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A GEOELECTRIC MAPPING OF IJAPO, AKURE SOUTHWEST NIGERIA AND ITS HYDROGEOLOGICAL IMPLICATIONS.

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ABSTRACT

Geoelectric resistivity sounding has been carried out at Ijapo Estate, Akure, Southwest Nigeria an area underlain by Basement Complex Rock. A total of 30 VES stations were occupied using Schlumberger electrode array. A maximum of four to five geoelectric layers – Topsoil, Clayed sand / Sandy clay, Weathered rock, Fractured rock and Fresh bedrock were delineated. The aquifer unit is characterized by Sand/Sandy Clay of resistivity 100 – 843Ωm and thickness of 0.6 – 10.8m; Weathered rock of resistivity 19 - 129Ωm and thickness of 6.50 – 58.0m and fractured rock of resistivity 155 - 640Ωm and thickness of 5.40 – 30.30m. The depth to bedrock vary from 4.58 to 62.08m. Suspected fault zones and series of bedrock ridges and depressions were delineated from the structural map prepared for the area. The bedrock depressions delineated form groundwater collection centers suitable for sustainable groundwater development.

Key words: Geoelectric, Bedrock, Ridges, Depression, Groundwater.

INTRODUCTION

The geological and geophysical investigation had revealed the existence of discontinuities of basement aquifers which form the basis of detailed knowledge of the subsurface geology, its weathering depth and structural disposition. Similarly, geophysical method has found useful applications in groundwater investigation and geologic mapping in areas of aquifer delineation, saline water mapping, lithological boundary differentiation and determination of structural trends among others (Zohdy, 1974; Van Overmeeren, 1981).

The use of electrical resistivity method to detect the fractured zones in the basement complex geology has proved to be useful geophysical tool

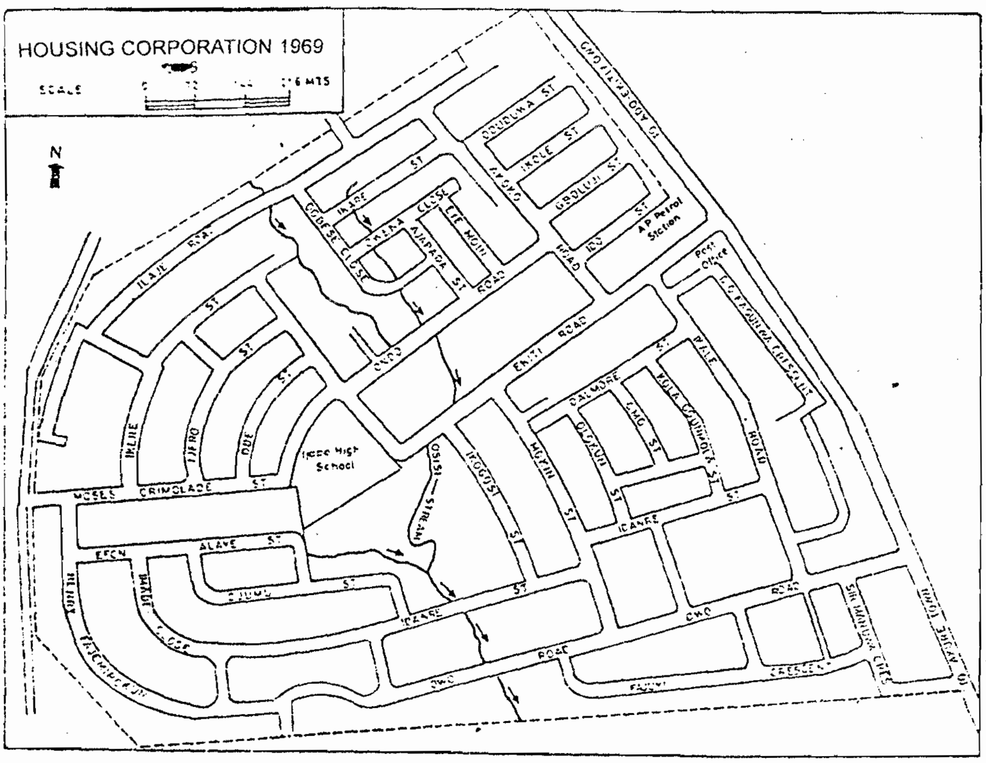

Fig. 1: General map of Ijapo Estate

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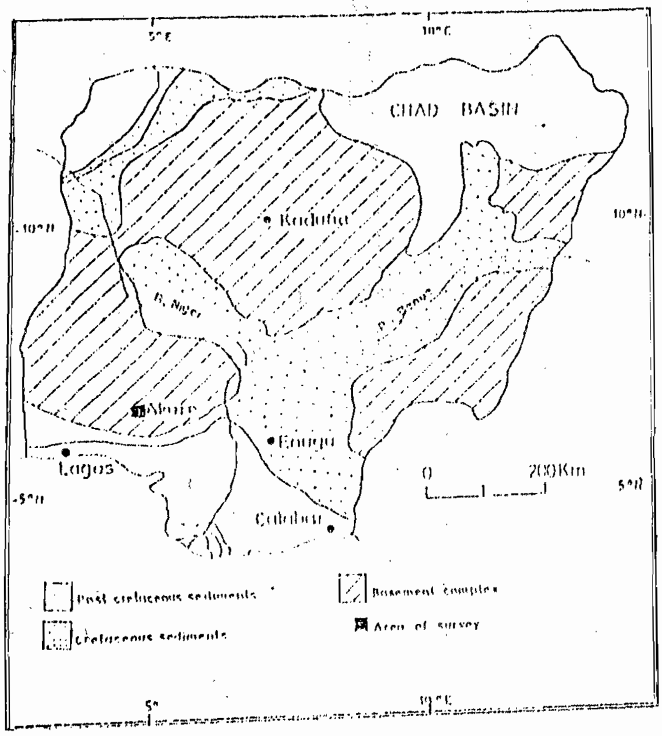

Fig. 2: Generalised Geological map of Nigeria showing the study area

because of its deeper investigation of the subsurface. Other areas of application include engineering and environmental geophysical investigations

The electrical resistivity method has been used for the determination of the depth to the bedrock, structural mapping and nature of the superficial deposit (Olorunfemi and Meshida, 1987; Olorunfemi and Okhue, 1992).

Ijapo Estate (fig. 1) in Akure, Ondo state located in the capital city in Southwest Nigeria occupies a large expanse of land (about $50km^2$) which is underlain by Precambrian basement complex rocks (fig. 2). In areas with basement complex rocks, waters are contained in the weathered and fractured zones (Hazell, et al, 1993; Olorunfemi et al 1999).

This study was therefore aimed at mapping the bedrock topography and the nature of superficial deposit in the study area using electrical resistivity method, thus, providing background information about the geoelectric parameters of the subsurface layers, the basement structures and the hydrology of the area.

PHYSIOGRAPHY

The study area and location of the sounding stations are presented in fig. 3. A network of motorable roads and footpaths make access to most parts of the area possible.

The area lies within latitude 7^0 13′ N and 7^0 17′ N and longitude 5^0 07′ E and 5^0 14′ E. The terrain is undulating, surrounded by isolated hills. The topographical elevations vary from 320 to 450m above the sea level (Owoyemi, 1996). River Ala and its tributaries drain the area. The drain pattern is dendritic flowing in N – S direction.

GEOLOGY AND HYDROGEOLOGY OF THE AREA

Rocks of the Precambrian basement complex underlie the Akure metropolis (fig. 2) of the Southwest Nigeria (Olorunfemi and Okhue, 1992 and Olorunfemi et al 1999). The major lithological units include the granite gneiss and migmatite gneiss (Olanrewaju, 1981). These rocks form isolated or residual hills and continuous ridges.

The area exhibit varieties of structural setting such as foliations, folds, faults, joints and fractures. The foliation trends of the area are NNW – SSE, the lineament of the rock in the area is E – W (Olorunfemi et al 1999).

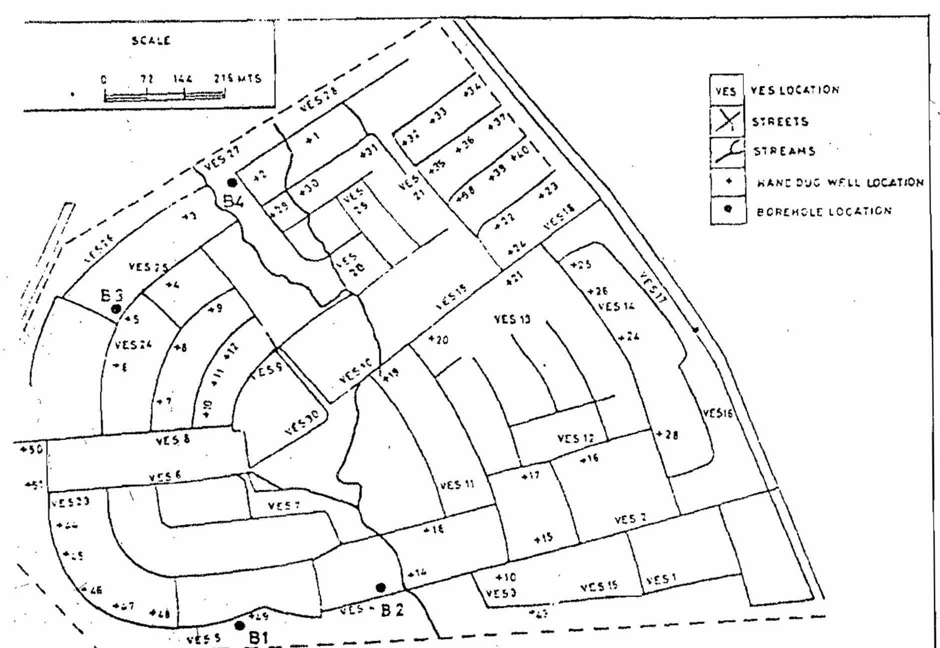

Fig. 3: Data Acquisition map of Ijapo Estate Akure

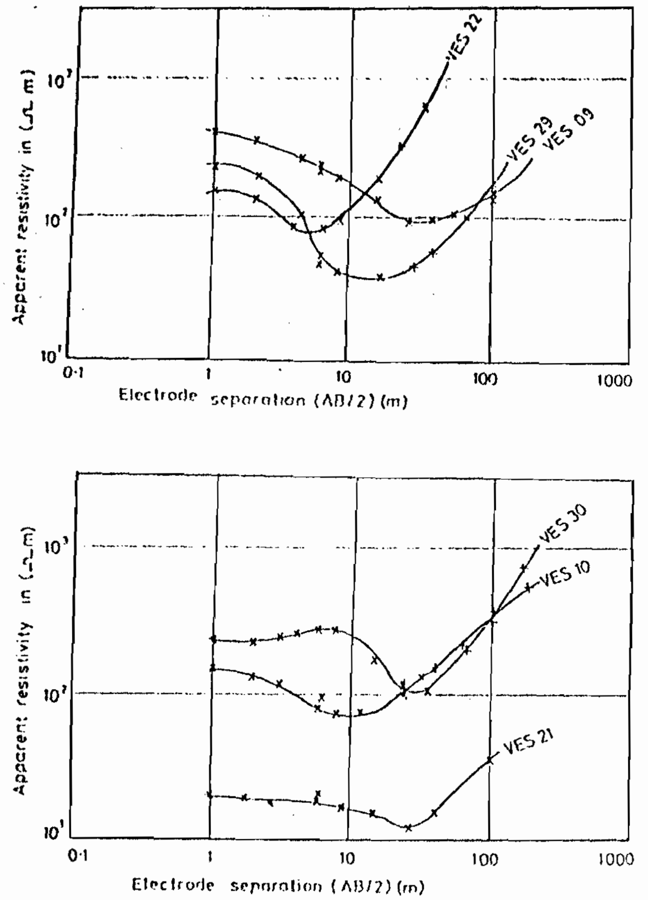

Fig. 4: Samples of Resistivity curve type obtained at the study area

Akure experiences high annual rainfall with a mean of 1333.2mm (Owoyemi, 1996). The vegetation is green, the outcrops of the solid rocks as granite gneiss hills and low lying bedded gneiss are common.

DATA ACQUISITION

Geophysical Investigation

A total of 30 Vertical Electrical soundings (VES) involving Schlumberger electrode array were carried out at eleven (11) localities within the estate (fig. 3). The maximum current electrode spacing (AB/2) of 150m was employed.

The ground resistance measurements were made using PASI E2 – DIGIT Terrameter units. Appropriate apparent resistivity values were obtained and plotted on log-log graph against current electrode separations.

The VES curves obtained, examples of which are shown in fig. 4 were quantitatively interpreted by partial curve matching method.

The theoretical VES curves were generated from partial curve matching interpretation results (thickness and resistivity) using a RESIST computer iterated program. The field curves were then compared with the computer generated curves, where a good fit was obtained between the field and computer generated curve, the interpreted results was considered satisfactory. Otherwise, the geoelectric parameters were modified as appropriate and the procedures repeated until a satisfactory fit was obtained.

RESULTS AND DISCUSSION

Static Water Level Map

The static water level measurements made from 46 hand-dug wells within the study area (fig. 3) show that depths vary from 2.0 – 19.0m. This is presented as map (fig. 5). The contour pattern is characterized by isolated closures typical of discontinuous basement aquifer system. An average thickness of 5.52m was shown in the NE-NW and SW directions. The higher values occurred at the eastern part of the study area while lower values were obtained at the south eastern end.

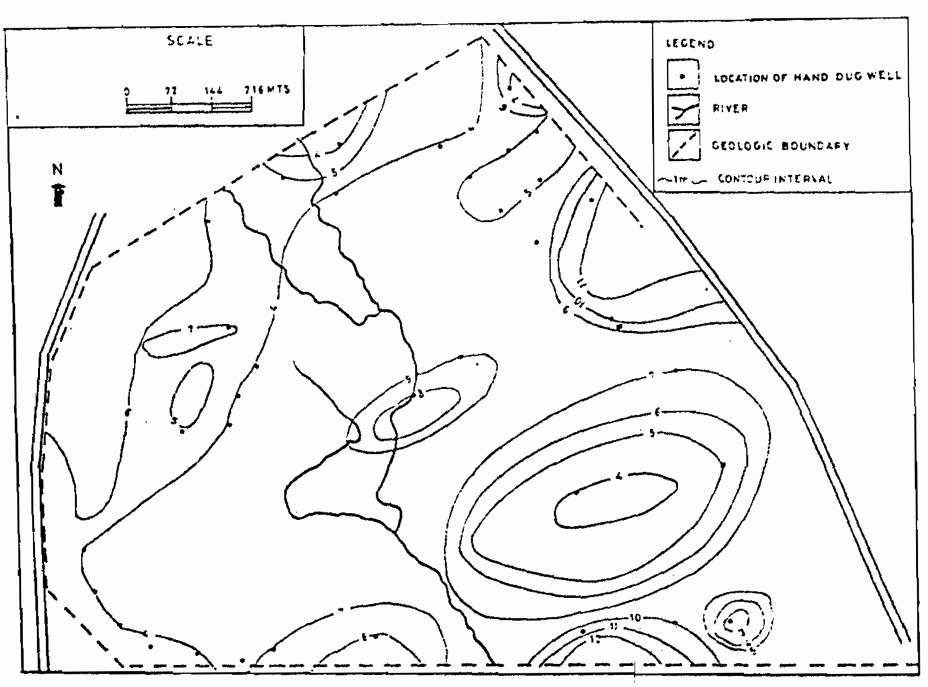

Fig. 5: Static Water Level map

Table 1: Summary of VES Results

VES Points	Layer Resistivity (Ωm)					Layer thickness (m)				Depth to bedrock (m)
	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	h_1	h_2	h_3	h_4	
1	360	240	213	3610	-	1.00	2.80	28.80	-	32.60
2	95	380	49	5148	-	0.85	3.80	29.76	-	34.41
3	250	167	19	1980	-	0.70	2.03	20.25	-	22.98
4	700	467	267	1470	-	0.75	1.50	21.72	-	23.97
5	85	57	440	∞		0.80	2.56	9.90	-	13.26
6	260	390	178	1400	-	0.85	2.13	9.90	-	12.88
7	220	330	62	1330	-	1.00	3.20	10.50	-	14.70
8	115	230	420	2160	-	0.80	2.80	20.80	-	24.40
9	460	307	129	1900	-	0.85	3.23	58.00	-	62.08
10	150	100	25	1482	-	0.90	3.60	6.50	-	11.00
11	210	172	32	1482	-	0.70	1.75	23.4	-	25.85
12	190	232	322	∞	-	0.90	10.80	30.30	-	42.00
13	300	245	567	60	2730	0.80	0.64	7.75	47.50	56.69
14	250	464	188	3800	-	0.70	1.75	13.00	-	15.45
15	460	376	640	7335	-	0.95	2.95	18.00	-	21.90
16	100	233	155	6240	-	0.85	4.25	14.00	-	19.10
17	200	244	330	5320	-	0.75	3.60	14.10	-	18.45
18	110	165	310	∞	-	0.85	4.25	21.00		26.10
19	1030	843	225	9750	-	0.85	5.10	12.60	-	18.55
20	200	300	213	39	1326	0.95	1.90	8.70	40.00	51.55
21	22	18	36	14	792	0.85	1.70	1.25	25.2	29.00
22	160	86	30	∞	-	0.85	2.98	0.75	-	4.58
23	140	93	165	420	722	0.80	0.51	2.80	14.70	18.86
24	150	183	510	207	∞	0.80	2.00	5.13	5.4	13.30
25	400	133	580	200	20790	0.80	2.80	8.10	15.00	26.70
26	225	184	1530	96	2565	0.80	1.2	4.41	4.2	10.61
27	250	83	26	2376	-	0.75	0.38	9.2	-	10.33
28	340	278	53	25	∞	1.20	2.16	0.63	24.00	27.99
29	250	167	27	28	3168	0.80	1.20	0.38	16.80	19.18
30	250	205	390	62	7920	0.80	0.60	5.70	18.50	25.60

Geoelectric Layers

A maximum of five geoelectric layers were delineated (Table 1) and are discuss below;

First layer: Topsoil composed of clay, sand/sandy clay, clayey sand and laterites with resistivity 22 – 1030Ωm and thickness 0.7 – 1.20m.

Second layer: Composed of clay / clayey sand with resistivity 18 - 93Ωm and thickness of 0.38 – 2.98m and sand / sandy clay of resistivity 100 - 843Ωm and thickness of between 0.60 and 10.80m. The sand / sandy clay layer form the aquifer unit from which most of the hand dug wells in the area tap their water while the clay / clayey sand layer overlies the weathered / fractured rock layer.

Third layer: Composed of clay / clayey sand of resistivity 27 - 53Ωm and thickness 0.38 – 1.25m; Weathered rock of resistivity 19 - 129Ωm and thickness

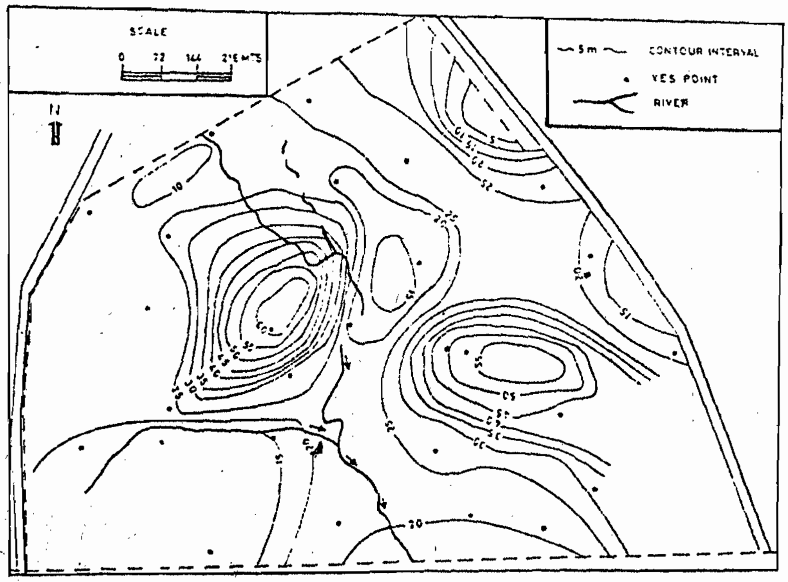

Fig. 6: Isopach map of the overburden

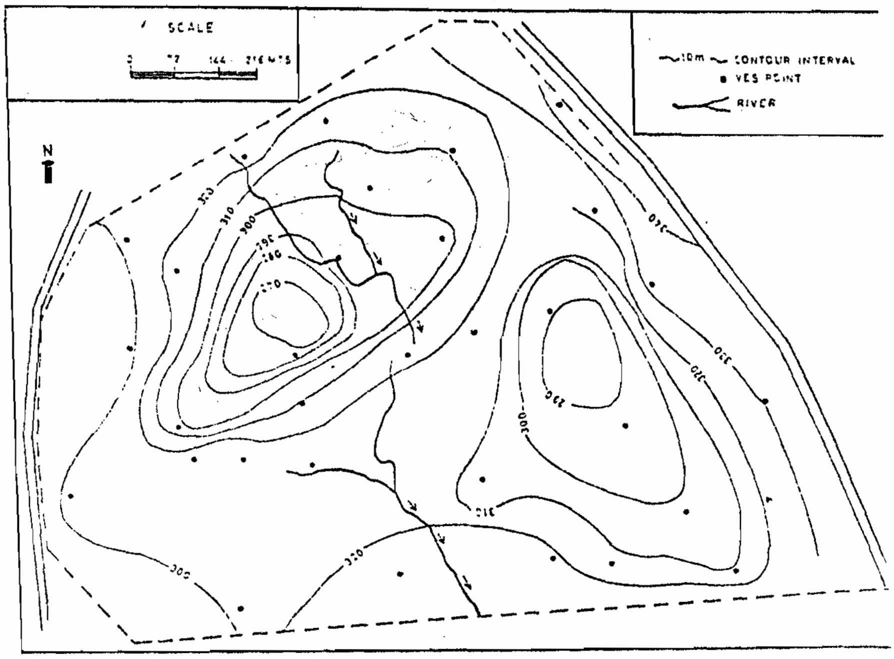

Fig. 7: Bedrock Relief map

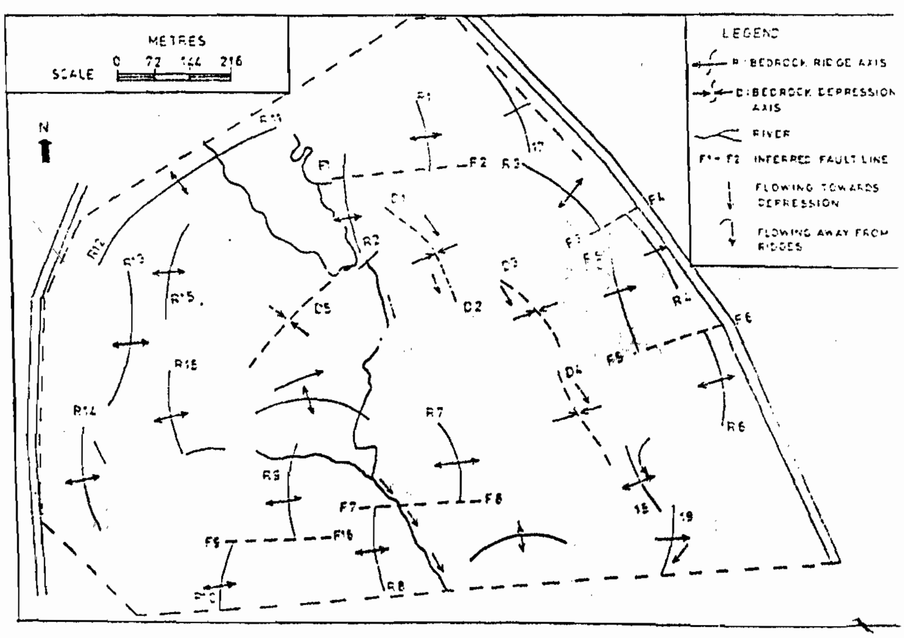

Fig. 8: Structural map

of between 6.50 – 58.00m; Sand / Sandy clay with resistivity range from 165 to 580Ωm and thickness of 2.80 – 8.10m and fractured rock with resistivity 155 – 640Ωm and thickness of between 9.90 and 30.30m. The weathered rock, sand / sandy clay, and fractured rock form the aquifer unit.

Fourth layer: Composed of fractured rock with resistivity range from 200 to 420Ωm having thickness of 5.40 to 15.00m represent the aquifer unit and the fresh bedrock with resistivity of 1330 - ∞ Ωm

Fifth layer: Composed of the fresh bedrock with resistivity of 722 - ∞ Ωm. The depth to bedrock in this area vary from 4.58 – 62.08m

Isopach Map Of The Overburden

The overburden is considered here as all the materials above the fresh bedrock at each of the VES locations. This is contoured as an overburden map (fig. 6) and reflects variation in thickness within the study area. The isopach map of the overburden shows a relatively thick overburden cover of 25 – 60m within a depression and relatively thin overburden cover of about 5 – 15m on the bedrock ridges. The bedrock depressions being groundwater collection centers are priority areas for groundwater development.

Bedrock Relief Map

The bedrock elevation beneath each of the VES stations was determined by removing the overburden thickness from the surface elevations at the VES stations to give the bedrock relief. Surface elevations were determined from the topographic map of the area as prepared by housing corporation, Akure.

The result was contoured to give the bedrock relief map (fig. 7) for the study area. The relief map is a reflection of the bedrock topography and shows bedrock ridges and depressions within the study area. The bedrock elevation of 304.0 – 343.0m were taken as bedrock ridges (R) while those of 272.0 – 299.0m were taken as bedrock depressions (D). The structural map (fig. 8) reflects the structural disposition with the axes of the bedrock ridges ($R_1 - R_{10}$) and depressions ($D_1 - D_5$). The major structural trends are approximately E – W. Ridges R_1 and R_2, R_3 and R_4, R_5 and R_6, R_7 and R_8 show a likelihood of being related, but have suffered deformations along their axes faulting along $F_1 - F_2$, $F_3 - F_4$, $F_5 - F_6$, $F_7 - F_8$ and $F_9 - F_{10}$. This is corroborated by the distortion of the contour lines (fig. 7) and the displacement of the axes $R_1 - R_2$, $R_3 - R_4$, $R_5 - R_6$, $R_7 - R_8$ and $R_9 - R_{10}$ about their suspected fault zones (fig. 8). These displacements may have resulted from the same tectonic activities in the past.

The bedrock depressions in a typical basement complex area are groundwater collection centers (Olorunfemi and Okhue 1992). The groundwater flows away from the crest of the bedrock ridges into the bedrock depressions. Bedrock depressions are therefore target area for groundwater development, most especially if they fall within a fractured zone. Similarly the courses of River Ala and its tributaries, of which Osisi stream is one, fall within some of the bedrock depression zones as depicted by D_1, D_2 and D_5.

CONCLUSION

A geoelectric mapping of Ijapo, housing estate, Akure, Southwest Nigeria and its Hydrogeologic implications has been reported in this paper. The analysis of 30 vertical electrical soundings carried out revealed the presence of four to five geoelectric layers with depth to bedrock of bewteen4.58 and 62.08m. The bedrock relief map and the structural map show series of bedrock ridges and depressions with major structural trends approximately E – W.

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