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Geophysical Study of Clay Deposit Properties in Agbor Area of Delta State, Nigeria.

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Abstract

Schlumberger array of vertical electrical sounding (VES) was carried out to study properties of clay deposit in Agbor Area of Delta State, Nigeria, geophysically. These properties include depth, thickness and nature of soil material above it. The need to prospect or search for clay deposits became inevitable so as to solve the problem of youth restivesness in the area by way of setting up industry in Agbor that rely on clay for manufacture purposes. Ten (10) VES, uniformly distributed in six different stations in Agbor was carried out using six (06) 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 resistivity survey showed that clay and clayey soil (clay mixed with other rock types) are present. The depths and thicknesses of each clay formation was then ascertained. Depth to probable clay formations varied from 0m to 85m while the thicknesses varied from 1.01m to 6.93m

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

Key words: schlumberger array, vertical electrical sounding, clay, Agbor, resistivity survey, industry.

1.0 Introduction

Nigeria whose economy is slowly growing in a developing nation blessed with abundant natural resources e.g oil, gas, rubber, coal, tin, clay e.t.c but currently depends heavily on finished products imported into the country [1]. These include refined oil, ceramics floor tiles, fabrics, shoe, pharmaceutical products, the list of which is endless. This dependence on importation of foreign products whose raw materials abound the country is a major draw back in the economy[2]. Clay and shale which occurs abundantly in the sedimentary basin of south eastern Nigeria, including part of Edo and Delta State are vital raw materials needed for the manufacture of a wide variety of products [3]. In domestic life, clay is used extensively in earth ware, China ware, cooking ware, vases plumbing fixtures, tiles porcelain ware and ornaments[4]. In building, it is used for bricks, floor files, sewer pipes, cement manufacture etc [5]. It is also useful in the electrical industry for the production of conducts, sockets, insulators and switches [6]. The usefulness seem limitness. The dependence on its chemical and physical characteristics has made clay useful in a number of industries [7].

This research paper tends to estimate the thickness, quantity and distribution of clay deposits in the state using geophysical survey method with the intention of providing detailed documentation of known clay deposits and recommend possible set up of an industry in Agbor that rely on clay for manufactured purposes.

Brief Geology And Hydrogeology Of The Study Area

The study area which is Agbor is underlained by Benin formation [8]. The Benin formation is known for the outcropping yellow, white sands and clay which occur in coastal Nigeria. The formation consists mainly of sands, gravels and backswamp deposits. It is structurally 'Plain because it has not been disturbed by earth movement. Intercalation of sand, clay and clayey sand are the predominant lithologies intercepted [10]

Agbor extends from the West across the whole Niger Delta area and southward beyond the present coastline. It compresses of over 90% sandstone with shale intercalation [11]

Hydrogeologically, the study area is very aqueferous because of low percentage of shalling layers [12]

The research area which is Agbor in Delta State, Nigeria lies on approximately on latitude 4.50^{o}N and longitude 5.50^{0}E[13]

Experimental Work

Schumberger array of vertical electrical sounding (VES) was employed for this research work, details explanation of the method have been documented [14]. Ten (10) VES were conducted using the ABEM 300 terrameter and its SAS (signal averaging system) 2000 Booster.

Measurements were taken at increasing current electrodes distance such that the electric current passed penetrates greater depths. The maximum current electrodes separation (AB) was 928m at six (06) points per decade. The operational efficiency of this six points per decade have been documented in previous research work [14] [15] [16] [17][18] thus leading to the computation of the apparent resistivity λ_a using equation [18].

The apparent resistivity values were plotted against semi – current electrode spacing $\left(\frac{AB}{2}\right)$, using log – log sheet. These plots were interpreted by the famous method of partial curve matching, and the results subjected to computer iterative interpretation [19].the resulting set of layer parameters were interpreted in terms of their lithologic equivalent using nearby bore-hole lithology/driller's log to obtain layer depths and thicknesses [20].

Theoretical Analysis

The basic theory behind electrical resistivity method was analysed by Maillet [21] and thereafter expanded by other researchers [12], [19]. In a homogeneous isotropic medium, the potential due to a single point current source such as the current electrode, satisfy laplace's equation arising from the equipotential surface that is clearly hemispherical so that

$$E = -\nabla V \quad and \quad J = \delta E$$

(4.1)

But $J = \delta E$ from Ohm's law

(4.2)

$$\therefore J = \delta \nabla V$$

(4.3)

Where ∇ represents del operator $= i\frac{\delta}{\delta x} + \hat{j}\frac{\delta}{\delta y} + \hat{k}\frac{\delta}{\delta z}$

(4.4)

V= electric potential E = electric field intensity

δ = Conductivity J = current density

$$\nabla .J = - \sigma \nabla \nabla V = 0$$

(4.5)

$$\nabla .J = -\sigma. \nabla^2 V = 0$$
(4.6)
$$:. \nabla^2 V = 0$$
(4.7)

Where ∇^2 (del squared) is the usual laplacian operator (4.8) can be expanded in spherical polar coordinates as

$$\frac{d^2V}{dr^2}+\frac{2}{r}\frac{dv}{dr}+\frac{1}{r^2\sin\theta}\frac{d}{d\theta}\left(\sin\theta\frac{dv}{d\theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{d^2v}{d\phi^2}=$$
(4.8)

The last equation 4.8 shows that potential distribution satisfy laplace's equation.

The solution to equation (4.8) may be developed from first principle for a particular earth's model by selecting a co-ordinate system to match the earth's model geometry and imposing appropriate boundary condition. This solution usually yield apparent resistivity $(\lambda_a) as\, a$ function of the electrodes array namely $\frac{AB}{2},\frac{MN}{2}$, electric current I and potential different ΔV.

The calculated apparent resistivity (λ_a) according to schlumberger array condition of AB $\geq$ 5MN is

$$\lambda_a = \pi\left[\frac{\left(\frac{AB}{2}\right)^2-\left(\frac{MN}{2}\right)^2}{MN}\right]\frac{\Delta v}{I}$$
(4.9)

AB = current electrodes spacing in meter, MN = potential electrodes spacing in meter.

Table 5.1: Apparent resistivities readings for typical stations 1-6

Δv = potential difference in volts, I = electric current in Amperes, $\Pi =$ constant = 22/7

Reading	AB/2	App. Resistivity for station 1 (ohm-m)	App. Resis for Station 2 (ohm-m)	App. Resis for station 3 (ohm-m)	App. Resis for station 4 (ohm-m)	App. Resis for station 5 (ohm-m)	App. Resis for station 6 (ohm-m)
1	1.00	484.8	89.25	311.40	232.99	247.31	1176.24
2.	1.47	531.2	216.75	374.85	288.05	271.00	1149.58
3.	2.15	551.52	264.0	427.68	348.84	323.63	1296.00
4	3.16	571.84	212.47	462.47	439.82	367.18	15545.88
5	4.64	653.3	188.10	481.08	582.36	428.75	13166.40
6	6.81	593.3	189.50	504.12	764.34	433.12	16014.68
7	10.00	440.79	164.87	292.09	1130.67	317.83	164889.90
8	14.7	425.0	149.60	324.17	1930.23	200.28	203648.40
9	21.5	393.8	218.41	353.65	1996.11	261.09	19370.58
10	31.6	259.0	313.80	523.37	2658.31	281.50	26306.54
11	46.4	919.2	454.30	759.22	3210.92	290.27	37442.16
12	68.1	1482.74	831.87	1247.88	3829.6	541.77	300741.52

13	100.0	2177.0	952.00	1412.80	4283.29	831.23	73302.68
14	147.0	2017.1	2954.5	2329.20	5364.19	574.76	73302.68
15.	215.0	3133.0	2420.9	3757.83	5555.90	928.90	755905.50
16.	316.0	3886.0	3212.78	3511.69	4515.03	1254.18	39302.4
17.	464.0	5164.0	1615.00	3776.81	2769.66	3147.91	352502.22

RESULTS AND DISCUSSION

The results and field or theoretical curves arising from computer iterated sounding curves are presented (Table 5.1-5.8 and figures -5.1-5.6)

Table 5.1 indicates sounding interpretation in six stations in Agbor area of Delta state. It shows the vertical electrical sounding (VES) semi current electrode spread or AB/2 (m) as indicated in the first column with a minimum of 2m and a maximum of 928m spread.

Computer iteration requires that the resistivity trend of the site is identified and the number of different layers is accurately estimated. Therefore, the field data above are fed into already designed computer software 1P12WIN which automatically matches the field curve with set standard curve or adjusted as necessary with an error tolerance [21]

Resistivity and layer thickness values within acceptable tolerance limits are sought as shown in tables 5.2 to 5.7 and figures 5.1 to 5.6

A standard table 5.8 showing approximate ranges for electrical resistivities of rock and soil presented by [12], reported by Akpotu, 1979 was used to estimate the clay content [22]

Geological interpretation of the layers electrical resistivities and thickness showing clay formation was carried out using table 5.8 above and nearby bore-hole lithology/driller's log [20]. The various clay positions and thicknesses are shown in figure 5.7 [20]

Table 5.2: lithology for station 1

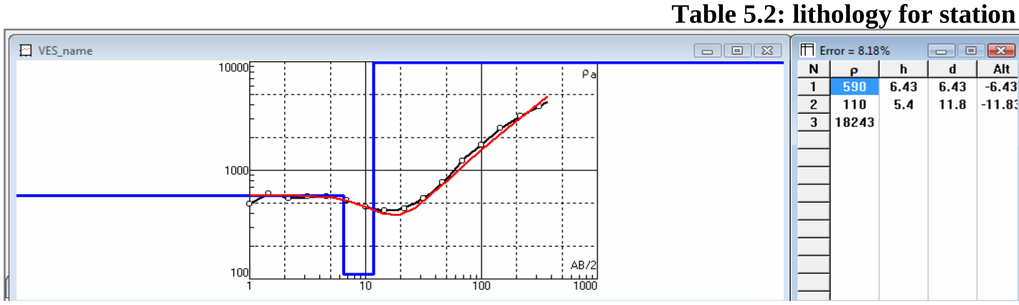


Fig 5.1: Iterated sounding curves for station 1

Table 5.3: lithology for station 2

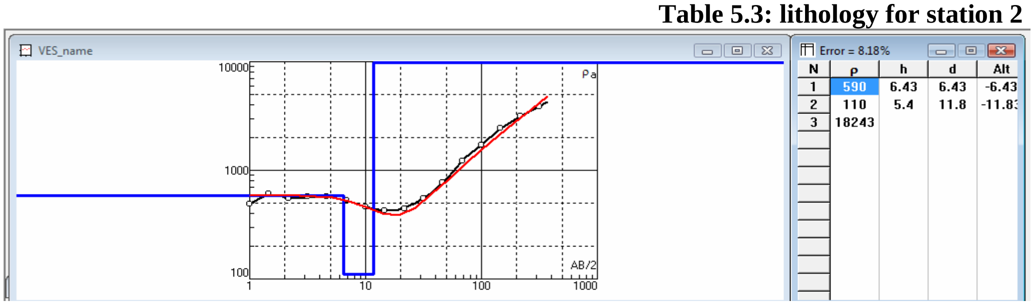


Fig 5.2: Iterated sounding curves for station 2

Table 5.4: lithology for station 3

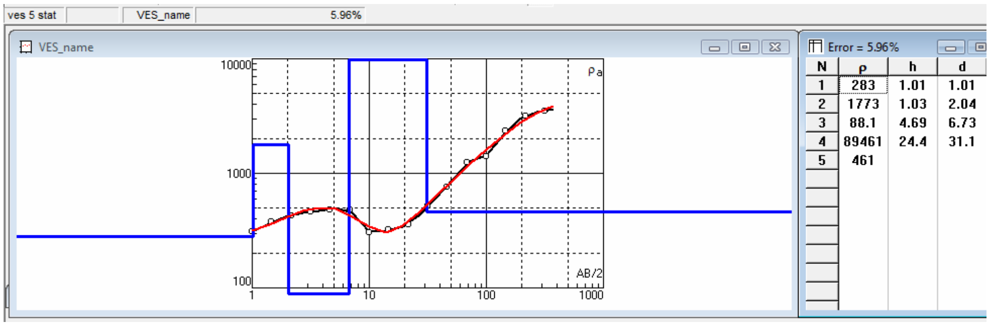


Fig 5.3: Iterated sounding curves for station 3

Table 5.5: lithology for Station4

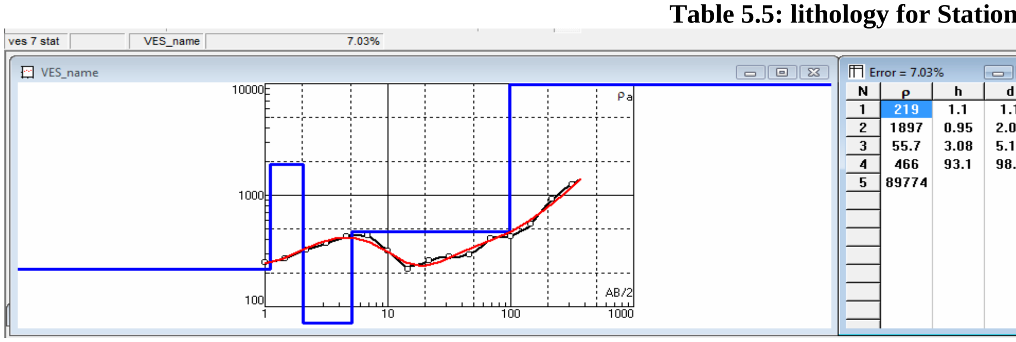


Fig 5.4 : Iterated sounding curves for station 4

Table 5.6: lithology station 5

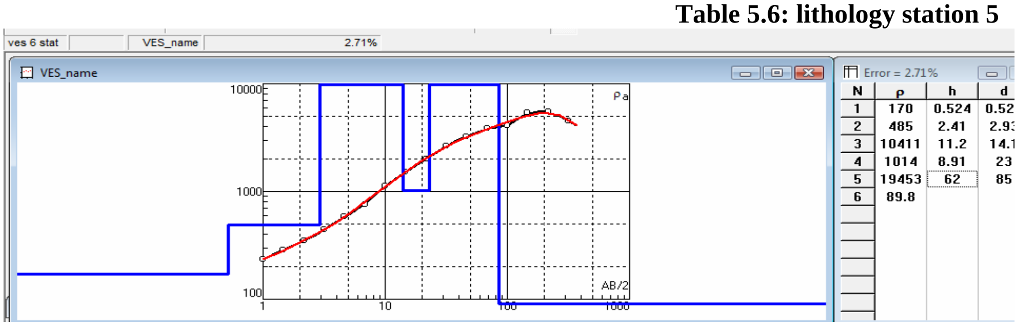
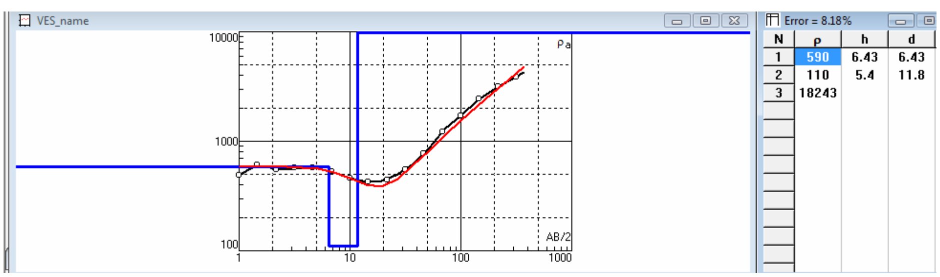


Figure 5.5: iterated sounding curve for station 5

Table 5.7: Lithology for curve for station 6



Figures 5.6: iterated sounding station 6

Table 5.8: Aproximate ranges for electrical resistivities of rocks and soil [22]

Rock Type	Resistivity ohm-m

Clay and Marl	1-100
Loam	7-70
Top Soils	60-200
Clay soils	100-500
Sandy Soils	700-6000
Loose Sands	1000-100,000
River Sand and gravel	100-6000
Sand Stones	30-10,000
Basalt	300-10,000

Clay Positions And Thicknesses

The various clay positions and thicknesses are shown in fig 5.7 below [20].

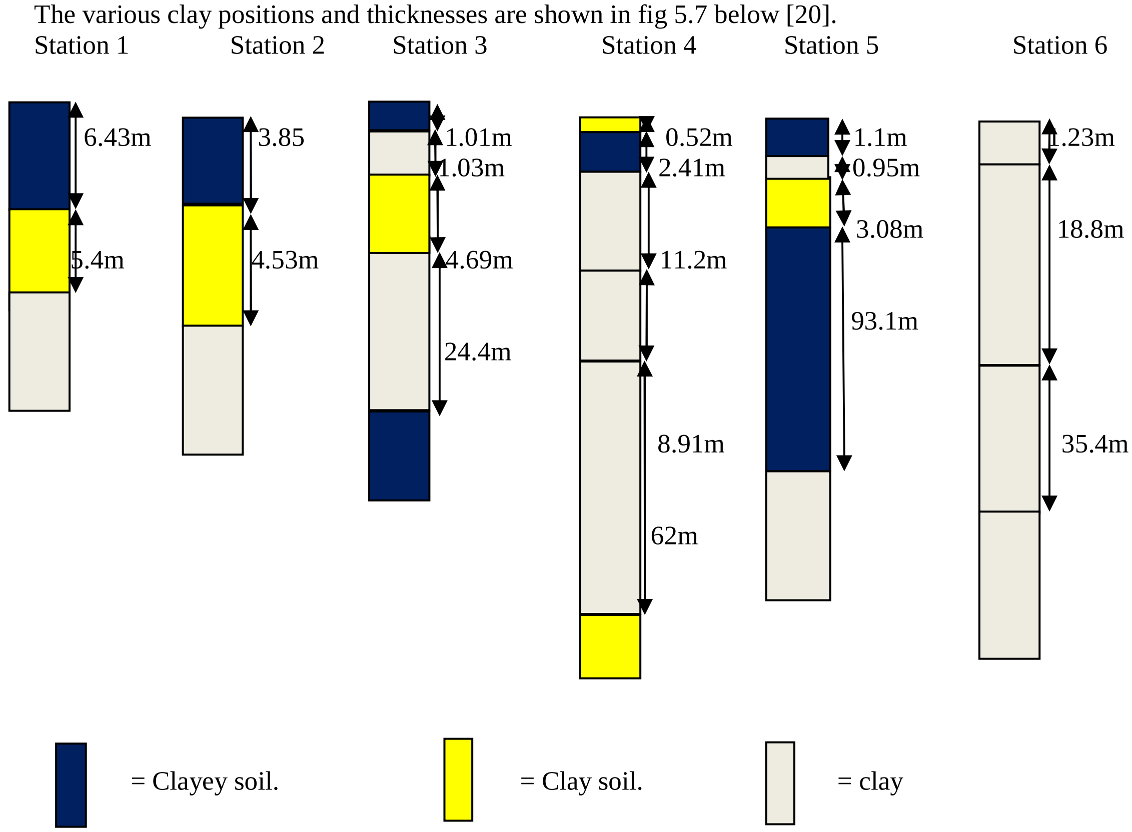


Figure 5.7: clay positions and thicknesses for stations 1-6 [20]

Clay is found in all stations except station 6. Thickness of clay beds are not uniform, it varies from station to station. Lateral discontinuity is observed between stations. For example, clay appeared in second layer of stations 1 and 2 and absence in station 3, reappear in station 4 and disappear in stations 5 and 6. The deepet clay is found in station 4. The near surface deposits are found in stations 1,2,3,4, and 5; it is thinnest in station 4. Depth to the clay beds vary, ,it is shallowest in station 4. Thus, Agbor is rich in clay deposit as revealed from the geologic interpretation shown in figure 5.7 above [20].

Conclusion

Schlumberger array of vertical electrical sounding (VES) has proved useful and successful in exploring for clay deposits in Agbor area of Delta State, Nigeria.

Depth to probable clay formations varied from 0m to 85.0m while the thicknesses varied from 1.10m to 6.93, as confirmed by nearby bore-hole logs [20].

Agbor is therefore rich in clay deposit and hence industry that uses clay as its major raw material should be cited in Agbor to create job opportunity for the youths and thereby reducing activities of youth restivesness in Delta State and also improving the economy of Delta state in particular and Nigeria in general.

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