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PRELIMINARY ASSESSMENT OF GROUNDWATER POTENTIAL AND STRUCTURAL DEVELOPMENT AT POMPOM VILLAGE, MINNA, NORTH CENTRAL NIGERIA USING ELECTRICAL PROFILING METHOD

Adetona A.A., Rafiu, A.A., *Salako, K.A., Ofor, N.P. & Alhassan, D.U.
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Abstract

The result of preliminary study of ground water assessment and structural development at Pompom village is presented. The profiling data were collected over a total number of sixty-six (66) VES points covering 500m by 1km, using Werner configuration method. The field was divided into two measuring 500m by 500m and the data collected were analyzed separately. The profiling data were analyzed using both Surfer 8 and Microsoft Excel package. The results of the analyses shows that the areas identified as suitable for ground water exploitation are northeast and southern parts of the study area where resistivity values are relatively low. Areas or points identified for civil engineering development are areas identified with relatively high resistivity values, these areas correspond to VES: B2, C1, C2, C4, D3, F3, F4 C'4 and F'1.

Keywords: Basement, geoelectric, resistivity, Wenner configuration and profiling

Introduction

The growth of any community is a function of the availability of basic infrastructural needs such as water, road, and electricity among others. As a source of good uncontaminated water, groundwater is becoming more important for many needs, especially for domestic, agricultural and industrial use.

The use of geophysical resistivity technique as a geophysical prospecting method and a technique for groundwater exploration is rapidly accelerating in this present time. Geophysical resistivity techniques are based on the response of the earth to the flow of electrical current. With electrical current passed through the ground and two potential electrodes to record the resultant potential difference between them, we can obtain a direct measure of electrical impedance of the subsurface material. The resistivity of the subsurface, a material constant, is then a function of the magnitude of the current, recorded potential difference and the geometry of the electrode array (Lowrie, 1997).

Measurement of the resistivity is in general, a measure of water saturation and connectivity of pore space. Resistivity measurements are associated with the varying depths relative to the distance between the current and potential electrodes in the survey, and can be interpreted quantitatively in terms of a lithologic and/or hydro-geologic model of the subsurface. In shallow subsurface, the presence of water controls much of the conduction variation. This is because water has a low resistivity and electric current will follow the path of least resistance (Salako, 2005).

Exploration for groundwater potential of the study area has not been fully undertaken. Hence information on the subsurface water is still insufficient. Because of changes in season, the water table level of the granite gneiss aquifer fluctuates (unconfined and discontinuous). The alluvial deposits are unconsolidated and often in a saturated state, their water which is close to the surface could be tapped with relative ease. Groundwater is confined to zones of weathered rocks, joints and fractures in the basement complex (Okosun, 1995a)

In some areas in Nigeria, like Minna, in north-central part of the country, sinking of borehole is both time consuming and relatively costly, most especially, for middle class citizens. In order to safe guard these problems, as there are many dry or failed borehole already drilled in this part of the country, there is need to conduct hydro-geological and geophysical survey of the area to give useful information on the possible locations for groundwater (borehole) development. This becomes necessary as the available sources of water (surface water and hand-dug wells) to this community are virtually non-existence. It is also expected that the available resources could also be overstretched as the community being one of the host communities to Federal University of Technology, Minna, which, provides alternative homes to some staffs and students of the institution. The end result of this work is expected also to guide in terms of structural development of the area.

This work aimed to provide alternative and lasting solutions to perennial water supply problems that have been facing the communities around the survey area for decades, by providing information about the subsurface structure that could be a guide to ground water supply and development. The information about the subsurface structure will also solve the lingering problems of collapsed building recently faced by the society (or Nigeria as a whole).

There are 3 categories of field techniques that exist for conventional resistivity analysis of the subsurface. These techniques include vertical electric sounding (VES), constant separation traversing (CST) and combined procedures which utilize characteristics of both VES and CST. Constant separation traversing also known as electrical profiling uses collinear arrays to determine lateral variations in shallow surface at a more or less fixed depth of investigation. The current and potential electrodes are moved along a profile with a constant spacing between electrodes, as done in this work (Kearey *et al.*, 2004)

Geology of Niger State

The Niger basement lies within the pan African belt of West Africa. Niger state is covered by two major rock formations, the sedimentary and the basement complex rocks. The sedimentary rocks to the south are characterized by sandstones, and alluvial terrace and terrestrial deposits particularly, along the Niger valley and in most parts of Borgu, Bida, Lapai, Mokwa, Wushishi LGAs (Ajibade, 1980). The majority of the sediments and minor intrusive rocks may well have been subjected to several periods of metamorphism (Ajibade, 1980). The subarea contains flood plains of the Niger and Kaduna River and this made the state to be the most fertile agricultural lands in the country (Ajibade, 1980). The sediments composing alluvium consists of consolidated gravel, coarse and fine sand, silts and clay of recent age which have been deposited in and along the channels. The sediments were laid down in the form of lenses on the flood plain.

To the North, is the basement complex characterized by granitic outcrops or inselbergs which can be found in the vast topography of rolling landscapes. Such inselbergs dominate the landscape in Rati, Shiroro, Minna, Mariga, Guarara and Suleja. The lithologic units in this area include migmatite, gneiss, metavolcanic rocks and metasediments, low grade schist which are N-S trending also include the granite rocks of the older granite suite.

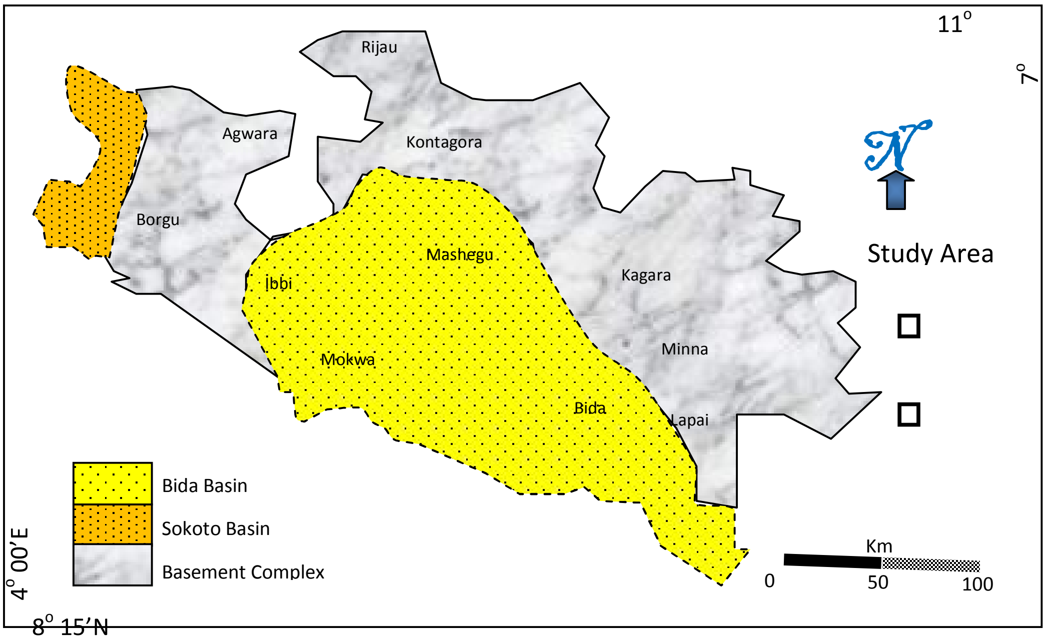


Figure 1: Geological Map of Niger State, Nigeria

Location and Accessibility of the Study Area

The area of investigation, pompom village is found in Bosso local government of Niger state, between km14 and km15, along Minna - Bida expressway, opposite Federal University of Technology, Gidan Kwano. It lies between latitude 9º 32ˈ N to 9º 33ˈ N and longitude 6º 28ˈ 30ˈˈE to 6º 29ˈ 30 ˈˈE (figure 2 and 3).

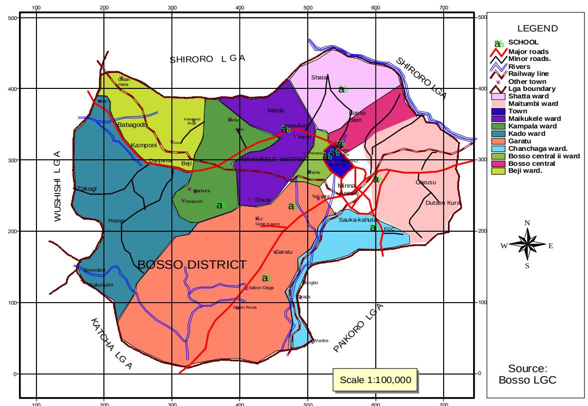


Figure 2: Map of Bosso LGA of Niger State, Nigeria

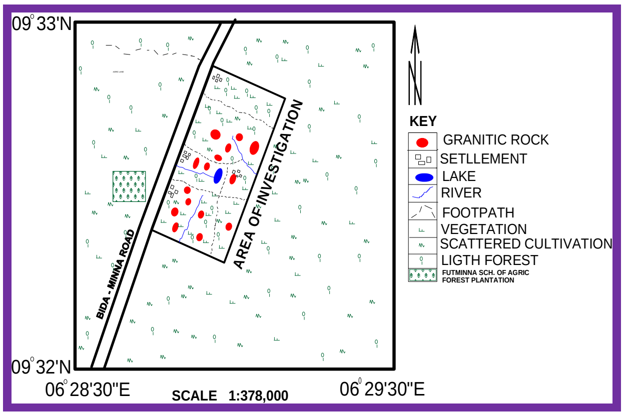


Figure 3: Map of the study Area

Method of Investigation

The constant separation traversing (CST) of profiling, using Werner electrical configuration method was employed in this survey. The four electrodes were kept at constant separation of 10m interval, which translate to 15m depth of probed (i.e. $^3/_2 a$, where "a" is the electrode separation). However, the results obtained from this survey imply that the resistivity that traverses the study area was the resistivity at 15m depth. Each profile trends west-east direction and a profile is 500m long. All profile has six number of VES points with inter-profile spacing of 100m and inter-grid spacing of 100m as well. The total number of profile in this survey is 11 profile combined. However, because of time factor, the field was divided into two, with six number of profile in each division.

Data Collection

The Terrameter SAS 4000 was used in this survey. This equipment operates in three different modes: Resistivity, self-potential and induced polarization. The data sets collected in this work was done in resistivity mode. The control knob was positioned on resistivity mode and the necessary connections and adjustments (electrode spacing) were made (ABEM Terrameter Instruction Manual).

E →

N ↑

A1	A2	A3	A4	A5	A6
B1	B2	B3	B4	B5	B6
C1	C2	C3	C4	C5	C6
D1	D2	D3	D4	D5	D6
E1	E2	E3	E4	E5	E6
F1	F2	F3	F4	F5	F6
A’1	A’2	A’3	A’4	A’5	A’6
B’1	B’2	B’3	B’4	B’5	B’6
C’1	C’2	C’3	C’4	C’5	C’6
D’1	D’2	D’3	D’4	D’5	D’6
E’1	E’2	E’3	E’4	E’5	E’6

Figure 4: Profile Trending.

The need for data reduction or two or more measurement was not necessary because the receiver of SAS 4000 discriminates noise and measures voltages correlated with transmitted signal current. More so, the system has the built-in function to average the best measurement of maximum of four staking with the standard deviation of unity or even less. Table 1 shows the profile trends through which the data were collected.

The electrical resistivity profiling data were collected using the Werner array configuration method of electrical sounding. A total number of 66 VES points were sounded covering 500 by 1km as shown in figure 4.

Data Presentation

From the preliminary survey through the use of Werner configuration, the following resistivity values were obtained, for profile A – F’ shown in tables 1 and 2.

Table 1: The resistivity (ohms-m) for profiling data obtained for profile A-F

INTER-GRID DISTANCE(M)	VES POINTS	A	B	C	D	E	F
0	1	153.4553	68.87264	308.8586	72.95724	79.8068	100.7325
100	2	152.01	286.6761	455.1501	80.05816	132.5924	94.26
200	3	133.7235	106.828	167.3429	270.9032	165.2692	200.5224
300	4	183.9327	70.56932	203.2874	138.0595	89.8612	406.889
400	5	137.3682	178.5913	101.6123	105.1942	158.4196	249.0349
500	6	41.97712	69.85923	97.90472	117.5736	80.81224	101.9893

Table 2: The resistivity (ohms-m) for profiling data obtained for profile A' (F) - F' (K)

INTER-GRID DISTANCE(M)	VES POINTS	A'	B'	C'	D'	E'	F'
0	1	100.73	87.34	109.59	98.53	155.78	266.31
100	2	94.26	153.39	77.54	87.97	116.19	152.51
200	3	200.52	108.77	89.23	93.50	133.15	50.96
300	4	406.88	162.00	218.43	97.77	125.36	119.14
400	5	249.03	133.84	82.06	94.69	112.35	115.81
500	6	101.98	69.81	78.11	54.29	78.80	58.56

Data Analysis

The field data collected was processed with Excel package to convert the resistance obtained to resistivity value with the use of appropriate geometric value. The end results here were graphically interpreted as presented in figures 5 and 6. Similarly, the resistivity values obtained were used to produce the resistivity contour map using Surfer 8 package from Golden Software (Golden Software Inc, 2002).

Data Interpretation

The data from the tables above for Werner were processed using Microsoft excel to produce the following curves according to their profiles.

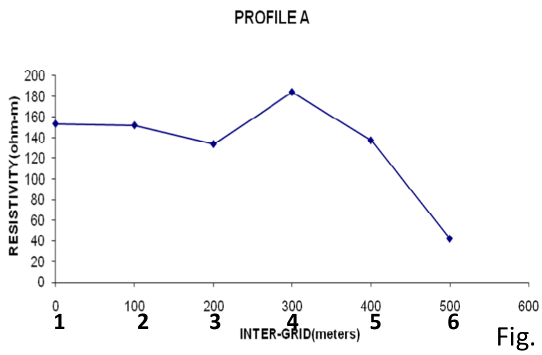


Fig. 5a

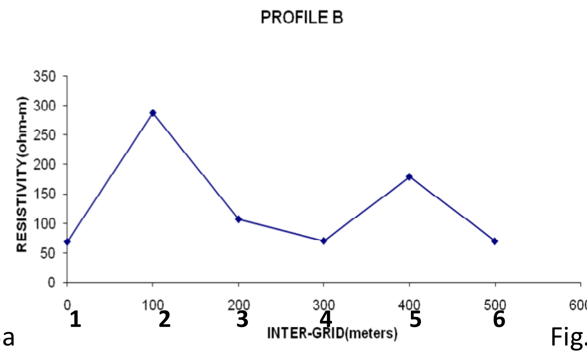


Fig. 5b

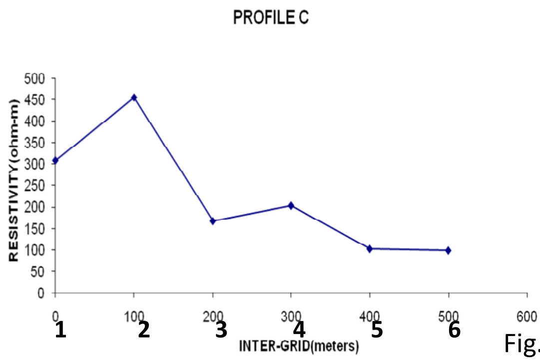


Fig. 5c

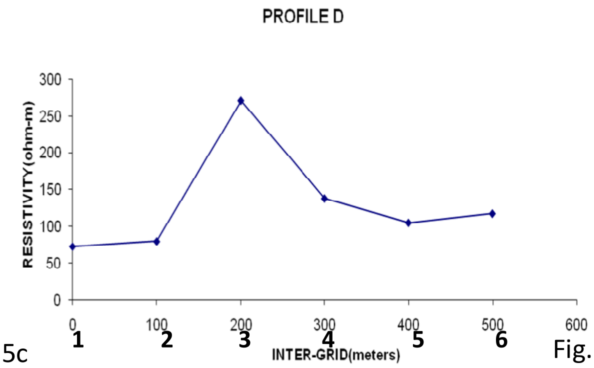


Fig. 5d

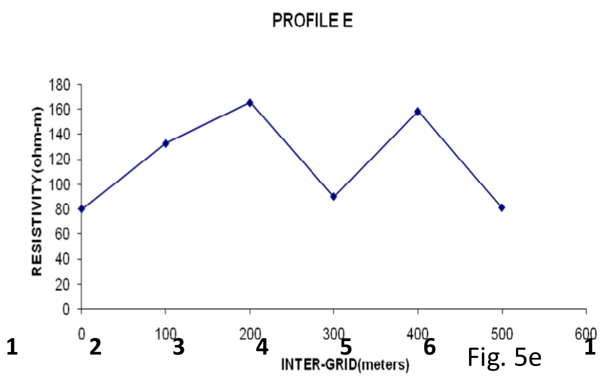


Fig. 5e

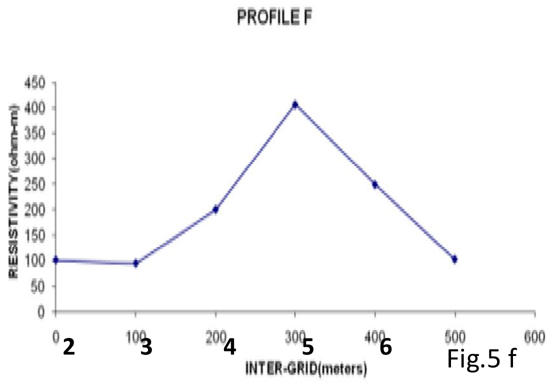


Fig.5 f

Figure 5 a - f: Wenner configuration curve for profile A - F

Profile A: Figure 5a is characterized generally with low resistivity values. It ranges between 40Ωm to about 180Ωm. The highest value could be found at VES point A4 while the lowest at point A6. This profile is generally characterized with fadama land as seen from surface.

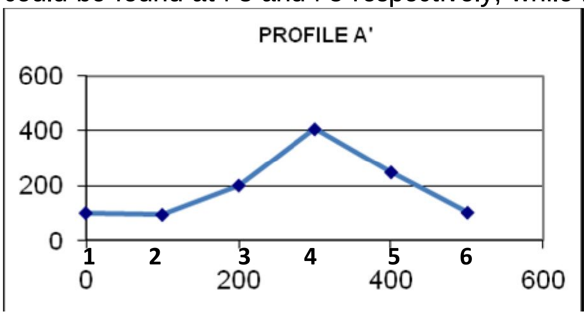
Profile B: Figure 5b shows a resistivity patern which ranges from 70Ωm to about 300Ωm. It has the highest value at B2 and the lowest values at B1 and B4. VES B2 was seen on the on field to be closer to large extrusion of gneiss which extends through profile C and D.

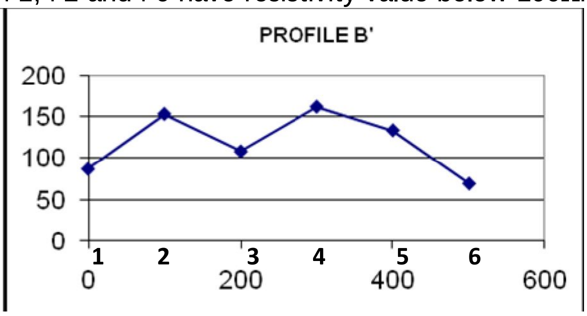
Profile C: Figure 5c, has relatively high resistivity values ranging between 100Ωm to about 450Ωm. The highest resistivity value could be found at C2 (closer to the outcrop) as evident from profile B. However, points C3 through C6 have relatively low resistivity value. This area is known from field as a low land area.

Profile D: From Figure 5d, the highest resistivity of about 270Ωm could be found at point D3 which has the same feature with C2 and B2, all other points are characterized with low resistivity between 80Ωm to about 140Ωm.

Profile E: Figure 5e is characterized generally with low resistivity values, which varies from 80Ωm to about 160Ωm, the highest resistivity value could be found at E3. This profile is characterized with low land feature and fadama around E4 through E6.

Profile F: Figure 5f, has resistivity values ranges between 80Ωm to about 410Ωm. The highest resistivity value could be found at F4. Similarly, relatively high resistivity value of 200Ωm and 250Ωm could be found at F3 and F5 respectively, while F1, F2 and F6 have resistivity value below 100Ωm





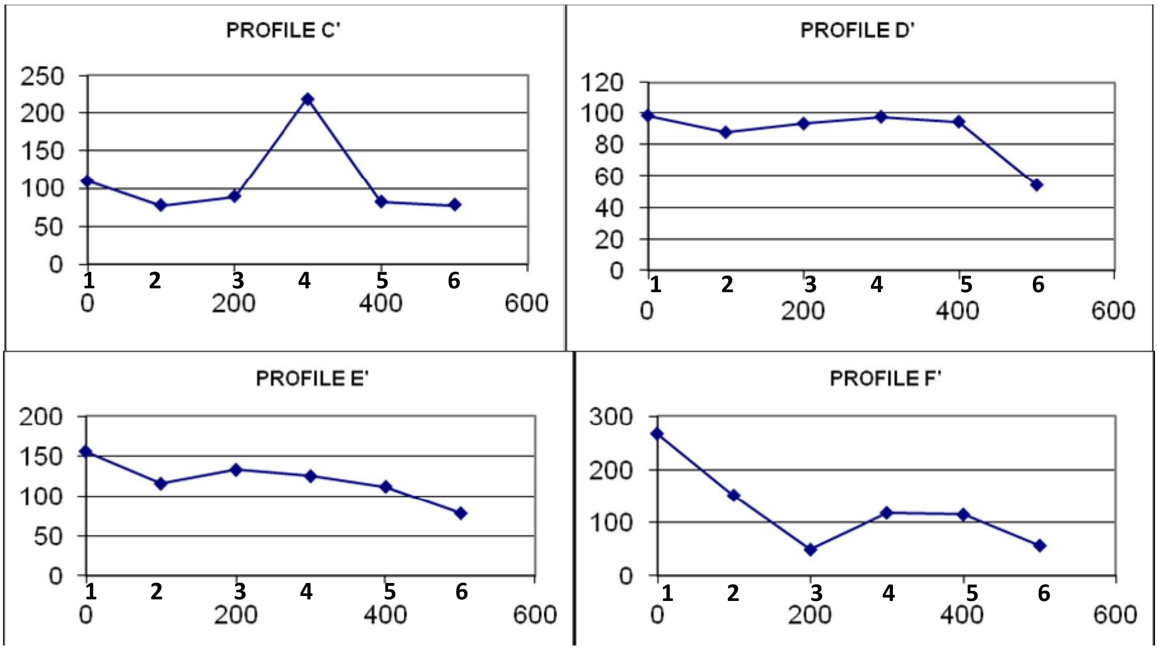


Figure 6: a - f: Wenner configuration (ρ (**Ωm**) Vs Distance (m)) for profile A' – F'

The second part of the survey area was characterize generally with large expanse of fadama and low land features, it was observed also that a river passess through end of all the profiles (i.e. B'6 to F'6). Therefore, profiles B' to F' were characterized generally with low resistivity values between 50Ωm to about 270Ωm (figure 6b – 6f). The ends of all the profiles here were characterized generally with low resistivity, which ranges between 54Ωm to 80Ωm (i.e. B'6 to F'6). The highest resistivity values could be found at F'1 (270Ωm), and C'4 (220Ωm). Figure 6a however, has the same feature as figure 5f. It only mark the beginning of the second half of the survey.

Contour Map of Profiling Data

The contour map of profiling data was done using Surfer 8 from Golden Software. This map was contoured at contour interval of 20Ωm, (figure 7). Figure 7 has high resistivity value (of about 450Ωm) at the western part of the survey area, most especially, the contour closure clustered around C2. Similarly, there is high contour value (400Ωm) at the south-eastern part, F4/A'4. Relatively high resistivity value could also be found at B2 and D3 with resistivity value of 300Ωm and 270Ωm respectively. However, the remaining part of the area (southern and North-eastern parts) were characterize with low resistivity value. These features were completely in agreement with figure 5 and 6. The Southern parts Profiles C' – F' (all of VES 1 - 3) are very close to the village where investigation was done.

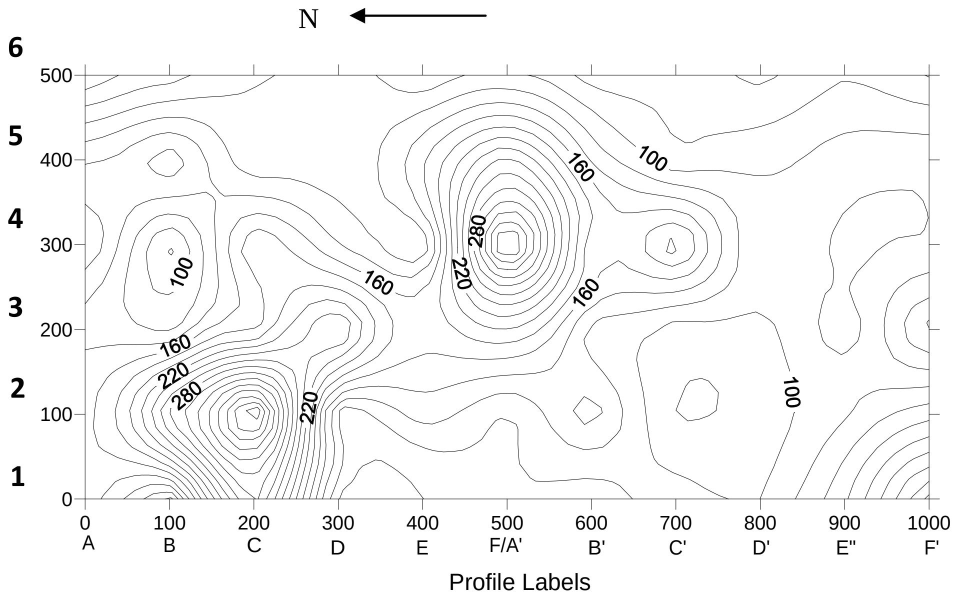


Figure 7: Contour map of Electrical Profiling at 15m Depth (Contour interval is 20**Ωm)**

Conclusion

The results obtained from the interpretation of the data for this survey have shown the efficiency and suitability in the use of electric resistivity method in probing underground water in the basement complex area. The areas identified as suitable for ground water exploitation are northeast and southern parts of figure 7, while points identified suitable for civil engineering development are: B2, C1, C2, C4, D3, F3, F4, C'4 and F'1 of figure 7 where resistivity values are relatively high.

Summary

The result of electrical profiling method of subsurface drilling using Werner configuration method, have shown clearly areas that could be of high potential for ground water development. This research had also identified areas that could be suitable for civil engineering and associated environmental development. Those points identified for civil engineering purposes are B2, C1, C2, C4, D3, F3, F4 of table1, figure 5 and figure 7 and points C'4 and F'1 of table 2, figure 6 and figure 7. These points should however be subjected to detailed geophysical investigation using seismic refraction method and or vertical electrical sounding (VES) method. This would enable proper delineation of subsurface structures and where basement is shallow, could be used for such purposes. While other points or areas are good for ground water development.

Recommendation

This research was tagged as a preliminary survey for both groundwater development and civil engineering purposes. However, one or more geophysical survey should be conducted on this area as a follow up to this research. The areas identified for groundwater development should be followed up with vertical electrical sounding (VES) using Schlumberger method or seismic refraction method, so as to check the viability of this method and to also get more detailed information about the subsurface lithology. The areas identified for ground water development should be drilled and the water should be collected and checked for its portability. Similarly, soil sample of those areas identified for good structural development should be collected for further analysis.

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