GEOELECTRICAL RESISTIVITY INVESTIGATION OF NORTHERN PART OF PAIKO AREA, NIGER STATE, NIGERIA.

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ABSTRACT

Vertical electrical sounding was carried out in northern part of Paiko using Abem Terrameter model SAS 4000. The study was carried out with a view to determine the subsurface layer parameters (resistivities, depths and thickness) that were employed in delineating the groundwater potential of the area. A total of six traverses with ten VES stations along each traverse, having separation of 50 m apart were investigated. It has a maximum current electrode separation (AB/2) of 100 m. Three to four distinct geoelectric layers were observed namely; Top layer, weathered layer, fractured/fresh layer, and fresh basement layer. Eight VES stations were delineated as ground water potentials of the area, having third and fourth layer resistivities range from 191 Ωm to 398 Ωm. Depths range found were from 13.60 m to 36.60 m and thickness varies from 9.23 m to 30.51 m. Viable boreholes for good portable water should be sited at VES stations J_8 and J_{10} having a fine aquifer at a depth of 36.60 m, and 17.80 m respectively with thickness of 9.23 m and 30.51 m respectively.

Introduction

The study area (Paiko) is the headquarter of Paikoro local government area of Niger State located in the central part of Nigeria. It has an elevation of 304 m above sea level with population amounts to 736,133 people as at 2006 census, and it coordinates are 9°25′60″N and 6 ° 37′60″E.

The availability of quality water resources has always been the primary concern of societies in semi arid and arid regions, even in areas of more abundant rainfall, the problem of obtaining adequate supply of quality water is generally becoming more acute due to ever increasing population and industrialization (Alisiobi and Ako, 2012). As a result of this, surface water can not be dependable throughout the year, hence, the need to look for other alternatives to supplement surface water. This makes the world depend on the largest available source of quality fresh water which lies underground and this is referred to as Groundwater. It is the water held in the subsurface within the zone of saturation under hydrostatic pressure below water table (Ariyo and Banjo, 2008).

Several methods employed in groundwater exploration include electrical resistivity, gravity, seismic, magnetic, remote sensing, and electromagnetic among others, out of which the resistivity method is the most effective for locating productive well and the Vertical Electrical Sounding (VES) technique can provides information on the vertical variations in the resistivity of the ground with depth (Ariyo, 2005). In view of the above, vertical electrical sounding (VES) techniques was used to investigate groundwater potential in northern part of Paiko, Niger state.

Resistivity is a principle or quantity that is governed sorely by pore fluid content or matrix mineral. If the matrix mineral is highly conductive (gold, clay, galena etc), the resistivity will be low, if pore fluid is water, resistivity will also be low.

There is a clear absence of conductive minerals on the outcrops. Therefore, low resistivity response can only be due to the presence of groundwater in the fractures.

GEOLOGY OF THE STUDY AREA

Generally, the area mapped forms part of the Minna- granitic formation that consists of Metasediment and metavolcanics. The Metasediment include quartzites, gneisses and the metavolcanics are mainly granites. Among the main rock groups are granites which occur at the central and northern part s of the area, while on the south and east, cobbles of quartzite are found especially along the channels and valley. However, the other bodies like pegmatites and quartz veins also occur within the major rock types, figure 2.

The rocks are mainly biotite –granites with medium to coarse grained, light colored rocks with some variation in biotite content. The mineral constituents are leucocratic to mesocratic. However the biotite minerals are thread like and are arranged rough parallel streak, although some are disoriented in the groundmass. The feldspar minerals occur as fine to medium grained though grains are cloudy as a result of alteration mostly along the twin planes while the quartz minerals are constituents of the granitic rocks which show strong fracturing in the granitic rocks of the area (Ajibade, 1980).

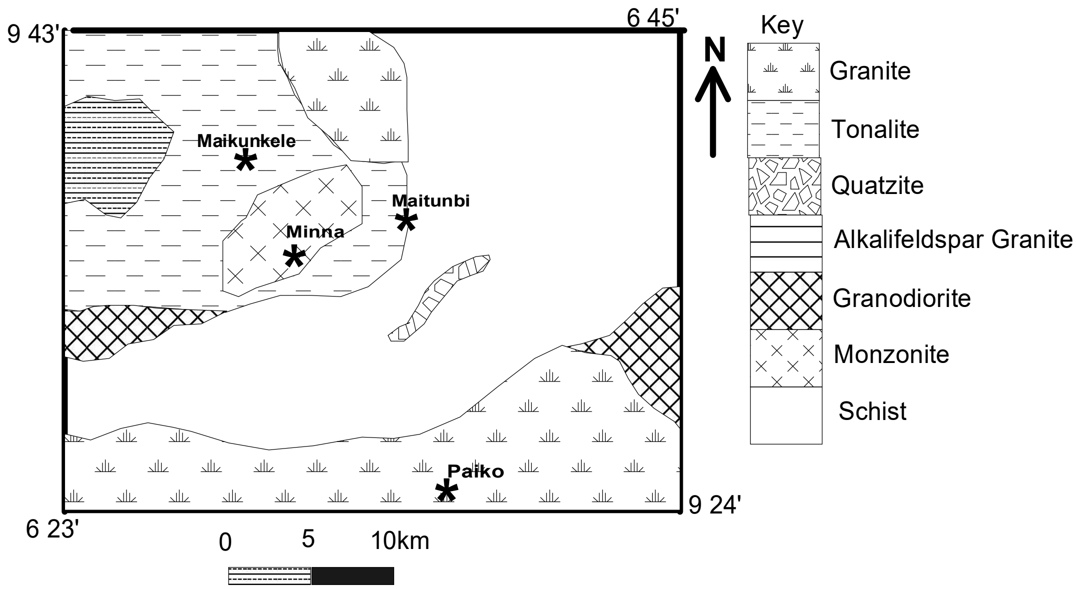

Figure 1: Geological Map of Minna. (After Alabi 2011)

MATERIALS AND METHODS

This research has utilized the electrical resistivity method in delineating the groundwater potential of the study area. Sixty vertical electrical soundings were carried out using SAS 4000 model Terrameter and its accessories. The conventional Schlumberger array pattern with half electrode spacing (AB/2) varying from 1 m to a maximum of 100 m was adopted. The apparent resistivity was computed using equation 1

$$\rho a = KR \qquad (1)$$

Where

Pa is an apparent resistivity

$R = \frac{\Delta V}{I}$, is the resistance

K is the geometric factor

The apparent resistivity values obtained from equation (1) were plotted against the half current electrode separation spacing using IPI2WIN software. From these plots, qualitative deductions such as resistivity of the layers, the depth of each layer, the thickness of each layer and curve types were made.

RESULTS AND DISCUSSION

The summary of the interpreted electrical resistivity survey is presented in Table 1 and 2. Table one consist of VES stations $G_1$to I_{10} while table two comprised of VES stations J_1 to L_{10}.The geoelectric section (Figure 2 a-f) reveals that the area is characterized by 3 to 4 geoelectric subsurface layers. Six transverses with sixty VES stations were covered and their subsurface geo-electric sections are presented in figure 2. From the figure, the geo-electric subsurface section ranged from 3 to 4 layers. Eight VES stations were delineated as ground water potentials of the area, having fractured layer resistivities range from 191 Ωm to 398 Ωm. The depths of these fractured layers are found to be from 13.60 m to 36.60 m and thickness varies from 9.23 m to 30.51 m as shown in table 3. In a basement complex terrain, areas with overburden thickness of 15 m and above and fractured layer resistivity of less than 400 Ωm are

good for groundwater development. The highest groundwater yield is often obtained from a Fractured aquifer or a subsurface sequence that has a combination of a significantly thick and sandy weathered layer and fractured aquifer (Olurunfemi, 2009). Therefore VES stations J8 and J10 are observed to be the best aquifer potentials of the area, having a fine aquifer at a depth of 36.60 m, and 17.80 m respectively with thickness of 9.23 m and 30.51 m respectively as shown in figure 3.
In order to investigate the continuous variation of resistivity with depth, iso resistivity map using Golden Surfer 11.0 version was obtained for the layers (figure 4).

Table 1: Layers resistivity, depth and curve types

VES	No of	Layer resistivity (Ωm)				Layer depth (m)				
station	Layer	ρ_1	ρ_2	ρ_3	ρ_4	d_1	d_2	d_3	d_4	Curve type
G_1	3	1248	184	60671		1.40	6.00	∞		H
G_2	3	1720	526	11221		1.38	7.27	∞		H
G_3	3	667	126	12178		1.14	4.07	∞		H
G_4	3	947	70.80	78315		1.63	5.11	∞		H
G_5	4	820	247	1021	308865	1.04	1.88	26.30	∞	HA
G_6	3	380	8244	1522		2.87	4.91	∞		K
G_7	3	1120	132	4920		2.07	3.93	∞		H
G_8	3	419	968	15552		3.91	23.30	∞		A
G_9	3	229	11184	1303		2.11	6.87	∞		K
G_{10}	3	117	351	13298		1.18	9.07	∞		A
H_1	4	1490	152	750	117922	1.18	3.21	25.40	∞	HA
H_2	3	415	124	3204		1.69	3.93	∞		H
H_3	3	308	130	13859		1.42	3.28	∞		H
H_4	3	1114	136	41263		1.93	7.16	∞		H
H_5	3	39.90	60825	5239		3.07	75.10	∞		K
H_6	3	1070	80368	224		1.38	4.81	∞		K
H_7	3	243	941	92291		1.85	26.10	∞		A
H_8	3	457	700	215028		1.45	12.40	∞		A
H_9	3	550	28	4233		1.12	3.30	∞		H
H_{10}	4	191	106	263	278439	1.43	3.03	17.60	∞	HA
I_1	3	595	46.40	194453		1.37	3.34	∞		H
I_2	3	761	110	3542		1.25	4.10	∞		H
I_3	3	536	153	7580		1.52	4.75	∞		H
I_4	3	527	32	103681		1.16	5.47	∞		H
I_5	3	180	27.70	55673		1.22	5.23	∞		H
I_6	3	1606	154	1796		1.12	3.72	∞		H
I_7	3	764	34.10	2027		1.06	2.18	∞		H
I_8	3	3082	131	43827		2.15	8.22	∞		H
I_9	3	474	27	38527		1.61	3.97	∞		H
I_{10}	3	1463	10.90	19302		1.11	2.78	∞		H

Table 2: Layers resistivity, depth and curve types

VES station	No of Layer	Layer resistivity (Ωm) ρ_1	ρ_2	ρ_3	ρ_4	Layer depth (m) d_1	d_2	d_3	d_4	Curve type
J_1	3	841	223	2867		1.36	3.61	∞		H
J_2	4	439	85.20	236672	696	1.35	3.53	8.57	∞	HK
J_3	3	1423	978	9225		8.53	15.70	∞		H
J_4	4	985	189	94441	288	1.05	3.27	11.20	∞	HK
J_5	3	83.80	29.40	131987		1.86	5.86	∞		H
J_6	2	62.20	1623			1.56	∞			A
J_7	3	982	199	2950		0.95	3.54	∞		H
J_8	4	387	140	398	118946	1.86	6.09	36.60	∞	HA
J_9	3	620	11.20	58241		1.00	3.00	∞		H
J_{10}	4	571	124	354	213414	1.30	2.73	17.80	∞	HA
K_1	4	554	4846	296	196873	3.57	7.19	16.40	∞	K
K_2	3	636	978	5752		4.06	26.20	∞		A
K_3	3	517	78	5437		1.17	3.22	∞		H
K_4	3	178	111	6005		1.42	4.47	∞		H
K_5	4	469	117	191	134745	1.07	3.00	15.70	∞	HA
K_6	3	198	331	95088		1.30	15.20	∞		A
K_7	4	776	61.30	1478	59411	1.21	2.76	40.30	∞	HA
K_8	3	712	61.20	108026		1.06	7.45	∞		H
K_9	3	786	114	29362		2.02	16.10	∞		H
K_{10}	3	433	113	1038		2.02	3.62	∞		H
L_1	4	300	196	27962	79.90	2.69	7.93	15.30	∞	HK
L_2	4	620	154	38600	130	1.18	3.24	8.02	∞	HK
L_3	4	625	132	113317	303	1.28	3.03	6.78	∞	HK
L_4	3	1052	232	172184		1.24	12.70	∞		H
L_5	3	656	289	4230		1.49	13.60	∞		H
L_6	3	85	15.20	78682		1.13	5.26	∞		H
L_7	3	584	156	2853		1.18	3.73	∞		H
L_8	3	1003	59.80	31877		2.54	7.28	∞		H
L_9	3	546	43.20	107599		1.42	7.54	∞		H
L_{10}	3	420	170	110943		2.31	14.40	∞		H

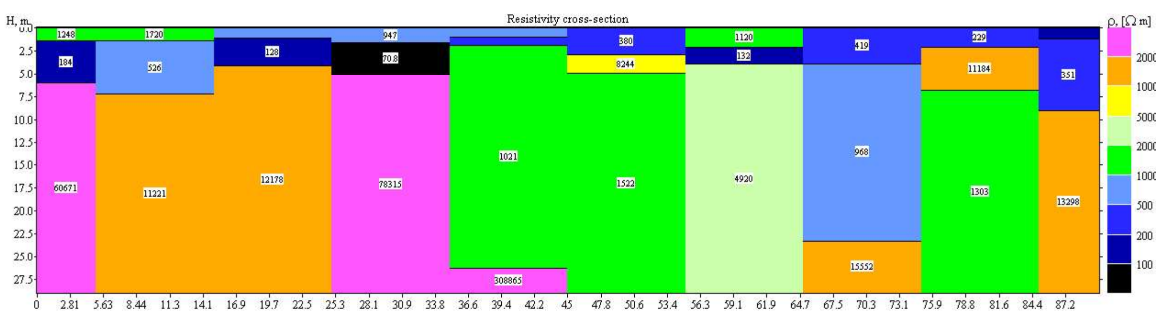

Figure 2 a: Geo- electric Section for Transverse G

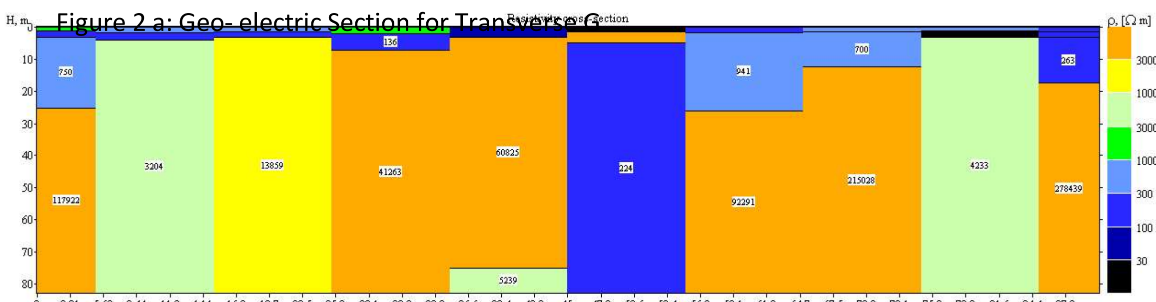

Figure 2 b: Geo- electric Section for Transverse H

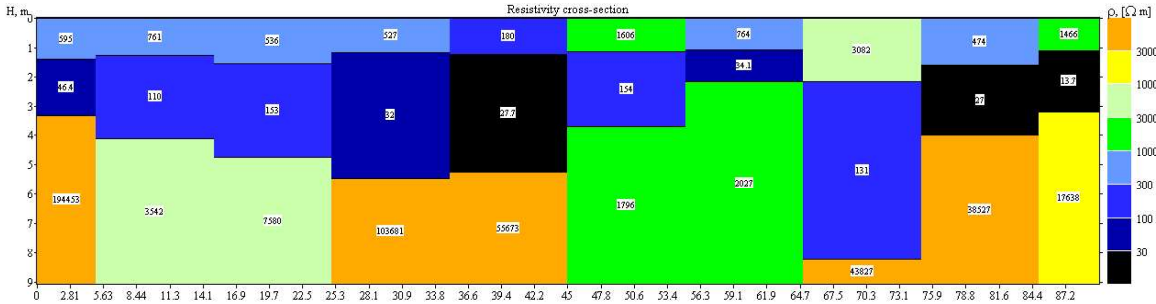

Figure 2c: Geo- electric Section for Transverse I

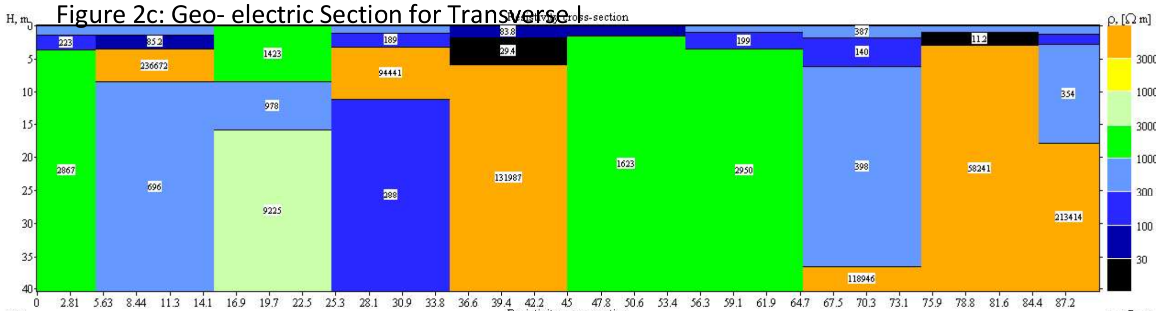

Figure 2d: Geo- electric Section for Transverse J

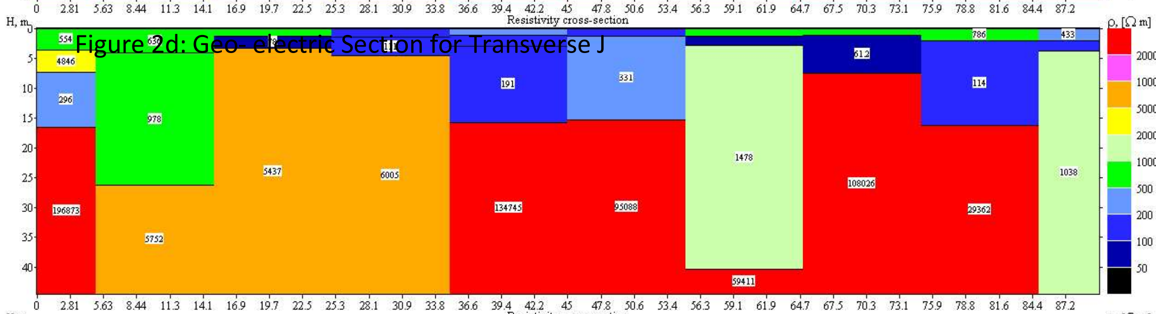

Figure 2e: Geo- electric Section for Transverse K

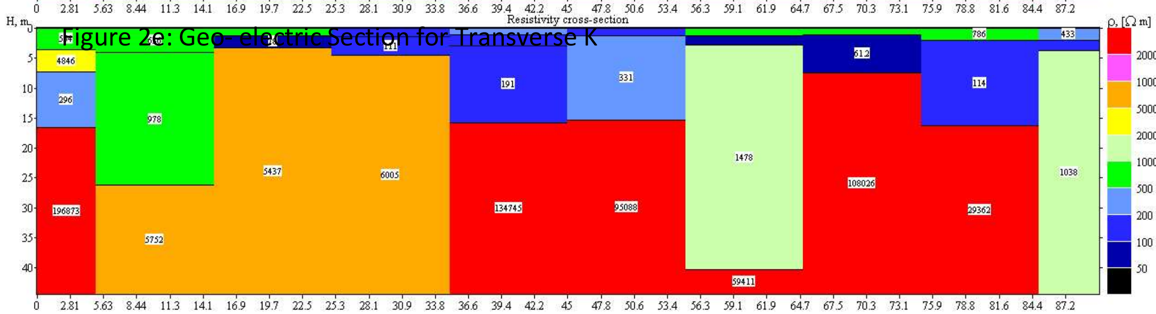

Figure 2f: Geo- electric Section for Transverse L

VES Stations	Layer Number	Layer resistivity (Ωm)	Layer depth (m)	Layer thickness (m)	Curve Type
H_{10}	3	263	17.60	14.57	HA
J_8	3	398	36.60	30.51	HA
J_{10}	3	354	17.80	15.07	HA
K_1	3	296	16.40	9.23	K
K_5	3	191	15.70	12.70	HA
K_6	2	331	15.20	13.90	A
L_5	2	289	13.60	12.11	H
L_{10}	2	170	14.40	12.09	H

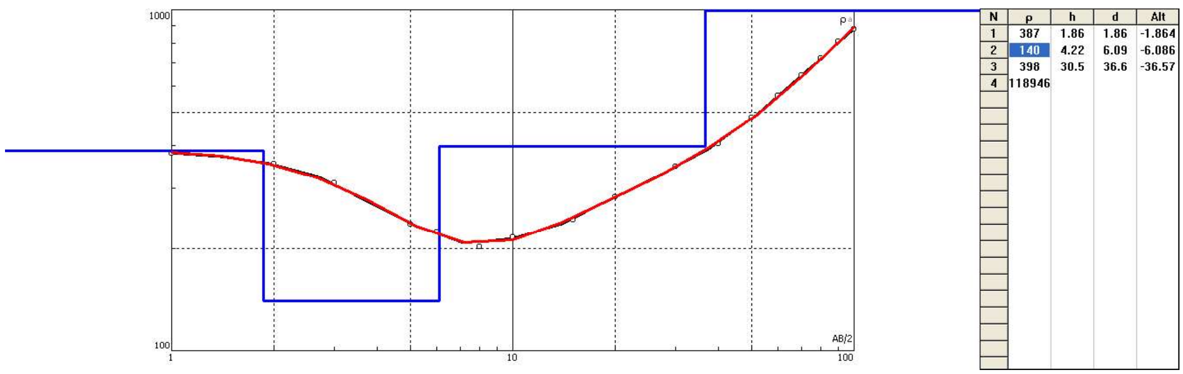

Figure 3a: VES Curve J_8

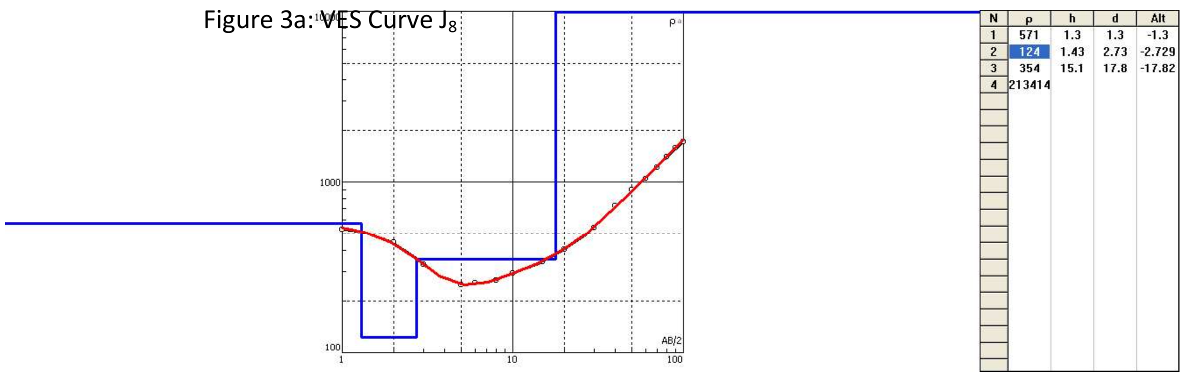

Figure 3b: VES Curve J_{10}

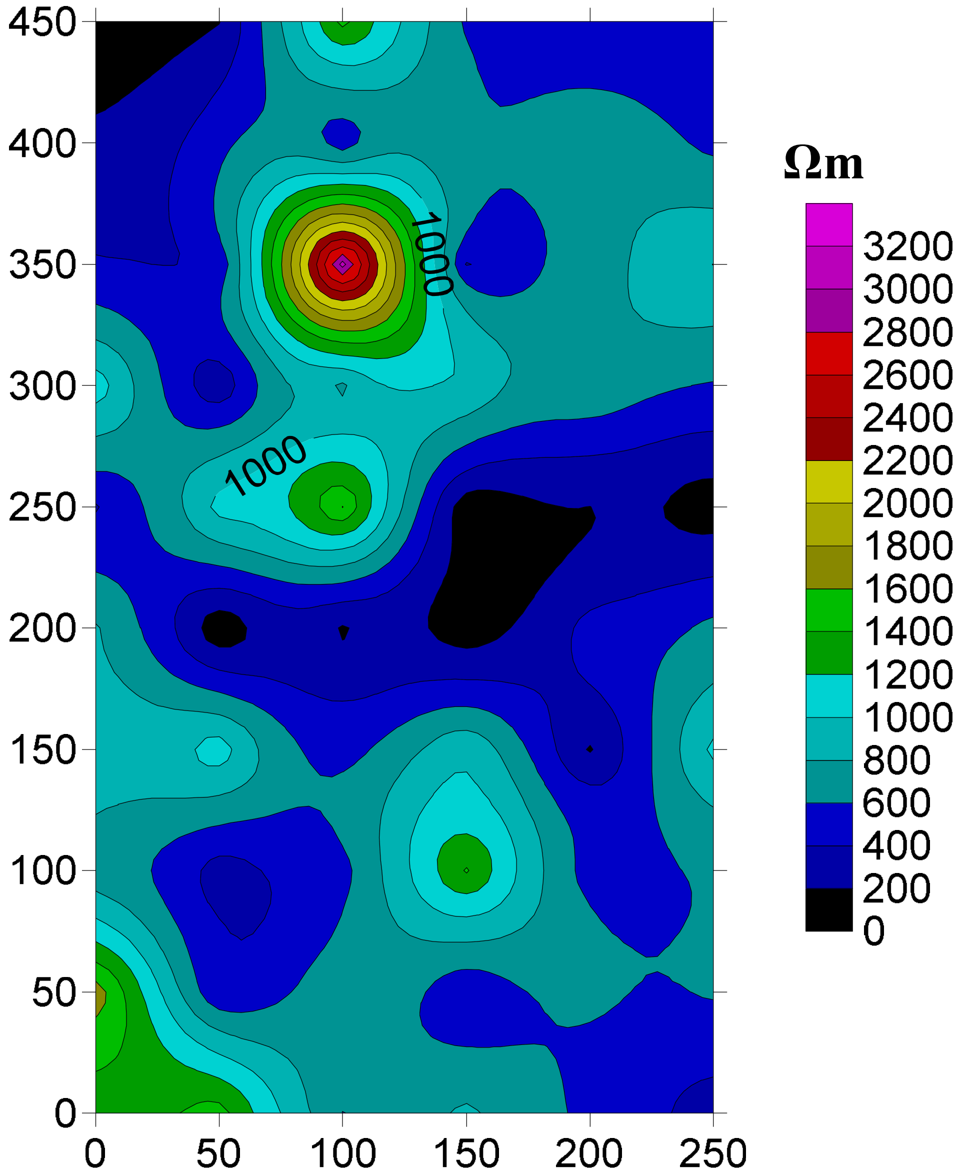

Figure 4 a: Iso – Resistivity Map for Layer One

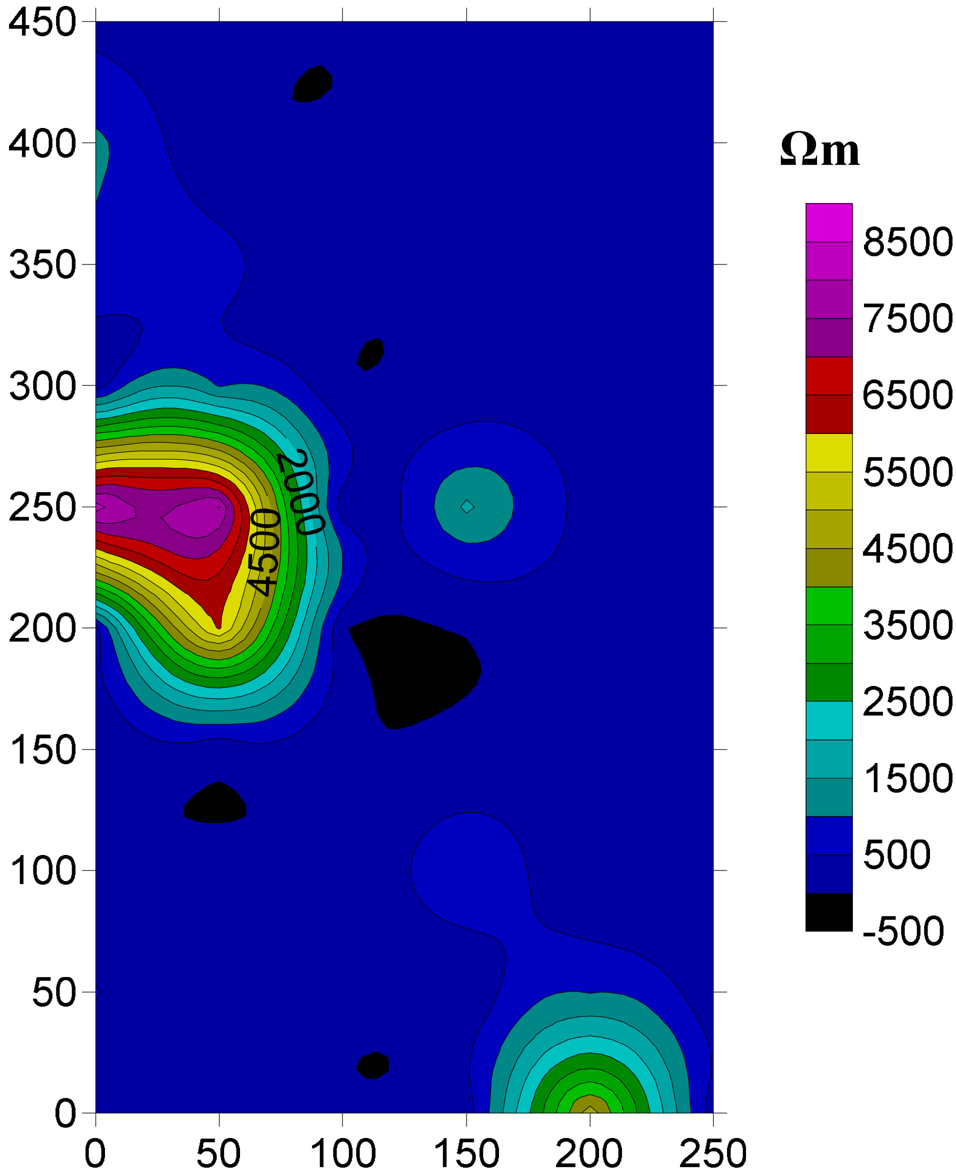

Figure 4 b: Iso – Resistivity Map for Layer Two

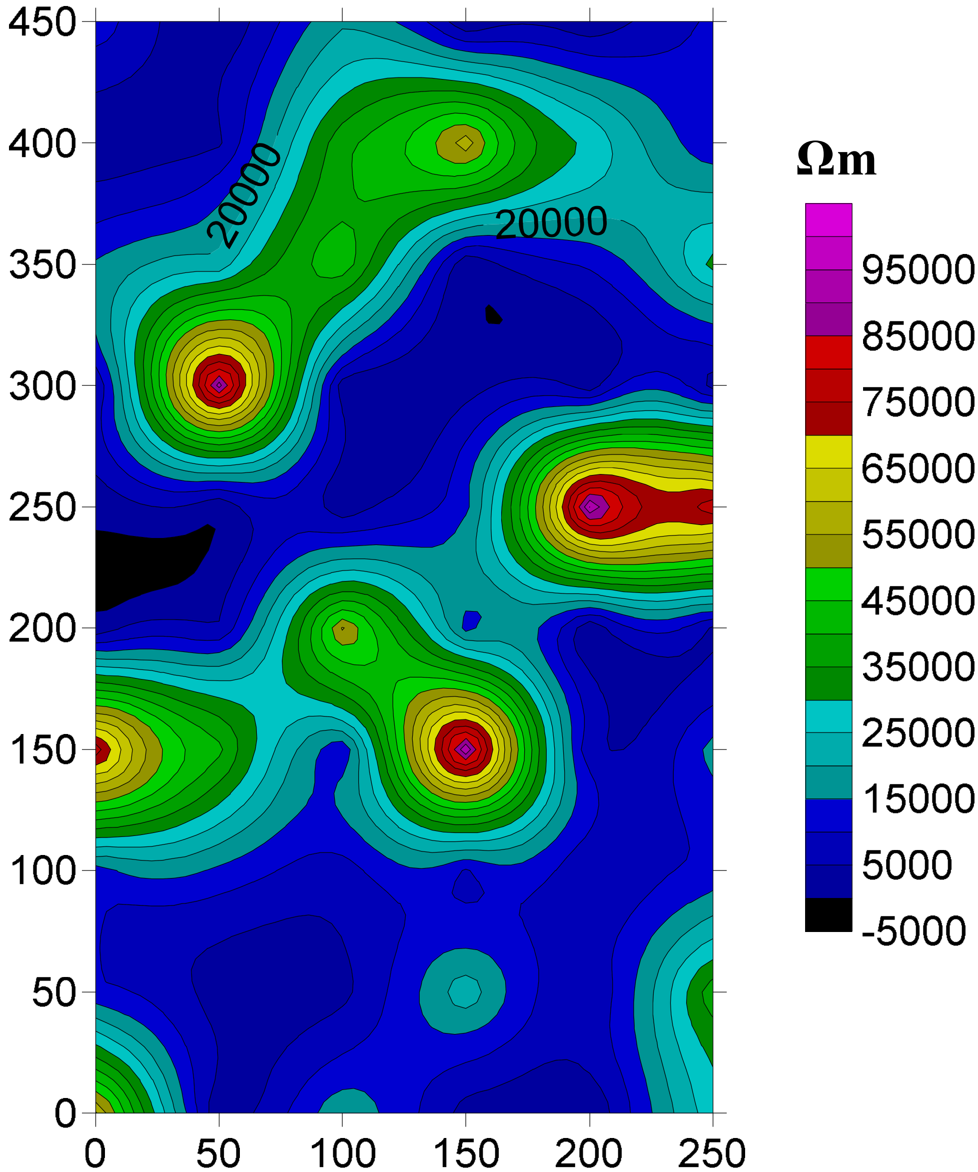

Figure 4 c: Iso – Resistivity Map for Layer Three

Conclusion

Groundwater usually occurs in discontinuous aquifers in basement complex area. Defining the potentials of the aquifers is normally a tedious exercise because of the intricate properties of the basement rocks (Adeniji *et al*, 2013). Therefore the uses of various electrical resistivity parameters (resistivities of the fractured layer, depth of the layer and thickness of the layer) were employed in classifying the groundwater potentials of the study area. Groundwater developments can be concentrated in the areas of possible groundwater potentials as indicated in table 3.

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