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GEOELECTRIC INVESTIGATIONS OF GROUNDWATER RESOURCES AT ONIBODE AREA, NEAR ABEOKUTA SOUTH - WESTERN NIGERIA

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ABSTRACT

Preliminary interpretations of electrical resistivity data from Onibode, near Abeokuta in the basement complex of South – Western Nigeria have been used to delineate zones of grondwater occurrence. The sites with low total longitudinal conductance values are indicative of poor zones of groundwater exploration while on the other hand, areas with high total longitudinal conductance are indicative of good groundwater exploration.

Four geoelectric layers have been inferred. These correspond to the topsoil, weathered layer, fractured basement and fresh bedrock. Their resistivity values and thicknesses vary from 36-82 Ohm-m, 65-110 Ohm-m and 156-268 Ohm-m and 1.2-2.7 m, 13.8-29 m and 18-36 m for the first, second and third layers respectively. Two probable aquifer units have been delineated based on the resistivity values. The first was observed beneath the weathered layer and the main aquifer unit was observed beneath the fractured basement rock. Based on the distribution of the total longitudinal conductance coupled with quantitative interpretation, probable drilling zones of water supply boreholes have been identified.

Keywords:- Aquiferous units, longitudinal conductance, regolith, resistivity contrast, abstraction wells.

INTRODUCTION

The Onibode area near Abeokuta South-western Nigeria is underlain by Precambrian basement complex rocks (Fig. 1). The Basement complex of Nigeria forms a part of the African shield. It consists predominantly of folded gneisses, schist and quartzites into which have been emplaced granitic and to a lesser extent, basic materials (Jones and Hockey, 1964).

As groundwater becomes more desirable as a source of good water supply, methods for locating good aquifers must be more efficient. Various geophysical methods find application in groundwater investigations, but the most widely used technique are the electrical resistivity methods. This might not be unconnected with their adequate depth penetration and quantitative results. These methods may not provide all the detailed information on the subsurface geology but in many cases reduce the amount of test drilling required by allowing a more intelligent selection of test hole sites. In most investigations, a combination of drilling and geophysical measurements will provide the optimal solution (Walter and William, 1981). In recent times, the technological advancement in the interpretation techniques of electrical resistivity data has provided more efficient ways of delineating areas of good aquifer qualities in the basement complex terrain (Olorunfemi et al., 1999 and Nurudeen, 1999).

Several workers, including Zohdy, 1969 had indicated that where a conductive regolith overlies a highly resistive bedrock, the total longitudinal conductance, S, is a good indication of the bedrock topography.

In Nigeria, authors like Olayinka, 1990 concluded that the resistivity of the weathered zone varies over a wide range, from about 10 to 200 Ohm-m, and that the overburden is generally less than 40 m thick during the electromagnetic profiling and resistivity sounding in groundwater investigations near Egbeda-Kabba, Kwara State.

In assessing the feasibility of any

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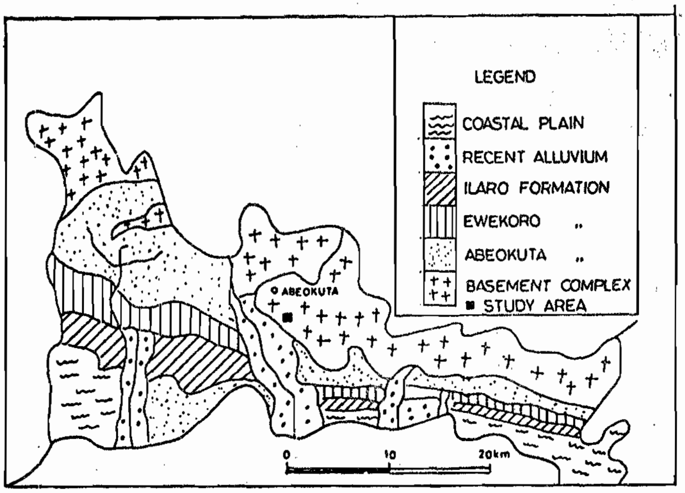

FIG. 1·0: GEOLOGIC MAP OF OGUN STATE SHOWING THE STUDY AREA

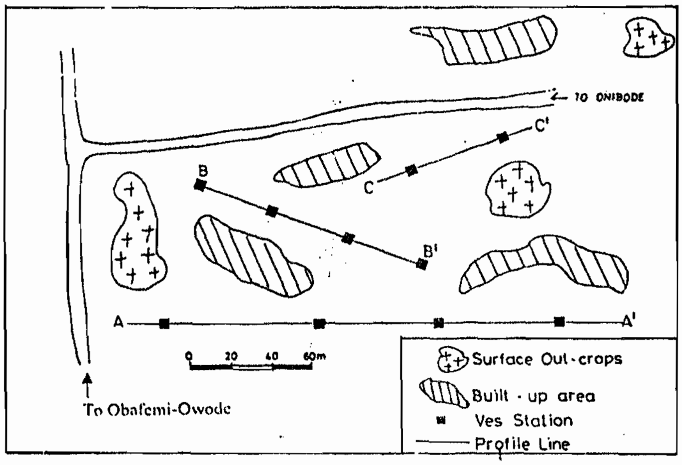

FIG. 2.0 MAP OF THE STUDY AREA SHOWING THE VES STATIONS

scheme of groundwater development and planning it more efficiently, it is highly desirable to carry out geophysical investigations prior to drilling. This will provide information on aquifer properties. But unfortunately, many areas in Nigeria where groundwater developments has taken place, or is going on lack such data and as such, many of the abstraction wells drilled were either seasonal or abortive in nature simply because they were not sited on the saturated aquifer.

For the correct assessment of groundwater possibility in a Basement terrain like this, a good knowledge of the total thickness of unconsolidated regolith overlying the crystalline bedrock in terms of their water bearing capacity is essential. In view of the above electrical resistivity methods were used to investigate groundwater potential of the study area based on the resistivity contrast between the weathered crystalline rocks and the fresh basement rocks. On the basis of the resistivity data, it has been possible to demarcate the unproductive zones, where a prevalence of clay is indicated, from the productive zones.

GEOLOGY AND HYDROGEOLOGY

The study area is underlain by crystalline Precambrian Basement rocks. On the surface, notable outcrops are gneiss, quartzite, migmatite gneiss and pegmatite. Major structural features include joints, folds, faults and foliation. The foliation trends are mostly NNW - SSE and NNE - SSW.

The groundwater is contained in weathered and fractured / jointed basement rocks. The River Ogun constitutes the surface water resource of the study area. The groundwater is primarily recharged by surface precipitation (rainfall and by lateral flow from rivers and their tributaries).

GEOPHYSICAL INVESTIGATIONS

Three profile lines and ten vertical electrical soundings (VES) involving the Schlumberger electrode array were carried out (Fig. 2). A maximum of 220 m (AB) was used. The VES curves were first interpreted by partial curves matching using 2-layer master curves and auxiliary charts. Iterative computer checking of the accuracy of the solution was later carried out by calculating a theoretical sounding corresponding to this model (RESIX-IP, 1988). A model was chosen

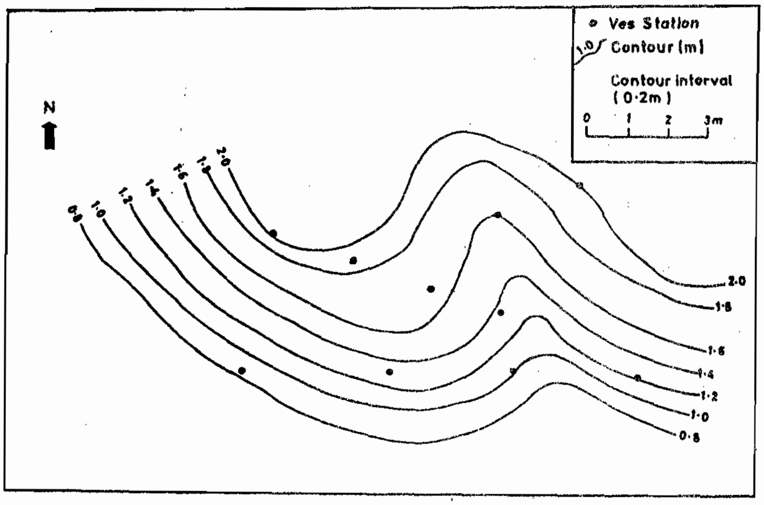

Fig. 3: DISTRIBUTION OF THE TOTAL LONGITUDINAL CONDUCTANCE IN THE SURVEY AREA

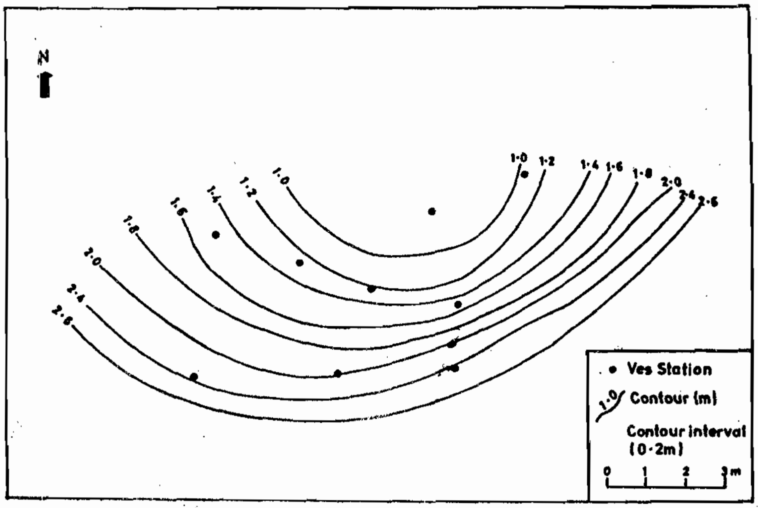

Fig. 4 : ISOPACH OF THE OVERBURDEN

that produces a good match between observed and the theoretical curve. The Geoelectric sections beneath the VES stations were later inferred for lithological delineated and aquifer identification based on the resistivity values.

DATA PRESENTATION

The VES data were presented as sounding curves (Fig. 5 and 6). The resistivity and thickness of each of the subsurface geologic media were determined. The groundwater potential of each of the formations was therefore easy to evaluate using their resistivity values.

RESULTS AND DISCUSSION

i. Preliminary Geoelectric Interpretation

Figure 3 shows the distribution of total longitudinal conductance of the survey area. The construction of a regional map of total longitudinal conductance has been regarded as an essential preliminary to any quantitative interpretation of the sounding data (Paul, 1977).

Transverse (unit) resistance T and longitudinal unit S are defined for a given geoelectric layer as

$$T = hp$$

$$S = \frac{h}{p}$$

where h and p are the thickness and resistivity of that layer respectively. These are called Dar Zarrouk parameters. The transverse resistance could be determined from sounding curves for strata which are resistive to both the immediate overburden and the underlying layer (Keller et al, 1966). The longitudinal conductance was evaluated for layers which are conductive relative to the resistive unit. This is achieved through a determination of the total longitudinal conductance of all layers lying above that relatively resistive bedrock (Keller and Frischnecht, 1966).

From Figure 3, it can be seen that there is a sizable area within which the total longitudinal conductance is less than 0.6S. This area should be accorded the lowest priority as regards groundwater exploration rating. On the other hand, there are other few places where the total longitudinal conductance exceeds 2.0S. Since the higher values of total longitudinal conductance are thought to be due to the heavily weathered / fractured units of the overlying layers, these maxima should be regarded as indicative only of a good groundwater exploration zones (Paul, 1977). Although Figure 3 cannot be used solely to define zones of poor groundwater potential, it is believed that an approach of this kind greatly reduces the effects of geoelectrical equivalence and suppression upon the interpretation of sounding data from areas where there is a dearth of surface outcrop and borehole control.

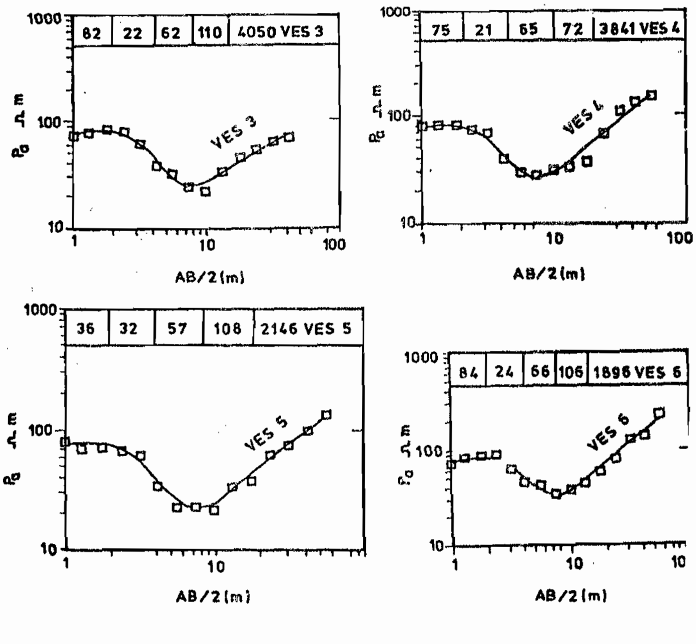

Figure 5 : Observed sounding curves beneath VES 3, 4, 5 and 6

ii. Quantitative Geoelectric Interpretation

Figures 7 and 8 show the geoelectric sections along profiles AA' and BB'. The details studies were carried out on eight VES stations along the two profile lines. Basically, four subsurface layers have been mapped, corresponding to the topsoil, the weathered basement, the fractured basement and the infinite bedrock. The topsoil is composed of clay / sandy clay with resistivities ranging between 36 and 82 Ohm – m and thickness values of 1.2 to 2.7m. The weathered basement is made up of clayey sand with minor intercalations of sandy clay. Layer resistivities range between 65 and 110 Ohm – m and layer thickness is between 13.8 and 29 m. This probably constitutes the first aquifer unit. Its resistivity value is a characteristic of sandy clay nature with moderate permeability tendency. The groundwater potential depends on the thickness of the bed. This column was observed beneath VES 3, 4, 5 and 6. The inflections along the VES curves are indicative of moderate fracturing. The resistivity contrasts beneath layer two is supported by the high Dar Zarrouk parameter obtained earlier. This could be a good probable area for groundwater development.

The fractured basement constitutes the main aquifer unit. Here, the bedrock is weathered and fractured. This occurs beneath VES 7, 8, 9 and 10. The resistivities value range between 156 and 268 Ohm–m. The thickness of the bed ranges between 18–36m. This is another good probable zone for groundwater development and it also falls witin areas of high S values. The fresh basement was encountered beneath VES 7, 8, 9 and 10. The resistivity values vary between 420 and 4050 Ohm–m. Along the two profiles the overburden thickness varies between 1.2 and 2.7m, while the depth to bedrock varies between 28 and 62 m. The overburden is thickest along South-East directions (Fig. 4). There are no detailed borehole data of the study area to correlate with the findings.

ISOPACH MAP OF THE OVERBURDEN

The thickness of the overburden ranges between 1.0 to 2.7 m and for simplicity, the subsurface picture of the overburden thickness is presented on Figure 4. The overburden thickness is trending along the North – South direction.

It can be seen that the contour bear a trough like depression, indicative of structural

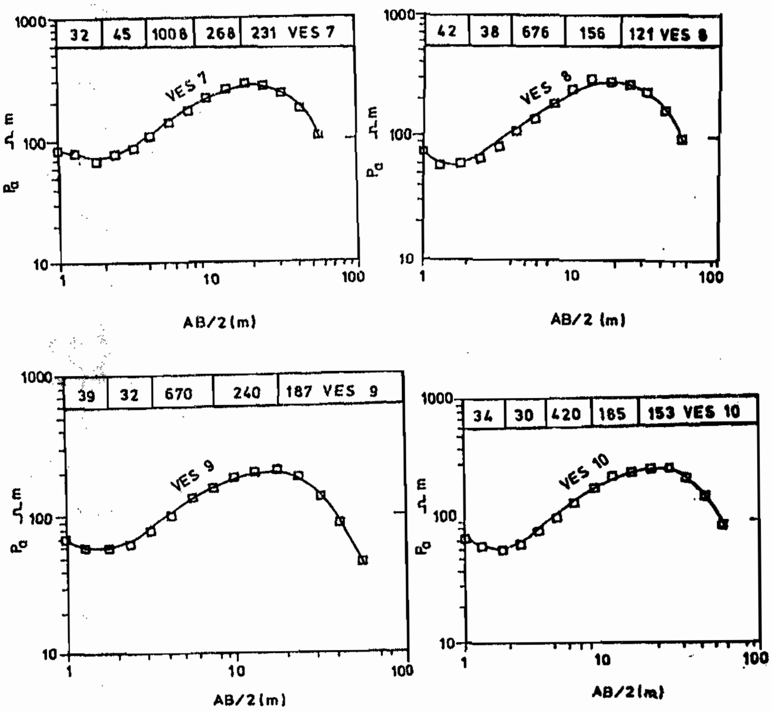

Figure 6: Observed sounding curves beneath VES 7, 8, 9 and 10

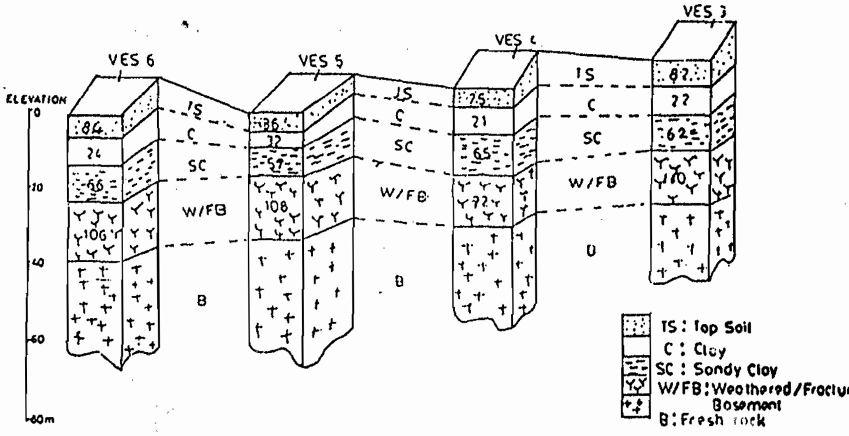

FIG. 7: GEOELECTRIC SECTION BENEATH VES. 3, 4, 5 & 6.

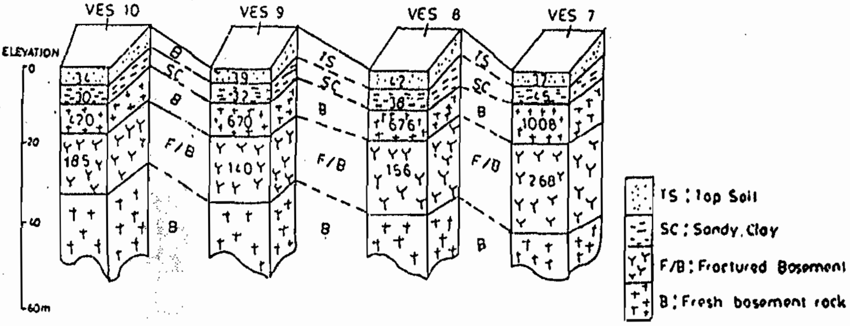

FIG. 8: GEOELECTRIC SECTION BENEATH VES. 7, 8, 9 & 10.

lows favourable for groundwater accumulation.

CONCLUSION

In this work, it was found that the electrical resistivity technique is a powerful tool for a reconnaissance survey in groundwater investigation in Basement Complex terrains. The preliminary and quantitative interpretations of electrical resistivity data carried out at Onibode near Abeokuta South-Western Nigeria have been used to delineate two probable zones of groundwater occurrence. The regional map of total longitudinal conductance produced showed area with high value of S. These areas fall within the weathered / fractured basement rocks and they are good zones for groundwater development.

Based on the quantitative interpretation of the VES data, a four-layer geoelectric section has been inferred. The top soil, which is composed of clay / sandy clay with resistivities that range between 36 and 82 Ohm-m and thickness values of 1.2 to 2.7m. The weathered basement with resistivity value that range between 65 and 110 Ohm-m and thickness values of between 13.8 and 29m. The fractured basement constitutes the main aquifer unit with resistivity values that vary between 156 and 268 Ohm-m and thickness values that range from 18 to 36m.

The fourth layer is the fresh basement rock which is highly resistive. For probable abstraction wells to be sited, it could be beneath any of the following VES stations: 3, 4, 5, 6, 7, 8, 9 and 10 respectively.

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