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Application of electrical resistivity survey to sand mining at Ewu near the coastal area of Delta state, Nigeria

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ABSTRACT

In recent time, utilization of sand has increased greatly and commercialized because many road-construction companies now use a lot of sand to enforce their roads to give face-lift. This is common near the coastal areas in Niger Delta region where the roads are often flooded in the rainy season. It is therefore necessary to empirically source for and ascertain sites with appreciable sand deposits for effective mining. Hence, Electrical resistivity soundings were made in five stations in Ewu, Delta State to investigate the occurrence of sand in relation to its economic viability. The field data were measured using a sensitive terrameter and were plotted on bi-log graphs. The sounding curves were analyzed and iterated with computer software. The results obtained were used to generate geoelectric sections from which the available sand deposits were quantified. The sections show that Ewu has six and seven subsurface layers of near homogeneous stratification with AQH, KHH, and KHA - curve types. They also indicate that Ewu has huge loose sand deposits to far depth of over 27 m which can be mined appreciably and commercially. From the study, it is also obvious that viable aquifer at Ewu is within 30 - 45 metres and the static water level is about 26 metres.

Keywords: Electrical resistivity soundings, Subsurface, homogeneous, Sand deposits, Ewu, Delta State

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INTRODUCTION

Ewu originally Eghwu kingdom is one of the 23 Urhobo clans. It is positioned mainly in Ughelli South LGA of Delta State (Fig 1). It is bounded on the South by riverine Burutu LGA and Bayelsa State, It is bounded by Evweni to the North, Uwherun to the East and Arhavwaren community to the West. Part of Ewu clan is riverine and characterized by low lying land of massive mangrove swamp with meandering network of water ways. The traditional headquarter of the people of Ewu clan is Ewu-Otor. Early exploration of natural resources such as hydrocarbon in this area resulted in huge economic prosperity. Hence a part of Ewu is today named “Orere” which means Prosperity [1]. Ewu is of interest here because of the annual depositions of sedimentary materials by the major River Niger and its numerous tributaries as they journey towards Focardos (the Escravos) from where they empty into the Atlantic Ocean. With this continuous flow and over flooding in Ewu for many years, large deposits of earth sedimentary formations have consolidated and accumulated to make upland Ewu where a good number of the people of Ewu now settle to earn a living. Although one lucrative business in the area is fishing, Delta State Government is now sensitizing communities on the economic importance and usefulness of sand mining as emphasis is being laid on solid minerals. Sand mining in this area will be more successful if an empirical study is initially made to ascertain its occurrence and estimate the available volume. Thus, geophysical investigation of the earth subsurface strata was done in Ewu to ascertain the occurrence of sand and viability of sand mining within and around the town. Five VES stations were sounded using Schlumberger configuration to obtain and analyze field data from which the subsurface formation strata was delineated for the stated purpose.

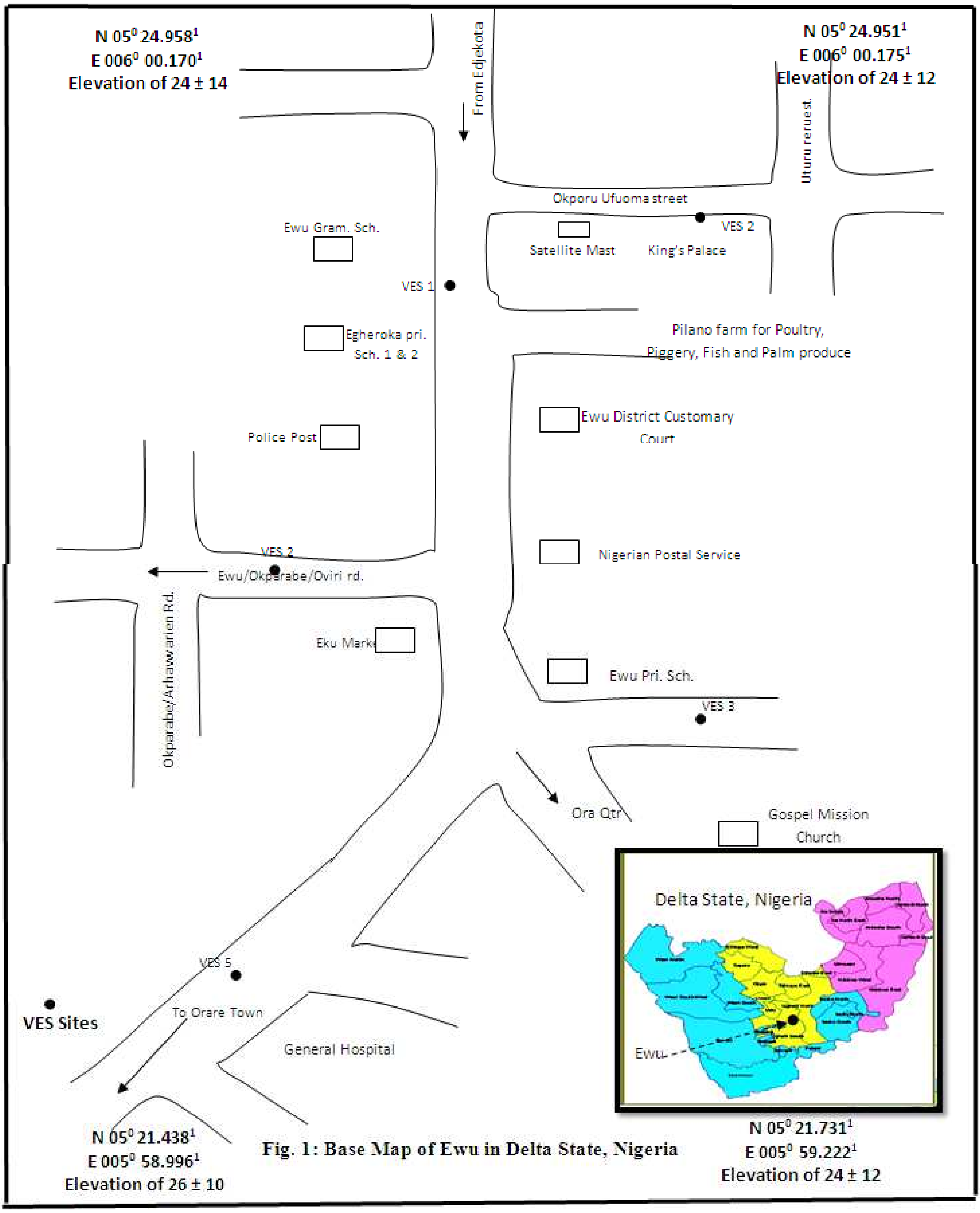

Fig. 1: Base Map of Ewu in Delta State, Nigeria

Location and Geology of Study Area

Initially, the physical geology and topography of Ewu was studied. The initial study revealed that Ewu is located in Ughelli South L.G.A of Delta State, Nigeria. The study area lies within latitude 05°24. 95/N and 05°21.44/N, and longitude 005°59/E and 006° 00.17/E. Ewu has a flat topography with an elevation of 24 ±14 m above sea level (Fig 1) and it is within the three major depositional structures typical of most Deltaic environments represented by the

Benin, Agbada and Akata formations which consist of a mix of marine and continental deposits [2] and [3]. It is underlain by the continental sands of Ughelli formation typical of settlements near the coastal area in Delta State [4]. It has appreciable rainfall for over seven months in the year. It is therefore prone to flooding and partly subjected to overflow of nearby rivers and creeks. It is thickly forested with a mix of loose sand and clayey top soil. A part of Ewu community is settled in the shore where the study could not be readily extended to due to logistic and other extraneous difficulties.

MATERIALS AND METHODS

Vertical Electrical Soundings (VES) were made in five sites in Ewu town using Schlumberger electrode configuration. The Schlumberger technique was employed for reasons of logistic of manpower and deep subsurface penetrations. In this case four electrodes are collinearly arranged and properly pinned into the ground to make good contact with the earth for effective current flow. In the Schlumberger array, the current electrodes spacing was much greater than the potential electrode spacing so that the relation $^{AB}/_2 \geq {}^{5MN}/_2$ where AB is current electrodes spacing and MN is potential electrodes spacing holds (Fig. 2) [5] and [6]. A sensitive ABEM SAS 1000 terrameter which is capable of passing current into the earth and measuring the potential established across the station is connected to the array and used as the field recording instrument [7]. The instrument is capable of computing recorded values along with the geometric factor of the particular sounding to obtain and display the apparent resistivity of the subsurface under investigation [8]. Care was taken not to allow unauthorized contact with the cable when readings were being taken by the terrameter [9]. The field array was made in line with the theory of resistivity (Eqn 1) which is derived from the first principle of resistivity investigations [10].

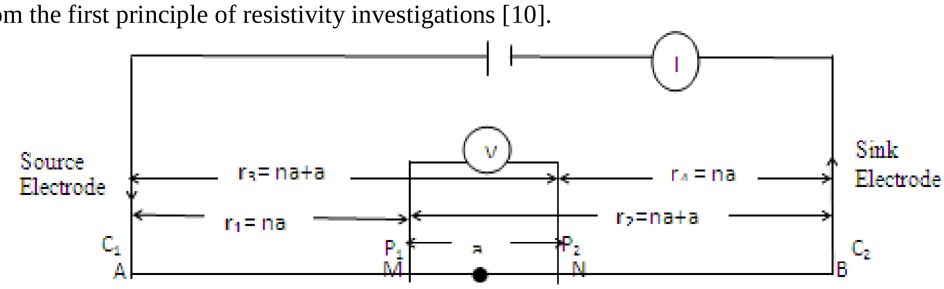

Fig 2: Field Array for Schlumberger configuration in which $^{AB}/_2 \geq {}^{5MN}/_2$

By definition, Electric field strength *E* is the negative of potential gradient with distance r. Therefore, for a sphere, the Potential by [11] is

$$U = -\int_o^r \frac{Q}{4\pi\varepsilon r^2} dr \quad\text{.........1}$$

$$\therefore U = -\frac{Q}{4\pi\varepsilon r} \quad\text{.........2}$$

Applying Ohm's law and obtaining resistivity relation the Potential by becomes

$$V = -\int \frac{\varrho I}{4\pi r^2} dr \quad\text{.........3}$$

and $V = \dfrac{\varrho I}{4\pi r}$ 4

For a hemispherical surface like the earth subsurface, the current density, *J* is given by

$$J = \frac{\varrho I}{2\pi r^2} \quad\text{.........5}$$

so that the potential at any point, r from a particular potential electrode in Fig 2 is

$$V = \frac{\varrho I}{2\pi r} \quad\text{.........6}$$

Thus, the resultant potential at electrode M due to the two current electrodes is,

$$V_c = \frac{I}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \qquad \text{7a}$$

Similarly, the resultant potential at electrode N due to the two current electrodes is

$$V_D = -\frac{\rho I}{2\pi r}\left(\frac{1}{r_3} - \frac{1}{r_4}\right) \qquad \text{7b}$$

R_1, r_2, r_3 and r_4 are distances defined in Fig.2 [3].

so that the potential difference ($V_c - V_D$) between the two inner electrodes measured by the instrument voltmeter connected between C and D according to [12] is

$$dV = (V_c - V_D) = \frac{\rho I}{2\pi}\left\{\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \left\{\frac{1}{r_3} - \frac{1}{r_4}\right\}\right\} \qquad \text{8}$$

Hence, the apparent resistivity of the subsurface under investigation by [13] is

$$\rho = 2\pi \frac{\Delta V}{I}\left\{\frac{1}{\left(1/r_1 - 1/r_2\right) - \left(\frac{1}{r_3} - \frac{1}{r_4}\right)}\right\} \qquad \text{9}$$

$$\Rightarrow \rho = 2\pi R\left\{\frac{1}{\left(1/na - 1/na + a\right) - \left(\frac{1}{na + a} - \frac{1}{na}\right)}\right\} \qquad \text{10}$$

$$\Rightarrow \rho a = \pi Rn\{n + 1)a \qquad \text{11}$$

With the Geometric Factor G given as $G = \pi n\{n + 1)a$.

In the field it is required that AB = 2(n+1)a with $n \geq 2$ to ensure that AB>>MN at all times. Thus when $r_1 = r_4 = na$, $r_2 = r_3 = na+a$

The apparent resistivity values obtained from the field measurements were tabulated (Table 1) and were plotted against half current electrodes spacing on a log-log graph. The curves were interpreted qualitatively by inspection and quantitatively by "partial curve matching" [14] and computer iteration from [15] Win Resist Version. The computer iteration involved entering the spread type used (Schlumberger), electrode separation (AB/2) and the apparent resistivity derived from the qualitative analysis into the columns provided by the computer software. These are then modeled by feeding-in the apparent resistivity and corresponding layer thickness of each stratum vis-à-vis the total number of layers deduced from curve matching. The final entries are then iterated to obtain the curve with the least root mean square (rms) value from which the apparent resistivities and thicknesses of the subsurface were deduced and geoelectric sections of the study sites drawn to stratify the lithology at Ewu (Figs 3-6).

Table1: Sample Field Data from Stations in Ewu town

Electrode Spacing		Resistivity Values Recorded by ABEM SAS 1000 Terrameter		
($^{AB}/_2$) (m)	($^{MN}/_2$) (m)	VES 1 ρ_a Ωm	VES 2 ρ_a Ωm	VES 3 ρ_a Ωm
1	0.5	1084	105	103
2	0.5	1194	187	167
3	0.5	1222	262	211
4	0.5	1200	333	231
6	0.5	1323	428	231
6	1	1386	430	249
8	1	1243	400	267
12	1	1834	340	309
15	1	2118	290	321
15	2	2009	220	300
25	2	2190	241	260
32	2	1753	250	244
40	2	1562	310	210
40	5	1486	350	208
65	5	931	430	238
100	5	989	510	276
100	10	953	600	290
150	10	572	530	309
225	10	311	477	319
225	20	197	323	334
250	20	228	270	340
300	20	380	355	270
350	20	461	451	210

RESULTS AND DISCUSSION

Five VES were sounded in Ewu at the Ewu Grammar school, Lawn tennis court, Ewu post office road and Ewu/Edjekota road. The results show that Ewu consists of AQH, KHH, and KHA curves mainly with six to seven stratified layers to a depth of about 60 m [16]. It also shows that the terrain has near surface waters with huge smooth to medium grain sand deposits to far depth. This is attributed to the long term depositional activities of the river Niger and nearby streams in this low land community. In some parts of the study area there are alluvial and clay deposits characteristic of parts of the lower Niger.

The first layer consists of clayey top soil with resistivity values ranging from 64.5 to 78 Ωm except at VES 1 which has loose sand with resistivity of 1067.1 Ωm. The layer thickness varies from 0.6 m to 1.7 m. The second layer is a mix of clayey sand and fine grain sand with resitivity values of 936 – 1492 Ωm (Fig 3 & 4) and 360 Ωm (Fig. 5) and thickness ranging between 2.5 and 4.2 m. This formation is of very smooth texture. The third to fifth layer show evidence of formation continuity from about 10 m to far depth of 30 m and beyond. The resistivities of these media show that the layers consist of loose sand in water bearing environment. The continuity is obvious from the near uniform resistivity values (Table 2) and (Figs 3 - 6). The low resistivity values in most sites are attributed to large volume of accumulated water within the subsurface. This is not however, an aquifer as it is only a blend of thick sand deposits and water. The resistivity values of these layers range from 107 m to about 300 m as in VES 2 & 3. VES 1 shows slight deviation from above which is indicative that that the sand deposits there are specifically loose, medium grain and more porous. At far depth however, the formation tends to be same as in VES 2 & 3.

From the study, groundwater accumulates to form viable aquifer at depth range of 30 to 45 m. This delineated aquifer is unconfined and extends to beyond 50 m into the sixth and seventh layers which consist of medium to coarse grain sand and gravelly sand respectively (Table 2 and Fig 3 - 6). The unconfined nature allows for some groundwater seep into the creek from beneath. It is pertinent to note that this study was done within the upland Ewu due to terrain difficulty. On the whole, the availability of sand deposits in Ewu is massive and of commercial value. It is also expected that a little shift of sand mining activity into the nearby Burutu creek and river shores will make for greater yield.

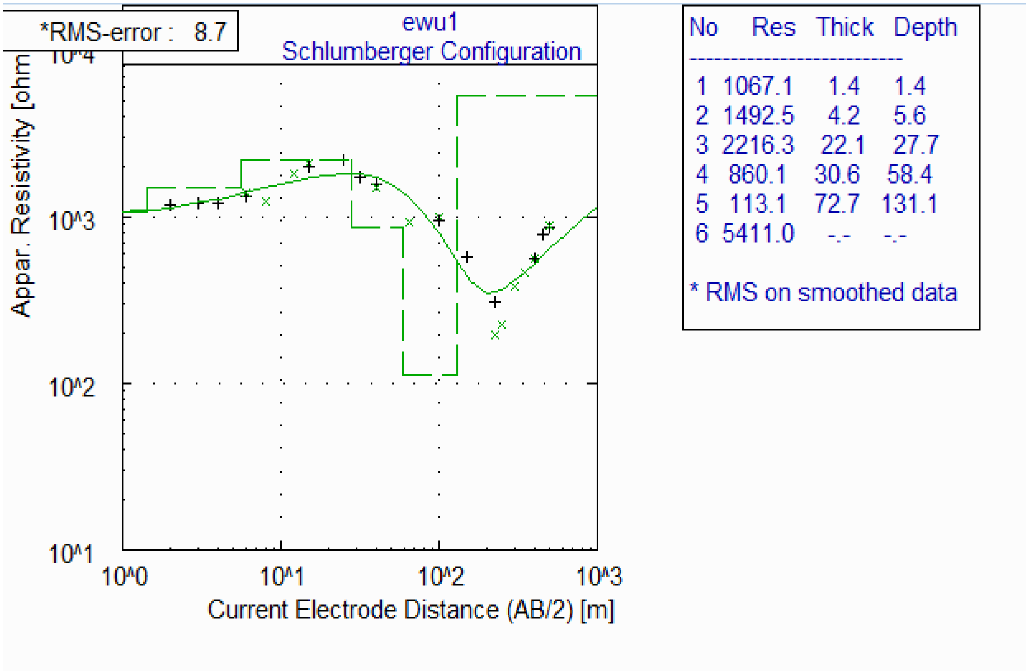

Fig 3: Field Curve from Station 1 in Ewu AQH - Curve type

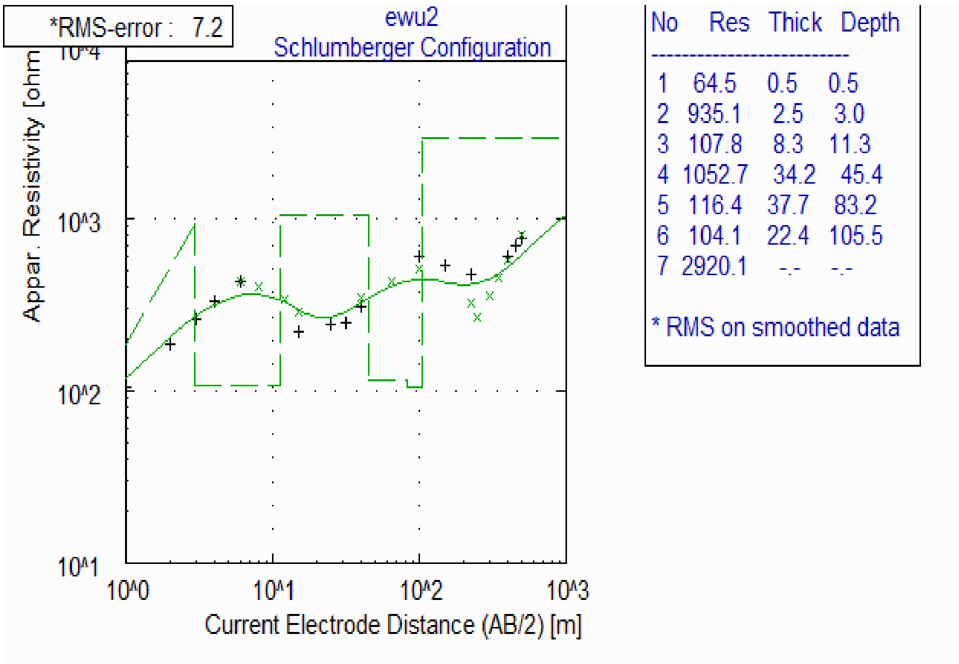

Fig 4: Field Curves from Station 2 in Ewu KHH - Curve type

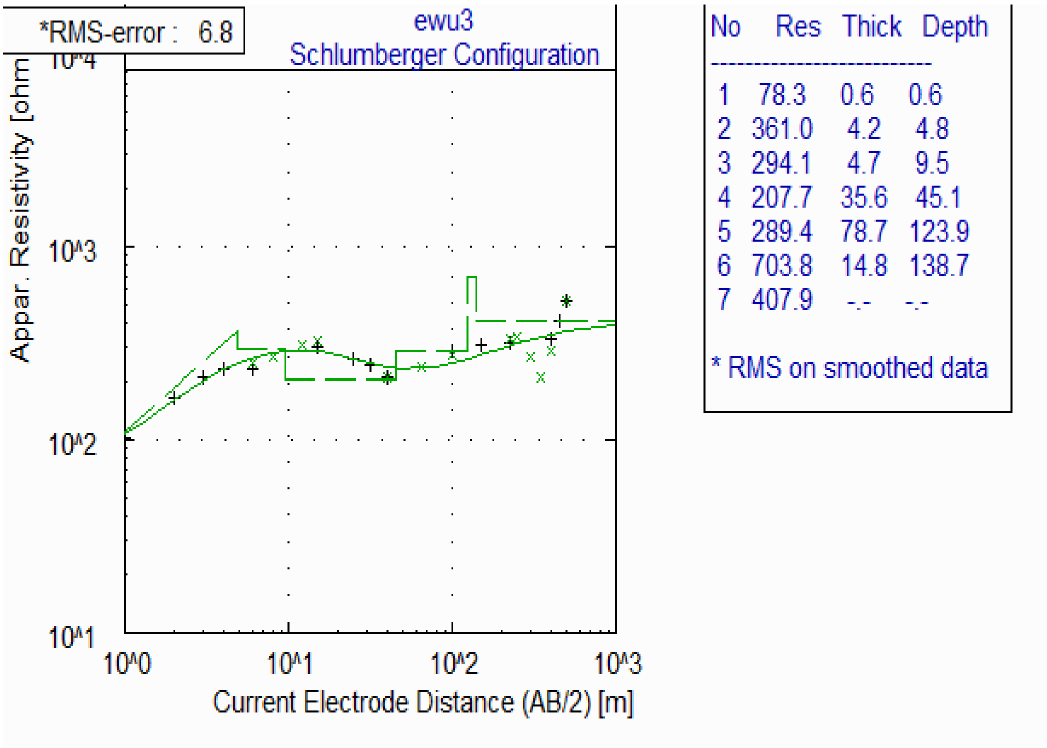

Fig 5: Field Curves from Station 3 in Ewu KHA – Curve type

CONCLUSION

The results of the study revealed six to seven layers in Ewu with AQH, KHH, and KHA type curves. The geoelectric sections delineate almost homogeneous formations to far depth. The top soil consists of clayey top soil and underlain by a mix of clayey sand and fine loose sand mainly. The third to fifth layer show evidence of formation continuity consisting of loose sand of near uniform resistivity in water bearing environment as evident by the low resistivity values of the subsurface strata in most sites sounded. The near surface sand deposits in VES 1 are specifically loose, medium grain and more porous. However, at far depth, the formation tends to be same as in VES 2 & 3. From the study groundwater accumulates to form viable aquifer at depth range of 30 to 45 m in the study area. This aquifer is unconfined and extends to beyond 60 m into the sixth and seventh layers from where it seeps into the creek. From the study, there is massive sand deposit in Ewu as there is a column of continuity deep down the subsurface and literally. Indeed the volume of sand delineated suggests that sand mining in Ewu is of economic value. Sand is an expensive commodity which individual, companies, Government agencies and other establishments consume extensively. It is therefore recommended that individuals, private organizations, Government agencies *etc* should respond to Delta State Government's call for harnessing the rich solid mineral deposits of this nature in the State to have a Delta State with less emphasis of oil and gas resources by mining for sand in Ewu town and environ.

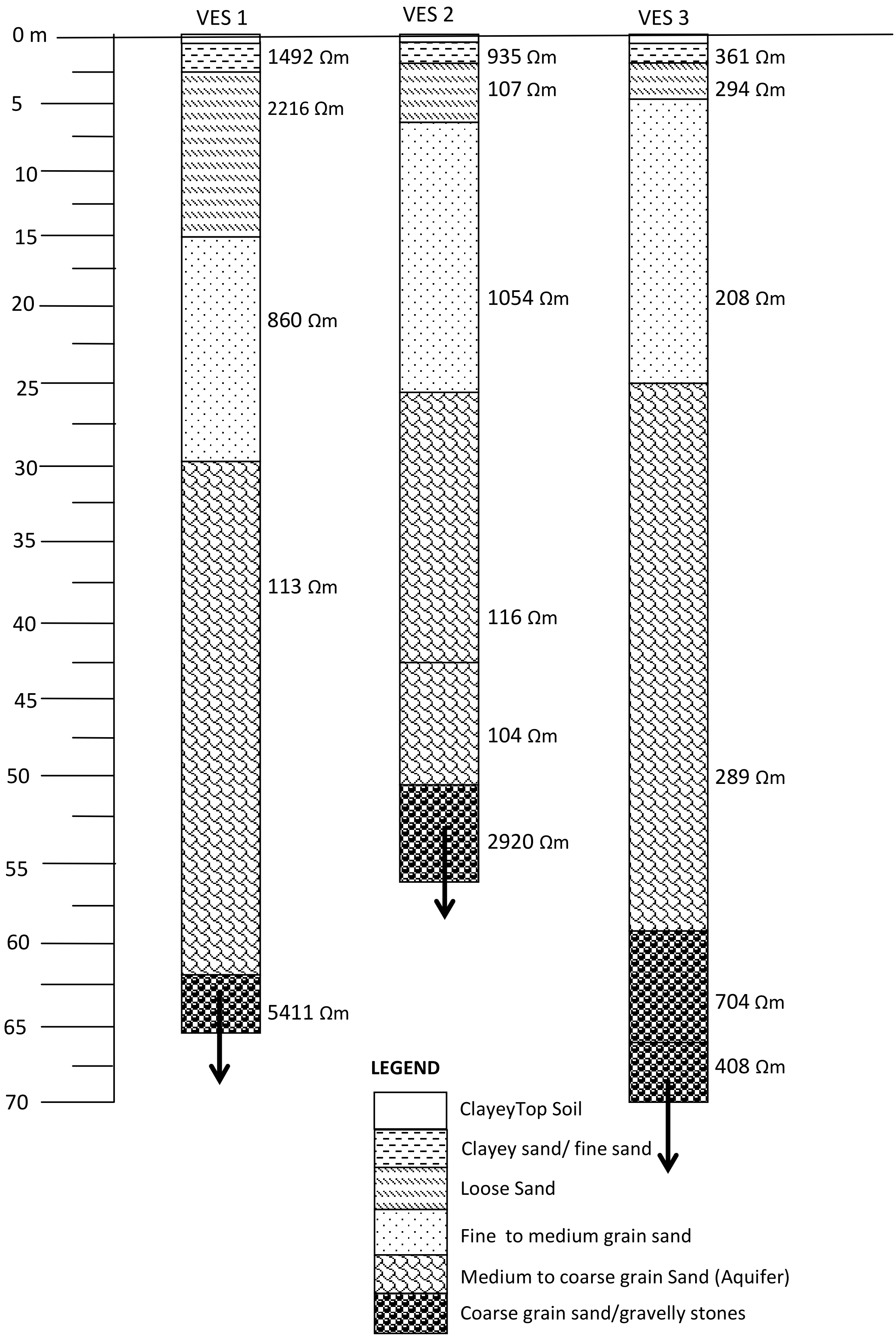

Fig 6: Sample Geoelectric sections of Ewu, Delta State

TABLE 3: Summary of Smoothened Iterated Results in Ewu

VES STATION	LAYER No	RESISTIVITY (Ωm)	LAYER THICKNESS (m)	DEPTH (m)	CURVE TYPE
Ewu1	1	1067.1	1.4	1.4	AQH P1 < P2 < P3 > P4 > P5 < P6
	2	1492.5	4.2	5.6	
	3	2216.3	22.1	27.6	
	4	860.1	30.6	58.2	
	5	113.1	72.7	130.9	
	6	5411.0	-----	------	
Ewu2	1	64.5	0.5	0.5	KHH P1< P2 > P3 < P4 >P5>P6<P7
	2	935.1	2.5	3.0	
	3	107.8	8.3	11.3	
	4	1052.7	34.2	45.5	
	5	116.4	37.7	83.2	
	6	104.1	22.4	105.6	
	7	2920.1	-------	-----	
Ewu 3	1	78.3	0.6	0.6	KHA P1< P2 >P3 >P4 <P5<P6 > P7
	2	361.0	4.2	4.8	
	3	294.1	4.7	9.5	
	4	207.7	35.6	5.1	
	5	289.4	78.7	83.8	
	6	703.8	14.8	98.6	
	7	407.9	------	-----	

Recommendation: Companies with more sophisticated and heavy duty equipment should be engaged in on shore and off shore drilling activities in Ewu to effectively harness this useful solid mineral.

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REFERENCES

[1] Olori OB, *Ewu-Urhobo Dynasty: A History of Ewu People in Urhobo Nation* Bengrey and Associates, Nigeria **2011**, pp 1-12
[2] Short KC, Stauble AJ, *Outline of Geology of Niger Delta,* Bulletin of the American Association of P*etroleum Geologist* **1967**, 51, 5, 701- 7793]
[3] Oyanyan RO, Soronnadi-Ononiwu CG, Omoboriowo AO, *Advances in Applied Science Research (Pelagia Research library)* ***2012,*** *3, 3, 1624 – 1638*
[4] Shankar K, Aravindan S, Rajendrans S, *Advances in Applied Science Research (Pelagia Research library)* **2011,** *2, 5, 92 – 103*
[5] Lowrie W, *Fundamentals of Geophysics*, Cambridge University Press Uk **2002** pp 212 - 217
[6] Ozegin KO, Oseghale AO, Ogedegbe EO *Advances in Applied Science Research (Pelagia Research library)* **2012,** *3, 1, 475 – 480*
[7] Okolie EC, *International J of the Physical Sciences htt/www.academicjournals.org/IJPS* ***2011****, 6, 2, 1156-1160*
[8] Ako BD, Osondu VC, *J Africa Earth Sciences* Great Britain **1986**, 5, 527-534.
[9] ABEM Instrument: *Instruction Manual for Terrameter SAS 4000/SAS 1000,* Sundyberg, Sweden **2005**, pp 10-23, 80-86
[10] Kearey P, Brooks M, *Introduction to geophysical exploration* 2^{nd} *Edition* Blackwell Scientific London Edinburgh **1991** pp 172 – 180
[11] Ozegin KO, Osaghale AO. *Advances in Applied Science Research (Pelagia Research library)* **2012,** *3, 1, 46 9 – 474*
[12] Griffith DH, King RF, *Applied Geophysics for Engineers and Geologists,* Pergamon Press **1976** pp 8 – 65
[13] Okolie EC, Atakpo EA, Okpikoro FE, *International Journal of the Physical Sciences http/www.academicjournals.org/IJPS* **2010**, 5, 6, 642- 650
[14] Okolie EC, Akpoyibo O, *International J of Research and Reviews in Applied Sciences* **2012**, 12, 3, 468 – 476
[15] Vander VBPA. *Resist Version 1.0.* M.Sc Research Project ITC, Netherlands, **1988**.
[16] Aigbogun CO, Egbai JC, *Advances in Applied Science Research (Pelagia Research library)* **2012,** *3, 2 , 625 – 633.*