Journal of the Nigerian Association of Mathematical Physics
Volume **19 (November, 2011), pp 329 – 334**

Geoelectric Investigation for the Delineation of the Subsurface in Ologbo and Ajoki, Edo State.

C.O. Aigbogun and B. O. Eromosele
Department of Physics,
University of Benin, Benin City.

Abstract

Geoelectric investigation was carried out in Ologbo and Ajoki, in Edo State, to delineate the subsurface in the area. The purpose of this study was to analyse the number of model layers, their resistivities, thicknesses and depths, as it is related to smooth and equivalence layers and also to know the number of suppressed layers. During the study, 7 VES were carried out in selected locations using the Schlumberger array. The maximum electrodes spacing was 294 m. The data collected were interpreted by curve matching and computer iterations. The curve types identify for the locations were KQH, HAK, KHK, HK, and KH with various layer resistivities and thicknesses and depths. Also 4-5 model earth layers, 14-smooth and 14-equivalence earth layers were encountered which implies that some layers have been suppressed.

Keywords: Geoelectric, Delineate, Vertical Electrical Soundings, Schlumberger array.

1.0 Introduction

The aim of this study is to determine the feasibility of using the geoelectric method for the following purposes in Ologbo and Ajoki: resistivity, depth and thickness determination of the model earth layers, estimation of the number of smooth and equivalence layers corresponding to the number of model earth layers (stratigraphic correlation) [1, 2, 3].

The VES methods were introduced by Schlumberger in 1934. Since then a wide variety of VES arrays were developed [4], but the Schlumberger array remained as the best array for depth sounding. However, application of the VES techniques were until recently, limited to shallow investigations, mainly because electronic measuring devices of sufficient sensitivity were not available except in bulky forms, and partly because deeper penetration would have meant a wider variety of resistivity layers than could possibly be incorporated in any set of standard curves provided the only means of interpretation by the standard curve techniques. The recent advances in electronics and the advent of high-speed computers made it possible to penetrate to large depths, while using portable equipment, and to interpret the result without the limitations imposed by the standard resistivity curve albums.

2.0 Brief geology of the area

The study area is underlain by the continental sand of the Benin formation figure 1. The geology of the area have been describes by several authors including [5, 6]. The subsurface sedimentary sequence has been sub-divided into three stratigraphic units; the Benin, Agbada and Akata formations. The lithological units of this area are generally composed of sands and clayey-sand. The area has a flat topography. Ologbo and Ajoki are bounded by coordinates N5^o 53^1 E5^o 58^1 and N6^o 2^1 E5^o 27^1 respectively.

3.0 Theory

The theory of this research is taken from [7]. In resistivity sounding, four electrodes are earthed along a straight line in the order of AMNB (with AB as current electrodes and MN as potential electrodes). The apparent resistivity for Schlumberger array is calculated according to:

$$\rho_a = \pi\left[\frac{a^2}{b} - \frac{b}{4}\right].\frac{\Delta V}{I} \quad (1)$$

Where a = half current electrodes spacing
b = potential electrodes spacing

ΔV and I represent the difference in milliVolts and current intensity in milliAmperes respectively. The data interpretation techniques used is seeking a solution to the inverse problem for the determination of the subsurface resistivity distribution from surface measurements.

Corresponding authors: C.O. Aigbogun, E-mail: -, *Tel*.: +2348023347509.

A very good solution to the inverse problem is the kernel function. It is used in the interpretation of apparent resistivity measurements in terms of lithology variation with depths [8]. The function assumes the earth to be locally stratified, inhomogeneous and isotropic layers, and unlike apparent resistivity function, it is independent of electrode configuration. It cannot be measured in the field but has been obtained from the transformation of measured apparent resistivities. The Kernel function used in this work is derived after [9, 10], if the observed apparent resistivity is given by:

$$\rho_a(r) = r^2 \int_o^\infty \lambda T(\lambda) J_1(\lambda r) dr \qquad (2)$$

Then the Kernel is given by [8] as:

$$T(\lambda) = \int_o^\infty \frac{1}{r} \rho_a(r) J_1(\lambda r) dr \qquad (3)$$

Where J_1 is the first order Bessel function of the first kind and $T(\lambda)$ is the transformed resistivity data.

Figure 1: Map of the study Area

4.0 Methods

The Schlumberger array was used in the soundings for this study; details of the method have been documented [11]. The instrument used for data acquisition was the ABEM SAS 300C Terrameter with SAS 2000 Booster for proper penetration of current at the subsurface.

Seven locations were selected: VES 1, 2, and 3, at Ologbo and VES 4, 5, 6, and 7 at Ajoki. Measurements of the apparent resistivity were taken as the current electrodes were spaced subject to the ratio of $AB \leq 5MN$ in order to ensure error reduction in field data collection. The maximum current electrodes spacing was 294 m at six points per decade. The accuracy and efficiency of six points per decade in subsurface investigation in the Niger Delta basin have been documented earlier [12]. The end result of the field measurements is the computation of the apparent resistivity using equation (1).

The apparent resistivity values were plotted against the half current electrodes spacing, using log-log graph sheet. The data were adjusted by smoothing, and curve matched before iteration in a computer assisted programme. The resulting sets of layer parameters were interpreted in terms of their geoelectric equivalents.

5.0 Discussion of Results

The result of the interpretation of the various VES in Table 1 showed the geoelectric layers resistivities, thicknesses and depths, also the model earth layers and the corresponding smooth and equivalence layers. The prominent curve types identify for the locations were KQH, HAK, KHK, HK, and KH with various layer resistivities and thicknesses. Also 4-5 model earth layers, 14-smooth and 14-equivalence earth layers were encountered which implies that some layers have been suppressed. The analysis of the data using Interpex I x 1D v2 computer software shows the corresponding Smooth and Equivalence layers to the model earth 5-layers for VES 1 (see Table 1, Figures 2, 3b and 4b). The same analysis is also applicable to Figures 5, 6b and 7b as well as other VES locations indicated in Table 1.

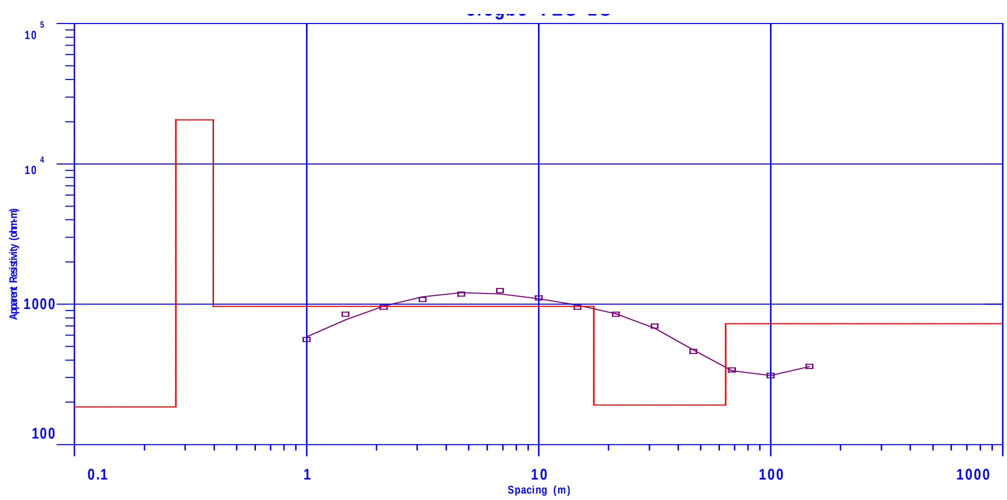
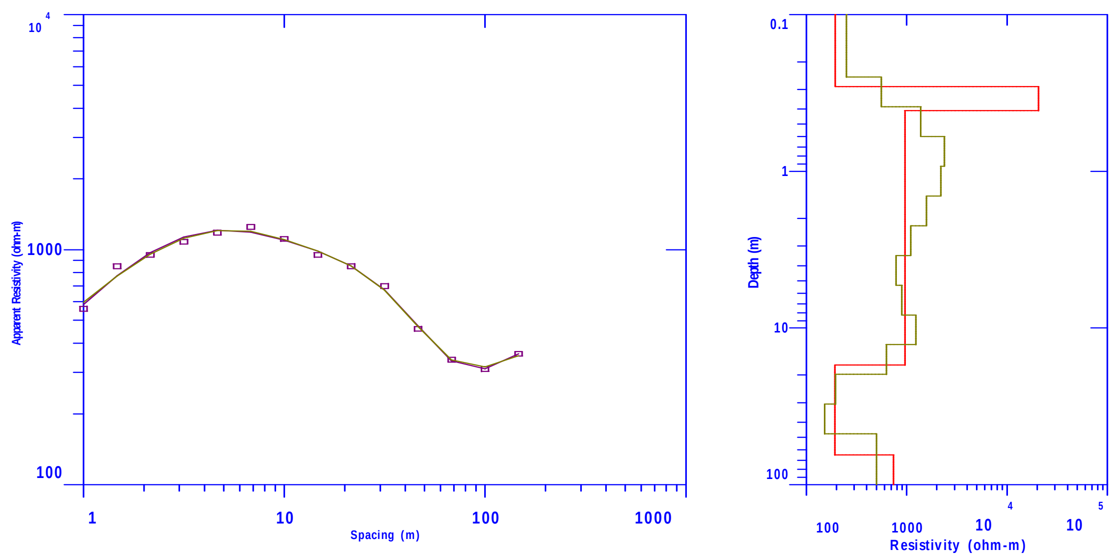
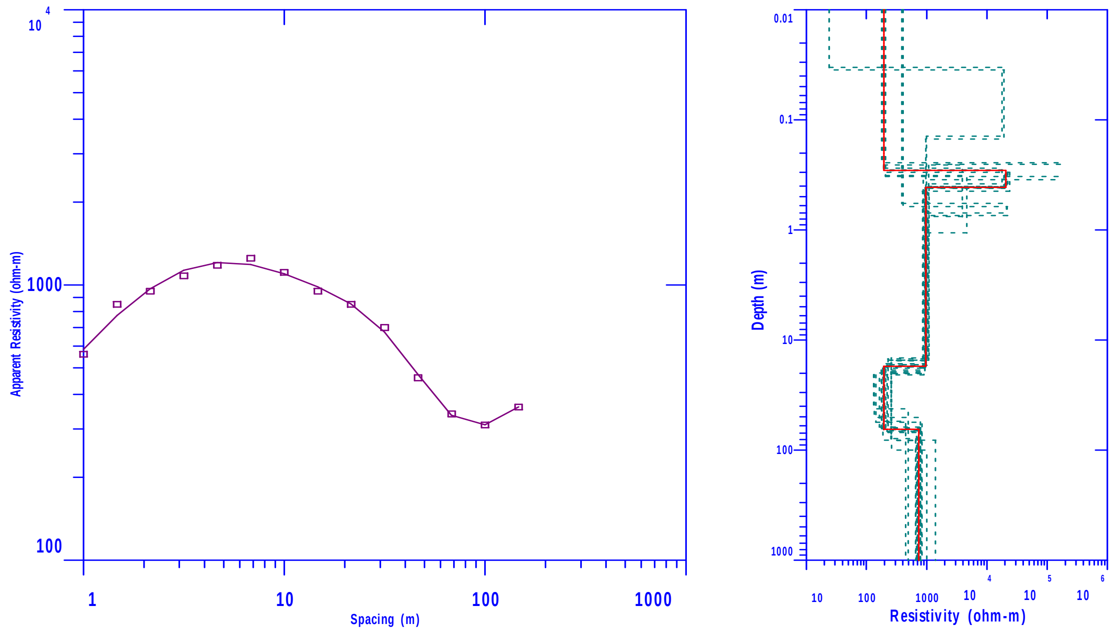


Figure2: Apparent Resistivity versus Spacing at Ologbo VES 1, showing Model Earth Layers.



(a) **(b)**

Figure 3: Ologbo VES 1: (a) Schlumberger VES Curve (b) Smooth Model Earth layers



(a) **(b)**

Figure 4: Ologbo VES 1: (a) Schlumberger VES Curve (b) Equivalence Model Earth Layers

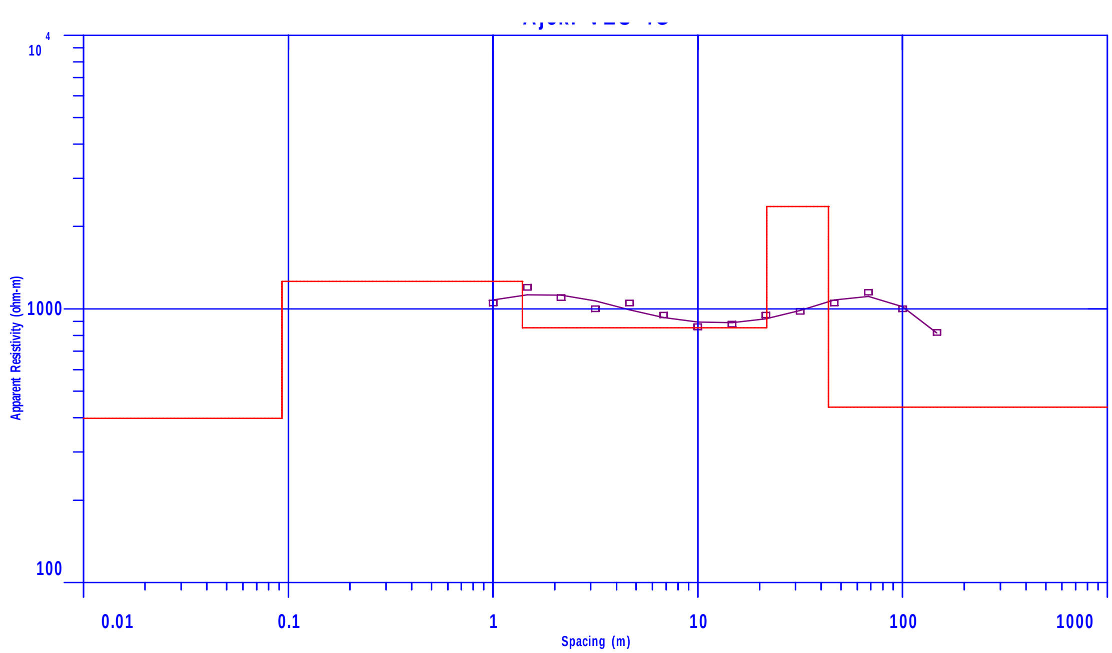
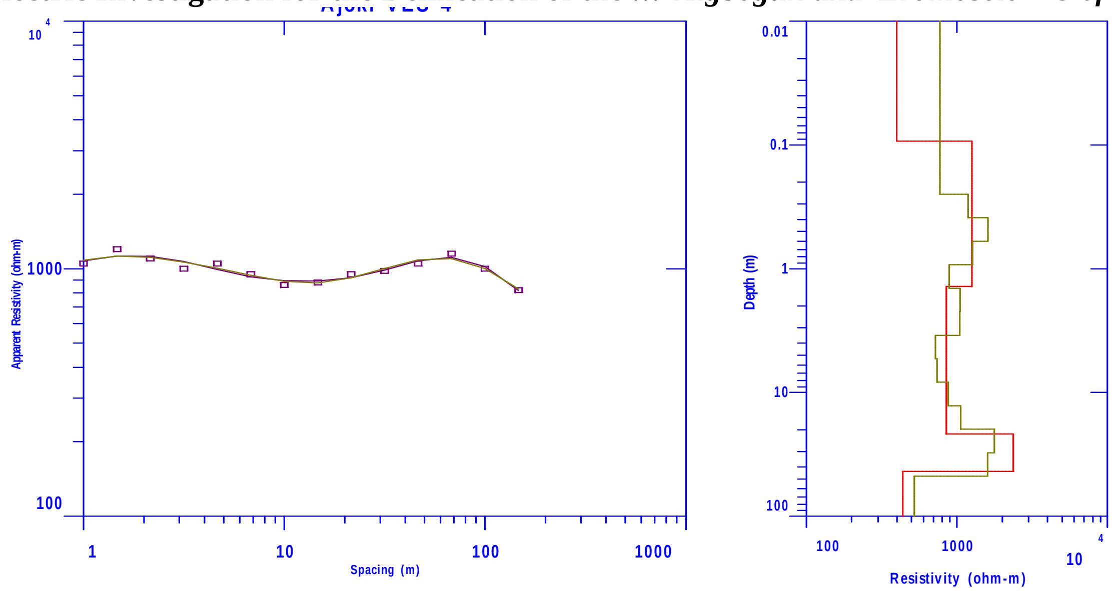
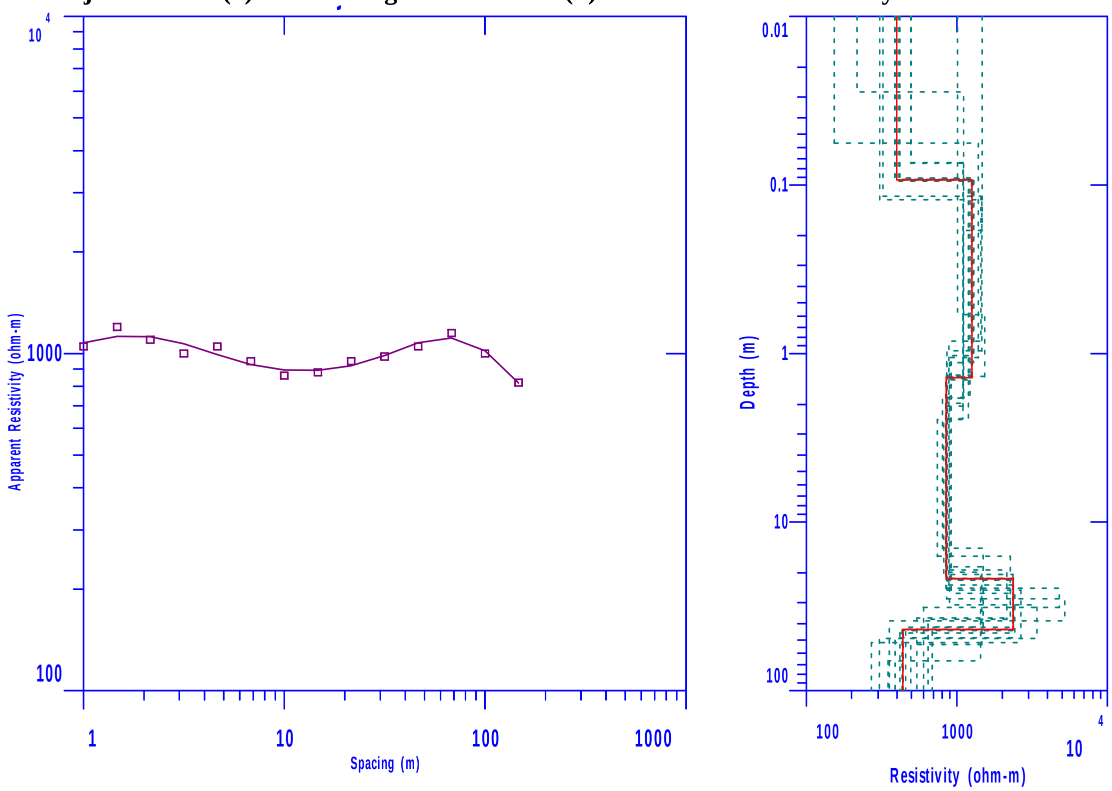


Figure 5: Apparent Resistivity versus Spacing at Ajoki VES 4, showing Model Earth Layers



(a) **(b)**

Figure 6: Ajoki VES 4: (a) Schlumberger VES Curve (b) Smooth Model Earth Layers



(a) **(b)**

Figure 7: Ajoki VES 4: (a) Schlumberger VES Curve (b) Equivalence Model Earth Layers

Table 1: Geoelectric Section showing characteristics of the Subsurface

VES No.	Geoelectric layers	App. Resistivity (Ohm-m)	Thickness(m)	Depth(m)	Smooth layers	Equivalence layers	Curve Types
1	1 2 3	185.2 20643.8 962.1	0.3 0.1 16.9	0.3 0.4 17.3	14	14	KQH

	4 5	191.9 726.5	46.5	63.8			
2	1 2 3 4 5	417.8 57.3 1169.8 2225.1 50.1	0.5 6.3 11.5 31.4	0.5 6.8 18.3 49.7	14	14	HAK
3	1 2 3 4	360.5 288.2 5996.9 987.9	1.6 1.4 1.7	1.6 3.1 4.8	14	14	HK
4	1 2 3 4 5	397.6 1259.3 851.8 2364.6 437.3	0.1 1.3 20.3 21.7	0.1 1.4 21.7 43.4	14	14	KHK
5	1 2 3 4 5	237.9 1012.9 263.6 1891.9 246.5	0.3 0.8 15.6 53.8	0.3 1.0 16.7 70.5	14	14	KHK
6	1 2 3 4	901.0 4178.6 347.0 1159.0	0.5 0.5 16.5	0.5 1.0 17.6	14	14	KH
7	1 2 3 4 5	201.5 548.2 137.3 3175.4 736.5	0.2 1.5 6.5 5.0	0.2 1.7 8.1 13.1	14	14	KHK

6.0 Conclusion

The results of the interpretation of the various VES indicates that the area is composed of 4-5 model earth layers, 14-smooth and 14-equivalence layers. That is 4-5 model earth layers was found to be corresponding to 14-smooth and 14-equivalence earth layers using the Interpex I x 1Dv2 computer software after multiple iterations of occam resistivity inversion. We believed more research has to be carried out in this direction to ascertain the ratio of smooth and equivalence layers associated with model earth layers. This study therefore stands as a guide for comparison of model earth, smooth and equivalence earth layers. These different earth layers were encountered at maximum current electrodes separation of 294 m

References

[1] Olayinka, A.I., (1997). Journal of African Earth Sciences, vol. 24 (4), 635-647.

[2] Kunetz, G., (1966). Principles of direct current resistivity prospecting, Borntraeger, Berlin.

[3] Egbai, J.C., (2011). Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 2 (2), 260-265.

[4] Keller, G.V., and Frinschknecht, F.C., (1966). Electrical Methods in Geophysical Prospecting, Pergamon press, New York, 179-187.

[5] Short, K.C., and Stauble, A.J., (1967). A.A.P.G. Bull., vol. 51, pp. 761-779.

[6] Akpokodje, E.U., and Etu-Efeotor, J.O., (1987). Journal of African Earth Sciences, vol.1, pp. 61-65.

[7] Egwebe, O and Aigbogun, C.O.,(2007). Journal of the Nigerian Association of Mathemetical Physics, vol. 11, 387-392.

[8] Muiuane, E.A. Muiuane and Pedersen, L.B., (1999). Journal of Applied Geophysics, 42, 35-45.

[9] Ghosh, D.P., (1971a). Geophys. Prosp. 19(4), 192-217.

[10] Ghosh, D.P., (1971b). Geophys. Prosp. 19(4), 765-775.

[11] Telford, W., Geidart, L., Sherrif, R and Keys, D., (1976). Applied Geophysics, Cambridge University Press, Cambridge, England.

[12] Egwebe, O., (2006). Journal of the Nigerian Association of Mathematical Physics, vol. 10, 77-82.