Winter 12-12-2016

Increasing the Success Rate of Groundwater Exploration in Developing Nation Using Geophysical Methods: Case of a Small Community in Nigeria

Solomon A. Isiorho
Indiana University - Purdue University Fort Wayne, isiorho@ipfw.edu

David O. Gbenga
Covenant University, Ota, Ogun State, Nigeria

P A. Aizebeokhai
Covenant University, Ota, Ogun State, Nigeria

Follow this and additional works at: http://opus.ipfw.edu/geosci_facpres

Part of the Civil and Environmental Engineering Commons, and the Earth Sciences Commons

Increasing the Success Rate of Groundwater Exploration in Developing Nation Using Geophysical Methods: Case of a Small Community in Nigeria.

K. S. Isiorho, Dept. of Geosciences (to be extinct Dec. 23, 2016), Indiana University Purdue University Fort Wayne, Fort Wayne, IN, USA,
D. O. Omole, Covenant University, Civil Engineering Dept. Covenant University, Ota, Ogun State, Nigeria
P. A. Aizebeokhai, Physics Dept., Covenant University, Ota, Ogun State, Nigeria

Abstract

Due to the lack of an adequate clean water supply system within Ogun State, Nigeria, many homes result to drilling their own private wells. This study examines the exploration for groundwater in Ogun State in Nigeria, using Ota as an example. However, due to the indiscriminate and lack of proper waste disposal, the vast majority of the surface waters and shallow well waters are impaired for many users. To access a deeper groundwater source, a geophysical survey using the vertical electric sounding (VES) with Schlumberger configuration was carried out. The data shows five layers within the proposed borehole site. Based on the data, a pump was installed at 66 m (217 ft.) that is within the 65-75 m (213-246 ft.) of the Abeokuta Formation. The first 50 feet of the borehole was grouted to prevent surface water from getting into the hole. A pumping test was performed for about two hours, but the water quality was not tested for during the pump test. More still needs to be done regarding groundwater procurement in developing nations.

Problems:

*Lack of public water supply

*High failure rates of boreholes

*Indiscriminate solid and liquid wastes disposal (Omole et al., 2015; Omole & Isiorho, 2014)

Background Information:

About ~35% of the population depends on groundwater.

Ogun State has both significant surface and groundwater resources.

However, due to the indiscriminate and lack of proper waste disposal, the vast majority of the surface waters and shallow well waters are impaired making them unsuitable for many users.

Several entrepreneurs have seized on the lack of adequate water supply to become water well drillers….often lacking training or understanding of the area geology.

Most groundwater is sourced from shallow wells (less than 30 m) and is often of poor water quality.

Procuring a good water in developing nation still takes great efforts and as such more than half of the people get their water in any way possible.

The geologic map of the western part of Nigeria indicates the Benin Formation overlays Ota, Ogun State
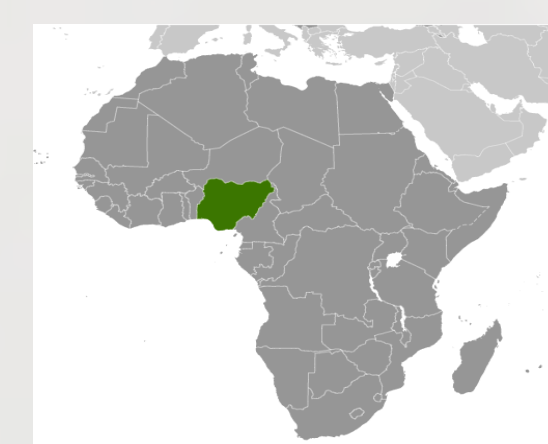
Map of Africa showing Nigeria in green

Geologic map of the Nigerian section of the Dahomey basin (modified after Gebhardt et al., 2010)
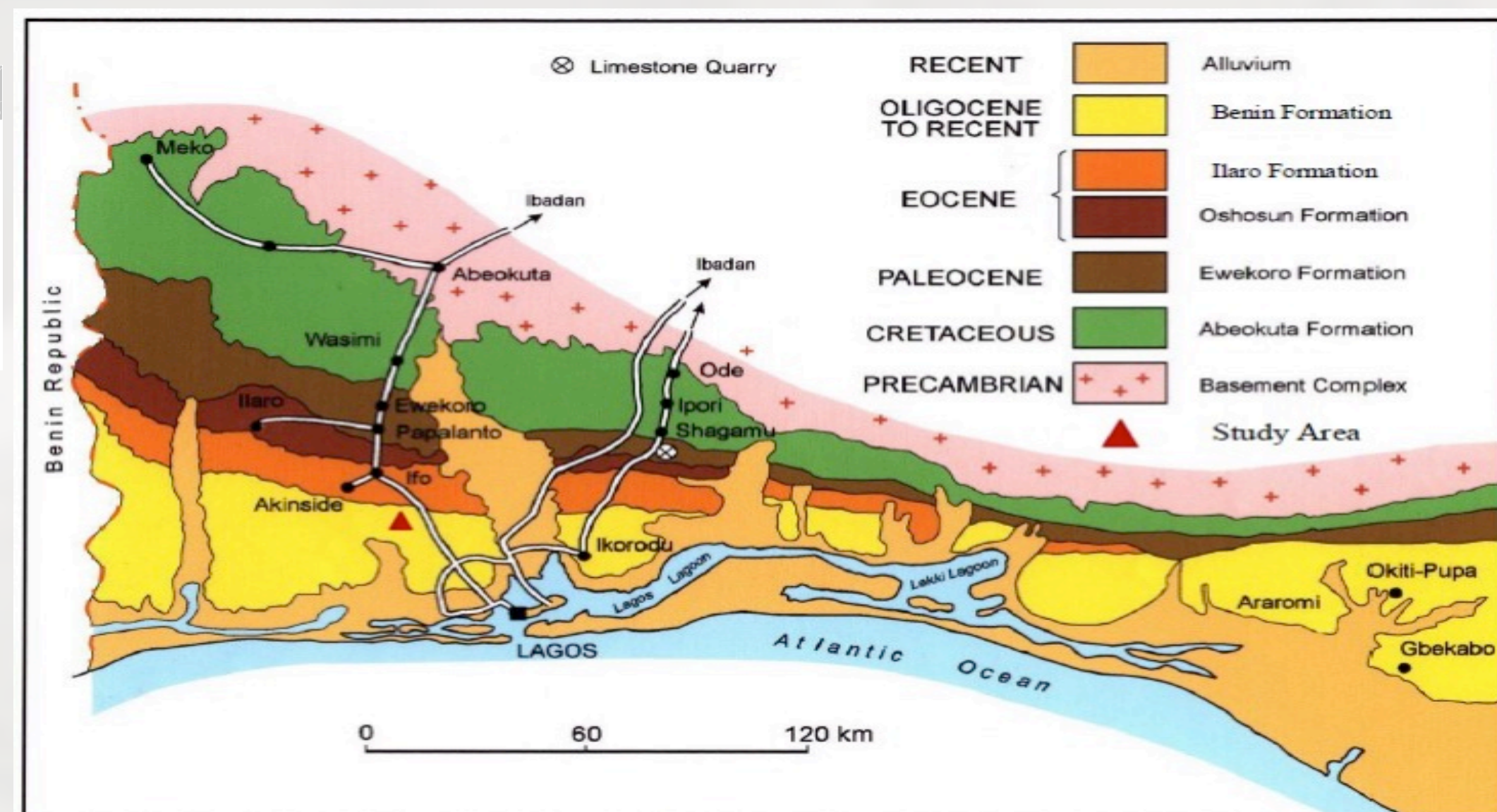
Approach:

The geophysical survey was conducted using vertical electrical sounding (VES) at a point closed to the proposed borehole. Schlumberger electrode configuration was used for the apparent resistivity measurements with ABEM Terrameter (SAS 4000); the half- current electrode spread (AB/2) used for the survey ranges from 1.0 m to 130 m as permitted by the available space and accessibility (AB/2 of 180 m was desired), and thus making a maximum electrode spread of 260 m. The observed apparent resistivity data was processed by plotting the apparent resistivity values against the corresponding half-current electrode spacing (AB/2) on a bi-logarithmic sheet. The resulting field curves were then curve-matched with Schlumberger master curves to delineate the number of layers and obtain estimates of the corresponding geoelectric parameters (resistivity and thickness) of the delineated layers. The estimated geoelectric parameters were then used as initial models for computer iteration using Win-Resist program to obtain the inverse model of the geoelectric parameters.
A bore hole was drilled to the depth suggested from the geophysical data and pumping test was conducted after drilling.

Electrode configuration (Schlumberger array) used for the data
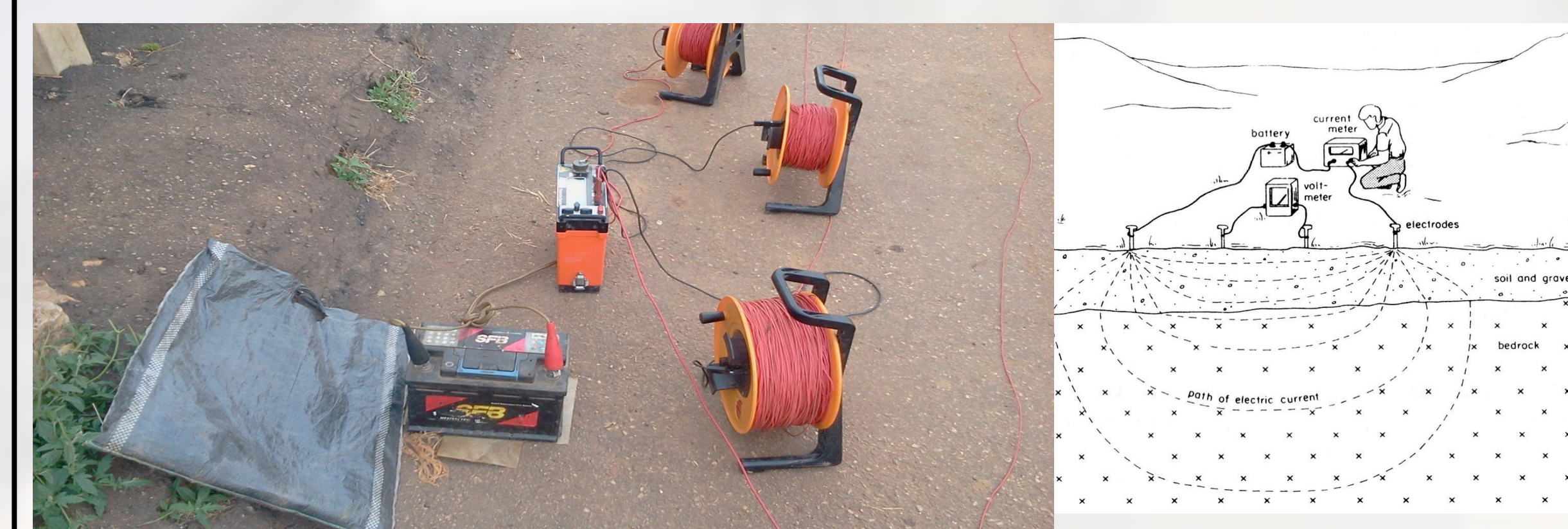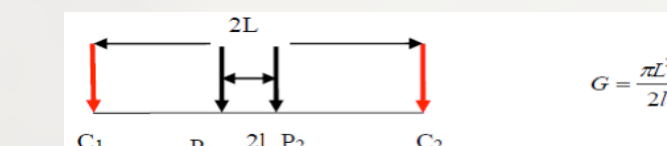
ABEM Tetrameter (SAS4000) lay out for resistivity measurement (lines drawing after Robinson and Coruh, 1988). Students preparing for field measurement are shown below.

A typical field area in Ogun State, Nigeria is shown to the right

Results and Discussions:

The apparent resistivity values measured (shown in the table to the right) were generally of good quality as the root-mean-square error observed in the measurements ranges from 0.01 to 0.3; root-mean-square up to 5% is usually acceptable. The sounding curve showing the inverse model geoelectric parameters is presented in the figure below. Five geoelectric layers are delineated from the sounding curve; the layers parameters and the inferred lithology are presented in the table to the right It is important to note that Layers 2 and 3 are very resistive and consolidated; Layer 3 is a very thick regional mudstone rich in kaolin and phosphate; this layer is about 37.3 m thick at the point investigated. Layer 3 overlies a saturated sandy formation (Layer 4) that is thought to be a low yield aquitard; it is thus serving as the confining bed to the aquitard. The aquitard in turn serves as the confining bed to the main aquifer delineated (Layer 5). Also, Layer 5 with model resistivity of 243.4 ohm-m at model depth of 63.6 m was targeted for a productive borehole. Based on the data, the pump installed at 66 m (217 ft.) that is within the 65-75 m (213-246 ft.) of the Abeokuta Formation.
A pumping test was carried out with a yield of 3,300 L/h (871.77 gal/h). However, no water quality was measured and repository of the well data was not made.

Layer	Resistivity (ohm-m)	Thickness (m)	Depth (m)	Probable Lithology	Hydro-geological significance
1	588.8	4.2	4.2	Top soil (sandy)	Unsaturated
2	941.9	9.2	13.4	Consolidated lateritic mudstone	Unsaturated
3	1535.2	37.3	50.7	Consolidated mudstone rich in kaolin and phosphate minerals	Unsaturated confining bed
4	382.6	12.9	63.6	Sandy formation	Saturated (slightly porous and permeable) low yield aquitard
5	243.4	-	-	Coarse sandy formation	Saturated (very porous and permeable) high yield aquifer

Table showing the layers and their corresponding formations.
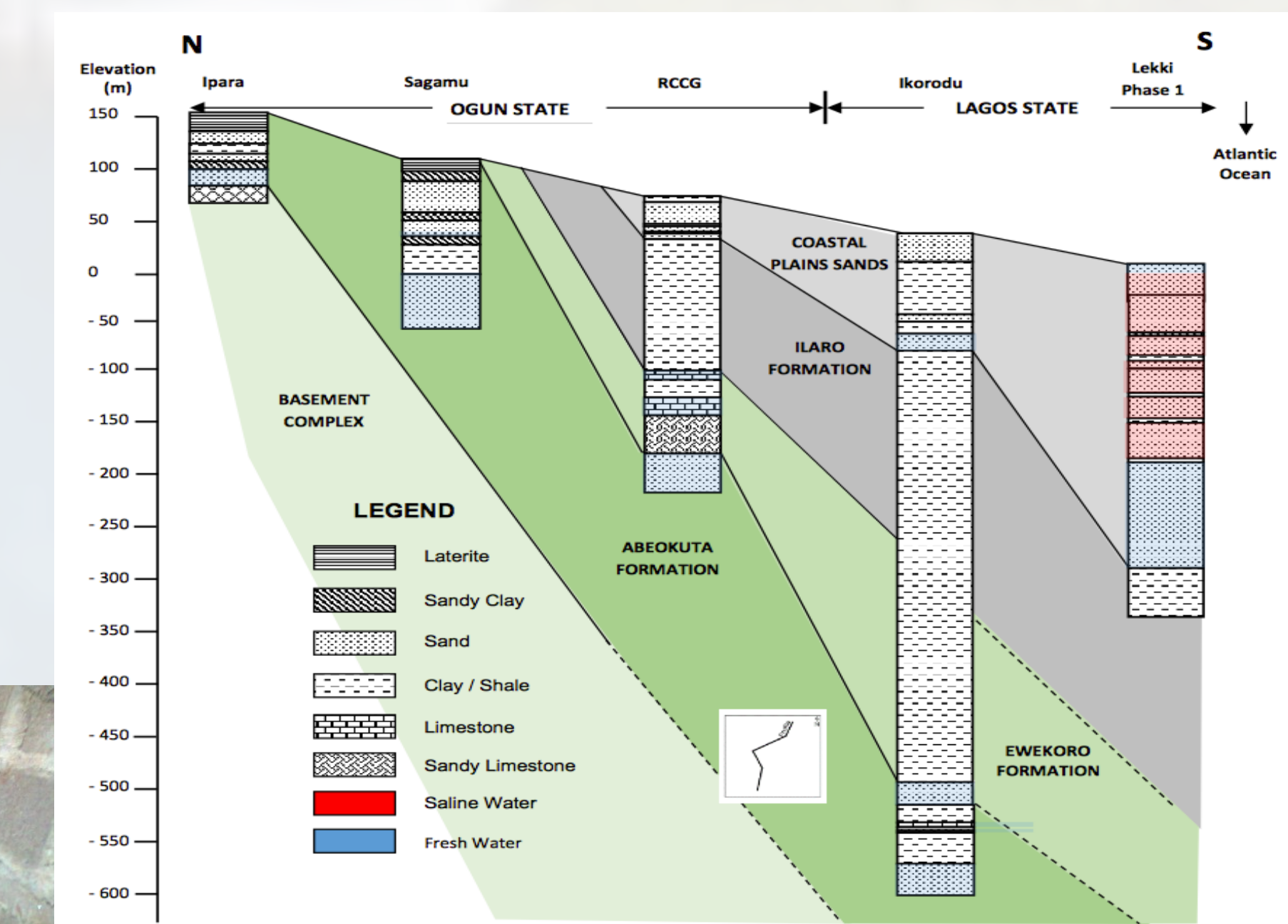
A hydrogeological cross section from the Atlantic to Ogun State inland (Oteri & Ayeni, 2015)
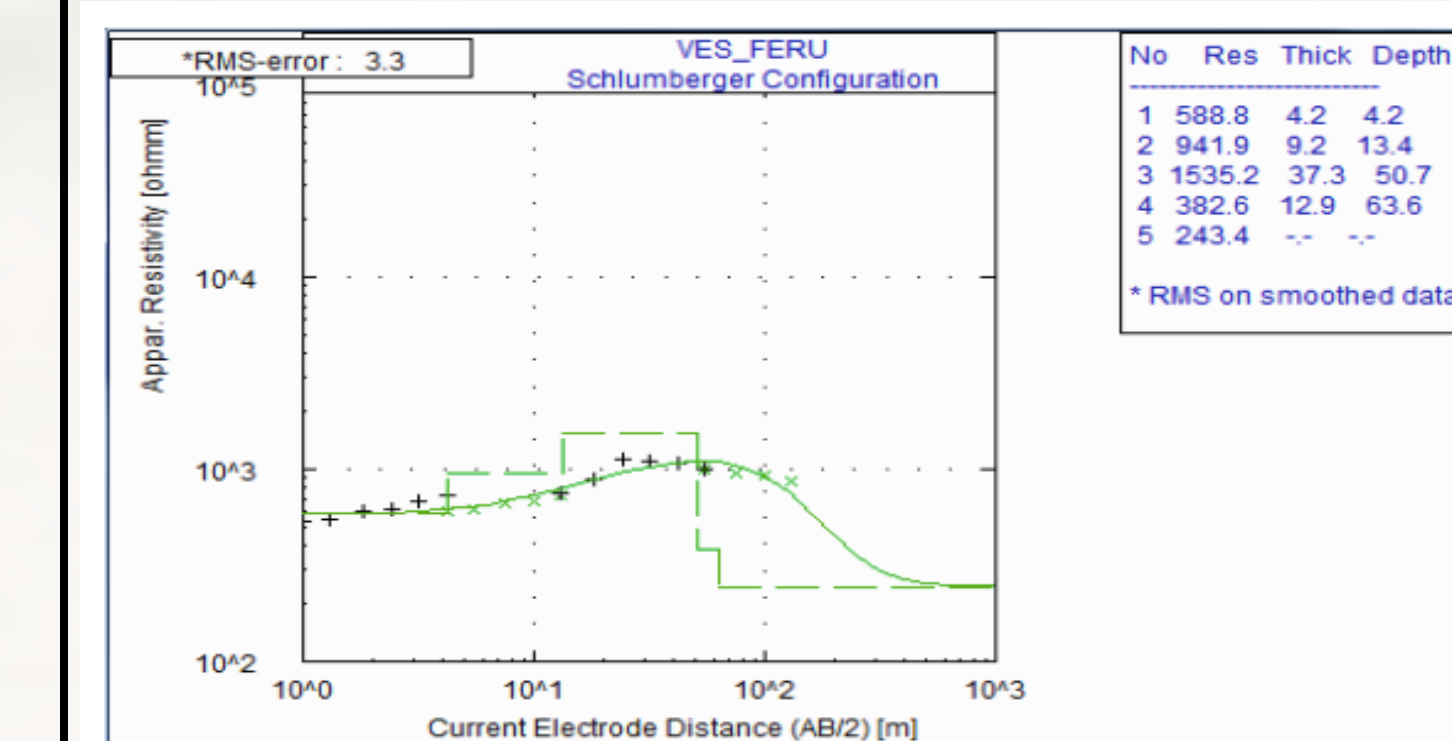
Geoelectric sounding curve

Finished bore hole

Procuring a good water in developing nation still takes great efforts and as such more than half of the people get their water in any way possible.

Pumping test at the location to the right.

Getting freshwater from the finished borehole

Conclusions:

The geophysical method was successful in helping determine the depth to water that should be drilled. Sufficient water rate was determined from the pumping test. However, water quality and recording of the well data were not made available to any central body. More work still needs to be done regarding record keeping. Procuring a good water in developing nation still takes great efforts and as such more than half of the people get their water in any way possible.

References:

Gebhardt, H., Adekeye, O. A., & Akande, S. O., 2010, Late Paleocene to initial Eocene thermal maximum foraminifera biostratigraphy and paleoecology of the Dahome Basin, Southwestern Nigeria. Gjahrbuch Der Geologischem Bundesantalt 150:407-419

Omole et al., 2015, Student emersion in Engineering and Geoscience research: One-way of strengthening the disciplines. GSA Abstract with programs Vol. 47, No 7, p.87

Omole, D. O. and Isiorho, S. A, 2014, Waste management practices in south-west Nigeria: Impact and Mitigation, GSA Abstract with programs vol. 46, #6

Oteri, A. U. & Ayeni, R. A.,2015, Lagos, The Lagos Megacity. http://eaumega.org/wp-content/uploads/2016/05/EN-Lagos-Monograph.pdf. Accessed Nov. 28, 2016

Robinson E. S. & Coruh C, 1998 Basic Exploration Geophysics, Wiley, New York, 562p