



Integrated geophysical investigation of aquifer and its groundwater potential in phases 1 and 2, Federal University Oye-Ekiti, south-western basement complex of Nigeria

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Abstract

Electrical resistivity method is frequently used in groundwater studies. It is one of the many geophysical methods used in finding, locating, and defining subsurface water. The geoelectrical survey was done in Federal University Oye-Ekiti, phases 1 and 2, south-western Nigeria, to assess the groundwater potential. Fifteen very low frequency electromagnetic traverses, three dipole–dipole profiles and three Wenner profiles and 25 vertical electrical soundings were occupied and investigated with maximum current electrode, were arranged with an equal potential spacing ($AB/2$) of 1–100 m with the aid of ABEM SAS 300C resistivity meter and presented as VES curves. Twenty-five VES location were evenly distributed within the study area. The VES interpretation results are of different VES curves types, namely QA, HA, KH, AH, H, KHK, KQ and AK types. The geoelectric sections delineated three to four geoelectric layers, which are the topsoil with resistivities and thickness values ranging between 113.4 Ωm and 753.1 Ωm and 0.4 and 4.4 m, respectively. The weathered layer has resistivity and thickness values ranging between 37.4 Ωm and 278.1 Ωm and 1.3 and 9.8 m, respectively. The partially weathered layer resistivity and thickness values ranging 495.1–651.1 Ωm and 10.2–22.2 m; for lateritic zones, it shows the resistivity and thickness values ranging 280.6–730 Ωm and 0.1–6.3 m. The geosections show a relatively thin overburden of less than 2.1 m. The third layer is the fractured basement. The fresh basement has a resistivity ranging between 930.5 and 4660 Ωm with depth starting from about 10 m to infinity (∞). Based on relatively thin overburden and the moderate to high fracture density of the basement bedrock, it was concluded that the groundwater potential of the study area is generally low to moderate. However, the aquifer in the north-eastern and south-eastern parts of the study area was determined to be of good quality. It can yield reasonable quantities of water that can serve the university community.

Keywords Electrical resistivity · Groundwater · Basement · Aquifer and fractures

General statement

The rocks of basement complex are naturally poor aquifers as they are characterized by crystalline igneous and metamorphic rocks with low porosity and negligible permeability. However, fracturing and weathering activities of basement complex rocks may lead to appreciable secondary porosity and permeability of the rocks, thereby making them good aquifers (Olayinka et al. 2004). Federal university Oye-Ekiti, which is the study area, occurs within the Precambrian

basement complex of south-western Nigeria and therefore should be expected to have groundwater problem unless there is/are evidence(s) of fracturing and weathering activities on the rocks constituting this area. Also, the degree or extent of these activities would determine the quality of aquifers. Highly productive water wells are obtained by drilling in rock that is broken along joints and small fractures. Federal University Oye-Ekiti (FUOYE), Oye campus Precambrian rocks are made up of the migmatite-gneiss complex. No parent rock was seen except for particles of igneous rocks–granite and also quartz (a constituent part of an igneous rock). Large part of the land mass of Fuoye-Oye campus is water-logged and there is presence of streams. Over years, the people of this university community have really suffered enormous problems of water supply either surface or groundwater. These problems have been noticed

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to be much more severe at the ultimate of the dry season when ironically demand for water is greatest and most of the surface sources dry up completely. Before now, greater majority in the community relied on such sources as streams and ponds especially during the dry seasons when hand-dug wells would have dried up. This situation definitely can lead to the outbreak of water borne diseases like cholera, diarrhoea, guinea worm that can seriously threatened lives in the university and its environs. Also, valuable time could be wasted in water fetching and trekking long distances to and from water points on the campus. However, efforts have been made in recent times to enhance the groundwater potential of this area. Boreholes have been drilled in different parts of the study area, but observation has shown that only few out of the boreholes are functioning perfectly well with appreciable volume of water production throughout the year. The major problem associated with the unproductive wells has been identified to be inadequate geological and geophysical survey which reveals the proper understanding of the hydrogeological characteristics, prior to drilling of boreholes in the area. Also, due to the yearly increase in population in the university campus, there would be need for sufficient supply of water in the campus, so the research was also carried out in order to delineate areas with good yield for siting boreholes. This research work will identify conductive zones and aquifer units, determination of geoelectric parameters and estimation of overburden thickness, and recommendation of priority areas for possible groundwater development. Moreover, the research work was carried out with the overview aim of mapping Federal University Oye-Ekiti, Oye campus for groundwater Exploration; for this execution, the following were performed: generation of a base map of the study area, determination of ground water potential; mapping possible basement structure; identification of conductive and resistive zones; identification of the nature of the subsurface layer and geoelectric parameter of the subsurface layer.

Location and accessibility

Federal University Oye-Ekiti, Oye campus lies approximately between latitudes 756500 N and 755000 N; and longitude 860100E and 860700E coordinates of the Universal Traverse Mercator (UTM) system (Minna Datum) Zone 31 N (Fig. 1) located in Oye- Ekiti phase 1 (Fig. 2), phase 2 (Fig. 3). The university campus is situated few kilometres away from the Oye-Afao Road. The study areas were easily accessed by foot, no major obstruction, or geologic structures.

Geology of basement complex

The Pan African Orogeny is the most recent orogeny and characterizes most of the rocks in the mobile schist belt

including the Nigeria basement complex. The Liberian orogeny, however, is the earliest orogeny and characterizes most of the Archean nuclei rocks which are rare in Nigeria. In each of these orogenies, there is incremental addition to the crust in the form of newly metamorphosed sedimentary and volcanic rocks. Also, many of the already metamorphosed rocks of a particular orogeny are caught up in subsequent orogeny and re-metamorphosed again. This is termed crystal reactivation, a process whereby rocks that were originally metamorphosed were cut up in subsequent orogenies, heated up, and subjected to further deformation and metamorphism. Effects of crystal reactivation include overprinting of pre-existing geological structures and radiometric age by later ones due to the reactivation. As such, careful mapping, sampling and geochronological analysis will help to interpret such an area properly without confusion.

Local geology

In the whole of the University campus in Oye at both phase 1 (Fig. 2) and phase 2 (Fig. 3). No clear outcrop was actually seen in the university campus, and this could be as a result of weathering processes. Stones & pebbles of migmatite-gneiss nature were present in this environment. It can be deduced that the types of rock present in this environment are migmatite- gneiss. FUYOYE campus geologic potential is similar to that of the south-western Nigeria geologic pattern.

Hydrogeology of the basement complex

The rocks of the basement complex terrain are relatively impermeable and lack primary porosity, i.e. interconnected pore spaces which are formed during rock formation. The porosity and permeability of a rock help to determine the hydrogeologic properties which in turn depend on the size, shape and arrangement of the grains and the mineralogy of the rocks. The presence of fractures (secondary porosity) and the nature and thickness of the material overlying the rocks are factors that control groundwater storativity and potential. Fractures in rock are mainly caused by tectonic activities within the crustal rocks. These are important in basement rocks as it increases weathering activities. The mineralogy of a rock type also determines the degree of weathering. Rocks rich in ferromagnesian minerals and feldspars are subjected to high degree of weathering to give clay minerals which are impermeable than rocks rich in silica that gives a permeable water-bearing sandy and gravelly medium (Offodile 1983).

Drainage pattern of the study area

The drainage pattern in the study area is dendritic which is probably related to the structures of the underlying rock.

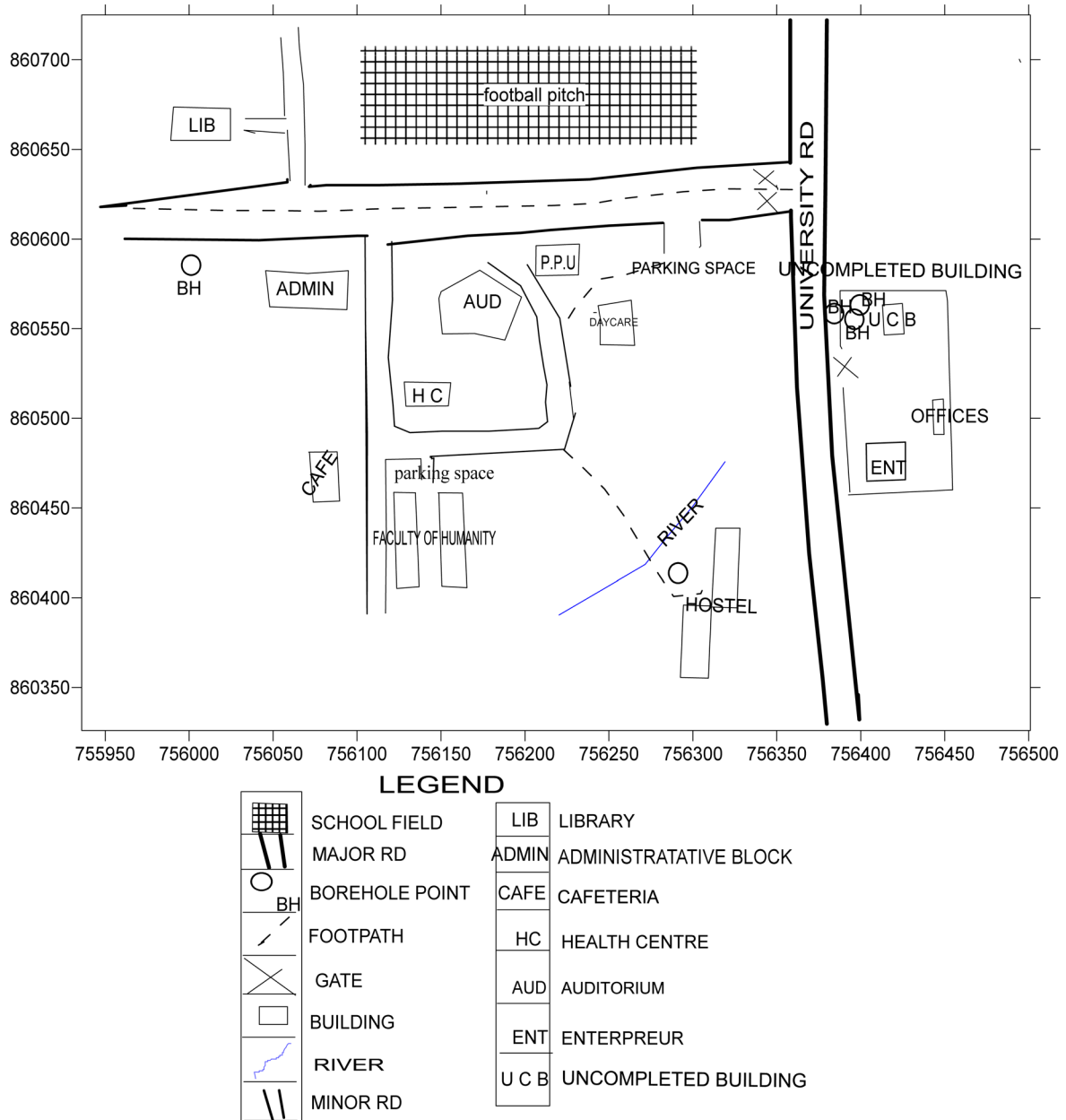


Fig. 2 Base Map of Federal University Oye-Ekiti, Oye Campus Phase 1

In recent times, many geological and geophysical researchers in Nigeria and all over the world have employed electromagnetic and electrical resistivity methods of geophysical investigation to resolve so many related problems. This is due to the fact that these methods have found applications in many ways which include groundwater investigation, mineral exploration, engineering site (dam) investigation, foundation engineering to environmental impact assessment.

Olayinka (1990) carried out electromagnetic profiling for groundwater in Precambrian Basement Complex areas of Nigeria. He employed the use of Geonics EM 34-3

instruments to determine the apparent conductivities of these areas and subsequent boreholes drilled suggests a good correlation between high EM 34 anomalies, deep weathering and high well yields. Okhue and Olorunfemi (1991) carried out electrical resistivity investigation of low land area of the Obafemi Awolowo University campus with a view to providing adequate information on the different subsurface geoelectrical layers, the structural disposition of the basement and the groundwater potential of the area. Their results revealed three to four subsurface geoelectrical layers and areas with thick overburden cover with less percentage of

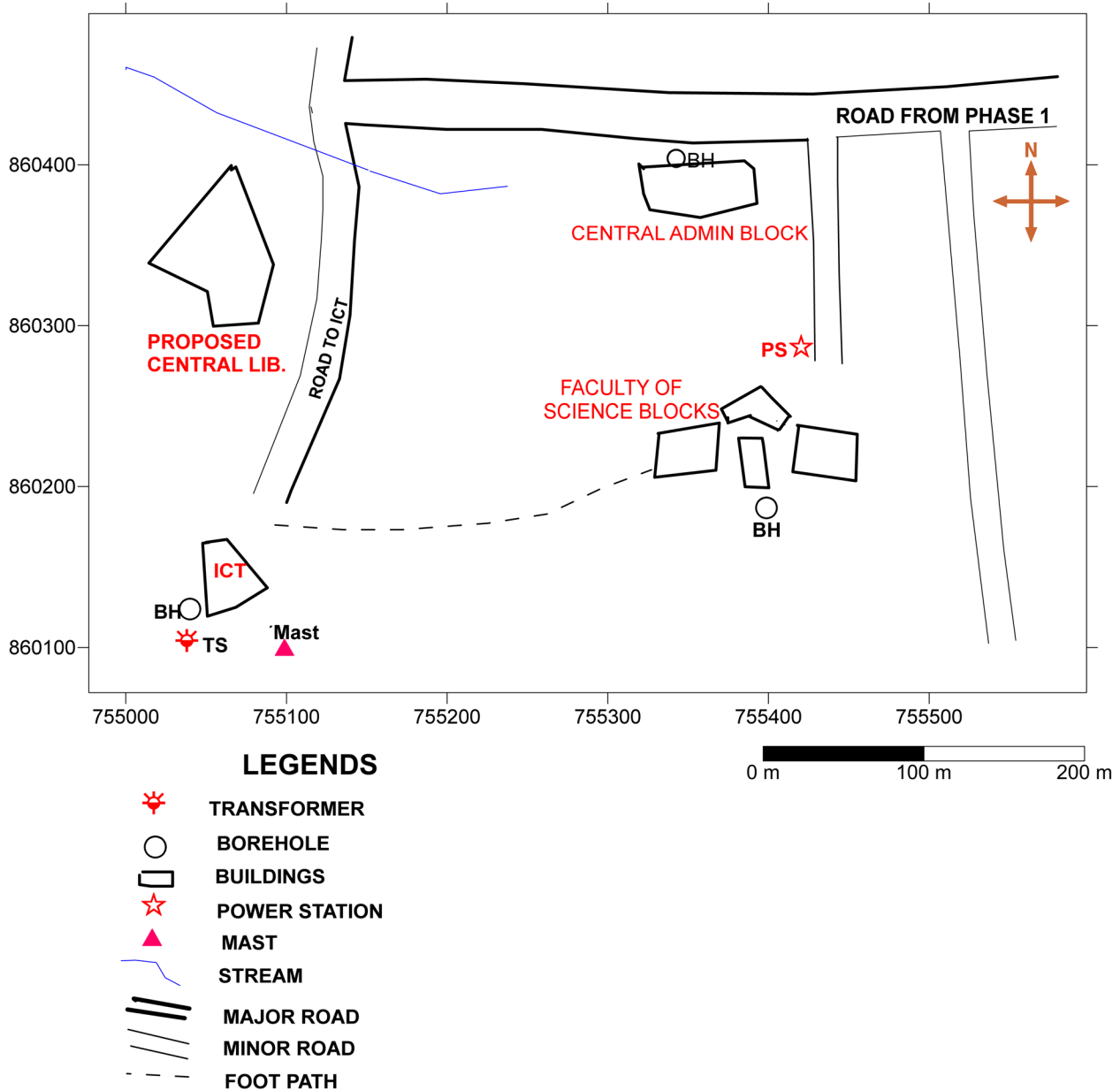


Fig. 3 Base Map of Federal University Oye-Ekiti, Oye Campus Phase 2

clay which could possibly be priority areas for groundwater development. Dan-Hassan and Adekile (1991) employed geophysical surveys involving electromagnetic and resistivity techniques to investigate the groundwater occurrence in Zabenawan Dansudu village, Kano-State. Their results revealed information on changes in subsurface layering and lithology, resulting in the delineation of areas of deep weathering and fractured bedrock. Olayinka et al. (1999a, b) employed an integration of VLF electromagnetic and electrical resistivity survey to investigate groundwater in a crystalline basement complex terrain of southwest Nigeria. Their results enabled them to identify locations for productive

boreholes (with groundwater yield of up to 2.0 l/s) within an area where dry boreholes were previously drilled.

Methods of study

The scope and methodology of this research work was grouped into three aspects, and this includes data acquisition, data analysis and data interpretation (qualitative and quantitative).

Data acquisition: This involved field acquisition of data for both geological and geophysical investigation. For

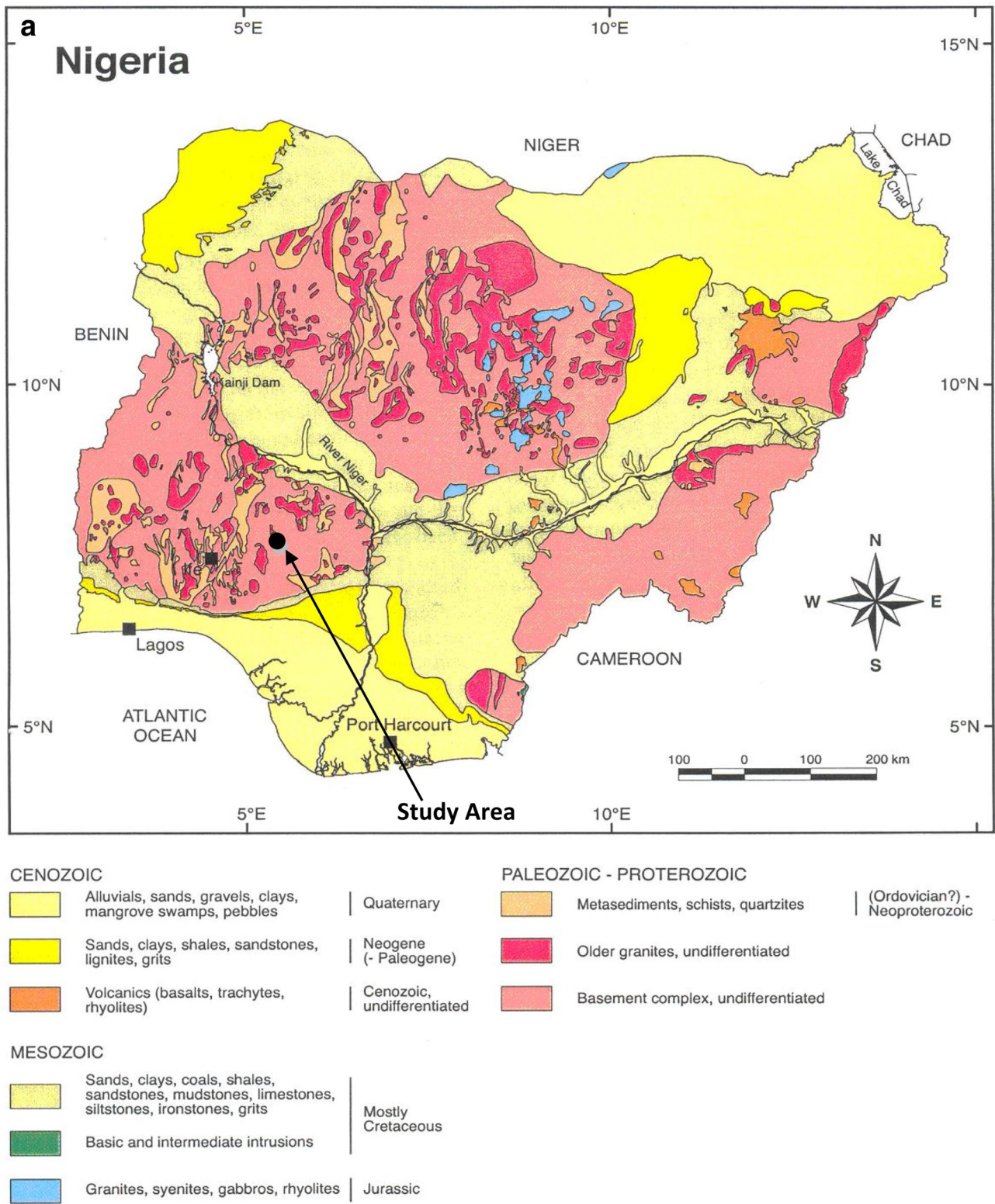


Fig. 4 a Geological Map of Nigeria Showing the Major Geological Components and the Study Area (Rahaman 1989). b Geological Map of Part of Ekiti State Showing Oye the Study Area. Adapted from Akure Sheet 56 Geological Map

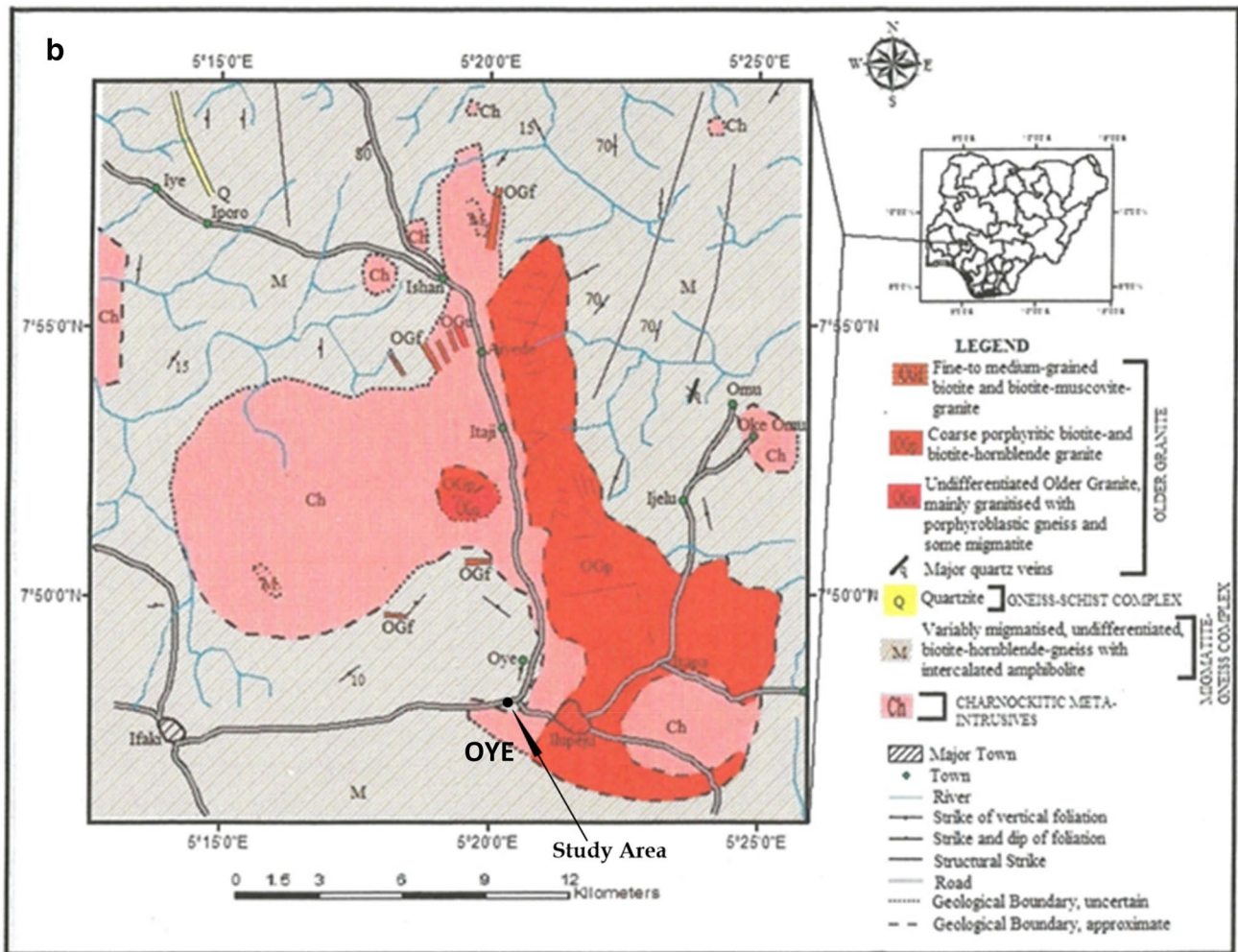


Fig. 4 (continued)

geophysical survey, two geophysical methods which are very low frequency electromagnetic and vertical electrical sounding was employed to acquire data in order to reveal the subsurface hydrogeological characteristics and groundwater potential of the area.

The acquired VLF-EM data were presented as curves of filtered real and filtered imaginary against the stations so as to delineate linear fractures of the basement. The acquired VES data were presented as depth sounding curves which were later transformed into geoelectric sections that revealed the subsurface geological sequences. Data interpretation involves both qualitative and quantitative interpretation. The analysed data were interpreted to enhance groundwater development in the area.

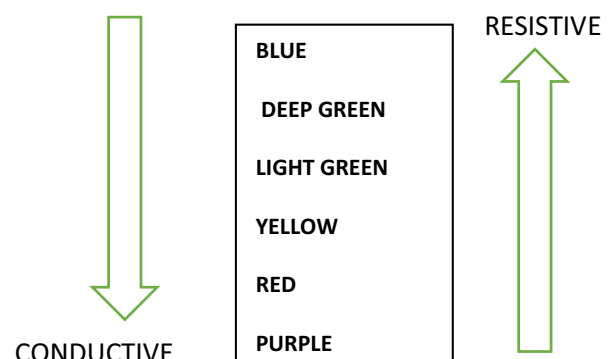


Fig. 5 A colour section which helps to indicate the level of resistivity and conductivity In VLF-EM

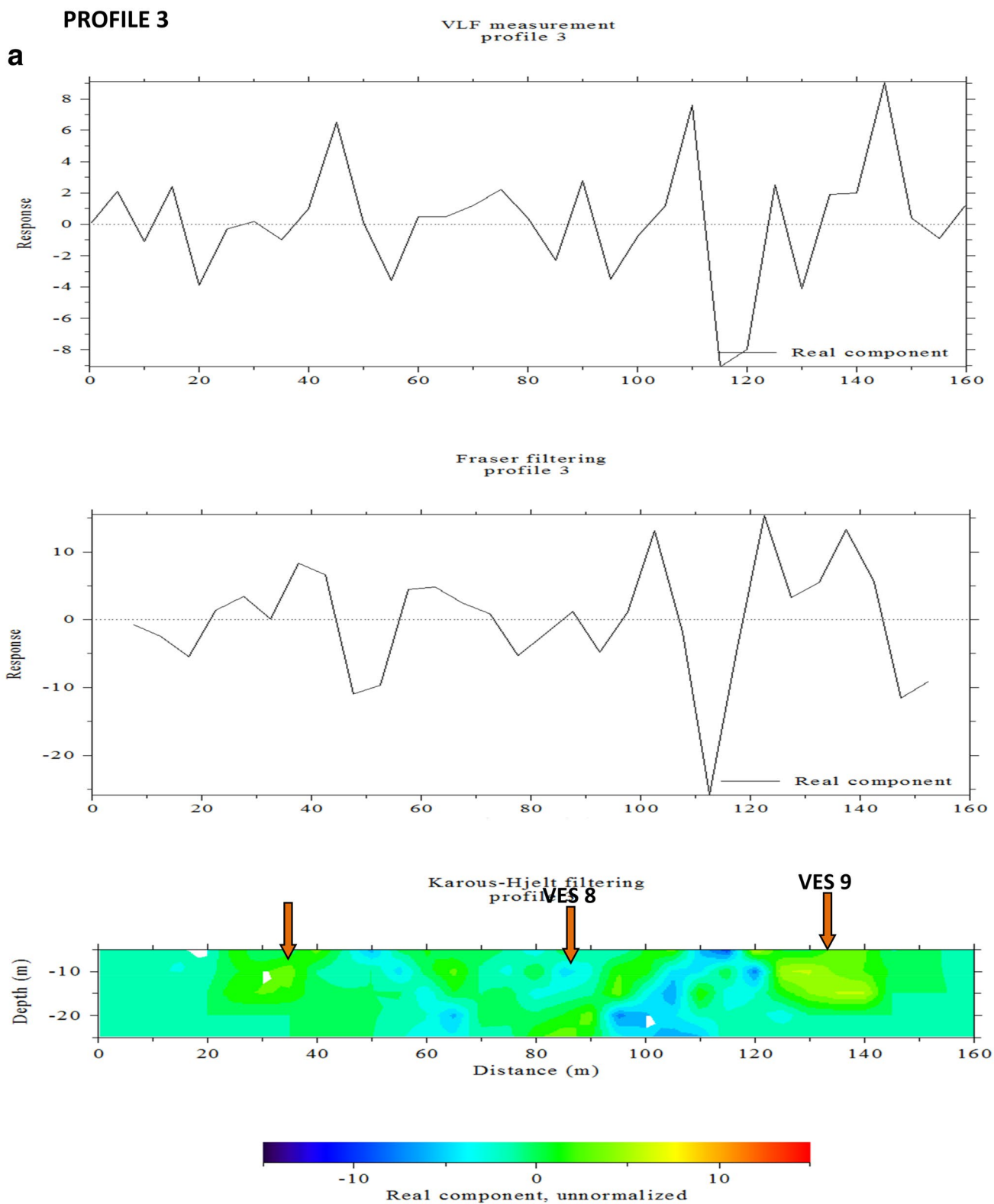


Fig. 6 a VLF pseudosection of Profile 3 showing the conductive zones with arrows and VES positions. **b** VLF pseudosection of Profile 4 showing the conductive zones with arrows and VES positions.

c VLF Graph of Profile 5 showing the conductive zones with arrows and VES positions. **d** VLF Graph of Profile 6 showing the conductive zones with arrows and VES positions

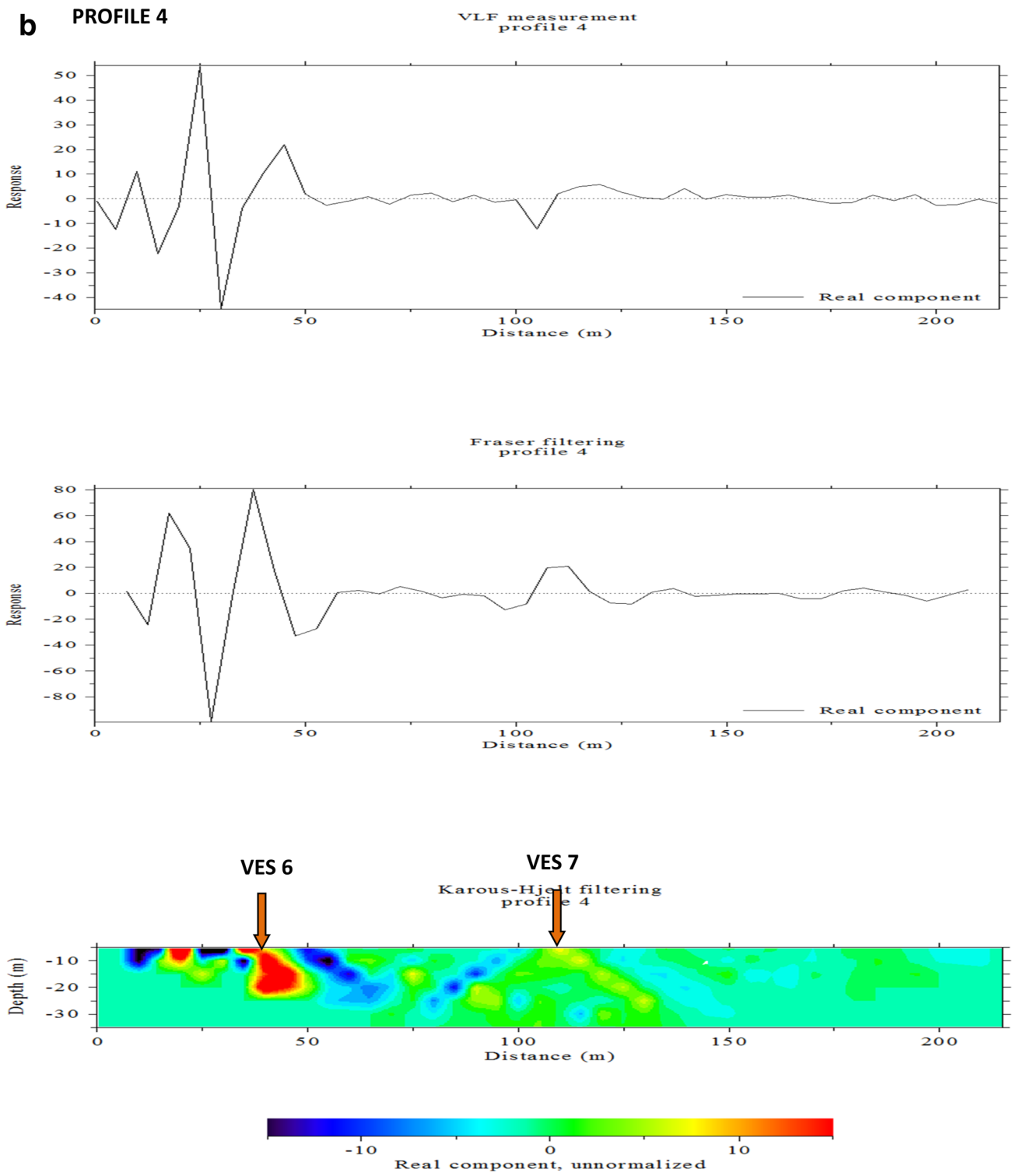


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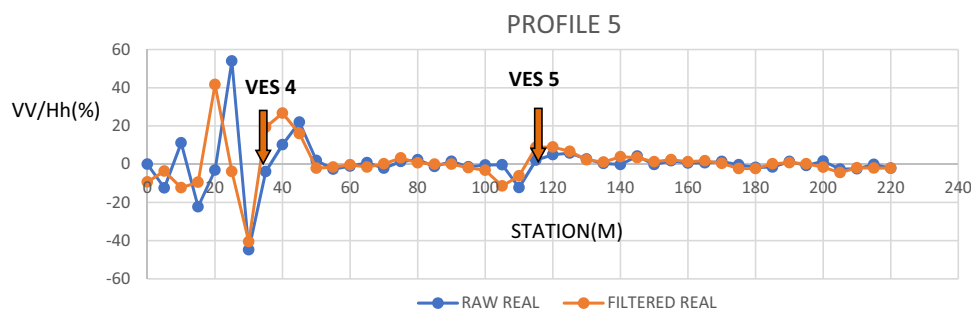


Fig. 6 (continued)

Instrumentation and measurement procedure for ER method

The instruments usually employed for the resistivity survey include the following;

Resistivity meter (ABEM terrameter): This is capable of measuring the resistivity of the earth over a wide range conditions. It is a composite unit that is made of a transmitter and a receiver with additional hardware which could be connected to a computer. The instrument is sensitive and accurate. It employs low-frequency alternating current rather than direct current in order to prevent polarisation effects at the electrodes and the possible interfering effects of natural (telluric) currents which cause regional potential anomalies.

Good quantity of groundwater can be associated with subsurface fractures or presence of a highly conductive body in the subsurface. At distance 45 m of the fourth profile, the high contrast noticed in filtered real curve compared to the immediate surroundings suggests either a fracture in the basement or presence of a conductive body. The highest apparent conductivity value has been revealed on VLF Profiles 3 and 4 at distance 80 m and 40 m, respectively, with 20S/m and 22S/m in that order. This moderately high positive anomalies in the filtered real part indicates a good conductor which could provide a reasonable zone for storage of groundwater. Apparent conductivity over Profiles 1,2,3,4, 5, 6, 8, 9, 10, 12, 14 and 15 is generally low with the highest value ranging from 1.5 to 10.5S/m.

Vertical electrical sounding investigation

A total of thirty-three vertical electrical soundings (VES) were carried out, using Schlumberger electrode array, with maximum current electrode spacing (AB/2) of 100 m. The separation between adjacent sounding points was between 50 m and 110 m but mostly 100 m. These soundings were made mostly on high-conductivity anomalies over the already established VLF-EM profiles and otherwise in case of difficult accessibility. Figure 4 shows the field layout for

VES points over the VLF-EM profile lines. The VES data consist of electrode spacing and apparent resistivity.

Data processing

KHFilt software was used to model the VLF-EM data. The VLF method is the cheapest and the fastest electromagnetic method; other methods are Dip-Angle method, Turam EM method, Shoot-Back EM method, Air-Borne EM method. The very low frequency is used majorly for military purposes, and it saves man power and also used for reconnaissance. Computer-generated curves were compared with corresponding field curves.

Data and results presentation

The results of the resistivity sounding field data, horizontal profiling field data and the electromagnetics (VLF-EM) field data were obtained as depth sounding curves, profiles, pseudosections and 2-D models, respectively. Electrical resistivity data can be presented as profiles, stacked profiles, VES curves, pseudosection and maps. The HP data can be presented as profiles and maps when it involves more than three traverse lines. Profiles are generated by plotting resistivity values against station positions along a particular traverse line. The station position is determined by the electrode configuration used. Maps are generated by posting the apparent resistivity values on their relative measuring positions and the values contoured. Maps give location of the target, geometry, width extent and strike length. The combine HP and VES or 2D Imaging data are presented as 2-D pseudosection. Such section gives the location of the target, width extent and altitude of the target.

Result and discussion

The combined geophysical survey involving very low frequency electromagnetic and electrical resistivity methods carried out within the study location, Federal university

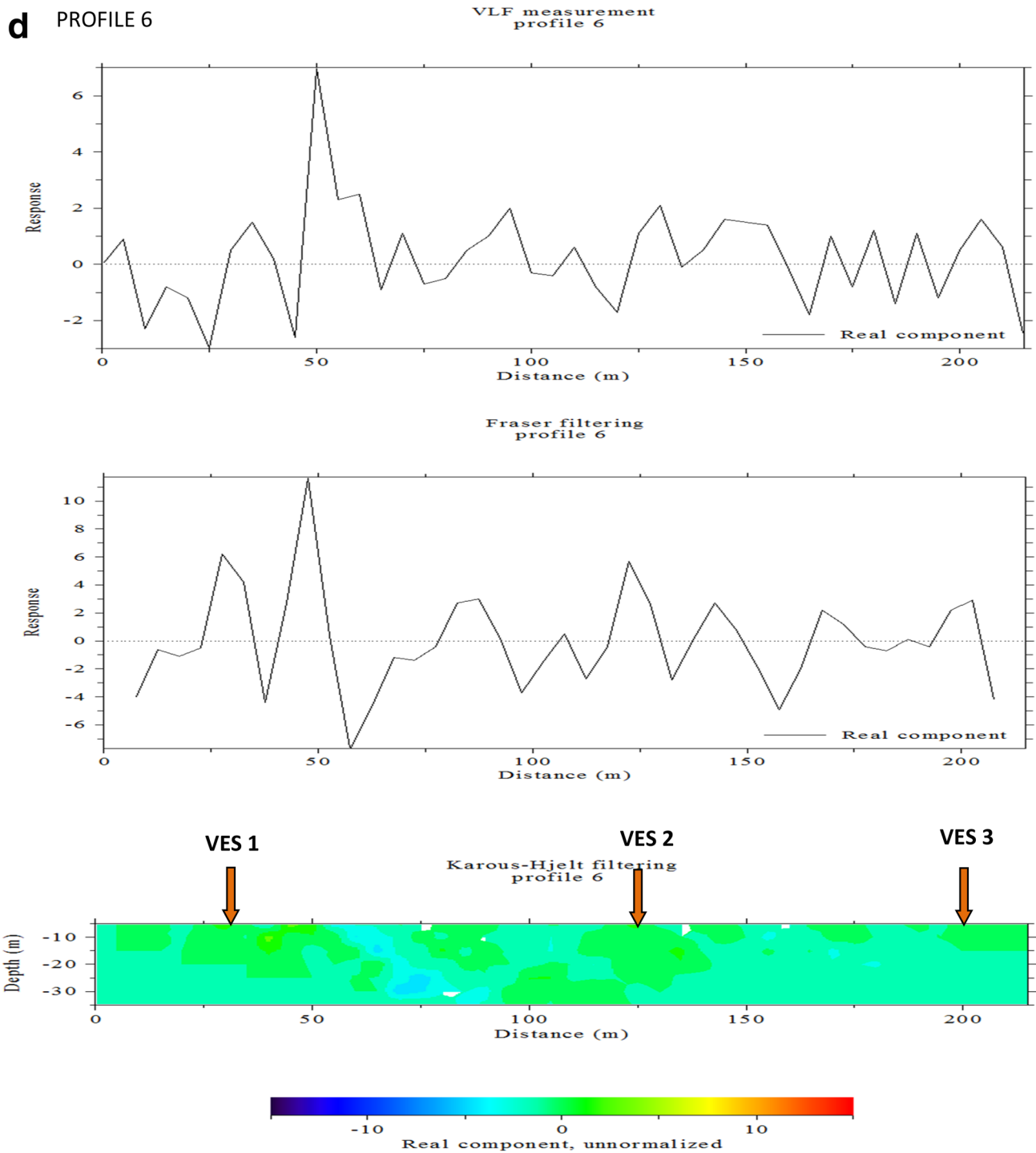


Fig. 6 (continued)

Oye-Ekiti south-western Nigeria, has revealed possible areas with fractures across the study location as interpreted from VLF electromagnetic results. Also, VES results further revealed the picture of the subsurface through geoelectric sections produced from the layer parameters and thus showed the occurrence of groundwater within the location.

VLF electromagnetic investigation

The very low frequency electromagnetic method has been used to investigate useful quantities of groundwater in the study area. This aspect of the geophysical survey was carried out by ABEM-WADI SYSTEM, and measurements were

Table 1 Table showing the geoelectric parameters of the entire subsurface lithology of the University Campus

VES stations	Traverse lines	Thickness (m) $h_1/h_2/h_3\dots/h_n$	Resistivity (ohm-m)	Lithological layers	Curve types
1.	6	4.4/1.4/4.2	418.1/37.4/965/880.7	Top soil/clay/fractured basement/weathered basement	HK
2.	6	1.4/0.4/2.4	153.3/730.9/680.8/226.2	Top soil/laterite/lateric clay/weathered basement	KQ
3.	6	3.1/9.8	207.6/278.1/789.5	Top soil/sand/fresh basement	A
4.	5	0.5/1.8/2.8/0.5	106.9/175.8/19/69.5/4660.1	Top soil/sand/clay/weathered basement/fresh basement	KHA
5.	5	2/0.3/8/13.8	124.8/106.9/16.4/11/1815.8	Top soil/sandy clay/weathered basement/fresh basement	QQH
6.	4	0.4/5.8	113.2/124.5/929.6	Top soil/sand/fresh basement	A
7.	4	0.4/1.7/2.4	505.4/317.0/37.3/3734.9	Top soil/gravel/weathered basement/fresh basement	QH
8.	3	0.7/4.5/4.3	215.8/23.8/494.6/11,324.1	Top soil/clay/weathered basement/fresh basement	HA
9.	3	0.3/0.7/7.1	753.1/148.9/39.8/2127.1	Top soil/sand/weathered basement/fresh basement	QH
10.	3	2.5/3.3	328.3/148.5/651.4	Top soil/sand/fresh basement	H
11.	4	1.5/9.5	222.3/40.6/104.4	Top soil/clay/fresh basement	H

taken at a between-point distance of 10 m along each profile line starting from 0 m. Eleven profile lines were established over the study area which run about 5 km with the longest profile of 450 m. Figure 5 shows the field layout for VLF profiles. The VLF-EM data consist of two parts—the real part and the imaginary part, each of which consists of the raw and filtered components as given by the ABEM-WADI SYSTEM. The filtered components for both real and imaginary parts of the EM data were plotted against distance for each profile. This double plot of filtered real and filtered imaginary anomaly curves enables qualitative identification of the top of linear fractures with positive peak filtered real component. These features are suspected to be basement fractures and so selected as probable VES points for further investigation. Figure 6a–d represents the VLF-EM anomaly curves along Profiles 3, 4, 5 and 6. The VLF-EM anomaly curves revealed that the study area generally has low apparent conductivities that indicate a highly resistive area. The apparent conductivities widely varied on each profile line and over the study area. Table 1 shows the highest apparent conductivity values obtained by the filtered real part of the anomaly curve as against its corresponding distance for each profile line. The results from the VLF electromagnetic anomaly curves indicated that apparent conductivities for the area are generally lower than about 24 S/m.

Dipole-dipole 2-d resistivity structure

The pseudosection measures the resistivity of the subsurface with respect to both the lateral inhomogeneity and depth of the interface. The Dipole–dipole profile gives the field data pseudosections, theoretical data pseudosections and the 2-D resistivity structure (Fig. 7a). The major interpretation is done using the 2-D resistivity structure. The various colours

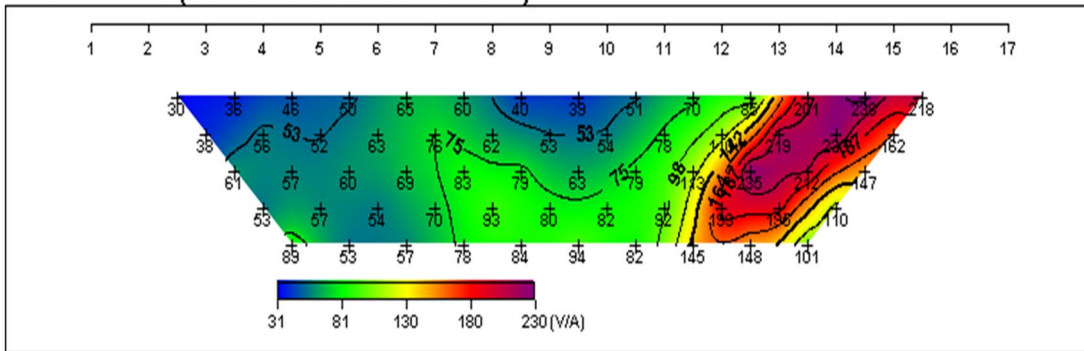
shown by the image profile depict the conductivity and resistivity nature of the subsurface. Generally, the blue colour indicates conductive zones, while the red and yellow colours indicate resistive zones. The more the blue colour, the more conductive (weak or fractured) the area is, and vice versa. That is, the scale is from conductive to more resistive areas. Profile 7 is situated behind the humanities block at phase 1 and has a fracture indicated by the profile. There is a very conductive portion at the upper part between distances 10 m and 55 m to a depth of 5 m. In Profile 8, the 2-D resistivity structures showed a very pronounced lateral inhomogeneity, i.e. about half portion of the entire profile is resistivity and the other half to be conductive (Fig. 7b). Finally, the entire Profile 10 (Fig. 7c) appears to be very conductive. The environment where this particular profile was established has already been polluted by some human factor (deposition of both waste material Urine), thus making this profile to be highly conductive and this was also seen in the Karous Hjelt pseudosection slightly conductive between 15 m and 30 m to a depth of about 2.5 m. At distances between 25 m and 30 m, the profile is more conductive to a depth of 15 m. Also, the upper part between 30 m and 40 m is resistive to a depth of about 2.2 m compared to the lower part that is conductive. Part of it is basement, while the other part is fractured.

Wenner profiling

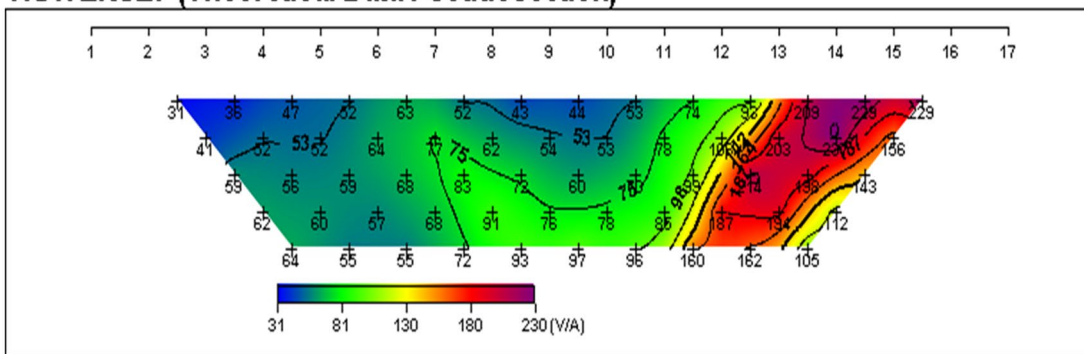
Wenner profiling was carried out on Profiles 7, 8 and 10 to investigate zones of low resistivity around the 3 profiles (Fig. 8a–c). For Profile 7, the range of resistivities is from 50 to 350 O-m and the distance falls between 7 m and 78 m, while for Profile 8, the range of resistivities is also from 50 to 350 and from a distance of 7 m to 93 m. Profile 10 has a range of resistivities is from 0 to 200 O-m.

a PROFILE 7

TRAVERSE7 (Field Data Pseudosection)



TRAVERSE7 (Theoretical Data Pseudosection)



TRAVERSE7 (2-D Resistivity Structure)

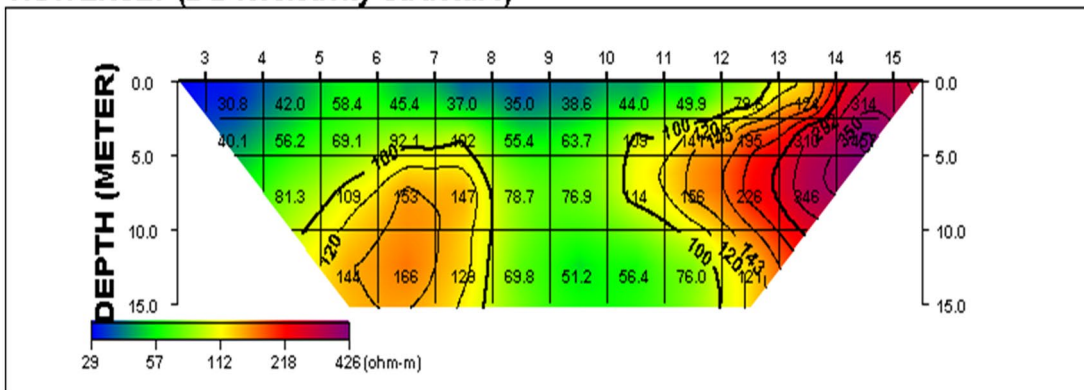


Fig. 7 a A Dipole–dipole pseudosection of Profile 7. b A Dipole–dipole pseudosection of Profile 8. c A Dipole–dipole pseudosection of Profile 10

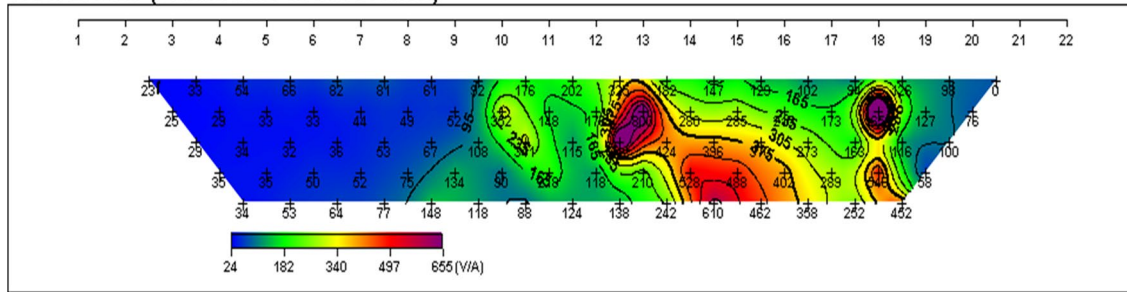
Profile 10, and the resistivity is high at electrode spacing of $a = 15$ m. This high resistivity value shows that the resistivity is slightly increasing. This meant something. It may mean that there is fault or fracture or change in lithology. It may also be due to shallow basement. But it may probable be due to fracturing within the same rock type or different rock types because of the sharp change.

Vertical electrical sounding (VES)

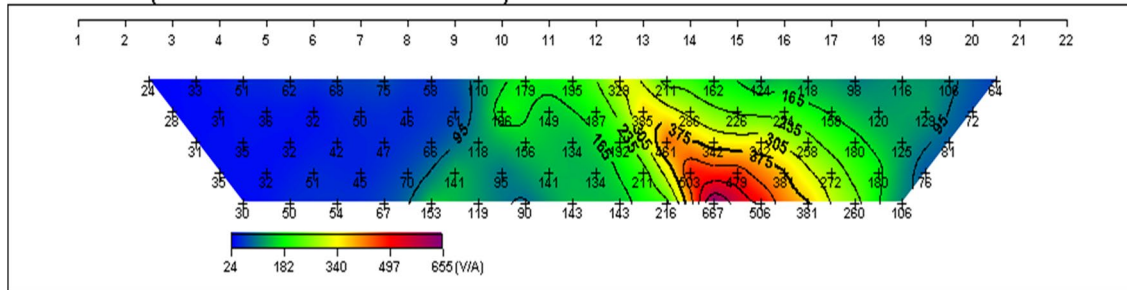
The results of the VES interpretation were presented as tables, charts and geoelectric sections. The curves have shown that the study area is underlain by three distinct layers in some parts, while other part is underlain by four layers in the proportion of 81.82% and 18.18%, respectively. Table 1 gives the summary of the geoelectric parameters

b PROFILE 8

TRAVERSE8 (Field Data Pseudosection)



TRAVERSE8 (Theoretical Data Pseudosection)



TRAVERSE8 (2-D Resistivity Structure)

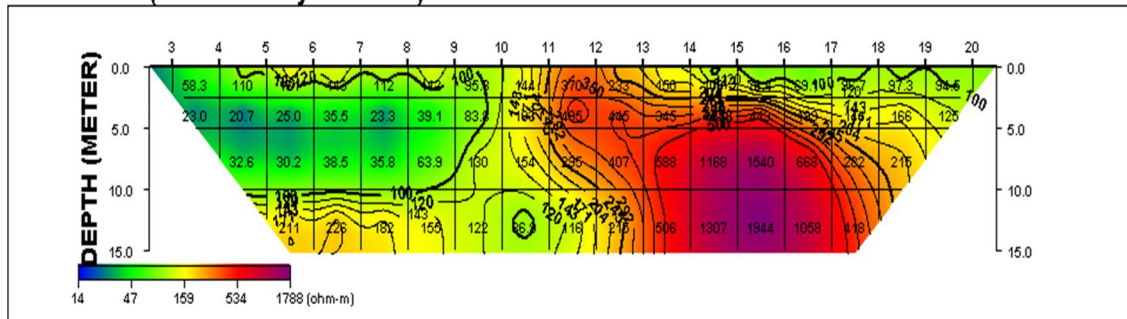


Fig. 7 (continued)

and the geologic interpretation. The geoelectric sections drawn across VES points showed that about 81.82% of the total sounded points across the study area revealed three subsurface geologic units—topsoil, weathered basement (clay, sandy clay, clayey sand) and fractured/fresh basement, while the remaining 18.18% was identified with four subsurface geologic units—topsoil, lateritic clay, weathered basement and fractured/fresh basement. The mean values for the thickness of these units are 1.3 m for topsoil, 2.6 m for lateritic clay and 8.1 m for weathered basement. Likewise, the mean values for the resistivity of these units are 648 Ohm-m for topsoil, 797 Ohm-m for lateritic clay, 156 Ohm-m for weathered basement and 1988 Ohm-m for fractured/fresh basement. The depth to basement or

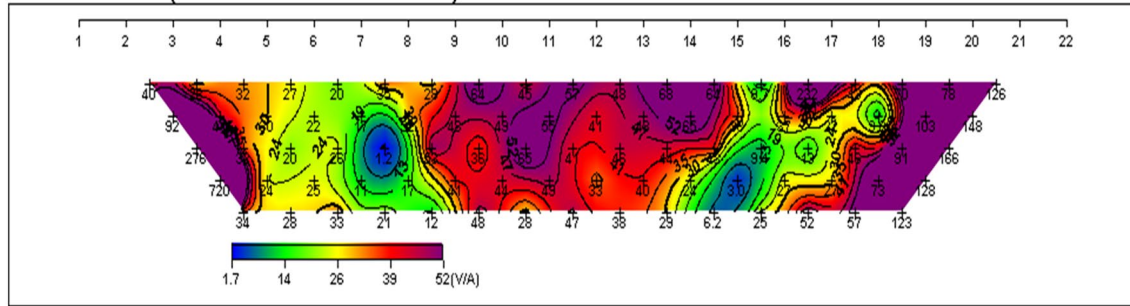
overburden thickness across the study area ranges between 2.3 m and 26.0 m at VES 17 and VES 26, respectively, with a mean value of 9.9 m, thereby indicating a shallow basement. The dominant curve types (Fig. 9a, b) are A, H and HA. They each have 18.2% dominance. Other curve types include HK, QH and KHA. They each have 9.1% dominance. The curves show that the layers of the subsurface have varying resistivity values over fractured and unfractured (Table 1).

Geoelectric section

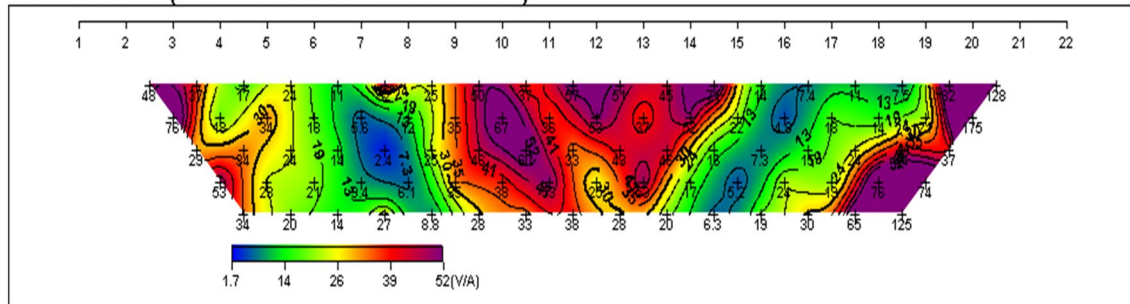
The results of the interpreted VES curves were transformed into geoelectric sections which gave a clearer picture of

C PROFILE 10

TRAVERSE 10 (Field Data Pseudosection)



TRAVERSE 10 (Theoretical Data Pseudosection)



TRAVERSE 10 (2-D Resistivity Structure)

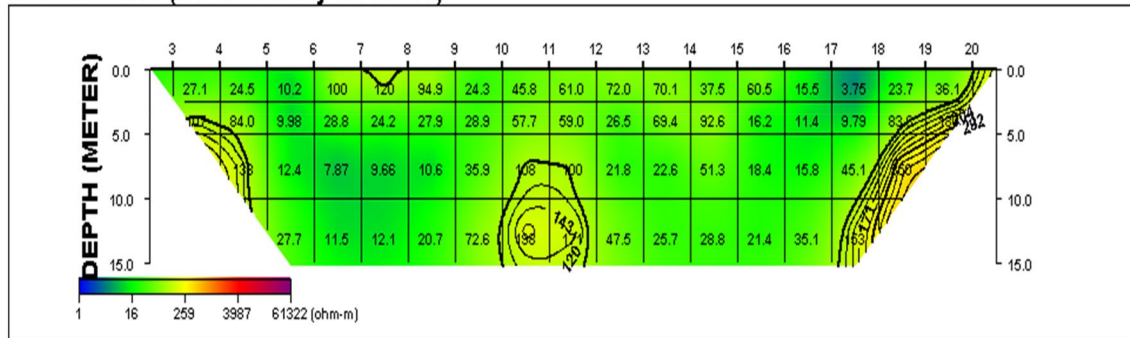


Fig. 7 (continued)

the subsurface in terms of lateral variation in resistivity of subsurface layers with respect to depth. Eleven geoelectric sections are drawn over the study area. Typical sections are shown in Fig. 10a, b. These geoelectric sections display three subsurface layers which are topsoil, weathered basement and fractured/fresh basement in some parts and four subsurface layers which are topsoil, lateritic clay, weathered basement and fractured/fresh basement in others. The thickness of the weathered layer and the fractured basement in some places as shown from these geoelectric sections are of much hydrogeological significance. Geoelectric section one runs over VES 1, VES 2, VES 3, VES 4 and VES 5

in northwest–southeast direction. This section covers about 425 m in length. The area is underlain by three subsurface units which are topsoil, weathered basement and fresh basement. The topsoil is relatively thin, while the weathered basement and overburden are thicker in the north-western part, especially at VES 2. Geoelectric section two in Fig. 7 runs over VES 6, VES7, VES 8, VES 9 and VES 10 in the northwest–southeast direction. This section covers about 400 m in length. The area is underlain by three subsurface units which are topsoil, weathered basement and fresh basement. Groundwater movement over this section will be towards VES 9. Geoelectric sections three and four run over

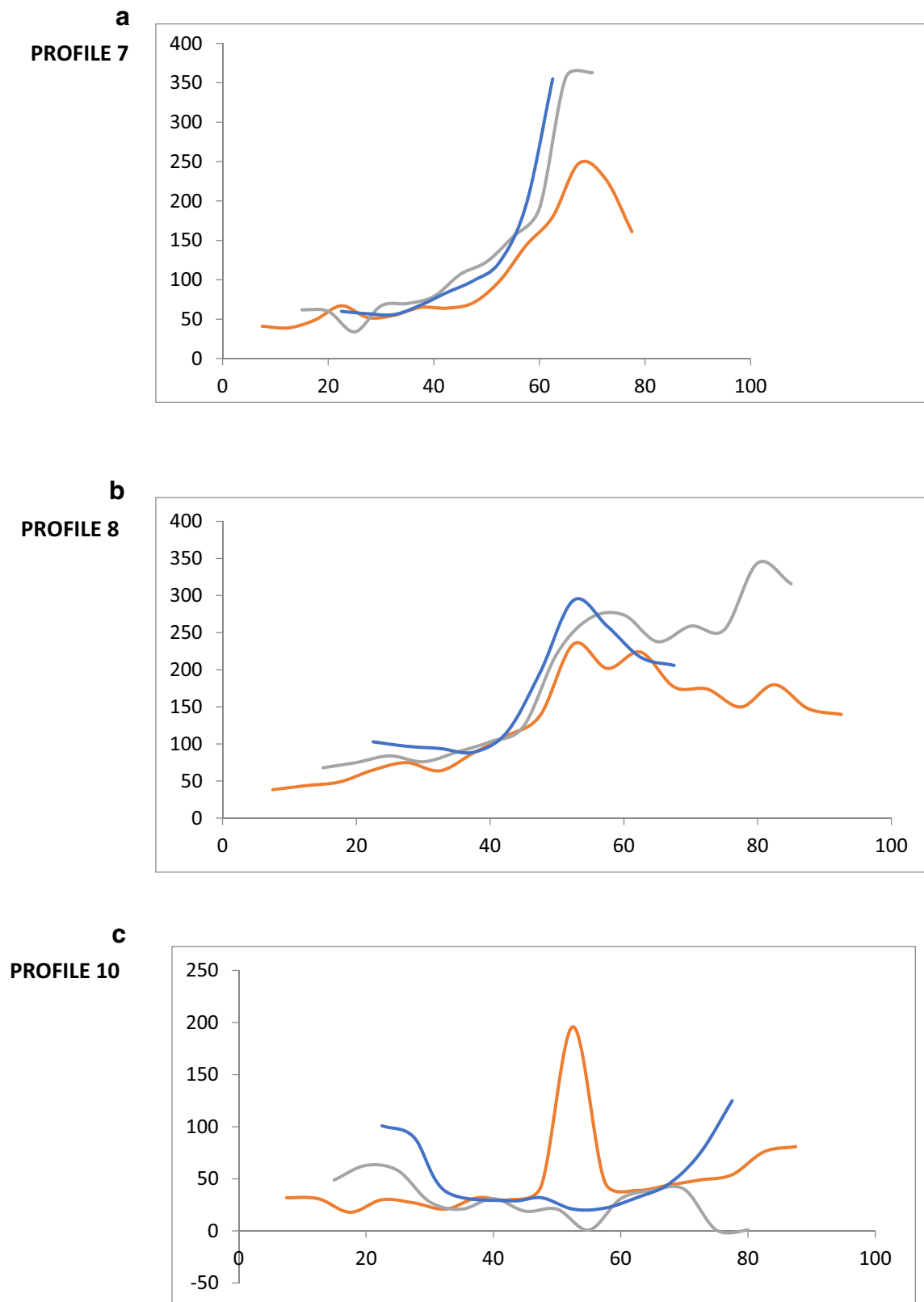
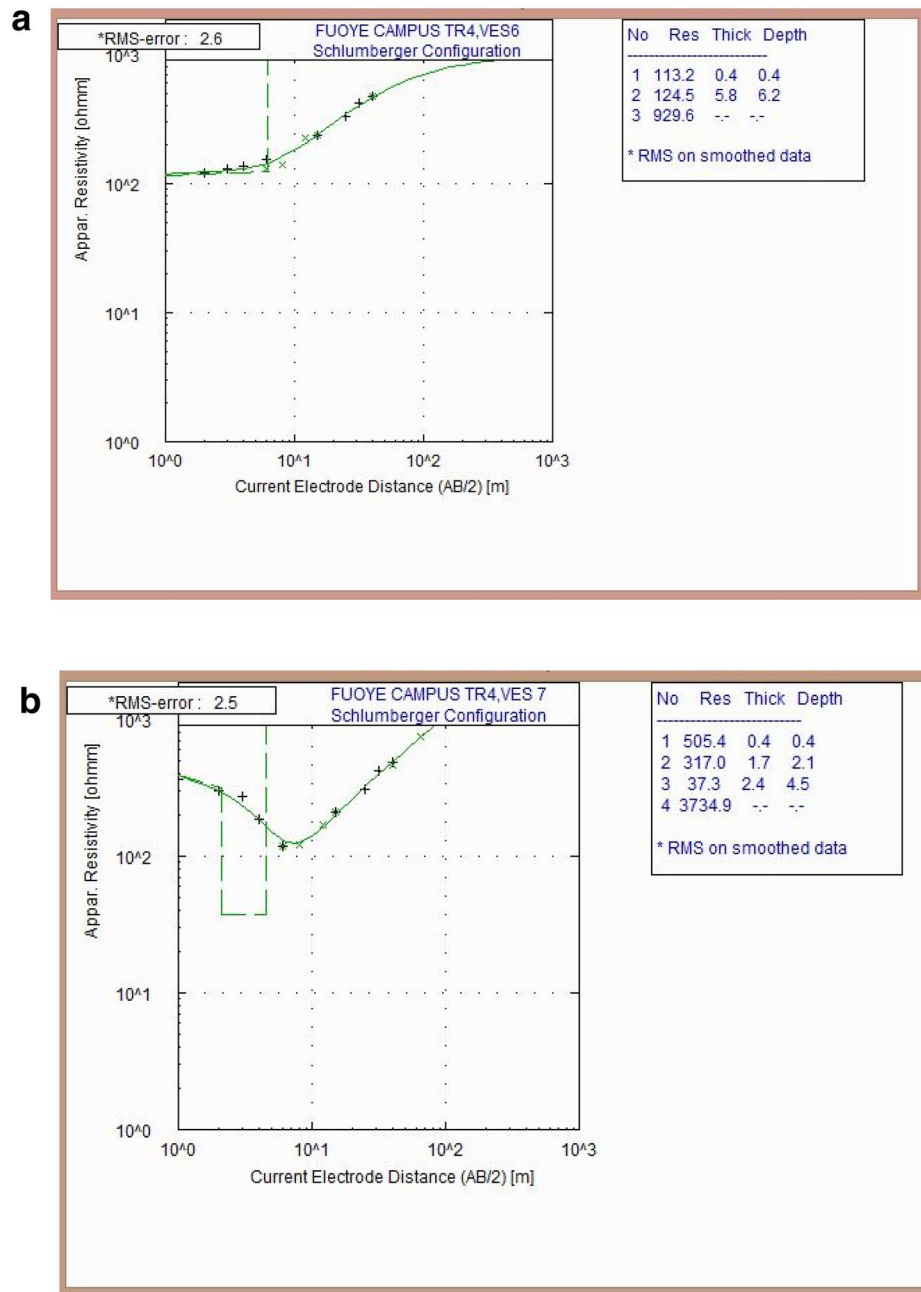


Fig. 8 **a** A Wenner profile of Profile 7. **b** A Wenner profile of Profile 8. **c** A Wenner profile of Profile 10

Fig. 9 a Curve type: A. b Curve type: QH

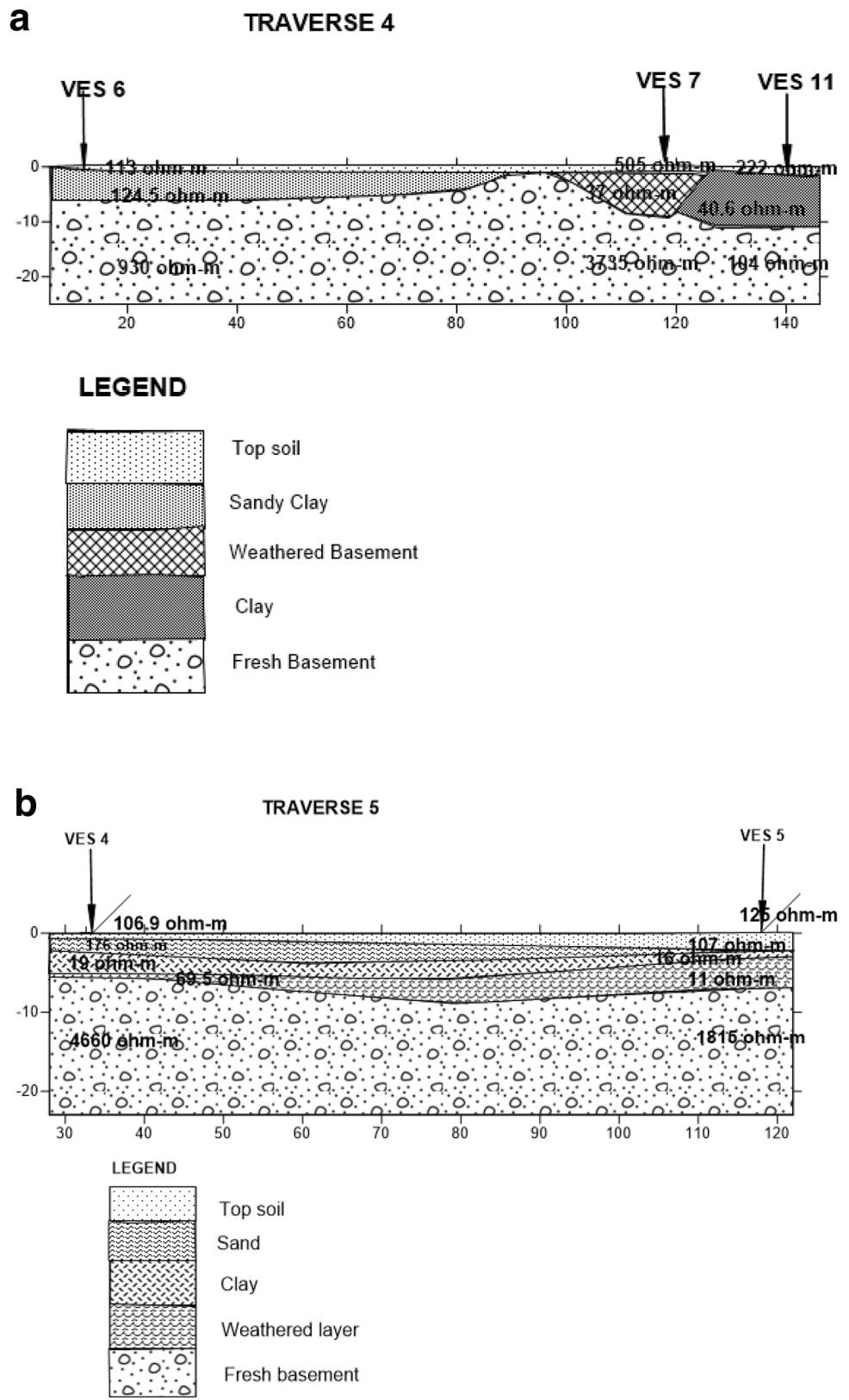


VES 11,12 and 13, VES 14 and 15, respectively, in north-east–southwest and northwest–southeast directions in that order. These sections are underlain by three subsurface units with thin topsoil and overburden. Therefore, this part of the study area does not have a significant groundwater potential. Geoelectric section five runs over VES 16,17,18,19, 20 and 21 in southwest–northeast direction. This is underlain by three subsurface units which are topsoil, weathered basement and fresh basement. Topsoil and overburden are thin in north-western part, and a sharp contrast in overburden thickness is noticed between VES 18 and VES 19. This reveals that groundwater flows towards the south-eastern part.

Conclusion

The geophysical investigation of Federal University Oye-Ekiti, Oye campus for the evaluation of groundwater potential, nature of subsurface geology. Geophysical methods are often used in combination in order to eliminate ambiguity arising from the interpretation of results obtained from one survey method. Very low frequency electromagnetic survey has been very relevant in the delineation of near surface fractures, while vertical electrical sounding of electrical resistivity survey has been more relevant and useful in the estimation of overburden thickness and presentation of geoelectric

Fig. 10 **a** Geoelectric section of Profile 4 showing the subsurface of the Profile. **b** Geoelectric section of Profile 4 showing the subsurface of the Profile



section. This work has identified zones of high, moderate and low ground water potentials. The research study has shown a good correlation with the groundwater potential of the boreholes drilled prior to this investigation and also provided adequate information for a good understanding of the hydrogeology potential of the subsurface.

Recommendation

It is very essential to always carry out both geological and geophysical surveys prior to borehole drilling for better understanding of the hydrogeology potential of the subsurface for selection of promising borehole sites. It is important to provide a proper management of borehole when in use after drilling. Areas with some thick weathered basement, low resistivity, thick overburden, fracture basement and basement depression are priority areas for possible groundwater development, and henceforth, a more detailed geophysical groundwater research could be carried out over these areas of the location to further ascertain the hydrogeology potential of these areas.

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