GEOELECTRIC INVESTIGATION OF BEDROCK STRUCTURES IN THE MINI-CAMPUS OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, SOUTHWESTERN NIGERIA AND THE GEOTECHNICAL SIGNIFICANCE

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Abstract: Thirty-two Schlumberger and 26 Wenner vertical electrical soundings (VES) were conducted to delineate the structural/geotechnical features of the overburden/bedrock underlying the mini-campus of the Federal University of Technology, Akure, southwestern Nigeria. The results show that the resistivity values vary from 21-965Ωm and 300-10,500Ωm within the overburden and the bedrock respectively. Five significant depressions and two major normal fault axes were also delineated. Suspected fault zones or axes, bedrock depressions and low resistivity (<600Ωm) areas within the bedrock and average resistivity less than 300Ωm within the overburden, are considered geotechnically incompetent. The soil/rock in these zones may require reinforcement in order to enhance its bearing capacity and increase the life span of engineering foundations in the area. However, relevant intrusive geotechnical investigations are recommended in conjunction with the geoelectric survey in order to determine the most suitable foundation design in the study area.
Keywords: Geosoundings, Bearing capacity, Competence, Bedrock structures.

1. INTRODUCTION

The Federal University of Technology (FUT), Akure, occupies about 6.4km^2 of land area on the outskirts of the Akure metropolis (Fig. 1). At present only about a quarter of the land area has been developed, or is being developed mostly into engineering structures. Also, geotechnical investigations in the area typically use intrusive tests (such as boring or percussion drilling) and these do not provide sufficient information concerning variations in depth to bedrock. The tests also have low probability of locating subsurface anomalous geological structures. Modern day geotechnical studies favour the use of geoelectric survey (in conjunction with intrusive tests) as an important component of verification methodology [1]. A variety of electrical methods have been used to directly image and monitor engineering structures [2]. Several workers have also used the vertical electrical soundings (VES) to delineate bedrock features in similar geologic settings in south-western Nigeria [3-7] and other parts of the world [2].

The aim of this work is to delineate the overburden/bedrock structural features at the mini-campus of the Federal University of Technology, Akure using vertical electrical soundings (VES). Appropriate modern processing and visualisation software has been used to enhance the imaging and subsequent delineation of bedrock structural features.

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The findings are intended to complement the routine engineering geotechnical investigations normally conducted prior to engineering constructions. The result of study is also expected to enhance our knowledge of the geotechnical characteristics of basement regolith and the structural disposition of the bedrock underlying the university mini-campus.

2. SITE DESCRIPTION AND GEOLOGY

The Federal University of Technology, Akure mini-campus is underlain by the Precambrian basement complex of southwestern Nigeria. The rock units recognised in the area are migmatitic gneiss, charnockite, granite and quartzite (Fig. 1). These rocks exhibit different types of syngenetic and epigenetic geological structures such as foliation, gneissic layering and banding, joints, folding and faulting [8].

The study area lies within the tropical rain forest belt characterised by alternating wet and dry seasons. The mean annual rainfall is about 2000mm. Humidity is relatively high during the wet season and low during the dry season. Temperature varies from 22^{0}C to 29^{0}C throughout the year. Within the study area, there are three perennial springs believed to be structurally controlled [9].

3. MATERIALS AND METHOD

Fifty-eight (58) vertical electrical soundings (VES) were conducted using Wenner and Schlumberger configurations. The current electrode spacing (AB) was varied from 1 to 200m for the Schlumberger and 3 to 192m for the Wenner soundings. Field measurements were made with PASI-E2 Digit resistivity meter.

The VES data were interpreted manually using the partial curve matching technique [10]. The geoelectric parameters obtained from the manual interpretation were further iterated (Figs. 2 and 3) using interactive computer software, RESIST VERSION 1.0 [11]. The results are presented as isoresistivity, overburden thickness and bedrock relief maps (Figs. 4 –7).

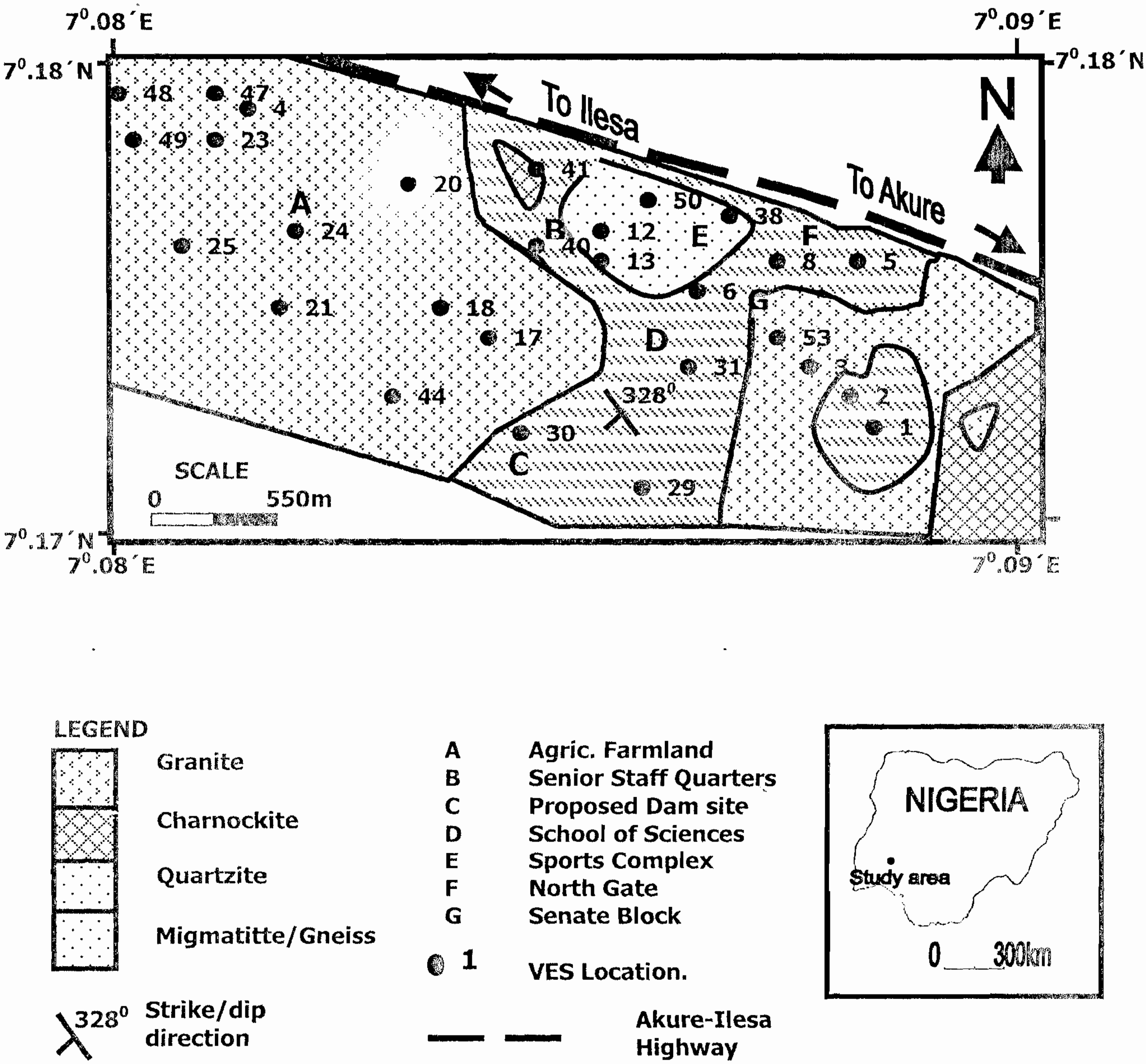
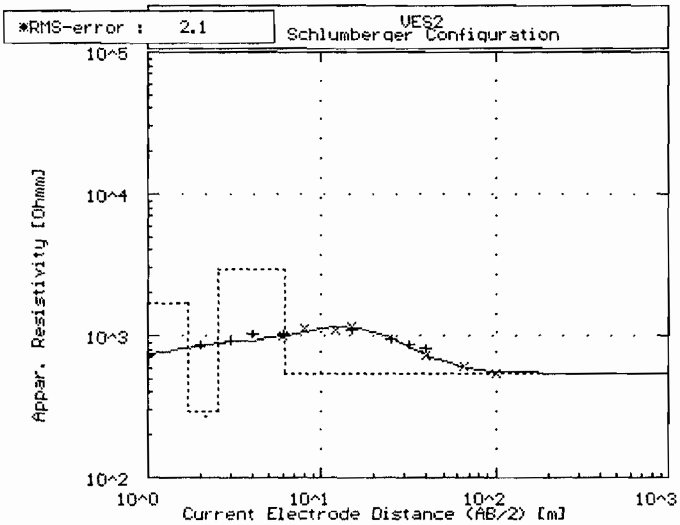


Fig. 1: Geologic map of the study area also showing some of the VES locations. (Modified after [12])



No	Res	Thick	Depth
1	649.9	1.0	1.0
2	1695.8	0.7	1.7
3	294.4	0.8	2.5
4	2928.2	3.7	6.2
5	545.5	----	----

* RMS on smoothed data

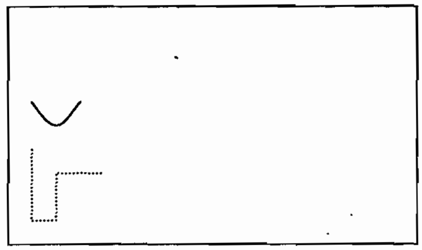
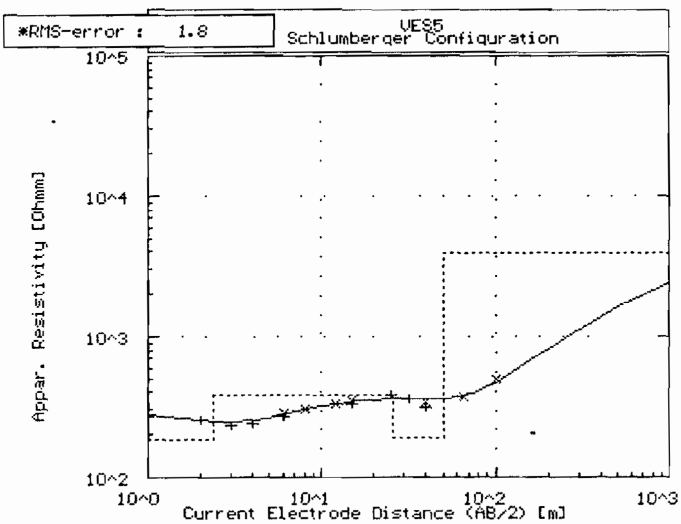


Fig. 2: Interpreted Schlumberger Depth Sounding Curve for VES 2.



No	Res	Thick	Depth
1	285.6	1.0	1.0
2	182.8	1.4	2.4
3	387.1	23.6	26.0
4	187.4	24.0	50.0
5	3907.0	----	----

* RMS on smoothed data

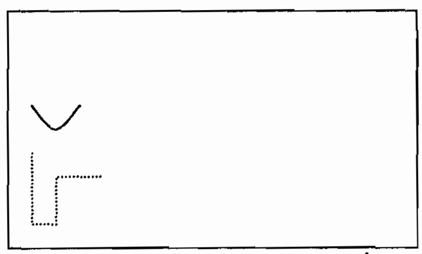


Fig. 3: Interpreted Schlumberger Depth Sounding Curve for VES 5.

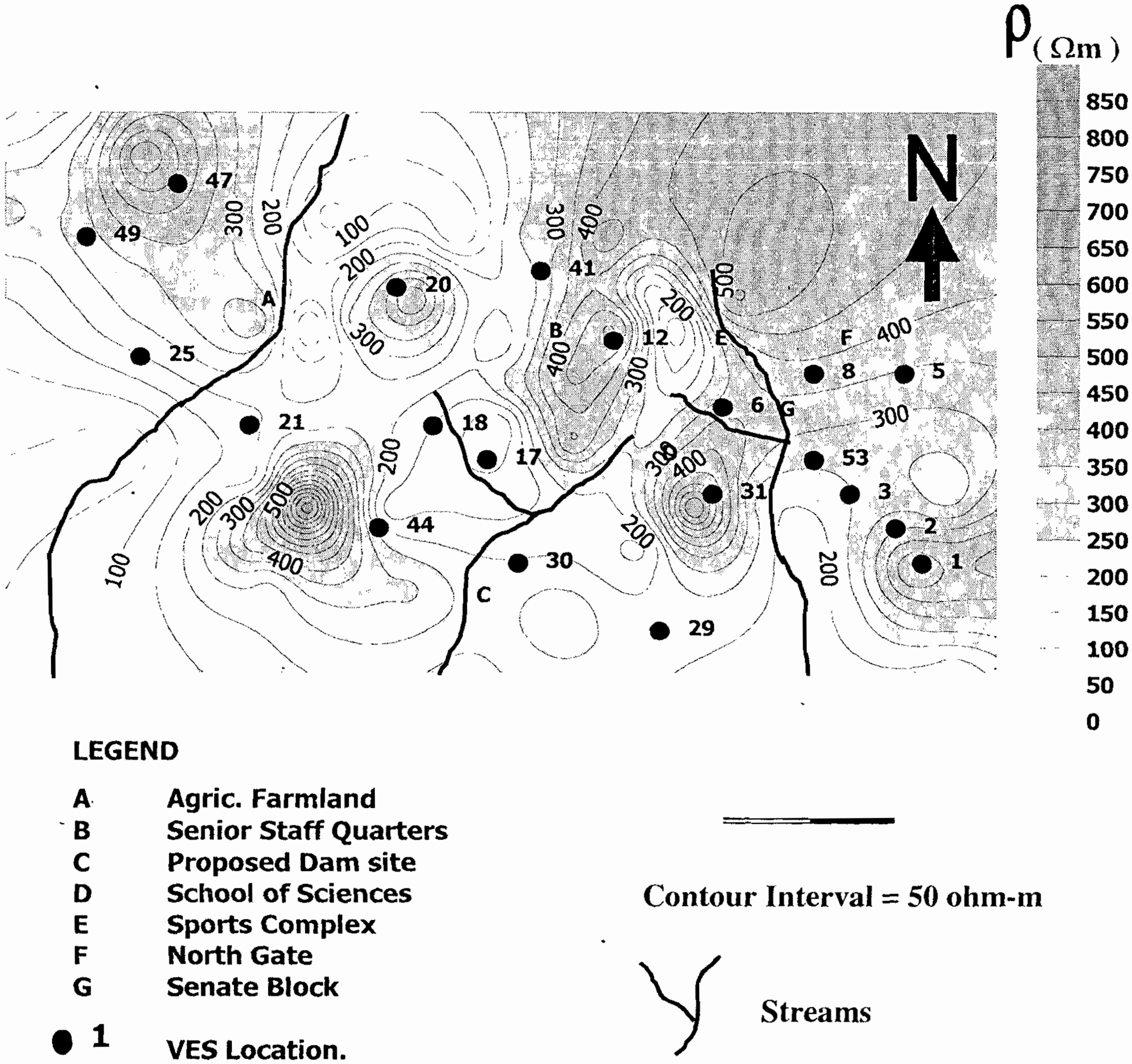
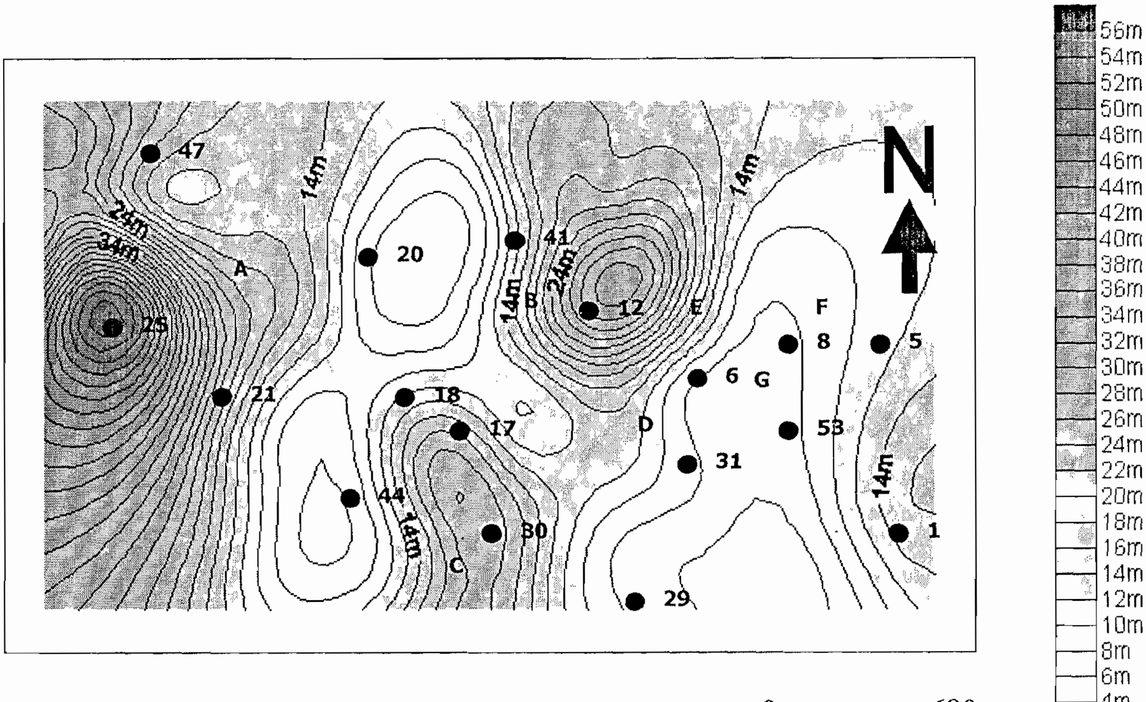


Fig. 4: Isoresistivity map of the topsoil of the study area.

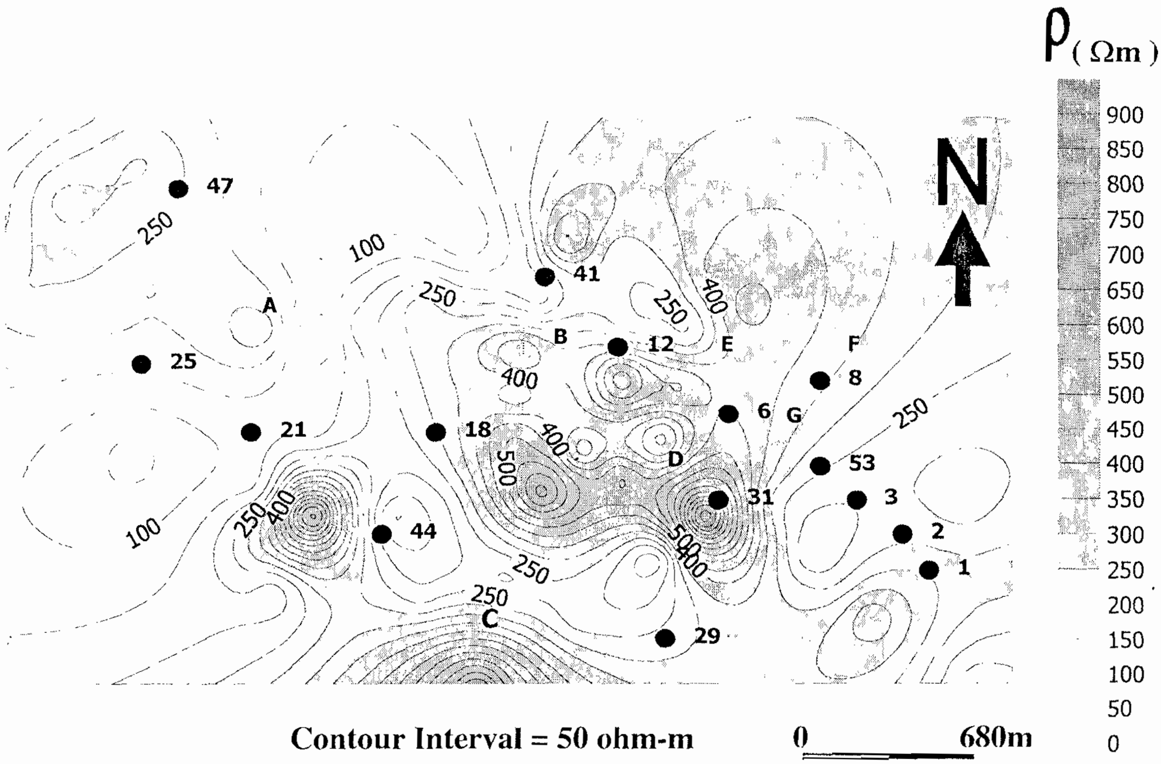


Contour Interval = 2m   0 680m

LEGEND

A	**Agric. Farmland**
B	**Senior Staff Quarters**
C	**Proposed Dam site**
D	**School of Sciences**
E	**Sports Complex**
F	**North Gate**
G	**Senate Block**
● 1	**VES Location.**

Fig. 5: Contoured map of the overburden thickness of the study area.



A Agric. Farmland
B Senior Staff Quarters
C Proposed Dam site
D School of Sciences
E Sports Complex
F North Gate
G Senate Block

● 1 VES Location.

Fig. 6: Isoresistivity map of the average resistivity of the overburden of the study area.

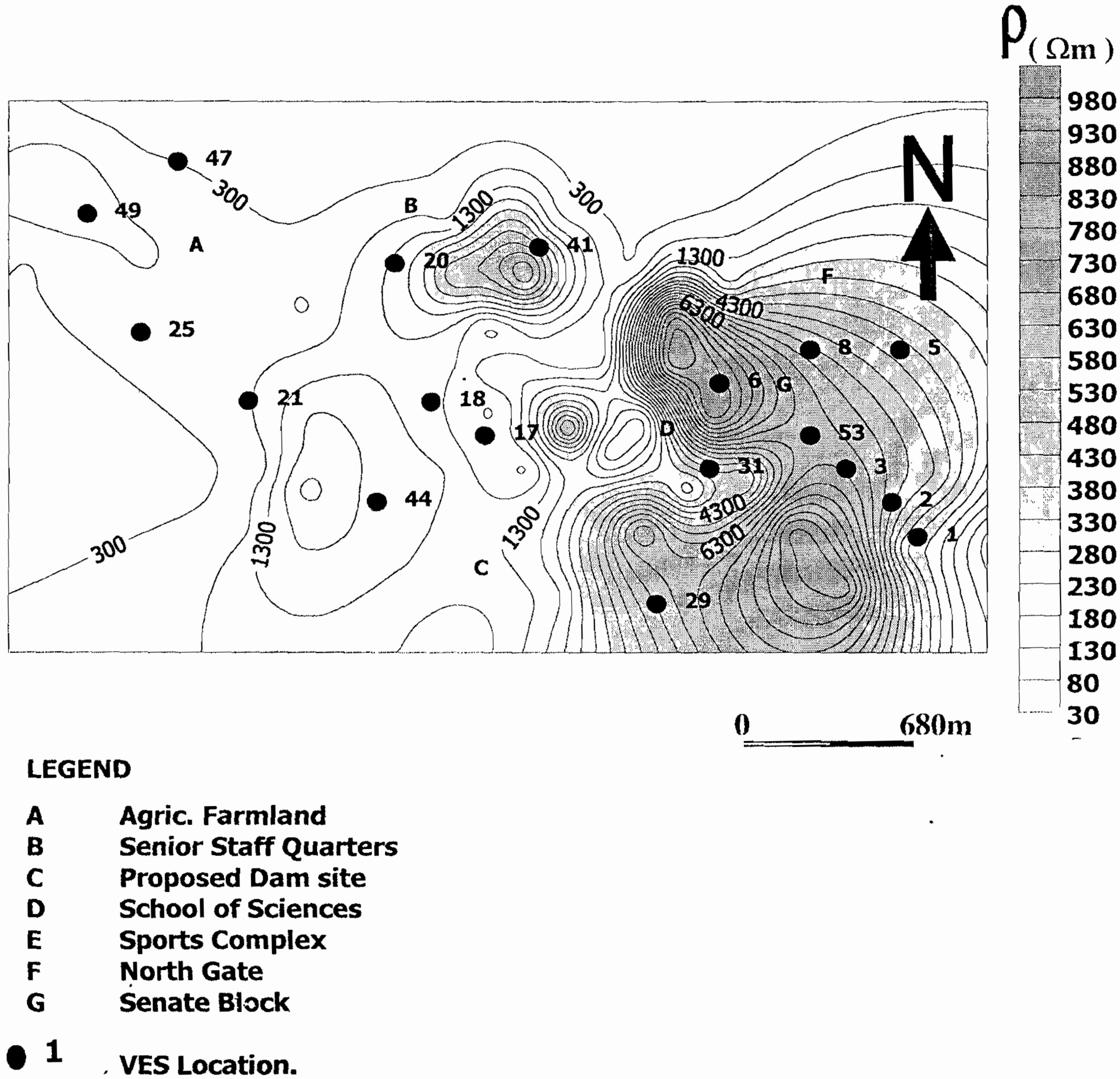


Fig. 7: Isoresistivity map of the bedrock of the study area.

4. RESULTS AND DISCUSSION

Fig. 4 shows the isoresistivity map of the topsoil. The resistivity of the topsoil varies from 50 to 900 Ωm while the thickness varies from 0.6 to 4.1m. Zones with low resistivity values tend to correspond to three stream channels [9]. The zones within the topsoil where the resistivity values are less than 300 Ωm are considered geotechnically incompetent and may require reinforcement in order to carry large engineering structures. The magnitude of the reinforcement will, however, be determined by the strength of the proposed structures.

The overburden thickness map (Fig. 5) shows that the depth to bedrock varies from 4-56 m. This implies that the study area is deeply weathered around the sports complex and agricultural farmland. The resistivity of the overburden (Fig. 6) varies from 21-965 Ωm. Areas within the overburden where average resistivity is less than 300 Ωm are equally considered geotechnically incompetent. Average resistivities less than 100 Ωm within the overburden suggest varying clay content, which may be detrimental to the overlying foundation [13].

The isoresistivity map of the bedrock (Fig. 7) shows that the bedrock is characterised by resistivities varying from 300-10,500 Ωm. This suggests that the bedrock is partially weathered/fractured beneath the western part and relatively fresh beneath the eastern part of the mini-campus. The bedrock is considered geotechnically incompetent where the resistivity falls below 600 Ωm.

The bedrock relief map (Fig. 8) shows two major structures: five bedrock depressions (in circles) and the two fault axes (X-X′ and Y-Y′). The faults are normal faults with their axes parallel to the general strike of the rocks (NW-SE). The fault zones and bedrock depressions should be avoided during the location of engineering structures in the study area.

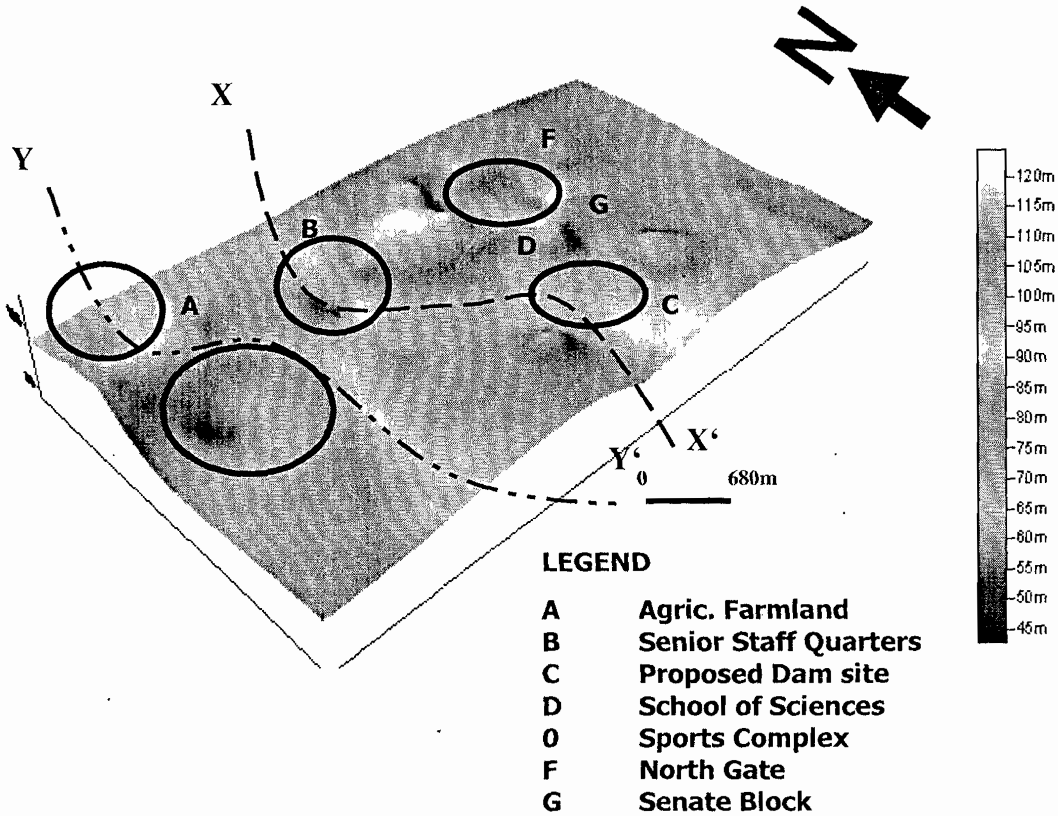


Fig. 8: Surface map of the bedrock of the study area showing the depressions (in circles) and the fault axes (X-X′ and Y-Y′).

5. CONCLUSIONS

The regolith material and the underlying bedrock at the Federal University of Technology, Akure are characterised by resistivities varying from 21-965Ωm and 300-10,500Ωm respectively. The bedrock has five significant depressions and two major fault axes. The faults are normal faults with their axes parallel to the general strike of the rocks (NW-SE). Suspected fault zones or axes, bedrock depressions and low resistivity (<600Ωm) within the bedrock and low average resistivity (<300Ωm) within the overburden, are considered geotechnically incompetent to bear significant engineering structures. The soil/rock in these zones may require reinforcement in order to enhance the bearing capacity, and increase the life span of a proposed foundation to be placed.

The regions delineated as geotechnically incompetent may require engineering reinforcements (to be determined by the proposed load) in order to enhance the bearing capacity of the soil/rock.

The electrical resistivity (geosounding) testing appears to be a valuable tool for geotechnical exploration to predict depth to bedrock and determine structural trends in the concealed bedrock. It is however recommended that the intrusive methods should be used alongside geosounding survey so that the most suitable foundation design can be adjudged.

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