

## 2-d resistivity imaging survey for water-supply tube wells in a basement complex: a case study of OOU Campus, Ago-Iwoye Sw Nigeria

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### Abstract

Groundwater search in hard and compact rocks of basement complex using 2-D resistivity imaging survey supported by 1-D vertical electrical sounding with Schlumberger array along the same profiles were carried out. Four (4) traverses with Wenner electrode configuration were established around the building complex. The results show 3-5 layers which signify different lithological units encountered as resistivity values were converted into geologically reasonable picture. 2-D resistivity image interpretation indicates that the apparent resistivity values are increasing gradually downward in the sections but pick up later in two of the four profiles; an indication of bedrock depression. The results of the VES points show a maximum of 3 to 5 geoelectric layers composed of topsoil, clay/clayey sand, sand/sandy clay, weathered/fractured rock and fresh basement. The aquifer unit is made up of the weathered layer of resistivity 23 – 106  $\Omega\text{m}$  and thickness of 6.55 – 19.19m and fractured rock with resistivity 133 – 750  $\Omega\text{m}$  and thickness 6.85 – 19.84m

**Key-words:** Groundwater. Depression. Bedrock Topography. Resistivity Imaging. Fracture. Ago-Iwoye.

### Introduction

Surface water was the major source of drinkable water for the earlier man. This was improved upon in the early years of increasing populations. Unfortunately, surface water reservoirs, which are historically safer and cheaper than groundwater as major portable water resources, have not been properly recharged and maintain to meet the population's need. On the other hand, groundwater is strategically valuable because of its high quality and availability as it represents about 97% of the planet's fresh water (Singh et al., 2006).

However, groundwater exploration and exploitation have pose a little challenge as it is not guaranteed that any place could be drilled for prolific water resource. Since the development of electrical resistivity methods in early 1900s, 1-directional electrical resistivity method was successfully employed to locate fractured zones in the basement complex. But for the last 10-15 years VES method has changed greatly from solution of traditional 1D model (horizontal layering) to 2D (and 3D) models for interpretation in heterogeneous media (Shevnin *et al*, 2006b).

Where it is difficult to locate aquifers such as water-saturated zones in hard and compacted terrain, it is also difficult to select suitable site for drilling. Resistivity imaging method has improved the chance of drilling success by identifying the fractured and weathered zones in these areas. The technique is gaining wider application been a veritable tool to solve environmental and engineering problems among other usage, (Loke, 2004).

### Physiography and Geology

The study site is Faculty of Art building of Olabisi Onabanjo University, Ago-Iwoye (Fig 1). Generally, Ago-Iwoye is a rainforest with annual rainfall of about 788mm to 1844mm and temperature range of about 22°C and 35°C. This affects the groundwater recharge as most hand-dug well dry up in dry season in the area. The topography is undulating. The geology falls within the Precambrian basement complex of southwestern Nigerian. This composed of the migmatite-gneiss Complex, the metasedimentary and metavolcanic rocks (The Schist Belts), the Pan-African Granitoids (The Older Granites), and the undeformed acid and basic dykes as reported by several workers such as Jones and Hockey, (1964), Rahaman (1989, 2006) and Caby (1989). The geology of the area is made up of gneiss and quart/quartzite schist, (Folorunso, 2008).

It is worthy to note that the rocks are highly weathered and fractured. These have created secondary porosity: a prerequisite for groundwater accumulation in hard rock terrain.

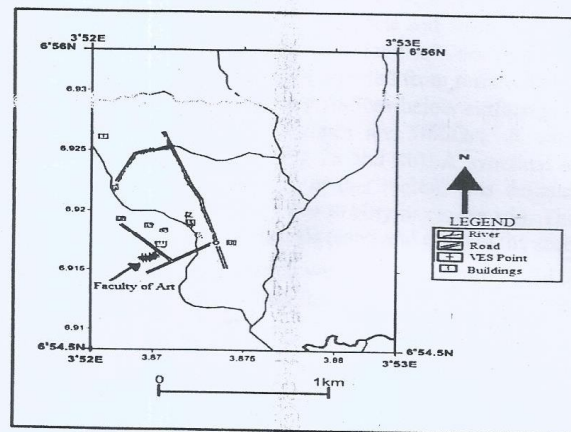


Figure 1: Location of the survey site in OOU Campus, Ago-Iwoye

### Materials and Method

The resistivity measurements are made by injecting current into the ground through two current electrodes and measuring the resulting voltage difference at two potential electrodes using the Wenner electrode configurations for the 2-D survey and Schlumberger array for the Vertical Electrical Sounding (VES). The ABEM 300 SAS terrameter used is renowned for accuracy tested and proven over the years. It measured the resistance of the earth material from which an apparent resistivity – not the true resistivity value- is calculated. Computer iteration enables the determination of true subsurface resistivity values for both surveys. The computer program DIPRO for Window Version 4.0 was used to determine the appropriate resistivity values for 2-D and WINKLINK software was employed for the VES.

### Results and Discussions



The inverted apparent resistivity images for the four profiles are shown in Fig 2 below. From these figures 3-5 layers are encountered as resistivity values were converted into geologically reasonable picture. The distribution of resistivity along the pseudosection at both sides is not uniform as apparent resistivity values are increasing downward in Profile 1 but decreasing downward in Profile 4. However, the trend differs in Profile 2 and 3. In Profile 2, apparent resistivity values are decreasing gradually downward at both sides of the section leaving very low resistivity region in between. The same was noticed in profile 3. The low resistivity area is basically an indication of either bedrock depression or a buried river channel or a saturated compressible soil (clay). It could be noticed that the low resistivity material was encountered from the earth surface. This was further confirmed by 1-direction survey, VES, established along the same profiles as shown in Fig 3.

Basically, 3-5 geoelectric layers were delineated from the VES results. They include topsoil, clay/clayey sand, sand/sandy clay, weathered/fractured rock and fresh basement. A prominent low-resistivity zone was encountered at the surface to a depth of 20m (blue) in profile 2 below surface positions at 22-80m. Similarly, it could be interpreted from resistivity section in profile 3 that a low-resistivity zone was observed at depth of 10-30m below surface positions at 65-95m (blue). The inverted resistivity values of these zones are 5-65 $\Omega$ m. A variable overburden thickness was encountered in profiles 3 and 4 (Fig 2a and 2b). A synclinal structural feature, which is interpreted as water accumulation zones in this region, was delineated in profile 3. Lower resistivity values in both figures are either due to silty or clayey soil. This was confirmed by the VES results, which depicts weathered materials (sand and clay) in the second layer (Fig.3).

Interpretation of the 2-D and VES results combined with geologic features and topography of the site reveal that the study area can be divided into three hydrogeological sequences; the topsoil variously composed of lateritic soil and sand/sandy clay, followed by highly water-saturated weathered/fractured rock sequence and deep-seated hard and compact fresh rock section.

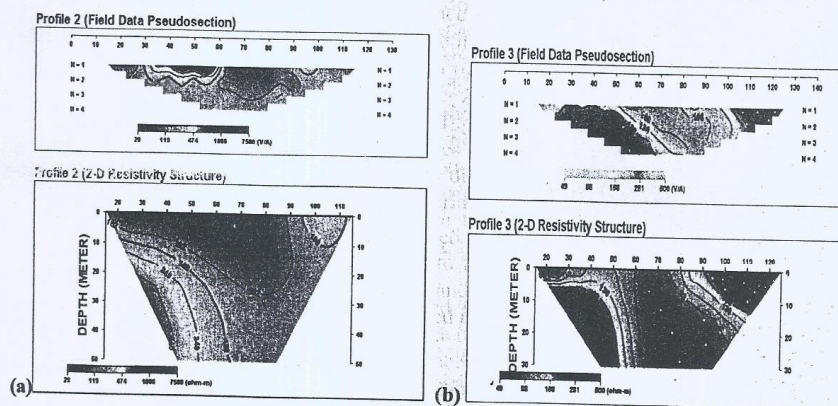


Figure 2: Resistivity Data along Profiles 2 and 3

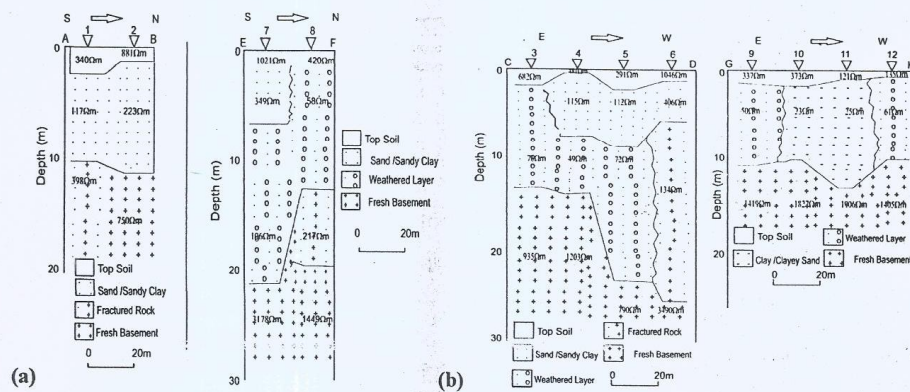


Figure 3: Geoelectric Section for the VES points

Based on the results of the survey a deep-drilled tube well site could be recommended up to a depth of 60m  $\pm$  10m at surface positions at 75m.

#### Bedrock Relief Map

The bedrock elevation beneath each of the VES points was determined to produce the bedrock relief map for the study area. This is a reflection of bedrock topography and shows bedrock ridges and depressions within the study area (Fig 4). The depression was overlain by saturated weathered materials of secondary porosity which serve as aquifer in this area.

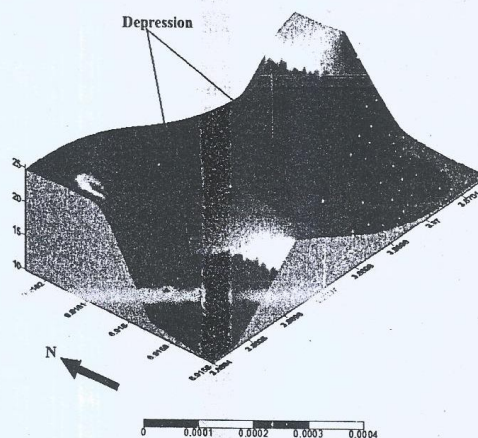


Figure 4: Bedrock Topography of the Study Area



### Conclusions

A resistivity imaging of survey carried out in the OOU campus has led to the following conclusions:

- A bedrock relief map of the area has delineated a bedrock depression.
- Deep water-bearing weathered materials overlying the bedrock depression have been encountered.
- The overlying materials are of good secondary porosity suitable for sitting a prolific borehole.
- A deep drilled tube well site was recommended up to a depth of 60m, plus or minus 10m based on interpretation of Fig 2b at a surface position of 75m.

The resistivity imaging technique has successfully located a groundwater aquifer overlying a bedrock depression in hard rock with a good secondary porosity and permeability.

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