A Short Note on Comparative Study of Schlumberger and Half Schlumberger Arrays in Vertical Electrical Sounding in a Basement Complex Terrain of Southwest Nigeria.

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ABSTRACT

A geoelectric survey involving the Vertical Electrical Sounding (VES) was conducted with the Schlumberger and Half-Schlumberger arrays in a basement complex terrain of southwest Nigeria with a view to assessing the effectiveness of the Half Schlumberger array as an alternative to the convectional Schlumberger array at sites with space constraints. Ten localities were investigated with both arrays and the resulting VES curves were interpreted using the convectional Schlumberger model and auxiliary curves and 1-D forward modeling involving W-GeoSoft/WinSev 5.1 software. The results of the study were analyzed using cross plots of the deduced geoelectrical parameters. For the different locations investigated, the Schlumberger and Half-Schlumberger curves display similar curve types and geoelectric sequence. The estimated geoelectrical parameters (layer thickness/depth and resistivity values) show significant correlation for both arrays with coefficient of correlation of between 0.95 and 0.99. It is established that the Half Schlumberger array is a viable alternative to the conventional Schlumberger array in resistivity depth sounding in areas with limited space.

(Keywords: comparative study, Schlumberger array, half Schlumberger array, basement complex terrain, southwest Nigeria)

INTRODUCTION

The Sclumberger electrode array is commonly adopted in the Vertical Electrical Sounding (VES) technique due to its field logistic advantage of having to move only two electrodes at a time. This reduces the man power requirement thereby minimizing survey cost. Where large depth of investigation is required, large electrode spacings are adopted. This is also the case when the substratum is very conductive due to high clay content or saline water intrusion and current flow lines converge, leading to shallow depth of investigation (Telford et al., 1990) There are cases where total spread length of up to two kilometers had been used (Choudhury et al., 2001). Such large linear electrode spread may be difficult to accomplish in built up areas where often there is need to carry out resistivity depth sounding, most especially for groundwater development. Due to inadequate space, depth of investigation is reduced and geoelectrical results are inconclusive and recommendations are difficult to make.

However, the modified or the so called Half Schlumberger array enables vertical electrical sounding with the movement of current electrode (A) while the other current electrode (B). is fixed orthogonally at a large distance away and relative to the centre of the potential dipole (M-N) (Frohlich and Rosenbach, 1986). This array enables resistivity depth sounding in areas with limited space, as in built up areas. It also has the advantage of low man power requirement. Two persons can conveniently carry out the survey. Interpretation model curves and software are available for the Schlumberger array while such are rare for the Half Schlumberger configuration.

This study attempts a comparative study of the Schlumberger and Half Schlumberger arrays in terms of deduced geoelectrical parameters, in vertical electrical sounding, in a typical basement complex environment.

DESCRIPTION OF THE STUDY ENVIRONMENT

The study area is the Staff Quarters of the Federal University of Technology, Akure. It lies between longitudes 5^o 7^1 58.00^{11}E and 5^o 7^1 49.46^{11}E and latitudes 7^o 18^1 27.82^{11} N and 7^o 18^1 15.00^{11}N (Figure 1). The topography is relatively flat with elevation ranging from 374m to 391m. The area lies within the tropical rain forest climatic region. It is characterised by two distinct seasons, the wet season (between April and October) and the dry season (between November and March). The annual rainfall is about 1600mm, while the average daily temperature is about 29°C (Iloeje, 1981).

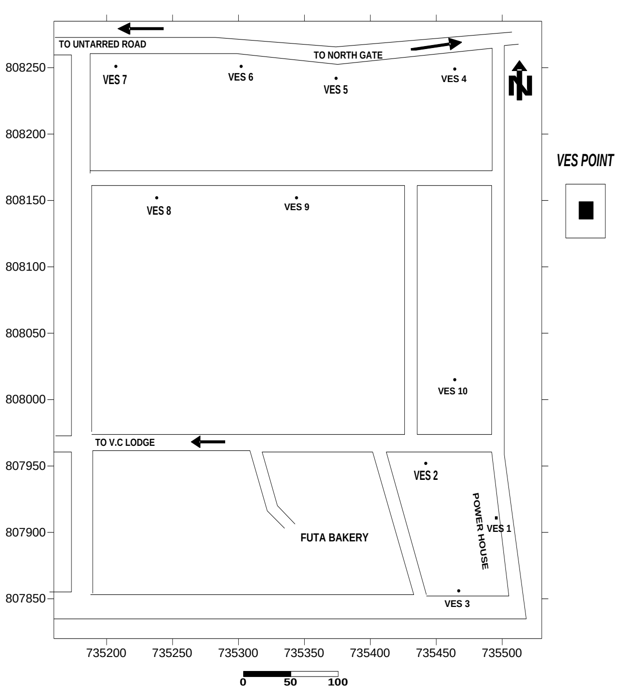


Figure 1: Plan Map of the Study Area.

The area is underlain by rocks of the Precambrian Basement Complex of the southwestern Nigerian (Rahaman, 1989). The lithological units include granites, biotite gneiss, Charnockite, and quartzite (Figure 2). Low lying outcrops of biotite gneiss occur at several locations within the university campus. In other parts of the campus, charnockite occurs as discrete bodies while granite occurs as intrusion within the biotite gneiss (Kareem, 1995).

METHOD OF STUDY

VES were conducted at ten locations with both the Schlumberger and Half-Schlumberger arrays using the Omega Resistivity Meter. The half current electrode separation (AB/2) was varied from 1 to 65m. The sounding stations were geo-referenced in the Universal Traverse Mercator (UTM) Zone 31 with a GARMIN 12 Global Positioning System (GPS).

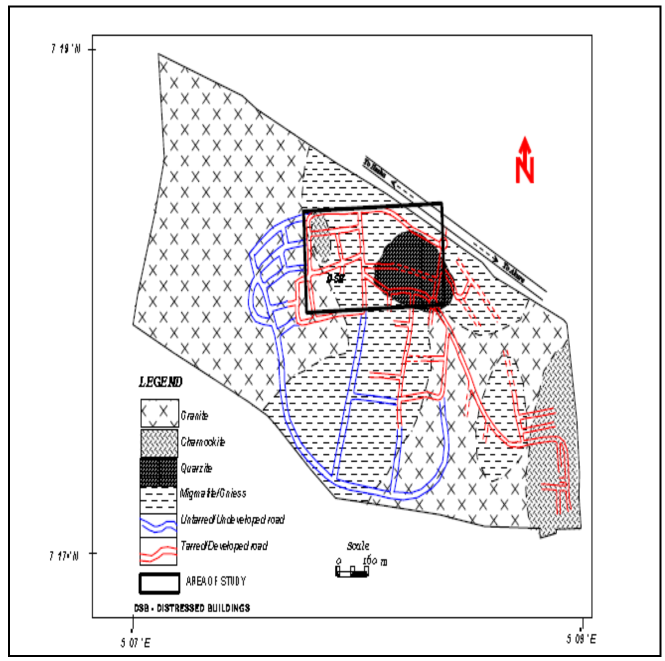


Figure 2: Geological Map of the Federal University of Technology, Akure (after Kareem, 1995).

The apparent resistivity measurements were used to prepare depth sounding curves. Preliminary interpretation of the depth sounding curves involved the partial curve matching method using, for both arrays, the Schlumberger model and auxiliary curves. The results of the partial curve matching (layer resistivities and thicknesses) were used as starting model parameters in a computer assisted 1-D forward modeling with the W-GeoSoft/WinSev 5.1 software. The final interpretation results, contained in Table 1, were subsequently compared.

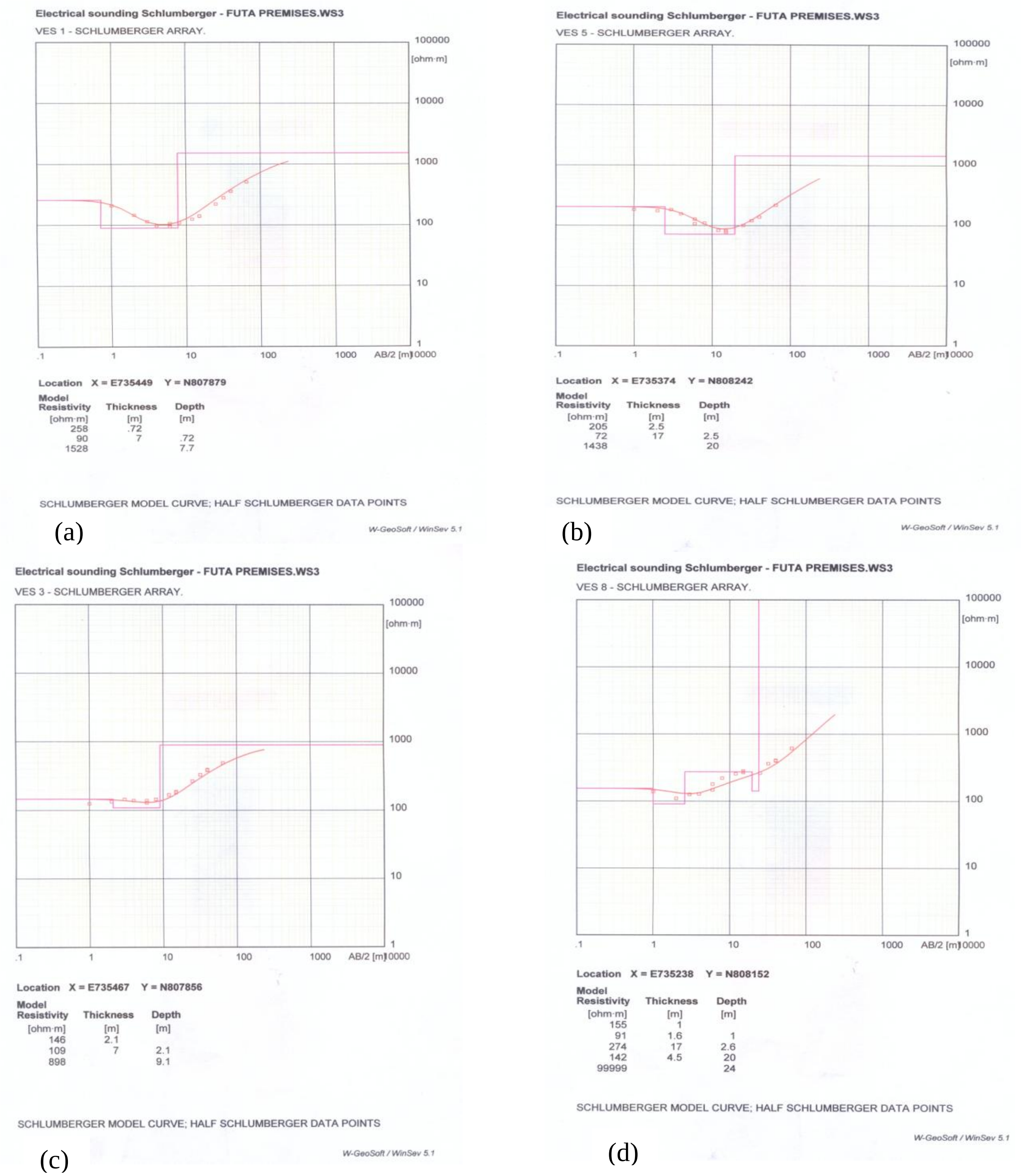
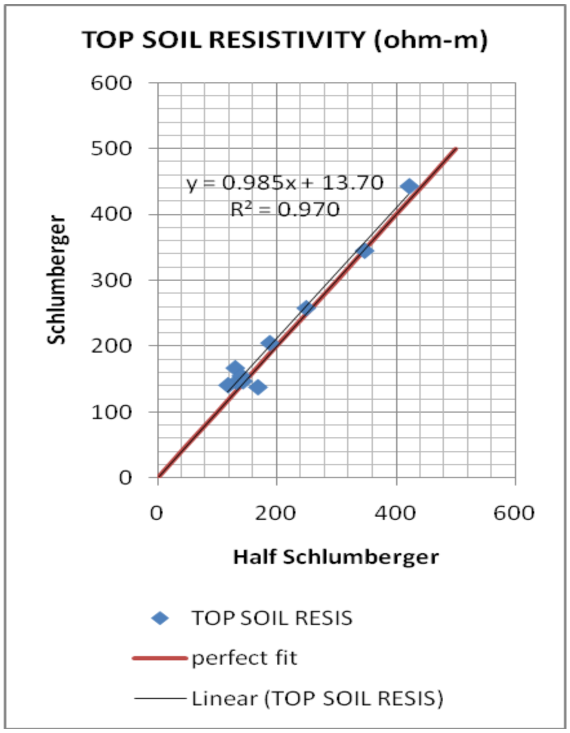
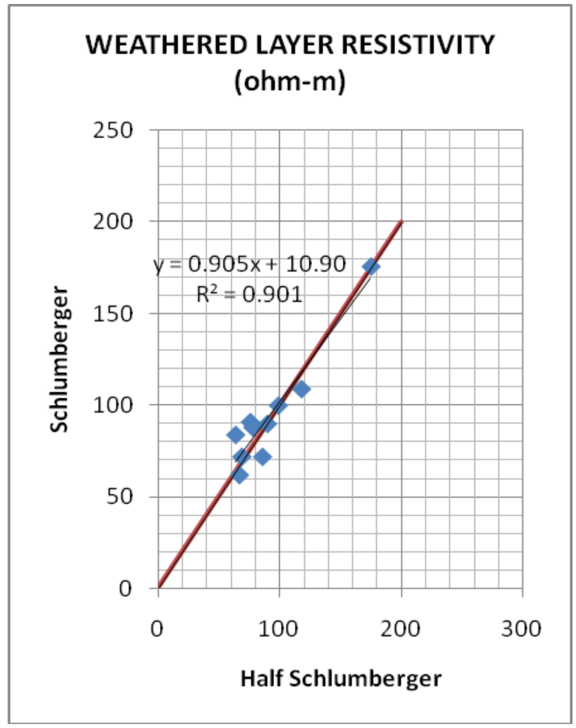


Figure 3: Typical Superimposed VES Curves/ Data Points for Schlumberger and Half Schlumberger Arrays (a) VES 1 (b) VES 3 (c) VES 5 and (d) VES 8.



(a)



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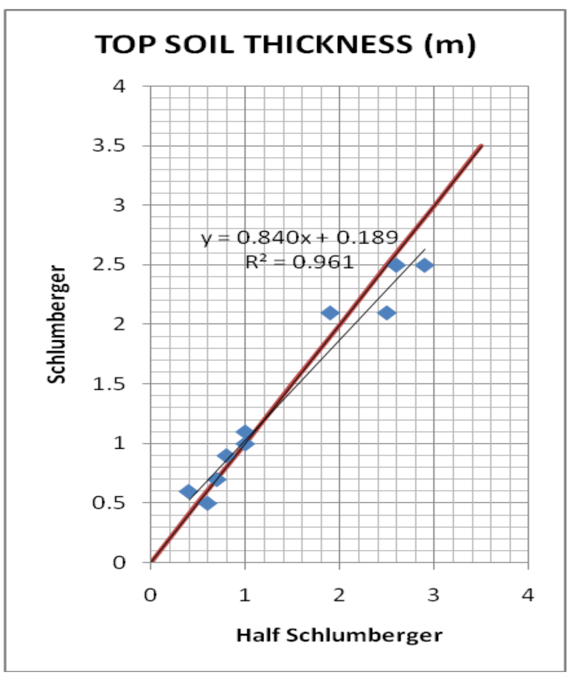

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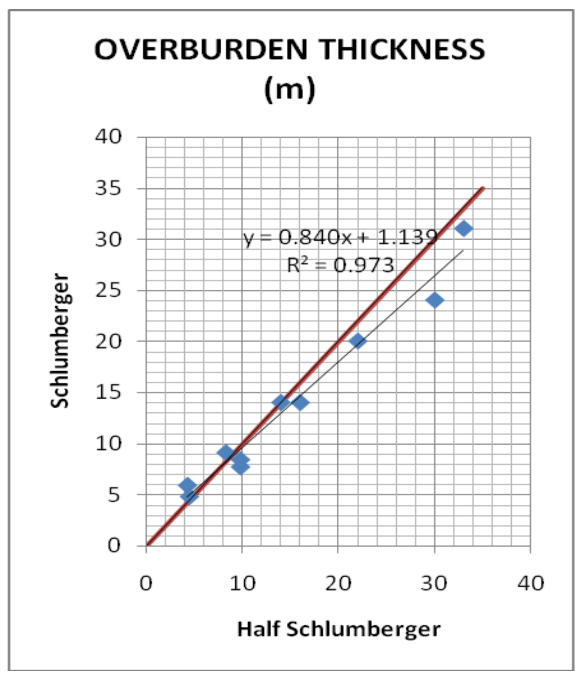

(d)

Figure 4: Cross Plots of (a) Topsoil Resistivity (b) Topsoil Thickness (c) Weathered Layer Resistivity and (d) Overburden Thickness for Schlumberger and Half Schlumberger Interpretation Results.

The field curves identified within the study area range from H to KH and HKH type (Table 1). Typical superimposed curves/data points for both the Schlumberger and Half-Schlumberger arrays are displayed in Figure 3. The curves/data points are similar in form and overlap significantly. Maximum of four geoelectric/geologic layers were delineated. These include the topsoil/laterite, weathered basement, partly weathered/fractured basement (at few locations) and the fresh basement bedrock.

Table 1: Vertical Electrical Sounding Interpretation Results

VES No.	Depth (m) $d_1/d_2/d_3/......d_{n-1}$	Resistivity (ohm-m) $\rho_1/\rho_2/\rho_3/.........\rho_n$	Type Curve
1	0.7/7.7	258/90/1528	H
1*	0.7/9.8	249/90/2928	H
2	0.9/4.0/14.0	167/230/84/∞	KH
2*	0.8/4.3/16.0	130/284/64/∞	KH
3	2.1/9.1	146/109/898	H
3*	2.5/8.3	132/118/879	H
4	2.1/6.3/31.0	443/516/176/∞	KH
4*	1.9/7.3/33.0	422/573/175/∞	KH
5	2.5/20.0	205/72/1438	H
5*	2.6/22.0	188/69/38644	H
6	0.5/8.4	141/72/598	H
6*	0.6/9.8	118/86/669	H
7	2.5/14.0	345/62/∞	H
7*	2.9/14.0	347/67/∞	H
8	1.0/2.6/20.0/24.0	155/91/274/142/∞	HKH
8*	1.0/2.3/24.0/30.0	140/76/372/202/∞	HKH
9	1.1/5.9	147/100/2448	H
9*	1.0/4.3	143/99/3449	H
10	0.6/4.8	138/88/5099	H
10*	0.4/4.5	168/78/1199	H

* Half Schlumberger

Figure 4 shows cross plots of some of the geoelectrical parameters (topsoil resistivity and thickness, weathered layer resistivity and the overburden thickness) for both arrays. The above listed geoelectrical parameters are relevant in groundwater and engineering site investigations. The estimated geoelectrical parameters show significant correlation for both arrays with coefficient of correlation ranging from 0.95 to 0.99 (Figure 4).

The deviation of the line of best fit from the line of perfect fit is small. Deviations in estimated geoelectrical parameters relative to the Schlumberger array are -22.1 to +21.7% for the topsoil resistivity; -33 to +20.7% for topsoil thickness; -23.8 to +19.2% for weathered layer resistivity and -27.1 to +16.7% for the overburden thickness. These deviations are significantly within the ± 20% interpretation error limits in a typical geophysical data interpretation. The practical implication of this finding is that the Half Schlumberger array is a viable alternative to the conventional Schlumberger array in vertical electrical sounding in areas with limited space

CONCLUSION

Geoelectrical investigation involving the Schlumberger and Half Schlumberger vertical electrical sounding was carried out at ten locations within a basement complex terrain of southwest Nigeria. Four geoelectric/geologic layers were delineated. These include the topsoil, weathered layer, partly weathered/fractured basement and the fresh basement bedrock.

The cross plots of the deduced geoelectric parameters for both arrays show significant correlation with coefficient of correlation varying from 0.95 to 0.99. It follows therefore that the Half Schlumberger array can provide a viable alternative to the conventional Schlumberger array especially in areas with limited space.

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