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A Geoelectric Survey for Determination of Suitable Sites for Construction of Tube-Wells for the Proposed Damari Irrigation Scheme in the North Central Basement Complex, Nigeria

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Abstract: At the request of the Upper Niger river basin development authority Minna, Niger state, vertical electrical soundings were carried out to determine favourable sites for construction of pump-fitted tube wells which will serve as a source for sustainable water supply for the proposed Damari irrigation scheme. The soundings were carried out with symmetric schlumberger configuration at stations chosen across the study area. The data collected were inverted with 1D Earth Imager iterative software program. Information from a borehole was used as control to delineate realistic geologic model of the study area. Results of the investigation revealed succession of subsurface resistivity layers with respective rock types. From the succession, sites which will provide utmost yield were suggested based on depth and thickness range of the aquiferous layers.

Key words: Vertical Electrical Sounding (VES), tube wells, resistivity layers, imager iterative, aquiferous layers, symmetric , Nigeria

INTRODUCTION

Electrical resistivity method is one of the most widely employed geophysical methods for solving groundwater, environmental, geotechnical and mining problems (Sundararajan *et al.*, 2007, Adepelumi *et al.*, 2001; Elawadi *et al.*, 2006; Macnea and Irvine, 1988). Its choice for exploration of groundwater in basement terrain is governed by resistivity contrast that usually exists between the aquifer components and fresh basement. Because of the proven success of this method in groundwater exploration (Sundararajan *et al.*, 2007), the method was employed at the request of the Upper Niger river basin development authority Minna, Niger state to determine favourable sites for construction of pump-fitted tube wells which will serve as a source of sustainable water supply for proposed the Damari irrigation scheme. The site for the proposed scheme is located in the Marshy (Fadama) part of Kaduna South along the Kaduna airport road. Bounded by latitude 10°40'415"-10°43'716"N and longitudes 7°19'995"-7°23'331"E, it is accessible by motorable road network.

Geology and hydrogeology of the study area: The proposed site for the scheme falls within the Northern sector of the Nigerian basement complex. Details of the geology of the sector are contained in McCurry (1976). However, the study area is underlain by precambrian rocks of the Nigerian basement complex which has the imprints of thermo-tectonic events of the Archean to early Paleozoic times (Oyawoye, 1972; McCurry, 1976). The rock types of the basement according to Adanu (1991) are medium to coarse grained granite, undifferentiated schist, gneisses, granite gneisses, fine grained biotites and biotites-hornblende granite, quartz monzonite, quartz diorite and granodiorites.

According to Eigbefo, the superficial deposits which overlie the basement rocks, act as recharge materials, especially where they are underlain by weathered basement. Presence of thick lateritic, top surface characterizes the superficial deposit within the site.

The major aquifer components of the basement complex of Nigeria are weathered and fractured basement. These are commonly explored with D.C resistivity survey because of the resistivity contrast between the aquifer components and fresh basement.

MATERIALS AND METHODS

Data collection and processing: Vertical Electrical Sounding (VES) data were acquired with Sting resistivity/IP meter at VES stations spread across the proposed irrigation site (Fig. 1). The schlumberger electrode configuration with maximum electrode

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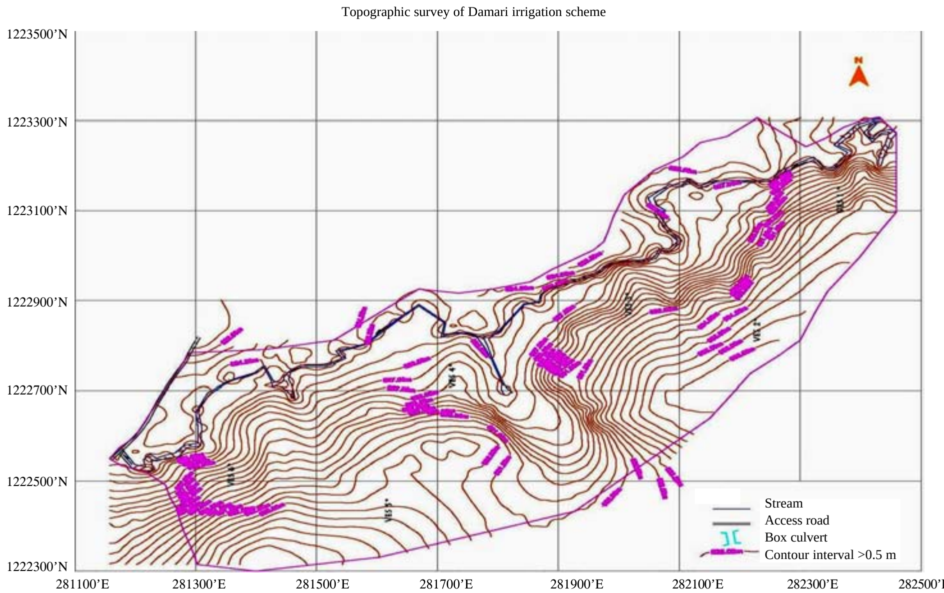
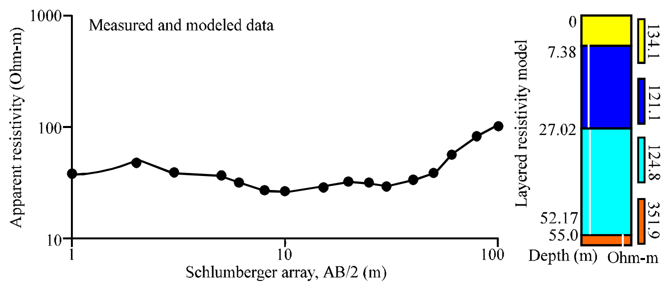
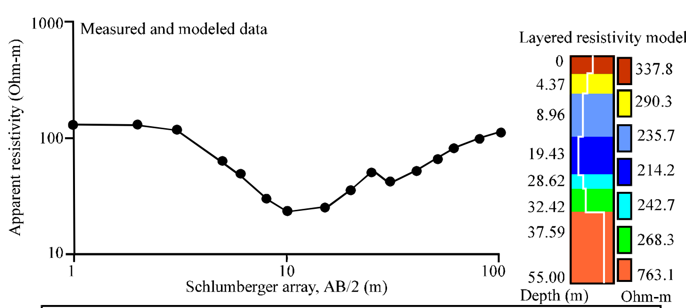


Fig. 1: Toprgraphic map of Damari irrigation scheme site howing distribution of VES stations



For: Surds engineering services limited			
Job code	VES 1	Survey date	Dec 11, 2010
Project site	Kaduna South irrigation scheme	Instrument	AGI ministing
Geophysicist	Raji Olawale	Software	Earth Imager 1D
Data file	Geoplus geophysical services, dat		

Fig. 2: Iterated field curve and the apparent resistivity model of VES 1



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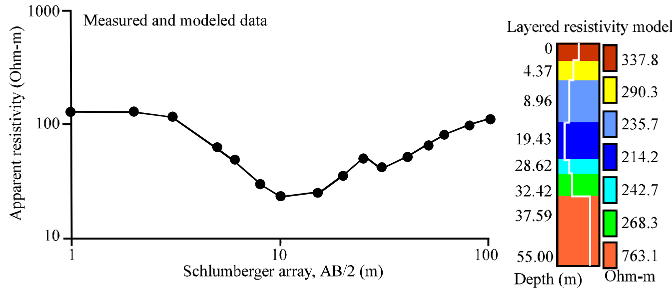
Project site	Kaduna South irrigation scheme	Instrument	AGI ministing
Geophysicist	Raji Olawale	Software	Earth Imager 1D
Data file	Geoplus geophysical services, dat		

Fig. 3: Iterated field curve and the apparent resistivity model of VES 2

configuration of 200 m was adapted. The acquired data were processed and interpreted with the 1D Earth Imager iterative software program developed by Advance Geosciences Incorporated (AGI) USA. Figure 2-7 shows



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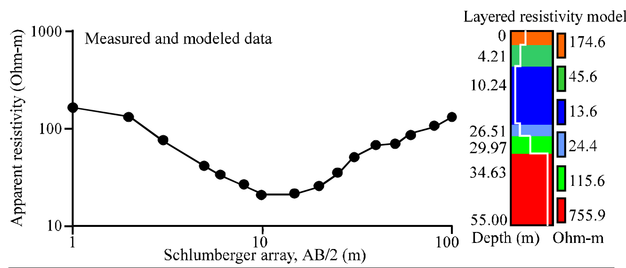
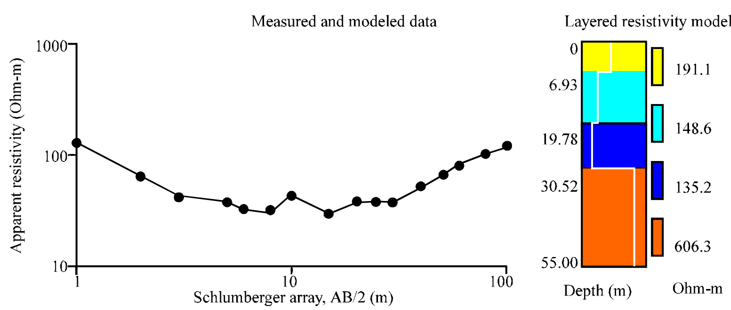
Project site	Kaduna South irrigation scheme	Instrument	AGI ministing
Geophysicist	Raji Olawale	Software	Earth Imager 1D
Data file	Geoplus geophysical services, dat		

Fig. 4: Iterated field curve and the apparent resistivity model of VES 3



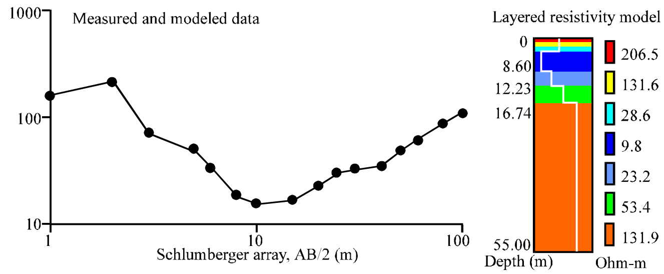
For: Surds engineering services limited			
Job code	VES 4	Survey date	Dec 11, 2010
Project site	Kaduna South irrigation scheme	Instrument	AGI ministing
Geophysicist	Raji Olawale	Software	Earth Imager 1D
Data file	Geoplus geophysical services, dat		

Fig. 5: Iterated field curve and the apparent resistivity model of VES 4



For: Surds engineering services limited			
Job code	VES 5	Survey date	Dec 11, 2010
Project site	Kaduna South irrigation scheme	Instrument	AGI ministing
Geophysicist	Raji Olawale	Software	Earth Imager 1D
Data file	Geoplus geophysical services, dat		

Fig. 6: Iterated field curve and the apparent resistivity model of VES 5



For: Surds engineering services limited			
Job code	VES 6	Survey date	Dec 11, 2010
Project site	Kaduna South irrigation scheme	Instrument	AGI ministing
Geophysicist	Raji Olawale	Software	Earth Imager ID
Data file	Geoplus geophysical services, dal		

Fig. 7: Iterated field curve and the apparent resistivity model of VES 6

the interpreted results of the iterated curves with apparent resistivity models of the data acquired at the VES stations. Because geoelectric and geologic sections do not often correlate (Keller and Frischknecht, 1966), realistic geologic equivalent of the geoelectric layers of the VES stations were obtained with information from borehole log, nature of superficial deposit (Tokarski, 1972; Wright and McCurry, 1970) and published resistivity data (Telford *et al*., 1976) used as control.

RESULTS AND DISCUSSION

Most of the sounding curves reflect presence of four geoelectric layers. Their equivalent geologic or lithologic layers are lateritic top layer, regolith (sandy soil, silty/sandy clay), weathered layer (weathered transition zone/poorly weathered basement rock with possible fractures) and fresh basement. The 1st two units constitute the overburden while the last two units make up the weathered and the fresh basement, respectively. The thickness of the overburden is estimated at range of 8-10 m. Nature of the apparent resistivity curves which reflects high degrees of weathering at the VES stations, reveal presence of thick and highly weathered/fractured basement layer. The low apparent resistivity value of this lithologic layer which extends up to 50 m indicates good conductivity which implies favorable groundwater condition.

The possibility of groundwater-yielding weathered formation is further indicated by the sharp resistivity contrast between the sufficiently weathered basement layer (as shown by the bluish colored section of the layered resistivity models) and the high apparent resistivity value of the crystalline/fresh basement (as shown by the reddish colored sections of the layered resistivity models) which are not aquiferous.

CONCLUSION

The intended purpose of this research has been addressed by the geophysical survey. From the geologic equivalent of the geoelectric layers of the site, the weathered basement, the fractured basement were determined to be the main aquifer components of the site. From the result of the interpretation, VES stations that are most favorable for the intended purpose of the irrigation scheme based on high thickness range (38-42 m) and low resistivity values of the aquifer components are 1 and 2. VES 1 and 2 are therefore, recommended for the sinking of the proposed pump-fitted tube wells.

The borehole drilling can be terminated between 50-55 m or as deemed right by the site geologist (depending on the yield/site situation). Proper screening of the aquiferous zone is therefore necessary in order to get most of the water coming from the formation into the borehole.

RECOMMENDATIONS

In addition for the proposed boreholes to work effectively, the following are recommended:

- Appropriate casings should be used with adequate number of screens and blinds cased to the bottom of the borehole. Only, clean adequate sized granite chippings/coarse river sand should be used for packing the borehole annulus to prevent clogging
- Proper backwashing and airlifting should be done until the borehole is clean (sand free)
- Cement seal (grouting) of adequate thickness should be used to seal the top of the borehole to prevent surface water contamination

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