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APPLICATION OF GEOPHYSICAL INVESTIGATION TO THE SYSTEM EARTHING OF BUILDINGS AT THE PHASE II OF FEDERAL UNIVERSITY OYE-EKITI, NIGERIA

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Abstract

Geoelectric method was employed in the investigation of the subsoil around the Phase II of the Federal University, Oye-Ekiti, Nigeria for the purpose of Electrical Earthing. Horizontal Profiling using Wenner array, Vertical Electrical Sounding using Schlumberger Array and 2-D imaging with dipole-dipole array were employed along four traverses in the area. The geoelectric sections developed from VES interpretation revealed four subsurface geologic layers, which comprise of the topsoil (sandy clay), the laterite, weathered rock and the bedrock. The topsoil has resistivity values that range from 68 to 240 Ohm-m and thickness ranging from 0.65 to 1.1 m. The second layer is made up of laterite with resistivity values range from 140 to 557 Ωm and thickness ranging from 0.5 to 14.0 m. The third layer is made up of the weathered rock with resistivity ranging from 38 to 384 Ωm and thickness ranging from 2.1 to 18.5m. The resistivity of the basement bedrock varies from 314 to 885 Ωm. Wenner profiling and 2D imaging also revealed averagely low resistivity topsoil. The study showed that most of the electrical problems experienced in Phase II, Federal University Oye-Ekiti are not soil related earthing problem because of the suitability of the topsoil. However, the areas with resistivity values that range from 25-60 Ωm with distance ranging from station 100-150 m at depth of 0.8 m along traverse 2 was found to be the most suitable area for earthing sensitive laboratories and equipment.

1.0 Introduction

Earthing can be said to be the connection of the neutral point of power supply system to the earth to avoid or minimize danger during discharge of electrical energy. This is done to avoid or reduce the danger of electrocution, fire due to leakage of current through undesired path and to ensure that the potential of a current carrying conductor does not rise with respect to the earth than its designed installation. In order to meet electrical safety standards, it is imperative that the high voltage appliances (i.e. laboratory equipment) be placed in a safe conductive medium; hence, the earthing medium must have high electrical conductivity or low electrical resistivity. Clays are characterized by low layer resistivity values in the 1-100Ωm range and hence are good earthing medium. One of the main objectives of earthing electrical systems is to establish a common reference potential for the power supply system, building structure, plant steelwork, electrical conduits, cable ladder and trays and the instrumentation systems. To achieve this objective, a suitable low connection to the earth is desirable. However, this is often dependent on a number of factors such as soil resistivity, stratification, size and type of electrode used, depth to which the electrode is buried, moisture and chemical content of the soil [1]. In many areas of human developmental programmes, especially development of infrastructures, environmental studies, geophysical applications are essential [2, 3, 4]. Therefore, the geophysical investigation involving electrical resistivity method is very useful in determining conductive medium in which the earthing installations will be carried out. Various authors have showed how to apply these geophysical techniques in ground resistance testing for proper down conductors grounding systems [3, 5, 6, 7, 8]. Most of their methods involve direct measurement of soil resistivity across the area of interest. Federal University Oye-Ekiti, Phase II hosts the science laboratories of the university. Electrical earthing problems such as electrical shock from the laboratory equipment, leakage current, melting of Van de Graaf generator belt (Physics Laboratory), dimming of light etc. are the common experiences during practical class. Therefore, there is need for assessment of the integrity of the earthing system of the buildings and find suitable area forearthing of the buildings under construction. Horizontal Profiling (HP) techniques using Wenner Array, Vertical Electrical Sounding (VES) with Schlumberger array and combined HP/VES using dipole-dipole array were employed.

2.0 Location and geology of the study area

The federal University Oye-Ekiti main campus is situated in Oye-Ekiti town along Are-Afao locality of Ekiti State. The climate condition of the study area is characterized by dry and wet season in a year. The dry season occurs between November and March. The months of December and January are the driest. The wet season lasts between April and October. The annual rainfall is about 1600mm, while the average daily temperature is 29ºC. The topography of the study area is gently undulating with an average elevation of 380m above the sea level. As shown in Figure 1, the study area is predominantly underlain by migmatite-gneiss [9, 11]. Olusiji [14] revealed three dominant lithological units namely: banded-gneiss, migmatite-gneiss, and granite-gneiss and also confirmed the preponderance of different types of folded structures such as pegmatic, recumbent, disharmonic and asymmetric folds which trend E-W to NNE-EEW. Other structures such as dykes, joints, quartz-veins, fractures and micro faults were detected on the rocks.

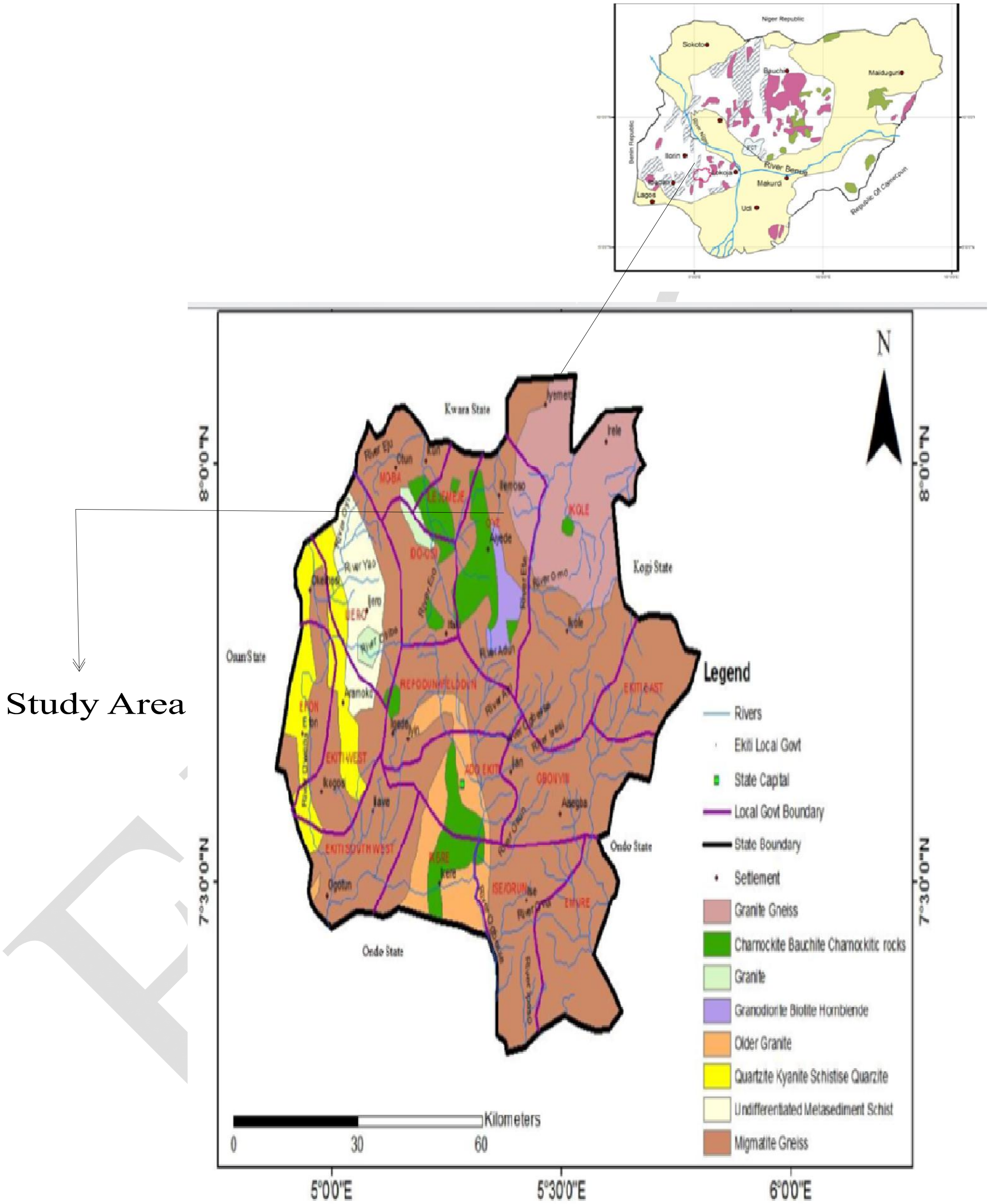


Fig.1: Geological map of the study area. (modified after Bayowa *et al*., 2014) [9]

3.0 Methodology

Reconnaissance survey of the study area was carried out using compass clinometer and GPS in order to construct the basemap of the area with surfer 10 software (Fig. 2). Horizontal Profiling (HP) using Wenner configuration was employed to determine resistivity distribution along traverses TR1 to TR4 with electrode spacing (a) spacing of 10 m and theoretical depth of investigation of approximately 3m.

The survey was followed by six (6) Vertical Electrical Sounding (VES) along Traverse TR2 with inter-station spacing of 20m using Schlumberger configuration with AB/2 varying from 1 to 65 m.The apparent resistivity values (ρ_a) at each station were plotted against half electrode spacing (AB/2) on a bi-logarithmic graph to generate sounding curves. Partial curve matching was carried out for the quantitative interpretation of the curves. The results of the curve matching (layer thickness and resistivity) were fed into the computer as starting model parameters in a 1-D forward modelling using the Win Resist software [13]. From the interpreted results, geoelectric sections were generated.

2D imaging using dipole-dipole configuration with dipole length of 10m and expansion factor (n) varying from 1 to 5 along traverse TR2. The data is processed with dippro for window software and display inform of 2D imaging.

4.0 RESULT AND DISCUSSION

4.1 Wenner results

The Wenner profiles were processed using the Microsoft Excel software by plotting apparent resistivity values against distance (m) (Figure 3) and interpreted qualitatively to determine the area of low resistivity suitable for electrical earthing.

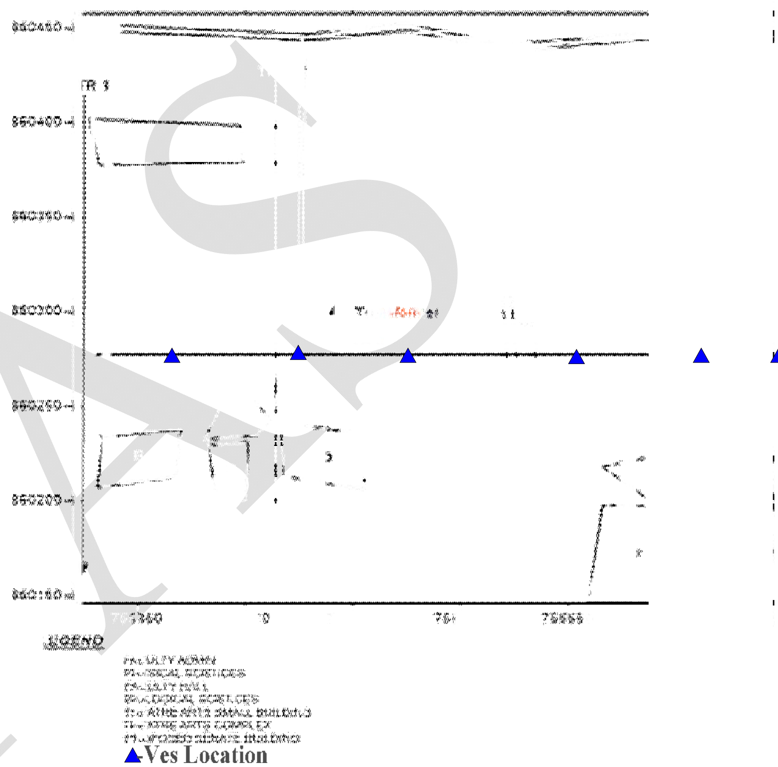


Figure 2: Base map of the study area.

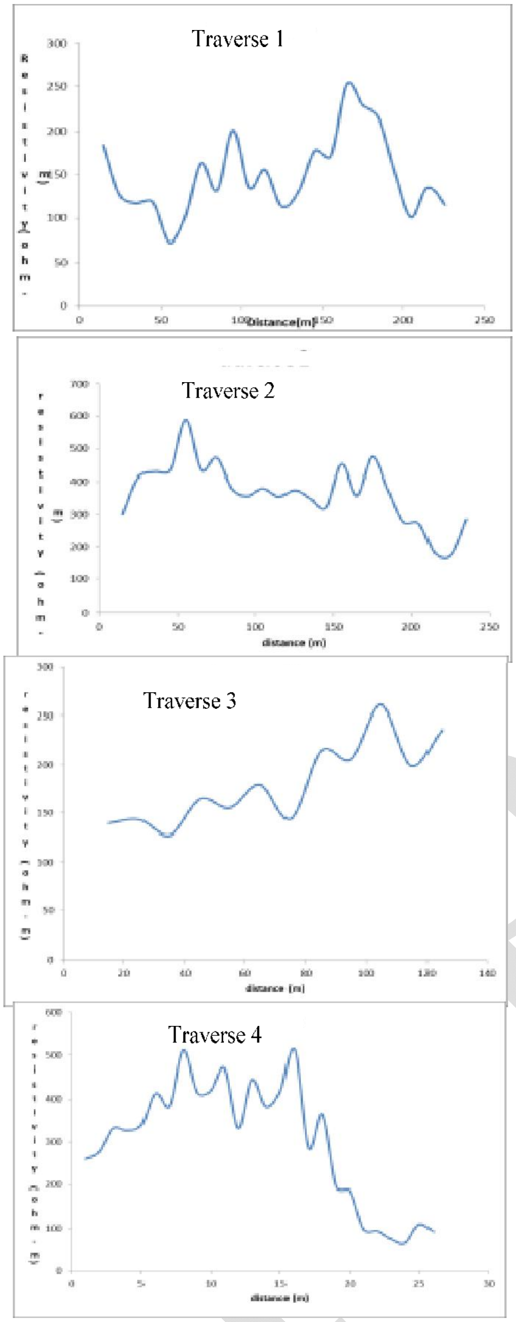


Figure 3: Horizontal Profiling Curves.

The results show that lowest apparent resistivity along traverse TR1 ranges between 60-75 Ωm at stations 50-70 m. The traverse TR2 has its lowest resistivity range between 110-120Ωm at stations 80-150 m. The traverse TR3 has its lowest resistivity range between 120-135Ωm at stations 30-40m and traverse TR4 has its lowest resistivity range between 50-80 Ωm at stations 20-25 m.

Figure 3: Horizontal Profiling Curves.

4.2 Vertical Electrical Sounding

The sounding curves are shown in Figures 4a - 4f. The VES curves showed KH curve type for all the VES stations which means that the topsoil or weathered layer are the most suitable for earthing purpose. The geoelectric parameters (Table 1) are interpolated to generate geoelectric section to have 2D overview of the subsurface. The section identified four geoelectric layers comprising of the topsoil, lateritic layer, weathered layer and basement bedrock.The geoelectric characteristics are as following:

(i) Topsoil: The topsoil varies in composition from clay to sandy claywith resistivity values varying from 68 to 180Ω-m. The thickness of the topsoil varies from 0.7 to 1.1m (Figure 5).

(ii) Lateritic Layer: The lateritic layer has resistivity value varying from 140 to 557Ω-m (Figure 5). The thickness of the lateritic layer varies from 0.5 to 6.8m.

(iii) Weathered Basement: The weathered layer varies in composition from clay to sand with resistivity values varying from 38Ω-m to 354Ω-m. The thickness of the weathered layer varies from 2.1 m to 18.5m.

(iv) Basement Bedrock : The resistivity of the fresh basement varies from 314 to 885 Ωm

Table 1: Table showing the VES interpretation results

VES	ρ_1 (Ωm)	ρ_2 (Ωm)	ρ_3 (Ωm)	ρ_4 (Ωm)	h_1 (m)	h_2 (m)	h_3 (m)	Curve Type
1	240	557	282	593	1	3.9	19.7	KH
2	99	156	94	885	1	7.6	32.4	KH
3	68	158	38	314	1	14	3.3	KH
4	172	475	384	737	0.65	0.46	2.09	KH
5	184	418	249	720	1.1	5.83	4.75	KH
6	97	140	118	373	1.1	3.85	9.96	KH

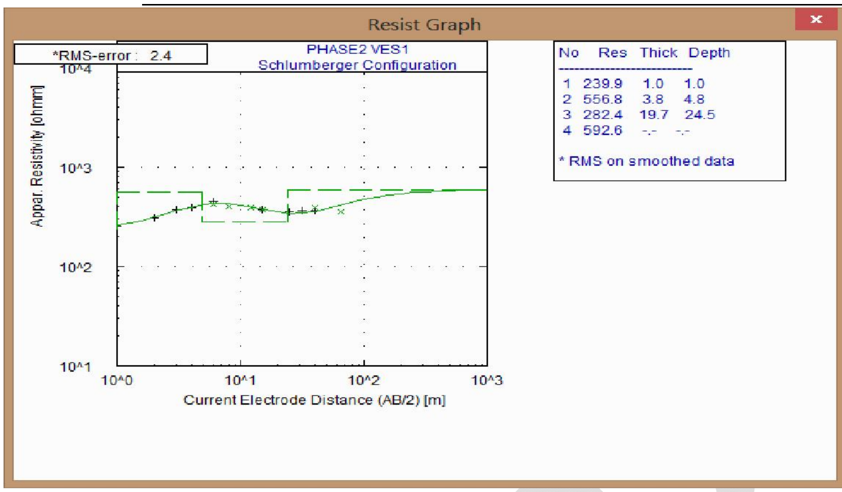


Fig 4a: VES 1 result on traverse 2.

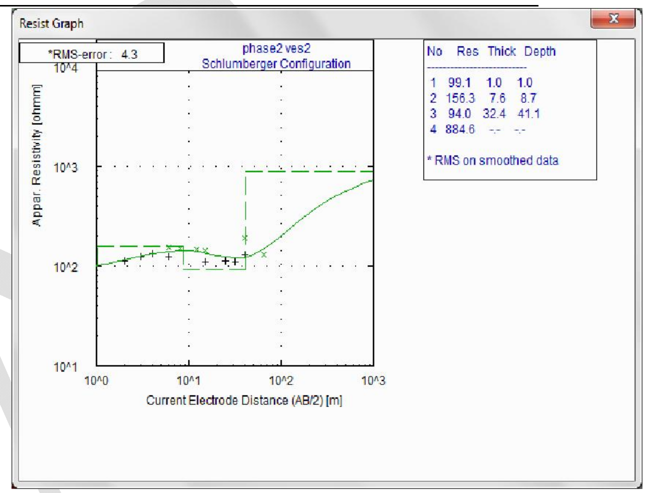
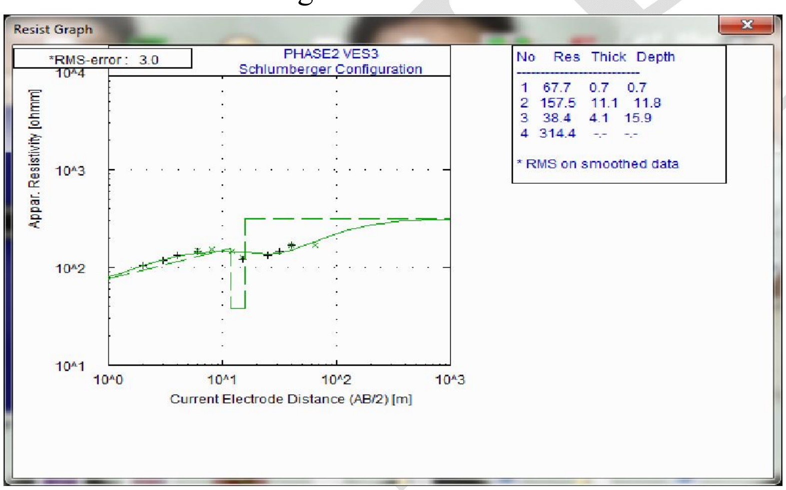


Fig 4b: VES 2 result on traverse 2.



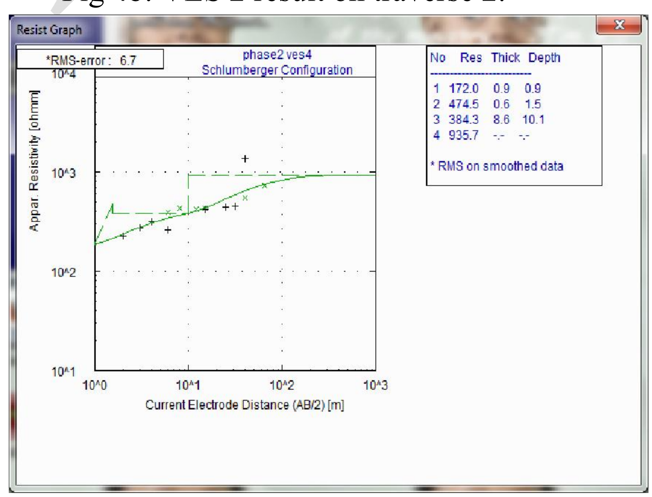
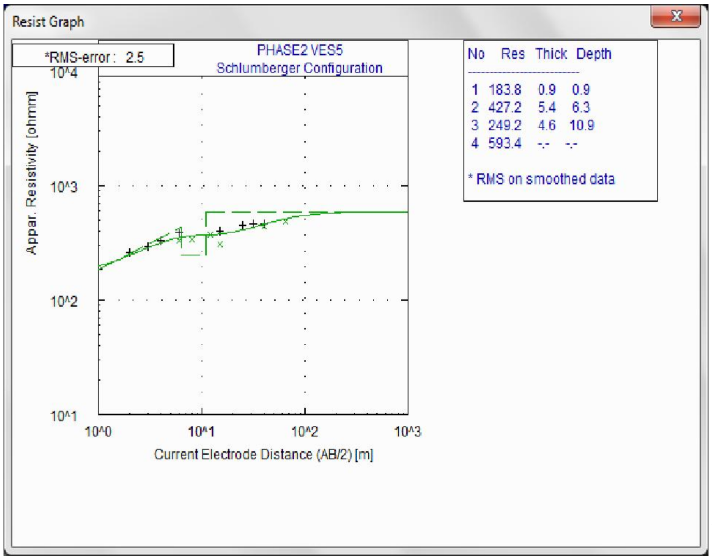


Fig 4c: VES 4 result on traverse 2. Fig 4d: VES 4 result on traverse.



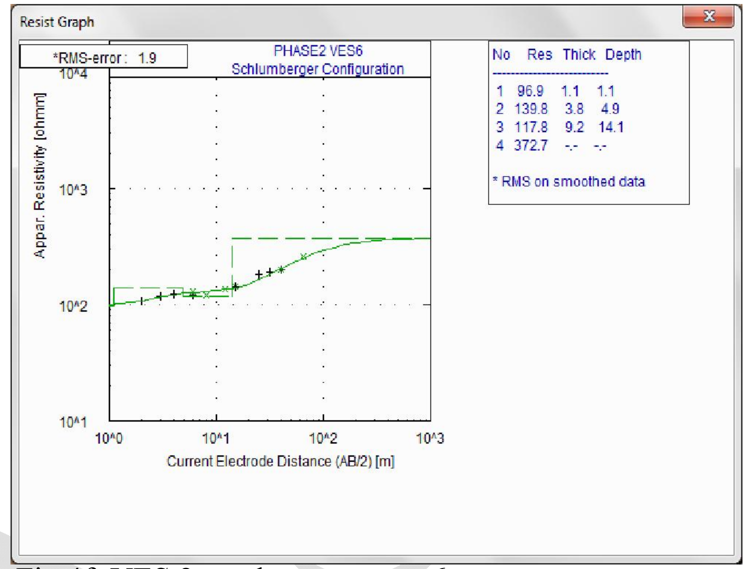


Fig 4e: VES 1 result on traverse 4. Fig 4f: VES 2 result on traverse 6.

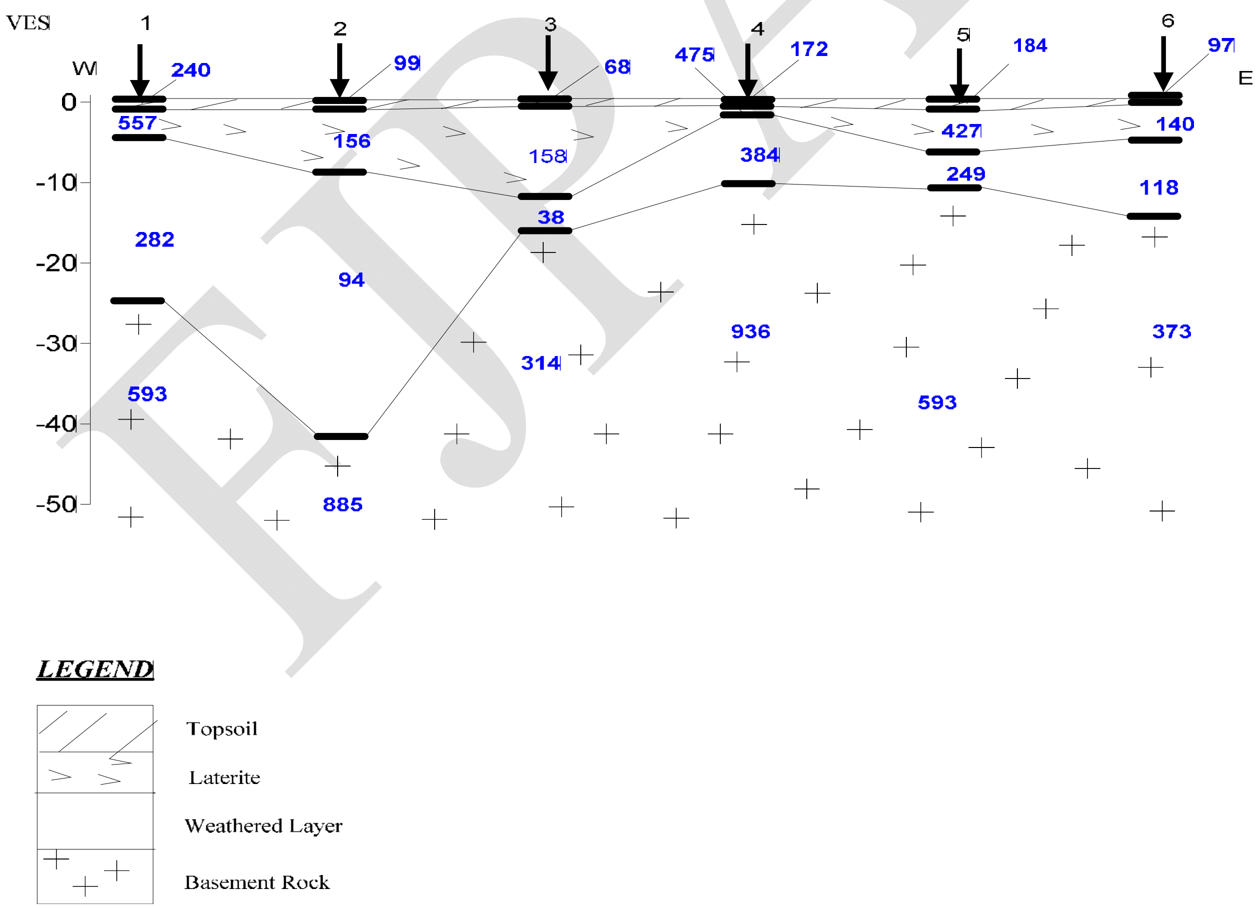


Fig 5: Geoelectric section along Traverse 2

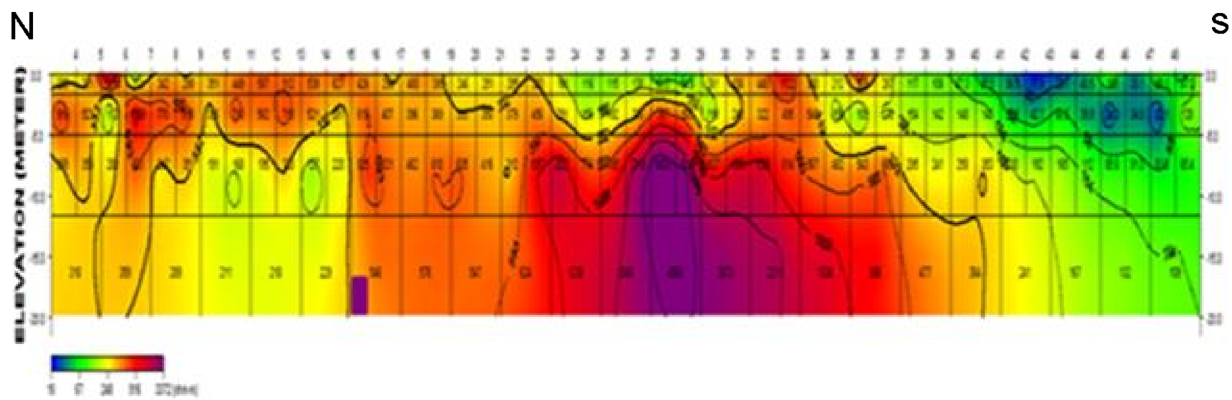


Figure 6: 2-D section of the dipole-dipole imaging (Traverse 2)

Generally, it was observed that though there are effective area of low resistance that might be exploited for earthing purpose in 100-150m on traverse 2 were found to be the most suitable area for earthing laboratories because of the sensitivity of the equipment, although this might need improvement on the conductivity of the soil by using a clay chamber or charcoal chamber.

5.0 Conclusion

The geophysical survey employed the Vertical Electrical Sounding technique using Schlumberger configuration, Wenner and Dipole-dipole configurations were adopted to determine area of low resistivity for electrical earthing within Phase II of Federal University Oye-Ekiti. The Vertical Electrical Sounding revealed four subsurface geologic layers, which comprise of the topsoil, laterite, weathered layer and basement bedrock. The topsoil varies in composition from clay to sandy clay with resistivity values varying from 68 to 180Ω-m. The thickness of the topsoil varies from 0.7 to 1.1m. The lateritic layer has resistivity value varying from 140 to 557Ω-m. The thickness of the lateritic layer varies from 0.5 to 6.8 m. The weathered layer varies in composition from clay to sand with resistivity values varying from 38 Ω-m to 354 Ω-m. The thickness of the weathered the topsoil, however, the areas with resistivity values that ranges from 25-60Ωm within the distance ranging from station layer varies from 2.1 m to 18.5 m. The resistivity of the basement bedrock varies from 314 to 885Ωm.The VES results showed KH curve type for all the VES points. The KH curve indicates the presence of clayey/sandy clay topsoil which is underlain by laterite. Wenner profiling and 2D imaging also revealed averagely low resistivity topsoil. The study showed that most of the electrical problems experienced in Phase II, Federal University Oye –Ekiti are not soil related earthing problem because of the suitability of the topsoil. However, the areas with resistivity values that ranges from 25-60Ωm with distance ranging from station 100-150m at depth of 0.8m along traverse 2 was found to be the most suitable area for earthing sensitive laboratories and equipment.

References

[1] LEM (2005): Electrical Grounding Techniques, A 99415 E publication, Ground Resistance –Principles, Testing, Techniques and Applications. Accessed from http://www.lem.com in June 2016.

[2] Herman , R (2001) An introduction to electrical resistivity *in geophysics.* Vol 69, pp 943-944.

[3] Akintorinwa O. and Adesoji ,I. (2009: Geo-electrical investigation for subsurface electrical system earthing. School of management technology, Federal University of Technology, Akure, Nigeria, *International Journal of Physical Sciences* Vol. 4 (8), pp 443-454.

[4] Ofomola ,O., Adiat ,A., Olanyanju ,J (2009) Integrated geophysical methods for post foundation studies, Obanla staff quarters of the Federal University of Technology, Akure,Nigeria. *The pacific journal of science and technology*, 10 (2), pp 333-359.

[5] Beackman ,W. and Schweak ,W., (1976) Handbook on cathodic protection. Theory and practice of electrochemical corrosion protection techniques. *Portucullus press survey*, London.

[7] Merger, (2005) Getting down to earth. A practical guide to earth resistance testing. Accessedfrom http://www.merger.com in June 2016.

[8] AEMC, (2012) Understanding Ground Resistance Testing. AEMC Instruments,USA. Accessed from http://www.aemc.com in June 2016.

[9] Bayowa O.G., Olorunfemi M.O., Akinluyi F.O., and Ademilua O (2014) Integration of Hydrogeophysical and remote Sensing Data in the Assessment of Ground water Potential of the Basement Complex terrain of Ekiti state, Southwestern Nigeria. *Ife Journal of Science* vol. 16, no. 3 (20)

[10] Iloeje, N.P., (1981): A new geography of Nigeria (New revised edition). Longman Nig. Ltd., Lagos, pp.201.

[11] Rahaman, M. A., (1988) Recent Advances in the study of the Basement Complex of Nigeria (In) Precambrian Geeology of Nigeria, second edition, pp 11-45.

[12] Ayodele Olusiji Samuel (2013): Geology and structure of the precambrian rocks in Iworoko, Are and Afao area, Southwestern Nigeria. *International Research Journal of Natural Sciences* Vol.1, No. 1, March 2013, pp14-29.

[13] Vander Velper BPA(1988) Resist version 1.0, Msc. Research project, ITC, Delf Netherland.

[14] Olusiji S.A (2013) Geology and Structure of Precambrian rocks in Iworoko, Are and Afao, Southwestern Nigeria; International Research Journal of Natural Sciences. 1(1), pp14-29