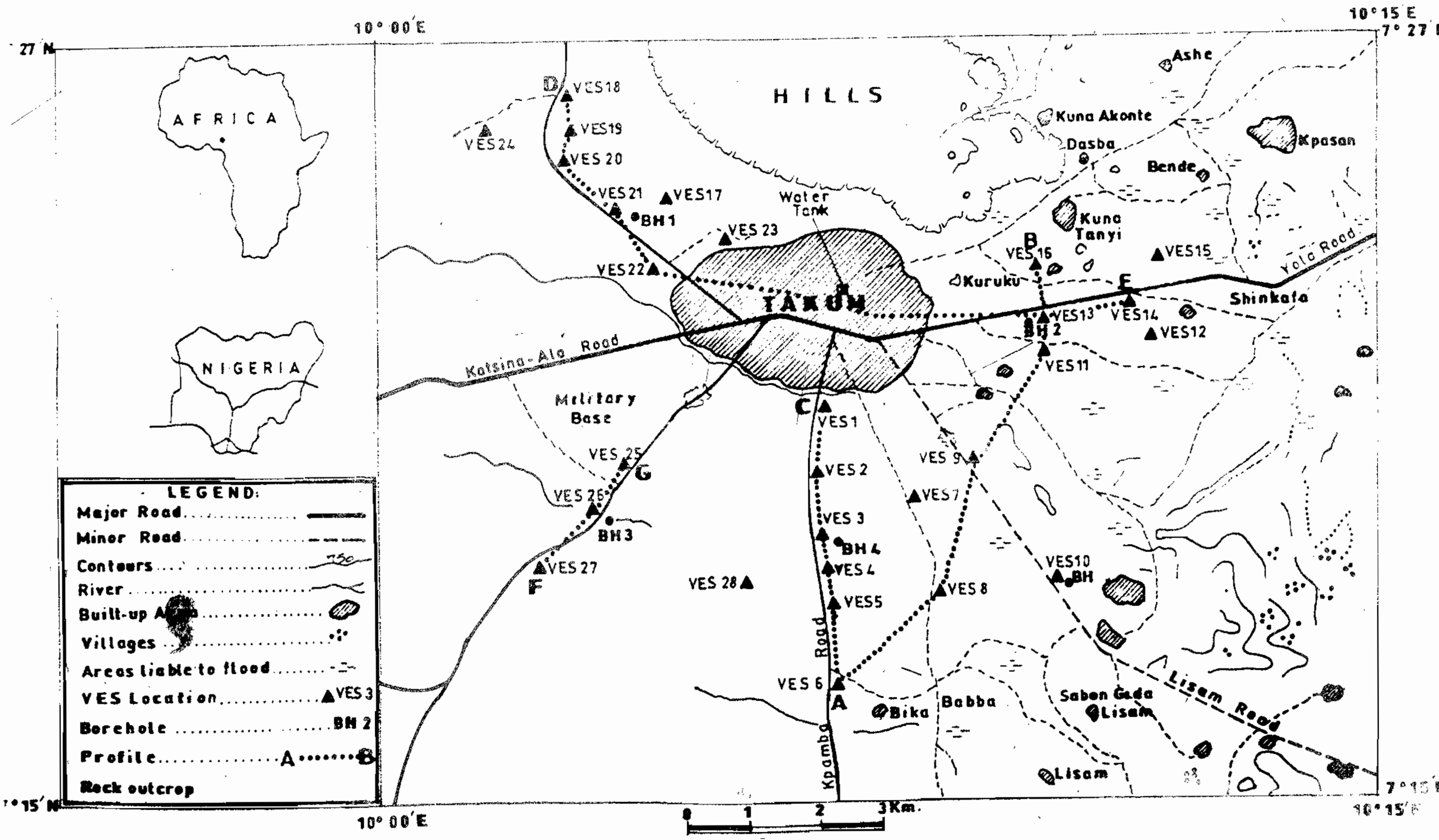

Fig. 1: Topographical map of the study Area. (After NGS 1974).

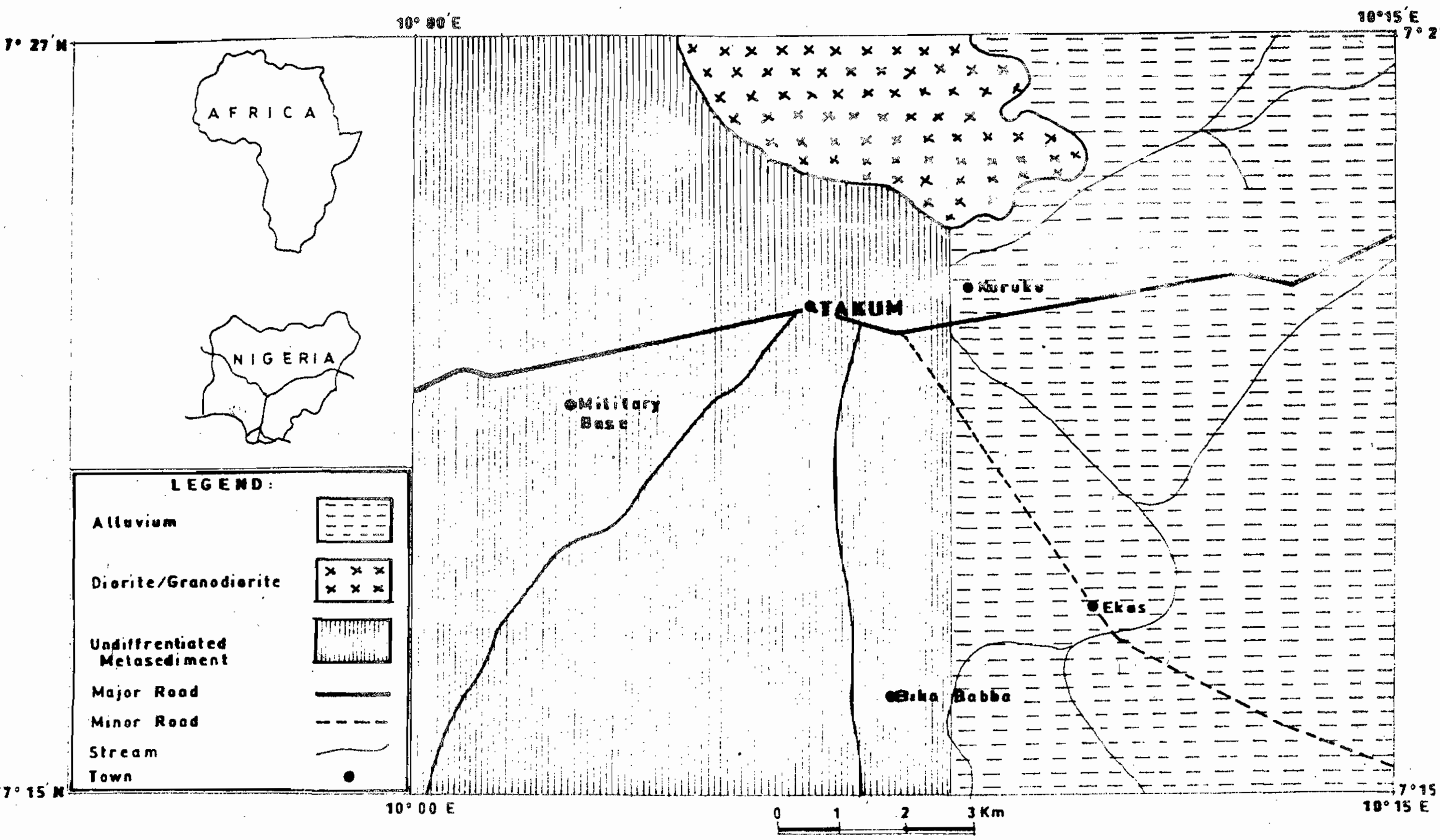

Fig. 2: Geologic map of study Area. (NGS 1974).

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 four vertical electrical sounding (VES) curves and their interpretation. Water samples were also collected from the five boreholes drilled in the study area and analyzed. The results obtained from the analysis are presented in Table 2. Correlation of lithologic logs of the boreholes is presented in Figure 5.

DISCUSSION OF THE RESULTS

The quantitative interpretation of the VES data has helped in the determination of the various depths to the basement bedrock in the study area. The VES interpreted results are summarized in Table 1. These results have helped in the identification of the topsoil, weathered/fractured basement rocks in Takum and its environs. From Table 1, 42% of the VES curves display a three geo-electrical earth model, while the remaining 58% display four-layer model. 2-D geo-eclectric section along profile A-B is presented in Figure 4a. The weathered/fractured basement is over 23 m thick beneath VES 8,9,11 and 13. Figure 4b (Profile A-C), shows thick compacted Clay. Maximum of five layers were obse ved below the profile D-E. The overburden here is over 35 m thick. Profile F-G (Figure 4d), has overburden thickness is less than 20 m. The results obtained from the resistivity data interpretation (Table1) and geoelectric sections in Figure 4 have assisted in the delineation of the thicknesses of the topsoil the weathered and fractured rocks, which in turn were

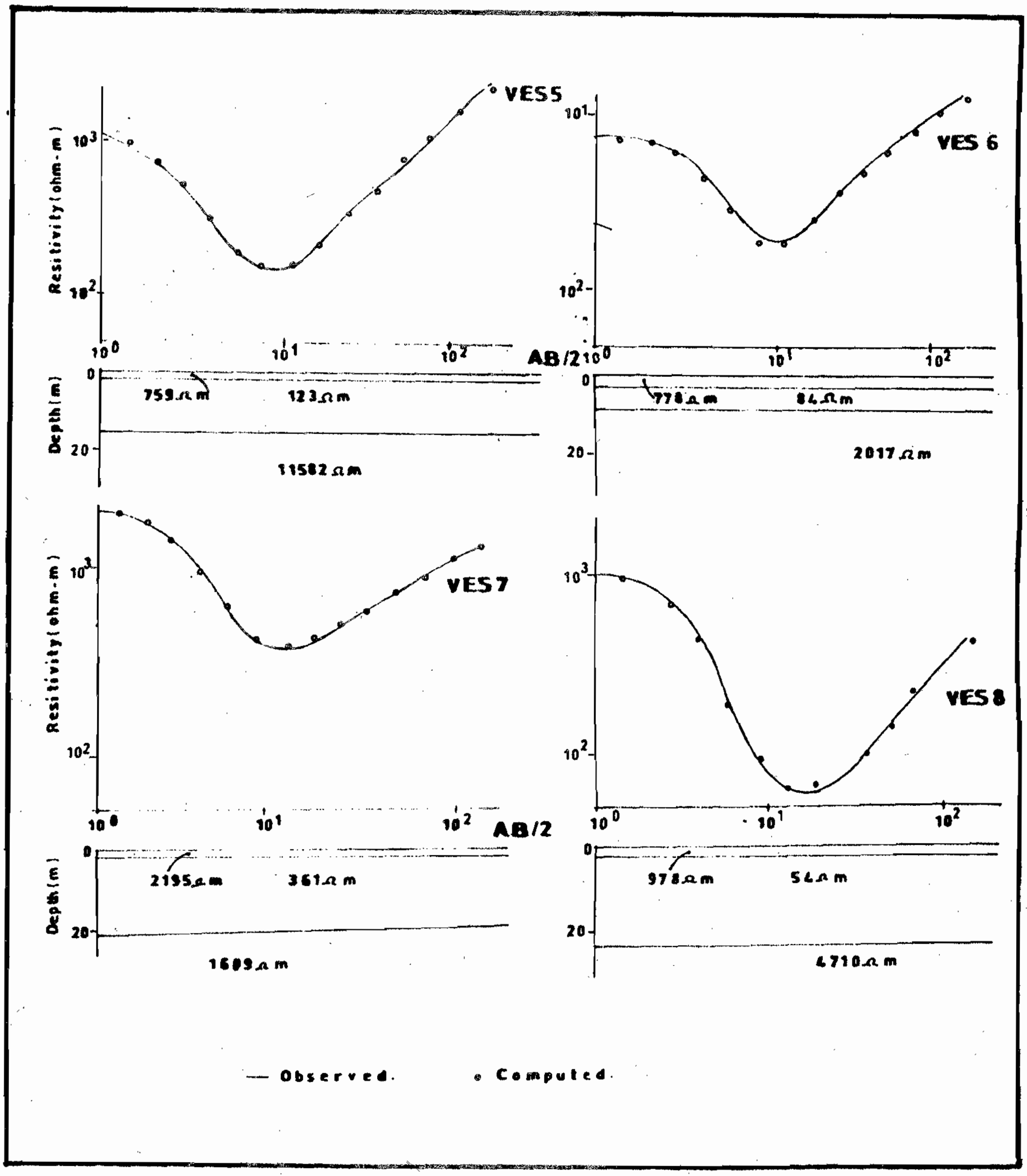

Fig. 3: Examples of computer interpretation in the study Area.

TABLE 1: SUMMARY OF RESULTS OBTAINED FROM THE COMPUTER OUTPUT OF THE TWENTY-EIGHT (28) VES IN THE STUDY AREA.

VES	Thickness of Layers (m)			Resistivity of Layers (ohm.m)				Resistance (ohm)			Conductivity (Seimen)			Fitting Error
	H1	H2	H3	ρ1	ρ2	ρ3	ρ4	σ1	σ2	σ3	R1	R2	R3	%
VES1	0.87	1.35	19.55	313.3	1492.2	78.8	4538.0	272.8	2020.9	1540.2	0.003	0.001	0.248	5.1
VES2	0.13	2.84	11.81	756.3	1371.3	88.0	6255.0	97.6	3889.3	1039.3	0.001	0.002	0.134	5.4
VES3	0.32	2.73	23.32	659.2	1382.5	148.7	26255.7	213.0	3775.0	3466.7	0.001	0.002	0.157	4.9
VES4	0.28	3.35	11.04	350.0	1785.0	36.4	3144.4	99.0	5978.3	402.1	0.001	0.002	0.303	6.3
VES5	1.49	13.24	-	758.8	123.0	11852.3	-	1129.5	1627.9	-	0.002	0.108	-	4.8
VES6	2.58	5.50	-	777.6	83.5	2017.2	-	2006.2	459.2	-	0.003	0.066	-	4.4
VES7	1.90	18.50	-	2195.4	361.0	1609.2	-	4171.3	6672.5	-	0.001	0.051	-	4.7
VES8	2.25	22.88	-	978.4	54.2	4709.9	-	2198.5	1239.1	-	0.002	0.422	-	4.1
VES9	0.03	2.48	19.80	589.9	729.0	98.1	1986.0	16.2	1810.7	1943.0	0.001	0.003	0.202	5.8
VES10	1.88	1.60	4.53	566.8	389.3	45.3	2579.5	1065.7	624.0	205.0	0.003	0.004	0.100	4.8
VES11	2.58	20.71	-	590.4	67.6	21447.0	-	1522.5	1398.7	-	0.004	0.307	-	5.3
VES12	1.43	9.08	19.63	1693.4	749.4	131.1	7113.6	2421.2	6807.7	2574.2	0.001	0.012	0.150	6.5
VES13	1.78	23.83	-	1035.4	171.2	12561.1	-	1843.0	4078.8	-	0.002	0.139	-	5.3
VES14	1.35	2.55	14.09	1956.6	638.2	43.2	9164.0	2345.4	1626.4	608.3	0.001	0.004	0.342	6.6
VES15	1.16	1.66	12.53	1755.0	480.5	80.6	4897.0	2032.8	799.9	1010.3	0.001	0.003	0.155	5.2
VES16	1.79	3.51	-	2617.6	208.2	1811.1	-	4673.6	731.8	-	0.001	0.017	-	2.9
VES17	0.80	1.90	16.20	274.1	875.0	47.3	10043.8	219.3	1662.5	766.3	0.003	0.002	0.342	4.4
VES18	0.55	2.74	41.04	2236.5	492.1	229.1	9189.0	1228.1	1346.5	9401.7	0.001	0.006	0.179	6.4
VES19	0.40	3.80	15.40	365.4	386.5	80.1	6857.4	146.2	1468.7	1233.5	0.001	0.009	0.013	5.5
VES20	1.82	27.43	-	1081.3	130.2	8699.5	-	1966.9	3573.0	-	0.002	0.211	-	6.1
VES21	1.18	0.89	12.76	298.1	889.0	61.3	7225.7	350.3	794.2	781.6	0.004	0.001	0.208	2.7
VES22	0.38	3.08	27.25	658.6	2092.4	85.5	2445.0	235.3	6436.4	2330.6	0.001	0.001	0.319	5.2
VES23	0.21	2.08	17.56	799.4	2380.6	101.7	5382.8	169.7	4958.3	1784.7	0.003	0.001	0.173	4.0
VES24	1.01	11.74	-	829.9	192.7	14079.3	-	838.7	2263.0	-	0.001	0.061	-	6.0
VES25	0.97	8.81	-	555.7	130.7	3257.1	-	540.8	957.2	-	0.002	0.081	-	4.8
VES26	1.64	1.30	11.35	567.2	268.0	47.3	3105.2	931.4	347.8	536.3	0.003	0.005	0.240	7.6
VES27	1.91	13.57	-	1979.3	152.7	4029.0	-	3783.6	2071.8	-	0.001	0.089	-	5.9
VES28	2.39	19.41	-	831.1	204.6	1749.8	-	1984.8	3969.8	-	0.003	0.095	-	7.0
Mean	1.25	8.31	17.37	1716.1	645.5	3186.6	6886.4	2726.6	2967.0	1851.5	0.002	0.060	0.200	5.4

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

Borehole Locations	Water Table (m)	Total Depth of Borehole (m)	Aquifer Thickness (m)	Hydraulic conductivity (m/day)	Transmissivity (m^2/day)	pH
Bika Babba	1.34	93	64	0.38	24.40	6.8
Ekas	5.10	78	54	0.68	36.50	7.0
Kuruku	4.78	72	50	0.24	12.00	6.7
Takum	3.65	69	62	0.39	24.00	7.2
Military Base	4.50	99	59	0.78	46.20	7.1
Mean	3.87	82.2	57.8	0.494	28.62	6.98

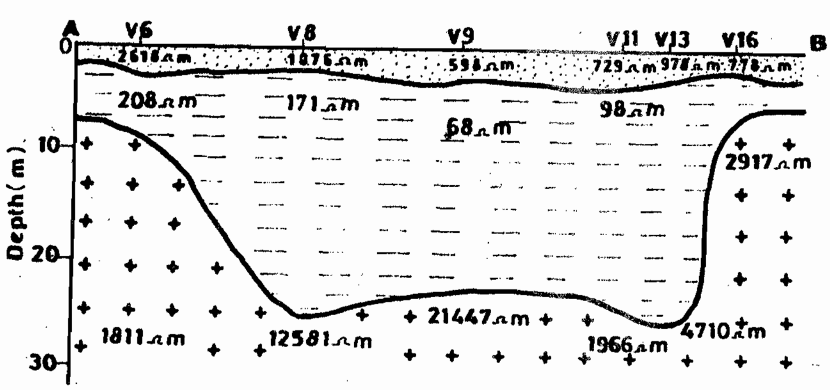

Fig.4a:2D Geo-electrical section beneath VES 6, 8, 9, 11, 13, 16.

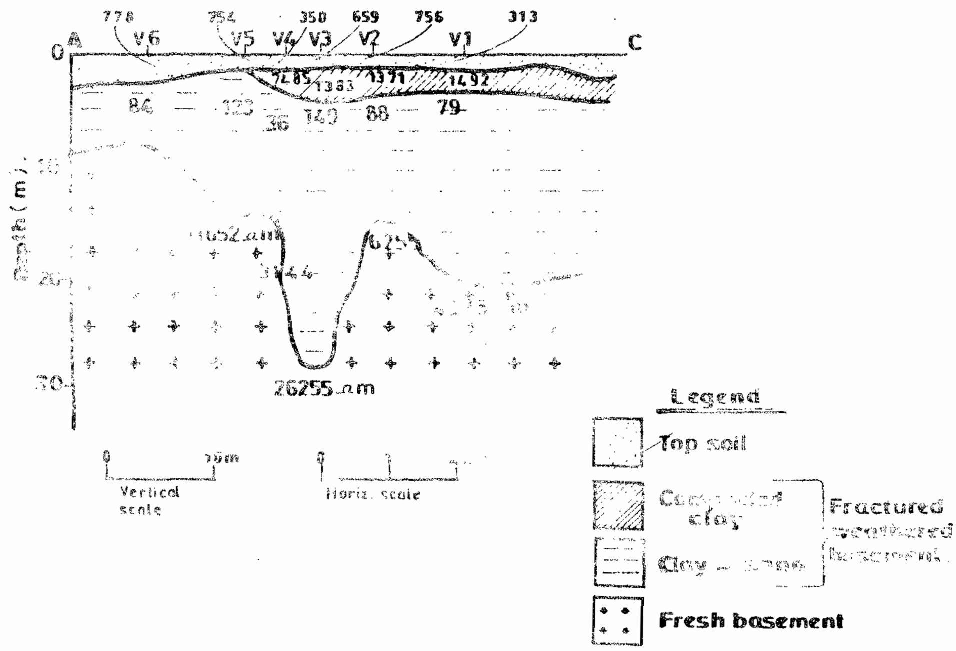

Fig. 4b: 2D Geo-electrical section beneath VES 1-6.

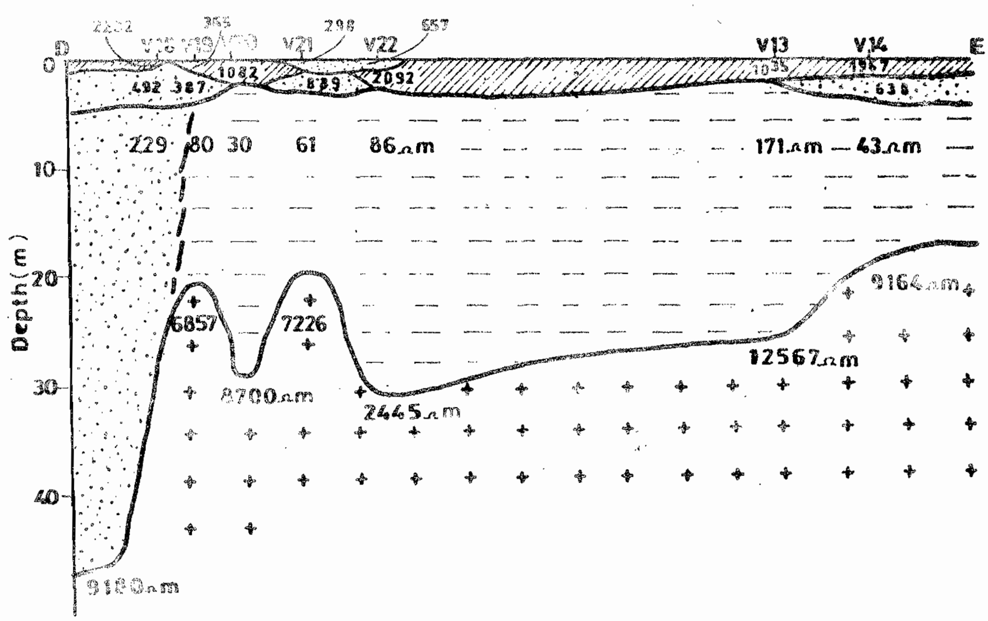

Fig. 4c: 2D Geoelectrical section beneath VES 13,14 and VES 18-22.

used for the locating the five boreholes drilled in the study area. The weathered/fractured basement aquifer unit has an average static water table of 3.9 m (Table 2). Figure 5 shows the correlation of lithologic log of the five wells drilled in the area of study. All the boreholes penetrated into the fresh basement except BH1 at Takum, where the drilling was terminated within the fractured basement.

The hydraulic properties determined from statistical methods indicate a mean hydraulic conductivity (k) value of 0.494 m/day and a mean transmissivity (T) of 29 m^2 /day (Table2). Comparison of the above with the hydraulic conductivity (k) (Todd, 1980) and transmissivity (T) (Gheoge, 1978 classifications) shows that the present results of k and T are relatively moderate. According to Obiefuna et.al. (1997) and Nur and Afa (2002), 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.

CONCLUSSION

Twenty-eight Schlumberger vertical electrical soundings (VES) were carried out in Takum and its environs in Taraba State. In the study area, 42% of the VES showed three layers

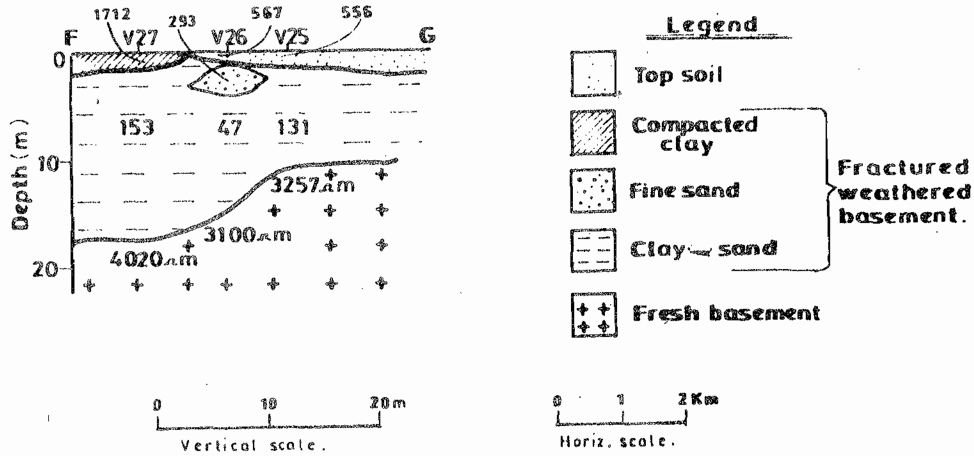

Fig. 4d: 2D Geo-electrical section beneath VES 25-27.

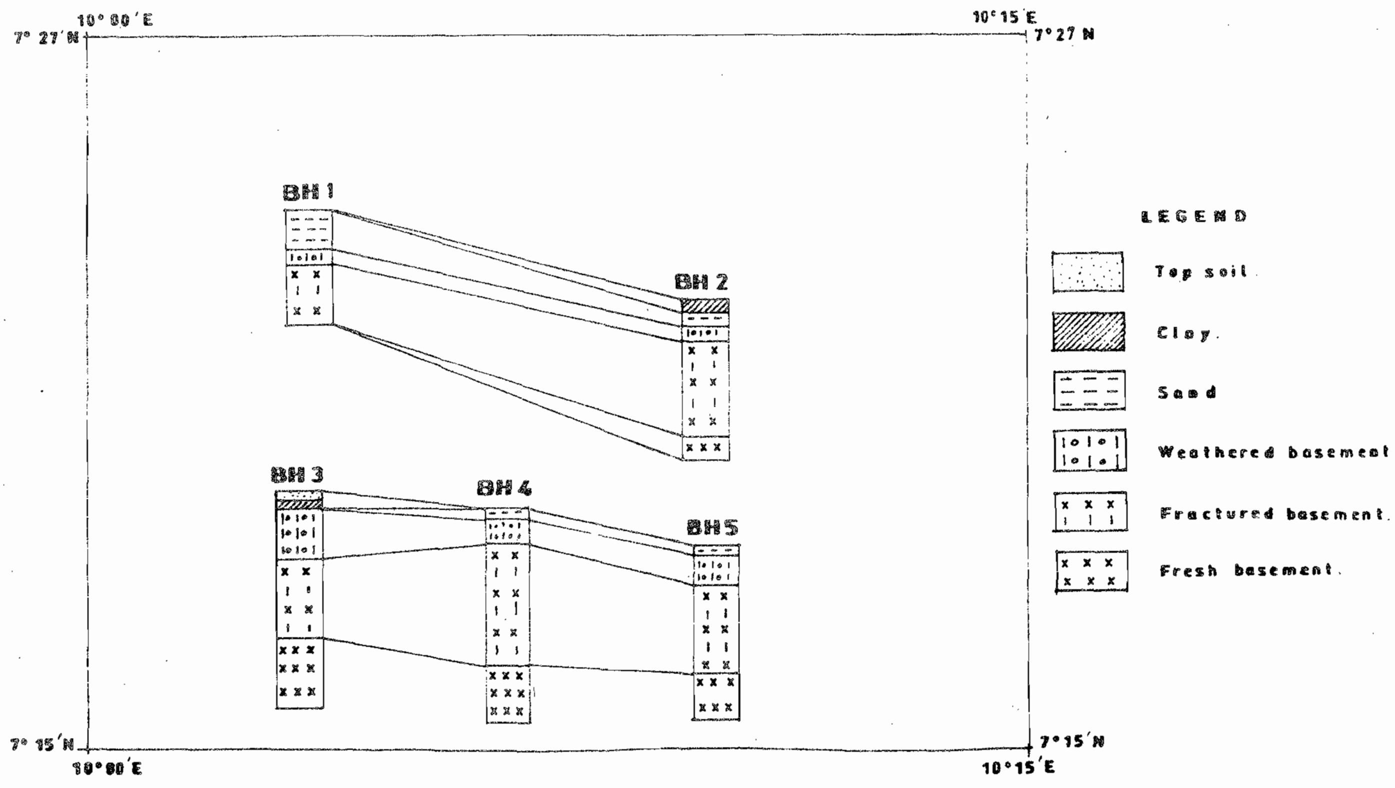

Fig. 5: Correlation of Borehole lithologic logs in the study Area.

earth model, while 58% of the VES showed four layer model. These basically indicate topsoil, weathered/fractured basement and the fresh basement. Areas where the resistivity values less than 600 ohm-m in the study area are considered as potential water bearing zones and therefore are targets for the drilling operations. The five boreholes drilled in the area penetrated up to the fresh basement except Borehole (BH1) at Takum town. A relatively moderate mean transmissivity of 29 m^2 /day, a mean hydraulic conductivity of 0.494 m/day and an average pH value of 6.98 were obtained.

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