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DC RESISTIVITY SURVEY FOR THE ASSESSMENT OF GROUNDWATER POTENTIAL IN OBA AKOKO, SOUTHWESTERN, NIGERIA

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ABSTRACT

A DC resistivity survey of Oba Akoko in southwestern Nigeria was carried out over the three major rock units of the Migmatites; granite, granite-gneiss and grey-gneiss underlying the study area. The objectives of the study included the delineation of the subsurface geological/geoelectrical sequences and aquifer unit(s) and types with a view to assessing prospective site for groundwater potential rating of the area. Fifty nine Schlumberger vertical electrical sounding data were acquired. The inter-electrode spacing (AB/2) varied from 1 to 100 m with maximum spread length of 200 m. The ground resistance measurements were made with ABEM SAS 1000 resistivity meter. Seven distinctive sounding curve types were obtained from the data inversion/interpretation techniques. These included H, A, HA, AA, HK, QH and AK curve types. Maximum of four geological/geoelectric layers were delineated; the top-soil, clay/clayey sand/sandy clay weathered basement, partly weathered/fractured basement and fresh basement with resistivity values that ranged from 20 - 360 Ωm, 25 - 850 Ωm, 476 - 979 Ωm and infinity ohm-m respectively, while the thickness values ranged from 0.4 - 3.8 m, 1 - 17 m, 4 - 17 m respectively, and depth to rock head of 24.9 m. Isopach maps of the weathered layer and overburden showed spatial distribution of the thickness with a relatively thick weathered/fractured basement not less than 10 m as basement depressions or pockets of closures. The thickness pattern showed uneven basement bedrock interface. It may, therefore, be concluded that groundwater potential of the study area is generally low arising from shallow depth to basement or thin regolith and few fracture density in places in the area. The localized fractured bedrocks and weathered basement columns/basement depressions arising from the deep weathering of the parent rocks may have constituted the main sustainable aquifer/groundwater storage units for consumption via borehole groundwater abstraction in the area.

KEYWORDS: Geology, Mapping, Geoelectrical, Resistance, Delineating

INTRODUCTION

Oba-Akoko is underlain by granite, granite - gneiss and grey - gneiss as the three dominant rock types of the Precambrian Basement Complex suites of the south-western Nigeria. The successful exploitation of basement terrain groundwater resources requires a proper understanding of the geological and geoelectrical characteristics of the underlying units.

A DC resistivity survey or measurement involving vertical electrical sounding technique is employed in this study. The technique is associated with the probing of the subsurface as a function of current and potential electrodes' separation. The measurement can be interpreted in terms of a lithologic and/or geo-hydrogeologic model of the subsurface. The above is a measure of the degree of water saturation and connectivity of pore space as the presence of water reduces resistivity (Telford *et al.,* 1990; Reynolds, 1998).

The resistivity survey method of investigation is quite inexpensive, fast and non-invasive (Barker and Olayinka, 1991; Reynolds, 1998; Oladapo *et al.,* 2004). It investigates a geological medium via the consideration of its electrical properties or resistivity responses. While the vertical electrical resistivity sounding technique is usually considered more suitable for the subsurface depth probe of any geologic environment, abrupt lateral changes in lithology and electrical properties could constitute steeply dipping beds, fractures and fault zones, or highly variable thicknesses of weathered bedrock materials (Telford *et al.,* 1990; Barongo and Palacky, 1991). This development usually makes interpretations difficult. However, with appropriate complementary method(s) and application of appropriate models (Benson and Jones, 1988), the technique can be best employed for depth determination and choice of drilling of successful water wells and other geo-engineering and environmental utilities.

Although, the dominant basement rocks in the study area are inherently characterized by low porosity and permeability, the sustainable groundwater yield in the terrain may be at best found in areas/zones where thick overburden overlies fractured zones. These zones are often characterized by relatively low resistivity values (Olorunfemi and Fasuyi, 1993; Bayode *et al.,* 2005; Mohammed and Olorunfemi, 2012). The most probable use of the dc resistivity survey in hydrogeological investigation is in relation to the delineation of aquifer units, lithologic contact zones and geological structures (Bose *et al.,* 1973, Mohammed and Olorunfemi, 2012). However, groundwater occurs either in the weathered mantle or in the joints and fractured system in the un-weathered rocks (Olorunfemi and Fasuyi, 1993, Mohammed *et al.,* 2012).

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Oba-Akoko, constituting the study area is situated in Akoko Southwest Local Government Area of Ondo State, Southwestern, Nigeria as shown in Figure 1 (Ilоeje, 1982). It is confined within latitudes 7^0 19' 5.82" and 7^0 24' 41.63" N and longitudes 5^0 42' 41.43" and 5^0 46' 29.43"E, and it is about 30 km northeast of Owo town and about 14 km from Ikare - Akoko, and about 70 km north of Akure, the capital of Ondo State. Oba Akoko has a linear settlement pattern with subsistence and cash crop farming as the mainstay of the economy in the area. The study area is characterized by relatively gentle undulating terrain with elevations of between 931 and 1062 ft. The landforms vary from hills and inselbergs to undulating plains.

Geologically, according to Rahaman (1976; 1988; GSN, 2001), the area is underlain by Migmatite – gneiss - quartzite Complex with the granite, granite gneiss and grey gneiss being the major units as shown in Figure 2, while the minor units include pegmatite and quartzite**.** The basement rock exposures are however found as lowland outcrop in few places particularly where basement is shallow and erosional activities are active.

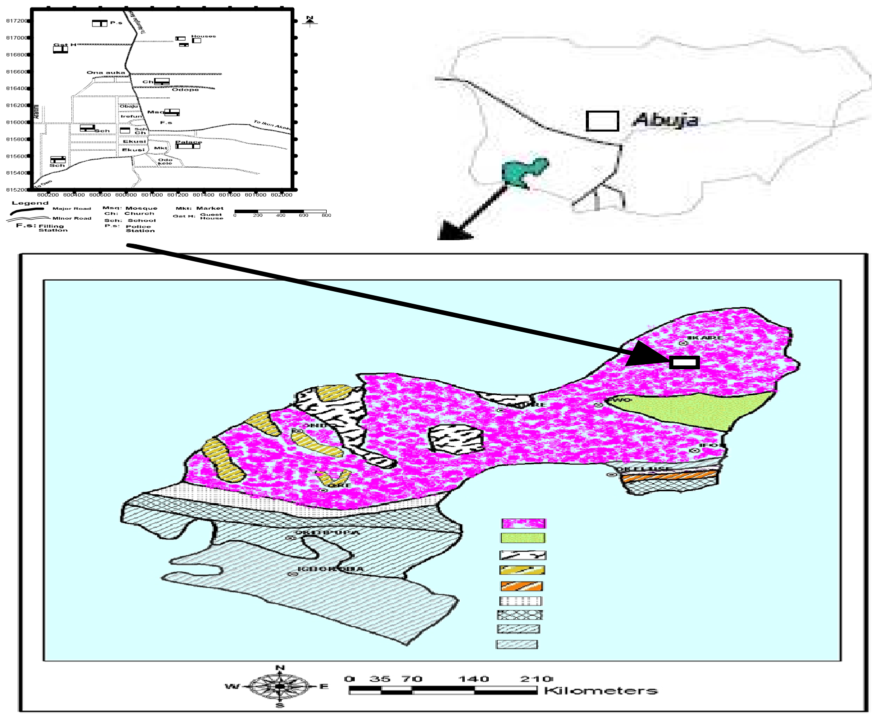

Fig. 1: Map of Ondo State Showing the study area

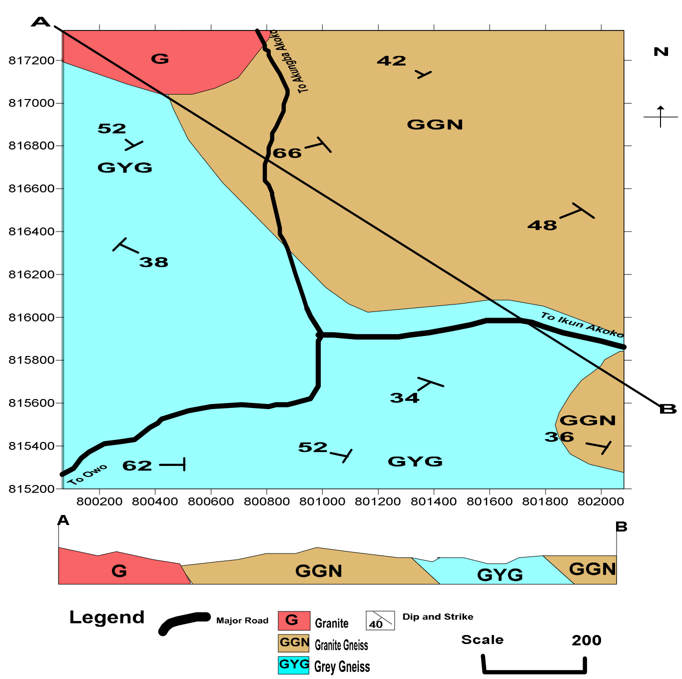

Fig. 2: Modified Geological Map of Oba Akoko (Jimoh, et al., 2013)

2.0. Method of study

Records and measurements of observations were made to include lithologic units and geologic features of interest such as foliation trends, inferred boundaries etc . A total of fifty nine (59) Schlumberger vertical electrical sounding data were collected from the direct current resistivity survey (Fig. 3). The electrode spacing (AB/2) varied from 1 - 100 m with a maximum spread length of 200 m. Measurements of the ground resistance were made with ABEM SAS 1000 resistivity equipment. Apparent resistivity values were calculated as the product of the ground resistance and the geometric factor of the array. The resistivity data were presented as sounding curves after inversion (Vander-Velpen, 1988). This process gave the true resistivity and thickness of various subsurface geologic/geoelectric layers.

3.0. RESULTS AND DISCUSSION

3.1. Results

The results of the study are presented as field sounding curves, tables, geoelectric sections and thickness and resistivity maps.

3.2. Discussion

The results of the model parameters arising from inversion or iteration are the geoelectric parameters associated with the study area. The layer resistivity combinations give simple three to four geoelectric layered model curves. The typical curve types are shown in (Fig. 4). The type curves' results were used to prepare 2-D geoelectric sections.

The geoelectric sections (A-A^1, B-B^1, C-C^1, D-D^1, E-E^1, and F-F^1) show respective layer resistivities and thicknesses (Figs. 5 a – f). The sections reveal the uneven basement topography/depressions and possible structural deposition of subsurface geology. The geoelectric sections delineate a maximum of four geoelectric subsurface layers comprising the top-soil, clay/clayey sand/ sandy clay weathered basement, partly weathered/fractured basement and fresh basement with resistivity values ranging from 20 - 360 Ωm, 25 - 850 Ωm, 476 - 979 Ωm and infinity ohm-m respectively, while the thickness values range from 0.4 - 3.8 m, 1 - 17 m, 4 - 17 m respectively, and the depth to bedrock is 37..8 m.

The isoresistivity map of the weathered layer is shown in Fig. 6 a. The map shows the distribution of the resistivity of the weathered layer within the study area. The resistivity varies from 50 - 850 Ωm, but generally low (< 250 Ωm) as observed in the west, east, north-west and south-eastern ends and moderately high between 250 – 500 Ωm in the central portion and as pockets of high resistive zones. The low resistivity (< 100 Ωm) is indicative of a clay, (100 < 250 Ωm) is typical of sandy clay, silt or clayey sand substratum while the moderately high resistivity (250 < 500 Ωm) may be indicative of localized pockets of coarser sandy column. Deduction from findings show that the groundwater potential of Oba Akoko is generally of low level rating.

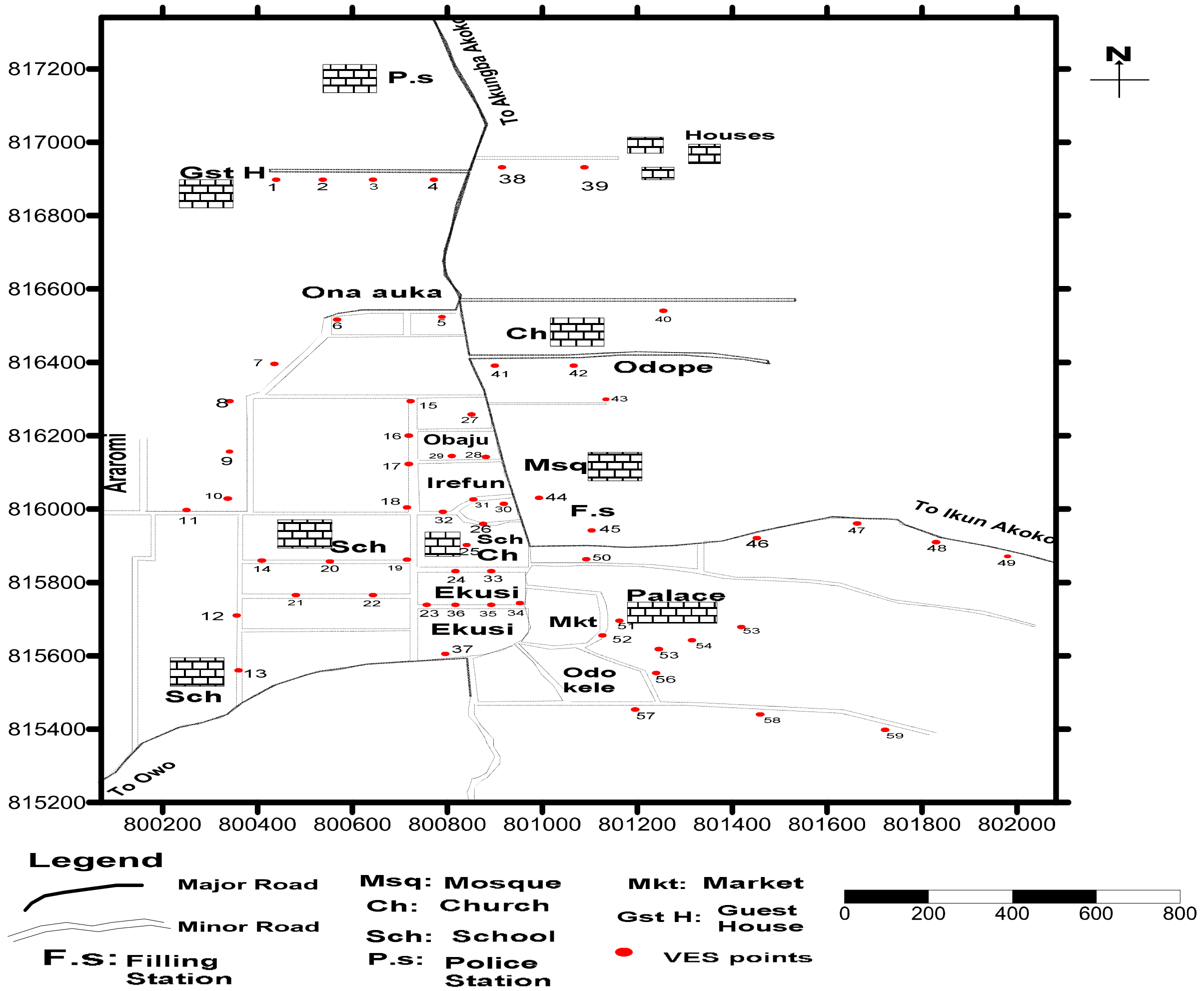

Fig. 3: Data acquisition map of the study area

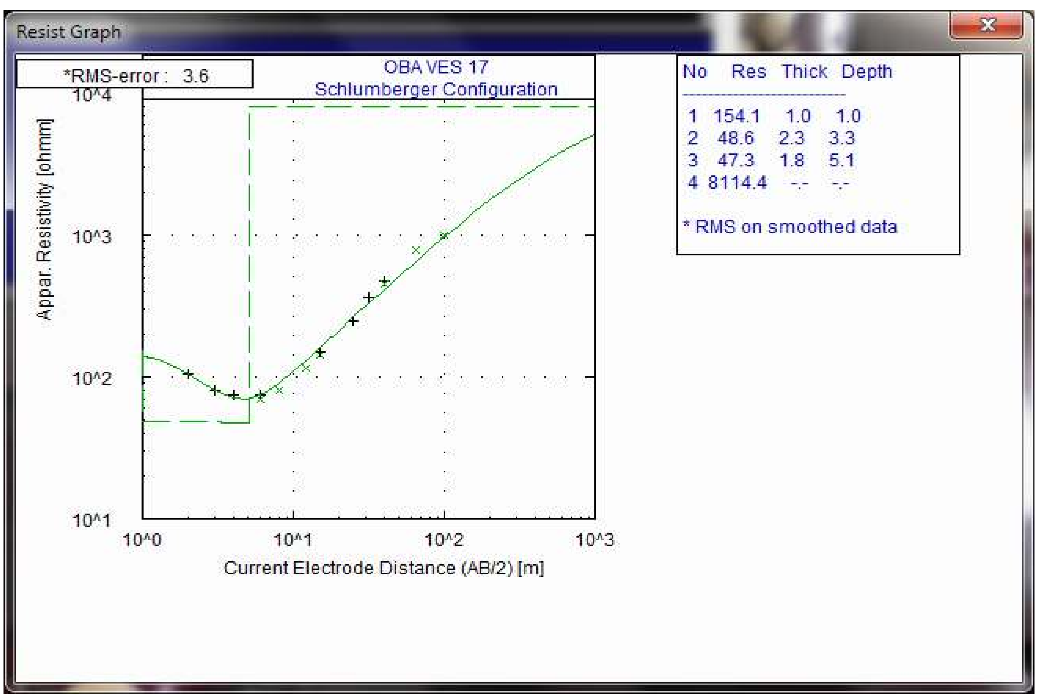

Fig. 4: Typical HA Curve Type

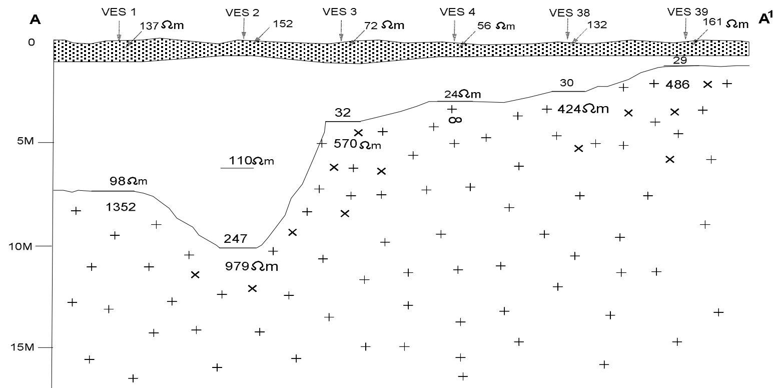

Fig. 5 a: A W-E Geoelectric Section obtained along line A-A[1]

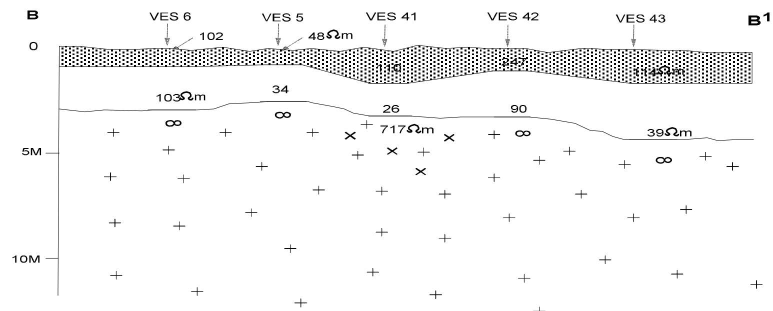

Fig. 5 b: A WNW-ESE Geoelectric Section obtained along line B-B[1]

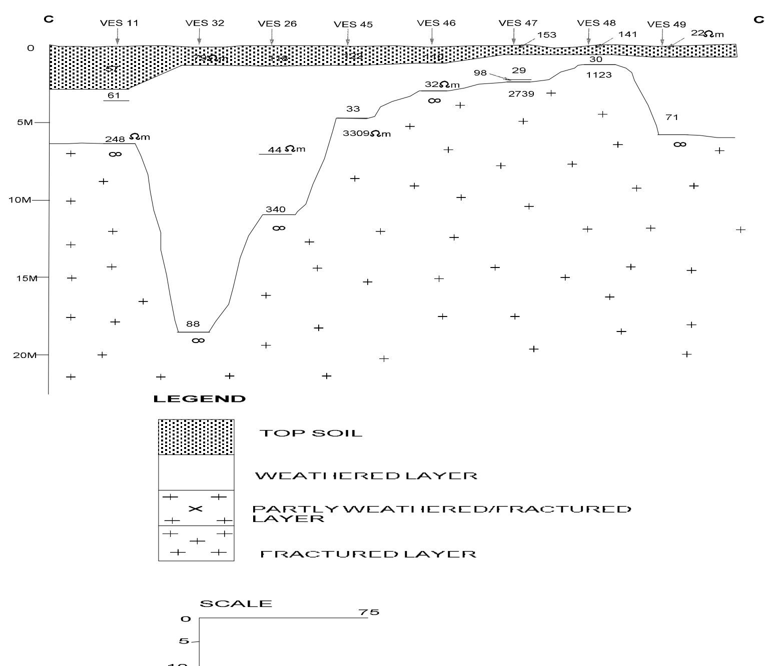

Fig. 5 c: A W-E Geoelectric Section obtained along line C-C[1]

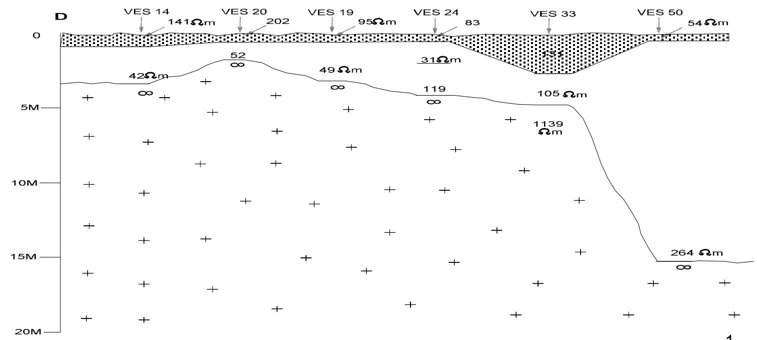

Fig. 5 d: A W-E Geoelectric Section obtained along line D-D[1]

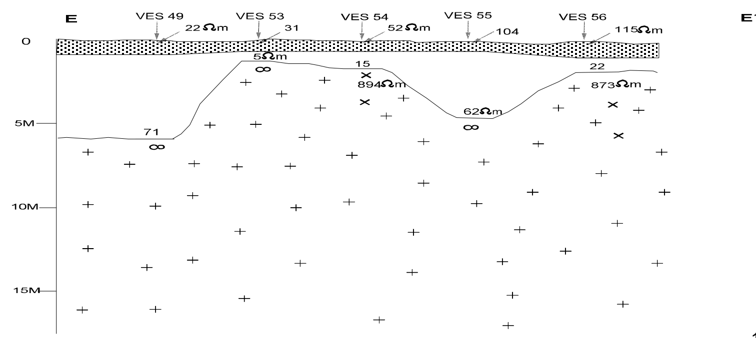

Fig. 5 e: A ENE-WSW Geoelectric Section obtained along line E-E[1]

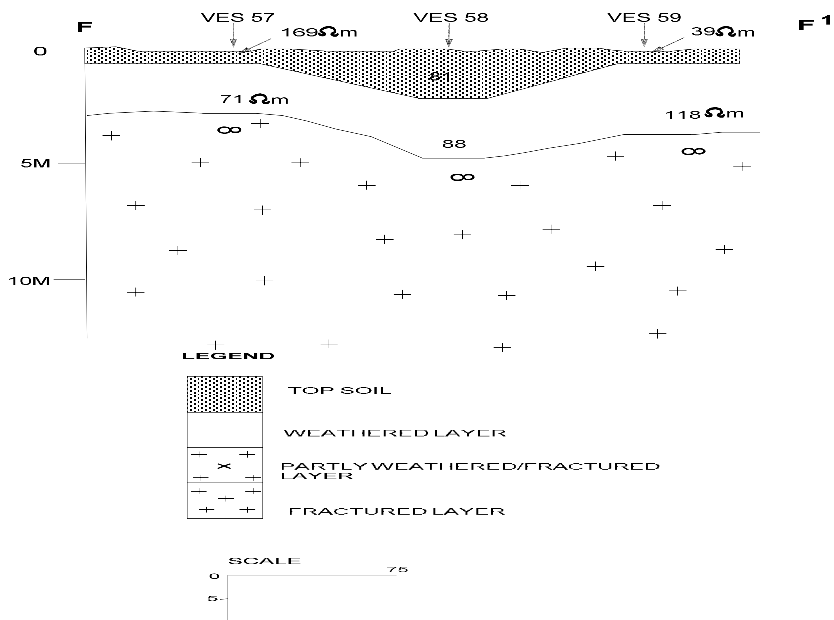

Fig. 5 f: A W-E Geoelectric Section obtained along line F-F[1]

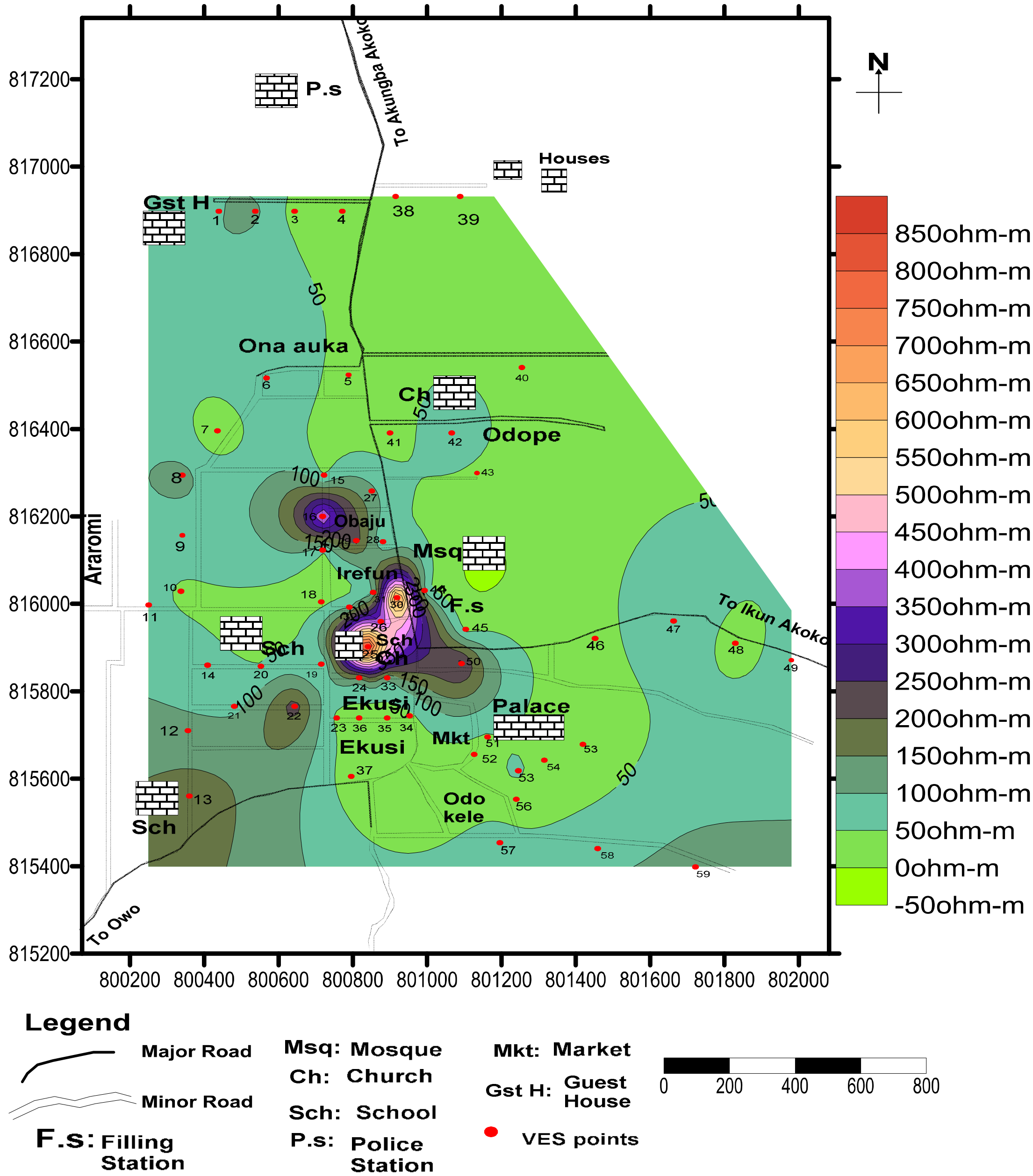

Fig. 6 a.: Isoresistivity map of weathered layer

Isopach maps in Figures. 6 (b - c) show the distribution in the thickness of the topsoil and overburden within the study area. The maps show spatial distribution in thickness. The topsoil thickness map (Fig. 6 b) generally shows thin nature of the topsoil thickness averagely 1.0 m. The distribution of the overburden thickness generally varies from 0.2 – 24.9 m. The overburden includes the topsoil and weathered basement/fractured basement. The relatively thick overburden covers/zones shown as trends of pockets of closures mirrored irregular geometry of the basement interface with alternating basement depressions (troughs) and ridges northwesternly. Areas with thin overburden (< 10 m) correspond to shallow depths of weathering while areas with relatively thick overburden (> 10 m) correspond to those with deep depths of weathering. The weathered (unconfined)/fractured (confined) basement columns may have constituted the aquifer units and types with the relatively thick portions as prospective sites for sustainably groundwater storage and yield if not too clayey

It may, therefore, be concluded that groundwater potential of the study area is generally low arising from shallow depth to basement or thin regolith and few fracture density in places in the area. The localized fractured bedrocks and basement depressions arising from the deep weathering of the parent rocks in few places may have constituted the main sustainable aquifer units for domestic consumption via borehole groundwater abstraction in the area.

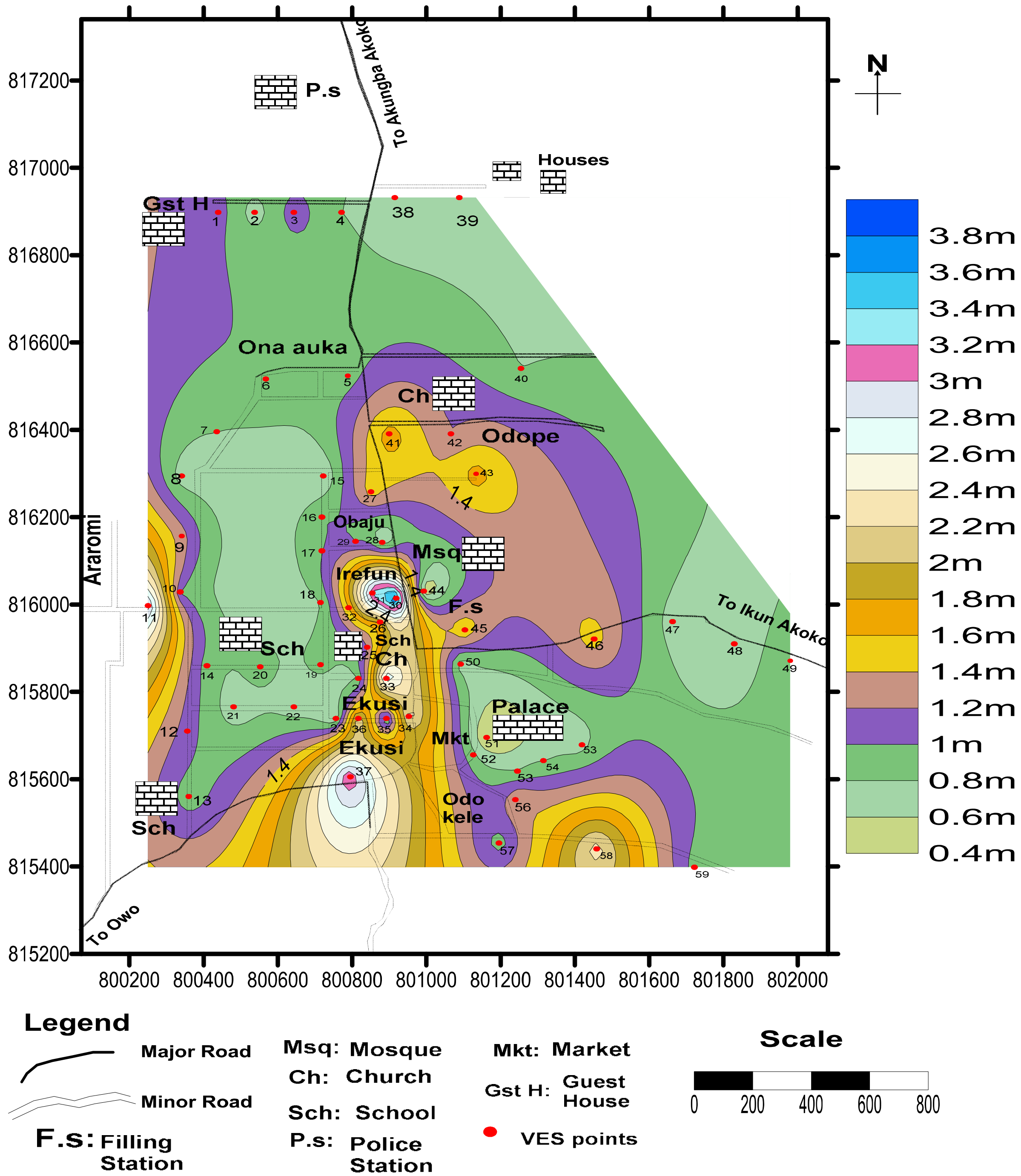

Figure 6 b: Isopach map of Topsoil

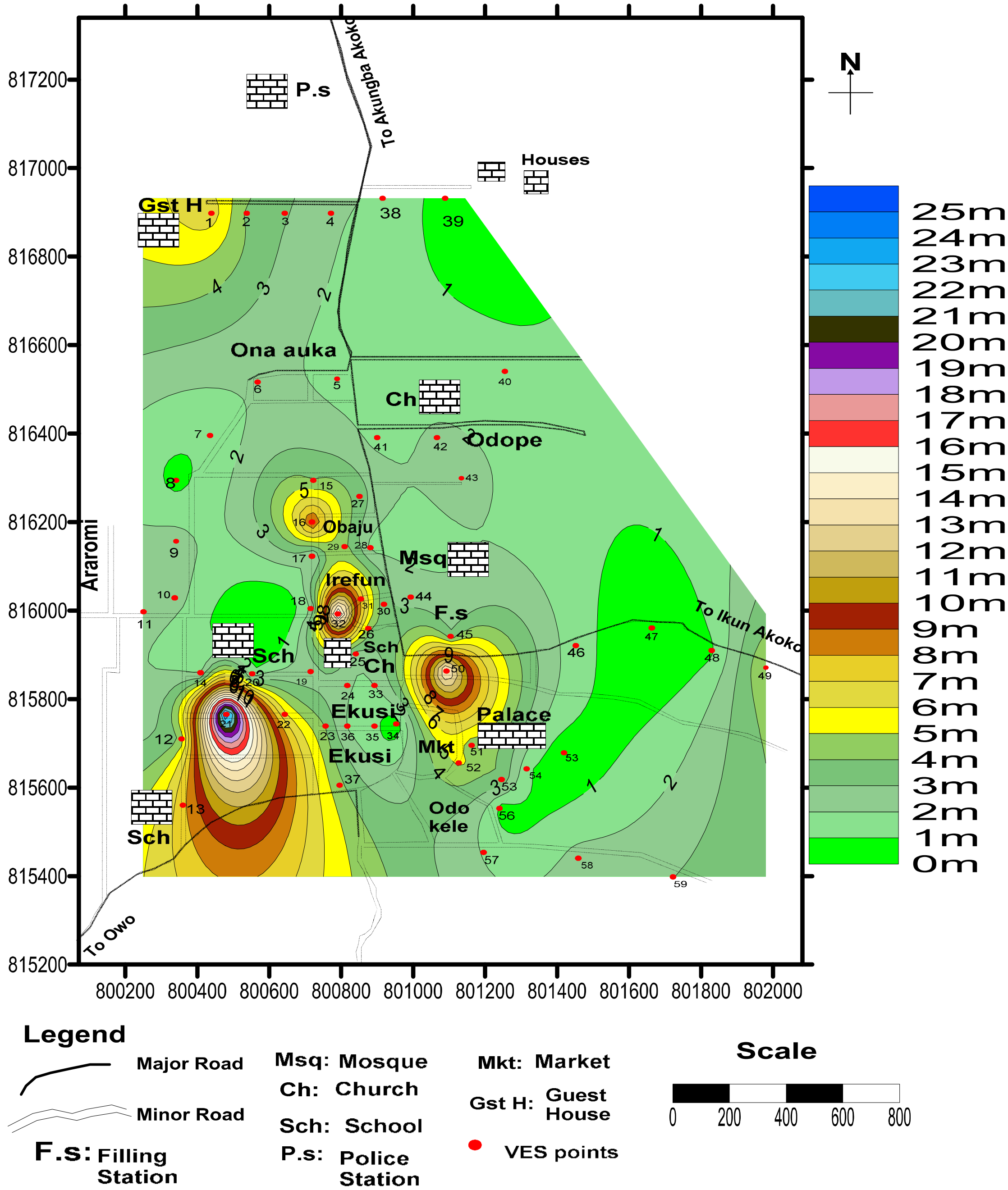

Figure 6 c: Isopach map of overburden.

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REFERENCES

Barker, R. D and Olayinka, A. I., 1991. Depth of investigation of collinear symmetrical four-electrode arrays. Geophysics 54, pp. 1031-1037.

Barongo, J. O and Palacky, G. J., 1991. Investigations of electrical properties of weathered layers in the Yala area, western Kenya, using electrical resistivity sounding. Geophysics 56, (O. I): 133-138.

Bayode, S., Ojo, J. S and Olorunfemi, M. O., 2005. Geoelectrical characterization of aquifer types in basement complex terrain of Osun state, Nigeria. Global journal of pure and Applied sciences, 12, (3): 37-385

Benson, S and Jones, C., 1988. "The Combined EMT/VES Geophysical Method for Siting Boreholes". Groundwater. 26, (1): 54-63.

Bose, K. N., Chatterjee D and Sen A. K., 1973. Electrical resistivity surveys for groundwater in the Aurangabad sub-division, Gaya district, Bihar, Indian, 171-181.

Geological Survey Nigeria., 2001. Geological map of Ondo state.

Iloeje, N. P., 1982. A new geography of Nigeria. New Revised Edition. Longmans Nig. Ltd., Ikeja, Lagos.

Jimoh A. T., Fasoye D. P and Akintuyi, S., 2013. Independent mapping of Oba Akoko, B. Sc. Geology & Applied geophysics, Adekunle Ajasin University, Akure.

Mohammed, M. Z., Ogunribido, T. H. T and Funmilayo, A. T., 2012. Electrical Resistivity Sounding for Subsurface Delineation and Evaluation of Groundwater Potential of Araromi-Akungba Akoko, SW Nig. In J. of Env. and Earth Sc., US, 2, (7): 29-40.

Mohammed, M. Z and Olorunfemi, M. O., 2012: Modeling Depth as a constraining factor for Optimum Groundwater yield – A Case Study. In J. of Environment and Earth Sc. New York, 2, (10): 13 – 26.

Oladapo, M. I., Mohammed, M. Z., Adeoye, O. O and Adetola, B. A., 2004. Geoelectric investigation of the Ondo-State Housing Corporation Estate, Ijapo, Akure, Southwestern Nigeria. In Journal of Mining and Geology, 40, (1): 41-48.

Olorunfemi, M. O and Fasuyi, A. S., 1993. Aquifer types and the Geoelectric/Hydrogeologic Characteristics of the Basement Terrain of Niger State, Nigeria. Journal of African Earth Sciences. 16, (3): 309-317.

Rahaman, M. A., 1988. Classification of Nigeria basement complex in southwestern Nigeria, (Kogbe, C. A., Ed) Elizabethan publishing company, Nigeria, 41-58.

Reynolds, J. M., 1998. An introduction to Applied and Environmental Geophysics. 453– 465, 653 – 658.

Telford, W. M., Geldart, L. P and Sheriff, R. E., 1990. Applied Geophysics. Second (2^{nd}) edition, Cambridge University Press.Cambridge.

Vander Velpen, B. P. A., 1988. RESIST Software Version 1.0. M. Sc Research Project. ITC, Delft, Netherlands Copyright © 2004, ITC, IT-RSG/DSG.