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FEDERAL UNIVERSITY
GUSAU-NIGERIA**INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL SUSTAINABILITY****Investigation of Layer Thickness and Groundwater Potentials in Federal University Gusau and Its Environs, Zamfara State, Nigeria**¹Shaibu, I., Owusa, M.O. and Abdullahi M,¹Department of Geology, Federal University Gusau, Zamfara State, Nigeria

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ABSTRACT

The groundwater potential and layer thickness were investigated using vertical electrical sounding (VES) method. A total number of 40 vertical electrical sounding VES points were used for the investigation using Schlumberger array and data obtained were analyzed using curve matching and computer iteration techniques. The data revealed a 3-layer (A, KA and H Curve type) and 4-layer (A and H-curve type). In the 3-layer system, the apparent resistivity of the first layer ranged from 18.90 Ωm to 183.20 Ωm with a corresponding thickness of 0.7 m to 14.8 m. The second layer has apparent resistivity value ranged from 13.50 Ωm to 423.80 Ωm with a corresponding thickness in the range of 4.5 m to 14.7 m while the third layer has resistivity values ranging from 1156.40 Ωm to 3732.70 Ωm with an infinite depth. For the four (4) layered model curves, first layer's resistivity ranged from 29.50 Ωm to 244.70 Ωm , with a corresponding thickness ranging from 0.8 m to 13.0 m. The resistivity of the second layers ranged between 25.2 Ωm to 183.4 Ωm with a corresponding thickness ranging from 8.0 m to 14.2 m. The third layer resistivity ranged from 119.4 Ωm to 586.7 Ωm with a corresponding thickness ranging from 8.1 m to 20.4 m. The forth layer has a resistivity value ranging from 1318.3 Ωm to 3240.9 Ωm with an infinite depth. An integration of both isopach and iso-resistivity maps for both the 3- layer model curves and 4- layer model curves indicates that most of the northwest parts of the study area have low apparent resistivity values and thick overburden while, the southern portion has a little higher resistivity values and shallow overburden, an indication of poor groundwater potential. Future boreholes in the area should reached an expected depth of 50 m to 70 m depth

Keywords: Investigation, Layer Thickness, Groundwater Potentials, Resistivity, Depth, Aquifer.**1.0 INTRODUCTION****1.1 Introducing the Problem**

The growth of any locality depends on availability of basic infrastructural needs such as water, roads and electricity among others. Surface water sources are often inadequate or non-existences (Amadi, 2017, Chinwuko and Akwuba 2015, which is the general case in Northern Nigeria where the rainfall is limited to very few months of the year with annual rainfall of about 1000- 1500 mm (Shaibu, 2017).

There is need for scientific identification of parameters governing ground water resources, investigation of layer thickness, groundwater potential, and management, particularly, if satisfactory living conditions of the people are to be catered for. This is very important, due to the presence increase in groundwater demand for

various human activities has placed great importance on water science and management. Groundwater accounts for greater percentage of the world's fresh water and it is fairly distributed throughout the world. It is the world's greatest essential factor for sustainable development and the need to delineate the areas that would be suitable for groundwater potential, layers thickness and need to conduct hydrological and geophysical survey of the area in order to provide useful information on the possible sites for ground water exploration. Since the object of vertical electrical sounding (VES) has been the most important geophysical method of water prospecting in area of deep in situ. The geo-electric resistivity method, particularly the (VES) method has been chosen for this particular work, because it has proven to be an economic, quick and effective means of solving most ground water and layers thickness problems

in different parts of the world (Breusse, 1963, Mohammed, Aboh, and Emenike, 2016).

2.0 MATERIALS AND METHODS

The equipment that will be used for the resistivity method is reasonably cheap and easy to use. The resistivity field data will be acquired with the aid of the following equipment:

2.1 Materials

2.1.1 Terrameter (ABEM SAS 1000)

This is the major power source of the whole set-up. It measures the resistance of the subsurface layers and can also measure the voltage of the power source. The equipment has an in-built system of reducing the effect of noise. The instrument is portable and fixed with a rechargeable battery. It has a maximum power of 18 watts, manual selection of current in steps up to 100mA, a choice of sample time/ signal length averaged three frequency settings.

2.1.2 Electrodes

These are steel rods of about 30cm with a base and a pointed end. The pointed end is used to penetrate the ground. The material makes it a good conductor. Four electrodes will be used; the first pair is the potential electrode while the second pair is the current electrode. Their basic function is to pass current into the ground and measure potential between two points. Two-third of the length of the electrodes will be driven below the earth surface.

2.1.3 Cables

They are made of conducting material (copper). There will be four reels of cables used during the geophysical survey. The cables will be connected to the terrameter on one end and the other is connected to the electrodes.

3.1.4 Clips

These are objects used for passing the currents from the cables to the electrodes by clipping the electrodes after wounding the cable on it. The mouth is made of conducting materials while the base (handle) is made of insulating material to prevent electrocution. The clips ensure good electrical contact

2.1.5 Hammer and Cutlass

These will be used to drive the electrodes into the ground. It consists of a relatively slim wooden cylindrical handle embedded into a metallic head. While the cutlass will be used to clear the path along which measurement are to be taken.

2.1.6 Tapes

These are used for making measurements of length on the field as they have been calibrated in metric units. The tapes used will be of 100m in length. They will be used in measuring electrode spacing on the field.

2.1.7 Global Positioning System and Compass-Clinometer

This equipment will be used for taking coordinates and bearing. GPS will be used for taking the longitudes, latitudes and elevation of various locations. It is portable and handy. The compass-clinometer will be used to take direction of the profiles.

2.1.8 Field Stationery

These are writing materials that will be used to record all observation and field data. The stationery consists of pencils, pens, recording sheets, rulers and so on.

2.1.9 Geology of the Study Areas

Federal University Gusau, main Campus is actually located along Zaria-Sokoto Road, within Kotokoroshi Community, , Nigeria (Fig. 1). The study area lies within Basement Complex of Northwestern Nigeria (Obaje, 2015). Indeed, many previous workers (such as, Black, 1980; Ajibade and Fitches, 2018; Obaje, 2015; Danbatta and Garba, 2017; Obaje, 2015; Nwachukwu *et al.*, 2016; Folorunso *et al.*, 2016; Opara *et al.*, 2015; Saleh and Maunde, 2017; Ekeleme *et al.*, 2017; etc.) have written so much on the basement complex of Nigeria. The Nigerian Basement Complex is a part of the Pan-African mobile belt which lies among the West African and Congo Cratons as well as south of the Tuareg Shield (Black, 1980).

However, Ajibade and Fitches (2018) reported that the basement comprises three major lithological groups: (i) the migmatite gneiss complex which is widespread throughout the country; (ii) metasedimentary and metavolcanic rocks which form schist belts and appear to be dominantly restricted to the western half of the country; (iii) the

Older Granites which intrude both the migmatite gneiss complex and the schist belts and have consistently yielded Pan-African ages. Thus, the study area is underlain by Old-Granites. While (Fig. 3) shows the general geology map of Federal University Gusau Zamfara State.

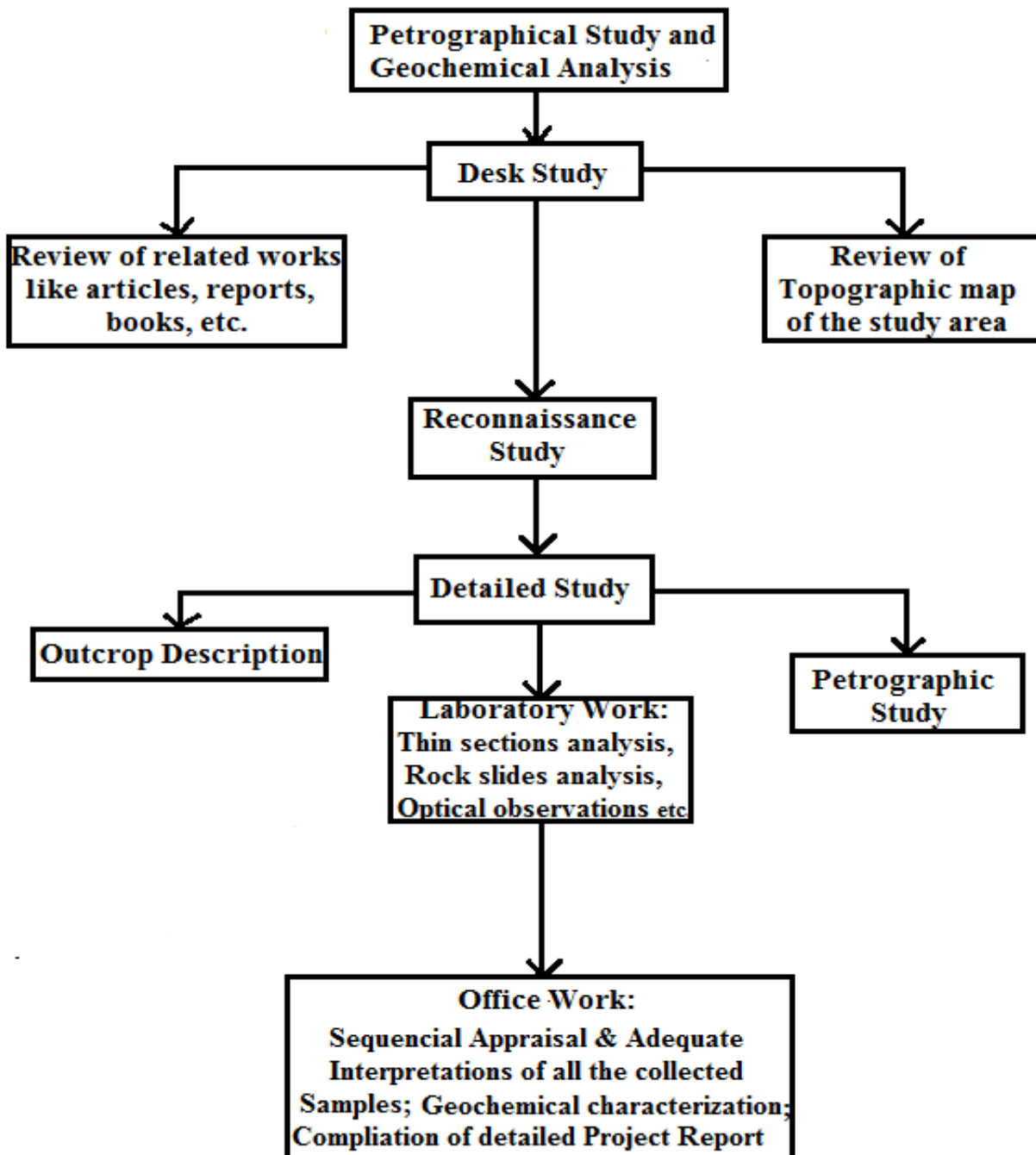


Fig. 1: Geological Map of Nigeria Showing the Study Area (After Obaje, 2009)

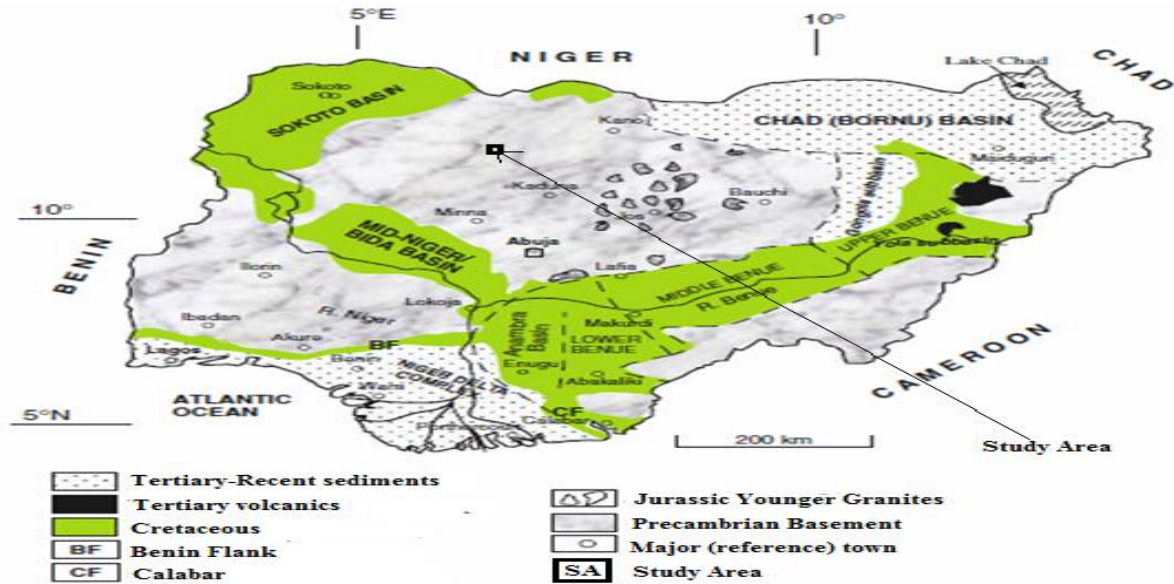


Fig. 2: Research Work

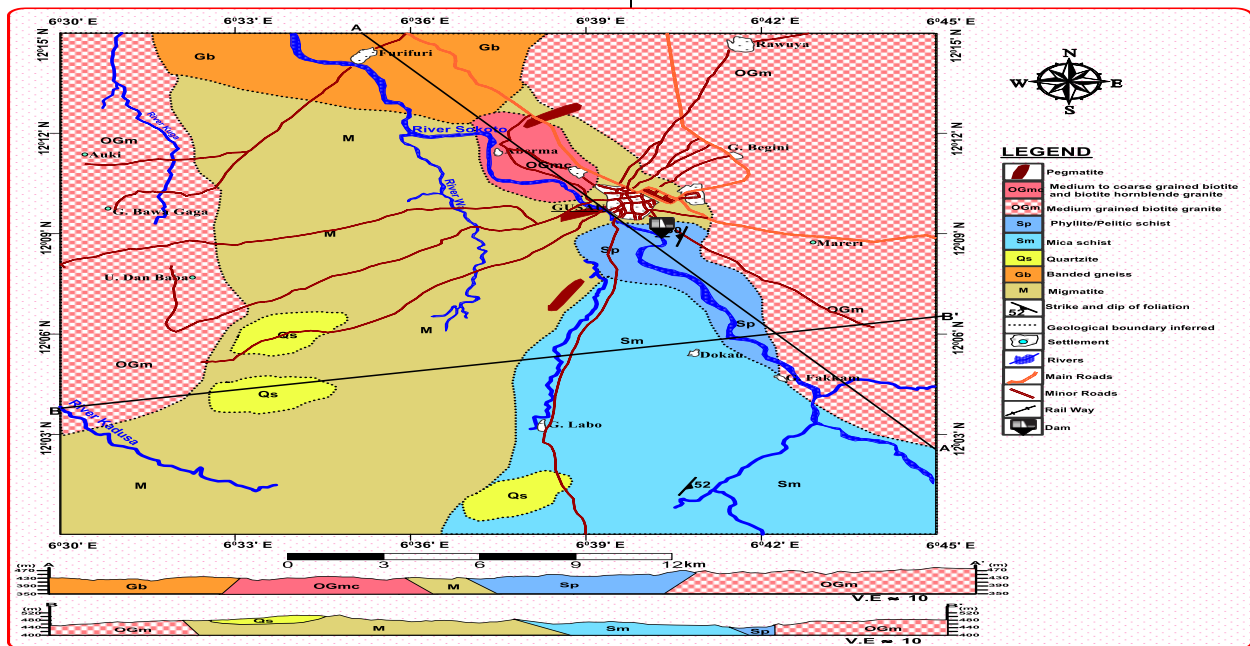


Fig. 3: Geological Map of Federal University Gusau Zamfara State (Shaibu I, 2018)

2.2 METHODOLOGY

In this study the data collected were basically collected from main measuring mode of the

Terrameter SAS 1000 (Resistivity). The profiling data were collected using Wenner electrical profiling method. 10m-electrode spacing was used

and this corresponds to 15 m probe depth. Care was taken to ensure that the electrode layout follow a straight line along the N-S profile layout. Similarly, Schlumberger method of electrical sounding was employed for electrical drilling (VES data). The maximum current electrode separation of 200 m and potential electrode separation of 30 m were reached and this corresponds to 20 m probed depth (i.e. AB/2). The Terrameter ABEM SAS 1000). The field layout is shown in Table. 1.

The apparent resistivity values acquired from the measurement were plotted against half the current electrode spacing on a bi-logarithmic graph in order to determine the apparent resistivities and thicknesses of various layers penetrated. Some

many researchers have written on the need and uses of Schlumberger method in groundwater investigation (Udensi, and Salako, 2005; Mohammed, 2007; Anakwuba *et al.*, 2014; Chinwuko *et al.*, 2015; Osele *et al.*, 2016; Chinwuko *et al.*, 2016 and others). An iterative software computer program called the (Win-Resis). This software performs automatic interpretation of the Schlumberger sounding curves which gives the equivalent n-layer model input from the apparent resistivity data of each sounding point. It converts the apparent resistivity as a function of electrode spacing to the true resistivity as a function of depth in two dimensions

Table 1: Show the Profile Layout along Which the Data Were Collected

	A1	A2	A3	A4	A5	A6
Faculty sci.	B1	B2	B3	B4	B5	B6
N	C1	C2	C3	C4	C5	C6
	D1	D2	D3	D4	D5	D6
	E1	E2	E3	E4	E5	E6
Students	F1	F2	F3	F4	F5	F6
Hostel.						

3.0 RESULTS AND DISCUSSION

Two different categories of model curve types were identified in the study area. The first category is those with four layers which represent about 60% of VES curves (Fig. 4) while the second category consists of three layers, which representing about 40% of the sounded points within the study area (Figure. 5). The geo-electric sections of the study area show that the subsurface lithology of the area

is not uniformly distributed. Area with thick regolith materials shows great potential for groundwater exploitation (Ako, 1996). The regolith are a product of weathering which induces the geological materials to be porous and permeable, which qualifies them as aquifers, since they can store and transmit groundwater in economic quantity (Amadi *et al.*, 2017; Shaibu *et al.*, 2017).

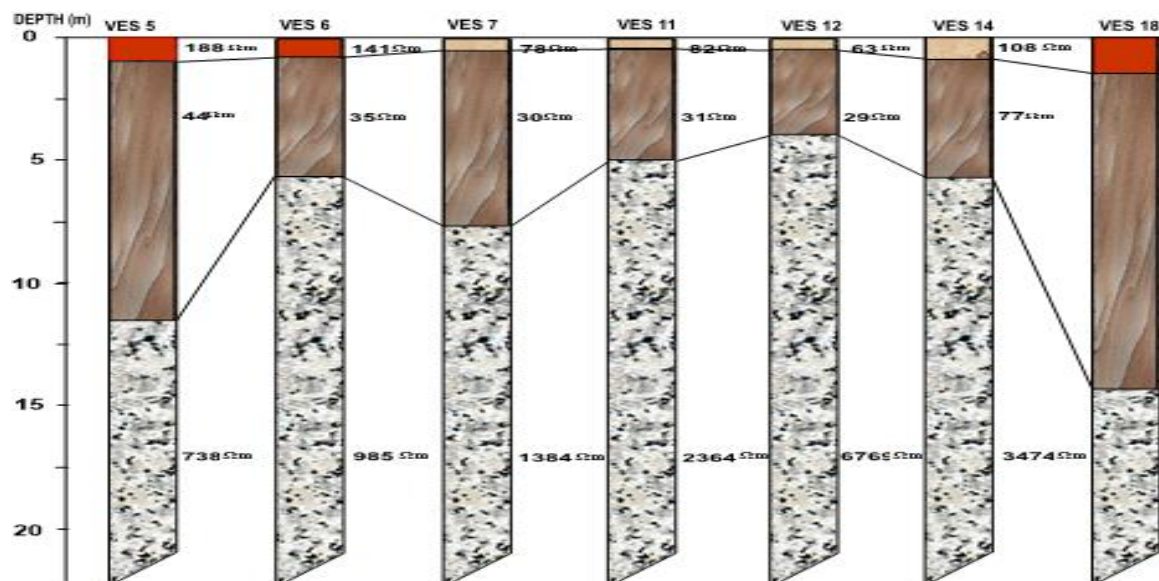


Fig 4: Geo-electric Sections for 3 Layer Thickness System

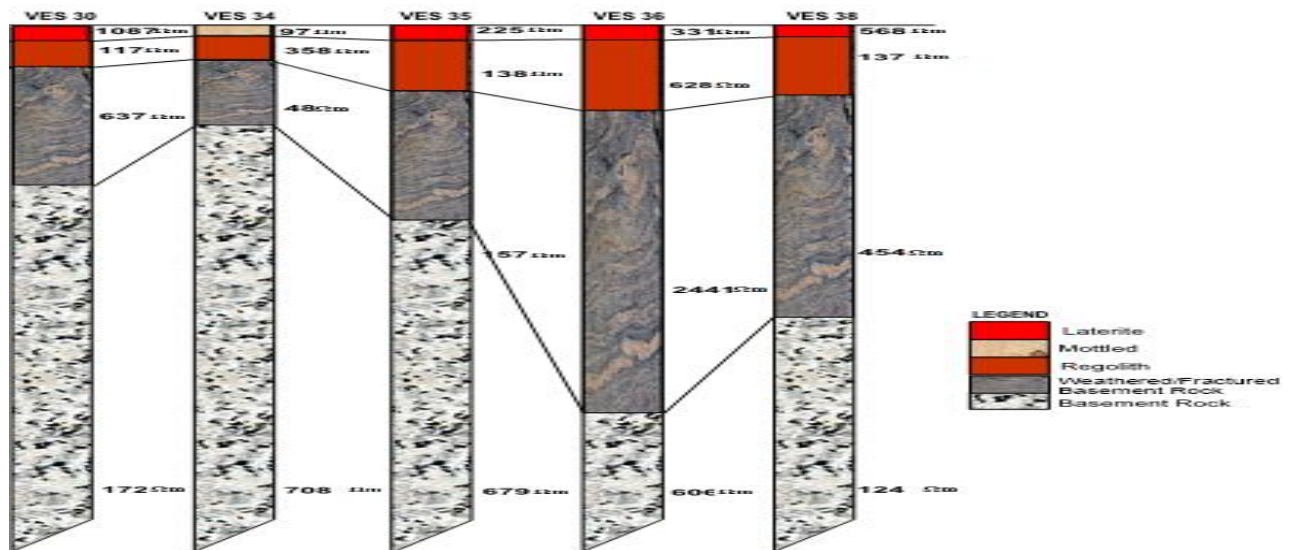


Fig. 5: Geo- electric Sections for 4 Layer Thickness

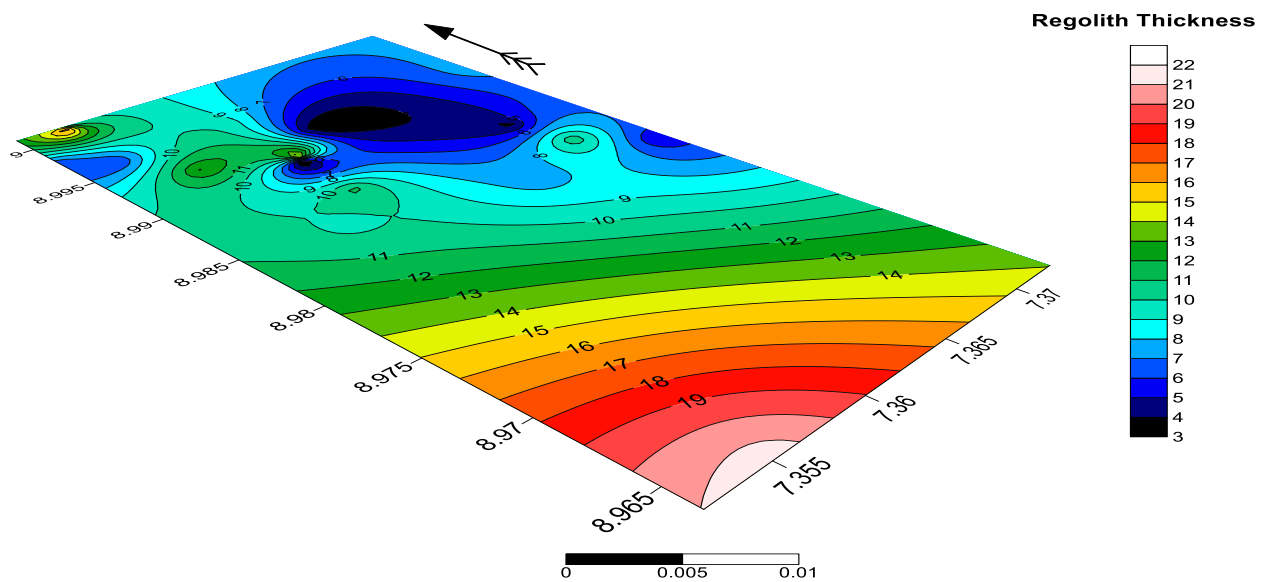


Fig. 6: Isopach Map of Regolith Thickness For Three Layered Model Curves

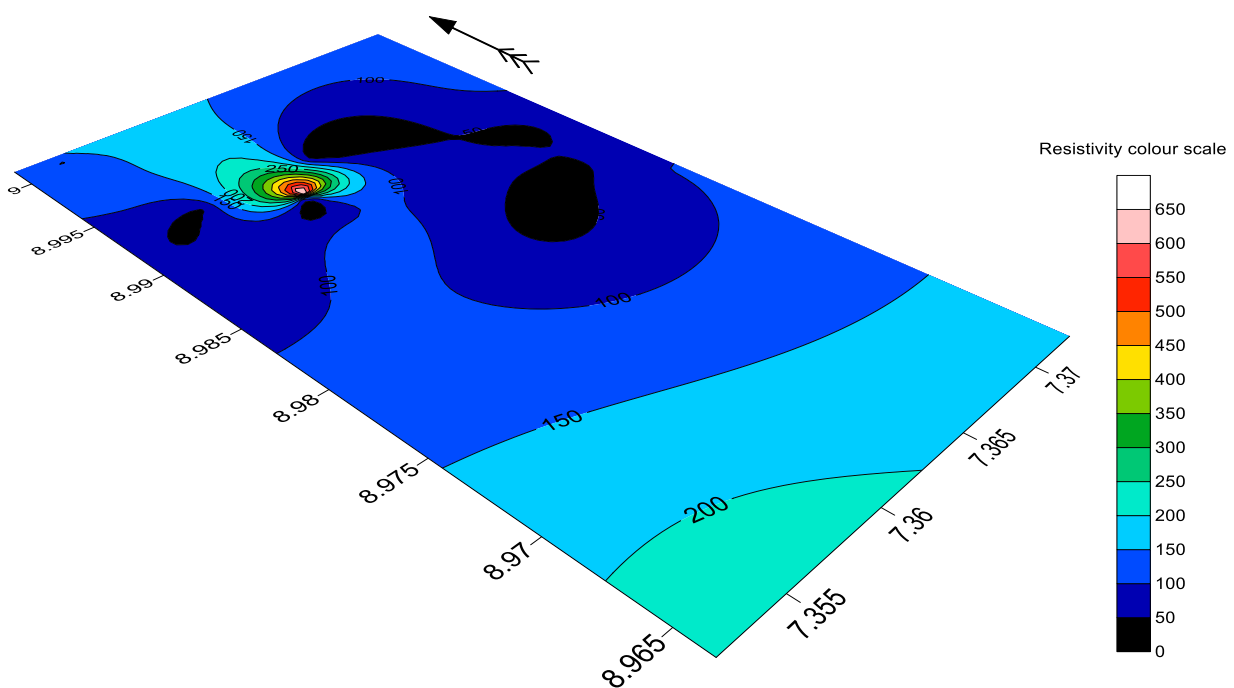
The geo-electric sections with the 3 layer thickness show laterite, mottled zone, regoliths/saprolith and basement rock as the lithologies (Fig. 4) while the four (4) layer curves shows laterite, mottled zones, regoliths/saprolith, fractured basement and fresh basement rocks (Fig. 5). The subsurface lithology varies from place to place within the study area and the finding conforms to the work done by other researchers (Mbonu *et al.*, 1991; Olorunfemi and Okakune, 1992; Ikpokonte, 2010; Aiyegbusi and Akujieze, 2010; Amadi *et al.*, 2013, Omeji *et al.*, 2013).

Iso-resistivity and Isopach maps of a three layer thickness model curves

From the isopach map of regolith thickness for three layered curves (Fig. 6), it can be established that the northern portion of the

area shows deep/thick overburden/regolith thickness, while south-western portion shows

shallow overburden. This corresponds to the iso-resistivity map, as the shallow overburden materials are seen around the ridge which shows lower resistivity values. The thicker the overburden materials the better chance for groundwater storage and this implies that the northern sector correspond to groundwater recharge zone while the southern portion are areas of groundwater discharge. The average thickness of regolith/overburden materials for the three-layered curve is about 11m. The iso-resistivity map of the three layer model curves indicates that the resistivity value is lower at the northern portion of the area compared to the southern portion of the area (Fig. 7). From the contour map the area with higher resistivity values indicate presence of no water or conducting materials while lower resistivity values are indicative of a thick overburden. For the 3 layer thickness system, the weathered/fractured zone is the second layer which is regarded as the regolith aquifer zone (Amadi *et al.*, 2015b; Olasehinde *et al.*, 2016). It is characterized by low resistivity values (high conductivity) compared to the first and third layers as illustrated in Fig 8. and fig. 7 shows different curve types



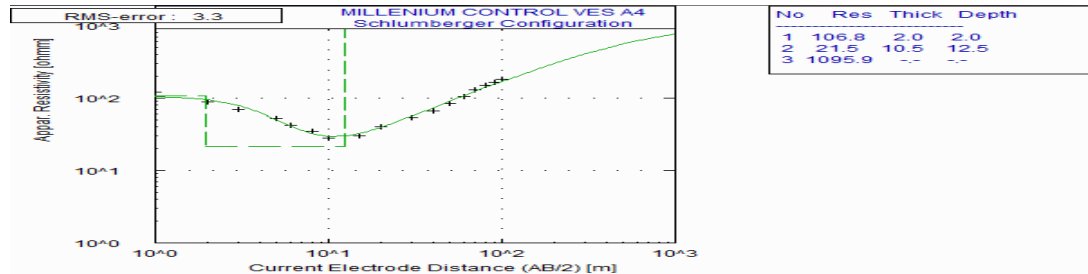


Fig. 8: Iso-Resistivity Map of Three Layered Thickness Model Curves

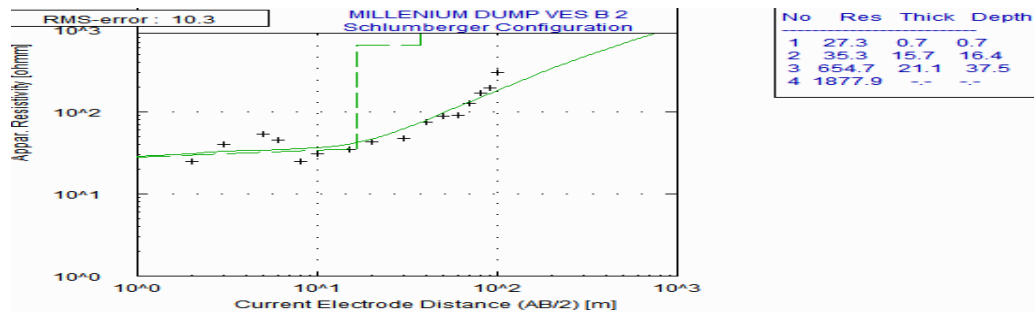


Figure. 9: A Typical VES Curve For 4 Layer System In The Area

Table 1: VES interpretation along profiles

VES.PT	NOOF LAYERS	TYPESOF LAYER CURVE	AVERAGE RESISTIVITY (Ωm)	LAYER THICKNESS(m)	Depth (m)
F1	1	H	22.50	0.79	0.00
	2		42.17	16.29	0.79
	3		658.80	∞	17.08
F2	1	H	590.03	0.85	0.00
	2		64.30	25.97	0.85
	3		310.66	∞	26.82
F3	1	KH	1735.48	0.44	0.00
	2		102.74	19.86	0.44
	3		541.82	∞	20.30
F4	1	H	262.45	0.79	0.00
	2		53.47	16.29	0.79
	3		45893.39	∞	17.08
F5	1	H	667.29	0.34	0.00
	2		5103.91	1.24	0.34
	3		478.08	9.21	1.58
	4		2324.71	∞	10.70

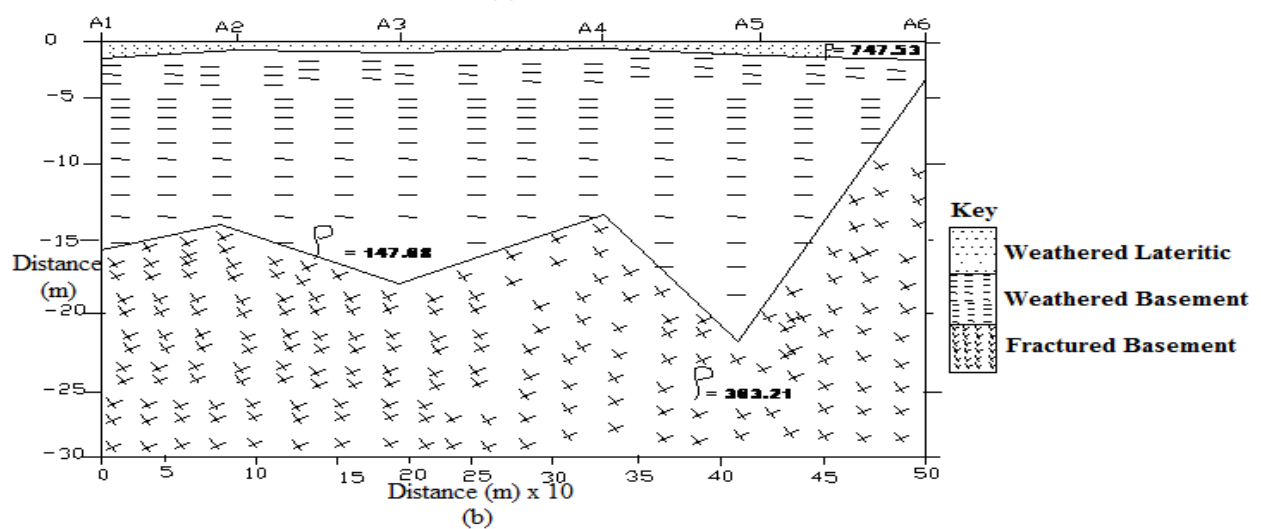
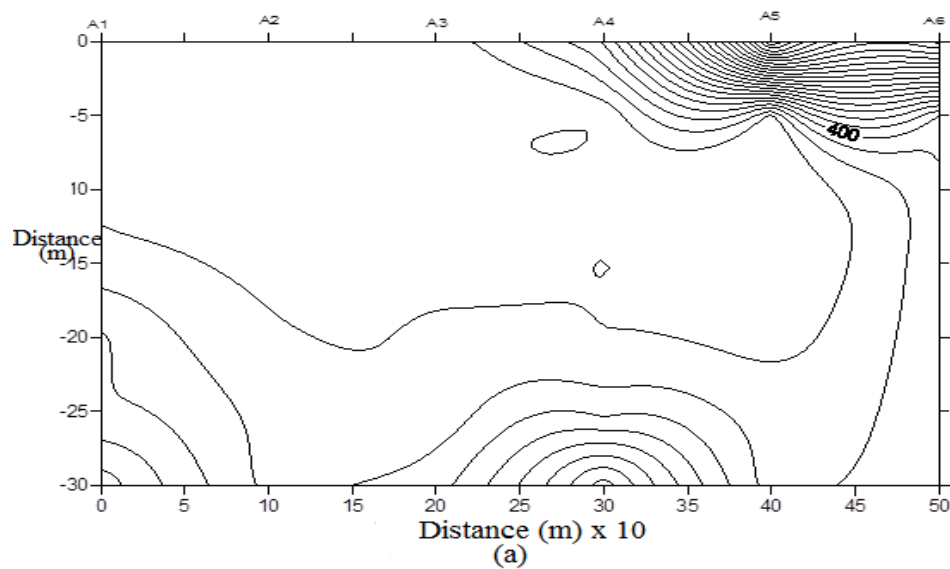


Fig.11: Correlation of geo-electric section with Geology of the area. The geo-electric sections with the 4-layer show topsoil or laterite, wheathered/ fractured basement and fresh basement (Fig. 9) while the the 3-layer curves show laterite, fractured basement and fresh basement rocks (Fig. 10). The subsurface lithology varies from place to place within the study area and the finding conform to the work done by other researchers (Olorunfemi and Olayinka, 2002; Osazuwa, I. B., & Abdullahi, N. K. (2008). Dan-Hassan, M. A., & Olarinfemi, M. O. (1991).

4.0 CONCLUSION AND RECOMMENDATIONS

The study aimed at investigating the groundwater potential and layers thickness in Federal University Gusau and Its Environs, Zamfara State, Nigeria, using Vertical Electrical Sounding of the Electrical Resistivity method. The study became necessary due to the increase in population of the area. A total number of 40 VES points were conducted and the data obtained were analysed through curve matching and computer software. The area comprises of both 3 layer and 4-layer system. The 3 layers were predominantly H-type curve while the 4-layer system was mainly HA-curve type and are typical of the basement complex terrain. The field data, geo-electric section, isopach and iso-resistivity maps of both the 3- and 4-layer model curves show that the northern parts of the study area correspond to recharge zone while the southern portion correspond to discharge zone. A total drill depth of 60 to 70 m was recommended for optimum groundwater yields in the areas

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CONFLICT OF INTEREST

There is no conflict of interest associated with this particular research work.

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