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Geophysical Prospecting Of Clay Deposits in Abudu Area of Edo State, Nigeria.

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Abstract

The urgent need to prospect or search for clay deposits in Abudu Area of Edo State Nigeria, geophysically became imperative in view of the fact that clay as one of the natural resources aid the general economy by setting up industry/factory where the citizen of the area can be gainfully employed and hence combating crime rate in the area.

The science of prospecting for clay deposits in the area actually entailed carrying out vertical electrical sounding (VES) of electrical resistivity survey method employing Schlumberger array. Ten (10) fairly distributed VES in eight (8) different stations in Abudu were carried out using six (6) points per decade with maximum current electrode spacing of 928.0m. The software IP12WIN utilizing computer iteration was used for interpretation of apparent resistivities data.

The result of the geophysical survey showed that clay and clayey soil (mixture of clay and other rock types) were intercepted at depths varying from about 9.75m to infinity below sea level, with thicknesses varying from about 7.32m to infinity(infinity value means that the area is very rich in clay). Its resistivities varied from about 1.0 ohm - m to 500 ohm-m.

Area of probable clay formation and their thicknesses have been identified especially for future mining of industries foundation, operations and drilling.

1.0 Introduction

Surface geophysical exploration techniques as a veritable tool in prospecting for clay deposits has the basic advantage of locating the targeted clay deposits before embarking upon drilling and thereby saving cost [1]. The techniques utilized electrical resistivity method to explore the properties of the earth's interior in order to prospect for natural resources such as clay, water and other minerals [2].

Clay which occurs abundantly in the sedimentary basin of South eastern Nigeria, including part of Edo and Delta State is a vital raw material needed for the manufacture of a wide variety of products [3]. In domestic life, clay is used extensively in earth ware, chinaware, cooking ware, vas plumbing fixtures, tiles porcelain ware and ornament. In building, it is used for bricks, floor tiles, sewen pipes, cement manufacture. It is also useful in the electrical industry for the production of conductor sockets, insulators and switches. In medicine and agriculture, it is used as Armenian bole to upset stomach, similar to the way parrots in south America originally used it, Kaolin clay and attapulgite have been used as anti-diarrhoea medicine. A more recent and limited use is as a specially formulated spray applied fruits, vegetables, and other vegetation to repel deter codling moth damage, and at least for application to prevent scald [4], [14]. The usefulness seem limitless. The dependence on its chemical and physical attributes has made clay useful in a number of industries.

The research area was Abudu and is underlined by Benin formation which cut across Niger Delta [5]. The following rock types or Lithologies are visible in the formation: Laterite, sandy clay, clay, sand, sand/gravel, dense limestone [9]. Abudu lies approximately on latitude of about 6°17'N and longitude of about 6°03$^{/}$E. Abudu is hilly and has little natural topographical variation with low terrain, having gentle slope [6] [10].

2.0 Experimental work

Schlumberger electrode configuration of vertical electrical sounding (VES) was employed for this research, full detail of the method have been documented [7], [8], [11] [13].

Ten (10) VES, fairly distributed were conducted using the ABEM signal averaging system (SAS) 300 terrammeter and its 2000 booster for deeper penetration,

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easurements were taken at increasing current electrode distance such that the electric current passed into the earth's surface penetrates greater depths. The greatest current electrode separation (AB) was 632m in a six (06) points per decade operation. The operational efficiency of six points per decade in subsurface geophysical study have been documented [2] [3] [4] [5] [6] [7] [11] [13].

3.0 Theoretical Analysis

There are different types of electrical resistivity theoretical approach based on electrode array for interpreting resistivity data. The techniques of data interpretation used involved seeking a solution to the inverse problem namely the determination of subsurface apparent resistivity distribution from surface measurements.

There is a function called Kernel function that represents a very good solution to the inverse problem. It describes the apparent resistivity measurements in terms of subsurface lithological variation with depths, The function assumes the earth to be locally horizontally stratified, inhomogeneous and isotropic layers, and unlike apparent resistivity function, it does not depend on electrode configuration. It cannot be measured in the field but has to be obtained from the transformation of measured apparent resistivities. The kernel function utilized in this work have been documented in previous research work, [11][13] if the observed apparent resistivity is such that

$$\ell_a(r) = \int_0^\infty \lambda T(\lambda) J_1(\lambda r) d\lambda \tag{3.1}$$

Where the kernel function is given as

$$T(\lambda) = \int_0^\infty \frac{1}{r} \ell_a(T) J(\lambda r) d\lambda \tag{3.2}$$

J_1 represents Bessel function of first order, first kind ant T (λ) is the transformed resistivity data.[13]

However, when the earth is approximately composed of horizontally stratified isotropic, and homogenous media such that the change of resistivity is a function of depth, the Schlumberger configuration is the most widely used array and may provide useful information in solving subsurface lithological problems. A vital aspect of the Schlumberger is the less sensitivity of the array to the effect of near surface lateral heterogeneities and easy recognition of their effects [2] [3] [4] [5] [6] [7] [11] [13].

In electrical resistivity sounding, four electrodes are earthed along a straight line in the order AMNB, where A and B are the current electrodes, M and N, the potential electrode. The calculated apparent resistivity (ℓa) according to Schlumberger array condition of AB≥5MN is

$$\ell_a = \pi \left[\frac{\frac{(AB)^2}{4} - \frac{(MN)^2}{4}}{MN}\right] \frac{\Delta v}{1} \tag{4.3}$$

AB = Current electrode spacing in meter

MN = potential electrodes spacing in meter

ΔV = Potential difference in volts, 1 = electric current in Amperes, π= 22/7

4.0 Results And Discussion

The result of the vertical electrical sounding (VES) based on electrical resistivity survey method in geophysical exploration is usually a function of apparent resistivity (ℓa) and current electrode separation because ℓa is always plotted (vertical axis) against current electrode separation (horizontal axis). This produced the computer iterated sounding curves shown in figures 1-8 and its associated Lithologies shown in table 1.

Computer iteration techniques was employed by using software IP12WIN. The lithologies or rock types of the different layers were then confirmed by using nearby borehole drillers log of the area [12]. We usually harmonize bore-hole driller's log of the area with standard table of electrical resistivities of some rocks and soil for Benin formation [15] for the purpose of interpretation because it is possible for different rock types to have the same ranges of resistivity [15] which usually make electrical resistivity data ambiguous to interpret.

By integrating the resistivity results with the borehole/driller's log lithologies, resistivity interpretation for VES stations 1-8 lithologies shown in table 1 was obtained.

In VES station one (1) clay/clayey sand occurred at a depth of about 9.75m below sea level with a thickness of about 7.32m. The clay formation is mixed with other rock types because it is outside the standard range for pure clay (1-100 ohm-m).

In VES station two (2), clay occurred at an infinite depth below the sea level, with a thickness of infinity. This showed however that this region has the thickest clay formation because it is not mixed with other rock types as seen in the standard resistivity table [15]. This means that, the clay in this region can be exploited industrially.

In VES stations three (3) and four (4), clay/clayey sand is not in existence as seen in table 1. In VES station five (5) clay/clayey sand with a resistivity of 101 Ohm-m (clay mixed with other rock types because it is outside the range 1-100 ohm for pure clay) occurred at infinite depth below the sea level. Though the clay formation here is very thick, it cannot be exploited geophysically and industrially because it is mixed with other rock types. Clay formation(s) did not occur in VES stations six (6) and seven (7). Also in VES station eight (8) the clay/clayey sand is mixed with other rock types, having resistivity value of 106 Ohm -m (standard clay value 1-100 ohm-m) and hence cannot be exploited industrially.

Close examination of all the VES stations revealed that the thickest pure clay formation can only be exploited industrially in VES station two (2).

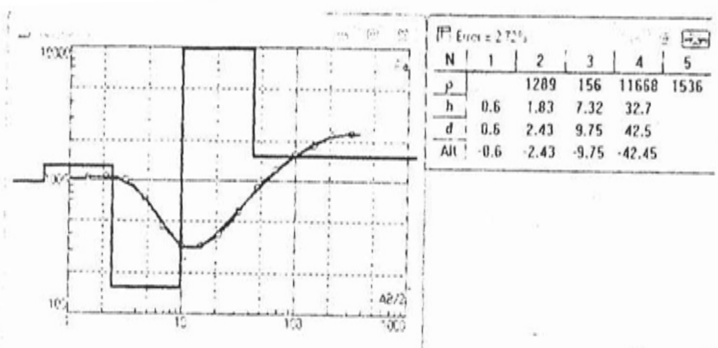

Fig 1: iterated sounding curve for VES station 1

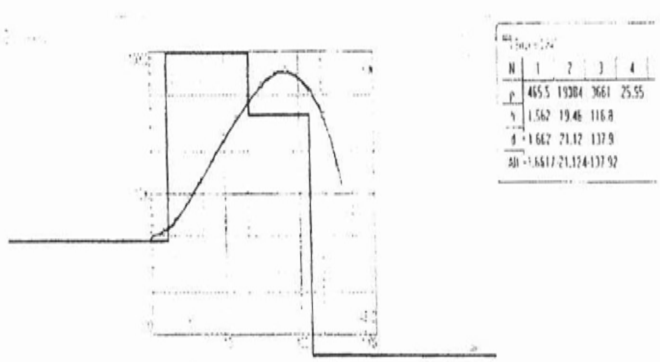

Fig 2: iterated sounding curve for VES station 2

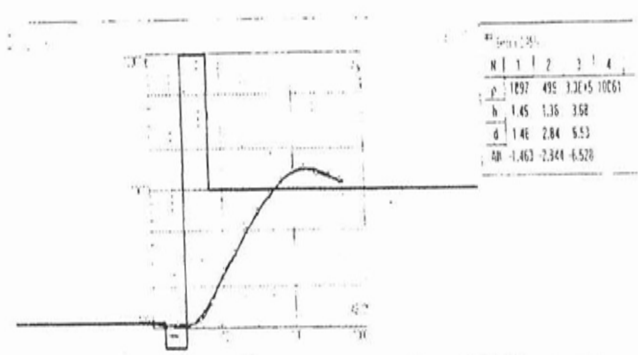

Fig 3: iterated sounding curve for VES station 3

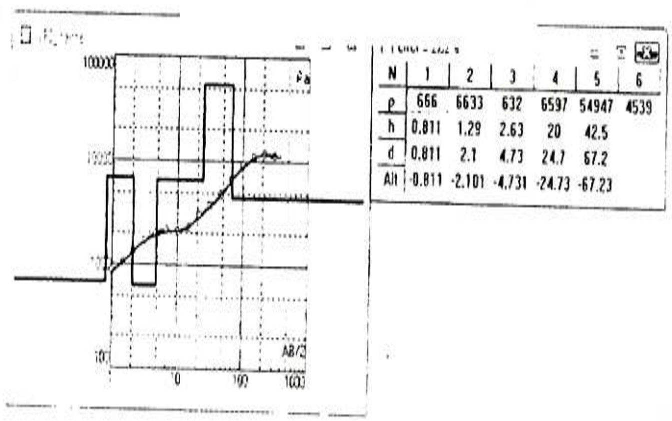

Fig 4: iterated sounding curve for VES station 4

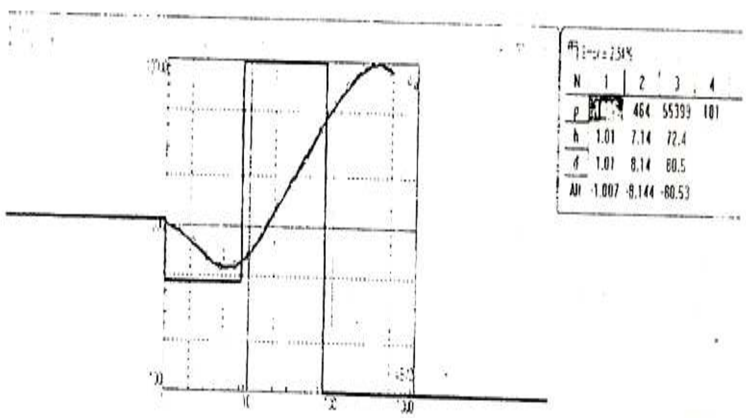

Fig 5: iterated sounding curve for VES station 5

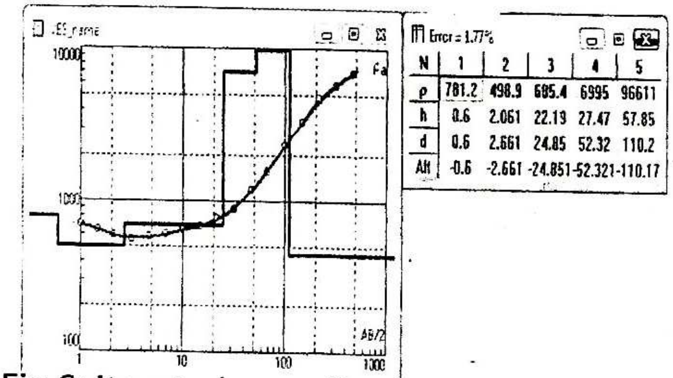

Fig 6: iterated sounding curve for VES station 6

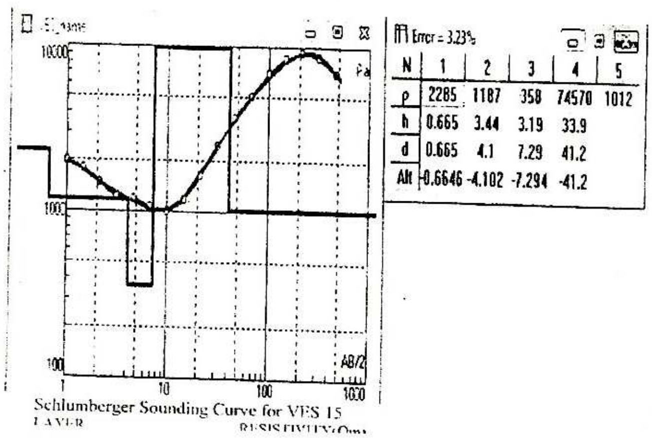

Fig 7: iterated sounding curve for VES station 7

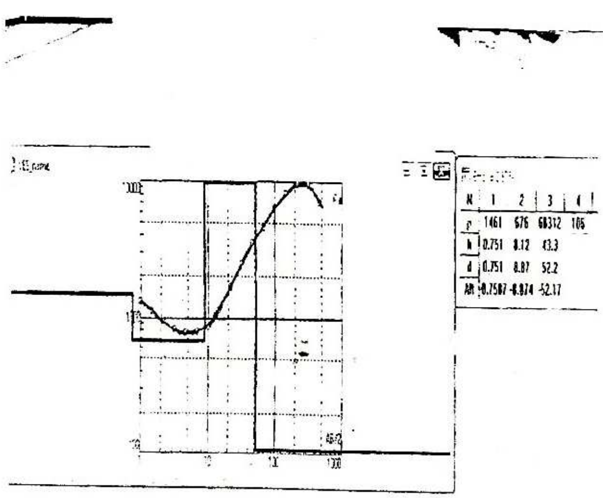

Fig 8: iterated sounding curve for VES station 8

VES	LAYER	RESISTIVITY (ΩM)	LITHOLOGY	THICKNESS (M)	DEPTH(M)
1	1	956	Wet Sand/sand	0.6	0.6
	2	1289	Laterite	1.83	2.43
	3	156	Clay/Clayey sand	7.32	9.75
	4	11668	Hard rock/dense limestone	32.7	42.5
	5	1536	Laterite	Infinity	Infinity
2	1	465.4	Laterite	1.662	1.662
	2	19084	Hard rock	19.46	21.12
	3	3361	Coarse sand/Gravel	116.8	137.9
	4	25.95	Clay	Infinity	Infinity
3	1	1097	laterite	1.46	1.46
	2	499	Wet sand/ Gravel	1.38	2.84
	3	300000	Hard rock	3.68	6.53
	4	10061	Hard rock	Infinity	Infinity
4	1	666	Moist silt	0.811	0.811
	2	6633	Dry coarse sand/coarse sound	1.29	2.1
	3	632	Laterite	2.63	4.73
	4	6597	Gravel	20	24.7
	5	54947	Hard rock	42.5	67.2
	6	4539	Laterite	Infinity	Infinity
5	1	1085	Laterite	1.01	1.01
	2	464	Silty sand	7.14	8.14
	3	55399	Hard rock/dense	72.4	80.5

			lime stone		
	4	101	Clay/clayey sand	Infinity	Infinity
6	1	781	Laterite	0.6	0.6
	2	498	Siltysand,	2.061	2.661
	3	685.4	Laterite	22.19	24.84
	4	6995	Gravel	27.47	52.32
	5	96611	Hard rock /dense lime stone	57.85	110.2
7,	1	2285	Coarse sand	0.67	0.67
	2	1187	Silty sand/gravel	3.44	4.1
	3	358	Laterite	3.19	7.28
	4	74570	Hard rock/dense lime stone	34.9	41.2
	5	1012	Clayey sand	Infinity	Infinity
8.	1	1461	Silty sand/gravel	0.751	0.751
	2	676	Laterite	8.12	8.87
	3	68312	Hard rock/dense limestone	43.3	52.2
	4	106	Clay/Clayey sand	Infinity	Infinity

Table 1: Iithologies for all the VES stations

5.0 Conclusion

Vertical electrical sounding (VES) of electrical resistivity survey method has proved useful and successful in prospecting or searching for desired clay deposits in Abudu area of Edo State, Nigeria.

Desired Depths to probable clay formations varied from about 9.75m to infinity while the thicknesses varied from about 7.32m to infinity.

To some extent, Abudu is therefore rich in clay deposit with huge amount occurring only in one location and hence industry that uses clay as its major raw material should be cited in this location to create job opportunities for the citizen of the area, thereby combating crime rates. This will however improve the economy of Edo State in particular and Nigeria in general.

References

[1.] Clinton, P. J. and Foster, S.S.D (1995): Evaluation of Groundwater using Schlumberger array. Hydrogeological Journal, 3:36-49

[2.] Ezomo, F.O. and Ifedili, S.O. (2005): Journal of Applied Science Vol 9,No 3, 6579-6588.

[3.] Ezomo, F.O. and Ifedili, S.O (2007): Journal of the Nigeria Association of Math. Physics 11(1), 597-604.

[4.] Ezomo, F.O. and Ifedili, S.O (2008): African Journal of Sciences 9:2195- 2203
[5.] Ezomo, F.O. and Akujieze, C.N (2009): Journal of the Nig. Association of Maths Physics 14(1), 177-180.
[6.] Ezomo, F.O. (2010): Journal of the Nig. Association of Maths Physics 16 (1) 597-602
[7.] Ezomo, F.O. (2010): Journal of the Nig. Association of math. Phy. 17(1),403-408.
[8.] Kogbe. C.A (1976): Geology of Nigeria, Elizabeth Press, London, U.K First published
[9.] Reymen, M.A, (1965b): Aspect of the Geology of Nigeria, Ibadan University Press, Ibadan, Nigeria.
[10.] Information Centre, Palm House, Sapele Road, Benin City, Nigeria-Introducing Abudu Village
[11.] Ezomo, F.O. (2010): World Journal of Biotechnology 11(1), 1662-1667.
[12.] Abudu Borehold/driller's log (2010): Courtesy of Edo State, Urban water board Sapele road, Benin City, Nigeria.
[13.] Ezomo, F.O. (2010): African Journal of Science 11 (1):2538-2546.
[14.] Information from www.cflud.gov/agm/engapplicaticmsubsurfacecharacter/613na.
[15.] Okwawueze, Akpotu (1979); standard table of approximate ranges of resistivities for rocks and soil of Benin formation.