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Groundwater Exploration In Parts Of Mangu-Halle North-Central Nigeria.

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Abstract **-** Geophysical survey using the Vertical Electrical Sounding (VES) technique of investigation was carried out for the determination of groundwater potentials in parts of Mangu-Halle and surrounding areas. The ABEM Terrameter (SAS 1000), precisely the Schlumberger array with $^{AB}/_2$ electrode spread of 1.5m-215m was employed in the data collection. A total of thirty-five (35) VES points were collected. The field data were interpreted using WIN RESIST computer iterative program. The results obtained from the interpretations were illustrated as geo-electric sections and depth to basement maps which revealed 3-4 geo-electric layers. The first layer consists of topsoil / lateritic cap with resistivity values of 123-2908Ω, the second layer consist of weathered zone with resistivity value of 6.0379Ω, the third and the fourth layers consists of fractured basement with resistivity from 194-4968Ω and possibly aquiferous, promising good quantity of groundwater source; and the fifth layer consists of fresh basement. With reference to the interpretation of data acquired i.e aquifer thickness and material constituents in the subsurface, the area was classified into high, medium and low groundwater potential zones with the sole aim of providing the background information for detailed groundwater exploration and development within the area.

Keywords: Investigation, Geo-electric, Vertical Electrical Sounding, Aquifer

1. INTRODUCTION

The electrical resistivity method is suitably used for groundwater exploration which makes it a well known method that can be successfully employed for groundwater investigations, especially where there is a good contrast in the electrical properties between the saturated and unsaturated sub surface layers[1]. This method is regularly used to solve a wide range of groundwater problems[2,3].

The provision of adequate water supply and sanitation to the rapidly growing urban populations is increasingly becoming a problem for governments throughout the world. Due to the rapid increase in the population growth within the study area and surrounding villages, which resulted to the consequent increase in the demand for potable water supply, this research was carried out in order to explore the possibilities of groundwater supply which is more reliable. The availability of groundwater is therefore, a major asset that can greatly influence agricultural production, domestic use, industrial use etc. improving the growth and sustainability of the area in order to meet the development agenda for Nigeria.

The purpose of this research therefore is to investigate the subsurface using the vertical electrical sounding technique as well as identify the aquiferous zones that could be harnessed for groundwater resources so as to meet the increasing demand.

2. LOCATION AND GEOLOGIC SETTING

The study area is located in north central Nigeria, it lies within latitudes N09^0 30’50’’ and N09^{0}31’47’’ and longitudes E009^{0}05’17’’ and E009^{0}06’13’’ (Fig. 1) on the Maijuju sheet 169 SW and covers an area extent of about 16km^2 The study area is accessible through Barkin Ladi- Mangu road or the Jos- Bisichi-Korot-Fan-Mangu-Halle road.

Fig. 1.Location Map of the Study Area Showing Settlements and Road-networks

The study area is underlain by rocks of the basement complex which forms smooth dome features with gentle slope, and exposures along the river channels. The entire study area is composed of granitic gneisses (Fig 2) which are predominantly medium-grained texture, although some samples showed granoblastic with coarse porphyroblastic texture. The rocks are crystalline, non-porous and therefore a poor source of groundwater unless weathered or fractured.

3. MATERIALS AND METHOD

A total of thirty five (35) VES were acquired using the ABEM terrameter SAS 1000 model. Other accessories attached to the terrameter include a power source, tapes, electrodes (current and potential), cables, clips and hammers. The Sclumberger array configuration was applied to carry out the investigation with an electrode spacing of 1.5m to 215m. The VES stations were sounded randomly within the study area with their corresponding coordinates noted using the Global Positioning System (GPS); these are displayed on figure 2 below.

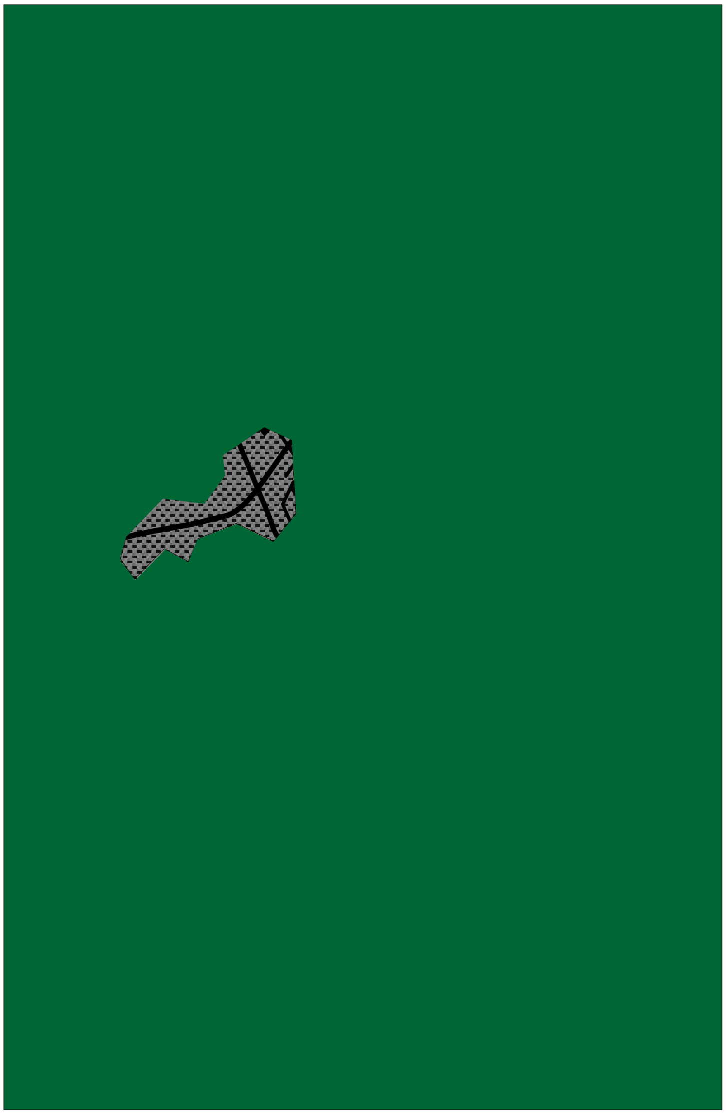

Fig. 2. Geological Map of the Study Area Showing the VES Points

4. DATA PROCESSING AND INTERPRETATION

Field data obtained were processed and interpreted qualitatively and quantitatively. The qualitative interpretation was the type-curve inspection to discern the layering. Furthermore, the type curves were quantitatively interpreted using computer iterative software (WIN RESIST Program), which were eventually presented in the form of geo-electric sections and maps.

The VES data acquired were plotted as depth sounding curves in terms of apparent resistivity versus AB/2 spread (electrode spacing). The different type-curves were classified based on their characteristics layering as shown in Table 1 below which ranges from 2 to 5 layers. From the VES interpretations 3-5 geo electric layers were delineated in the study area.

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Table 1: Summarized Table of the Vertical Electrical Sounding (VES) Locations

VES Points	Longitude	Latitude	Elevation (m)	Curves Types	No. Of Layers	Curve Range
P_1	E008.53261	N009.39452	1262	QA	4	$P_1>P_2<P_3<P_4$
P_2	E009.09588	N009.52352	1130	HA	3	$P_1>P_2<P_3$
P_3	E009.09534	N009.52433	1147	HA	3	$P_1>P_2<P_3$
P_4	E009.09490	N009.52513	1141	H	5	$P_1>P_2<P_3<P_4<P_5$
P_5	E009.09750	N009.52195	1134	H	3	$P_1>P_2<P_3$
P_6	E009.09533	N009.52875	1142	KH	4	$P_1<P_2>P_3<P_4$
P_7	E009.09573	N009.52761	1145	QH	3	$P_1>P_2<P_3$
P_8	E009.09652	N009.52651	1139	KA	3	$P_1<P_2>P_3$
P_9	E009.09757	N009.52541	1136	HK	3	$P_1>P_2<P_3$
P_{10}	E009.09852	N009.52416	1133	H	3	$P_1>P_2<P_3$
P_{11}	E009.09933	N009.52264	1132	H	3	$P_1>P_2<P_3$
P_{12}	E009.09855	N009.52124	1130	A	3	$P_1<P_2>P_3$
P_{13}	E009.09933	N009.52034	1124	HA	3	$P_1<P_2>P_3$
P_{14}	E009.10038	N009.51898	1116	HA	4	$P_1>P_2<P_3>P_4$
P_{15}	E009.10143	N009.51712	1122	QH	5	$P_1>P_2<P_3<P_4>P_5$
P_{16}	E009.10192	N009.51608	1126	HA	4	$P_1>P_2<P_3<P_4$
P_{17}	E009.09980	N009.51705	1122	AK	5	$P_1<P_2>P_3>P_4<P_5$
P_{18}	E009.09841	N009.51706	1119	KHA	4	$P_1<P_2>P_3<P_4$
P_{19}	E009.09844	N009.51568	1122	HK	5	$P_1>P_2<P_3>P_4<P_5$
P_{20}	E009.09692	N009.51685	1119	KH	4	$P_1<P_2>P_3<P_4$
P_{21}	E009.09433	N009.51721	1120	H	4	$P_1>P_2<P_3>P_4$
P_{22}	E009.09322	N009.51795	1108	HA	3	$P_1>P_2<P_3$
P_{23}	E009.09264	N009.51833	1144	HA	3	$P_1>P_2<P_3$
P_{24}	E009.09464	N009.51858	1131	HA	3	$P_1>P_2<P_3$
P_{25}	E009.09593	N009.52141	1137	H	3	$P_1>P_2<P_3$
P_{26}	E009.09218	N009.51986	1142	H	3	$P_1>P_2<P_3$
P_{27}	E009.09165	N009.51978	1150	QH	4	$P_1>P_2>P_3<P_4$
P_{28}	E009.09274	N009.52155	1136	H	3	$P_1>P_2<P_3$
P_{29}	E009.09636	N009.51834	1124	H	3	$P_1>P_2<P_3$
P_{30}	E009.09751	N009.51943	1123	H	3	$P_1>P_2<P_3$
P_{31}	E009.09770	N009.52014	1133	HA	3	$P_1>P_2<P_3$
P_{32}	E009.09856	N009.52000	1131	HA	3	$P_1<P_2>P_3$
P_{33}	E009.09813	N009.52300	1152	QH	2	$P_1>P_2$
P_{34}	E009.09980	N009.52416	1133	KA	3	$P_1>P_2<P_3$
P_{35}	E009.09701	N009.52189	1124	H	4	$P_1>P_2>P_3<P_4$

Furthermore, geo-electric sections were taken along 3 different profiles i.e A-A', B-B' and C-C', as shown on Figures 3a, 3b and 3c below. These section revealed 3-4 major geo-electric layers underlain within the area under investigation. The first layer consists of topsoil/laterite, the second layer comprises the laterite/weathered basement, the third and the fourth layers consist of fractured basement grading to fresh basement respectively.

The various depth of overburden to fresh basement generated at each VES points were plotted and contoured using the suffer GIS Program as Isopach of overburden thickness (fig, 4), the overburden thickness ranges from 2m- 40m. As a result, the depth to basement maps, geo-electric sections, and lithologic sections reveal factual character about the subsurface which have aided to classify the groundwater potentials within the area as displayed on Fig. 5 below. Thus, he groundwater potential of the study area has been characterized into high, medium, and low water potential zones with the following characteristics:

i. High groundwater potential zones which are areas with intense and deep weathering/overburden thickness of 28-40m coupled with fractured basement. For this reason, such regions are promising with good quantity of groundwater source.
ii. Medium groundwater potential zones include area with weathering depth from 16-28m and also some fractured basement.
iii. Low groundwater potential zones comprise areas with depth of weathering from 2-16m**.**

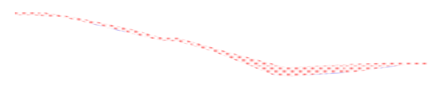

Fig. 3a. Geo-electric section along A-A' profile

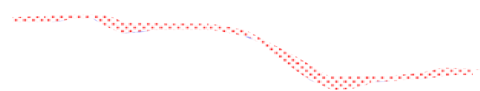

Fig. 3b: Geo-electric section along B-B' profile

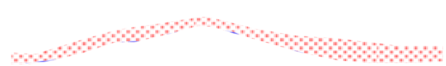

Fig. 3c: Geo-electric along C-C' profile

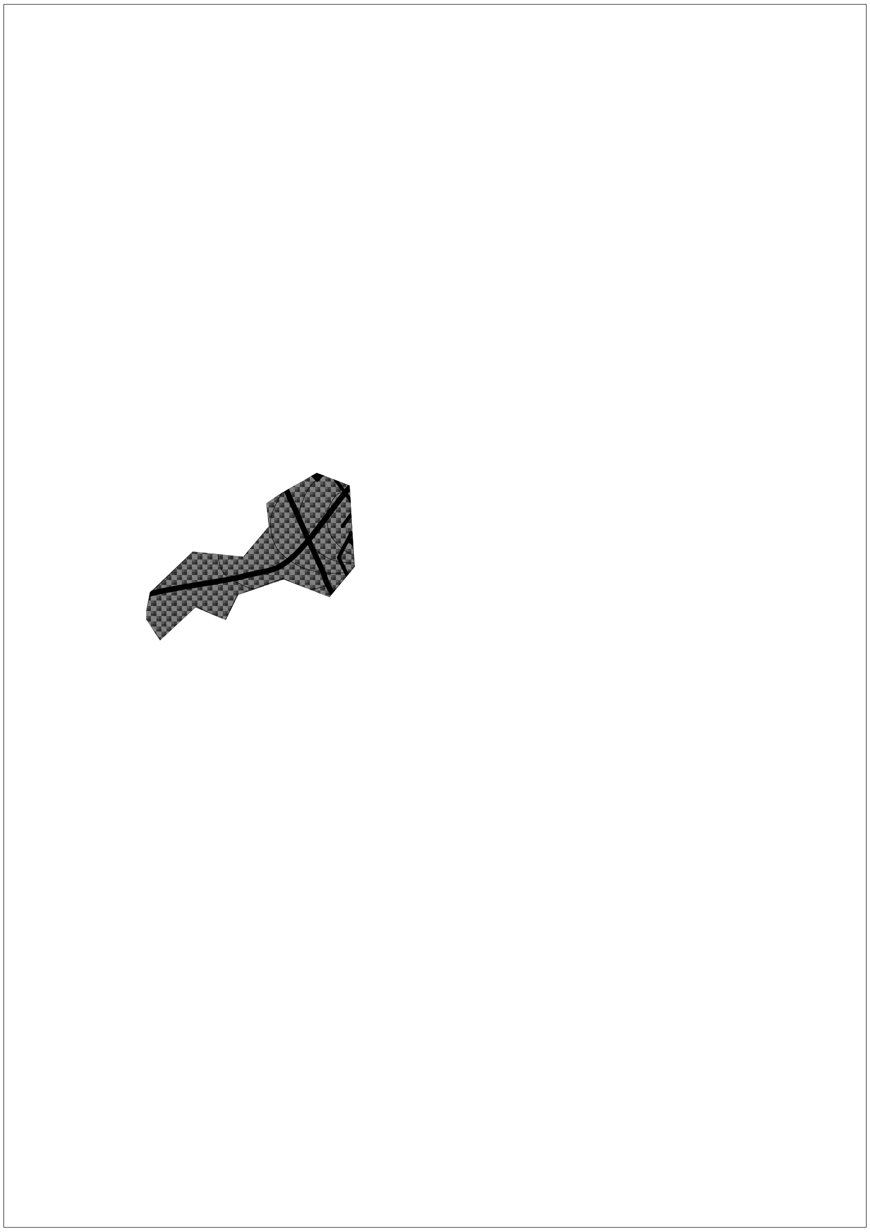

Fig. 4: Depth to Basement Map

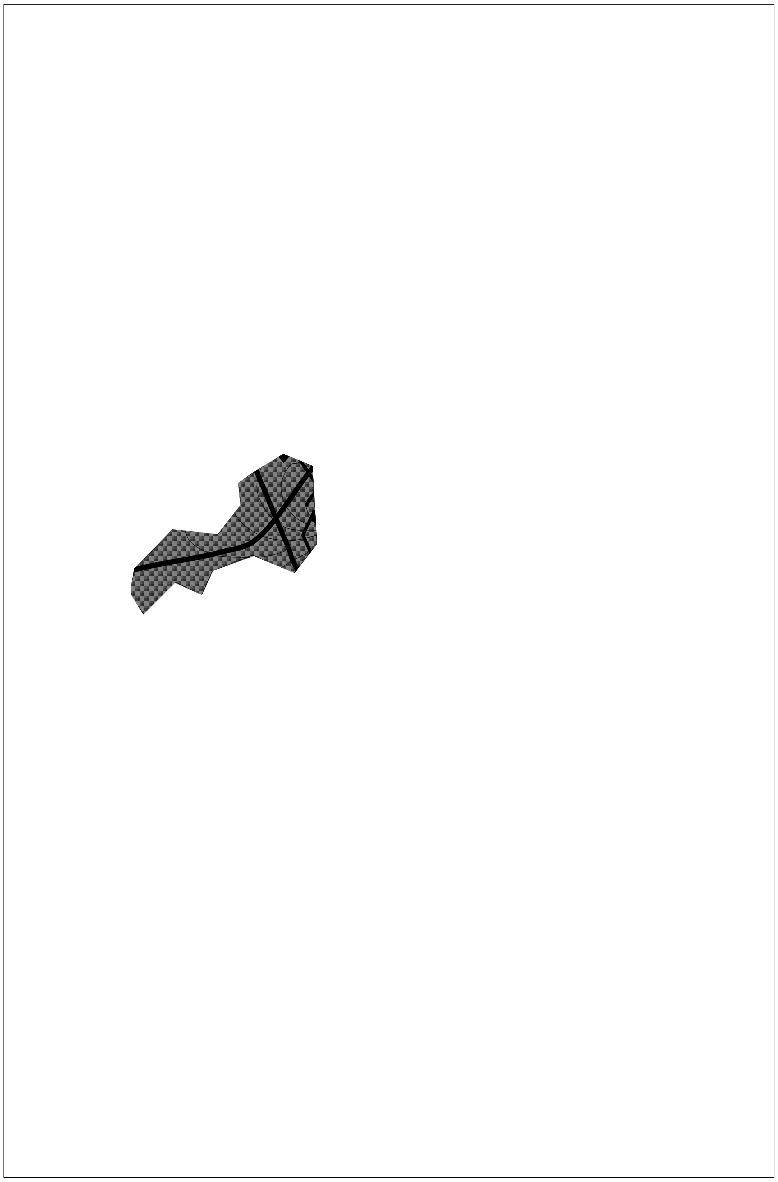

Fig. 5: Groundwater Potential Map

5. CONCLUSION

The electrical resistivity method of investigation adopted in this study has proven useful in the identification of groundwater potential zones within the study area. High groundwater prospective areas encompass P2, P3, P9, P10, P11, P18, P20, P29 and P30. On the other hand, areas that must be avoided include P6, P12, P13, P14, P15, P17, P32 and P34 because of the low groundwater potential nature of these points. However, areas with moderate groundwater potentials include P1, P4, P5, P7, P8, P16, P19, P21, P22, P23, P24, P25 others are P26, P27, P28, P31 and P33 as illustrated in figure 5 above.

By way of contributing to knowledge, this research has helped characterize the entire study area for future groundwater development which will serve to benefit the inhabitants and Plateau state at large.

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