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Hydro-Geoelectrical Investigation Of Gwoza Town And Environs, Northeastern Nigeria.

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Abstract
Eighteen vertical electrical sounding (VES) of maximum electrode separation of AB/2= 100m were carried out in Gwoza town and environs Borno State, Northeastern Nigeria. All the VES data indicates a three layered earth model and the curves obtained are all H-type curves. The first layer is top soil with an average thickness of 1.59m and an average Resistivity value of 73.5 ohm-m. The second layer is weathered/fractured basement with an average thickness of 22.8m and an average Resistivity value of 19.7 ohm-m. The third layer is fractured basement except at VES3, VES5, VES10, VES12, VES13, VES14 and VES17 where fresh basement were encountered with an average Resistivity value of 1359.0 ohm- m. Geological and geophysical studies made it easy to locate feasible groundwater pockets like valley fills and weathered fractured zones in the study area. Geological structures are confirmed by geo-electrical survey which suggests bore wells should be drilled to a depth of 25-46m from ground surface.

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I. Introduction

The study area is located in Gwoza Local Government area of Borno State which falls within Northeastern Nigeria between longitudes 13' 33°E to 13' 47°E and Latitudes 11' 00°N to 11' 08°N. Domestic water supply in Gwoza and environs comes largely from the groundwater; much of this is taken from either the top soil where there is thick overburden or from the weathered/fractured basement.

Over the years, boreholes have been drilled with or without previous knowledge of the subsurface information, as a result of multiple failed boreholes, research grew up to minimize failed wells there by reducing the risk as well as cost of drilling. The use of geoelectric data method can give the approximate depth to aquifer, thereby making the cost of contract known. Location of the aquifer by geophysical techniques is used to provide data which are interpreted in terms of depth and thicknesses. The general geology of the sheet 114 Gwoza west is on a scale of 1:50,000 topographical maps and were first studied by Carter et al published in 1963. They concluded that geologically, the area consists of coarse to medium grained granite. Islam and Baba (1990) studied the geology of Mandara hills were Mylonite was mapped, occurring more abundant at Limankara, Jige and Liga areas. They occupy shear zones running approximately North-South and are often found within the coarse grained pegmatite.

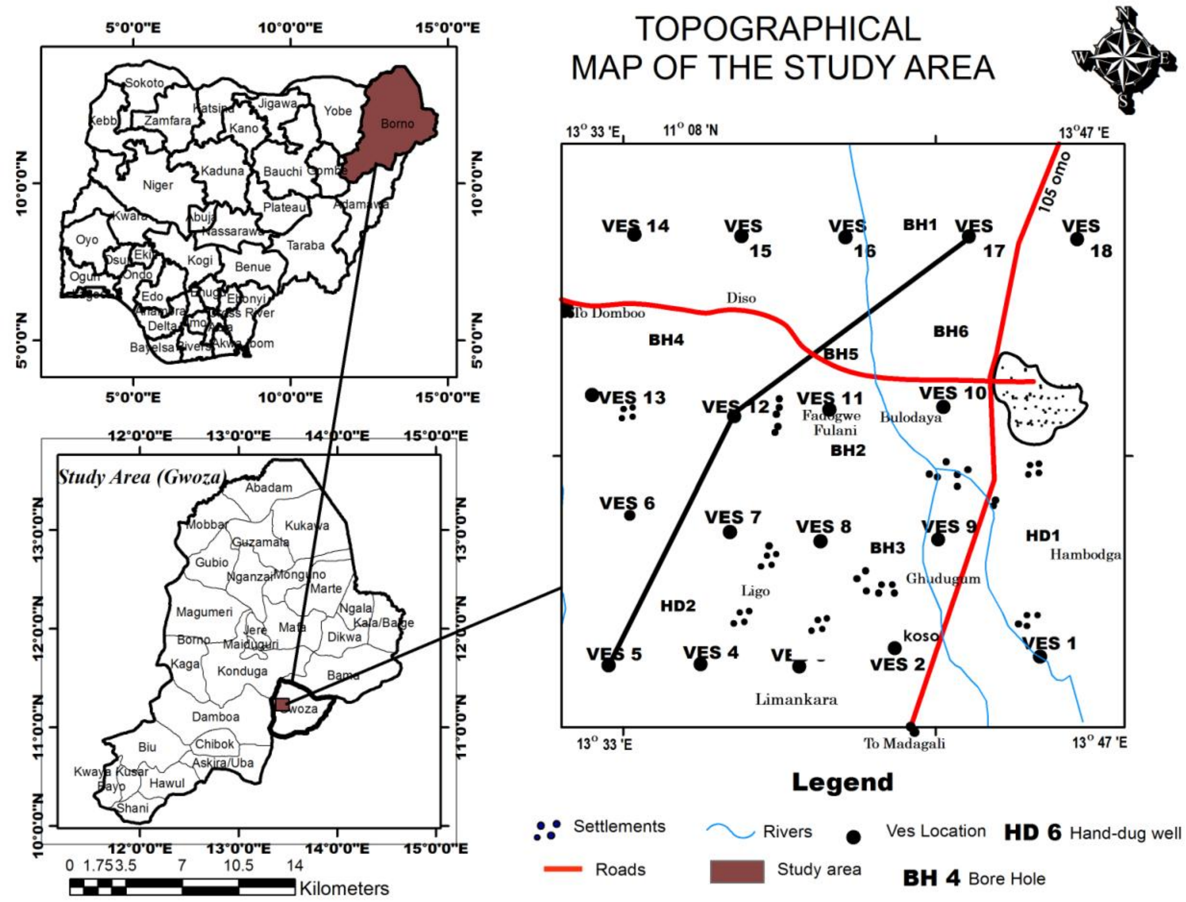


Figure 1: Topographic map of the study Area

II. Aim And Objectives:

The aim of this research work is to conduct vertical electrical sounding in Gwoza town and environs with the view to fulfill the following objectives:-

- Determine the pattern of resistivity and depth variation of geologic materials in the study area.
- Relate the resistivity and thickness to water bearing layers of units.
- Delineate units that are favorable to groundwater development in the study area.

III. Methodology:

Terrameter SAS 300B system was used to obtain resistivity readings from the field while the GPRS positions of all the VES positions were also taken. The resistivity method of survey is considered to be the most versatile among the electrical survey methods because it is easy, quick and economical to obtain details about depth and resistivity variations of subsurface formation. Schlumberger arrangement was employed in this research with a total spread of AB = 200m (AB/2=100m).

Geologically, the area is underlain by series of Igneous and Metamorphic rocks believed to be Precambrian age (Basement complex). Most published works have shown this area as being underlain by undifferentiated basement complex rocks. However, Islam et al (1998) Islam Baba et al (1991) and Baba (1992) have tried to differentiate the rock units broadly. They have shown the area as been underlain by Older Granites enveloped in a Migmatites-gneiss-quartzite complex considered as country rock. The country rock outcrops along margins of the Granite, and also as xenoliths within the Granite bodies.

The study area is composed of low-laying Gneisses, Quartzite minor Amphiboles and Granites. The Migmatites outcrops more often at the margins of hilly Granites where sharp contact relationship is more common than gradational. They also appear as xenoliths within the Granites. In Amdaga quarry Northwest of Gwoza, the gneisses are well exposed and it is apparent that they were migmatised by the intruding acid magma resulting in to felsic and marfic bands. The granites are the dominant outcrops practically forming the main Mandara Mountain, they vary in texture from fine, medium, coarse grained to coarse porphyritic variants with gradations between them and Pegmatite are also common. Dolerites dike cross-cut most Granite and were seen to have been emplaced by faulting. Major faulting in the area generally trends N-S with minor perhaps younger NW-SE and E-W faults. The faulting appears to be post-granite emplaced and affected all the rock units in the southern part of the study area (Liga and Limankara). Magnetic anomaly and satellite imagery interpretations carried out by Bassey (2006) shows the granites and gneisses are tectonised resulting to the formation of cataclasites.

IV. Results

The result of this work is presented as sounding curves, Iso-resistivity maps, geoelectric sections, maps, and tables.

There are two major anomalies high in the study area, one at the extreme North with resistivity reaching a maximum value of 110ohm-m (Dale) with a minimum resistivity value of 89ohm-m and another one at the southwestern part of the study area reaching a maximum value of 160ohm-m (Disa Daya) the highest recorded value in the study area (Fig 1). While two major anomaly low were depicted in the study area, one around the central portion of the study area trending east with a maximum value of 16.2ohm-m (Fadagwe Fulani) and another one around the centre of the study area trending northwest with a minimum value of 12.5ohm-m (Lokodisa Chiki). The Iso-resistivity map was prepared by plotting the resistivity obtained from sounding curves at a given electrode spacing common to all the sounding points for AB/2=50m (fig 2 and 3). Points of equal resistivity values were contoured. This is a qualitative interpretation that represents the variation in resistivity at a given electrode spacing and also indicates the general lateral change in the electrical properties around the area. In the study area, one major anomaly high were recorded at the extreme northeastern part of the study area (Luvwa) reaching a maximum value of 120ohm-m while one low anomaly value was recorded at the southwestern part of the study area (Disa Daya) with a maximum value of 24.7ohm-m.

TABLE 1: results obtained from computed output of Eighteen (18) VES locations in Gwoza and Environs.

	VES Location	Coordinates	Thickness of Layers (m)		Depth (m)	Resistivity (Ωm)			Longitudinal Conductance (Siemens)		Transverse Resistance		Fit Err %
			h1	**h2**	**h3**	**ρ1**	**ρ2**	**ρ3**	***L1***	***L2***	***T1***	***T2***	
1	Takaskala (Ves1)	E13°46'N11°01'	1.2	8.00	9.2	36.5	7.37	730.7	0.0318	1.07	42.42	58.59	0.8
2	Takaskala (Ves2)	E13°43'N11°01'	0.9	11.0	11.9	48.4	10.6	396.3	0.0182	1.03	42.70	115.7	1.0
3	Limankara (Ves3)	E13°41'N11°03'	0.8	24.7	25.5	72.3	16.1	1590	0.0109	1.53	57.20	396.3	1.2
4	Jaje (Ves4)	E13°37'N11°01'	1.9	25.7	27.6	36.1	17.7	102.7	0.0531	1.45	69.01	455.0	1.0
5	Disa Daya (Ves5)	E13°34'N11°01'	1.6	39.3	40.9	162.8	33.6	3322	0.0090	1.17	262.4	1318	1.1
6	Ghudughum(Ves6)	E13°43'N11°01'	0.9	11.0	11.9	48.4	10.6	396.3	0.0165	1.34	234.7	2686	1.2
7	Ghudugum(Ves7)	E13°38'N11°03'	3.6	24.9	28.5	89.7	15.1	816.4	0.0396	1.65	318.8	374.7	0.7
8	Jige (Ves8)	E13°41'N11°03'	1.4	10.8	12.2	91.0	37.8	86.00	0.0154	0.28	127.7	407.6	1.1
9	Disa Biyu (Ves9)	E13°44'N11°03'	1.0	44.1	45.1	127.9	24.4	238.2	0.0075	1.81	121.9	1081	0.8
10	Balangwe (Ves10)	E13°44'N11°05'	1.1	18.7	19.8	37.1	27.8	2749	0.0300	0.68	41.30	520.6	1.0
11	Fadagwe (Ves11)	E13°41'N11°05'	1.0	13.9	14.9	71.4	11.8	179.6	0.0136	1.17	68.94	165.1	1.0
12	Lokodisa (Ves12)	E13°38'N11°05'	1.0	12.4	13.4	41.8	11.4	1226	0.0228	1.09	39.99	141.2	0.9
13	Valangede (Ves13)	E13°35'N11°01'	1.0	26.9	27.9	61.0	23.0	2280	0.0158	1.16	58.97	619.4	1.2
14	Gleri (Ves14)	E13°34'N11°08'	1.0	16.9	17.9	79.7	23.9	2371	0.0119	00.7	76.12	404.1	1.0
15	Dale (Ves15)	E13°37'N11°08'	2.1	49.6	51.7	101.9	46.9	486.9	0.0204	1.05	212.2	2327	0.8
16	Muni (Ves16)	E13°44'N11°03'	1.0	44.3	45.3	127.9	24.4	238.2	0.0075	1.81	121.9	1080	0.7
17	Kudame (Ves17)	E13°43'N11°08'	1.0	18.3	19.3	71.0	12.5	1242	0.0133	1.45	67.54	229.8	1.1
18	Luvwa (Ves18)	E13°46'N11°08'	3.5	26.6	29.1	90.7	16.1	615.2	0.0385	1.59	317.4	410.9	1.0

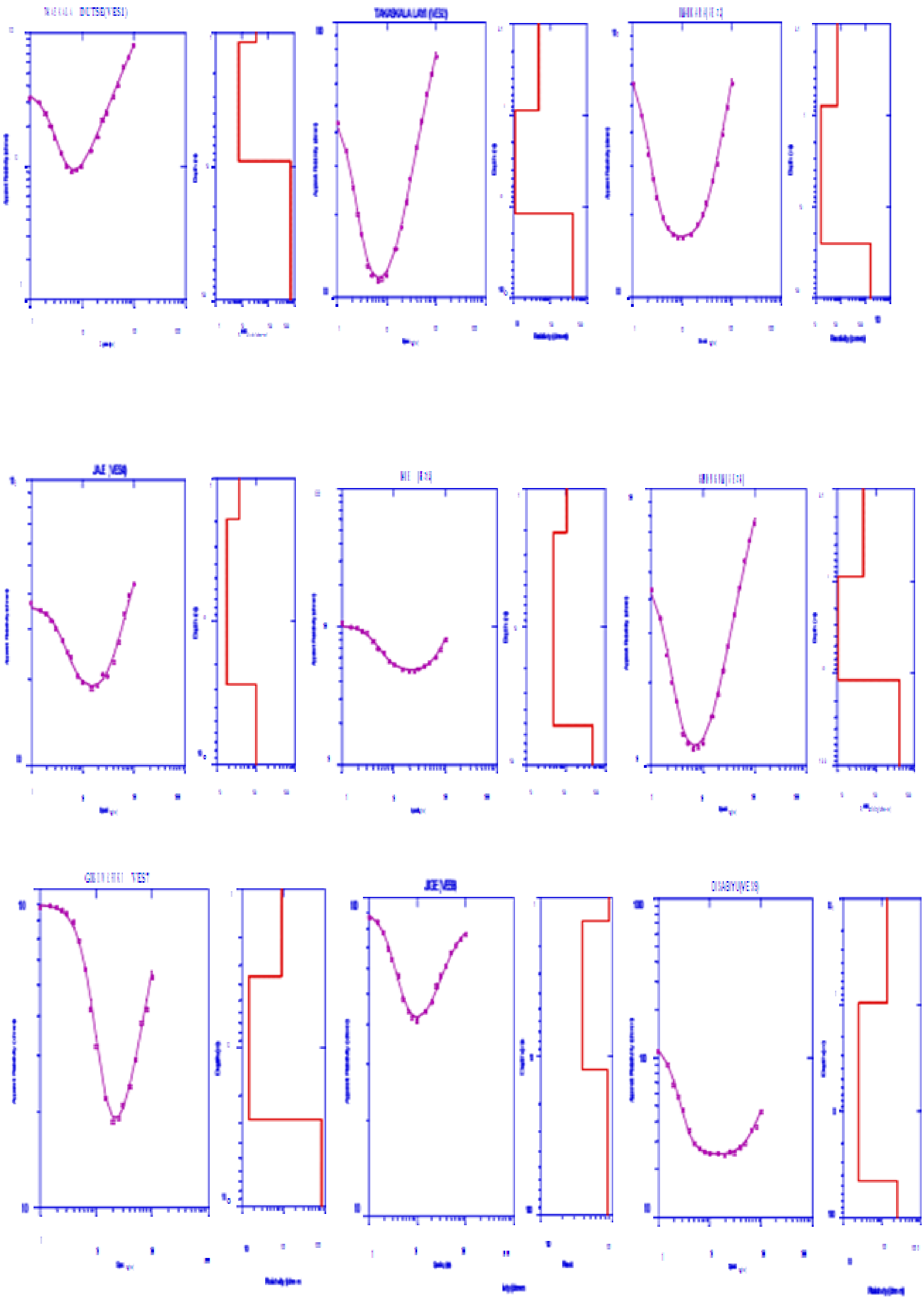


Fig 2a: Computer interpreted H-Type Curves

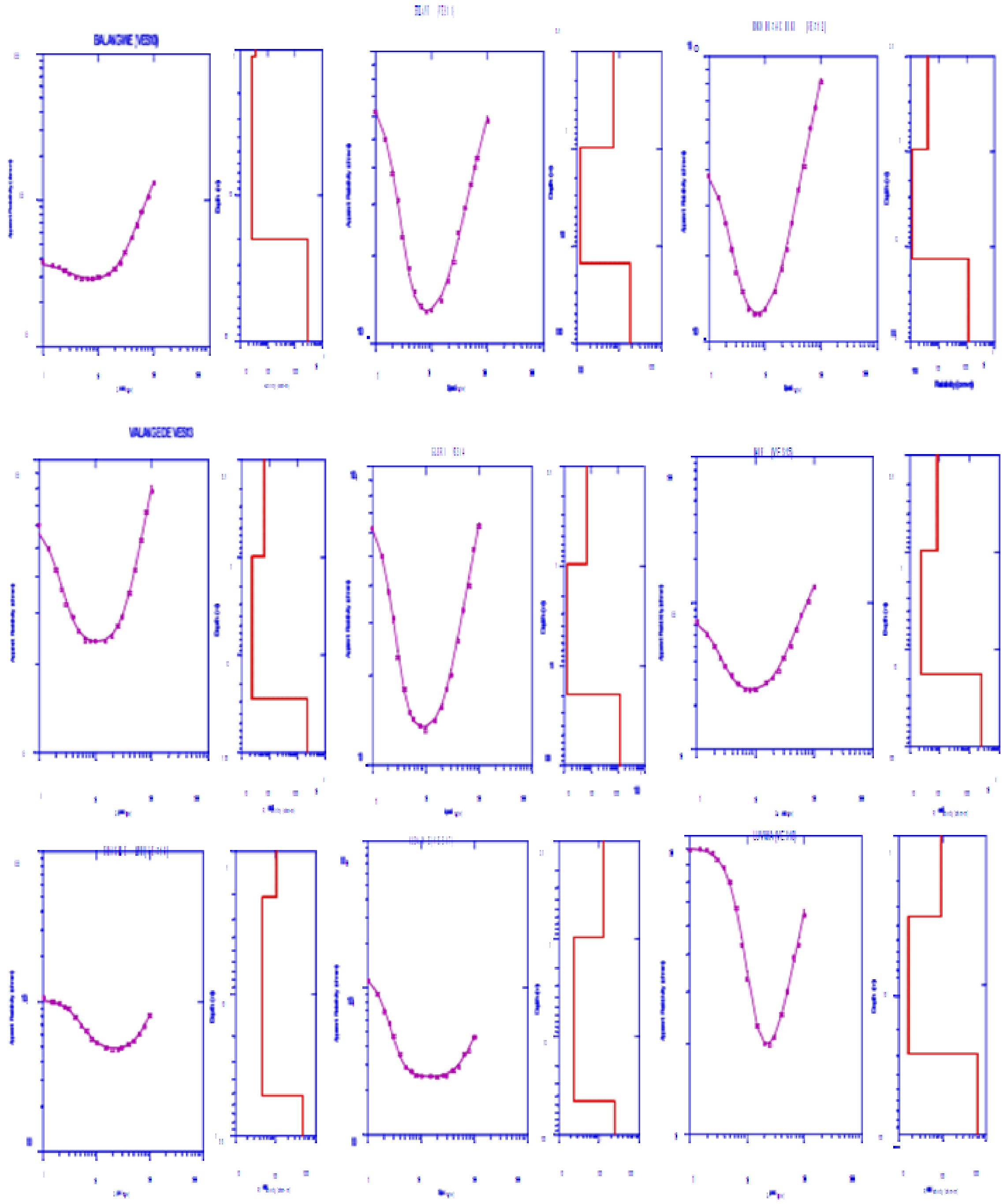


Fig 2b: Computer interpreted H-Type Curve

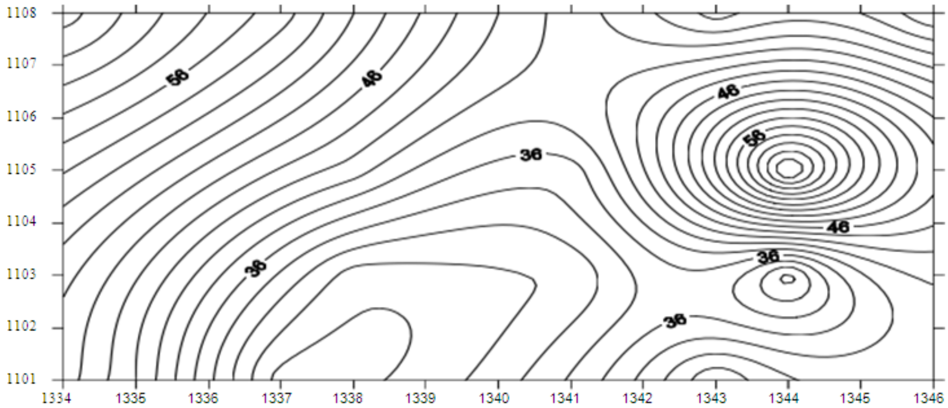


Fig 4a: Iso-resistivity map at AB/2 = 50m

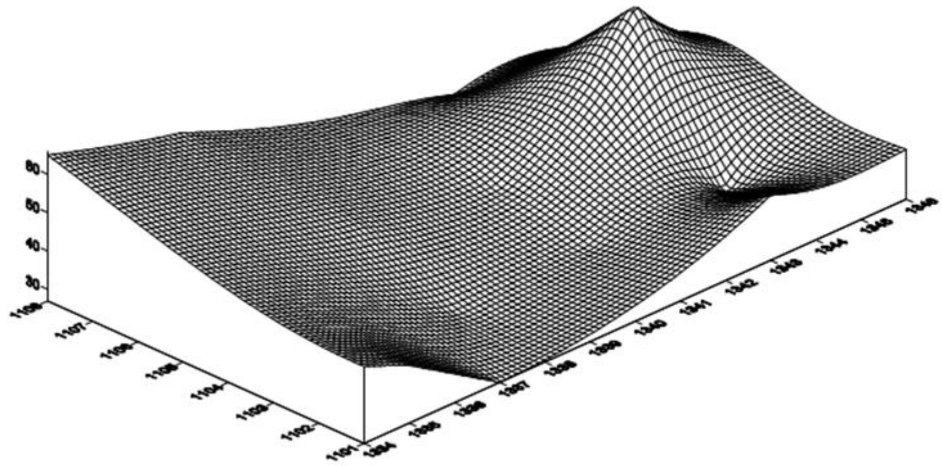


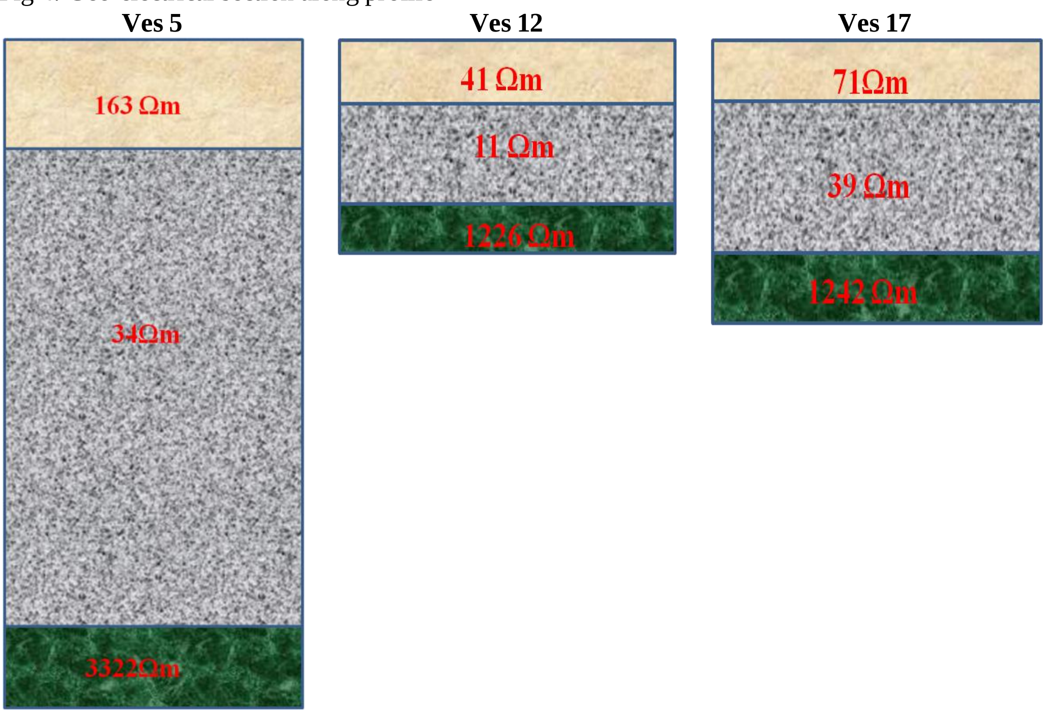
Fig 3b: Frame of Iso-resistivity of AB/2 = 50m.

Table 2: Iso-Resistivity values of AB/2 = 50m

S/No	VES STATION	Resistivity at AB/50m (ohm-m)
1	Takaskala Dutse (VES1)	40
2	Takaskala Layi(VES2)	44
3	Limankara(VES3)	30.5
4	Jaje(VES4)	27
5	Disa Daya(VES5)	47
6	Ghudugum(VES6)	44
7	Ghudugum Chiki(VES7)	29
8	Jige(VES8)	67
9	Disa Biyu(VES9)	29
10	Balangwe(VES10)	67
12	Fadagwe Fulani(VES11)	35
13	Lokodisa Chiki(VES12)	41
14	Valangede(VES13)	42
15	Gleri(VES14)	65
16	Dale(VES15)	55
17	Fadagwe Muni(VES16)	29
18	Kudame(VES17)	33
	Luvwa(VES18)	30

The vertical geo-electrical section X-X' is shown in fig 6. The resistivities and thicknesses of layers in Disa Daya (VES 5) are 1.6m and 39.3m and 163ohm-m, 34ohm-m and 3322ohm-m respectively, The resistivities and thicknesses of layers in Lokodisa Chiki (VES 12) are 1.0m, 12.4m, and 41ohm-m, 11ohm-m and 1226ohm-m respectively, The resistivities and thicknesses of layers in Kudame (VES 17) are 1.0m and 18.3m and 71ohm-m, 13ohm-m and 1242ohm-m respectively. The resistivity of the top layer varies from 41-163ohm-m with varying thicknesses of 1.0 - 1.6m. Below it is the weathered/fractured basement with varying resistivity ranging from 11-34ohm-m with varying depths ranging from 12.4m – 39.3m. Below it is the fresh basement with varying resistivities of 3322ohm-m in VES5, 1226ohm-m in VES12 and 1242ohm-m as in VES17

Fig 4: Geo-electrical section along profile



V. Conclusion

The resistivity pattern shows the top soil to have an average resistivity value of 73.5ohm-m with the range of 36.1ohm-m as in VES4 to 162.8ohm-m as in VES5 and the aquifer zone having an average resistivity value 19.7ohm-m with ranges of 7.37ohm-m as in VES1 and 46.9ohm-m as in VES15. The average thickness of the top layer is 1.5m with ranges of 0.8m as in VES3 to 3.6m as in VES7, while the average thickness of the aquifer is 22.8m which ranges from 0.8m as in VES1 and 49.6m as in VES15. The iso- resistivity map of the study area at AB/2 = 50m indicates the southern part of the study area as favorable for groundwater exploration having a resistivity value of 28ohm-m. The information gathered from qualitative interpretation of eighteen vertical soundings in the study area reveals, that the curves are H-types depicting a three layer earth model. The first layer has an average thickness of 2.4m with an average resistivity value of 126 ohm-m (Top soil), the second layer has an average thickness of 44m with average resistivity value of 26ohm-m (Weathered/Fractured basement), the third layer has an average resistivity value of 2505ohm-m, an average longitudinal conductance of S1 = 0.048 and S2 = 2.21Siemens. While transverse resistance has an average values of T1 = 188.3 and T2 = 1013.

Geological and geophysical studies made it easy to locate feasible groundwater pockets like valley fills and weathered fractured zones in the study area. Geological structures are confirmed by geo-electrical survey suggests bore wells should be drilled to a depth of 25 - 46m from ground surface.

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