REDUCING INHERENT AMBIGUITIES OF GEOELECTRIC PARAMETERS USING PSEUDO SECTION: AN ILLUSTRATION FROM MARO EARTH DAM

Momoh, O. L.
Department of Geology,
School of Science and Science Education,
Federal University of Technology, Minna, Nigeria
E-mail: momohodapo@yahoo.com
Phone No: +234-706-759-6900

Abstract
A sum total of sixty-four (64) Schlumberger Vertical Electrical Sounding (VES) points have been occupied using ABEM Terrameter SAS 300 unit with maximum electrode spacing of 100m in Maro earth dam site, Kachia Local Government Area (LGA) of Kaduna State. The aim is to demonstrate the capability of pseudosection in reducing common ambiguities such as suppression, equivalence and k-type equivalence arising from interpretation of electrical resistivity data that can obscure subsurface geology. The data were analysed and interpreted using the curve matching technique and the Resist software respectively. An isopach map was prepared by posting and contouring the depth to bedrock beneath each VES to show the subsurface bedrock topography and structural disposition. The resistivity data were prepared into pseudosections by plotting the electrode spread, AB/2 (m), against the corresponding resistivity values beneath each VES data point. The resistivity data spread were then contoured to show the subsurface resistivity pattern along two chosen traverses suspected to have been fractured from the isopach map. The results show that pseudo-section is a better representation of the subsurface geology than geoelectric section due to the former ability to give precise and clear pictures of the subsurface geology than the latter. In addition, Pseudosection can delineate linear structural features undetected by the geoelectric section as shown in the case studies where one of the recommended traverses based on the geoelectric section have been confirmed fractured from the pseudosection and hence unsuitable for the dam site location.

Keywords: Pseudosection, Geoelectric Ambiguities, Geoelectric Parameters, Accuracy, Geoelectric Section and Earth Dam

Introduction
The problem of ambiguities of geoelectric parameters have long standing recognition as the sole factor responsible for non-uniqueness of electrical resistivity data interpretation (Zohdy, 1980 and; Abdullaev and Dzhafarov, 1964). Geoelectric section is a one dimensional tool routinely used in constructing the subsurface geoelectrical configurations (Momoh, 2010., Momoh and Olasehinde, 2010) but handicapped in the essential task of detailing structural analysis due to data ambiguities arising from curve matching. Electrical resistivity surveys are carried out for direct and indirect mineral exploration, lithological mapping, engineering site investigation, hydrogeophysical and geological surveys, salt/fresh water interface delineation among others (Momoh et al, 2008; Flathe, 1967; Banwell and MacDonald, 1965 and Hansen, 1966). The relatively cheap cost of and/or recent advancement in automation of data acquisition has further widened the scope of electrical resistivity method. There is therefore a practical need to device a simplified and accurate method for geoelectric/geologic subsurface presentation.

For any aim of electrical resistivity survey to be achieved, the boundaries between the geologic layers are expected to coincide with geoelectric layers (layer resistivities and depths). It is a common knowledge that the interpretation of a multilayer sounding curve is generally never unique. This means that a given electrical sounding curve can correspond to varieties of subsurface distribution of layer thicknesses (h_i) and resistivities (ρ_i) through curve matching. Hence both the resistivities and thicknesses of earth layers can be altered and yet the conductance (h_i/ρ_i) remain the same giving the interpretation problem commonly referred to as equivalence (Fig. 1) or $h_i\rho_i$ can be evaluated in multi forms by varying the same data set for constant geologic model defining another limitation of electrical method termed the k-type equivalence (Fig. 2). Similarly, an intermediate layer thickness can be totally suppressed to give room for thickness increase in another layer. Case histories of the above mentioned problems abound in literature (Maillet, 1947; Flathe, 1955 and 1963; Bhattacharya and Patra, 1968.). These indeed constitute huge limitations to interpretation of electrical resistivity data that require serious attention.

	1000 Ωm		1000 Ωm		1000 Ωm
h= 10.0 m	100 Ωm	h= 10.0 m	50 Ωm	h= 10.0 m	10 Ωm
	5000 Ωm		5000 Ωm		5000 Ωm
	S=10/100=0.1		S=5/50=0.1		S=1/10=0.1

Conductance (s) = h_i/ρ_i where h is the thickness of a geoelectric layer and ρ is the corresponding resistivity values

Fig.1: Typical Geoelectric Sequence of Equivalence

The present work attempt to presents pseudo-section as an alternative form of presenting geoelectric data since the direct data used in the construction of pseudo-section give accurate and clear pictures of the subsurface geology in a simplified form. This is based on the premise that an acquired field data with a minimal noise level represent a true model of the subsurface

Transverse Resistance, T = Resisitivity x thickness = $h_i x \rho_i$

	50 Ωm		50 Ωm		50 Ωm
h= 1.0 m	100 Ωm	h= 1.0 m	100 Ωm	h= 1.0 m	100 Ωm
	20 Ωm		20 Ωm		20 Ωm
	T=10X100=1000		T=2X5000=1000		T=1X1000=1000

Fig. 2: Typical Geoelectric Sequence of K-Type Equivalence geology that can be automated as pseudosection compared to processed curve matched method that is normally accompanied with the above inherent limitations (Nwankwo et al, 2004).

Methodology

A case history of Maro Earth Dam involving sixty-four (64) Schlumberger Vertical Electrical Sounding (VES) carried out to investigate possible axis of a dam site location in Maro village, Kachia Local Government Area (LGA) of Kaduna State was adopted in this work (Momoh and Olasehinde, 2010) as shown in Figure 3 and Figure 4. The dam is to enhance water supply for Maro populace and irrigation. The site geology consists of rocks of Precambrian Basement Complex of Nigeria that are Pan-African in ages and classified as undifferentiated by Dan Hassan and Olorunfemi, 1999 (Fig.5).

Although, the VES data were acquired along eight geophysical traverses as shown in Figure 3 and used in the previous work (Momoh and Olasehinde, 2010), traverses G-L, I-J, K-L and M-N with approximate perpendicular trend to the river channel were selected and adopted for the present work to detail the suspected structural features. Profile length of 800m were adopted for traverses G-L and K-L while traverses I-J and M-N were 1km and 900m long respectively. Inter-traverse and station interval of 100 m was adopted for the VES. The data were analysed and interpreted in the aforementioned publication above using the curve matching technique and the Resist software respectively.

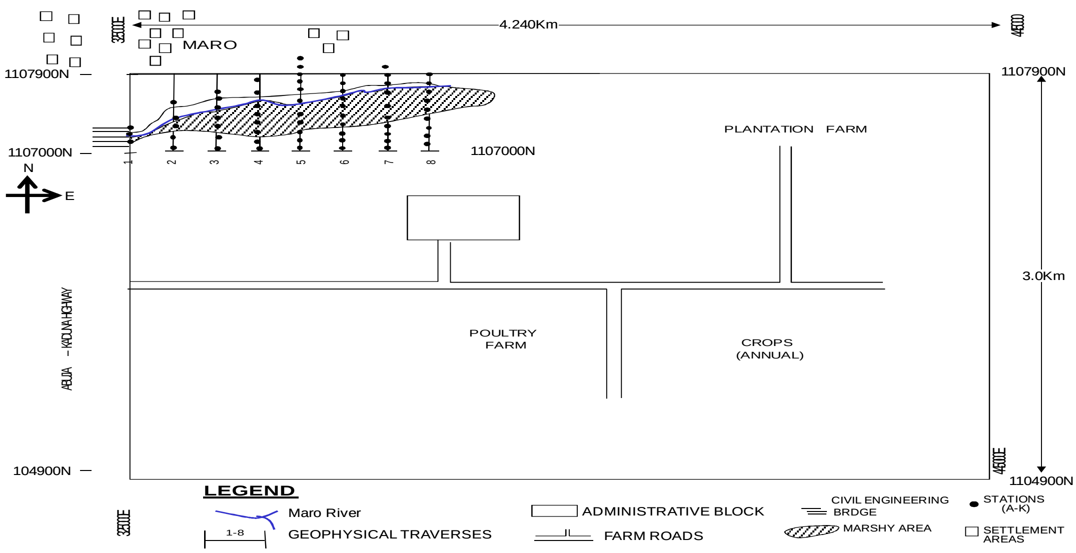

Fig. 3: The location map of the case study area

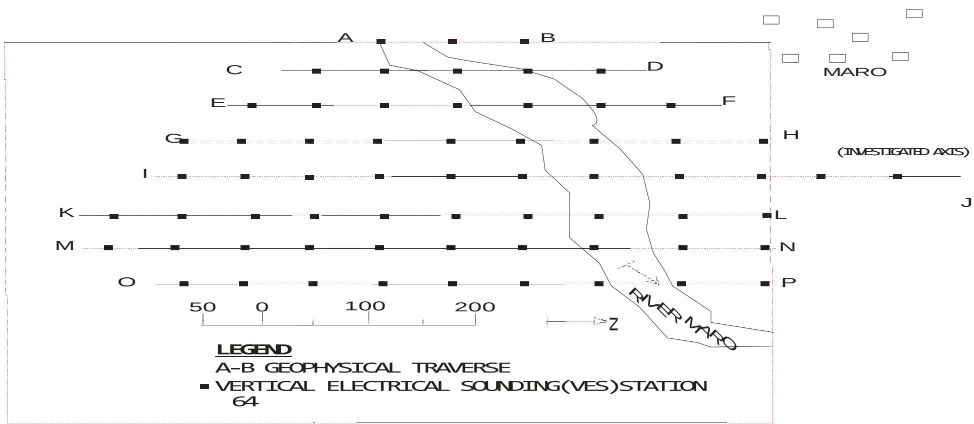

Fig. 4: The geophysical data acquisition map

An isopach map was prepared by posting and contouring the depth to bedrock beneath each VES to show the subsurface bedrock topography and structural disposition. The resistivity data were prepared into pseudosections by plotting the electrode spread, AB/2 (m), against the corresponding resistivity values beneath each VES data point. The resistivity data spread were then contoured to show the subsurface resistivity pattern along two chosen traverses suspected to have been fractured from the isopach map. Comparisons of the obtained pseudosections with the geoelectric sections for characteristic similarity/difference pattern determination were done for interpretation of the subsurface geological sequences.

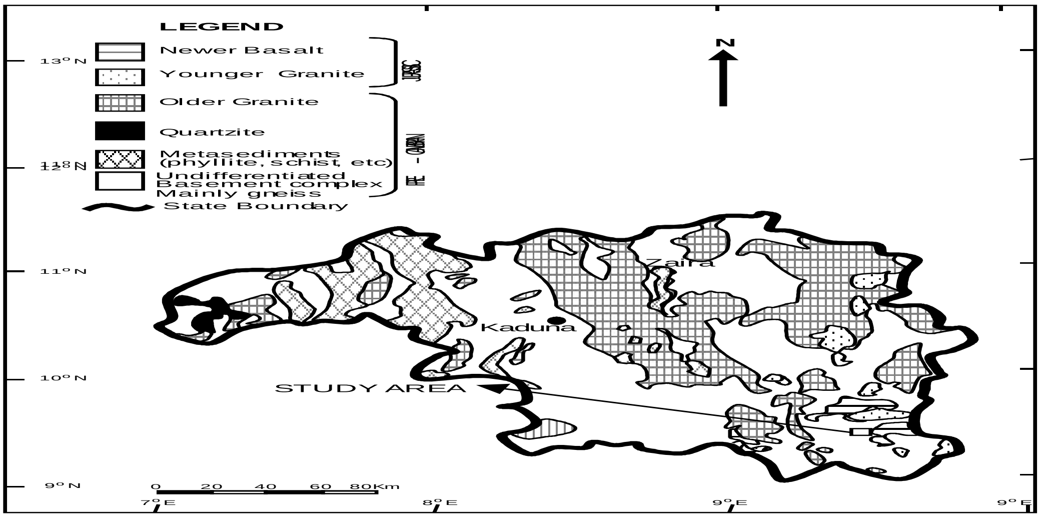

Fig. 5: The geological map of the area (After Dan-Hassan and Olorunfemi, 1999)

Results and Discussion

Fig. 6 is an isopach contoured map of the case study area showing the subsurface relative thickness of the geoelectric sequences and the associated structural dispositions. Aside pockets of relatively thick overburden in the southern end of the study area, two major basement depressions; D1—D1 and D2—D2 characterised by thick overburden were delineated within the eastern to southeastern part of surveyed area. The distortion of contour lines shows that the basement depressions have been affected by tectonism and hence the displacements of their once continuous axis giving rise to the inferred fault, F---F. Relatively thinner overburden characterised the other parts of the investigated area. The basement depressions observed from isopach map falls within traverses G-H, I-J, K-L and M-N corresponding to zones of ancient river channels shown by the geoelectric sections (Fig. 7).

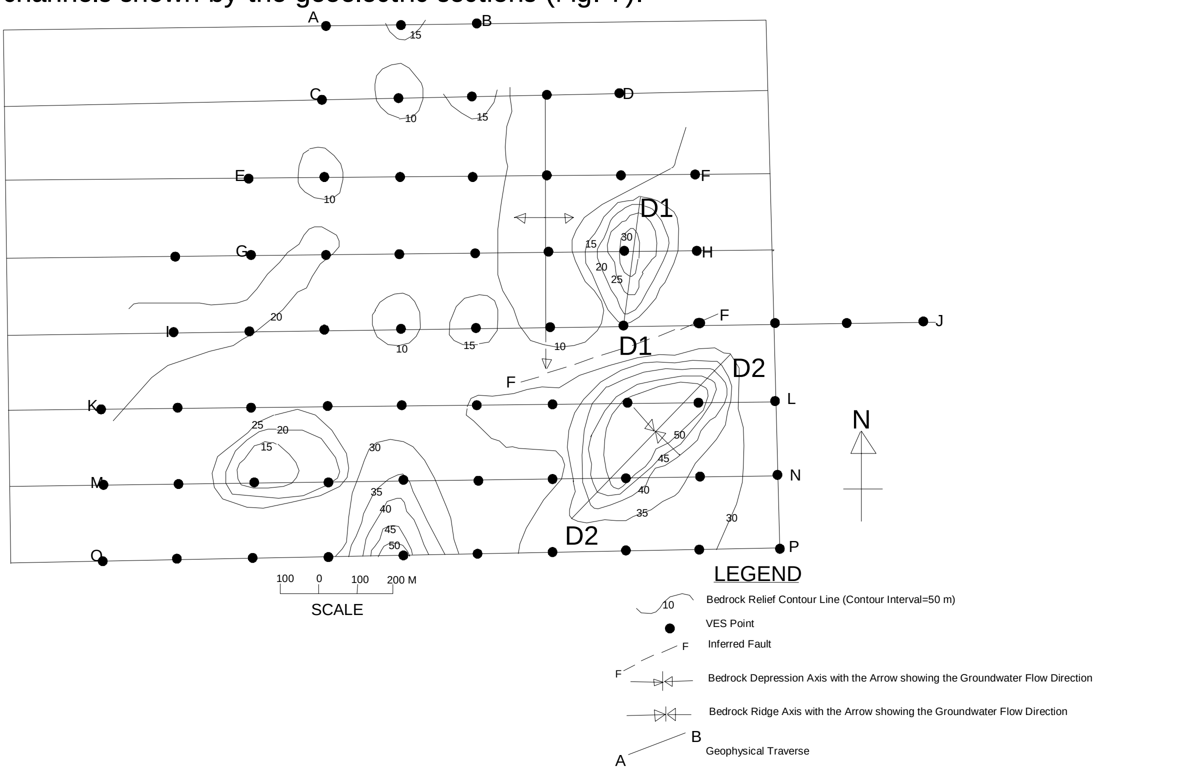

Fig. 6: Isopach contoured map showing the subsurface structural features of the study area

From the pattern of the contour lines in Figures 7 and 8, four different geoelectric layers which include the top soil, the lateritic layer, the weathered layer and the resistive bed rock can be differentiated. The four layers were equally delineated by the geoelectric sections (Fig. 9). The top soils characterised by depth range of generally <1.0 m from Figures 7 and 8 are lateritic with pockets of sands in places with resistivity values ranging between 1154 and 2068 Ωm, 337 and 2550 Ωm respectively.

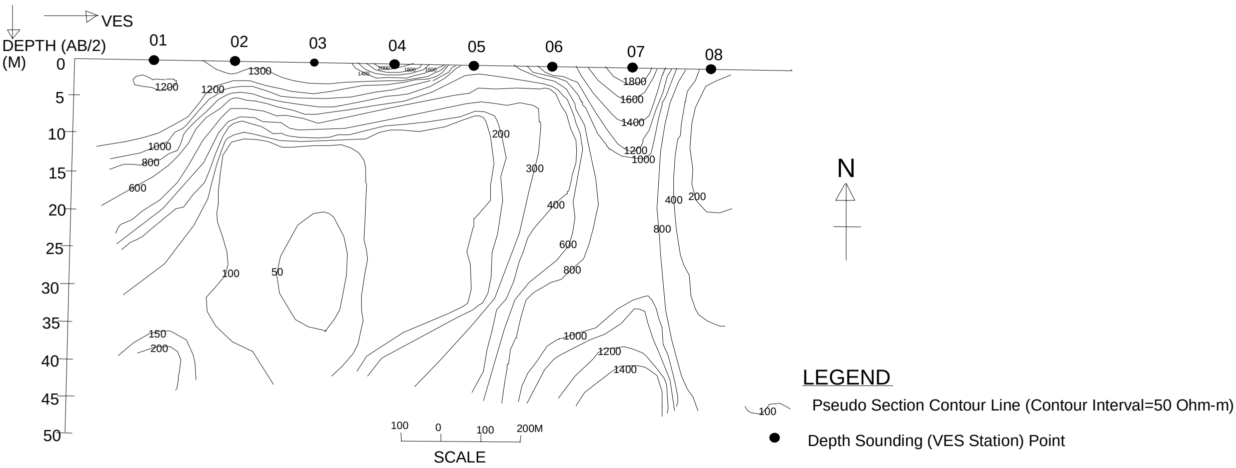

Fig. 7.0: Pseudo Section Beneath Traverse G-H

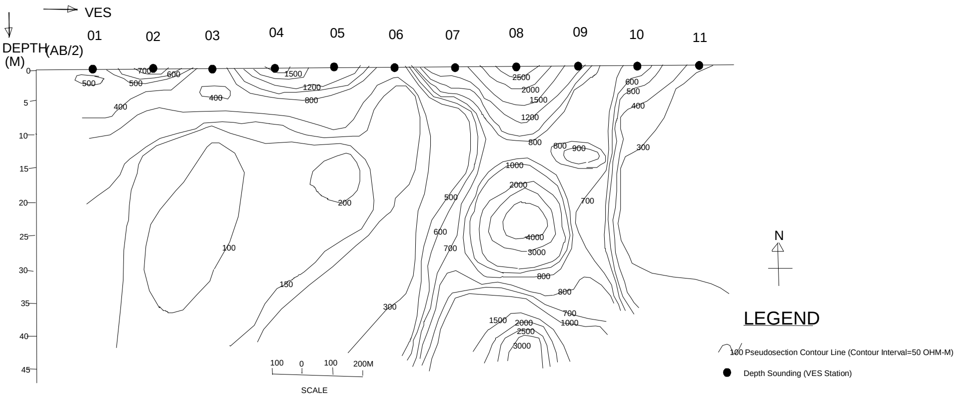

Fig. 8: Pseudo Section Beneath Traverse I-J

VERTICAL EXAGERATION (V.E.) = X 2.5

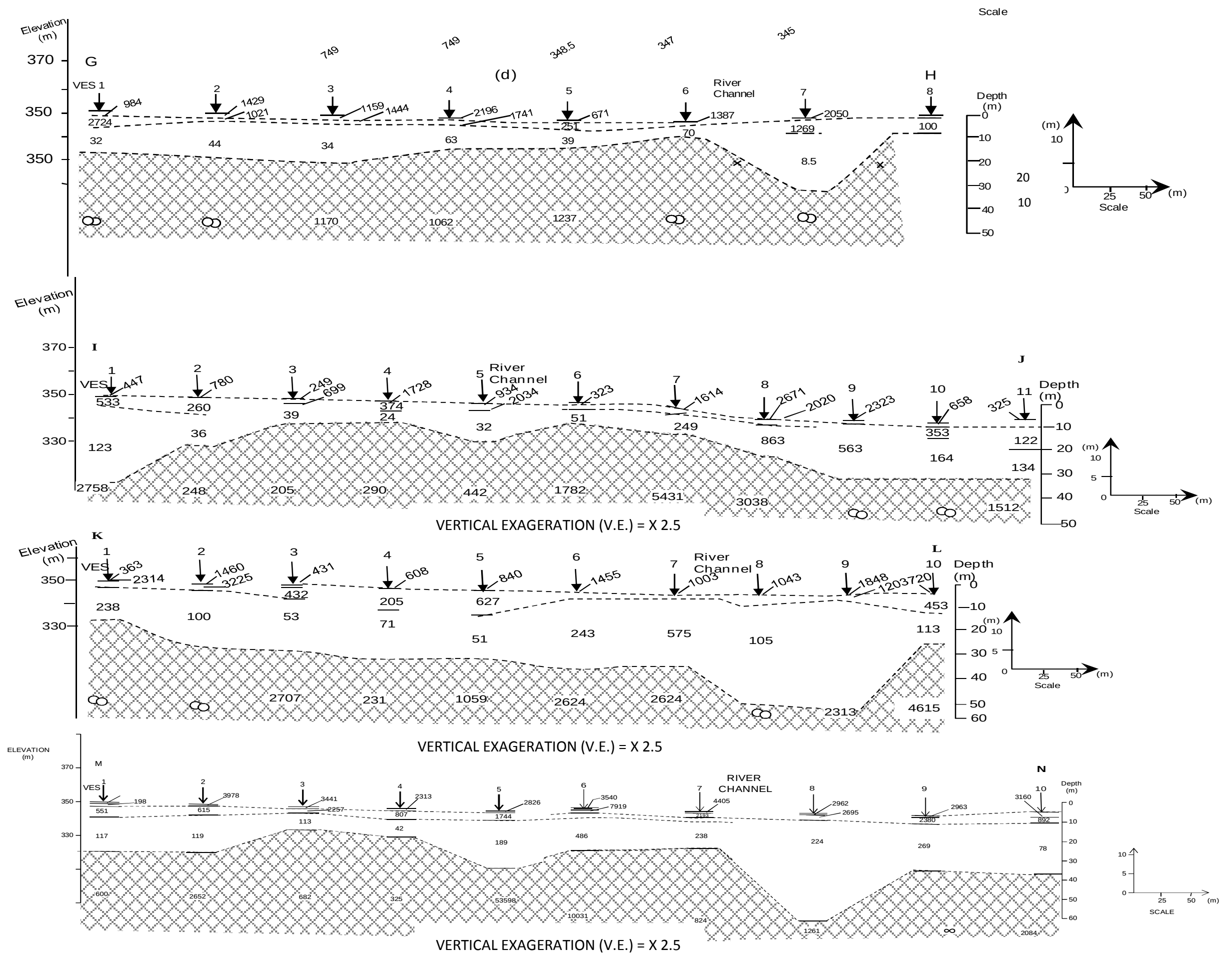

Fig.9: Geoelectric section for traverses G-H, I-J, K-L and M-N in the surveyed area

The representative contour lines defined a relatively straight to curved course across the two traverses. The second lateritic layer to a depth of 10.0 m beneath Fig. 7 and 8 respectively are characterised by curved to hemispherical contour with resistivity values varying from 500 to above 1600 Ωm and 1050 to 2446 Ωm while the weathered layer represented by near to complete contour closures has corresponding resistivities values of between 50 and 400 Ωm, and 100 and 300 Ωm. This shows that the weathered layer is composed of clay/sandy clay/clayey sand materials. Their equivalent depth ranges are from 10-40 m and 15-65 m accordingly. The highly resistive bed rock exhibit characteristic contour arch up to an infinite depth with values of resistivities varying from 350 to 1250 Ωm and 350 to 1000 Ωm beneath Fig. 7 and 8 respectively. Contour divergence and distortion is observed beneath VES 06 and 08, and VES 07 and 10 along traverses G-H and I-J respectively. These zones are characteristically defined by contour discontinuity and fall within the basement depressions along traverses G-H and I-J respectively. The isopach map inferred a fault within these regions. The observed contour discontinuity along traverse G-H probably indicates the influence of the same inferred fault along the traverse.

The circular contour typify by contour kink and divergence observed beneath VES 07 and 10, along traverse I-J is characterised by a central contour closure of values ranging from 800 to over 4000 Ωm, showing an existence of confined fracture at depth greater than 30.0 m. These features are conspicuously missing in the corresponding geoelectric section (Traverse I-J in Figure 9).

Conclusion

Pseudosection has been shown in this work to have the capability of reducing inherent problems of ambiguities in electrical resistivity data such as suppression, k-type equivalence and equivalence. A case study involving the use of Schlumberger VES for a dam site location in Maro village of Kachia LGA in Kaduna State have been presented and the work shows that pseudosection give clearer and more accurate picture of the subsurface geology than geoelectric section and the former can as well delineate linear features undetected by the latter.

Acknowledgement

Atlantic Geophysical is thanked for allowing the publication of the data used for this research. The contributions of the anonymous reviewers are equally acknowledged as well as the insightful discussion of the field data with Prof. Olasehinde P.I.

References

Abdullaev R. A. & Dzhafarov, K. D. (1964). *Theory and practices of the interpretation of geophysical observations (in Russia):* Baku, Azerbaydzh. Gosudarst. Izd. (State Press of Azerbaydzhan), p. 117-119

Banwell, C. J. & MacDonald, W. J. P. (1965). *Resistivity surveying in new zealand thermal areas: eighth commonwealth mining and metallurgical congress*. Australia and New Zealand, New Zealand Section, paper No. 213, p. 61-78.

Dan-Hassan, M. A. & Olorunfemi, M.O. (1999). Hydro-geophysical investigation of a Basement Terrain in the North-Central part of Kaduna State, Nigeria. *Journal of Mining and Geology, 33(2), 189-206.*

Flathe, H. (1967). Interpretation of geoelectrical resistivity measurement for solving hydrogeological problems: mining and groundwater geophysics. *Geol. Survey of Canada, Econ. Geol. Report 26, p. 580-597.*

Flathe, H. (1963). Five-layered master curves for the Hydro-geological Interpretation of geoelectric resistivity measurements above a two-story acquifer. *Geophys. Prosp., 11, 471-508.*

Flathe, H. (1955). A practical method of calculating geoelectric model graphs for horizontally startified media. *Geophys. Prosp, 3, 268-294.*

Hansen, H. J. (1966). Pleistocene stratigraphy of the salisbury area, Maryland, and its relationship to lower Eastern shore: A subsurface approach. *Maryland Geol. Survey, Report of Investigation, 2, 27, 5.*

Maillet, R. (1947). The fundamental equations of electrical prospecting. *Geophysics, 3, 529-556.*

Momoh, O. L. (2010). Can resistivity type curves be used in engineering site characterisation? *Nigerian Journal of Technological Research, 4(2), 185-195.*

Momoh, O. L., Akintorinwa, O. A. & Olorunfemi, M. O. (2008). Geophysical investigation of highway failure-a case study from the basement complex terrain of Southwestern Nigeria. *Journal of Applied Sciences Research, 4(6),637-648.*

Momoh, O. L. & Olasehinde, P. I. (2010). Geoelectrical investigation of a damsite in Maro area of central basement terrain of Nigeria: *Journal of the Nigerian Association of Hydrogeologists, 20(1), 53-59.*

Nwankwo, L. I., Olasehinde, P. I. & Babatunde, E. B. (2004). The use of electrical resistivity pseudo-section in elucidating the geology of an east-west profile in the basement complex terrain of Ilorin, West-Central Nigeria. *Nigeria Journal of Appl. Sci. 19, 1676-1682*

Zohdy, A. A., Eaton, G. P. & Mabey, D. R. (1980). *Techniques of the water resources investigation of the united states geological survey-application of surface geophysics to ground-water investigation*. Collection of Environmental Data, Book 2, pp106