
GEOPHYSICAL EXPLORATION FOR MINNA CITY CENTRE IN NIGER STATE

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ABSTRACT

Geophysical exploration of the proposed Minna City Centre, at Minna the capital of Niger state was carried out with the objective of finding out the subsoil conditions based on geophysical site exploration methodology in order to take precise engineering decisions on the best locations for different utilities and ground water profile establishment. The major instruments used in carrying out the fieldwork include: SAS 300, Reels of cables, sets of electrode, hammer, tapes and sealed battery. Two survey profiles were used with 200m length each. Dedicated geophysical software was used for the data processing. Results show that the thickness of the overburden which ranges between 26 m to beyond 35 m is more in the south western part of the survey area and lowest in the north eastern part. This suggests that the thickness of the underground water aquifer will be more in the south western part of the survey area. Best locations of boreholes were recommended based on observations.

KEYWORDS: Geophysics, Site investigation, Subsoil exploration, Resistivity imaging, Underground water aquifer, Fresh basement.

INTRODUCTION

The most common site investigation techniques involve the drilling of holes in the ground, sampling at discrete points, and in situ or laboratory testing. Given the relatively small sums of money involved in ground investigations of this type, only a very small proportion of the volume of soil and rock that will affect construction can be sampled and tested (Engineer Manual, 2001). Geophysical techniques offer the chance to overcome some of the problems inherent in more conventional ground investigation techniques. Many methods exist with the potential of providing profiles and sections, so that the ground between boreholes can be checked to see whether ground conditions at the boreholes are representative of those elsewhere. Geophysical

techniques also exist which can be of help in locating cavities, backfilled mineshafts and dissolution features in carbonate rocks (Holubec, 2010).

Site investigation should be a carefully considered process of scientific discovery, tailored both to the conditions existing on site and to the form of construction which is expected to take place (Clayton et al., 2004; BS 5930, 1981). In order to make the most of site investigation, it is important that the design team (who may be led by architects, quantity surveyors and other non-engineering professionals) obtain at the conceptual design stage the advice, however briefly, of a geotechnical engineer. This geotechnical specialist can give the initial and most important guidance on the likely risks associated with the project, and the way in which they may be

investigated and dealt with. For most construction projects, the natural variability of the ground and groundwater conditions represent a major risk, which if not properly addressed can endanger not only the financial viability, but also the physical stability of the construction, either during construction or during the use of the building.

Geophysics provides an efficient and cost-effective means of collecting geologic and hydro-geologic information (ISSMGE TGI, 2005). Various techniques can be used to help determine the hydro-stratigraphic framework, depth to bedrock, extent of ground water contaminant plumes, location of voids, faults or fractures, location of abandoned wells, and the presence of buried material, such as steel drums, tanks, or pipelines. Geophysical investigations are most effective when used in conjunction with a drilling or boring program and should not be a substitute for such a program (TGMGWI, 2008).

The Niger state government as part of its developmental plan in the state intends to build a City Centre called Minna City centre, at Minna the capital of Niger state. As a pre-requisite for the development of the site, a physical development master plan for the site is required which include the topographical and boundary survey of the site, geotechnical and groundwater profiling, environmental impact assessment and development of the master plan of the

site. This study was aimed at investigating the subsoil conditions based on geophysical site exploration methodology for field data obtainment in order to take precise engineering decisions on the best locations for different utilities and ground water profile establishment.

METHODOLOGY

In this geophysical investigation, the major instruments used in carrying out the fieldwork include: SAS 300, Reels of cables, sets of electrode, hammer, tapes and sealed battery. The length of each of the survey profiles were 200m. The point on the red line labelled on the image map (see Figure 1) marks the starting point where the measurement began. Sets of electrodes were laid out at consecutive interval along the 200 m profile. When all the connections were completed, four electrodes were selected each time during the measurement. Two of the four electrodes served as the current electrode, by means of which current was ejected into the ground. The remaining two electrodes were the potential electrodes that were used to measure the resulting potentials. The measured resistivity values are regarded as the apparent resistivity values, which will be used later to generate the true resistivity using inversion method. Figure 1 shows the satellite image Map of the survey area with the profile line indicated in red lines. P1 and P2 stands for Profiles 1 and 2 respectively.



Figure 1: Satellite image Map of the survey area

The coordinate points for the various profiles are shown in Table 1. The coordinate points were taken at the beginning, the centre, and at the end of the

various profile. These coordinates measured in degree, minutes, and seconds were converted to degrees in order to generate the various 3D surfaces.

Table 1: The coordinate points of profiles

S/N	Profile	Start point		Centre Point		End point	
1	P1	9°36'59.47"N	6°32'57.92"E	9°36'56.81"N	6°32'55.77"E	9°36'54.45"N	6°32'53.79"E
2	P2	9°37'0.86"N	6°32'54.74"E	9°36'58.31"N	6°32'52.72"E	9°36'55.74"N	6°32'50.86"E

LOCATION AND GEOLOGY OF THE STUDY AREA

The site is in Minna, the Niger state capital. It is located between longitude 6°25"E and 6°45"E and latitude 9°24"N and 9°48"N. Minna occupied the central portion of the Nigerian basement complex. The geology of the soils in the study area comprises of meta-sedimentary and meta-igneous rocks which have undergone poly-phase deformation and metamorphism

(Ola, 1983). The site, which is about 1.2 km², is an abandoned local market which is generally flat in topography.

RESULTS AND DISCUSSION

The geophysical investigation results include the processing of the resistivity imaging data and analysis of the results.

Processing of Resistivity Imaging Data

Dedicated geophysical software was used for the data processing. In processing the data the observed (measured) apparent resistivity was subjected to inversion using the forward modelling procedure. This involves generating a calculated model from the field observed apparent resistivity by assuming an initial model. This calculated model was iteratively compared with observed apparent

resistivity, until a very good fit was observed between the two. The resulting true model at the point of close agreement between the observed and calculated was adopted as the true resistivity model that gave rise to the observed. Figure 2 (a) – (c) shows the observed apparent resistivity, the calculated apparent resistivity and the generated true model.

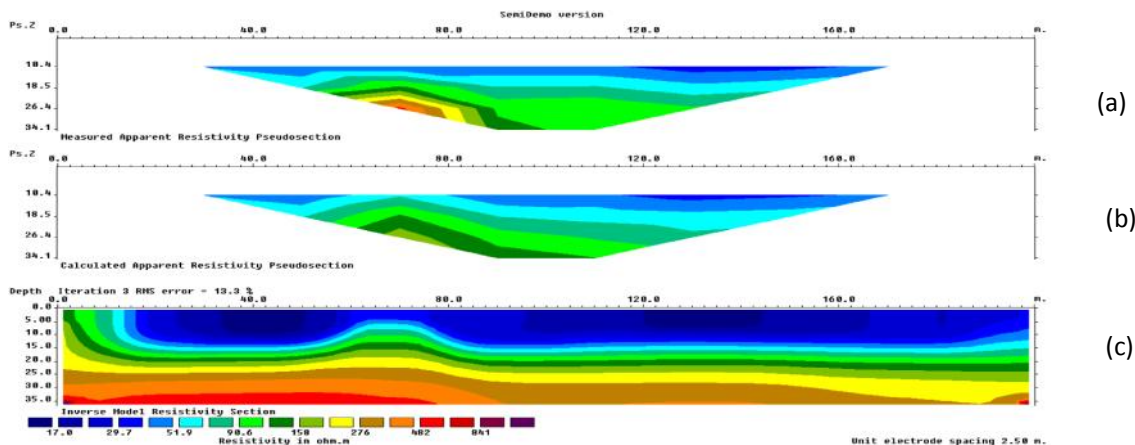


Figure 2: Resistivity Imaging section showing: (a) Observed apparent resistivity (b) Calculated apparent resistivity (c) True model

The results of the 2D resistivity imaging section for profiles 1 and 2 are shown in Figures 3 and 4, with only the true resistivity model shown. Each of the sections shows the distribution of true resistivity within the subsurface. It should be noted that the resistivity sections are not to be interpreted base on their colours but base on the resistivity value attached to the representative colours. A close examination of

the 2D resistivity imaging sections shows a level of discontinuous layering structure, which is basically a characteristic of the resistivity structure of the basement complex. The resistivity values ranges from 17 Ωm, which represent area of very low resistivity to 841 Ωm that represent the fresh basement structure within the subsurface (Schuppener, 2008).

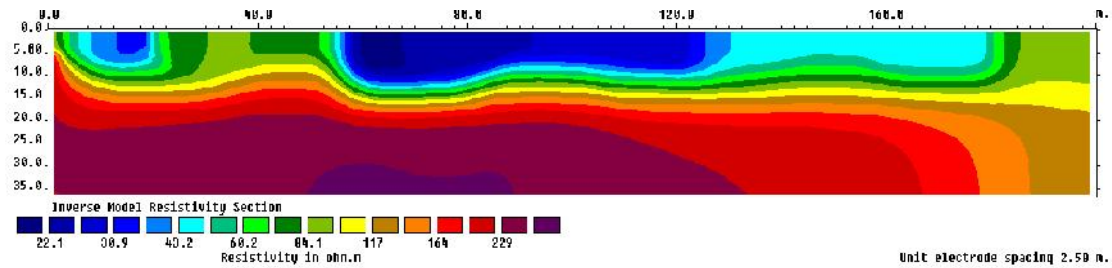


Figure 3: 2D subsurface distribution of true resistivity along profile 1

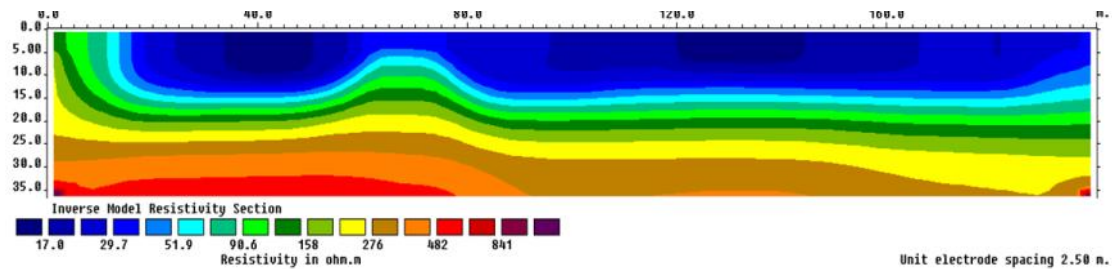


Figure 4: 2D subsurface distribution of true resistivity along profile 2

Base on the resistivity values, the overburden thickness from the various 2D resistivity sections were extracted along with their coordinate points. Also extracted with their coordinate points from the various 2D resistivity profiles are the depth to the fresh basement, and the resistivity values of a specific depth that represent the average depth to

water table. These extracted values for the overburden thickness, depth to fresh basement and average depth to the resistivity of the water table along with their coordinate points, were used to build the 3D surfaces for easy visualization of the results. 3D surface for the thickness of the overburden in the survey area is shown in Figure 5.

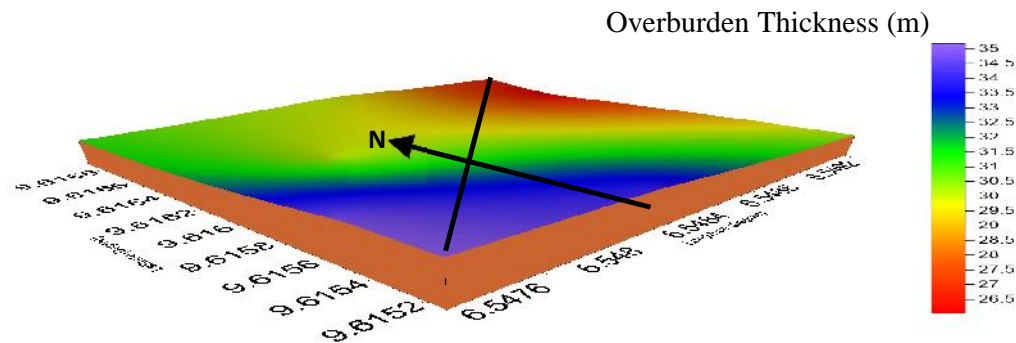


Figure 5: 3D surface showing the general overburden thickness within the survey area

The 3D Surface in figure 5 shows that the overburden thickness within the survey area is largest at the south western part of the area under investigation and least in the north eastern part. The thickness of the overburden ranges between 26 to 35 m. The thickness of overburden in a given area

Figure 6 shows the 3D surface indicating the depth to the fresh basement within the survey area. The 3D surface showed that the fresh basement is shallower in the north eastern and deepest in the

determines the amount of interconnecting pores within the subsurface where the underground water resides. This goes a long way to influence the water potential of a given area.

The 3D surface for the depth to fresh basement in the survey area is shown in Figure 6. south western part of the survey area. The depth to fresh basement ranges from 32 m to beyond 35 m in the area under investigation

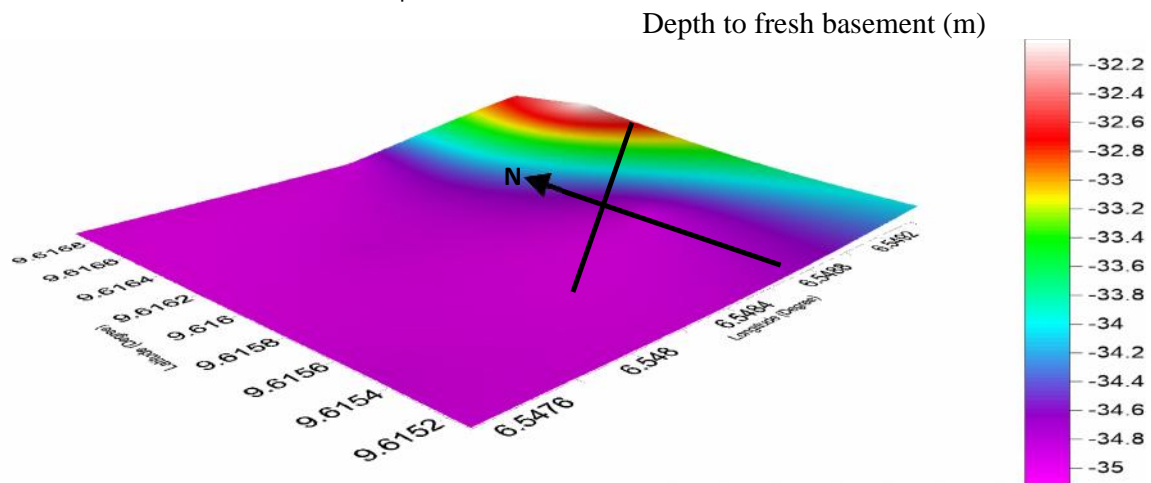


Figure 6: 3D surface showing the depth to the fresh basement of the of the survey area

Figure 7 shows the 3D resistivity surface generated by averaging the depth to the water table

from the various 2D profiles. The average depth from which the resistivity values were extracted is 16 m.

A very close observation of the distribution of resistivity values within the 3D surface, revealed that there is lower resistivity values in the south eastern part of the area under investigation and highest in the north western part. The resistivity distribution within the southern part is in close agreement with the resistivity of underground water which lies within the range of 10 Ω m to 150 Ω m. The resistivity distribution

in the northern part matches with the basement (weathered and Fresh) resistivity which lies in the range of 450 to 1000 Ω m. This section is in close agreement with the 3D surface of overburden thickness in Figure 5, giving an indication that a larger part of the underground water lies within the southern part of the survey area (TGMGW1, 2008).

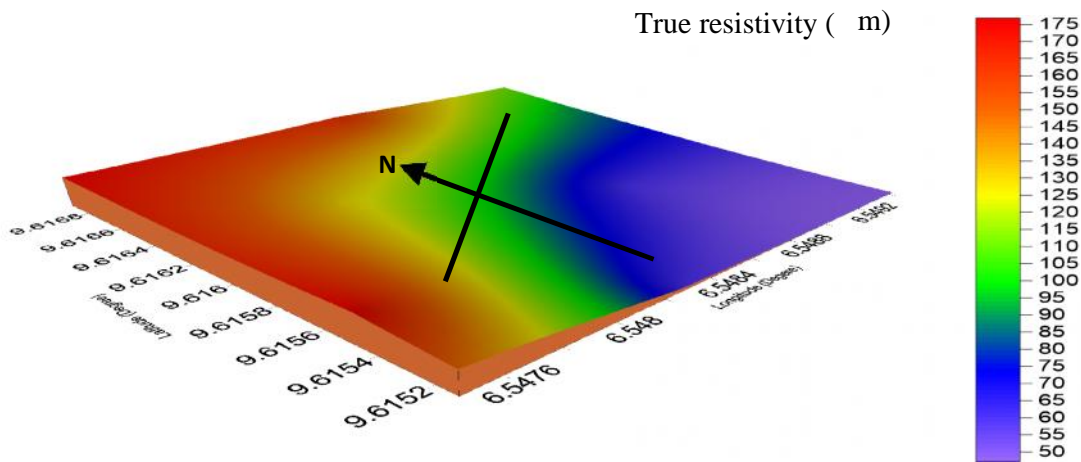


Figure 7: 3D surface showing the distribution of resistivity at an average depth

CONCLUSION

The results of this study show that:

1. The thickness of the overburden which ranges between 26 m to beyond 35 m is more in the south western part of the survey area and lowest in the north eastern part that has thin overburden thickness. This suggests that the thickness of the underground water aquifer will be more in the south western part than in the north eastern part of the survey area.
2. The depth to the fresh basement ranges between 1 m to beyond 35 m. The difference in the range of values between overburden thickness and depth to fresh basement is as a result of the thickness of the weathered basement with a range of thickness value of 0 to 6 m, and lies between the overburden and the fresh basement. On a general note,

the survey area can be said to be covered by thick overburden.

3. The 3D resistivity surface showed that a greater percentage of the aquiferous layers under investigation lies within the southern part.

RECOMMENDATION

Based on the results of this study, it is recommended that, in the event of siting boreholes for municipal use, 140 m along profile 2 with coordinate point 9° 36' 57.13" N, 6° 32' 52.01" E (9.61587° N, 6.54778° E) and 160 m along profile 1 with coordinate point 9° 36' 55.43" N, 6°23' 54.62" E (9.61540° N, 6.54851° E), will serve as the best points for drilling borehole that will result in very good yield of water. The boreholes should be drilled to a depth of 35 m.

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