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CONTENTS

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HYDROGEOPHYSICAL EXPLORATION FOR GROUNDWATER POTENTIAL IN KATAEREGI, NORTH-CENTRAL NIGERIA

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ABSTRACT

Katerigi town is of geologic importance because it host the contact between the older crystalline basement complex rocks (hard-rocks) and the younger sedimentary formations (soft-rocks). There exists a clear transition from the basement complex terrain to the sedimentary rocks belonging to the Bida Basin. Detailed hydrogeological mapping as well as Schlumberger Vertical Electrical Sounding (VES) and Horizontal Resistivity Profiling (HRP) techniques were employed in the exploration for groundwater in the area. Results of the hydrogeological mapping indicate the basement portion of the study area is dominated by granite and gneiss while sedimentary terrain consists of sandstone belonging to the Bida Basin. The rosette diagram plot of outcrops joint shows a NNE-SSW fracturing and it is recommended that groundwater exploration within the basement portion in the area should concentrate on the NNE-SSW direction. The pseudo-vertical resistivity sections also confirm a NNE-SSW fracturing. The investigation of the subsurface lithology via VES and HRP also shows deep weathering and basement fracturing. These zones of deep weathering and basement fractures are high groundwater potential area. The NNE-SSW principal joint direction controls the weathering and groundwater flow in the basement portion, making it hydrogeologically important as sandstone aquifers from the sedimentary portion.

Introduction

A mixed geological terrain is one that comprises of both a crystalline basement complex (hard rock) and the sedimentary rocks (soft rocks), with the contact between the two rock types well exposed on the surface. Water is life and its availability governs civilization and industrialization sites. Efforts should continue to be directed at providing potable water till every household can access clean, pure and safe water. Part of these efforts has been in drilling boreholes to exploit groundwater for private and community water supply. The success of this effort hinges largely on successful groundwater exploration. Many geophysical methods can be employed for groundwater

Keywords: Groundwater Exploration, Transition Zone, Hydrogeology, Geophysics And Kataeregi

exploration, but electrical resistivity method is employed in this work because of its efficiency and cost-effectiveness.

In electrical resistivity method, artificially generated electric current are introduced into the ground and the resulting potential difference are measured at the surface. It is based on the measurement of the electrical resistivity of the ground which is dependent primarily on the porosity, fracturing, degree of saturation and the salinity of the pore water (Etu-Efeotor and Akpokodje, 1990). Electrical resistivity method has been used successfully by many geoscientists to evaluate groundwater potential in different parts of the Basement Complex rocks (Offodile, 1983; Olorunfemi and Fasuyi, 1993). Although the electrical resistivity method will never replace test drilling for quantifying aquifer yield, it has reduced the cost and incidents of drilling abortive boreholes. The basement complex terrain has many challenges as regards to groundwater potential evaluation (Olasehinde and Amadi, 2009) and it explains why well yield in basement complex is lower than well yield in sedimentary terrain (Adeleye, 1976; Amadi, 2010).

The present study is targeted at evaluating the groundwater potential of parts of Katerigi through combined hydrogeological and geophysical investigation, thereby finding lasting solution to the acute water scarcity problem encountered by the people in the area.

Materials And Method

Study Area Description

Katerigi town is situated Km 42 and Km 48, along Minna-Bids road (Figure 1). It lies between latitude 9°20′N to 9°25′N of the Equator and longitude 6°15′E to 6°20′E of Greenwich Meridian.

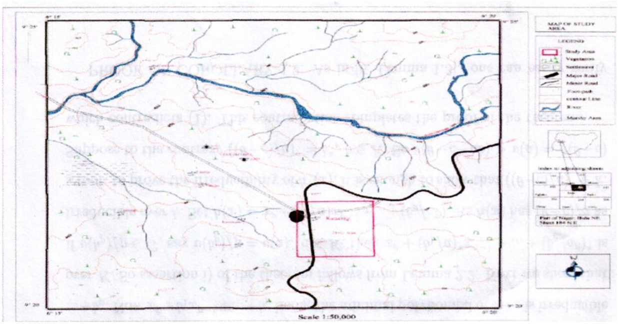

Figure 1 : A Topo Map Showing The Study Area.

Drainage pattern, Vegetation and Climate of the area

The area is drained by River Dagga and its tributaries (Rivers Weminafia and Kwakodna) flowing in NNE-SSW direction in accordance with one of the fracture patterns in the area. The area falls within the Guinea savanna vegetation comprising grasses, shrubs and trees with greater concentration of the trees found along river channels.

The climate alternates between rainy season (April to October) and dry season (November to March) with the highest amount of rainfall (1525 mm) recorded in August/September (Ajibade and Woakes, 1976; Grant, 1978). The dry season is marked by the influence of harmattan which is as a result of north-east trade wind that blows across the sahara and is often laden with dust lasting from December to February. During this period, the area is reduced to bare land due to bush burning resulting from dryness of the soil and grasses.

Geology Of The Area

An accurate interpretation of resistivity data of an area may not be obtained without a good knowledge of the local geology of that area, thereby necessitating a detailed geological mapping of the area. About half of the landmass of Niger State is underlain by the Basement Complex rocks while the remaining half is occupied by the Cretaceous Sedimentary rocks of the Bida Basin (Figure 2). It lies within the north-central portion of the Nigerian Basement complex rock which is characterized by three lithofacies: the migmatite-gneiss complex, the low grade schist belt and the older granites (Olarewaju, et al., 1996; Olasehinde, 1999). The geological mapping revealed that the area is underlain by granite and gneiss which in most locations are undifferentiated granite-gneiss-complex (Figure 3).

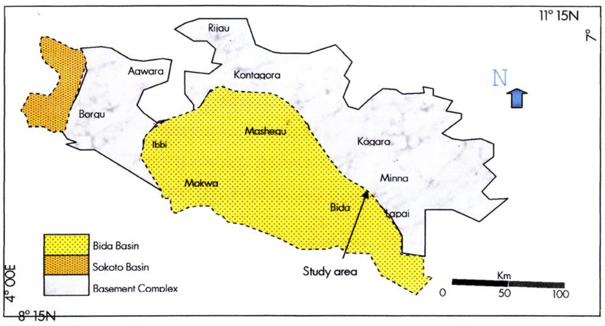

Figure 2 : Geological Map Of Niger State Basement Complex And Sedimentary Basins

Fieldwork

Published regional geological map of the area published by Geological Survey of Nigeria was studied in order to have an insight of the local geology of the area. This was followed by field mapping to indentify the actual rock types in the area. Joint directions were measured in the field and rosette diagram made to ascertain the principal joint axes while other structures like faults (Figure 4) were also observed. The readings taken from the global positioning system (GPS) in the fieldwork were used to generate a digital terrain model (DTM) for the area (Fig 5). An ABEM Terrameter (SAS) 300B with a liquid crystal digital read-out and automatic signal averaging micro processor was used for data acquisition. A total of 10 vertical electrical soundings (VIES) were carried out across the area, using the schlumberger symmetrical electrode array configuration. The soundings were conducted along eight separate profiles. The sounding data were interpreted using Zohdy and Winresist interpretation softwares. The interpretations were integrated with some available borehole log data from the area.

Figure 4 : Dextral Faulting In An Outcrop Across A Mineral Vein In The Study Area.

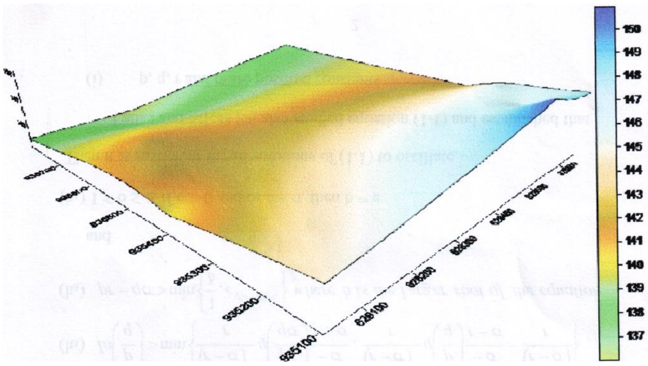

Figure 5 : Digital Terrain Model (DTM) Of The Area

Result Presentation And Discussion

The field VES data obtained was analyzed and the representative winresist modelled subsurface resistivity variation curves typical of the area are shown in Figures 6 and 7. A typical geoelectric layer in the area is given in figure 9. It is important to understand that low resistivity values indicate deep weathering while very high resistivity values are an indication of very shallow weathering.

HA-Type Curve

This is the apparent resistivity curve for a four-layer subsurface structure. The first layer is the top soil with apparent resistivity l_1, the second layer is the weathered zone with apparent resistivity l_2, the third layer is the fractured basement with resistivity l_3 and the fourth layer is the unfractured fresh basement. The magnitude of the various layers resistivity values is in the following pattern: $l_1 > l_2 < l_3 < l_4$. The second and third layers are the groundwater drilling objectives in the basement terrain characterized by HA-type curve. The kink (convex upward shape) on the middle portion of the rising right-hand arm of the curve differentiates it from the H-type curve. The kink often indicates that l_3 value is intermediate between l_2 and l_4 values.

A-Type Curve

This marks a subsurface structure in which resistivity continuously increases with depth irrespective of whether it is a three layer or four layer subsurface. This is common in the Fadama (flood plains) portions of the basement terrains.

H-Type Curve

It is the apparent resistivity curve for a three-layer subsurface structure in which the intermediate layer has the minimum resistivity. The middle layer is typically the groundwater saturated weathered zone sandwiched between the highly resistive top soil and the highly resistive dry, unfractured basement. It is common apparent resistivity curve type in the basement terrains in which the basement rocks are partly fractured. Thus the intermediate layer is of hydrogeological importance. The length and extent of flatness of the minimum resistivity portion of the curve is directly proportional to the thickness of the water saturated intermediate layer.

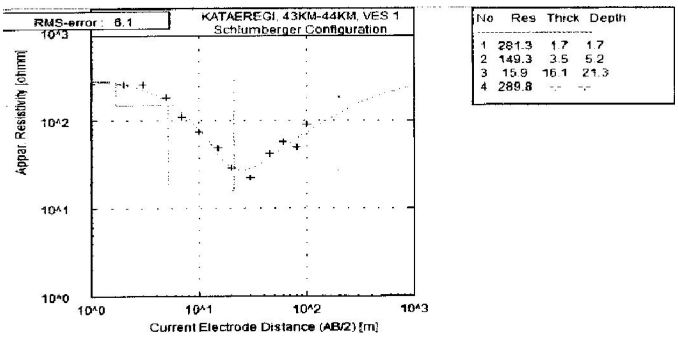

Figure 6: A Typical-Curve From The Area

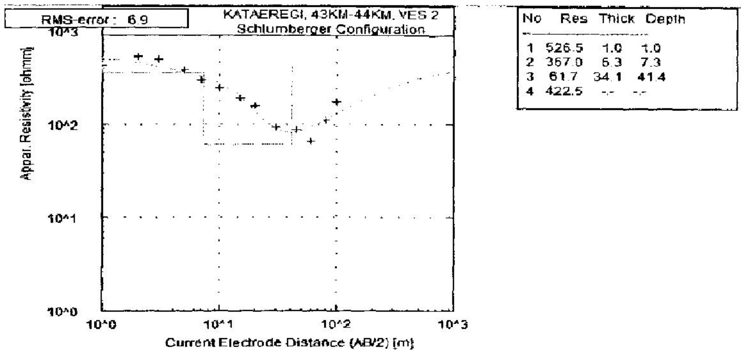

Figure 7 : A Typical Curve From The Area

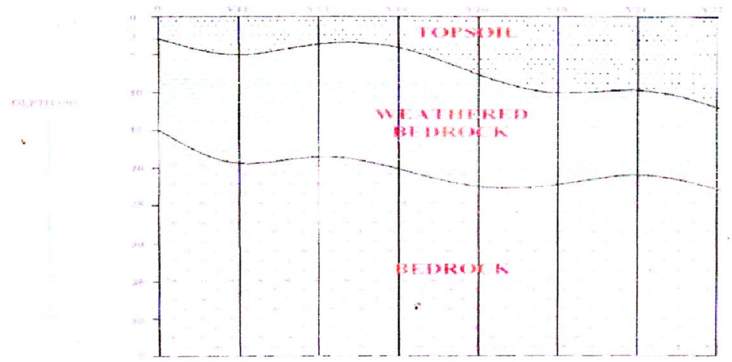

Figure 8 : Geo-Ectric Section Across KM 44 To KM 45 Along Minna Kataereg Road Of Basement Sedimentary Transition Of Niger State (Cummulative Plot Method)

Figures 9 and 10 illustrate pseudo vertical resistivity section and isopach map of depth to basement respectively. The pseudo vertical resistivity sections show deep weathering and fractured basement zones trending in a NNE-SSW. This is in conformity with the finding from isopach map of depth to basement, rosette diagram (Figure11) and the fracture map (Figure 12).

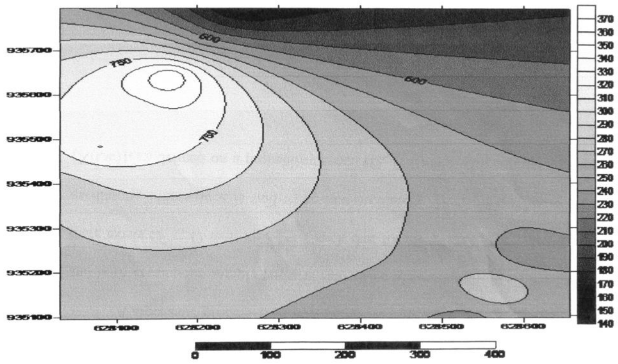

Figure9 : Pseudo Vertical Resistivity Section Along Profile 5

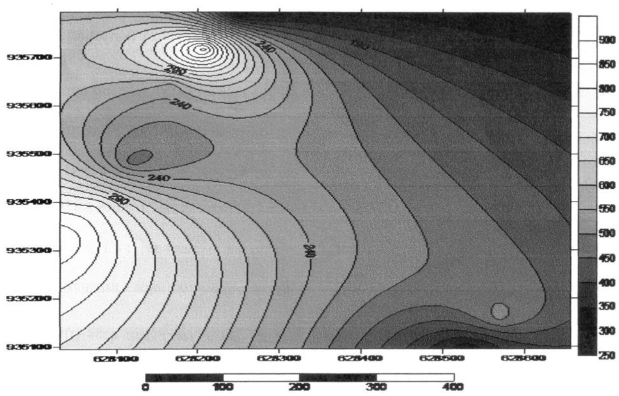

Figure 10 : Isopach Map Of Depth To Basement

The rosette diagram (Figure 11) for the measured outcrop joint directions show the NNE-SSW and NE-SW fractures control weathering depth and are more important hydrogeologically.

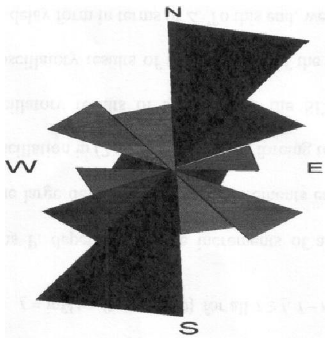

Figure 11 : Rosette-Diagram Showing The Principal Joint Direction (NNE-SSW)

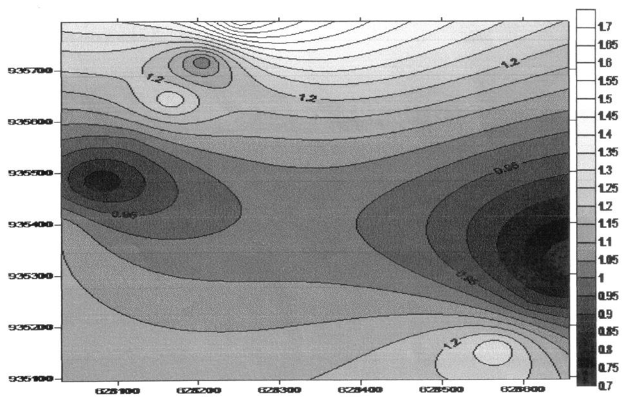

Figure 12 : Fracture Map Of The Study Area

Conclusion

The NNE-SSW fracturing patterns are hydrogeologically important in for the basement portion of Kataeregi and borehole drilling should be concentrated on this direction. The borehole yield from the sedimentary portion of the study area is expected to be higher as sandstones are good aquifer with high porosity and permeability tendencies.

Acknowledgement

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