

HYDRO-GEOPHYSICAL INVESTIGATIONS FOR GROUNDWATER AT ATAN/ODOSENBORA AREA, SOUTHWESTERN NIGERIA

S.O. ARIYO¹⁺, and O.O. OSINOWO

1. Department Of Earth Sciences, Olabisi Onabanjo University, Ago-Iwoye,
2. Department of Geology, University of Ibadan. Ibadan

Abstract

A hydro-geophysical evaluation of the groundwater potential of the Atan/Odosenhora area of Ogun State, Southwestern Nigeria was carried out. The investigation involved the Vertical Electrical Sounding (VES) technique that applied the Schlumberger array. The study area is located within the Basement Complex terrain of Southwestern Nigeria. Migmatitic gneisses and granitic rocks underlie the area predominantly.

The data acquired from the Ten (10) VES stations were interpreted using the partial curve matching method and later subjected to computer based iteration interpretation.

A maximum of five (5) subsurface layers comprises of topsoil, sandy clay, weathered basement, fractured basement and fresh bedrock have been delineated in the study area. The depth to bedrock varies from 5.5 - 53.1m with resistivity values ranging between 61 - 11,292 ohm-m. The hydro-geologic study focused on measurement of depth to water table and actual depth of the hand dug wells while the geological aspect of the work was hinged on a geologic mapping. The results of hydrogeologic study show that the actual depth of the hand-dug wells ranged between 2.5 and 8.3m while the static water level varied between 0.83 and 3.3 m.

The study gave an insight to the ground water potential of the area with the southern part of the study area having the highest potential based on the geoelectric parameters calculated.

1. Introduction

It is predicted that by 2010 half of the world's population of 6500 million will be living in town or cities. A high proportion of these urban dwellers will depend on groundwater for day-to-day domestic industrial and commercial water supply since surface water cannot be dependable throughout the year because of effects of drought.

Groundwater is more desirable than surface water for at least six following reasons:

- (i) it is commonly free of pathogenic organisms and need no further purification for domestic and industrial used.
- (ii) temperature is nearly constant which is a great advantage if the water is to be used for heat exchange.
- (iii) turbidity and colour are generally constant
- (iv) groundwater storage is always greater than surface water storage, so that groundwater supplies are not seriously affected by short duration of droughts.
- (v) biological contamination in groundwater is seldom noticed.

The successful exploitation of basement terrain groundwater- requires a proper understanding of its hydro geological characteristics. This is particularly important in view of the discontinuous (localized) nature of basement aquifers (Satpathy and Kanungo, 1976). Hence, drilling programme for groundwater development in areas underlain by basement terrain

is generally preceded by detailed hydro-geophysical investigations.

In basement complex terrain, groundwater occurs either in the weathered mantle or in the joint and fracture system in the unweathered rocks (Ako and Olorunfemi, 1989; Olayinka and Olorunfemi, 1992). The highest groundwater yield in basement terrain is found in areas where thick overburden overlies fractured zones (Olorunniwo and Olorunfemi, 1987; Olorunfemi and Fasuyi, 1993). These zones are often characterized by relatively low resistivity.

The vertical electrical sounding (VES) method was used to delineate the different subsurface geoelectric layers, aquifers units and their characteristics, the subsurface structure and its influence on the general hydro geological investigation conditions in the study area.

The hydro-geological investigation involved the measurement of the static water level and the actual well depth of the hand dug wells within the study area in order to establish the source of water resources in the area.

2. Location and Geomorphology of the study Area

Atan/Odosenhora in Ijebu-North East Local government area of the present Ogun State, Southwestern Nigeria lies, between latitudes 6° 50' N and 6° 54' N and longitudes 3° 47' E and 3° 50' E. The area is accessible through secondary roads from

+ corresponding author (email:ariyof@yahoo.com)

Ijebu-Igbo in the north and Ijebu-ode in the south (Figure 1).

The relief of the study area shows that the region is an undulating coastal plain with elevation hardly rising above 240 m above sea level. The area is fairly well drained with rivers, both perennial and seasonal with some minor streams, which form minor tributaries of the main rivers. The drainage pattern of most rivers in the area is dendritic, hence it can be interpreted that the existing rivers have taken the advantage of faults in the area and hence they are structurally controlled.

(a) Geology and Hydrogeology

The study area lies within the basement complex area of southwestern Nigeria (Figure 2). The predominant rocks found within the study area are migmatitic gneiss and granites. The youngest rock type in this area is granite as it outcrops in several places and fresh except in some places where it is seen to be weathered.

The crystalline basement rocks are mechanically competent (granite more so gneisses) and therefore respond to impose strains by brittle fracture (Dan-Hassan and Olorunfemi, 1999). Surface water percolates down through the fractures and the process of chemical weathering proceeds. These two features of the erosion cycle provide crystalline area with water bearing zone. In general, gneiss and migmatite weathered more easily than granite (Olorunfemi *et al.*, 1991). However, the weathering products if the gneiss and migmatite are richer in clay material and hence, less permeable with attendant lower ground water yield.

(b) Method of study

Two methods were involved in the study area. These are:

(i) Geophysical investigation: Vertical Electrical Sounding (VES) employing, the Schlumberger array was used during the geophysical investigation. Ten (10) stations were occupied and each VES station has a total spread of 100 m. The VES data collected were plotted on a log-log graph paper for curve matching and computer iteration interpretation.

(ii) Hydrogeological investigation: This involved the measurement of the depth to water table (static water level) and actual depth of the wells with the aid of a rope and measuring tape. Ten (10) of such hand dug wells were measured in the study area. The measured parameters were used in ascertaining the source of groundwater resources in the area.

(c) Interpretation Techniques of VES Data

The VES curves were interpreted quantitatively by partial curve matching and computer iteration techniques. The partial curve matching involved segment-by-segment matching of the field curves with two layers model curves and their corresponding auxiliary curves.

The results of the partial curve matching were input into the computer for the final results in which both the calculated and observed values were plotted on the same graph.

3. Result and Discussion

The sounding curves were analysed quantitatively. The interpretation of the ten (10) Schlumberger array soundings conducted in the area-studied reveals the existing of 3 to 6 geoelectric layers. The geoelectric layers comprise of topsoil made up of sandy clay/clayey sand and gravel with layer resistivity values varying from 50.2-867.2 Ω -m while the thickness ranged between 0.6-3.3 m. The sandy clay second layers have layer thickness and resistivities of between 0.9 and 4.0 m and 128.0-202.0 Ω -m respectively.

The weathered layers, which constitute the third layer has layer resistivity values that vary from 46.0-416 Ω -m. The thickness varies from 1.3-49.5 m.

The fractured basement that represent the fourth layer has resistivity values that vary from 552.0-854.0 Ω -m and the fifth layer which form the fresh bedrock has high resistivity values of 2009.0-11,292.0 Ω -m. The overburden thickness varies from 4.6-53.1 m.

From the hydrogeological investigation, it was observed that depth to the static water table varies from 0.8 m to 8.3 m while the actual depth of the wells ranges from 2.5 m to 8.3 m (Table 1)

Generally, areas with thick overburden and a low percentage of clay in which the intergranular flow has either a dominant or important role to play are known to have high groundwater potentials particularly in a basement complex areas (Okhue and

Table 1: hand-dug wells parameters

Hand-dug Wells	Depth to water Level (m)	Actual Wells depth (m)
01	0.80	2.50
02	1.75	3.55
03	1.25	3.43
04	1.82	4.40
05	2.00	4.42
06	1.20	5.60
07	1.60	6.80
08	3.30	8.30
09	2.00	7.60
10	2.10	6.90

Olorunfemi, 1991). Using the results of the vertical electrical sounding interpretation, a geoelectric section showing the subsurface lithologic characterization was produced (Figure 3).

The static water level measured, it was observed that the Northern part of the study area has the highest static water level of the hand-dug wells measured which ranged from 1.6-3.3 m with depth of the wells ranging between 6.8 m to 8.3 m while the Southern part has the lowest static water level of 0.8 m to 1.75 m and depth of the wells values ranges between 2.5 m to 3.43 m. The central part of the area has the medium value of both static water level 2.0 m and 4.4 m and 10 5.6 m respectively (Table 1).

4. Conclusion and Recommendation

The hydro-geophysical investigation of the Atan/Odosenbora area of Southwestern Nigeria has revealed five major geologic units. These are topsoil, sandy clay, weathered basement, fractured basement and fresh basement. The bedrock in some places has high resistivity values while in other places have low resistivity values. The relatively low resistivity weathered/fractured basement constitutes the main aquifer unit in the study area.

The calculated overburden thickness shows that depths to the fresh basement vary from 5.5-53.1 m. Boreholes located within basement depression zones, which correspond to area with relatively thick overburden, will give relatively high yields than other zone, all things been equal. Such areas with thick overburden materials are priority zones for possible groundwater development, most especially when the clay content is low (Dan-Hassan *et al.*, 1999).

The static water level measured shows that the Northern part of the study area has the highest static water level couple with high actual depth of the wells.

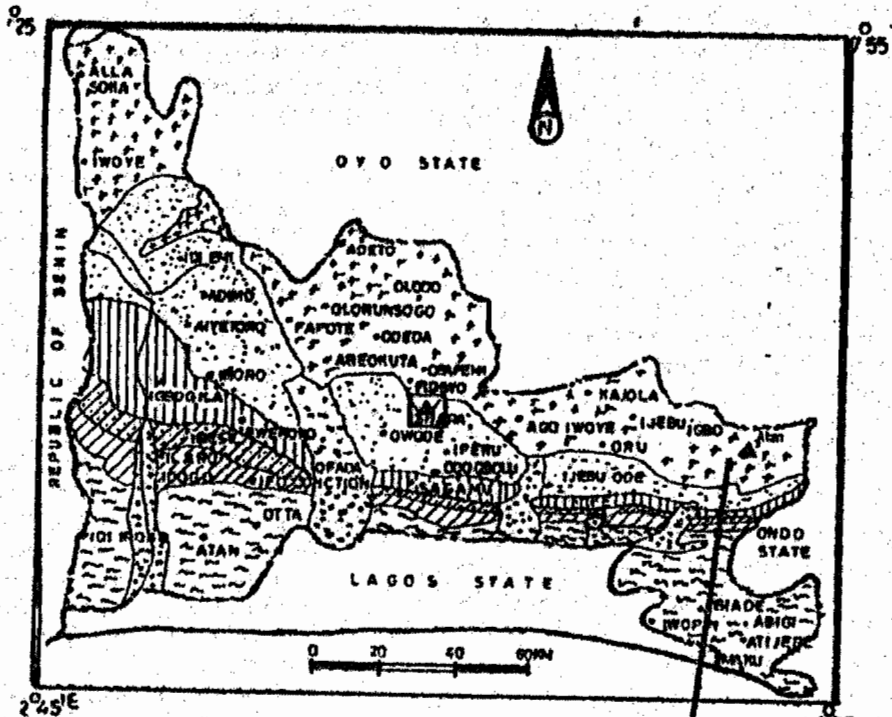
Based on the hydrogeologic and geoelectric characteristics of the study area, the Northern part

has the highest groundwater potential than the Southern part.

I therefore recommend that extensive geophysical and hydrogeological investigations be further carried out in other parts of the study area in order to have an insight to groundwater potentials in the entire area. Finally, this study has provided a baseline for further study in the area.

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Insert Geological Map of Ogun State (after Kehinde-Phillips 1992)

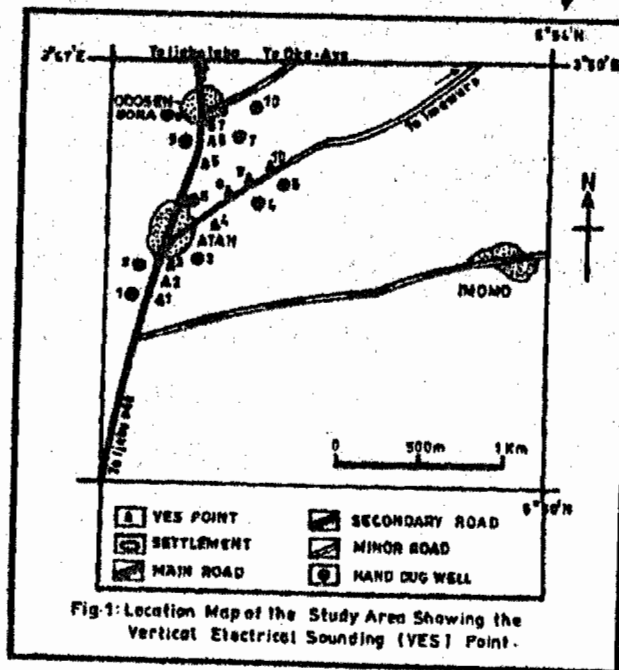


Fig.1: Location Map of the Study Area Showing the Vertical Electrical Sounding (VES) Point.

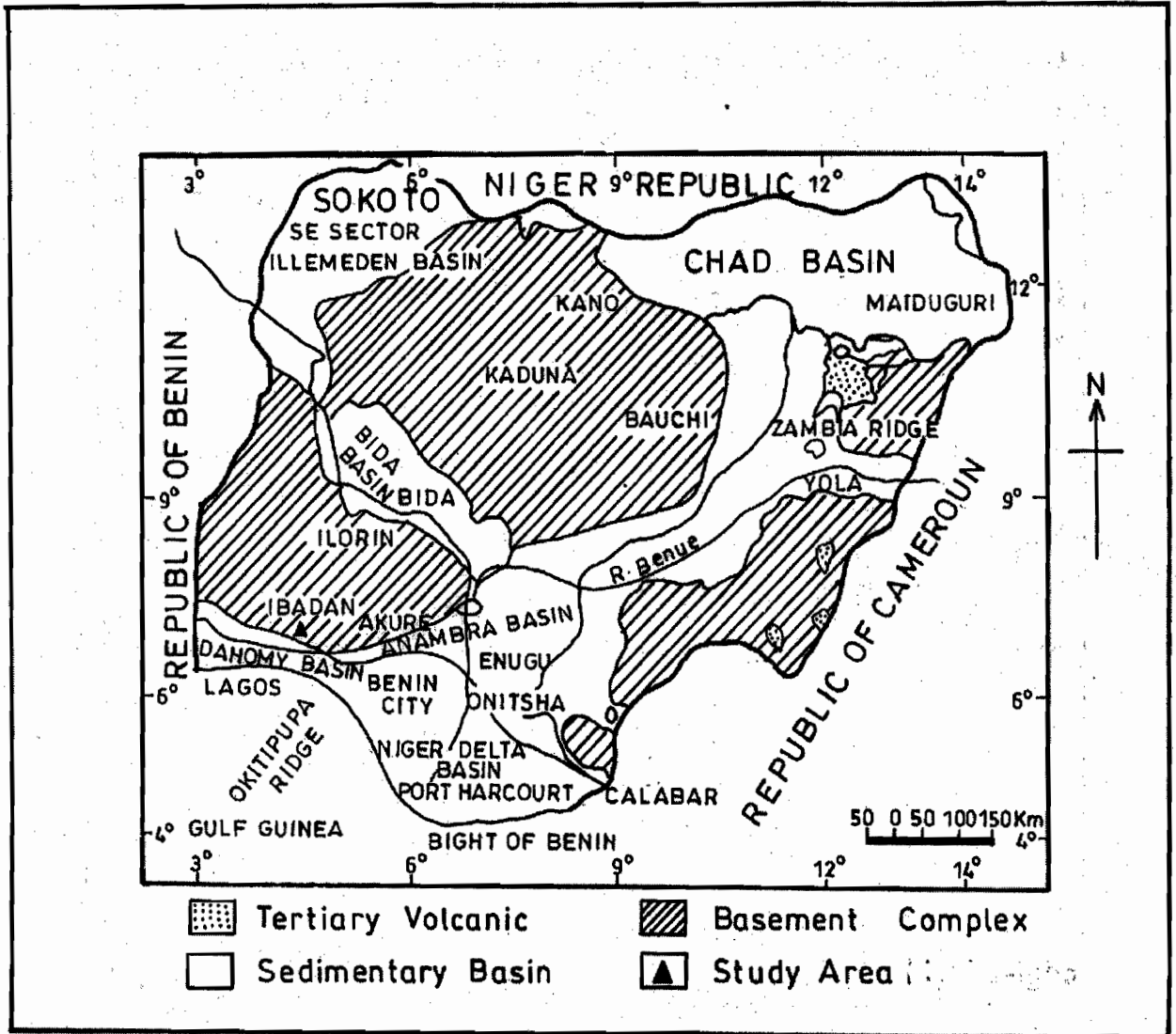


Fig.2 : Location Map of the Study Area within the Basement Complex of Nigeria.

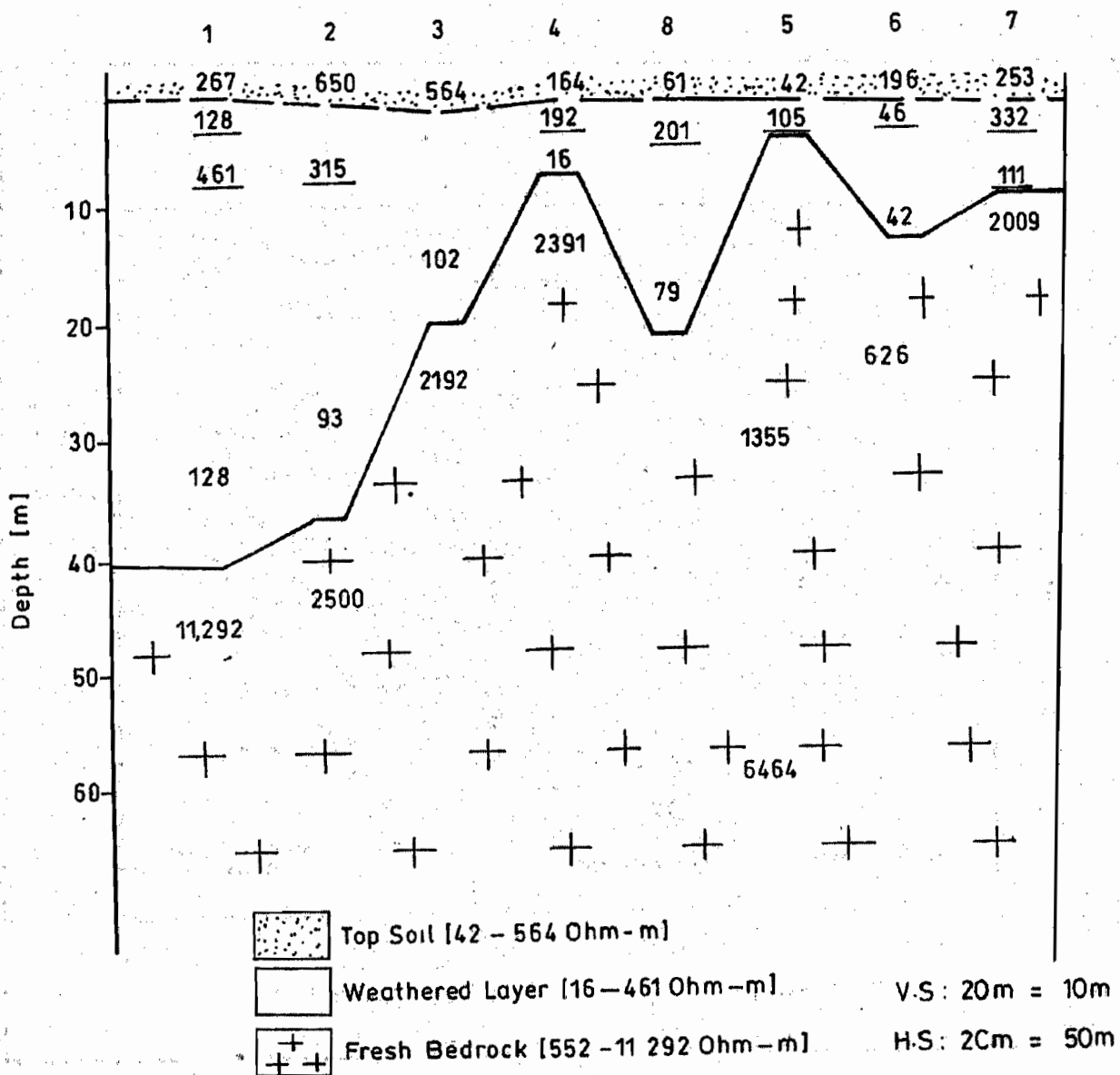


FIG.3.GEOELECTRIC SECTION OF THE STUDY AREA