Resistivity Survey of the Western Part of Plataeu State Polytechnic Permanent Site, Barkin Ladi, Nigeria

SHUAIBU, O.Y, UDENSI, E.E., ADENIYI, J.O., JONAH S.A.
Department of Physics, Federal university of Technology, Minna, Nigeria

Abstract

A geoelectrical resistivity investigation, using Schlumberger vertical electrical sound (VES) was conducted in the western part of the permanent site of the Plateau State Polytechnic Barkin Ladi, Jos. The purpose of survey was to determine electrically the structure of layers, their thickness, their relative positions, and depth under the surface. Sixty-six VES were carried out over an area extent of 1.0km by 0.5km. The result indicated three, four, five, and six layering structure. The thickness of the horizon overlying the basement range from 1.5m to 37.2m. Typical geologic sections of the area consist of red laterite, sticky clay, sandy clay, highly weathered, weathered and fairly weathered granites. The weathered granite and sandy clay horizons are considered in this study as water bearing horizons.

Introduction

The vertical electrical sounding is an electrical method of geophysical investigation. This method determine the variation of resistivity of formation with depth. It is used in engineering site investigation, hydrological investigation and geologic mapping (Olorunfemi and Okhue, 1972), (Okwueze and Ezeanyi, 9185), (Shaw and Cole, 1949),. (Olorunfemi and Fasuyi, 1993), (Okwueze *et al*, 1981), (Ake and Olorunfemi, 1982), (Ako *et al*, 1978). The Plateau State Polytechnic, Barkin Ladi Campus, occupies a large expanse of land out of which a small portion have been developed. For the future development of the area, geophysical survey of this nature will provide the authorities with useful subsurface (ground) information in terms of the layering structure, thickness, depth, the bedrock structure and the water potential of the area. In the present work, the Schlumberger array was used in which the inner pair of potential electrode is kept fixed and the current electrode expanded in a straight line. The result obtained were processed and analyzed using automatic iterative programme which uses a new method for the automatic interpretation of Schlumberger and Werner sounding curves (Zohdy, 1989) to plot digitized and calculated curves of apparent resistivity values against half-current electrode spacing on a bi-logarithmic scale. It is from this digitized curves that the various layer resistivities and their thickness were obtained (Olayinka and Mbachi, 1994)

Location and Geology

The study area shown in Fig.1 is located at the western part of Plateau State Polytechnic along Jos-Barkin Ladi road. The survey covers an area extent of 1.0km by 0.5km. the study area is within the basement complex rocks of the Northern Nigeria. The general geology of the basement complex of Nigeria is composed of mainly migmatic, gneisses, granite, schist and quartzite (Macleod, 1950). The Jos Plateau of Nigeria comprises Precambrian to lower Paleozoic basement complex into which the Jurassic Younger granites are intruded, Fig.2. The general geology has been summarized by Macleod *et al*, (1971), Barbour *et al*, (1971). The basement rock covers some three-quarters of the younger granite province and can be divided into two main groups:

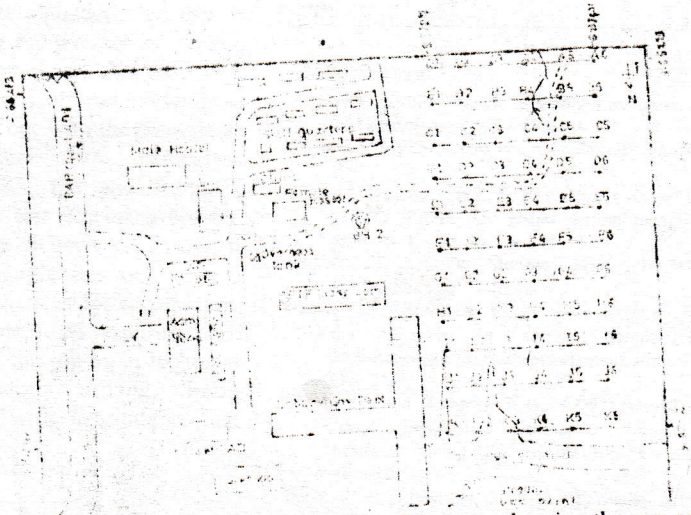

Fig. 1: Sketch map of the Plateau Polytechnic Barkin Ladi campus showing the survey area and verticals electrical sounding (VES) stations

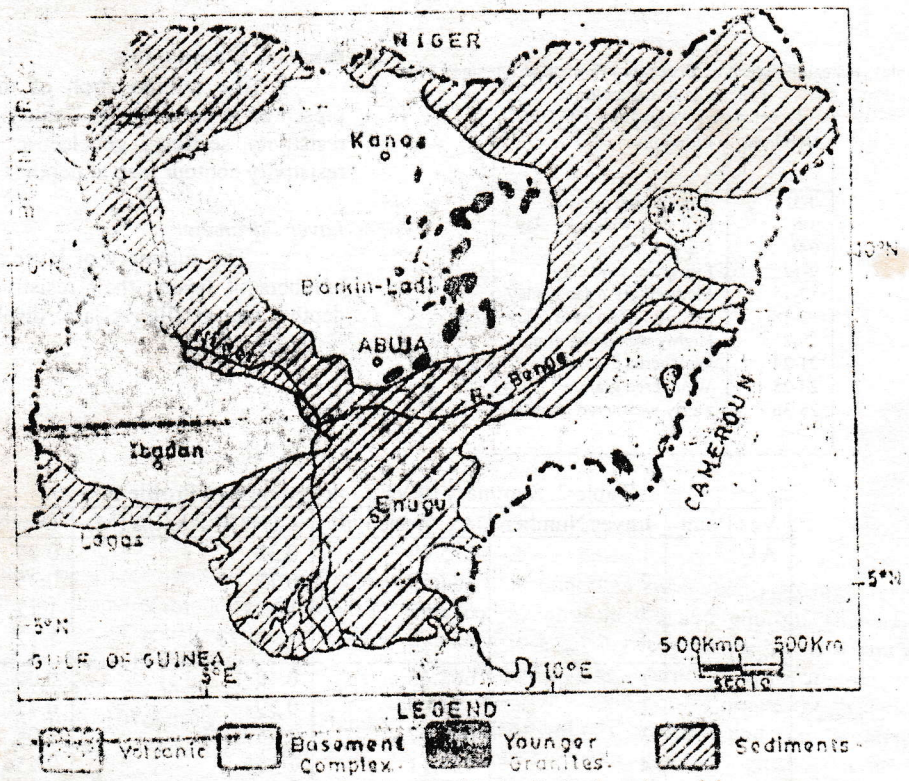

Fig. 2: Geological map of Nigeria showing Barkin-Ladi, the location of the survey area (after Barbour *et al.* 1982)

The younger metasediment (Oyawoye, 1964) which consist of granite gneisses in small and widely scattered outcrops and few small bodies of rocks which are considered to be older than 200 million years (Grant, 1964). The second group is more extensive, comprising the migmatites, granite, gneisses. The group is believed to be the result of the remobilization during the pan-African orogeny which dates from 873-435 million years. The migmatite and granite gneisses are believed to have been form largely from the pre-existing gneisses by process of granitization and the granites are considered to be of replacement and intensive origin. The dominant foliation in the basement is North-South which is also a general structural trends in many of the granite masses in the Northern basement complex (Macloed *et al*, 1971).The study area is featureless fold rising gently towards the north. The lithology as obtained from a drill hole information in the vicinity of the study area reveal the presence of top soil, red laterite, weathered and fairly weathered granite materials.

The Geoelectric Survey

The geoelectric survey involved the vertical electrical sounding (VES) using the Schlumberger configuration. The instrument used was the ABEM Terrameter Model SAS 300B which calculated the ratio of potential difference to the current and displayed the resistance directly. A total of sixty-six VES points were occupied with half-current electrode separation increase gradually from 0.5m to1.5m. The data collected were processed, analyzed and presented as VES sounding curves. This curves were generated by a computer program based on a new method of automatic interpretation of Schlumberger and Werner sounding curve by Zohdy(1989). The program plot digitized and calculated sounding curve of apparent resistivity against half current electrode spacing. From the series of curves obtained, the layer parameters (resistivities and thickness) were deduced. The layering of the subsurface structure in the area varies from three to six layers. The geologic interpretation of the geoelectric model resulting from the quantitative interpretation of VES curves was based on a borehole lithological log obtained in the vicinity of the study area as shown in Table I below.

Table1: Plateau Polytechnic Borehole Information Obtained from Plateau State Agricultural Development Programme (PADP)

Depth(m)	Lithology
0-3	Top soil/red laterite
3-6	Red + brown sticky clay
6-9	Grayish sticky clay
9-12	Fire grain sand clay
12-15	Medium grain sandy clay
15-18	Medium grain sandy clay
18-21	Highly weathered granite
21-24	Weathered granite
24-25	Weathered granite
25-36	Fairly weathered granite

Result and Discussion

The interpretation of the VES curves are presented in summary as Table of layers parameters, resistivity sections, geoelectric cross section, iso-resistivity contour map at depth (Hassan *et al*, 1991).

Layer Parameter

The summary of layer parameters showing numbers of layers, their resistivities, thickness and depths for profile A are displayed in Table 2.

Table 2: Summary of VES interpolation of Profile A

Ves Point	Layer Number	Av. Resistivity	Layer Thickness (M)	Depth(M)
A1	1	675.69	0.35	0.00
	2	137.59	0.77	0.35
	3	683.06	10.08	1.12
	4	426.92		1.12
A2	1	668.48	0.49	0.00
	2	1149.06	0.59	0.49
	3	640.07	21.57	1.05
	4	428.11	10.55	22.56
	5	261.38		33.11
A3	1	119.20		0.00
	2	270.36		0.49
	3	106.89		1.99
	4	111.06		5.31
	5	56.33		10.92
	6	252.57		23.01
A4	1	971.95		0.00
	2	388.90		0.49
	3	295.86		15.37
A5	1	103.37		0.00
	2	451.17		0.49
	3	276.54		2.26
	4	330.63		10.47
A6	1	470.36		0.00
	2	549.50		0.44
	3	292.97		1.38
	4	249.17		9.42

Curves of Profile A

Figure 3 shows the interpretation of apparent resistivity data of VES points A_3, A_5 and A_6 on profile A which typifies the data collected at other stations within the study areas. The shape of the curves suggested that VES A_3 have six geoelectric units, A_5 have four geoelectric units respectively. The tation of VES A_3 shows that the first layer has resistivity of 119 ohm-m and a thickness of 0.5m. The second layer of resistivity 270 ohm-m is 1m thick. The third layer has a resistivity of 106 ohm-m and a thickness of 5.3m. the fifth layer is thick with a resistivity of 56ohm-m has a thickness of 12.09m while the resistivity of the sixth layer of about 253 ohm-m has infinite thickness.

Fig.3: Apparent resistivity curves of VES A_3, A_5 and A_6

The geoelectrical cross-section of profile A is the explanation and deduction made from the VES points of equal or range of resistivity value along profile A in a vertical plane, Fig. 4. In the middle of the profile beneath VES A_3 there occurs a low resistivity of 56 ohm-m to 107ohm-m. It has a lateral extent of about 100m and thickness of about 20m. This low resistivity area may be interpreted as sandy clay. It is underlain by a relatively high resistivity unit of 253ohm-m and 296 ohm-m. This unit also appears to a great depth on the western end of the section and may be interpreted as weathered layer. A high resistivity zone occurs above the basement on the eastern end of the section and may be interpreted as a sticky clay zone. The geological deduction of the cross-section of a profile A is shown in Fig. 5.

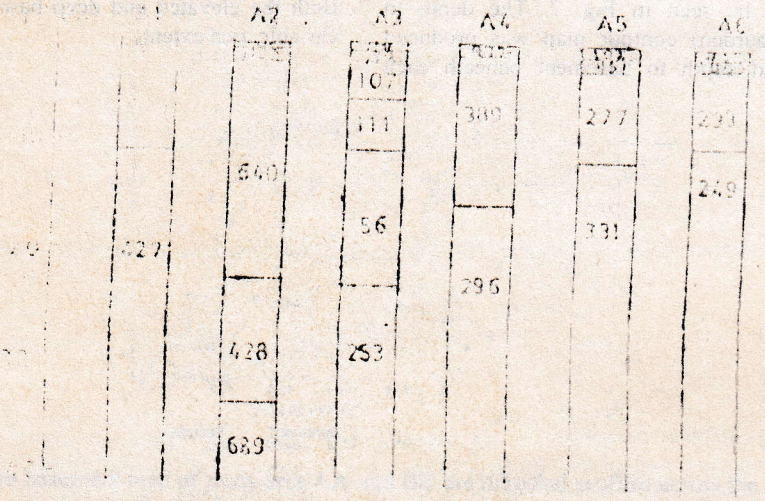

Fig. 4: Subsurface geoelectric bar section of VES curves A_1, A_2, A_3, A_4, A_5 and A_6. The numbers in columns represent the resistivity values in Ohm-m of the respective layers.

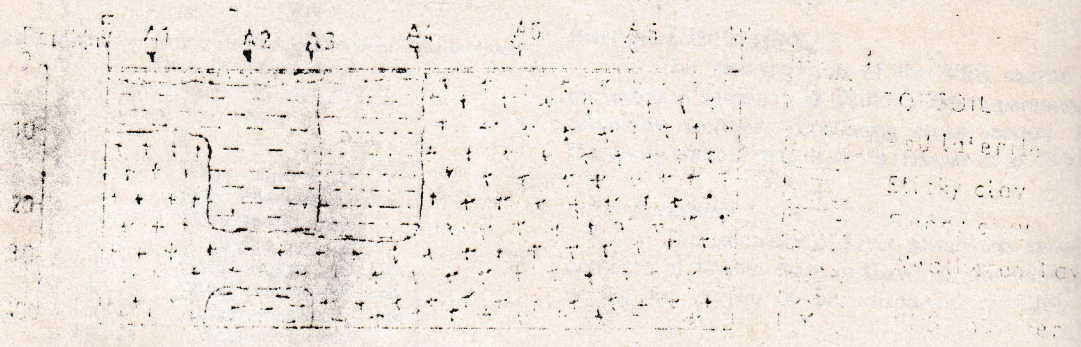

Fig. 5: Geologic section equivalent to geoelectric layering section along profile A (A_1 A_6)

In order to look at the areal conductivity distribution of the study area at various depths of interest (on a horizontal plane) the contour maps of the whole area is produced at these depth level. Hence the iso-resistivity contour map at 15m depth is presented Fig.6. This contour map has a contour interval of 50ohm-m. The zones of high resistivity anomaly lie beneath VES A_1, B_1 C_1, F_1, E_6 and I_5 with the highest resistivity value around VES B_6. Apart from this point all other VES point on that depth level expresses low resistivity indicating a conductivite zones likely to be made of sandy clay material composition. The geologic deduction of this map at 15m depth can be seen in Fig. 7. The depth to basement (overburden) contour map was produced using interpreted depth to basement beneath each VES sounding point. The purpose is to present an aerial view of the bedrock surface and also to know the overburden thickness. Fig.8. shows the depth to basement contour map of the study area constructed with an interval of 2m. This map reveal the structural trend of the basement in the area. It also shows that the basement is very deep (37m) underneath VES K_1 and very shallow under G_1. The cross-sections of the basement along two diagonal profile AA` and BB` are shown in Figs. 8, 9 and 10. The sections show a series of bedrock elevation and depressions. The depression underlay areas of thick overburden and the elevation underlay areas of thin overburden thickness. Both the elevated and deep basement structure have variable area extent.

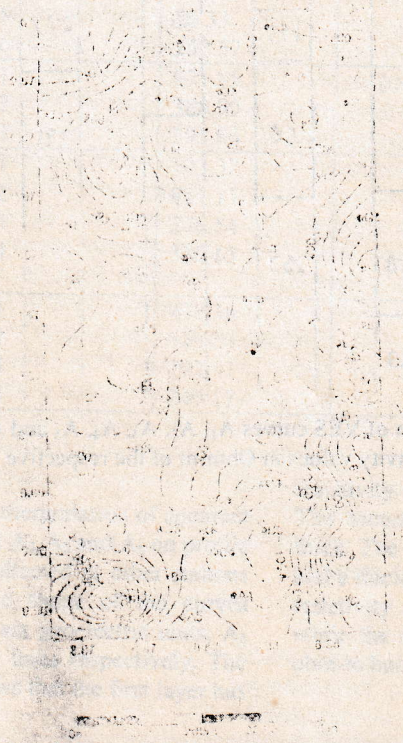

Fig. 6: Iso-resistivity map of the study area at 15m depth

Fig. 7: Geologic interpretation of Iso-resistivity contour map at 15m depth

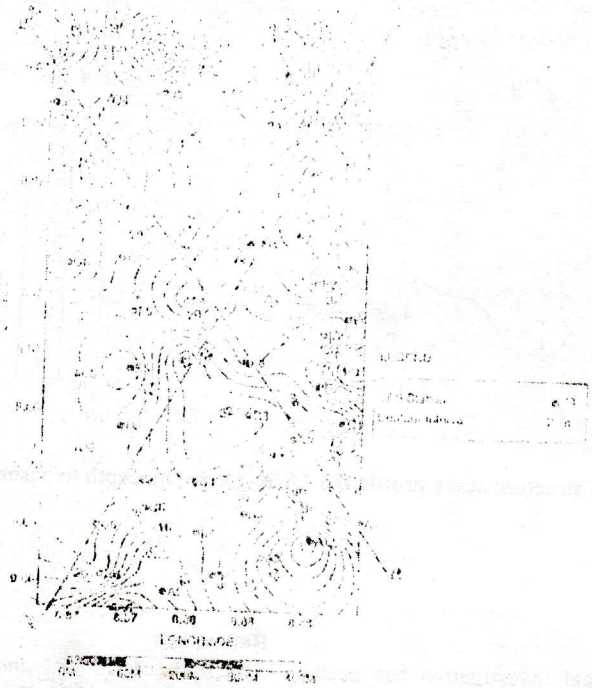

Fig. 8: Depth to basement map of study area AA and BB are diagonal profiles across the study area.

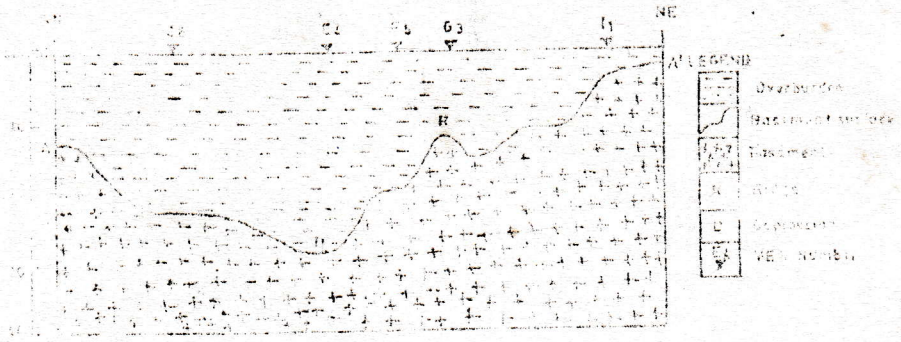

Fig. 9: Basement structure along profile AA' (C_6I_1) from the depth to basement contour map.

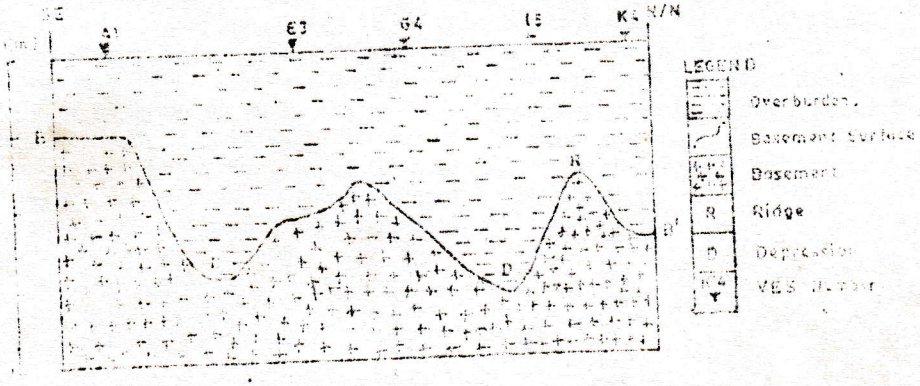

Fig. 10: Basement structure along profile BB' (A_1K_6) from the depth to basement contour map.

Conclusion

A detailed geoelectrical investigation has been carried out at the western part of the Plateau State Polytechnic. The results based on the interpretation of the electrical resistivity of the areas lead to the following conclusion:

i) Three to six geoelectric units were identified.
ii) The thickness units of the formations overlaying the basement ranges from 1.5m to 37.2m.
iii) Areas with hydrologic prospects were delineated.
iv) Basement map and profiles reveal the relief the bedrock.
v) Area of sand and clay deposit were mapped.

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