

Integrated Geophysical Delineation of the Aquifers in a Part of the Basement Complex of Akure, South Western Nigeria

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Abstract

Electrical resistivity and Electromagnetic data were acquired using the Schlumberger and VLF techniques to investigate zones of favourable groundwater conditions in the hard rock of the Federal Housing Estate Akure, Ondo state, Nigeria. The static water level of the study area ranges from 0.3 m – 4.2 m. Four prominent lithological series delineated are: topsoil, weathered layer, fractured basement and the fresh basement. The topsoil has resistivity range of 73-267ohm-m and thickness ranges 0.4-5.1 m. The weathered layer has resistivity range of 41-205 ohm-m and thickness range 1.1-8.4m while the fractured basement has resistivity range of 85-2387 ohm-m and its thickness varies from 40 to 122.5 m. The low resistivity in the fractured basement which shows in all the four traverses could indicate presence of conductive matters such as water in there. Fresh basement has highest resistivity of 20614ohm-m, indicating the freshness of the hard rock in the area. A significant highest positive filtered real VLF value of 40% that indicates high conductivity occurs at traverses 2 and 3 while traverse 1 shows as much as 30%. In conclusion, interpretation of results of the stations along four established traverses revealed that the area is generally of a favourable groundwater condition provided the fractured zones are fully penetrated within the basement in order to exploit reasonable quantity of water from the area.

Keywords: Resistivity, VLF, Aquifer, Akure, Schlumberger

Introduction

The use of electrical resistivity method plays a prominent role in the study of earth crust because it is commonly employed for finding detailed information about hydro-geological setting, geological mapping and foundation study (Omosuyi, 2007). It is routinely employed in groundwater exploration to locate zones of relatively high conductivity corresponding to saturated strata, as well as providing structural and lithological information (Olayinka and Olorunfemi 1992). The method has been successfully employed for boreholes sites location in Nigeria

Basement Complex (Olorunfemi and Oloruniwo, 1985). This technique have been widely used in groundwater investigations because of its good correlation between electrical properties and fluid content (Fraseri, Lubonja, and Alikaj, 1995; Zohdy, 1969; Fitterman and Stewart, 1986; McNeil, 1990). One of its varieties; VLF-EM methods utilizes Very Low Frequency radio communication signals to determine electrical properties of near surface soils and shallow bedrock, particularly in characterizing fractured zone in a Basement Complex area (Ajayi and Adegoke, 1998; Omosuyi, 2007). This

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technique can be run quickly and inexpensively to identify anomaly such as faults, fracture zones and areas of mineralization.

This method was employed for the geophysical work was carried out in parts of Akure, South-western Nigeria for fracture zone delineation. The aim of this research is, to delineate the subsurface ground water zones which will further help to delineate the subsurface geologic sequence to be used in evaluating the hydrogeologic settings of the area. The study area is located within the Federal housing Estate, North Eastern part of Akure and lying within longitudes $7^{\circ}41'40''$ E and $7^{\circ}43'20''$ E (UTM) and latitudes $8^{\circ}05'00''$ N and $8^{\circ}06'25''$ N(UTM) (Fig. 1). The study area is about 2100km square which is accessible through Owo-Ilesha expressway (Fig. 1). This area is known to be associated with the problems of groundwater aquifer as many of the boreholes drilled including hand-dug wells are either perched or later dried-up during the dry seasons. Therefore there is need to investigate the frequent causes of this aquifer failure in the area.

The study area is relatively populated and can boast of internal road links and fairly distributed social amenities. It lies within the tropical rain forest belt of hot, wet equatorial climate region characterized by wet and dry seasons with mean monthly temperature of about 27°C . Some part of the layout has tick secondary vegetation comprising of several evergreen leaves and trees. The area is characterized by high reliefs consisting of undulating hills and ridges with isolated rock bodies and so exposed to effect of erosion. It has a tropical climate and the natural vegetation is rain forest. Mean annual rainfall is

between 1000 m to 1500 m, and mean annual temperature is between 24°C and 27°C (Ileojo, 1980).

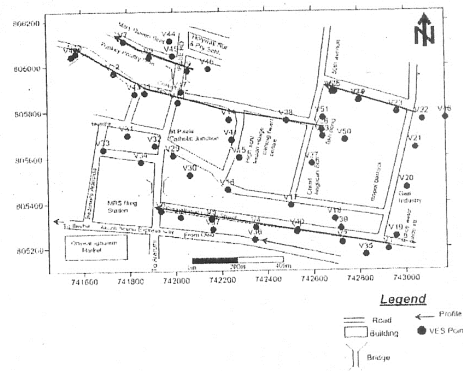


Fig. 1: Location Map of the Study Area

Regional Geologic Settings

The study area is the Federal Housing Estate, northeast of Akure. Akure lies within the basement complex of Nigeria. Rocks in the area are classified (Fig. 1) into: The Migmatite Gneiss – Quartzite Complex; Low to medium grained schist belt of supracrustal and Meta – igneous rocks; Pan African Granitoids (Older Granites) and other related rocks – charnockitic rocks and syenites; and Minor felsic and mafic intrusives – intruding the Migmatite-Gneiss-Quartzite Complex (Rahman, 1974; 1976; Adekoya *et al.*, 2003). The rock in the study area are inspected for mineralogical composition, structural and textural features, and mode of occurrence.

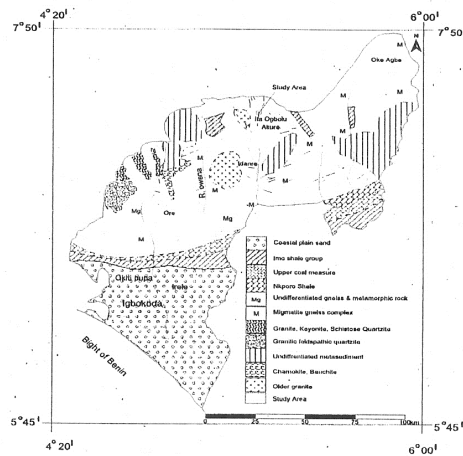


Fig. 2: Geological Map of Ondo State Showing the Major Geological Components

Methodology

For this research work, four profiles were marked for detailed geophysical survey. Geo-electric section study was carried out along the four profiles to know the general trend of rocks resistivity in the area. Station intervals of 15 m and 30 m are used. Subsequently, Very Low Frequency Electromagnetic Profiling was stationed at interval of 10 m along each profile. A number of resistivity meters are in use for measuring the earth's subsurface apparent resistivity. For this research work, R50 DC Resistivity meters was used for data acquisition along with the metal electrode, connecting cables, hammers, compound/clinometers, measuring tapes and ropes. The current and potential electrodes are maintained at a fixed separation and progressively moved along a profile. Traverse 1 has a total length of 1020m and runs along E-W direction of the study area with the station interval of 10m (Fig. 3.1a). Traverse 2 has a total length of 400m and also runs along E- W direction (Fig. 3.1b).

Results and Discussion

VLF-EM

VLF data recorded along the four profiles were plotted with distance as shown in figs 3.1a-d. The data showed some anomalies from E-W within each traverse. The 2D tomographic structures of the VLF values shows places of corresponding high/positive peak interpreted to have higher groundwater potentials than the areas with low/negative values. Also, according to Palacky *et al.*, (1981) and Alvin *et al.*, (1997), the high positive filtered real VLF values indicates high conductivity which can be related to water saturated geological layers typical of groundwater aquifers or shallow fracture harbouring conducting fluid. Because, high VLF anomaly may be caused by conductivity in rocks that is due to dissolved mineral, while, the low resistivity may be due to mineralization of soil contamination within the area. Based on VLF results, places corresponding to distances between 100m – 120m, 330m-350m and 610m – 620m along profile AA were interpreted to have high potential for groundwater. Other places with similar interpretations include 40m-50m, 235m – 250m and 295m-305m along profile BB, and 340m-350m along profile CC.

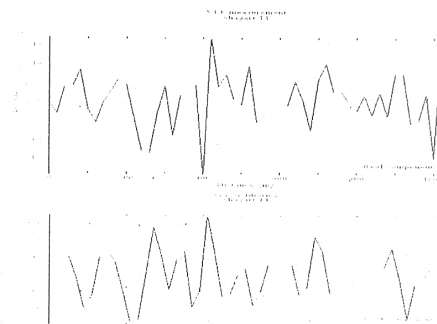


Fig. 3.1a: VLF-EM Profiles along Traverse 1 (E-W) in the study Area

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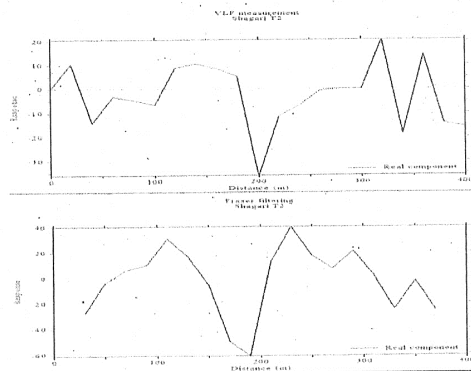


Fig. 3.1b: VLF-EM Profiles along Traverse 2 (E-W) in the study Area.

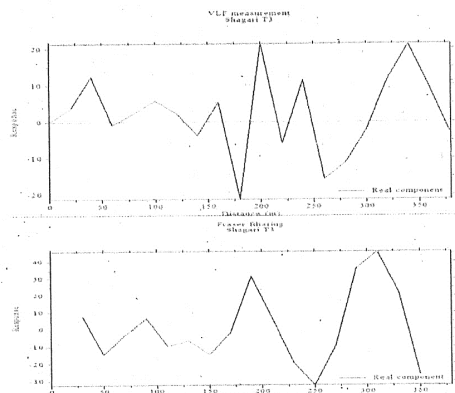


Fig. 3.1c: VLF-EM Profiles along Traverse 3 (E-W) in the study Area

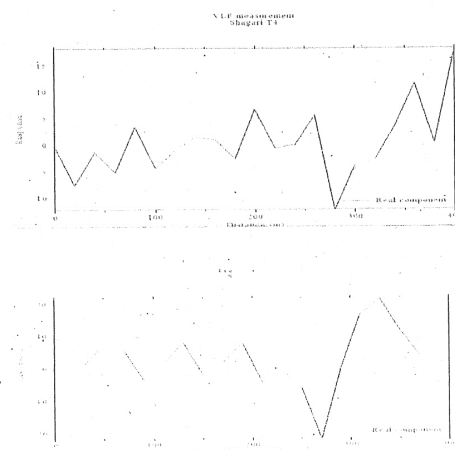


Fig. 3.1d: VLF-EM Profiles along Traverse 4 (E-W) in the study Area

Inferred Geology from Geo-electric Sections

The interpretation of field resistivity data are in terms of resistivity, depth to the bedrock and the interfaces across which a strong electrical contrast exists. The electrical resistivity varies between different geological materials, depending mainly on variation in water contents and dissolved ions in the water. The analysis and interpretation of the survey data showed different geo-electric layers. To achieve these, resistivity field curves were plotted for all the VES points using 'WINRESIST' software. The curves indicated that the area is mostly underlain by 4 geo-electric layers. Samples of such plots are shown in Figs. 3.2a and 3.2b. Thereafter, geo-electric sections equivalent to the identified geologic structures were obtained from the software.

The geo-electric sections generated across the study area are presented in Figs. 3.3a-d. Four subsurface geo-electric units were delineated. These are the topsoil, weathered layer, fractured basement and the fresh basement. The topsoil is the first layer. The resistivity values ranges from 73-267ohm-m. The thickness values ranges from 0.4-5.1m. The topsoil is made up of clay, sandy-clay, clayey-sand and laterite. The second layer is the weathered layer. The resistivity values ranges from 41-205ohm-m. The thickness varies from 1.1-8.4m. The weathered layer is composed of clay, sandy clay and clayey sand. The third layer is the fractured basement. The fractured basement has resistivity range of 85-2387 ohm-m and its thickness varies from 40 to 122.5 m. The last layer is the fresh basement. The resistivity values ranges from 582-20614ohm-m. The weathered and the

fractured basement constitute the aquifer units in the study area.

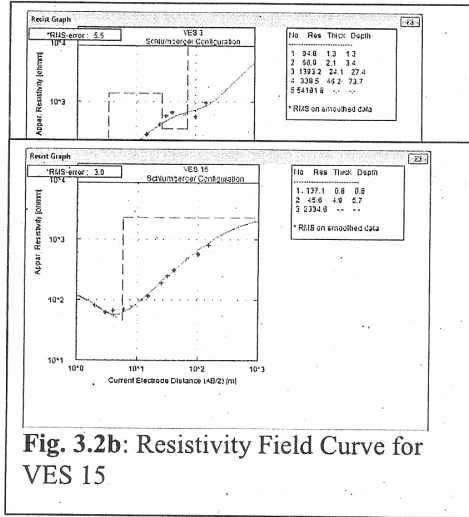


Fig. 3.2b: Resistivity Field Curve for VES 15

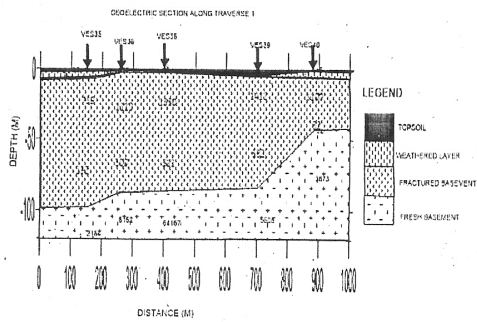


Fig. 3.3a: Geo-electric Section along Traverse 1 (E-W) in the Study Area

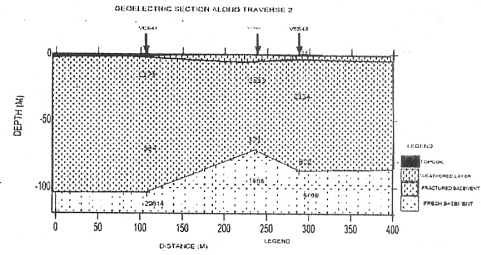


Fig. 3.3b: Geo-electric Section along Traverse 2 (E-W) in the study area.

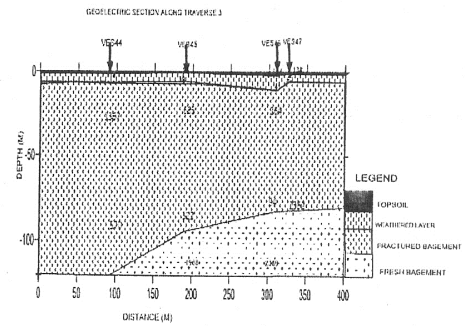


Fig. 3.3c: Geo-electric Section along Traverse 3 (E-W) in the study area.

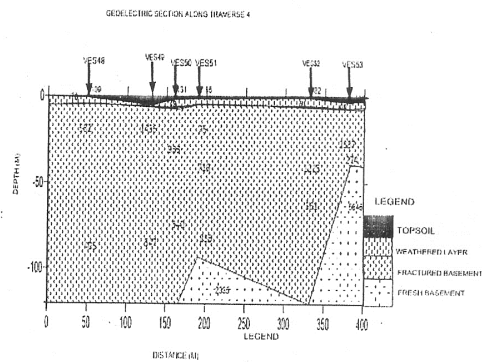


Fig. 3.3d: Geo-electric Section along Traverse 4 (E-W) in the study area.

Conclusions

The results of the interpretation of the data obtained from geo-electric exploration for favourable groundwater conditions in hard rock environment of Federal Housing Estate, Akure are presented in this study. VLF-EM was further carried out along the four established traverse stations where fractured on zones were under probe based on zones low resistivity values has been identified by the HP. The correlation of the results of the Geo-electric section and VLF-EM shows that the study area is characterized by low groundwater potential. Also, the north-western part of the study area is of favourable groundwater condition for any hand-dug well as a result of the low depth of water static level.

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