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Hydrogeological Implications of Characteristics Features of Apparent Resistivity Curves, River Ogun Flood plain, Ikorodu, Southwestern Nigeria

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Abstract

The aim of the study is to investigate the hydrogeological potential of river Ogun flood plain, Ikorodu, a sedimentary area in southwest Nigeria located between longitude $3^o30'$and $3^o45'$E, and latitude $6^o30'$and $6^o45'$N. This was accomplished by the interpretation of apparent resistivity curves obtained from electrical resistivity method using Schlumberger electrode configuration and physico-chemical analysis of the water samples. The results corroborated with the lithological correlation of the apparent resistivity section reveal that the HA-type apparent resistivity sounding curves obtained has a geoelectrical section comprises well graded silt top soil of resistivity 13 to 192 Ωm and of average thickness 0.69m. The less resistive second layer ($\rho < 5$ Ωm) is constituted probably by clayey material of the coastal plain sand unit and 22.90m to 31.30m thick. It indicates the presence of conductive sedimentary section saturated with salt-water as exemplified by high conductivity (122 mhos) and salinity (60mg/l) of the water sample. The saprolite zone is constituted by grayish fine sand with intercalations of grayish clay of resistivity 35 to 59Ωm. The resistivity of the fourth layer, ranged from 350 to 400 Ωm and falls within the shale and limestone resistivity range (300-500Ωm). Hydrogeologically, the zone of aeration which is 42.30-78.00m thick comprising alluvial and coastal plain sand aquifer units

and overlying conductive sedimentary rock could support productive water bore hole. However, the salinity of the water saturation zone as well as the tendency of the sedimentary rock being a fresh-water aquifer could result to a fresh-saline water interface.

Keywords: Salt-water, Floodplain, Coastal Plains Sands, Fresh-saline water interface, Sedimentary terrain

Introduction

Electrical resistivity methods employ a phenomenon which makes possible, the differentiation between types of earth materials the resistivity of which are closely related to the moisture content and its chemical characteristics. It therefore plays a major role in mineral resources exploration and in environmental and geotechnical investigations such as mapping of overburden, faults, fractures, salt water intrusions, contaminant plumes and waste dumps (Chunduru *et. al*., 1996). Other applications include spatial delineation in groundwater contamination studies (Buselli and Kanglin, 2001; Olayinka and Olayiwola, 2001); hydraulic conductivity field characterization (Dam *et al*., 2000) based on site-specific relation between hydraulic conductivity and electrical resistivity (e.g. Cassiani and Medina, 1997); and in petrophysical study by resistivity mapping (e.g. Shevnin *et al.*, 2006). Its application in groundwater exploration has been fully established both in basement areas (Dan-Hassan and Olorunfemi, 1999; Omosuyi, 2010) and in unconsolidated formation (Gomez and Fuentes, 2010). This is accomplished by the interpretation of the apparent resistivity curves obtained from surface measurements of apparent resistivity using vertical electrical sounding (VES) technique. These curves could be of different forms such as Q-type ($\rho_1>\rho_2>\rho_3$), A-type ($\rho_1<\rho_2<\rho_3$), H-type ($\rho_1>\rho_2<\rho_3$) and K-type ($\rho_1<\rho_2>\rho_3$) for a 3-

layer section or their mixture for a section having more than three layers. The nomenclature is dependent of the relationship between the resistivity of the layers that constitute the section starting from the first layer (Sharma, 1997).

In H, A, KH ($\rho_1<\rho_2>\rho_3<\rho_4$), HA ($\rho_1>\rho_2<\rho_3<\rho_4$) and other related type sections, the terminal branch in the bedrock unit on the apparent resistivity curve often rises at an angle of 45^o (Zohdy *et al*., 1974; Olayinka *et al*., 2000). This indicates igneous or metamorphic rocks of very high resistivity ($\rho>1000\ \Omega$ m) if the bedrock is fresh, and low resistivity ($\rho<1000\ \Omega$ m) if the bedrock is fractured (Badmus and Olatinsu, 2010; Adabanija *et al.*, 2008). The objective of this research is to investigate the hydrogeological potential of river Ogun flood plain, Ikorodu, a sedimentary area in southwest Nigeria.

Location and Geology of the study area

The area of study is located in the sedimentary terrain of Lagos state between longitude $3^o30'$and $3^o45'$E, and latitude $6^o30'$and $6^o45'$N (Figure 1) and at an altitude of above 6.40m above sea level (Figure 2). It is concealed within the coastal plains sands stratigraphic unit of Dahomey basin (Figure 3) which is an arcuate coastal basin underlying the on-shore parts of Togo, Benin and the southwestern Nigeria. The basin is separated from the Benue trough by a basement ridge, the Okitipupa ridge a paleographic high. It is bounded in the east by Benin hinge line, a major regional fault structure marking the western limit of the delta basin (Adegoke, 1969). The regional fault consists of horst and grabens (Omatsola and Adegoke, 1981) and confirmed by gravity and aeromagnetic studies (e.g. Nur *et. al*., 1994). The stratigraphy of Dahomey basin is as depicted in Table 1. It consists of six dif-

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ferent formations (Figure 4) namely: Abeokuta, Ewekoro, Akinbo, Oshosun, Ilaro and Coastal Plain Sands Formation.

Abeokuta formation is the oldest sedimentary unit in the Dahomey basin and it is unconformably on the basement complex of south western Nigeria (Figure 4). It consists of lower cretaceous, coarsely grained, poorly sorted micaceous sandstone with interbedded mudstone conformably overlying the basement complex and it is overlain by finer detrital sandstones, siltstones and shale that are transitional in nature. It thickens towards the west and dips at an angle of 1o towards the coast. The formation has an average thickness of 200m. It is about 244m thick at the Nigerian-Dahomey border but just about 183m around Abeokuta, southwest Nigeria. Omatsola and Adegoke (1981) further divided this formation into three members viz: Ise, Afowo and Araromi members (Table 1).

Ewekoro formation overlies conformably the Abeokuta Formation (Figure 4) and it consists predominantly of limestone. The limestone body is fossiliferrous consisting of closely inter bedded bands and lenses of shelly limestone but became arenaceous (sandy) towards the base where it grades into Abeokuta formation. The age is Eocene.

Akinbo formation conformably overlies the Ewekoro Formation. It consists of well-laminated greenish-grey and black shale which is Palaoecene-Eocene in age. The type section varies in thickness between 7 and 14m of black- grey shales with minor intercalations of thin and sometimes inconsistent marly limestone nodules. The shale becomes more silty and sandy as it grades into the overlying Oshosun Formation.

The Oshosun Formation overlies the Akinbo Formation. It is composed of green, greenish-grey or beige clay and shale with inter-beds of sand. The shale is usually laminated and glauconitic. The basal portion of this formation is sand and sandy facies. It exhibits signifi-

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cant lateral and lithologic variation. The presence of fauna such as corals, crinoids, mollusks, planktonic foraminifera within the Formation suggests marine environment of formation. The age is Eocene.

Ilaro Formation overlies the Oshosun Formation. It consists dominantly of marine, yellowish, poorly consolidated limestone with developed mottles of red and brown weathered surfaces. The contact is placed at the top of the first major sandy bed of Oshosun Formation. The age of this formation is Middle-Upper Eocene.

Coastal Plain Sands Formation is the youngest unit in the Eastern Dahomey basin. It consists of soft, very poorly sorted clayey sands, sandy clays which are pinkish-red and brownish in colour due to weathering. This formation lacks fossils but contains plant remains which have been used to date the Formation. The age of this formation ranges from Oligocene to Recent and its thickness ranges from 10 to 100m.

Locally, the information on the geology of the area could not be established by visual investigation due to rarity of outcrops of the strata. Nonetheless, based on the geological map of Lagos area and the bore hole lithology (Figure 5), the study area consists of coastal plain sands constituted by pebbly sands, sandy clays and lignites of mainly recent quaternary alluvium overlain Ilaro formation.

Materials and methods

For the geophysical investigation, a total of eight vertical electrical soundings (VES) Schlumberger curves of maximum electrode spread of 200m were quantitatively interpreted by partial curve matching technique (Orellana and Mooney, 1966) and computer iteration using a resistivity software, resist version 1.0 developed by Velpen (1988). The slopes of the terminal branch of the apparent resistivity curves were determined by the intercept of the extension of the S-line with the horizontal line at apparent resistivity (ρ_a) equals 1 Ω m (Zohdy *et al.*, 1974; Olayinka *et al.*, 2000). The total longitudinal conductance S was determined explicitly using the expression

$$S = \sum_{i=1}^{n-1} \frac{h_i}{\rho_i}$$

Where n is the number of layers, h_i is the thickness of layer i and ρ_i is the resistivity of layer i. Typical HA apparent resistivity curve obtained from the area is as shown in Figure 6.

For the hydrogeological investigation, available borehole information (lithological logs) was used for subsurface geological sequence delineation and aquifer type identification. Physico-chemical analysis of the water sample from the borehole in the area was also carried out. The significance of this analysis is to enhance effective geophysical interpretation and ascertain the quality of water in the area.

Results and Discussion

The layering parameters, resistivity and thickness of the layers; the geoelectrical parameters, longitudinal conductance; the overburden thickness; and the slope of the rising portion (S-line) of the apparent resistivity curves inferred from the interpretation are as on Table 2. The resistivity of the topsoil mostly silt, range from 13 Ωm to 192 Ωm and it is relatively thin (0.55 - 0.90m). The second layer probably made up of clayey material and of thickness

22.90-31.30 m is less resistive (ρ< 5 Ωm). The transition zone, mainly constituted by greyish fine grained sand with intercalation of lenses of greyish clay, as evidenced in the lithologic correlation of the compressed borehole lithologic log and the apparent resistivity section shown in Figure 7, has resistivity ranging from 35 Ωm to 59 Ωm. The fourth layer has resistivity ranged between 350 Ωm and 400.0 Ωm, probably occupied by sedimentary rock. However, due to the less resistive second layer, the water table could be saturated with salt-water. This could henceforth make the sedimentary rock saturated with salt-water and therefore conductive. Under this condition, the sedimentary rock is referred to as 'electric-basement' (Zohdy *et al;* 1974, p.35). In some sedimentary area, the rock could be limestones or sandstones having reistivities of only 200-500 Ωm (Zohdy *et al;* 1974, p.35). However, in the present study, it could be shale or limestone as evidenced by the lithologic correlation of the borehole lithology and the apparent resistivity section (Figure 7). The curves therefore exhibit geoelectrical characteristics associated with sedimentary terrain as established by Zohdy *et al*. (1974). The rising portion of the curve indicated by S-line in Figure 6 inclined at an angle less than 45^o. This is a clear departure from the expected angle of rising portion, approximately 45^o (Olayinka et al., 2000) of a similar geoelectric section in a crystalline terrain.

The hydro-geological potential of the area is appraised in terms of the material that constitutes the aquifer. The work of Kampsax-Kruger and Schwed Associates (1977) on hydrogeology of Lagos state identified four major aquifers horizon: first, second and third aquifers called collectively upper aquifers which are abound in the alluvium and coastal plains sands formation, and the fourth aquifer; the lower aquifer in Abeokuta formation.

In the present study, the major aquifers identified in this part of Lagos state and corroborated by the lithologic correlation in Figure 7 and generalised stratigraphic section in Figure 4 are located in alluvial deposits, Coastal Plain Sands (CPS) and Ilaro formation aquifer unit. The former is unconfined consisting of greyish fine grained sand intercalated by lenses of greyish clay and extends to the topsoil where it occurs as well graded silts, laid down on flood plains. It occupies a total depth of about 102m. The second aquifer horizon comprises greyish medium to coarse sand underlain by impervious fossiliferrous pale gray clay, fossilied grey shale and black Lignite. It extends from the coastal plain sands unit to the Ilaro formation and occupies a depth of about 528m. The aquifers are of upper, middle and lower aquifer class corresponding to Quaternary, tertiary and cretaceous age respectively (Table 3). By virtue of the composition of the second aquifer horizon, the fourth layer of the apparent resistivity section could probably be shale extending to the infinitesimal part of upper Ewekoro formation where it occurs as limestone. Lending credence to this is the fact that both shale and limestone has resistivity ranging from 300-500 Ωm and is a peculiar geoelectrical feature of a typical conductive basement (Zohdy *et al.*, 1974). This is as revealed by the resistivity of the bottom layer (Table 2) which ranged from 350-400 Ωm.

The groundwater potential of the area is enhanced by highly permeable sandy clay which overlain the confined 'electric basement', thick zone of aeration (42.30-78.00m) as evidenced in Table 2 and conductive sedimentary rock that occupies the fourth layer are favourable for groundwater recharge. However, the water could be saline because of the resistivity of the second layer that is less than 5 Ωm as supported by high conductivity (122 mhos) and high salinity (60mg/l) in physico-chemical analysis of water sample from the area (Table 4). This is a further confirmation of Oterie and Atolagbe (2003); and Oyedele and Momoh (2009) of the occurrence of salt-water intrusion into the coastal plains sands of Lagos state. Consequently, the tendency of the sedimentary rock being a fresh water aquifer can not be over ruled, thereby leading to the establishment of fresh-saline water interface, probably at the saprolite zone. This is recommended for further research using Time Domain Electromagnetic (TDEM) geophysical method. This is based on its proven and efficient ability (e.g. Kafri *et al.*, 1997; Yechieli *et al.*, 1998, 2001) in delineating the configuration of inter related fresh-water and saline bodies and the interface between them. This would strongly enhance the remediation process.

Conclusion

The hydrogeological potential of river Ogun flood plain, a sedimentary terrain in Ikorodu, southwestern Nigeria has been investigated. The apparent resistivity curves obtained indicated geoelectrical succession comprising top-soil mostly silt; a less resistive second layer ($\rho<5$ Ωm); a saprolite zone of resistivity ranged between 35 Ωm and 59 Ωm; and the fourth layer constituted by a conductive sedimentary rock, probably shale of resistivity 350.0 - 400.0 Ω m. The rising portion of the apparent resistivity curves inclined at an angle less than 45^o, a clear departure from a similar geoelectrical section usually obtained in crystalline terrain. Hydrogeologically, the thick zone of aeration (42.3 – 78.0 m), highly permeable aquifer unit and conductive sedimentary basal rock are good hydrogeological indicators which could enhance groundwater recharge for high well yield, but the salinity of the water saturation zone could be a draw-back.

References

Adabanija, M.A., E.O. Omidiora and A.I. Olayinka, 2008. Fuzzy logic modeling of resistivity and hydrogeologic parameters for aquifer assessment in basement complex. Hydrogeol. J., 16(3): 461-481

Adegoke, O.S., 1969. Eocene stratigraphy of southern Nigeria. Bull. Geol. Mem. 60: 23-48.

Badmus, B.S. and O.B. Olatinsu, 2010. Aquifer characteristics and groundwater re charge pattern in a typical basement complex southwestern Nigeria. African Journal of Environmental Science and Technology, 4(6); 328-342

Buselli, G. and Lu. Kanglin, 2001. Groundwater contamination monitoring with multi channel electrical and electromagnetic methods. Journal of Applied Geophysics, 48(1): 11-23

Cassiani, G. and M.A.Jr. Medina, 1997. Incorporating auxiliary geophysical data into groundwater flow parameter estimation. Ground Water, 35(1).79-91

Chunduru, R.K., M.K. Sen and P.L. Stoffa, 1996. 2-D resistivity inversion using spline parametrization and simulated annealing. Geophysics, 61(1):151-161.

Coode, B., 1997. Hydrogeological Investigation of Lagos State. Lagos State Water Cor poration. pp: 4.1-5.6

Dam, D., S. Christensen and N.B. Christensen, 2000. Characterizing the Hydraulic Conductivity Field Using Electrical Resistivity and Inverse Modeling. In: Bjerg, P.L., P. Engesgaard and T.D. Krom (Eds.). Groundwater, Copenhagen Denmark, Vol. 1, pp: 526

Dan-Hassan, M.A. and M.O. Olorunfemi, 1999. Hydro-geophysical investigation of a basement terrain in the North Central part of Kaduna State, Nigeria. J. Mining Geol., 35(2):189-206.

Gomez, L.S. and Fuentes, O.E., 2010. The application of electrical methods in explora tion for groundwater resources in the river Malacatoya sub-basin Nicaragua. Geofisica Internacional, 49(1): 27 – 41

Jones, H.A. and R.D. Hockey, 1964. The geology of the southwestern Nigeria. Geol. Surv. Nig. Bull., 31: 101.

Kafri, U., M. Goldman and B. Lang, 1997. Detection of subsurface brine, fresh water bodies and the interface configuration in between by the TDEM method in the dead sea rift Israel. Environmental Geol. Journ., 31:42-49

Kampsax-Kruger and Schwed Associates, 1977. Underground water resources investi gation of the metropolitan Lagos. Final Report, Federal Ministry of Works and Planning Lagos.

Nur, M.A., K.M. Onuoha and C.O. Ofoegbu, 1994. Spectral analysis of aeromagnetic data over the middle Benue trough, Nigeria. J. Mining Geol., 30(2): 211-217.

Olayinka, A.I., 1992. Geophysical siting of borehole in crystalline basement areas of Africa. J. Afr. Earth Sci., 14(2):197-207.

Olayinka, A.I., F.O. Obere and L.M.Jr. David, 2000. Estimation of longitudinal resistive ity from schlumberger sounding curves. J. Mining Geol., 36(2):225 – 242.

Olayinka, A.I. and M.A. Olayiwola, 2001. Integrated use of geoelectrical imaging and hydrochemical methods in delineating limits of polluted surface and groundwater at a landfill site in Ibadan area, southwestern Nigeria. J. Mining Geol., 37(1):53 - 68.

Omatsola, M.E. and Adegoke, O.S., 1981. The tectonic evolution of cretaceous strati graphy of the Dahomey basin. J. Mining Geol., 18: 130-137

Omosuyi, G.O., 2010. Geoelectric assessment of groundwater prospect and vulnerabili ty of overburden aquifers at Idanre southwestern Nigeria. Ozean J. Applied Sci., 3(1):19 - 28

Orellana, E. and H.M. Mooney, 1966. Master tables and curves for vertical electrical sounding over layered structures: Madrid Interciencia, Costanilla de los Angles, 15, Madrid, Spain. 150pp. 66Tables

Oterie, A.U. and F.P. Atolagbe, 2003. Saltwater intrusion into coastal aquifers in Nige ria. Proceedings of the 2ND International Conference on Saltwater Intrusion and Coastal Aquifers–Monitoring, Modeling and Management. Merida Yucatan Mexico. March 30 – April 2, 2003: 1-6

Oyedele, K.F. and E.I. Momoh, 2009. Evaluation of sea water intrusion in freshwater aquifers in a lagoon coast: A case study of the University of Lagos Lagoon Akoka Nige ria. Report Opinion, 1(2): 61 – 72

Sharma, P.V., 1997. Environmental and Engineering Geophysics. Cambridge University Press, Cambridge UK.

Shevnin, V., O.D. Rodriguez, A. Mousatov, D.F. Hernandez, H.Z. Martinez and A. Ry jov, 2006. Estimation of soil petrophysical parameters from resistivity data: Application to oil contaminated site characterization. Geofisica Internacional, 45(3): 179 – 193

Velpen, B.P.A.V., 1988. A computer processing package for DC resistivity interpreta tions for an IBM compatibles. ITC Journal Vol. 14, The Netherlands.

Yechieli, Y., U. Kafri and M. Goldman, 1998. Mapping of fresh and saline water bodies in the coastal aquifer of the Dead sea using TDEM method. Geological Survey Isr. TR-GSI/8/98

Yechieli, Y., U. Kafri, C. Goldman and I. Voss, 2001. Factors controlling the configure tion of the fresh-saline water interface in the Dead sea coastal aquifers: synthesis of TDEM surveys and numerical groundwater modeling. Hydrogeol. J., 9(4): 367-377

Zohdy, A.A.R., G.P. Eaton and D.R. Mabey, 1974. Application of surface geophysics to groundwater investigations. Techniques of water resources investigation of the United States Geological survey, United States Department of Interior Geological Survey Washington DC I19.13:1492

Table 1. The Stratigraphy of the Dahomey Basin

		Jones and Hockey 1964	Omatsola and Adegoke 1981
Quaternary	Recent Oligocene to Pleistocene	Alluvium Coastal Plains Sands (CPS)	Alluvium Coastal Plains Sands (CPS)
Tertiary	Eocene	Ilaro formation	Ilaro formation
	Paleocene- Lower Eocene	Ewekoro formation	Oshosun formation
			Akinbo formation
			Ewekoro formation
Cretaceous	Cretaceous	Abeokuta formation	Araromi formation
			Aofowo formation
			Ise formation
Pre-Cambrian	Pre-Cambrian	Basement complex	Basement complex

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Table 2. Layering and Geoelectrical parameters

Stations	Layers	Resistivity* (Ω m)	Thickness (m)	Depth to Bedrock (m)	Longitudinal Conductance (mhos)	S-line Slope
KRD01	1	189	0.90			
	2	3	23.40			
	3	35	18.00	42.30	7.652	38.0^o
	4	356	-			
KRD02	1	13	0.70			
	2	3	31.30			
	3	45	46.00	78.00	10.501	43.0^o
	4	363	-			
KRD03	1	154	0.60			
	2	3	22.90			
	3	53	20.80	44.30	7.800	36.5^o
	4	483	-			
KRD04	1	192	0.55			
	2	3	23.40			
	3	59	20.30	44.25	7.660	37.5^o
	4	350	-			
KRD05	1	176	0.65			
	2	3	23.10			
	3	46	18.50	42.25	7.626	38.0^o
	4	380	-			
KRD06	1	39	0.58			
	2	4	26.80			
	3	37	31.30	58.68	7.556	38.0^o
	4	395	-			
KRD07	1	43	0.90			
	2	4	28.00			
	3	38	36.20	65.10	7.633	38.0^o
	4	366	-			
KRD08	1	38	0.60			
	2	4	28.90			
	3	37	37.00	66.50	8.432	38.0^o
	4	400.0	-			

*The resistivity of the layers indicate the first layer is top soil, mostly silt and wet; the second layer is probably saturated clayey soil; the third layer is admixture of sand/clayey sand; and the last layer as the "electric basement" probably Shale or Limestone.

Table 3. Delineation of aquifers in Lagos state

Formation	Age	Kampsax\Schwed
Alluvium	Quaternary	1st, 2nd, 3rd
Coastal Plain Sands (CPS)		
Ilaro-Ewekoro	Tertiary	
Abeokuta	Cretaceous	4th

Table 4. Results of Physico-chemical analysis of water sample

Temperature Water	27^{o}c
Temperature Air	28^{o}c
Appearance	Clear
Colour (Alpha Platinum Cobalt standard)	10
Turbidity	3 FTU
Conductivity at 25^{o}c	122 mhos
Acidity (CC of 5% Na_2CO_3 of 100cm^3 sample)	2.1
pH	5.1
Total Alkalinity as $CaCO_3$	23 mg/l
Total Hardness as $CaCO_3$	9 mg/l
Calcium Hardness as $CaCO_3$	6 mg/l
Magnesium Hardness as $CaCO_3$	3 mg/l
Free Carbon Dioxide (CO_2)	24 mg/l
Iron (Fe)	1.8 mg/l
Manganese (Mn)	NIL
Chlorides (Cl^-)	14.9
Sulphates (SO_4^{2-})	NIL
Nitrates (NO_3^-)	NIL
Phosphates (PO_4^{3-})	NIL
Nitrites (NO_2^-)	NIL
Dissolved Oxygen	-
Salinity	60 mg/l

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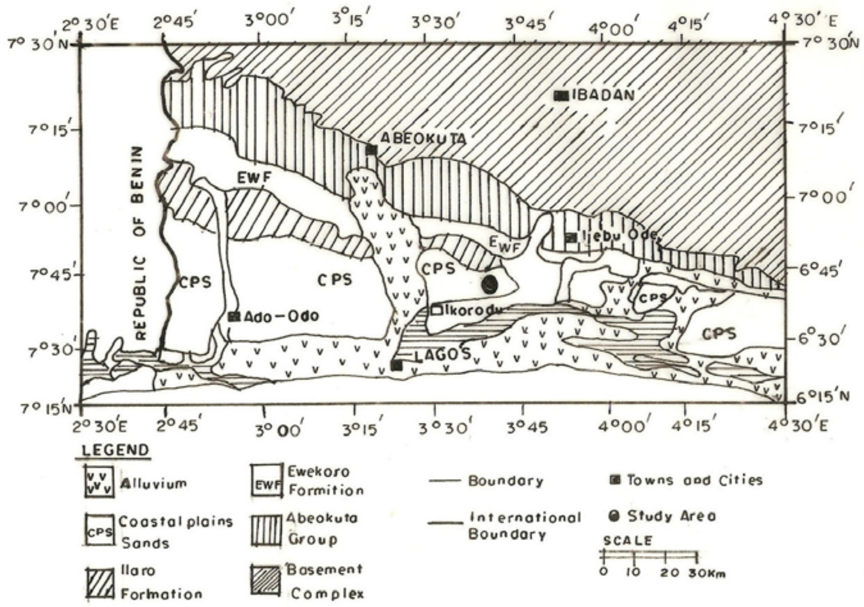
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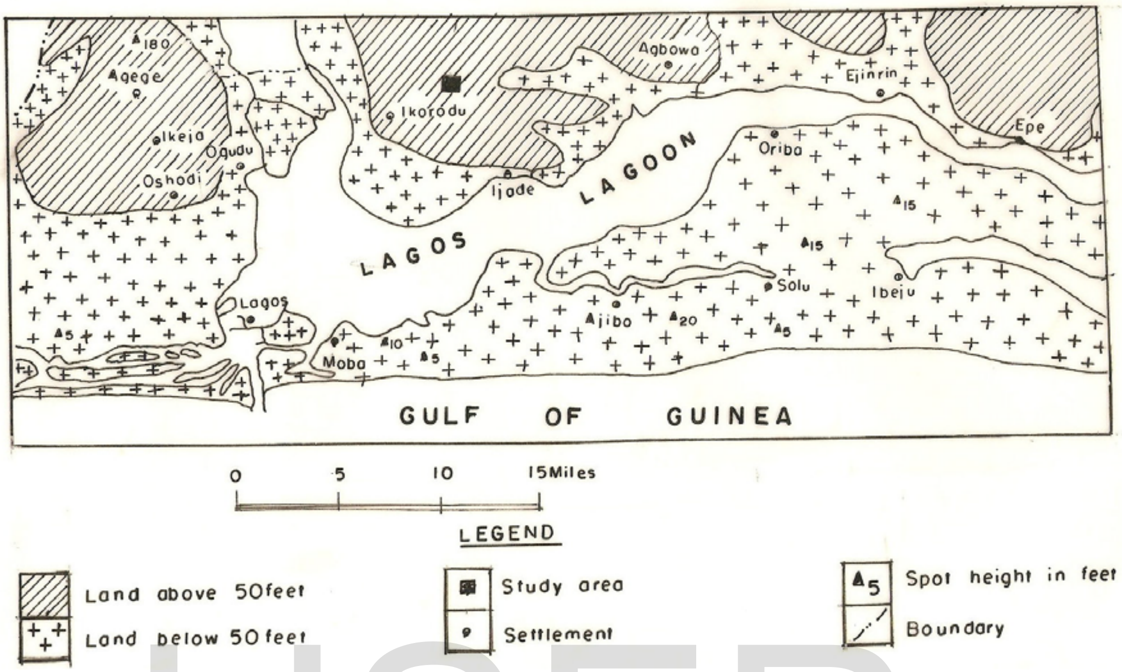
ABEOKUTA
EWF
REPUBLIC OF BENIN
Ijebu Ode
CPS
Ado-Odo
Ikorodu
LAGOS
LEGEND
Alluvium
Coastal plains Sands
Ilaro Formation
Ewekoro Formition
Abeokuta Group
Basement Complex
Boundary
International Boundary
Towns and Cities
Study Area
SCALE
0 10 20 30Km

Figure 1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Ogudu
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Ikorodu
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Oriba
Ijade
LAGOS
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15
Solu
Ibeju
Lagos
Ajibo
20
Moba
10
5
GULF OF GUINEA
0 5 10 15Miles
LEGEND
Land above 50feet
Land below 50 feet
Study area
Settlement
Spot height in feet
Boundary

Figure 2

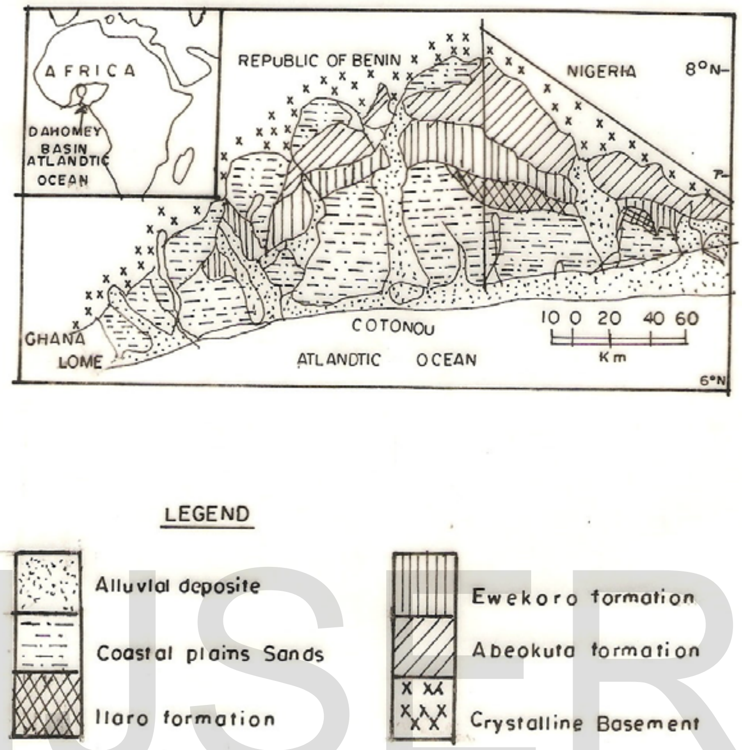
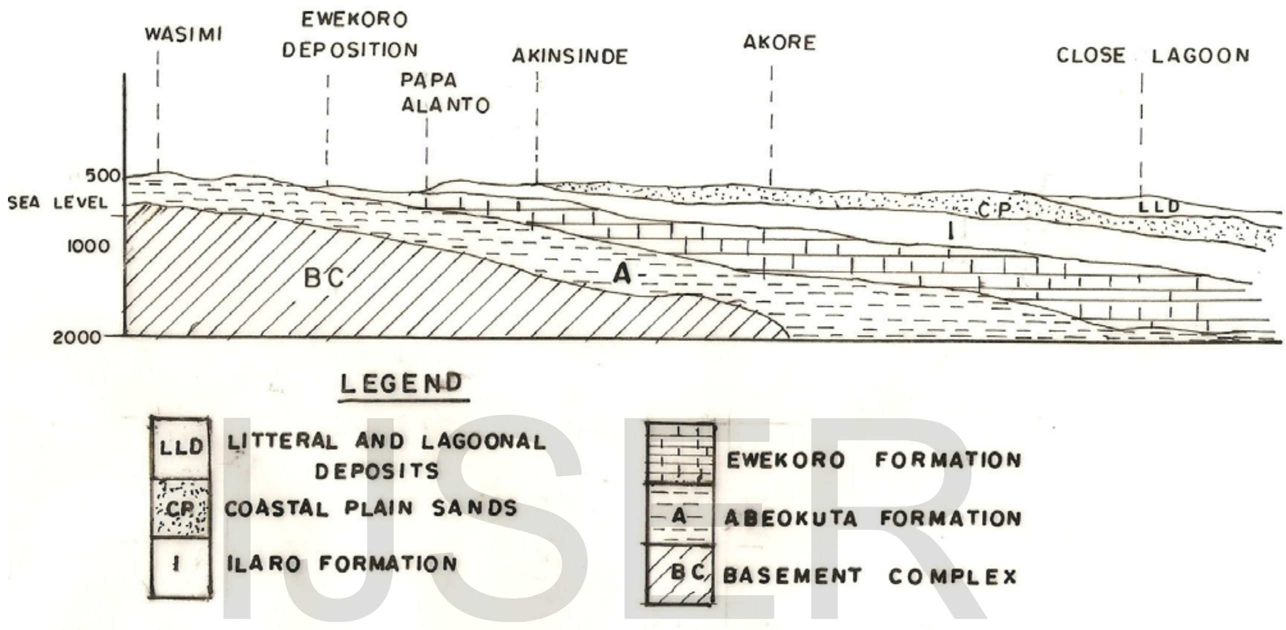

AFRICA
DAHOMEY BASIN
ATLANDTIC OCEAN
REPUBLIC OF BENIN
NIGERIA
8°N
GHANA
LOME
COTONOU
ATLANDTIC OCEAN
10 0 20 40 60
Km
6°N
LEGEND
Alluvial deposite
Coastal plains Sands
Ilaro formation
Ewekoro formation
Abeokuta formation
Crystalline Basement

Figure 3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PAPA ALANTO
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SEA LEVEL
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BC
A
I
C.P.
LLD
LEGEND
LLD LITTERAL AND LAGOONAL DEPOSITS
CP COASTAL PLAIN SANDS
I ILARO FORMATION
EWEKORO FORMATION
A ABEOKUTA FORMATION
BC BASEMENT COMPLEX

Figure 4

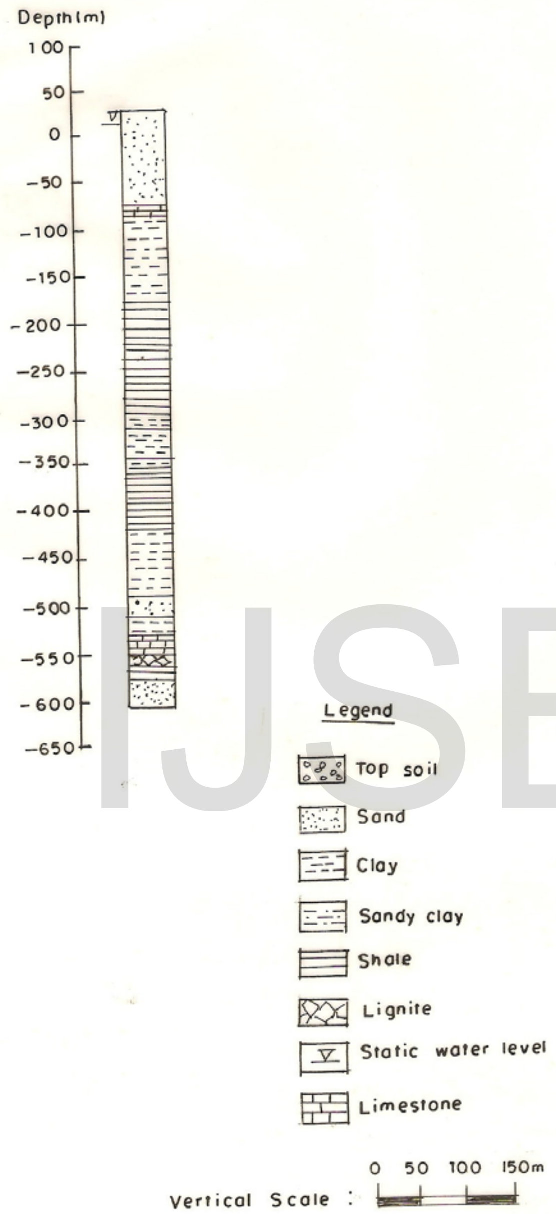
Depth(m)
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
-600
-650
Legend
Top soil
Sand
Clay
Sandy clay
Shale
Lignite
Static water level
Limestone
0 50 100 150m
Vertical Scale :

Figure 5

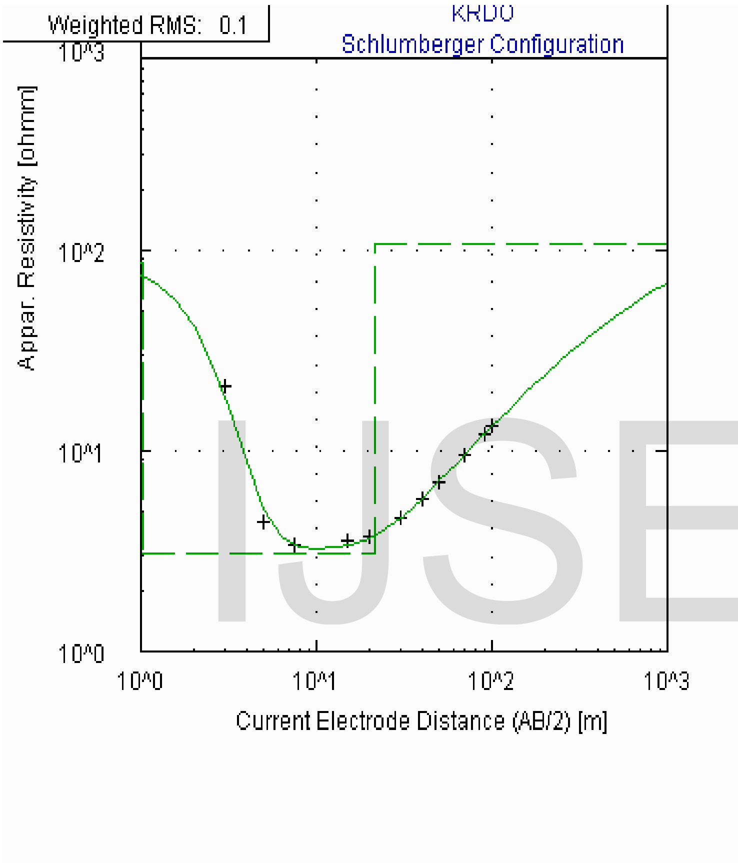
Weighted RMS: 0.1
KRDO
Schlumberger Configuration
Appar. Resistivity [ohmm]
10^3
10^2
10^1
10^0
10^0
10^1
10^2
10^3
Current Electrode Distance (AB/2) [m]

Figure 6

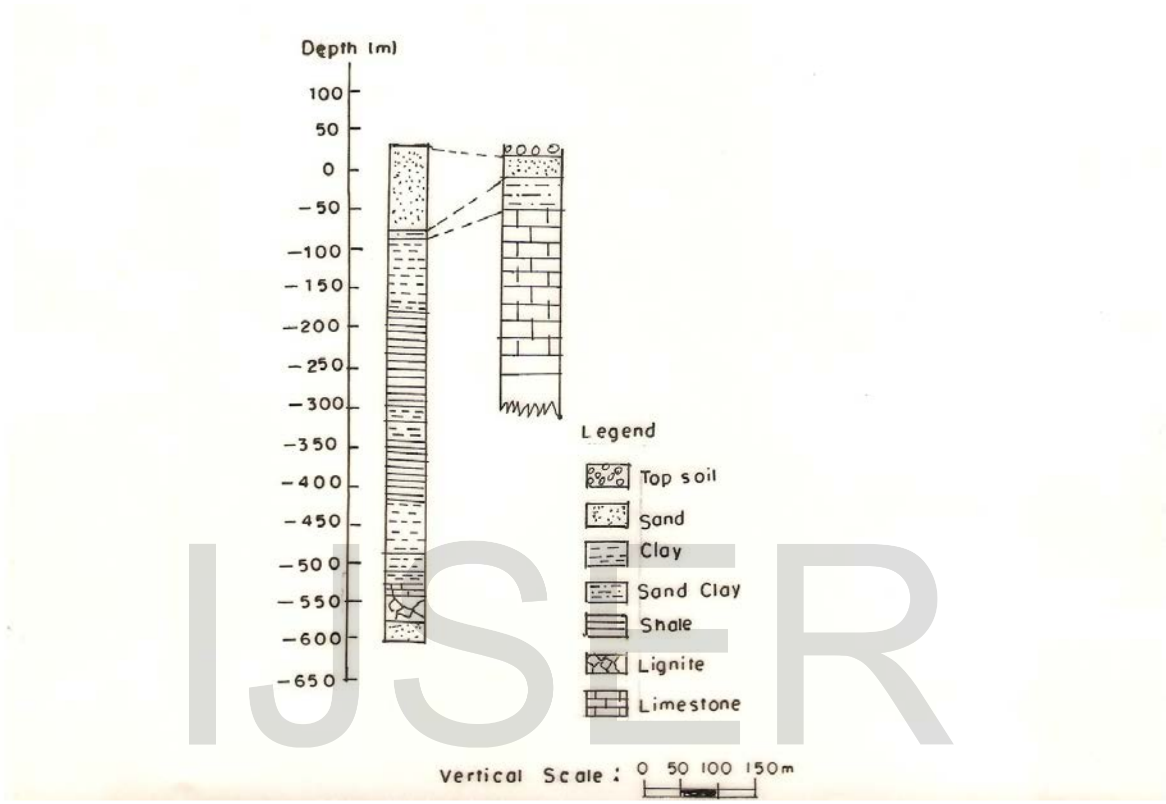
Depth (m)
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
-600
-650
Legend
Top soil
Sand
Clay
Sand Clay
Shale
Lignite
Limestone
Vertical Scale : 0 50 100 150m

Figure 7