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APPLICATION OF ELECTRICAL RESISTIVITY METHOD FOR GROUNDWATER EXPLORATION IN A SEDIMENTARY TERRAIN. A CASE STUDY OF ILARA-REMO, SOUTHWESTERN NIGERIA.

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ABSTRACT.
A geophysical evaluation using Electrical Resistivity method for groundwater exploration at Ilara-Remo, southwestern Nigeria was carried out. The investigation involved the utilization of Vertical Electrical Sounding (VES) technique with schlumberger electrode array system. The studied area is located within the sedimentary basin (Dahomey basin) of southwestern Nigeria, ferrigenous sandstone was found to be the major rock type in the study area. The data acquired from the ten (10) VES stations were interpreted using the partial curve matching method and computer assisted iteration technique. The VES results of the data revealed three to five layers which include the topsoil, clayey/sandy clay, clayey sand, conglomeratic sandstones and sandstones/wet sands with resistivity values ranging from 133.3-1305.6Ωm, 41.6-1924.5 Ωm, 488.4-9658.3 Ωm, and 164.1-8095.6 Ωm. The sanstones/ wet sands constitute the main aquifer units. From the overall results the studied area can be classified as prolific zones for groundwater development.

KEY WORDS: Electrical, Groundwater, Exploration, Sedimentary terrain, Southwestern Nigeria.

INTRODUCTION

The availability of quality water resources has always been the primary concern of societies in (Semi Arid and Arid region, even in areas of more abundant rainfall, the problem of obtaining an adequate supply of quality water is generally becoming more acute due to ever increasing population and industrialization.

As a result of this, surface water cannot be dependable throughout the year, hence, the need to look for other alternatives to supplement surface water. This makes the world to depend on the largest available source of quality fresh water which lies underground and this is referred to as Groundwater. It is the water held in the subsurface within the zone of saturation under hydrostatic pressure below water table.

The groundwater can be in sedimentary terrain where it is less difficult to exploit except for its chemical composition. It can also be in the basement complex terrain where it can be a bit difficult to locate especially in area underlain by crystalline unfractured or unweathered rock. The research for groundwater today has become essential, due to its cheapness and its chance of obtaining quality water from the bedrock.

Therefore, the application of geophysics to the successful exploration of groundwater in sedimentary terrain requires a proper understanding of its hydrogeological characteristic. Evidence has shown that geophysical methods are the most reliable and the most accurate means of all surveying method of subsurface structural investigations and rock variation (Carruthers, 1985 and Emenike, 2001).

Several methods employed in groundwater exploration include electrical resistivity, gravity, seismic, magnetic, remote sensing, electromagnetic e.t.c out of which the resistivity method is the most effective for locating productive well since the Vertical Electrical Sounding (VES) method can provide information on the vertical variation in the resistivity of the ground with depth and the Constant Separation Traversing (CST) provides a means of determining interval variation in the resistivity of the ground (Olayinka and Mbachi, 1992 , Olorunniwo and Olorunfemi 1987, Ariyo,2003).

AIM OF THE STUDY

The research work was carried out in order to have an insight into the subsurface geology of Ilara, Ogun State Southwestern Nigeria with the following objectives:-

(1).To detects subsurface layering and thickness and their resistivities.
(2). To investigate the hydrological conditions of the area with the view of delineating the potential area for groundwater development.
(3). To locate possible and suitable site for productive boreholes in the study area.
(4). To calculate the geo-electric parameters such as resistivity, anisotropic coefficient, longitudinal conductance etc. in order to delineate good aquifer zone,
(5). To detect depth of bedrock and soil profile.

LOCATION AND ACCESSIBILITY OF THE AREA

The study area is one of the major towns in Remo-North Local Government area of Ogun State Nigeria. It lies within the sedimentary terrain of southwestern Nigeria between longitude 3º 42.5'E and 3º 44.5' E and latitude 6º55.5' N and 6º57.5' N and cover an area extent of approximately 9.18 km^2. The study area is accessible; it is linked with some town like Ode Remo, Akaka, Ilisan and Irolu via motorable roads and some villages by footpath. (Fig. 1).

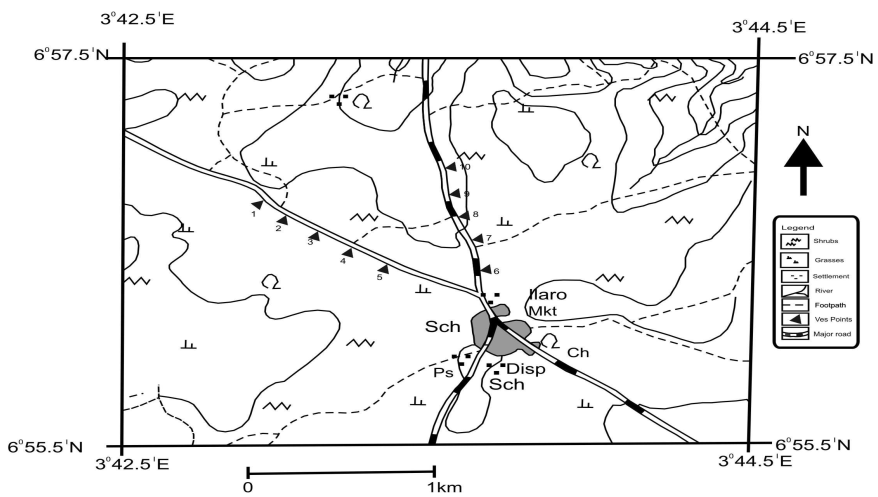


FIG.1 LOCATION MAP OF THE STUDY AREA SHOWING THE VES POINTS

2.5 GEOLOGY OF THE STUDY AREA

Ilara lies in the sedimentary basin. It covers part of the Abeokuta group of the Dahomey basin. The Abeokuta group consists of coarse grained poorly sorted micaceous and ferruginous sandstone. The sandstone is arkosic and has fair to good bedding. Minor intercalation of marine shale and mudstone to exist (Adegoke *et al*, 1976).The age of the basal members of the formation is not known. It is certainly diachronous and is probably not older than Maastrichtian. (Fig 2)

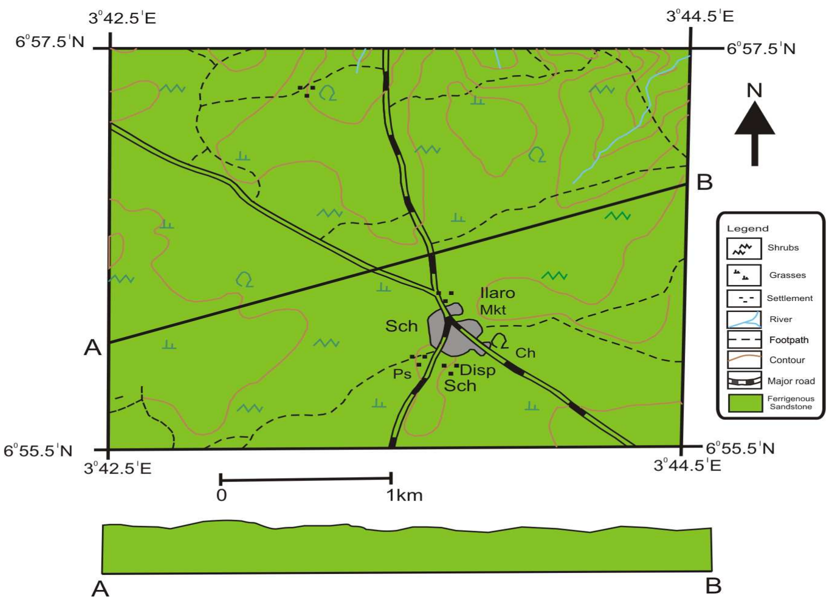


FIG. 2: GEOLOGICAL MAP OF THE STUDY AREA

METHODS OF DATA AQUISTION AND INTERPRETATION

The type of geophysical surveying method used during the course of this project, is the Electrical Resistivity method, which investigates the subsurface conditions by passing electric current into the ground through a pair of current electrodes and measuring the resulting voltage difference between a pair of potential electrodes.

The Electrical Resistivity method is based on the principle of measurement of physical parameters of the formation namely the electrical resistivity and the factors, which control the electrical resistivity of rocks, include the amount and arrangement of the rock grains, porosity of the rock, and the salinity of saturating subsurface water.

Interpretation of electrical resistivity is usually very difficult in the absence of other geophysical data, not withstanding, the apparent resistivity curves obtained during the field procedure can be interpreted both qualitatively and quantitatively, but the quantitative method seems to be the simpler of the two, due to its simple theoretical basis, and best used for the logarithm curves of VES.

The data of the vertical Electrical sounding (VES) are usually presented as a series of apparent resistivity with increasing electrodes separation. These curves give a qualitative representation of the variation of the resistivity with the depth.

Several authors have introduced many methods of interpreting resistivity data obtained in the field, such method includes numerical method of interpretation, interpretation by curve matching technique and interpretation by auxiliary point, method (Zohdy, 1965) or with the computer assisted program. But in the course of this work only two methods of interpretation were adopted and these are partial curve matching and computer iteration programme called RESIST.

This consists of comparing successive portions of the field curve with schlumberger theoretical master curves of similar shapes.

The apparent resistivity is plotted against electrode spacing on a transparent bi-logarithm paper of the same modules as the theoretical curves. The field curves on the transparent sheet are super imposed over the master set. Matching starts from the left hand side of the profile towards the right hand side, then the profile is adjusted towards the left, right, up and down but always ensuring parallelism of co-ordinate axes until best fit of the field curve against one of the theoretical curves is obtained.

The computer iteration method involves two main stages, which are a follows:

1. Determination of an initials model from the field data, which is achieved by curve matching
2. From the results of the curve matching, models for computer modeling are obtained which give the final accepted geoelectric structure.

A fast observation is allowed based on this alteration nature of the program. The layered parameters are altered until a good fit is achieved between the observed and calculated values. The iteration process of curve can go as far as 30 times in achieving a perfect match, after which the computer displays the final result of the iteration in form of curve and the layer parameters. This method is the most efficient method of all the interpretation methods in terms of speed and accuracy.

RESULTS AND DISCUSSION

RESULTS

The interpretation of the sounding curves was done both qualitatively and quantitatively. The qualitative interpretation entails the observation of the sounding curves as plotted on the bi-logarithm graph paper.

Ten VES stations were conducted in the study Area using the Schlumberger array. The result revealed the presence of three to five (3-5) layers.

LAYERS VES CURVES.

Two VES stations (VES 1 and 3) in the study area have 3 geoelectric layers. The topsoil has resistivity values of 1305.6 and 207.8 ohm-m and thickness values of 1.2 and 2.0m respectively. The second layer which was classified as sandy has resistivity values of 730.3 and 1924.5 ohm-m respectively. The last layer is sandstone with resistivity values of 5823.8 and 1355.4 ohm-m. The depth to basal rock is 6.5 and 20,2 m respectively. The shallow depth to basal rocks in these VES stations may not be able to sustain accumulation of quantity groundwater.

LAYERS VES CURVES.

These VES curves comprises of VES 4.6.7, and 8 VES stations. They revealed the presence of 4 geoelectric layers which has been classified as topsoil, sandy/ clayey sand, conglomeritic sandstone and sandstones. The topsoil has resistivity values ranges between 191.0 and 660.0 ohm-m with an average thickness of 1.8m. The second layer has resistivity values vary between 276.9 and 995.5 ohm-m with an average thickness of 4.98m. The resistivity value for layer 3 varies between 5589.6 and 8646.7 ohm-m while that of layer 4 was 379.2 and 8095.6 ohm-m. There is decrease in resistivity values between layer 3 and 4 in VES 4, 7, and 8 stations which is an indication of water saturated zone.

LAYERS VES CURVES.

These set of VES curves were found in VES stations 2, 5, 9, and 10. They displayed 5 geoelectric layers which are classified as topsoil, sandy clay, conglomeratic sandstones, sandstones and wet sand. The resistivity of these geoelectric layers ranges between 133.3 and 516.9 ohm-m, 41.6 and 287.9 ohm-m, 4200.0 and 8383.7 ohm-m, 2822.3 and 9658.3, and 164.1 and 1077.0 ohm-m respectively. The depth to basal rocks ranges between 35.1 and 111.8 m. These VES stations can be classified as prolific zones for groundwater development in the study area.

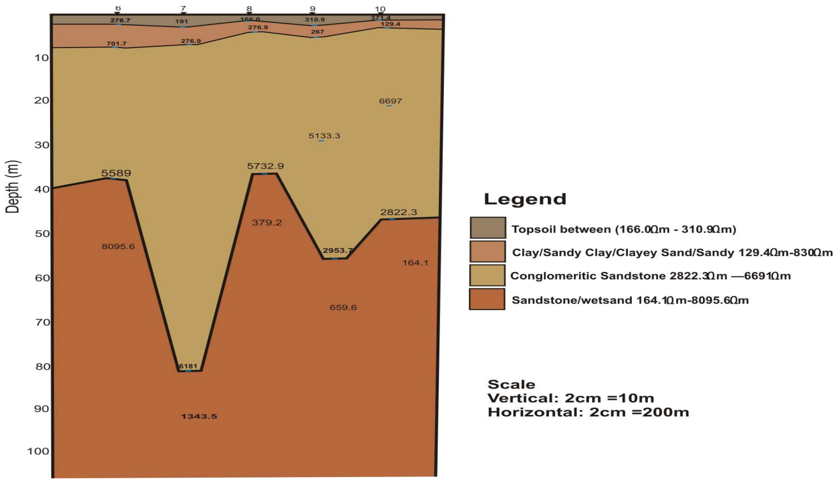
GEO-ELECTRIC LAYER

Geo-electric section of the study area was produced, revealing three to four geo-electrical layers; the top soil, clay/sandy clay/clayey sand/ sandy, the conglomeritic sandstone and sandstone/wet sand as illustrated in Figs 3 and 4.

The top soil which is the first layer has resistivity values ranging from 133.3Ωm to 1305.62Ωm and depth ranging from 0.6m to 2.4m.

The second layer which can either be clay/sandy clay/clayey sand/sandy has resistivity values ranging from 41.6Ωm to 1924.5Ωm and depth ranging from 2.4m to 20.2m.

The third layer which contains conglomeritic sandstone has relatively high resistivity values ranging from 488.4Ωm to 9658.3Ωm and depth ranging from 20.8m to 111.8m.



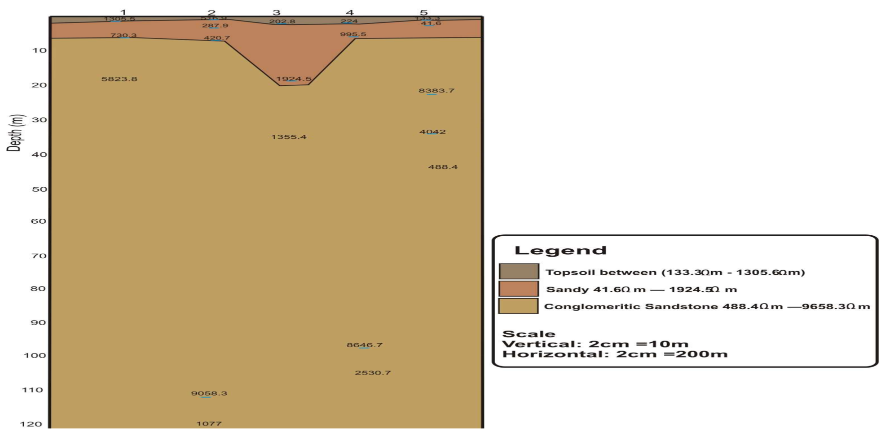


Fig. 4 : Geoelectric section through VES 6-10

The last layer is made up of sandstone/ wet sand has resistivity values ranging from 164.1Ωm to 8095.6Ωm. This layer has the potential for groundwater.

The sandstone/ wet sand are the main aquifers in the study area; they are usually associated with high porosities and permeabilities. (Ariyo, 2005). They should also constitute the object of further exploration for groundwater in the area. It should be noted that sandstone/ wet sand are found at different depth in the study area.

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