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Hydro Geophysical Investigation of Kushi and its Environs, Northeastern, Nigeria

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Abstract: *The hydro geophysical investigation of Kushi and environ, part of Gombe State, Northeastern Nigeria was carried out. It lies between latitude 9`35'0" and 9`37'45" Longitude 11`09'11" and 9`37'45" Longitude 11`09'11" and 9`37'45" Longitude 11`09'11" and 11`11'52. Vertical electric sounding was carried out at eight (8) different positions using Tetrameter Omega employing Schlumberger method of electrode spread. The curve-types in the study area are Q, HA, KQ, H and AK. From the interpreted results, the study area is characterized by three-four geo-electric layers; the first layer having thickness range between 0.6-4.6m, the second layer thickness ranging between 5.5-16.3m, the third layer thickness ranging between 16.6m and fourth layer is extended beyond probing depth. From the studies it can be deduce that the second and third layer identified as porous sandstone to sandy-clay materials which can serve as the aquiferous zone, suitable for borehole sites to a depth of 20-30m. Iso-resistivity analysis at 60m indicates the lateral variation in the electrical properties of the area with about 800mΩ in both the western and eastern part.*

Keywords: *hydro geophysical, Kushi,, Groundwater, Shlumberger, Aquiferous.*

1. Introduction

Insuffient drinking water supply in Nigeria have been documented (Hati et al., 2011 and Fragio, 2005). The availability of water sources are becoming depleted due to accelerated increased in population, climate change and urbanization (Khatri and vanavamoorthy, 2007).

Geophysical methods have been a very useful tool in determining the geological characteristics of the subsurface rocks by measurement of there physical properties. There are various techniques employed in groundwater exploration, electrical resistivity method is reliable in delineating zones of relatively low resistivity which might be a signatory of saturated strata in various geophysical terrain (Sinha,*et al* 2009, Fasunwon, 2010 Mbiimbe *et al.*,2012). Records have shown that the depths to aquifer differs from one place to another due to variation in geo-thermal and geo-structural occurrence (Dahlin, 2009, Alile *et al.,* 2010)The quality and quantity of ground water resources of any area are controlled by the climate and geology of the area. The climate through rainfall and surface water resources ensure constant supply or recharge to groundwater resources of an area in a complex hydrological cycle. The geology of the area determines the aquiferous zones where exploitable groundwater may occur and influences the geochemical characteristics of the groundwater; amongst other factors such as human activities (Domenico, 1992, Emenike, 2001, Guelala, *et al*, 2009).This work involves the application of resistivity method to locate sites that will be suitable for drilling of boreholes. Vertical electrical sounding (VES) conducted in eight points were interpreted to establish the influence of physical parameters on the occurrences and distribution of groundwater in the study area.

1.1. Geological Setting

Benue Trough of Nigeria is a rift basin in central West Africa that extends NNE–SSW for about 800 km in length and 150 km in width. The Benue Trough is one of the most important of all the Cretaceous sedimentary basins in Nigeria, Benkelil, (1986). It stretches in the NE-SW direction for about 1000 km over a Precambrian Basement Complex. The southern limit is northern boundary of Niger Delta, while the northern limit is the southern boundary of the Chad Basin. The trough is bordered on each side by crystalline Basement Complex,(Carter, *et al.*1963,Oyawoye, 1972),(Fig. 1). The Trough contains up to 6,000 m of Cretaceous – Tertiary sediments of which those predating the Mid-Santonian have been compressionally folded, faulted, and uplifted in several places.

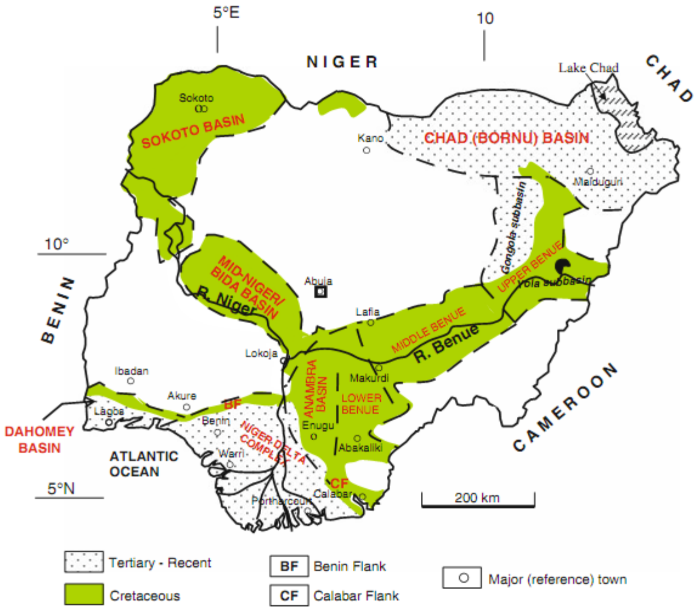


Figure1. *Map of Nigeria showing Benue Trough and other Sedimentary Basins after Obaje (2004)*

The study area lies within the Gongola sub-basin which is characterized by different stratigraphic units (Fig.2 and 3), the units have been divided into the following formations: Bima sandstone, Yolde formation, Pindiga formation, Gombe sandstone and Kerri- Kerri formation (Carter *et al.* 1963). In the Gongola Basin, the Late Aptian to AlbianBima Formation is the oldest Cretaceous sediment which unconformably overlies the Precambrian Basement rocks. This is successively overlain by transitional Yolde Formation (Cenomanian to Turonian) and succeeded by the marine Turonian to CampanianPindiga, Gongila and Fika Formations. These successions are overlain by MaastrichtianGombe Formation. The Tertiary Kerri-Kerri Formation forms the topmost the sequence west of Gombe in the Gongola Basin (Dike, 1994).

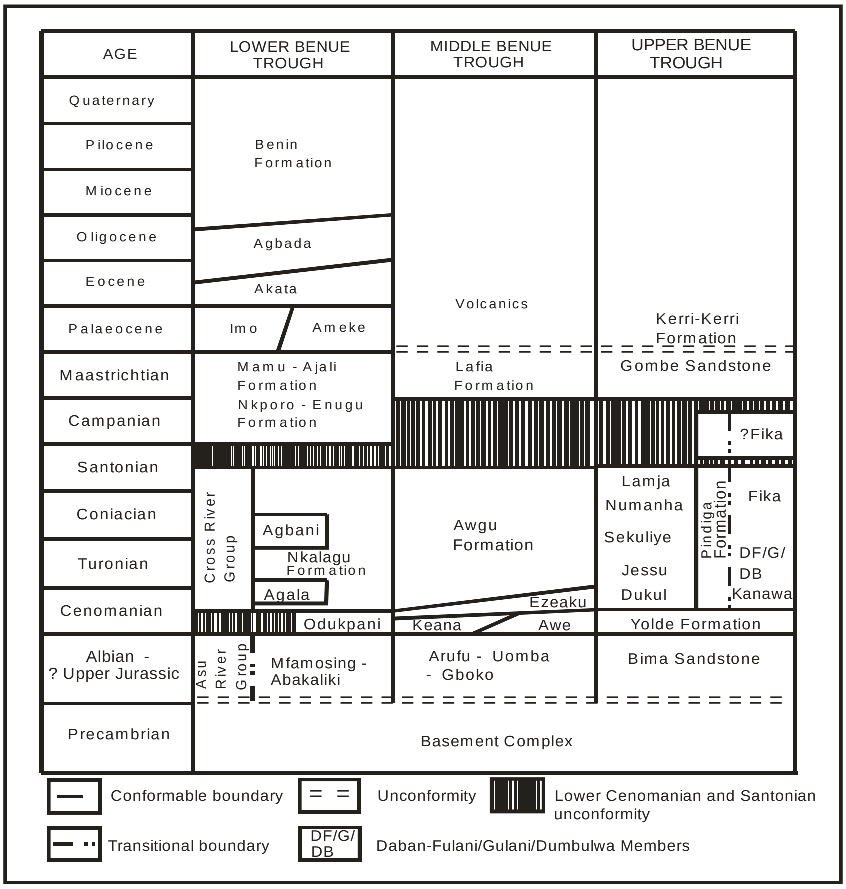


Figure2. *Stratigraphic Succession in the Benue Trough Nigeria (modified from Obaje, 1994).*

Compressional folding during the mid-Santonian tectonic episode affected the whole of the Benue Trough and was quite intense, producing over 100 anticlines and synclines (Benkhelil, 1989). Following Mid-Santoniantectonism and magmatism, depositional axis in the Benue Trough was displaced westward resulting in subsidence of the Anambra Basin. The Anambra Basin, therefore, is a part of the Lower Benue Trough containing post-deformational sediments of Campanian-Maastrichtian to Eocene ages. It is therefore logical to include the Anambra Basin in the Benue Trough, being a related structure that developed after the compression stage (Akande*et al*, 1992).The Benue Trough is arbitrarily subdivided into lower, middle and upper portions.

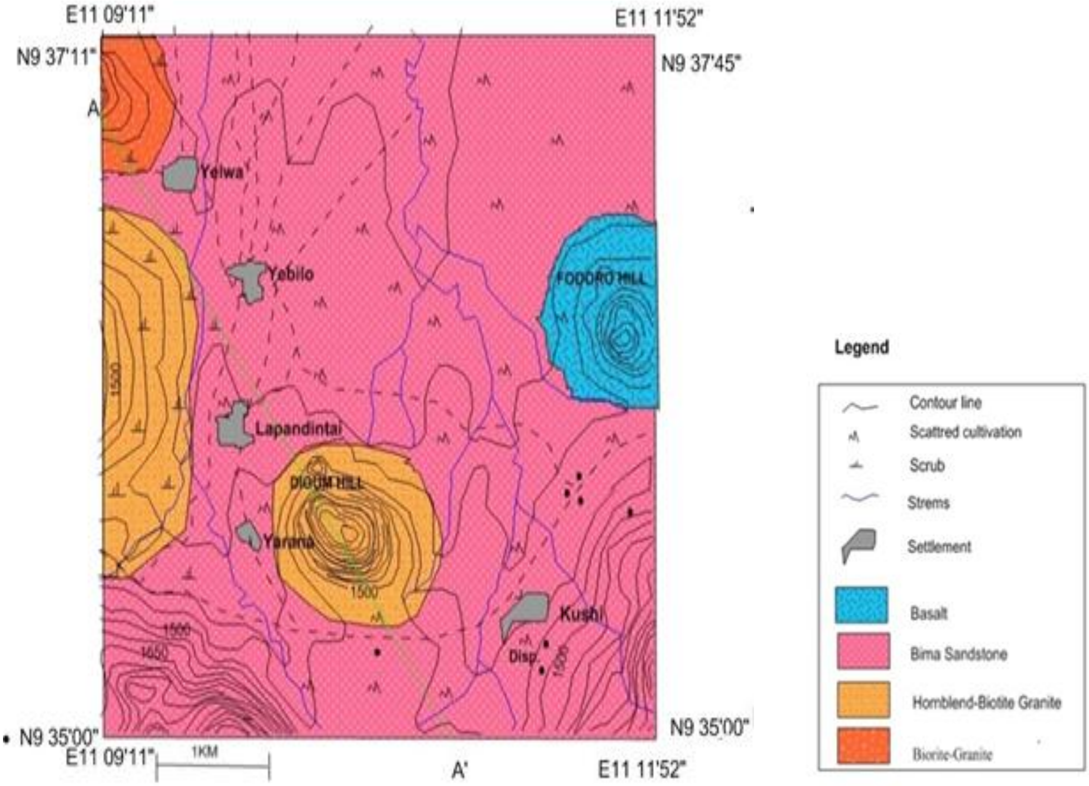


Figure3. *The Geology of the study area*

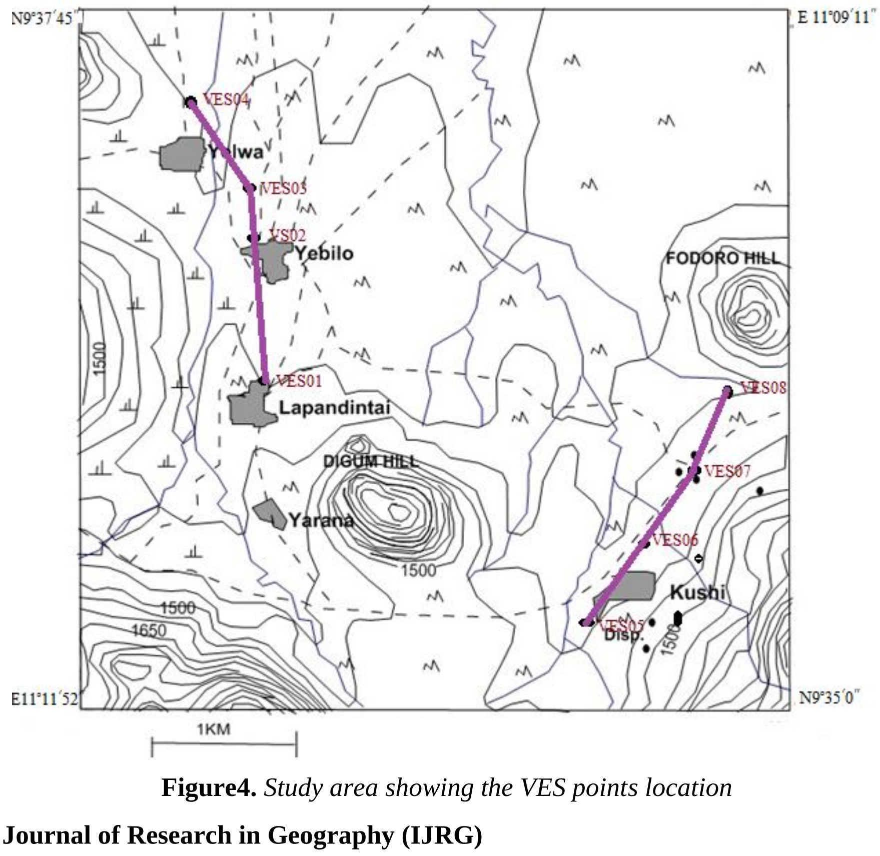


Figure4. *Study area showing the VES points location*

2. Methodology

Vertical electric sounding was carried out at eight (8) different positions using Terrameter Omega which gives a direct readout resistance using Schlumberger method of electrode spread of maximum AB/2 = 100m. The interval between the potential and current electrodes was increased only a few times and in relatively small steps in order to obtain the differences large enough to be measured with satisfactory precision. In this method, a fixed point called the VES station was marked and noted; two electrodes (C1and C2) of equal distance on the opposite sides of the VES station were measured and driven into the ground with the aid of a sledge hammer for proper contact to be made with the ground. Similarly, two other electrodes called the potential electrodes (P1and P2) of equal distance and between the current electrodes were measured and driven in to the ground with the aid of the sledge hammer. The arrangements of the current and potential electrodes were in such a way as to maintain a straight line. These pairs of electrodes were connected to the Terrameter through points AB and MN. The locations and coordinates of VES points were taken (Table 1 and Figure 4). The apparent resistivities obtained from the field work were plotted on a log-log graph paper; partial curve matching technique was employed at initial stage before computing with Win Resist version1.0 software.

3. Discussion

Kushi and environs is within the Northern (Upper) Benue Trough. Qualitative analysis of the curve types by inspection revealed that VES01 and VES06 has Q-type, VES04,VES05 and VES08 has H-type, VES03 has KQ-type, VES07 has AK-type while VES02 is HA-type (Figure 5-12). Since groundwater accumulates in sedimentary rocks (sands, gravels, silt, limestone, etc.), and in weathered overburden, joints, fractures and faults zones in crystalline basement rocks, the electrical resistivity of subsurface materials (rocks, minerals, etc.) can be determined by the subsurface resistivity distribution to the ground which is at times related to the physical conditions of interest such as lithology, porosity, degree of water saturation and presence or absence of voids in the rocks Galin,(1979). The VES method of electrical resistivity gives detailed information of vertical succession of individual thicknesses, resistivities and their different conducting zones. In each case, the VES was used to delineate the subsurface Stratigraphy based on resistivity differences; from those values the aquifer thickness and other parameters were established. Five types of sounding curves have been identified from the study area, these are Q-type curves, H-type, KQ-type, AK-type and HA-type of curve; and the layers vary from three to four.

The quantitative treatment of the vertical electrical soundings provided geo-electrical information characterized by the values of resistivity and thickness, these geo-electrical parameters defined the geo-electrical model. The inversion of the field data was done using the WinResist version 1.0. The algorithm determines the model whose theoretical geo-electric curves best fit the field data by successive iteration dictated by the numerical program in which estimate of input parameter is made for each layer and the observed and theoretical curves were calculated during the analysis. Further iteration reduces the discrepancies to a predetermined value or less as the case may be. The assumption during the interpretation is that the underlying formation is horizontal and parallel to the earth’s surface.

The geo-electric curves of the eight VES data from the study area are presented in Figure 5 to 12 and the curves are explained by table (Table 1) which gives more information concerning the curves. The first layer is the top soil with resistivity and thickness ranging from 0.6-4.6 m and 11.5-899.5 Ωm. The second layer is clay-sandy clay and consolidated sandstone in some location with thickness and resistivity values of 3.4-15m and 3.7-4597.4Ωm respectively. The third layer is consolidated sandstone with resistivity values of 8.2-14.9 m and 8.9-5547.9Ωm. The fourth layer is characterized by consolidated sandstone and fresh basalts, with thickness and resistivity range from 0.8-21m and 200.4-2611.7 Ωm.

Profile AA′ along VES (04, 03, 02 and 01). The first layer represents top soil with a thickness and resistivity range from 1.3-2.8 m and resistivity 31.6-846.3Ωm. The second layer which is clay has a thickness that ranges between 6-13 m and resistivity 7.5-151Ωm. The third layer is clayey sand, which is the inferred zone for groundwater potential in the study area, with thickness and resistivity range from 4m-20m and 8-489 Ωm respectively. The fourth layer is sandstone may be water saturated. For maximum ground water potential, the boundary between the third and fourth layer which correspond to clayey sand-consolidated sandstone is recommended, the reason here is at this depth all the aquifers has been exhausted.

Profile BB′ along VES (08, 07, 06 and 05). The first layer is top soil with a thickness and resistivity range from 0.8-4 m and 62.0-595Ωm respectively. The second layer reflects clayey material with thickness and resistivity value ranges between 3-14 m and 3.7-69.0 Ωm which may be aquiferous. The third layer is the clayey-sand with thickness and resistivity ranges from 4-10m and average resistivity 152.6 Ωm. The fourth layer represents consolidated sandstone and fresh basalts.

Table1. *Geophysical Survey Data of VES 01-VES 08*

VES No.	Layer No.	Resistivity (Ωm)	Thickness (m)	Depth (m)	Inferred Lithology	Curve Type	% Error
VES 01 Lapandintai N9^{0}36′14.34″ E11^{0}09′50.62″	1	123.8	0.7	0.7	Top soil	Q	4.1
	2	9.7	4.8	5.5	Clay		
	3	8.9	--	--	Clay		
VES 02 Lapandintai N9^{0}36′40.9″ E11^{0}09′49.0″	1	899.5	2.1	2.1	Top soil	HA	5.6
	2	150.2	14.3	16.3	Clay		
	3	204.2	7.9	24.2	Clayey sand		
	4	1443.4	--	--	Sandstone		
VES 03 Yebilo N9^{0}37′01.1″ E11^{0}09′50.5″	1	31.6	0.6	0.6	Top soil	KQ	9.4
	2	4597.4	5.8	6.4	Consolidated Sandstone		
	3	489.0	14.9	21.3	Sandstone		
	4	200.4	--	--	Sandy clay		
VES 04 Lakalgam N9^{0}37′30.48″ E11^{0}09′36.19″	1	846.3	1.4	1.4	Top soil	H	7.0
	2	7.8	6.7	8.1	lay		
	3	24.2	--	--	Clay		
VES 05 KammoDran N9^{0}36′12.2″ E11^{0}11′39.5″	1	210.4	1.0	1.0	Top soil	H	2.5
	2	38.5	6.9	7.9	Clay		
	3	152.6	8.2	16.1	Sandstone		
	4	843.5	--	--	Consolidated Sandstone		
VES 06 Gomle N9^{0}35′50.9″ E11^{0}11′30.7″	1	595.4	1.1	1.1	Top soil	Q	2.5
	2	69.0	15.0	16.1	Clay		
	3	19.4	--	--	Clay		
VES 07 Kauri N9^{0}35′29.4″ E11^{0}11′09.3″	1	62.0	2.9	2.9	Top soil	AK	4.1
	2	1967.1	3.7	6.6	Fresh Basalt		
	3	5547.9	14.6	21.2	Fresh Basalt		
	4	2611.7	--	--	Fresh Basalt		
VES 08 Kushi N9^{0}35′23.22″ E11^{0}11′06.06″	1	11.5	4.6	4.6	Top soil	H	5.8
	2	3.7	11.4	16.0	Clay		
	3	14.2	--	--	Clay		

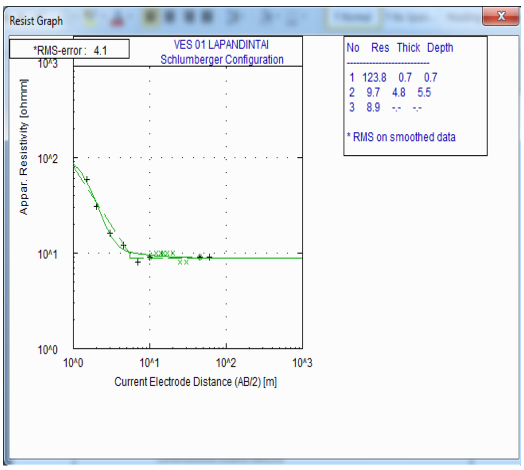


Figure5. *Computed VES01 Data*

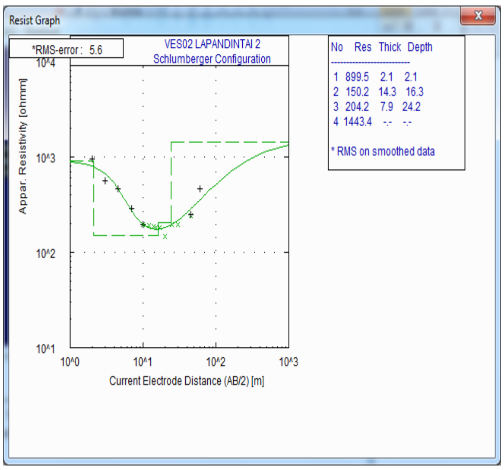


Figure6. *Computed VES 02 Data*

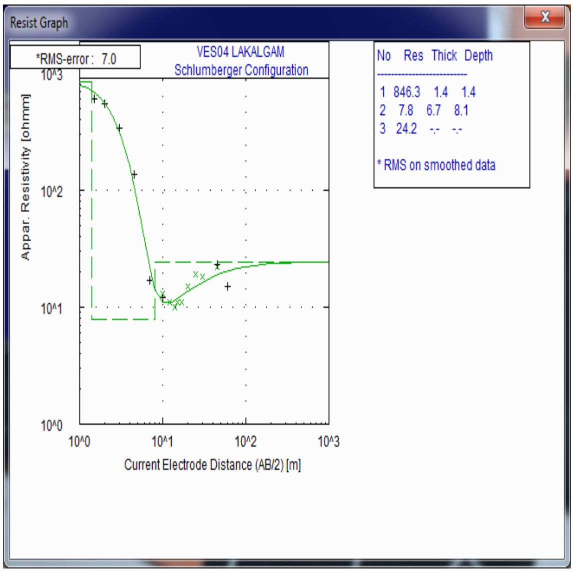


Figure7. *Computed VES03 Data*

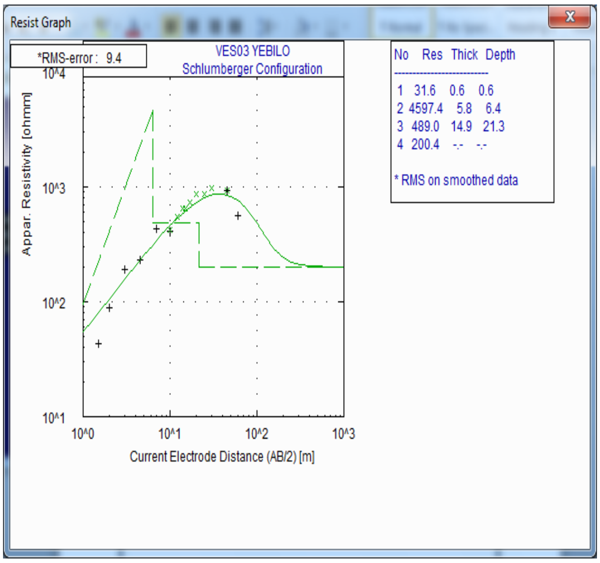


Figure8. *Computed VES 04 Data*

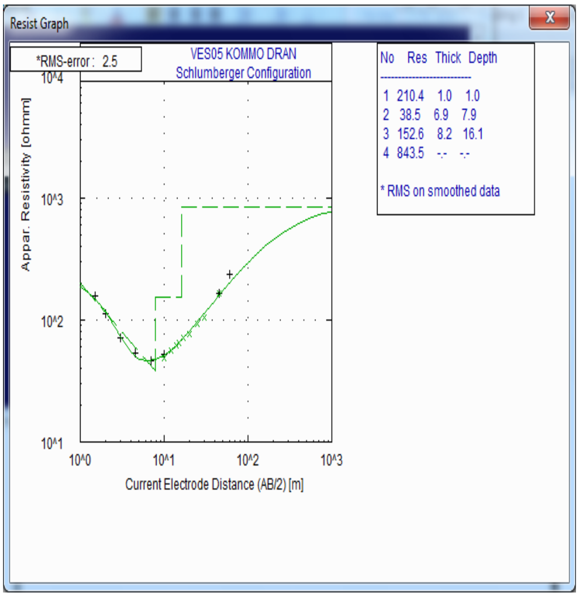


Figure9. *Computed VES 05 Data*

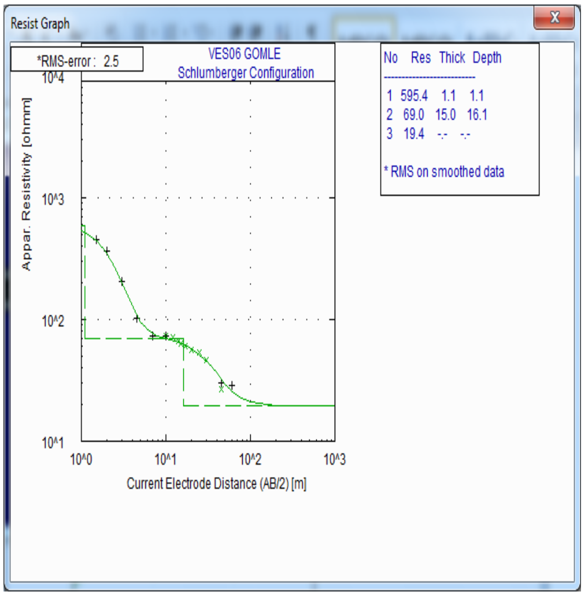


Figure10.*Computed VES 06 Data*

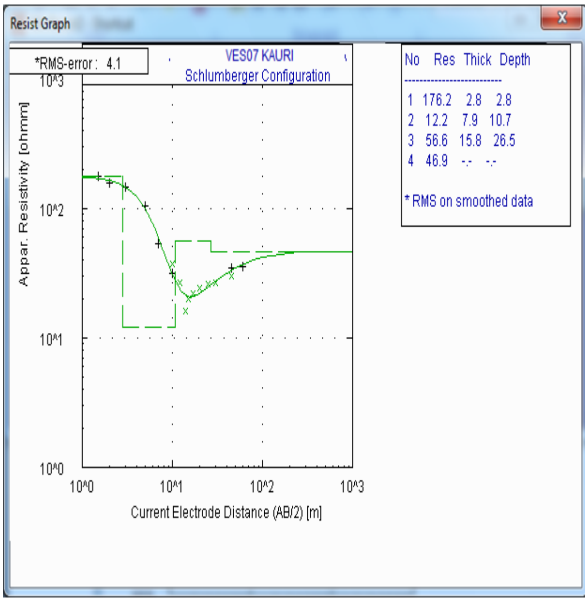


Figure11. *Computed VES 07 Data*

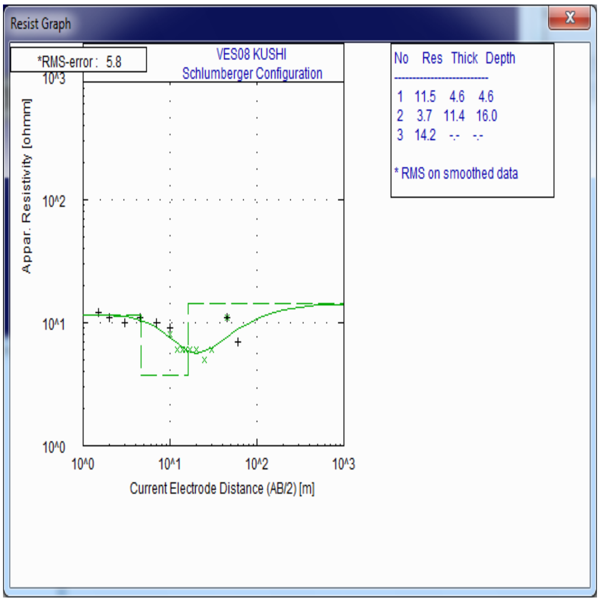


Figure12.*Computed VES 08 Data*

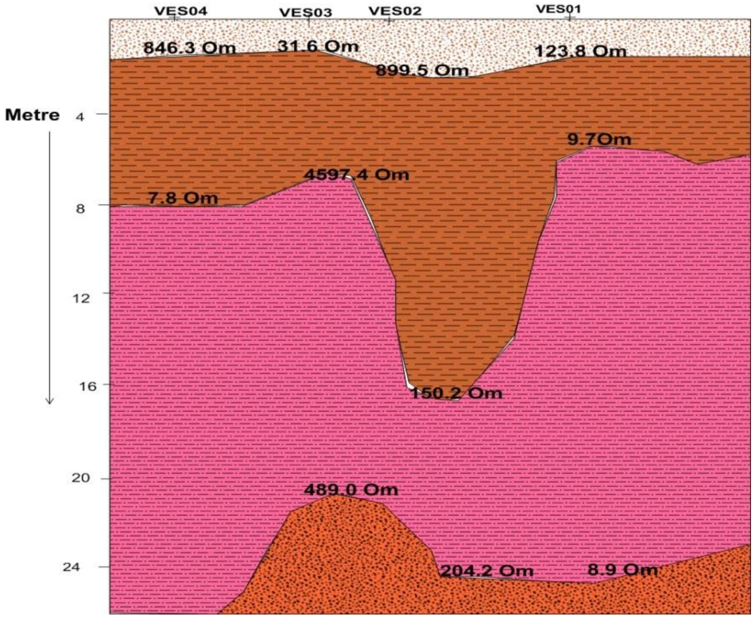


Figure13.*Geoelectric Section along VES01-04*

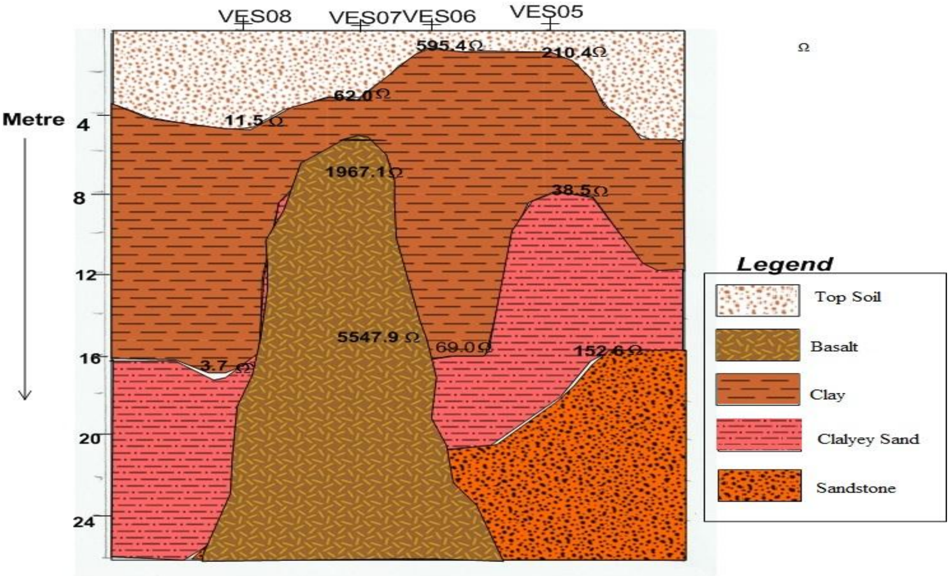
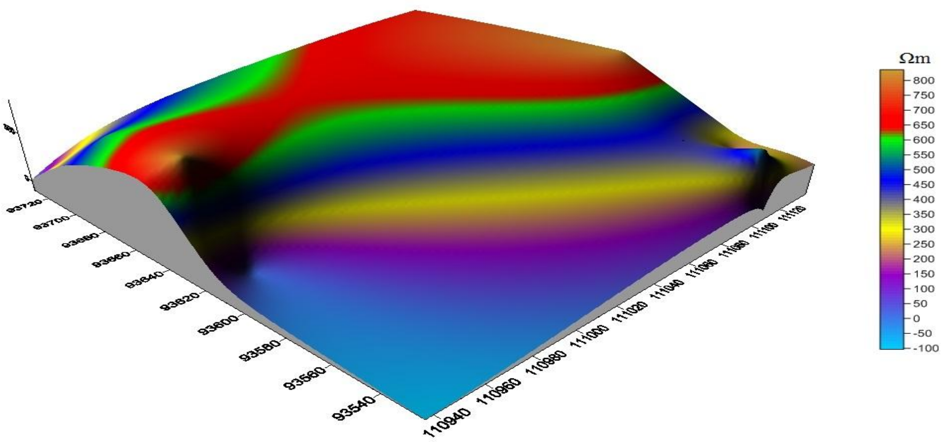
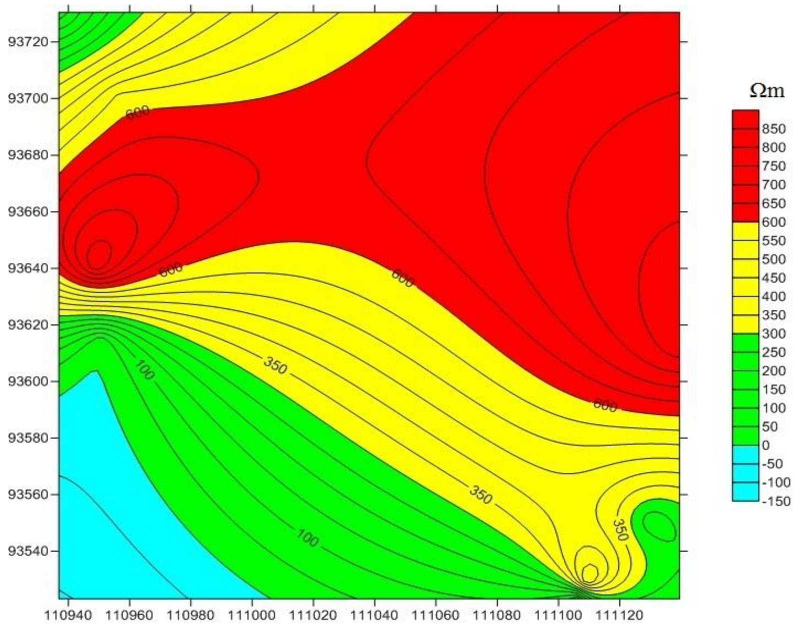


Figure14. *Geo-electric Section along VES05-08*

Iso-resistivity analysis gives the qualitative interpretation that represents the variation in resistivity at a given electrode spacing and also indicates the general lateral change in the electrical properties around the area. The study area has anomalies high at the Eastern and western part with resistivity reaching a maximum value of 800mΩat Yelwa with another one with same value at North East of Kushi(Fig.15), while major anomaly low was depicted in the southwestern portion of the study area.





Contour interval 50 Ohm-meter

Figure15. *a. Iso-resistivity 3D surface map at 60metre.*

b. Iso-resistivity Contour map at 60metre

4. CONCLUSION

The results of VES carried out in Kushi and its environs in order to locate suitable sites for portable water supply. The curve-types in the study area are Q,HA,KQ,H and AK. From the interpreted results, the study area is characterized by three-four geo-electric layers; the first layer having thickness range between 0.6-4.6 m, the second layer thickness ranging between 5.5-16.m, the third layer thickness ranging between 16.6m and fourth layer is extended beyond probing depth. From the studies it can be deduce that the second and third layer identified as porous sandstone to sandy-clay materials which can serve as the aquiferous zone, suitable for borehole sites to a depth of 20-30m.

REFERENCES

Alile, O. Ujuanbi, M. O. and Evbuomwan, I. A.**,** 2010**.** Geoelectric investigation of groundwater in Obaretin –Iyanomon locality, Edo state, Nigeria.*Journal of Geology and Mining Research Vol. 3(1), 13-20pp.*

Akande S.O, Hoffknecht A, Erdtmann B.D (1992) Rank and petrographic composition of selected Upper Cretaceous and Tertiary coals of Southern Nigeria.*Int J Coal Geol 20:209–224.*

Benkhelil, M.J. 1982. Benue Trough and Benue Chain.*Geol. Mag. 112,155-424.*

Benkhelil M. J (1989) The origin and evolution of the Cretaceous Benue Trough, Nigeria. *J*

African EarthSci. 8:251–282

Carter, J.D. W. Barbar, E.A. Tati, and G.P. Jones, (1963): The northeastern Nigeria: geological survey of Nigeria Bullentin, *Vol. 30, and P. 1-108.*

Dahlin, T. (1996)"2D Resistivity Surveying for Environmental and Engineering Applications," *First Break,Vol. 14, No. 7, , pp. 275-283.*

Dan-Hassan, M.A and Adelike, D.A (1991).Geophysical exploration for ground water in crystallinebasement terrain; A Case study of Zabenawan Dansudu, Kano state; *Journal of mining and Geology vol.27 no.2*

Dike,E.F.C;Shemang, E.M and Dan-Hassan M.A (1994):Water exploration in A.T.B.U main campus at Gubi using electromagnetic and resistivity techniques.

Emenike E.A (2001). Geophysical exploration for ground water in a sedimentary environment. *Global J. Pure Appl. Sci., 7(1): 97-102.*

Fasunwon, O.O., Ayeni, A.O. and Lawal, A.O. (2010).A Comparative Study of Borehole Water Quality from Sedimentary Terrain and Basement Complex in South-Western, Nigeria.*Research Journal of EnvironmentalSciences,4(3): 327-335pp.*

Fragio, A.G. (2005) The European Response to the Challenges of Water and Sanitation in Developing Countries, *Tribune* 2, 86-89.

Galin, D. L. (1979). Use of Longitudinal conductance in Vertical electrical sounding Induced Potential Method for Solving Hydrogeological Problems, VestrikMoskovskogoUniver, *Geol, 34, 74-100*.

Guelala, R., Inoubli, M.H., Amri, F. 2009. New elements on the structure of the Ghardimaou superficial aquifer (Tunisia): electrical geophysics results. *Hydrological Sciences Journal, 54(5) : 974-983*

Hati, S. S.,Dimari G. A. and Ngueadoum N., 2011. Quality status of drinking water sources in Gombe metropolis of Nigeria.*Am. J. Sci. Ind. Res., 2011, 2(4): 537-542.*

Khatri, K.B. and Vairavamoorthy, K. (2007) *Challenges for Urban Water Supply and Sanitation in the Developing Countries*, Discussion Draft Paper for the session onUrbanisation*Delft, pp. 2-20.*

Mbiimbe, E.Y. Olasehinde, A and Bute I. S. (2012): Hydrogeophysical Investigation of the area around Angware in Jos East. *Global Journ. Geol. Sci. Vol 10 (2) pp141-148*

Obaje N.G (1994) Coal petrography, microfossils and paleoenvironments of Cretaceouscoal measuresintheMiddleBenueTroughofNigeria.*TuebingerMikropalaeontologischeMitteiluge11,116*

Obaje, N G; H, Wehner; G, Scheeder; M, B Abubakar; A, Jauro;. (2004). Hydrocarbon Prospectivity of Nigeria's inland basins: From the viewpoint of organic geochemistry and organic petrology. *AAPG Bulletin, 88 (3), 325-353.*

Oyawoye,M.O(1972)ThebasementcomplexofNigeria.In:DessauvagieTFJ,WhitemanAJ(eds)*African geology.Ibadan University Press, pp 66–102*

Sinha, R Israil, M and Singhal, D.C (2009) "A Hydrogeo-Physical Model of the Relationship between Geoelectric and Hydraulic Parameters of Anisotropic Aquifers," *Hydrogeology Journal, Vol. 1 pp. 495-503.*

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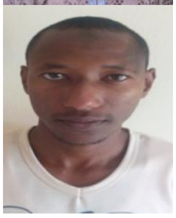

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