Role of Electrical Resistivity Method for Groundwater Exploration in Hard Rock Areas: A Case Study from Fidiwo/Ajebo Areas of Southwestern Nigeria.

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ABSTRACT

Hard rocks occupy large parts of the earth's crust. These rocks are devoid of primary porosity and permeability. Most crystalline rock areas of Nigeria are located in areas of high relief; as a result, run off is high and infiltration rates very low. Most often, the occurrence of groundwater in this terrain is localized and confined to weathered/fractured zones. Hence detailed pre-drilling geophysical investigations become inevitable. This present work gives a brief geological background of the hard rock encountered in the study areas and explains the usefulness of the electrical resistivity method, most especially vertical electrical sounding, in locating weathered/fractured zones that are the major source of groundwater development in the study area. A total of twenty-eight such vertical electrical sounding locations were probed in the study area and the interpreted result gives an overview of various aquifers that are present in the area which are weathered/fractured basement and the groundwater situation of these hard rock units in the study area.

(Keywords: electrical resistivity, groundwater exploration, hard rock, Fidiwo, Ajebo, southwestern Nigeria, vertical electrical sounding, VES)

INTRODUCTION

Next to air, the most critical natural resource for life on earth is water. Fortunately, this water has been gifted by nature in bounteous proportion with its quality of transformation through perennial hydrogeological evaporation, condensation, and precipitation. With the population explosion, increasing tempo of industrialization, and agricultural growth, the demands on the potable water supply have increased beyond our perception. It is within our comprehension that surface water is unable to cope with the ever increasing demands and the only alternative source of perennial water supply is groundwater. In order to pursue large scale development of groundwater it is essential to have a reliable estimate of groundwater potential (Singh, 1985).

This is possible by a systematic exploration program using modern scientific tools. Use of geophysical methods provides valuable information with respect to distribution, thickness, and depth of groundwater bearing formations. Various surface geophysical techniques are available but the most commonly used in Nigeria for rural/urban water supply is the Electrical Resistivity Method because of its low cost and relatively high diagnostic value.

AIM OF THE STUDY

i. To determine the geoelectrical and hydrogeological characteristics of the aquifer present in the study area.

ii. To correlates the Vertical Electrical Sounding (VES) curves with various rock types and relate them to the aquifer potential.

iii. To establish the usefulness of the electrical resistivity method as a potential tool in solving the complex geohydrological problems associated with groundwater occurrence and its development in a typical hard rock terrain.

GEOLOGY AND OCCURRENCE OF GROUNDWATER

The study area is located on latitude 3º40' & 3º43'E and longitude 7º03' & 7º07'N in southwestern Nigeria and lies within the basement complex of south Western Nigeria

(Figure 1). The area is underlain by Biotite Granite Gneiss, Migmatite Biotite Gneiss, Biotite – Muscovite Granite, Hornblende Granite, and Schists. These crystalline rocks, unlike unconsolidated and semi consolidated sediments, have primary porosity and permeability. They only possess secondary porosity which is of two types: 1) Joints, fissures and fractures as a result of tectonic features and 2) secondary intergranular porosity due to the action of weathering agents.

Occurrence of groundwater is rather shallow and its movements are controlled largely by topography. At Bedrock depressions in a typical Basement Complex area in Nigeria are groundwater collecting centers. They also show relatively high overburden thickness while bedrock ridges are characterized by thin overburdens. Consequently the groundwater flows away from the crest of the basement ridges into bedrock depressions (Ariyo, 2005).

METHODOLOGY

Among the various geophysical methods of groundwater investigation, the Electrical Resistivity Method has the widest adoption in groundwater exploration (Olorunfemi, 1999; Ariyo, 2007; and Afolayan et al., 2004). This is due to the fact that the field operation is easy, the equipment is portable, less filled pressure is required, it has greater depth of penetration, and it is accessible to modern communication systems (i.e., computer). This is the method employed in the study presented here.

About 28 stations were probed in the study area using Vertical Electrical Sounding (VES) with Schlumberger electrode configuration. The result was interpreted by both Partial Curve Matching Technique and Computer Iteration Program.

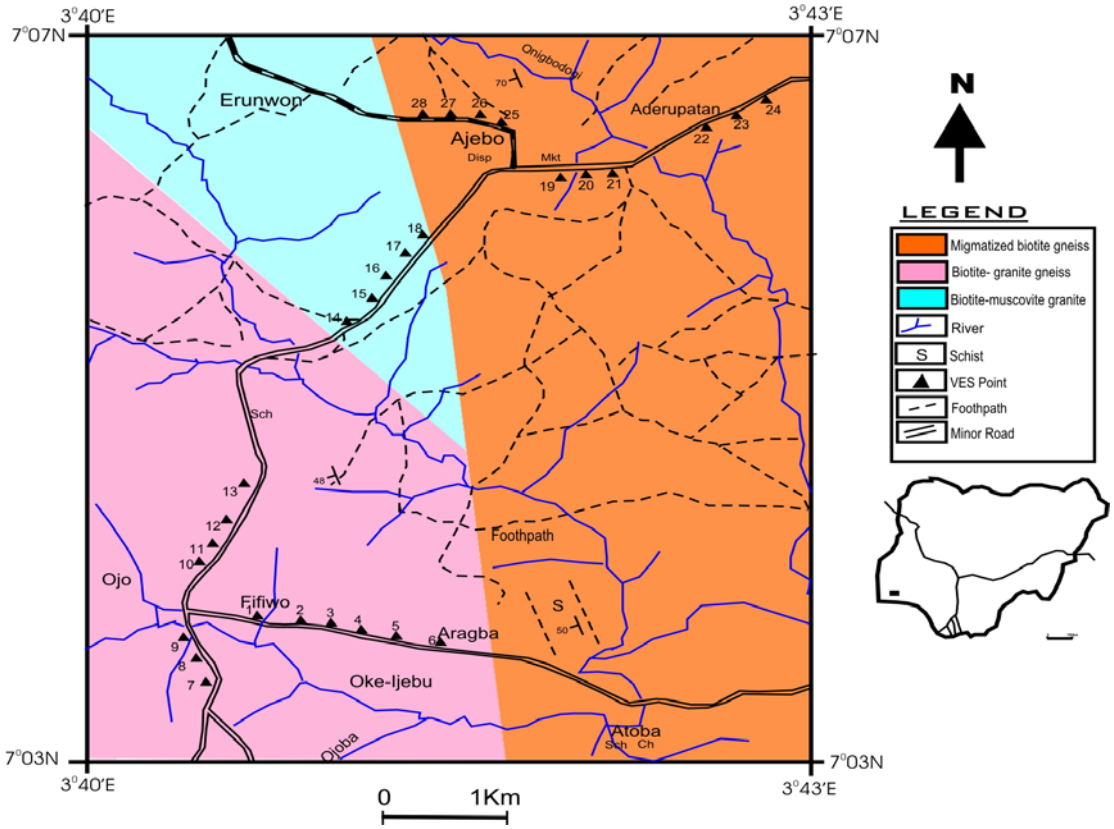

Figure 1: Location Map of the Study Area.

RESULTS AND DISCUSSION

The interpretation of the 28 VES conducted in the study area reveals the presence of 3-5 geoelectric layers. These geoelectric layers fall into three groups and these are topsoil; the weathered layer which can be sandy, clayey sand, or clayey; and the Fractured/Fresh Bedrock layer.

The resistivity of the topsoil ranges between 80.1 and 550.0 ohm-m while the thickness varies between 0.3 and 6.5m. The Resistivity and thickness of the weathered layer ranges between 10.0 and 389.8 ohm-m and 4.1 and 35.0m, respectively. The bedrock rock has resistivity values which ranges between 80.6 and 4018.4 ohm-m while the depth to bedrock ranges between 7.5 and 52.5m.

From the use of this electrical method, the common aquifer is a typical Basement Complex of Nigeria was identified and these are weathered and fractured bedrock (Ariyo, 2007 and Olayinka, 1999). From the depth of few hand dug wells in the study area, it was discovered that they only tap their water resources from the regolith and this lead to the dryness of these well at the peak of Harmattan season in Nigeria.

From the interpreted data, it was observed that the thickness and resistivity value of the aquiferous layers varies from one rock to another and this is shown in the isoresistivity maps drawn (Figures 2-4).

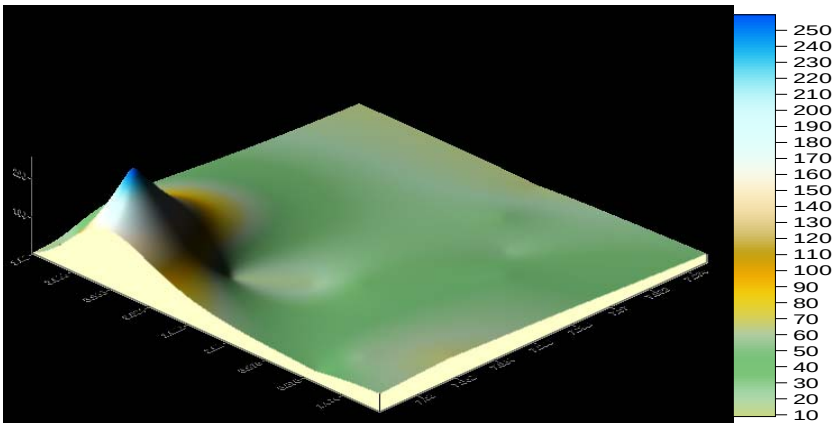

Figure 2: Isoresistivity Contour Map of VES Stations on Biotite Granite Gneiss.

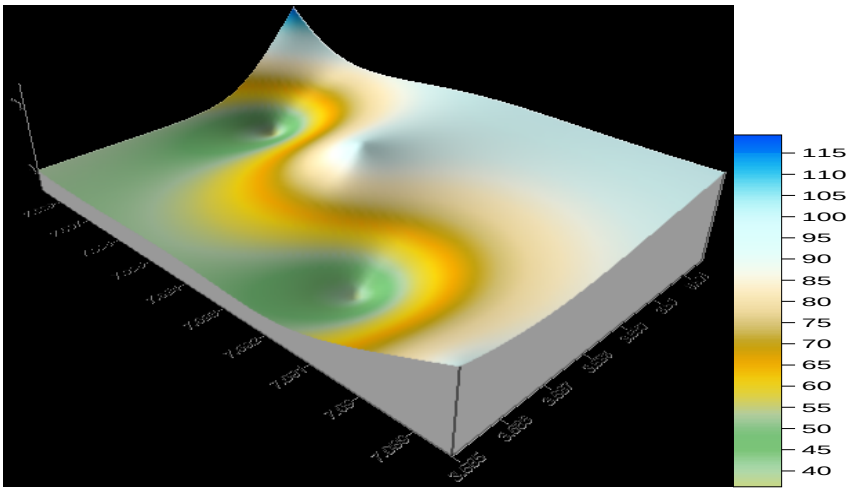

Figure 3: Isoresistivity Contour Map of VES Stations on Biotite-Muscovite Granite.

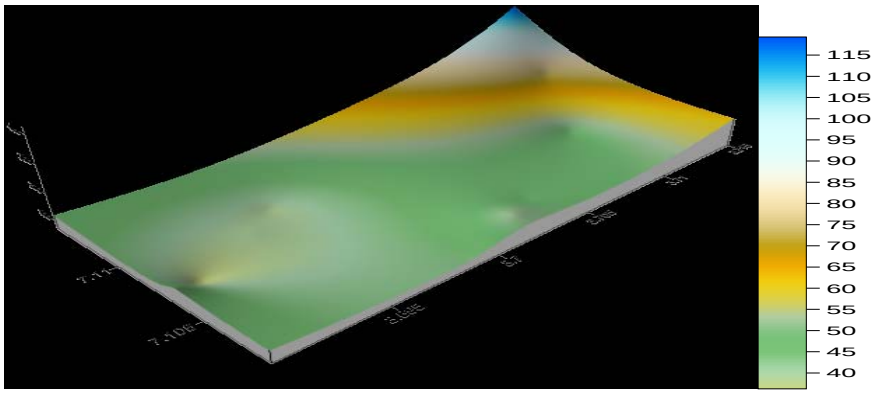

Figure 4: Isoresistivity Contour Map of VES Stations on Migmatised Biotite Gneiss.

This variation is attributed to the fact that different rocks respond to weathering activities differently and this further confirms the uncertainty and erratic groundwater occurrences in a typical basement complex terrain.

CONCLUSION

The Electrical Resistivity Method has helped in the identification of, and better understanding of, aquifer dimensions. It has been established from this study that electrical resistivity methods are suited for estimating thickness of weathered mantle and mapping of bedrock topography and fractured zones. It is therefore suggested that geophysical methods, most especially the electrical resistivity method, along with geological methods should form an integral part of groundwater exploration programs in solving complex geohydrological problems associated with ground water occurrence and resource development.

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