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ELECTRICAL RESISTIVITY SURVEY FOR CONDUCTIVE SOILS AT GAS TURBINE STATION, AJAOKUTA, SW, NIGERIA.

A. ADESIDA and J. FATOBA

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ABSTRACT

Ten (10) vertical electrical soundings (VES) using Schlumberger configuration were carried out to delineate subsurface conductive soils for the design of earthling grid for electrical materials installation at the Gas Turbine Station, Ajaokuta, SW Nigeria.

Interpretation of the resistivity data revealed three major geoelectric layers namely; topsoil, clay, and partially weathered/fresh basement. The topsoil and the clay layers are the main conductive media in the study area.

The conductivity of the topsoil varied from 0.0068 to 0.0833mho.m^{-1} It is generally conductive with a slightly resistive area beneath one of the VES stations. However the top layer is relatively thin (0.5-4.0m). The underlying layer is made up of clay that is very conductive. Its conductivity varies from 0.0098 to 0.0909 mho.m^{-1} The thickness of this second layer is considerable (3.4-25.7m) and should be able to neutralise external charges. Therefore the first and second layers are recommended for earthling of the electrical materials. The recommended depth for the earthling is between 1.5 and 2.0m. This depth is within the conductive topsoil and a very conductive clay layer underlies it. The third layer in the study area is the partially weathered/fresh basement. It is highly resistive within the region and it is not recommended for earthling.

KEYWORDS: Electrical Resistivity, Conductivity, Earthling.

INTRODUCTION

Geophysical investigation is commonly used in engineering site investigation, mineral exploration and groundwater investigation. Its relevance is in depth to bedrock determination, structural mapping, lithologic boundary differentiation, aquifer delineation of the nature of superficial deposit etc. (Agunloye, 1984; Olayinka and Oyedele, 2001 Olayinka and Olorunfemi, 1992, Olorunfemi and Okhue, 1992). However, another significance of geophysical investigation is in the area of environmental protection. An important aspect of this is applicable for investigation of subsurface for delineation of conductive soils for the design of earthling grid for electrical materials installation.

The factors influencing the conductivity of soils include porosity, ionic concentration of dissolved salts and moisture content. These same factors also control the resistivity of soils (Archie, 1942, Patnode and Wyllie, 1950, Baeckman and Schwenk, 1975, Fontana and Greene, 1978, Adesida et. al., 2002) Soil conductivity increases with increase in soil porosity, groundwater saturation and the amount of dissolved salts. Generally, the lower the resistivity of the soil, the higher the conductivity.

This paper presents the results of the electrical resistivity survey carried out at the Gas Turbine Station, Ajaokuta, SW, Nigeria. The aim was to delineate various lithologic units (and their apparent resistivities) that constitute the subsurface. The results of this work would aid the electrical engineers in the design of an adequate safe earthling grid system for the proposed Gas Turbine Station.

HYDROLOGY/GEOLOGY OF THE STUDY AREA

The study area lies within longitudes 7^0.00′-7^0.30E′ and latitudes 6^0.30′-7^0.00′N (Fig. 1). Two main rivers namely, River Osara and River Uba drain the area.

The drainage pattern within the area is dendritic. The area falls within Tropical Forest-Savannah mixture characterised by a mixture of trees, shrubs and grasses. Ajaokuta and it's environ has the peculiar climate of long dry season (October to April) and a short wet season (May to September). The mean annual rainfall is between 1000-1500mm while the mean temperature is about 26.1^{0}C (97^{0}F) (Agboola, 1979).

The geology of the study area is made up of migmatite gneiss complex, charnockite, quartzite, pyllite/schist and granite (Rahaman, 1976).

FIELD MEASUREMENTS AND DATA ANALYSIS

In order to delineate the nature of the subsurface, thickness and the apparent resistivity of the layers, ten (10) vertical electrical soundings (VES) were carried out using the Schlumberger electrode configuration with maximum current electrode spacing (AB/2) of 50m. Fifteen meters (15m) is the maximum depth of interest. The instrument used was the ABEM SAS 300C digital terrameter. The field layout of the sounding points is as shown in Fig. 1.

The VES data were plotted on log-log graph paper with the apparent resistivity (ρ_a) values on the ordinate and the electrode separation (AB/2) along the abscissa. The resulting curves were interpreted manually using the partial curve matching technique and the results were further iterated using RESIST computer software (Vander Velpen, 1988 and Figs. 2 and 3). Isoconductivity maps (Figs. 4-6) were also prepared for the topsoil and for depths of 5m and 10m. 3D geoelectric section (Fig. 7) was prepared for the study area.

DISCUSSION OF RESULTS

Table 1 shows the summary of the interpretation of the results. Three major geoelectric layers were delineated from the ground surface to an average depth of 15m.

TABLE 1: SUMMARY OF THE INTERPRETATION

Layer	Thick-ness (m)	Resistivity (Ωm)	Conductivity (mho.m^{-1})	Geologic Interpretation
1	0.5-4.0	12-147	0.0068-0.0833	TOPSOIL
2	3.4-25.7	11-102	0.0098-0.0909	CLAY
3	-	214-30,000	0.00003-0.0047	WEATHERED/FRESH BASEMENT

A. ADESIDA, Department of Applied Geophysics, Federal University of Technology, Akure, Nigeria.
J. FATOBA, Nigerian Building and Roads Research Insitute, Ota, Ogun State, Nigeria.

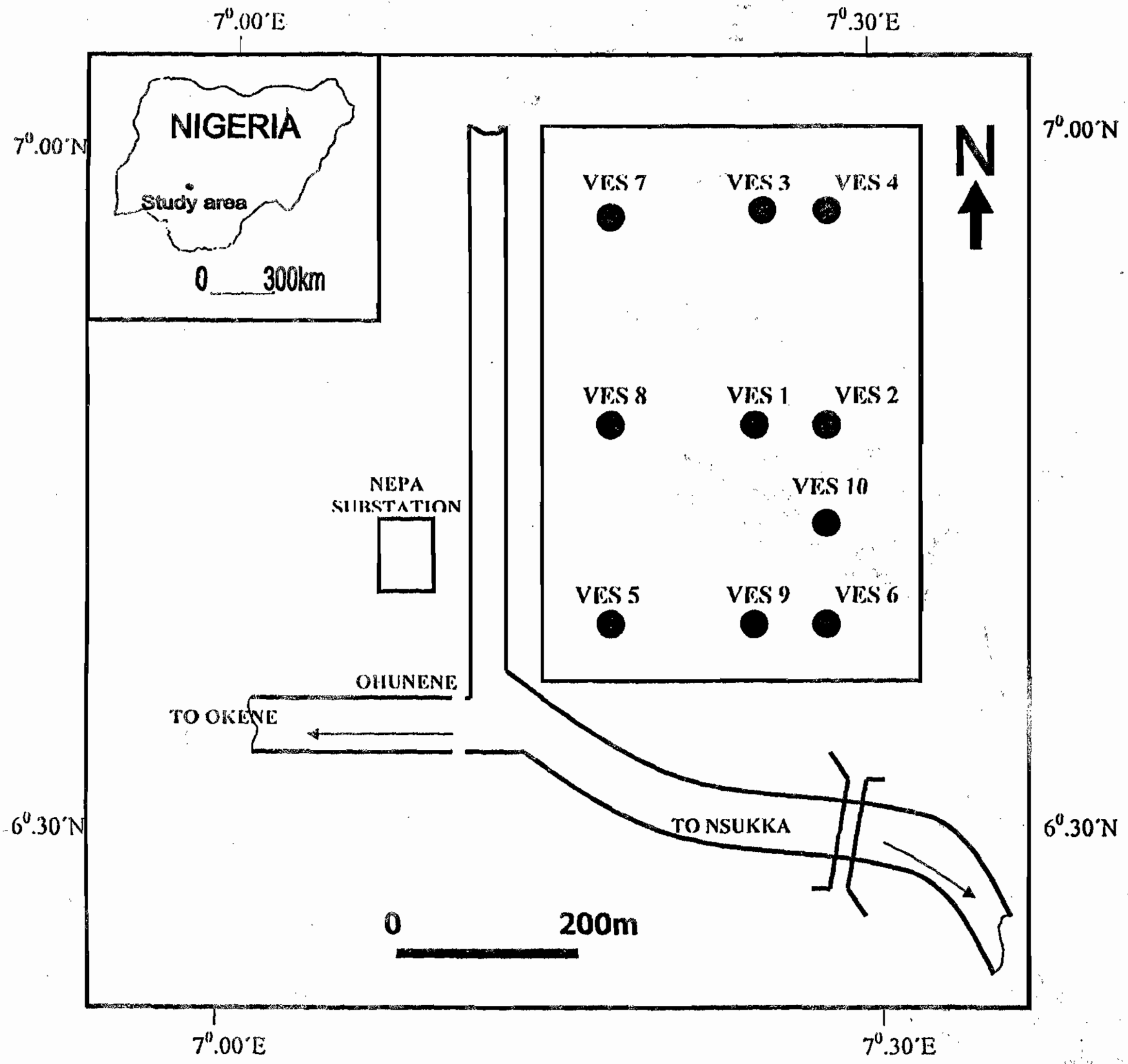
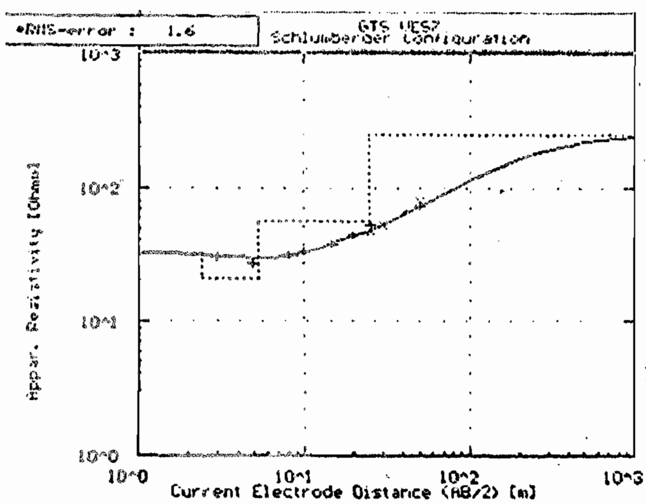


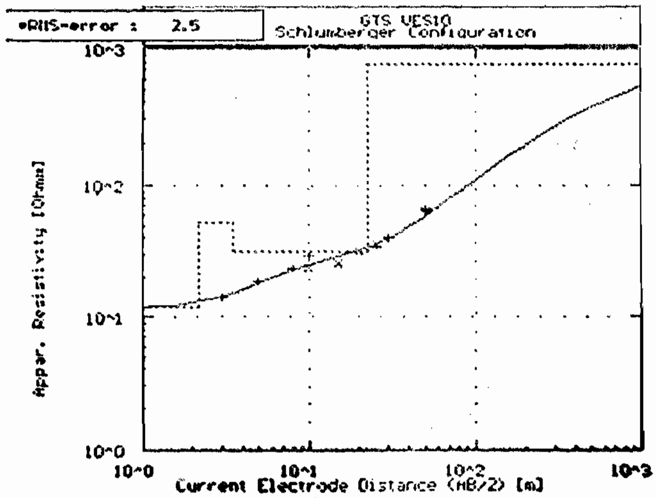
Fig. 1: Sketch map of the study area showing the VES stations.



No	Res	Thick	Depth
1	32.0	2.4	2.4
2	21.0	2.9	5.3
3	56.0	19.5	24.8
4	250.0	-.-	-.-

* RMS on smoothed data

Fig. 2: Interpreted Schlumberger Depth Sounding Curve -VES 7.



No	Res	Thick	Depth
1	11.8	2.2	2.2
2	51.9	1.3	3.5
3	31.9	18.6	22.1
4	766.8	-.-	-.-

• RMS on smoothed data

Fig. 3: Interpreted Schlumberger Depth Sounding Curve -VES 10.

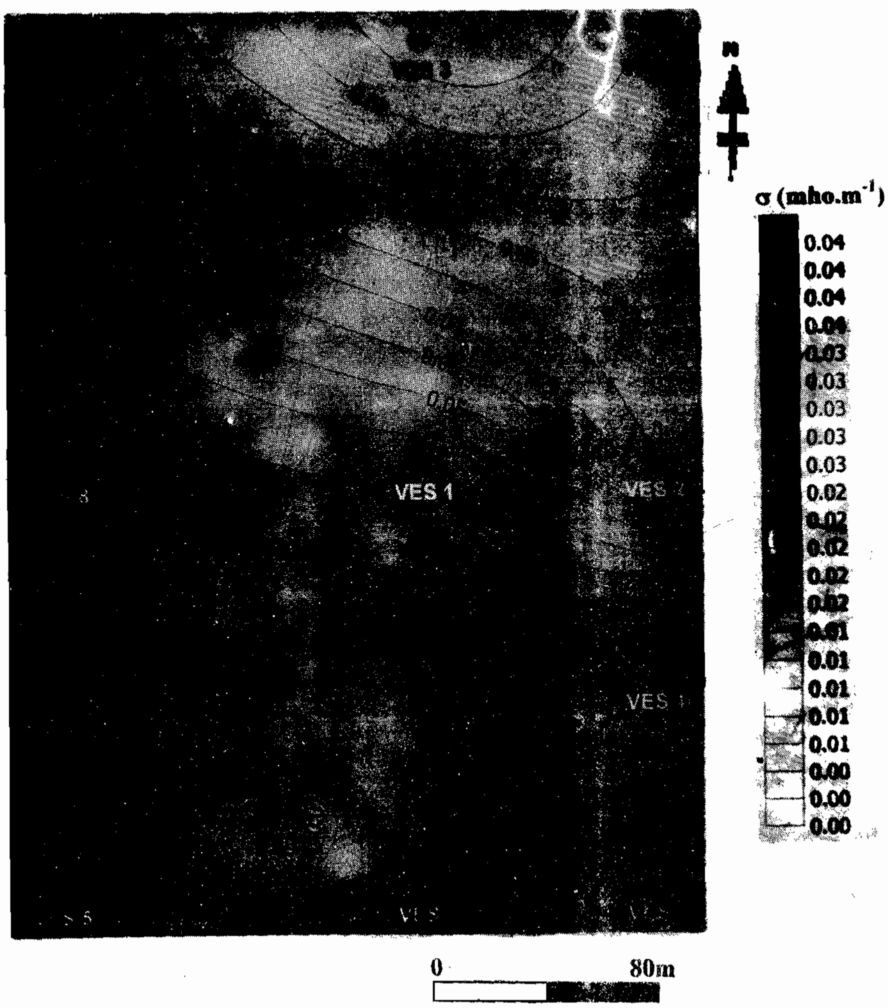


Fig. 4: Isoconductivity map of the topsoil of the study area.

ISOCONDUCTIVITY MAPS

The isoconductivity maps (Figs. 4-6) show the areal distribution of the conductivity of the study area at different depths. The isoconductivity map of the topsoil (Fig. 4) shows that the topsoil is generally conductive. The degree of conductivity increases southward of the study area. The isoconductivity map of the area at 5m depth (Fig. 5) also shows that the layer directly underlying the topsoil is very

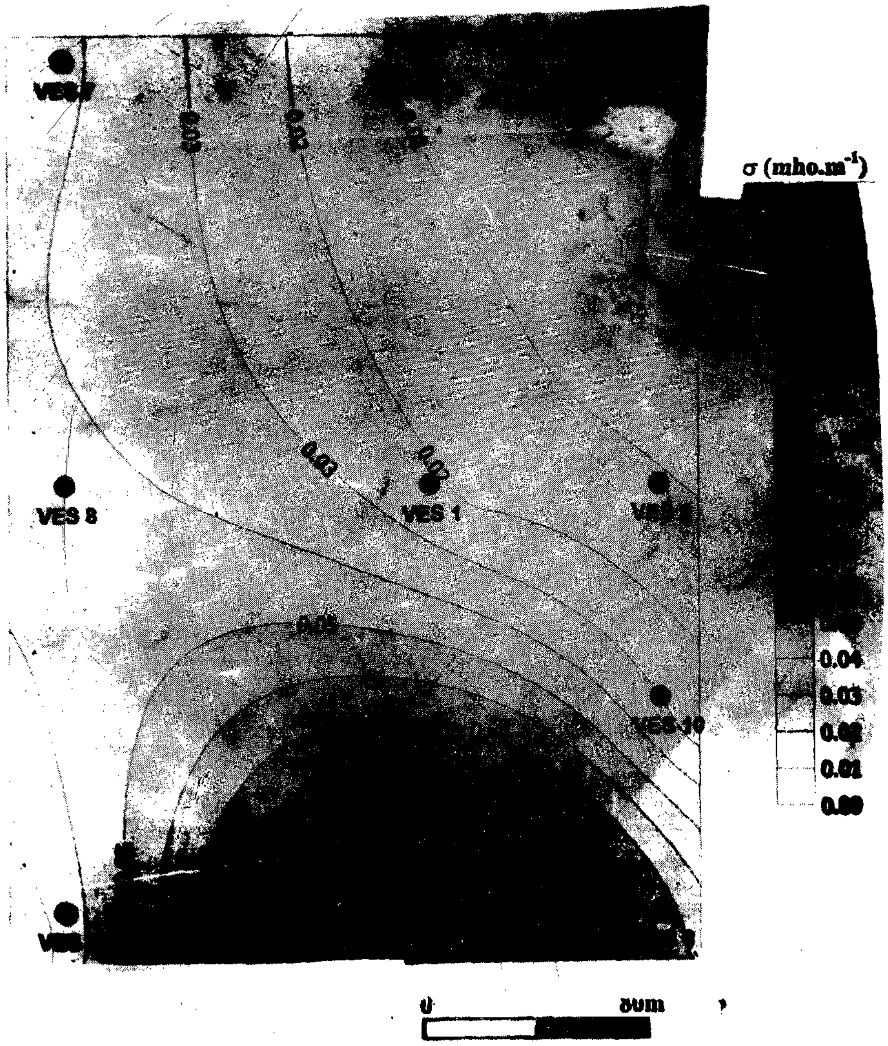


Fig. 5: Isoconductivity map of the study area at the depth of 5m.

conductive. It is most conductive beneath VES 9. The distribution pattern further shows that the southern part of the study area is still more conductive. The isoconductivity map of the study area at 10m depth (Fig. 6) shows that the conductivity of the area has reduced considerably with depth. However, the layer beneath VES 8 and 10 is slightly conductive.

3D GEOELECTRIC SECTION

The geoelectric section (Fig. 7) shows the vertical distribution of the resistivities beneath the VES stations (with depth). The first layer is the topsoil that it is very conductive. Its conductivity varied from 0.0069 to 0.0833mho.m^{-1} and its thickness varied from 0.5 to 4.0m. It is basically made up of clay. However, it is expected to be sandy beneath VES 3.

Beneath the topsoil is the second layer that is also made up of clay and it is conductive. The conductivity of this layer varied from 0.0098 to 0.0909mho.m^{-1} while its thickness varied from 3.4 to 25.7m. This layer is very thin beneath VES 3 but it has considerable thickness beneath VES 10.

The third layer is partially weathered/fresh basement. It is the least conductive layer. Its conductivity varied from 0.00003 to 0.0047mho.m^{-1}. This layer is highly resistive beneath VES 4, 5, 8 and 9.

CONCLUSIONS

Three major geoelectric layers were delineated within the study area namely; topsoil, clay, and partially weathered/fresh basement. The topsoil and the clay layers are the main conductive soils in the area.

The topsoil is generally conductive though slightly resistive beneath VES 3. However the layer is relatively thin and it is not recommended for the earthling of the electrical materials. The second layer is made up of clay that is very conductive. The thickness of this layer is considerable and should be able to neutralise external charges. Therefore the first and second layers are recommended for the earthling of the electrical materials. The recommended depth is between 1.5 and 2.0m. This depth is just beneath/within the topsoil and the underlying conductive clay formation.

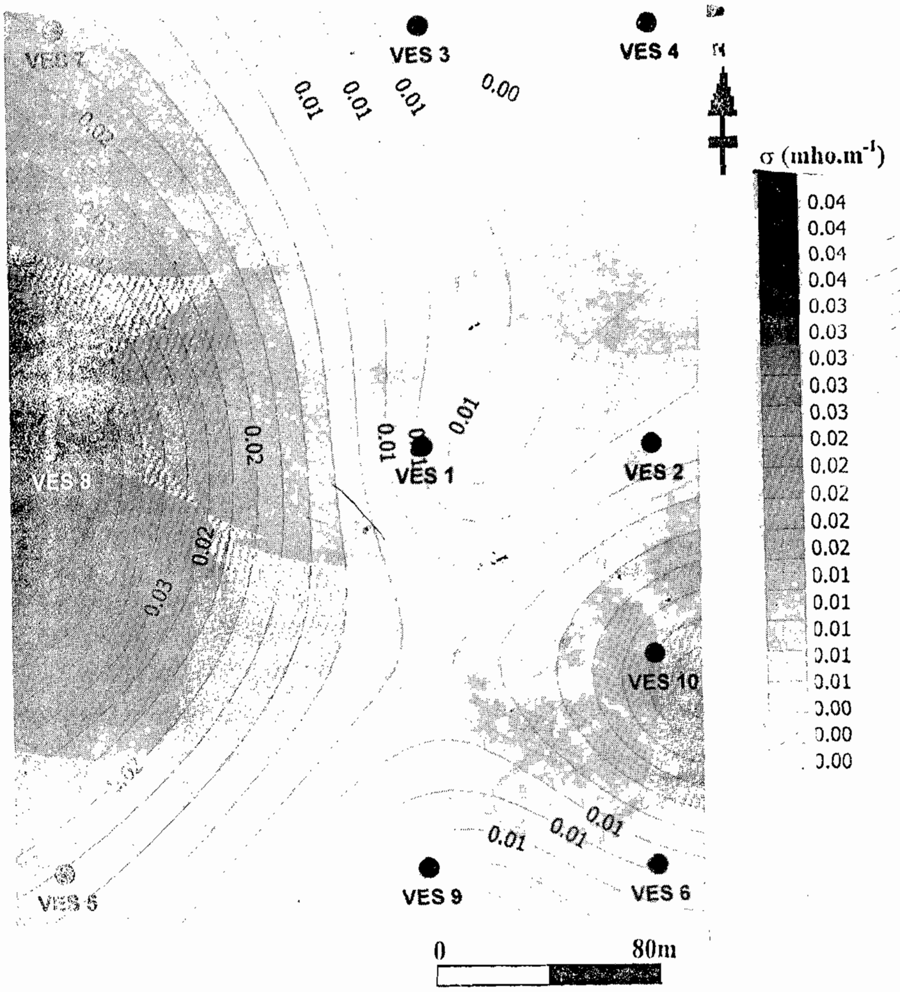


Fig. 6: Isoconductivity map of the study area at the depth of 10m.

The third layer in the study area is the partially weathered/fresh basement. It is highly resistive and so it is not recommended for earthling.

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