

GEO-ELECTRICAL EXPLORATION FOR GROUND-WATER IN GBATAKO, EDU L.G.A., KWARA STATE, NIGERIA.

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ABSTRACT

Schlumberger Vertical Electrical Soundings (VES) for groundwater exploration in Gbatako, Edu Local Government Area (L.G.A.) of Kwara State, was carried out with a view to establishing the different subsurface geoelectric layers, the aquifer units and their hydrogeologic properties. Data were collected from 5 VES stations. From the quantitative interpretation of the data collected, using the usual method of curve matching with the Orellana-Mooney Master curves and 1-D forward modeling with WinResist 1.0 version software, four lithologic units were identified.

The resistivity data interpretation has revealed three lobes of low resistivities which constitute the prospective zones for water in the area to exist below station 1 at depth 5.5 to 19.7m (with resistivity 101.7 ohm-m), station 2 at depth 8.6 to 19.4m (with resistivity 144 ohm-m) and station 4 at depth 11.8 – 25.2m (with resistivity 83.5 ohm-m) . The study concluded that the best location in the study area to site a borehole is station number 1 as it contains a major lobe of low resistivity which could be explored for water supply.

Keywords: Geophysical, Aquifer, Lobe, Resistivity, Lithology, Geoelectric.

INTRODUCTION

Water is one of the most basic necessities needed for sustainable development of any region. In countries like Nigeria, there is inadequate supply of water in terms of quality and quantity and the available water comes from rivers, streams, ponds, lakes e.t.c. These limited water resources shared between human beings and animals are therefore often highly contaminated (Bello and Makinde, 2009). This depressing situation is caused by such compelling factors as climate, geomorphology, physiography, geology and hydrogeologic settings. To overcome these problems, many boreholes were drilled in the rural areas in Kwara state by the State, National and International agencies for groundwater exploration. Consequently, detailed geophysical investigations preceded boreholes drilling in order to evaluate the geologic and geoelectric characteristics of the aquifers. The electrical resistivity method has been used to delineate aquiferous units in many parts of the world (Omosuyi *et al.*, 2008).

LOCATION, GEOMORPHOLOGY AND PHYSIOGRAPHY

The study area, Gbatako town, is situated within Edu LGA in the southern-end of the Nupe Basin and lies within the northern edge of Kwara State in the North-central part of Nigeria (Fig. 1). This area is also called the lower Niger Basin which is an elongated approximate NW-SE trending topographic depression of low relief with an average elevation of less than 150m above mean sea level (Bello and Makinde, 2009). The vegetation is mainly of the derived Guinea savannah type (Udo, 1982) with tropical Guinea type climate (Kehinde and Leohnert, 1989).

GEOLOGY

Nupe Basin is an approximately NW-SE trending trough filled with mainly Santonian to Maestrichtian sediments of sandstones, siltstones and superficial alluvial deposits (Adeleye, 1976, Ajibade, 1980). Borehole log reports from UNICEF-RUWATSAN project (1988) show that primary porous and permeable formations of the Nupe Sandstones Group predominate the northern and central parts of the Edu and Pategi LGA. The lithology of these formations, according to Idornighie and Olorunfemi (1992), Mallam and Ajayi (2000), are alluvium, weathered laterite, sandy clay and clayey sand.

The southern part of this Basin, to which the study area belongs is characterized by formations with secondary permeabilities with the following lithologies: weathered laterite, sandy clay/ clayey sand, fractured basement and fresh basement rocks. Generally the rock units in this region is suggested to be highly characterized by intercalations of clay stone, siltstone, silt, clay and weathered bedrock (Biwater Shellabear, 1985; UNICEF-RUWATSAN Project, 1988).

These geological materials are usually liable to act as aquitard or aquifer zone in both the sedimentary terrain and the crystalline basement complex existing in this area. In areas underlain by crystalline rocks, presence of structures like fractures, fissures, veins, joints and such other structural deformations of the basement complex control the flow of groundwater and also influence the rate of recharge and discharge of the main aquiferous units (Biwater Shellabear, 1985). There is the existence of minor fractures with approximate NW-SE trends which intrude the basement complex rock in the southern and eastern part of Edu LGA and create relatively thick highly weathered overburdens.

PRINCIPLE AND METHOD

Electrical resistivity surveys are usually designed to measure the electrical resistivity of the subsurface materials by making measurements at the earth surface (Abdel-Azim, et al., 1996). The common electrode arrays suitable for VES work are the Wenner and the Schlumberger arrays. In the Schlumberger configuration the spacing between the potential electrodes must not exceed 40% (i.e 2/5) of half the distance of spacing (AB) of the current electrodes (Adewumi, et al., 2005). Apparent resistivity for the Schlumberger array ($P\alpha$) is computed from the equation below:

$$P\alpha = \frac{nL^2}{I} \frac{\Delta V}{2l} \quad (\text{Sharma, 1997})$$

Where (2L) is the distance between the current electrodes (AB), (2l) is the distance between the potential electrodes (MN), $\frac{\Delta V}{2l}$ is the surface gradient of potential at the midpoint between M and N, and I is the input current.

Five vertical electrical soundings (VES) were conducted in the study area (Fig. 2). The profiles were run on the remaining open spaces within the town. The current was sent into the ground through the outer electrodes. The potential difference derived from the current obtained from the 12V (d.c) battery was measured using a voltmeter. The apparent resistivity values were calculated by multiplying the resistance value obtained at the point with the geometric factor value.

For the vertical electrical soundings, the maximum spread of the current electrodes was one hundred metres which is adequate for good penetration into the basement rock which is not far from the surface. The VES curves were quantitatively interpreted by partial curve matching (Kearey *et al.*, 2002) and computer iteration techniques. The partial curve matching involved segments by segment matching of the field curves with two layers model curves and their corresponding auxiliary curves.

RESULTS

The VES interpretation results indicated four to five major layers/lithologies: the alluvial sediments (Fine to medium grained sands, silts, clays and laterites), the lateritic layer, the weathered basement, the fractured basement and the fresh basement or bedrock. The topsoil and the lateritic layer are merged in places especially where the two units share identical electrical properties. Typical sounding curves are shown in Figs. 3a and b, most of whose geoelectric layers vary from three to five. The curves are typical of the study area (Reynolds, 1997).

DISCUSSIONS

The alluvial sediments resistivity values vary from 110 to 511 ohm-m with the highest frequencies in the 110 to 240 ohm-m range. The low resistivity end (<110 ohm-m) is diagnostic of clay-sandy clay and clayey sand, while the high resistivity end (>250 ohm-m) typifies compact sand and laterites. The layer thickness varies from 0.6 to 0.9m. This layer is composed of clays, lateritic clay, sandy clay, clayey sand, sand and silts which accounts for the wide resistivity range.

The resistivity values for the second layer (laterites) vary from 957 to 4290 ohm-m with the most frequently occurring resistivity values in the 957 to 1534 ohm-m range. The layer thickness varies from 1.4 to 8m.

The resistivity values for the weathered basement vary from 101 to 1748 ohm-m with the most frequently occurring layer resistivity values from 101 to 765 ohm-m. The thickness of this horizon varies from 4.6 to 23.4m. The electrical resistivity of this layer depends on the sand to clay ratio and the degree of saturation. The clayey sand- sand layer has a high sand content which increases the conductivity value and perhaps the hydraulic conductivity and transmissivity. The sandy clay- clay layer with high clay content imposes some confining characteristics on the aquifer unit. A high degree of saturation could also account for some reduction in resistivity. The weathered and fractured layers constitute the major aquifer units. In some places, fractured zone occurs immediately beneath the weathered horizon. Where the fractured zone is saturated, a relatively high groundwater yield can be obtained from boreholes penetrating such sequence.

Furthermore, from the resistivity interpretation, lobes or zones of low resistivities occur below stations 1, 2 and 4 at depths of 5.5 to 19.7m, 8.6 to 19.4m and 11.8 to 25.2m with resistivities 101.7 ohm-m, 144 ohm-m and 83.5 ohm-m respectively in the area under study. Locations 1 and 4 appear to be more promising for groundwater exploration and borehole siting because of the thickness of their aquifers and tendency for good productivity and sustainability. However, location 1 is most preferable.

CONCLUSION

Geophysical investigation of Gbatako town, Edu L.G.A, Kwara State, Nigeria was carried out with the aim of identifying prospective zones of groundwater accumulation which could be exploited for public consumption and other household purposes. The geoelectric section has revealed four to five geoelectric units. The horizons include the alluvial sediments, the lateritic layer, the weathered basement, the fractured basement and the fresh basement unit. The weathered/ fractured basement constitutes the main aquifer unit in the study area. The resistivity data interpretation has revealed that the subsurface lithology is characterized by lobes or zones

with low resistivity which constitutes the prospective zone for water exploration in the area. These lobes of low resistivities in the study area exist below stations 1, 2 and 4 at depths of 5.5 to 19.7m, 8.6 to 19.4m and 11.8 to 25.2m with resistivities 101.7 ohm-m, 144 ohm-m and 83.5 ohm-m respectively in the area under study. Locations 1 and 4 appear to be more promising for groundwater exploration and borehole siting because of the thickness of their aquifers and tendency for good productivity and sustainability. The study concluded that either of the two locations could be chosen for borehole siting but location 1 is most recommended.

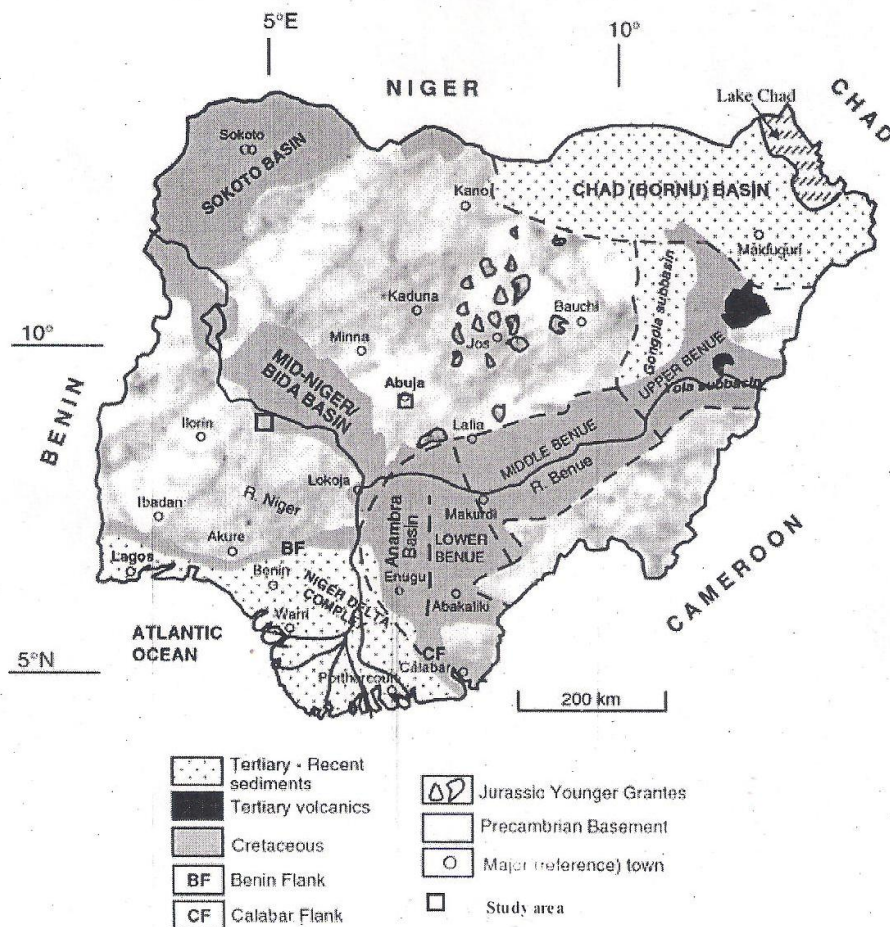


Fig. 1 : Geological sketch map of Nigeria showing the major geological components (Basement, Younger Granites and Sedimentary basins) and the study area (After Obaje, 2009).

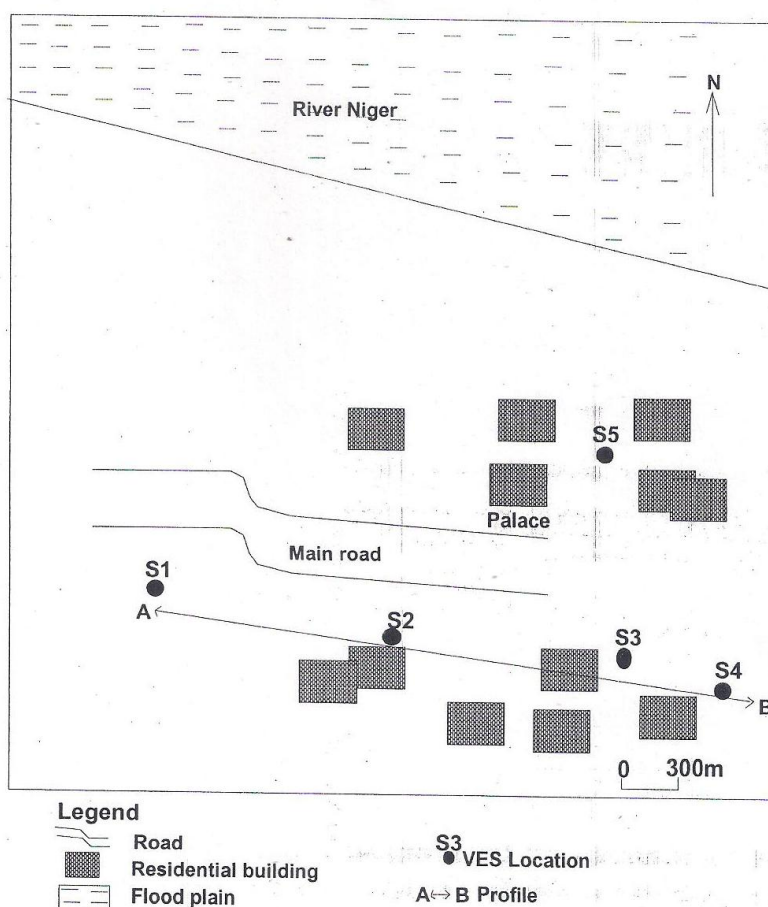


Fig. 2 : A sketch map of Gbatako town showing the VES sites

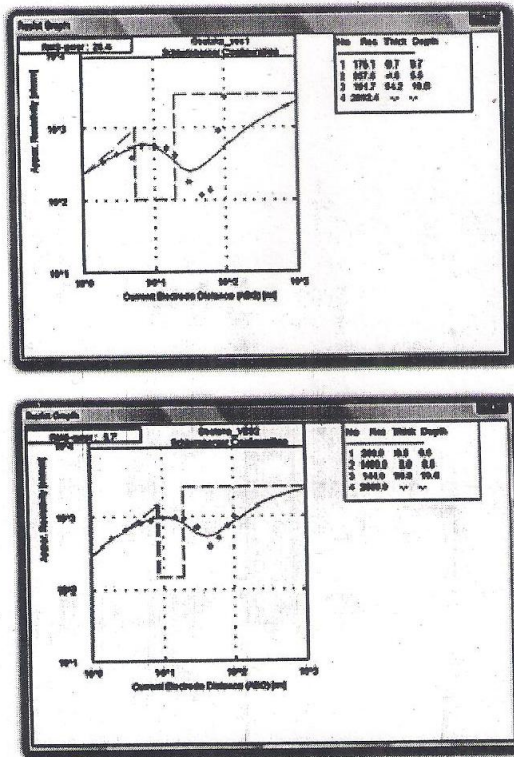


Fig.3a: Typical Schlumberger Sounding Curves (VES 1 and 2) obtained in the study area.

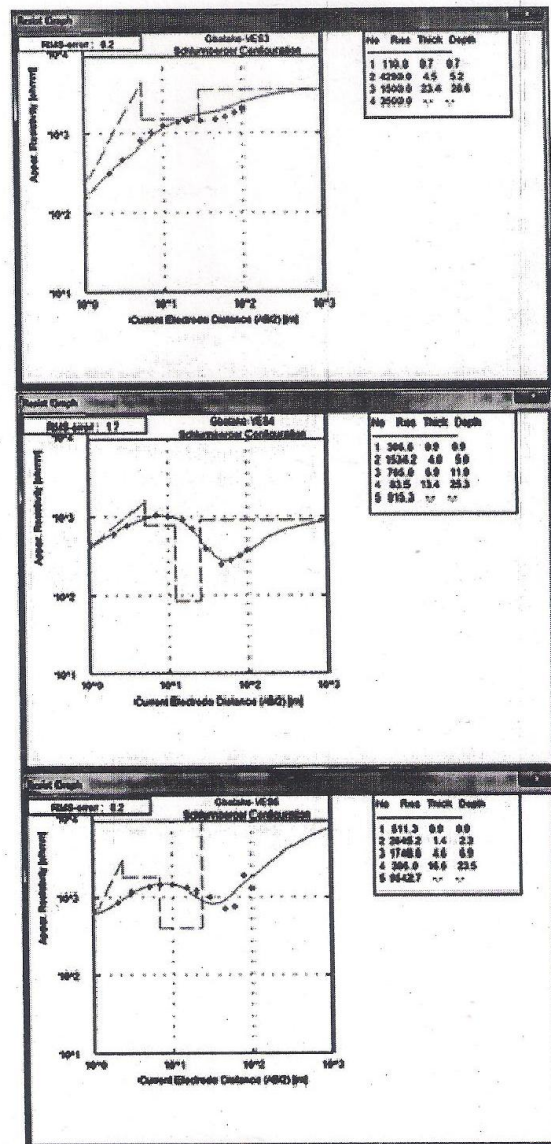


Fig3b: Typical Schlumberger Sounding Curves (VES 3, 4 and 5) obtained in the study area.

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