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Geoelectric Quantification of Building Sand Deposits in Ogan, Edo State, Nigeria

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Abstract
Electrical resistivity survey using Schlumberger electrode configuration was carried out at Ogan, Orhionwon Local Government area of Edo State, Nigeria. The survey was aimed at investigating the building sand deposits within the community. Eleven vertical electrical ssoundings (VES) were carried out in the survey. The data got from the field were analsed using the conventional curve matching and iteration techniques where the model parameters and curves were obtained. The geoelectric parameters and litholgic delineation at Ogan of six layers consisting of lateritic topsoil, clayey sand, fine medium sand, medium sand, medium to coarse and coarse sand. The result shows that from the third down to the fifth layers is made up of sand indicating considerable quantity of sand. The investigated area was of a triangular block. The analysis shows that reserve of building sand deposit was established as 1520559767kg (1520559.8 tonnes). The deposits could be mined economically for domestic purposes.
Keywords: Sand deposits, vertical electric soundings, Ogan, topsoil, geoelectric parameters.

INTRODUCTION

Sand is a substance that consists of very small grains of rock. It occurs naturally as granular materials composed of finely divided rock and mineral particles.

There are two types of sand depending on the local rock sources and conditions. These are silicon dioxides (S_iO_2) and calcium carbonate.

Sand mining is done to extract sand mainly from an open pit, from beaches, inland dunes and dredged from ocean beds and rivers beds (Martin, 2003). The most common type of sand, found in non-tropical coast and continiential areas in the silica which usually takes the form of quartz. This type of sand is extremely resistant to weathering due to its chemical composition (S_iO_2), which makes the grain very hard. It is used in manufacturing as an abrasive used to make concrete. When mixed with cement in certain proportion with water, concrete is formed used in road, house, bridge etc construction.

In addition, sand has industrial use as raw material in glass making. Due to its increasing effective demands, sand is over extracted at different depths varying from one to twenty metres, from different pits, streams, rivers and basins (Bashir and Adebayo, 2002). As sand is extracted rapidly, groundwater evaporates fast, reducing groundwater recharge, increasing failure of irrigation, wells and the associated predicament in farming (Alexander & Hansen, 1983). Sand mining is a direct cause of erosion which destroys farmland and local wild life.

Building sand is a pit sand which can only be used for building or filling. It has no chemical associated with it. It can also be used as filler for concrete.

In Ogan, the availability of sharp sand has become a major concern to the inhabitants due to numerous failed dredging or mining resulting in loss of lives and destruction of equipment. It is important to know the thickness of the lithology so as to quantify the sand deposit in the study area. As a result of this, pre-dredging study was carried out to obtain detailed geological information of the area before citing sand dredging site.

This study is aimed at determining the existence and quantity of building sand in Ogan, Edo State. The study was carried out using the electrical resistivity method. The method is commonly used in engineering site investigation. It is used in depth to bedrock determination, structural mapping, determination of nature of superficial deposits etc (Afolabi et al, 2004; Bisdorf, 1985; Egbai, 2011; Lucius & Bisdorf, 1995). The method is very useful for mineral exploration (Afolabi et al, 2004, Egbai, 2011).

Due to the increasing demand of sand for domestic and industrial purposes, it is considered necessary that detailed geological information of the area should be carried out before citing sand mining site for productive mining.

LOCATION

The study area is Ogan, Orhionwon Local Government Area of Edo State. Fig. 1 shows a sketch map of Ogan and VES locations. It lies in latitude 06^o 16.245^1N and 06^o 19.565^1 N and longitude 006^o 2.104^1 E and 006^o 4.258^1 E. The area is of equatorial climate made of two main season, the wet and dry season. The wet season begins from April and ends in September while dry season begins from October and ends in March. The topsoil is reddish in colour and lateritic. The inhabitant practice subsistence farming. The area is prone to erosion due to

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the highland and valley and the presence of a river (River Orhionwon) which serves as boundary between Ogan and Abudu. Figure 1 shows a sketched map of the study area showing VES locations.

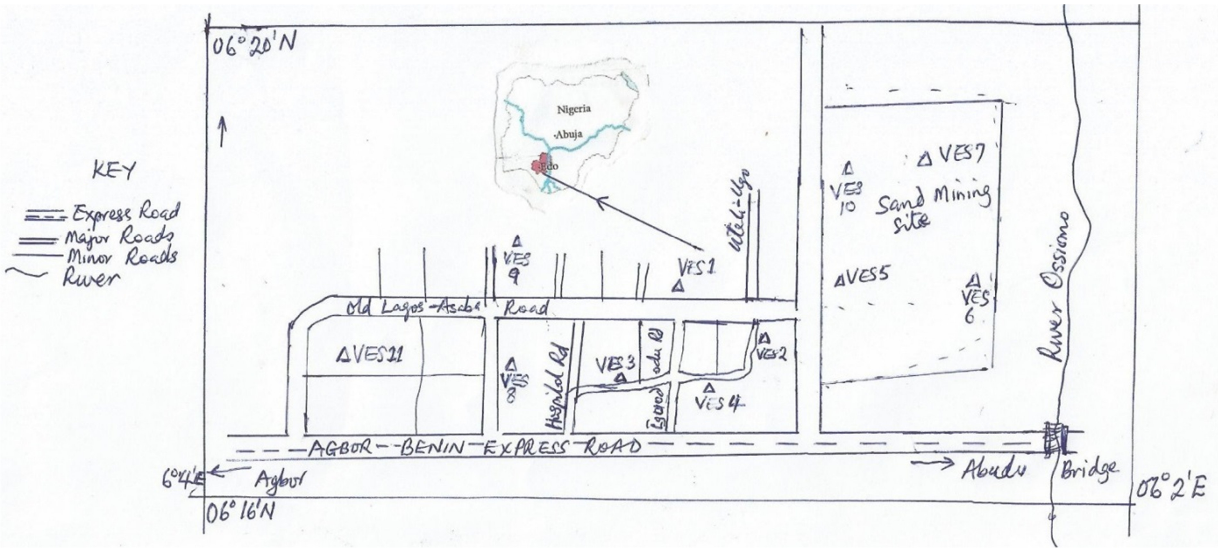

Figure 1: Sketched map of the study area showing VES locations

GEOLOGY
The geology of the study area could be seen from the work of Egbai, 2011 and Egbai, 2012.

METHODOLOGY AND DATA ACQUISITION
The geophysical survey was carried out at Ogan to determine the quantification of building sand in the area. The Schlumberger configuration of maximum current electrode (AB/2) separation of 300m was adopted. Eleven Vertical Electrical Sounding (VES) were carried out in the area with a view to ascertain the quantification of building sand in the area. It is also to ascertain the volume of building sand deposit and volume of excavable overburden. The Abem Terrameter SAS 1000B with an inbuilt booster for greater current injection into the subsurface was used for exploration in the field (Egbai, 2013). The apparent resistivity is given by the use of the formula shown below

$$e_a = \pi \left\{ \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \right\} \frac{\Delta V}{I}$$

where AB= distance between the two current electrodes
MN= distance between the two potential electrodes.

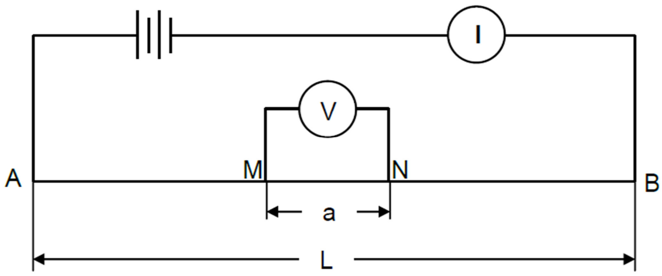

Figure 2: Schlumberger Configuration.

A graph of apparent resistivity was plotted against current spacing for all locations. The curves obtained were curve matched and those values were iterated using WinResist software (Vander Velpen, 2004).

Three Vertical electrical sounding (VES) were taken in a triangular shape in order to quantify the volume of building sand and the excavable overburden volume in the study area as shown in figure 3 below. The angles formed between the three VES in equilateral which is 60°. The triangular surface area and the thickness of each layer were used to calculate the volume of sand. This is also applicable to excavable overburden in terms of its volume. Standard density bottle was used in the determination of density of sand by displacement method (Egbai, 2013). This was done three times and the average determined. The result obtained for the density of building sand at Ogan by displacement method was 1.602g/cm^3. The product of the volume and density gave the reserve of the building sand deposit.

Table 1 shows the model parameters where the resistivity, thickness and lithology of the various locations as well as the curve types for the 11 VES could be determined.

Table 1: Geoelectric parameter and Lithologic delineation of Ogan

VES	Layers	Resistivity Ωm	Thickness (m)	Depth (m)	Lithology	Curve Type	RMS % error
1	1	101.7	0.9	0.9	Lateritic Topsoil	KHAA	
	2	187.0	5.4	6.3	Clayey sand	$\rho_1<\rho_2>\rho_3<\rho_4<\rho_5\rho_6$	
	3	68.1	10.5	16.8	Clay		2.5
	4	180.5	11.8	28.6	Fine to medium sand		
	5	384.3	19.7	48.3	Medium sand		
	6	1249.5	-	-	Coarse sand		
2	1	673.8	1.1	1.1	Lateritic Topsoil		
	2	1570.5	5.7	6.8	Clayey sand	KQHA	2.5
	3	689.9	10.3	17.1	Fine to medium sand	$\rho_1<\rho_2>\rho_3>\rho_4<\rho_5\rho_6$	
	4	629.3	21.6	38.7	Medium sand		
	5	1647.9	33.9	72.7	Medium to coarse sand		
	6	1845.6	-	-	Coarse sand		
3	1	68.7	1.1	1.1	Lateritic Topsoil		
	2	287.7	4.3	5.4	Clayey sand	AAKH	
	3	1653.7	6.1	11.5	Fine to medium sand	$\rho_1<\rho_2<\rho_3<\rho_4>\rho_5<\rho_6$	3.4
	4	2472.7	20.0	31.5	Coarse sand		
	5	372.9	30.7	62.2	Clayey sand		
	6	1981.8	-	-	Coarse sand		
4	1	3086.2	1.4	1.4	Lateritic Topsoil		
	2	1502.6	6.2	7.6	Clayey sand	HKQH	
	3	5306.3	8.5	16.1	Coarse sand	$\rho_1>\rho_2<\rho_3>\rho_4>\rho_5<\rho_6$	2.5
	4	4243.6	18.7	34.8	Medium to coarse sand		
	5	1485.4	13.9	48.7	Fine to medium sand		
	6	2670.4	-	-	Coarse sand		
5	1	1625.9	1.6	1.6	Lateritic Topsoil		
	2	441.4	3.9	5.5	Clayey sand	HAKH	
	3	2152.3	4.5	10.0	Fine to coarse sand	$\rho_1>\rho_2<\rho_3>\rho_4>\rho_5<\rho_6$	2.7
	4	4611.5	19.5	29.5	Coarse sand		
	5	513.6	30.5	60.0	Clayey sand		
	6	2401.5	-	-	Coarse sand		
6	1	1754.2	1.4	1.4	Lateritic Topsoil		
	2	581.3	4.6	6.0	Clayey sand	HKQQ	
	3	3865.5	9.8	15.8	Medium sand	$\rho_1>\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$	2.5
	4	2392.7	16.7	32.5	Fine to medium sand		
	5	1183.6	15.1	47.6	Fine sand		
	6	2355.7	-	-	Clayey sand		
7	1	1108.8	1.1	1.1	Lateritic Topsoil		
	2	2355.7	5.1	6.2	Clayey sand	KHKH	2.4
	3	743.0	10.9	17.1	Fine sand	$\rho_1<\rho_2>\rho_3<\rho_4>\rho_5<\rho_6$	
	4	2088.0	16.5	33.6	Fine to medium sand		
	5	395.4	23.4	57.0	Medium sand		
	6	1316.3	-	-	Coarse sand		
8	1	1260.6	0.9	0.9	Lateritic Topsoil		
	2	2215.3	4.2	5.1	Clayey sand	KHAK	2.4
	3	544.7	10.5	15.6	Fine sand	$\rho_1<\rho_2>\rho_3<\rho_4<\rho_5<\rho_6$	
	4	2400.5	23.1	38.7	Medium sand		
	5	3032.1	20.0	58.7	Medium to coarse sand		
	6	877.4	-	-	Fine to medium sand		
9	1	1334.9	1.0	1.0	Lateritic Topsoil		
	2	740.4	4.0	5.0	Clayey sand	HKQH	2.5
	3	4035.7	8.0	13.0	Coarse sand	$\rho_1>\rho_2<\rho_3>\rho_4>\rho_5<\rho_6$	
	4	1372.2	13.6	26.6	Medium sand		
	5	314.8	31.2	57.8	Clayey sand		
	6	3058.2	-	-	Coarse sand		
10	1	361.6	1.0	1.0	Lateritic Topsoil		
	2	2138.9	5.6	6.6	Clayey sand	AKQQ	2.5
	3	3073.5	8.6	15.2	Coarse sand	$\rho_1<\rho_2<\rho_3>\rho_4>\rho_5>\rho_6$	
	4	2712.1	13.9	29.1	Medium sand		
	5	1959.5	22.3	51.4	Fine to medium sand		
	6	1024.1	-	-	Coarse sand		
11	1	417.7	1.0	1.0	Lateritic Topsoil		
	2	781.9	5.4	6.4	Fine sand	KHAA	2.4
	3	306.9	17.9	24.3	Clayey sand	$\rho_1<\rho_2>\rho_3<\rho_4<\rho_5<\rho_6$	
	4	414.1	17.9	42.2	Fine sand		
	5	947.2	11.9	54.1	Fine to medium sand		
	6	1056.0	-	-	Coarse sand		

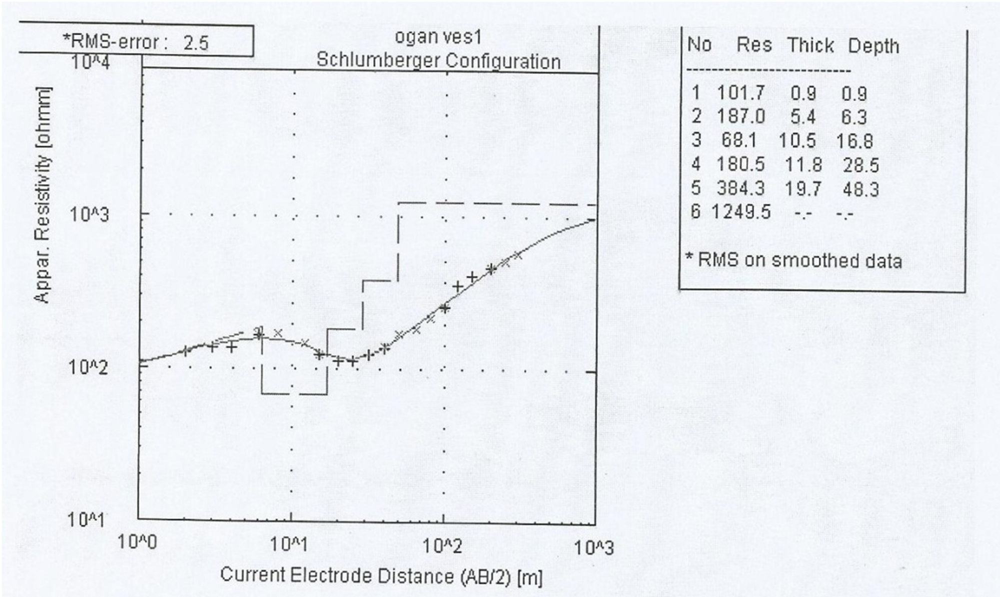

Figure 3: Sounding curve for VES 1 at Ogan

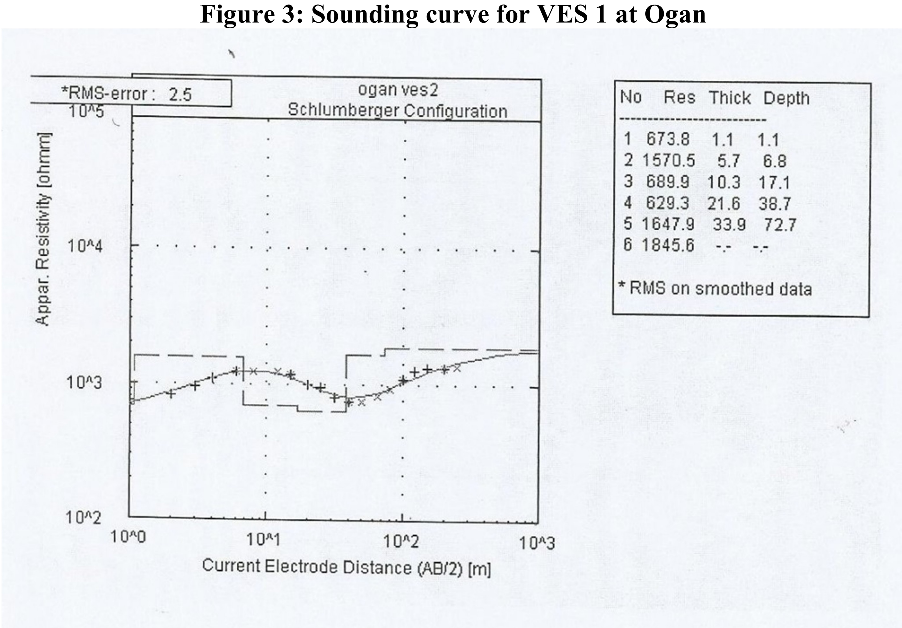

Figure 4: Sounding curve for VES 2 at Ogan

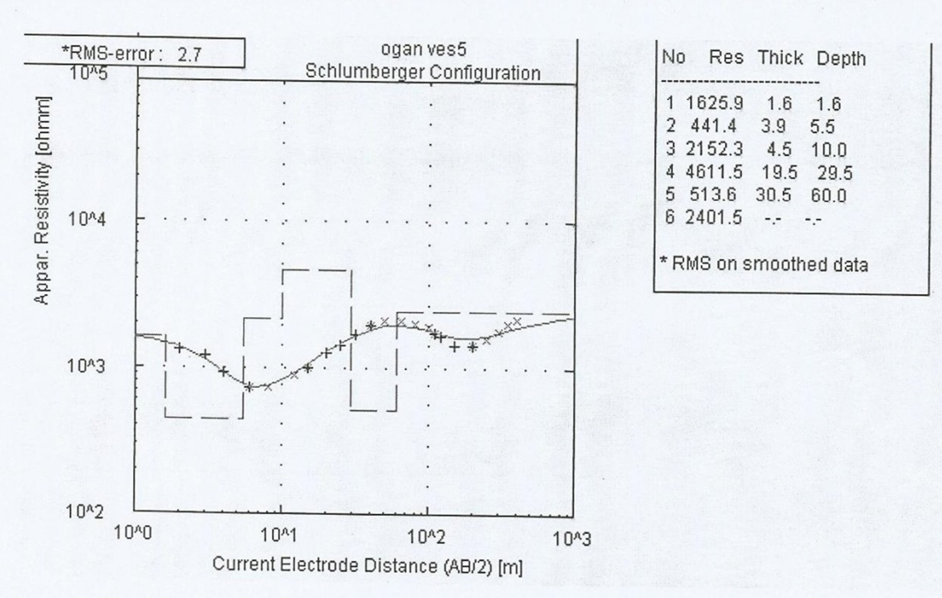

Figure 5: Sounding curve for VES 5 at Ogan

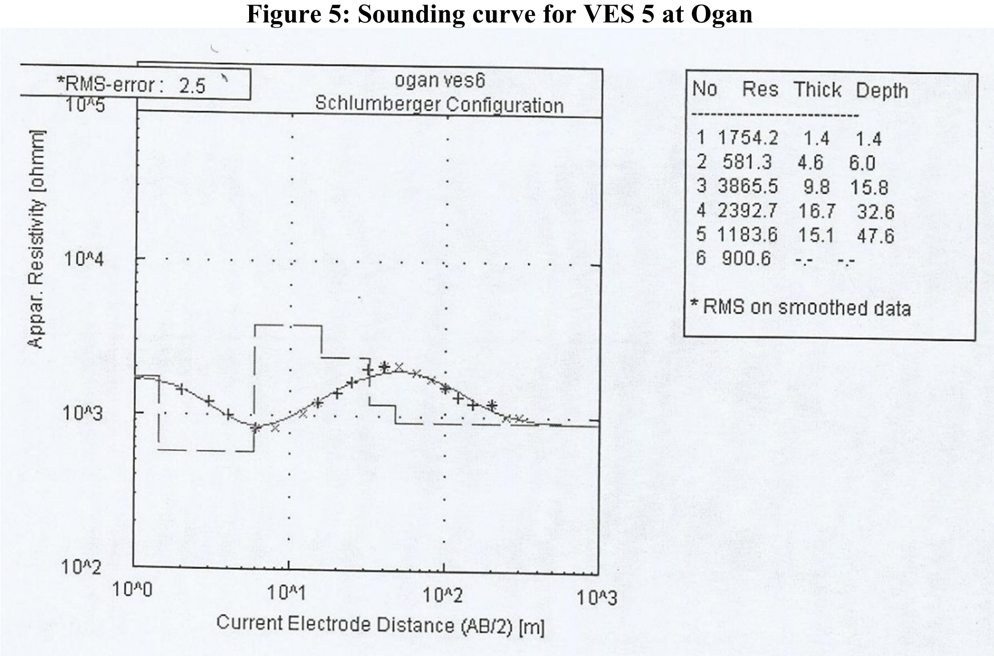

Figure 6: Sounding curve for VES 6 at Ogan

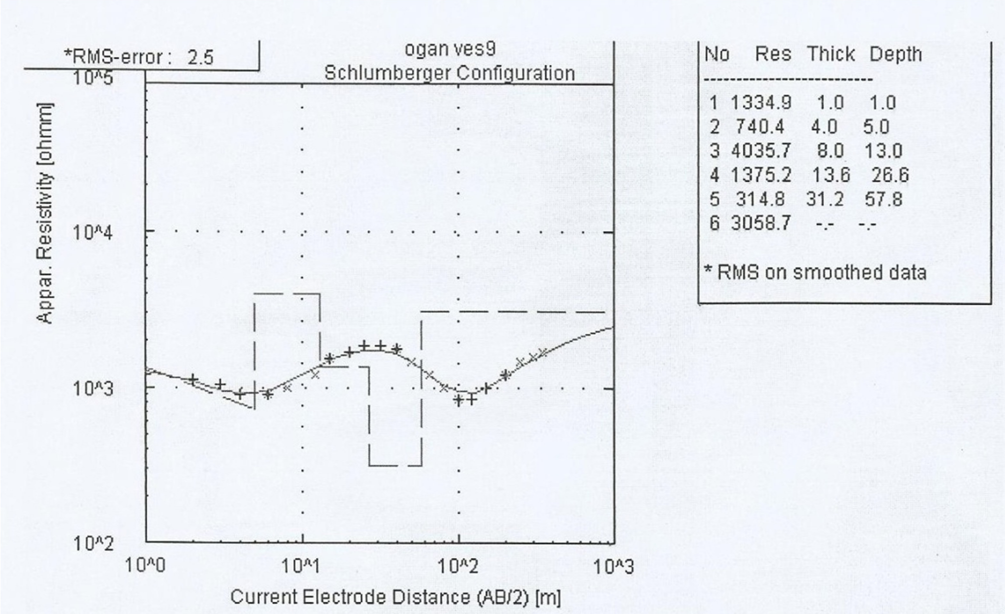

Figure 7: Sounding curve for VES 9 at Ogan

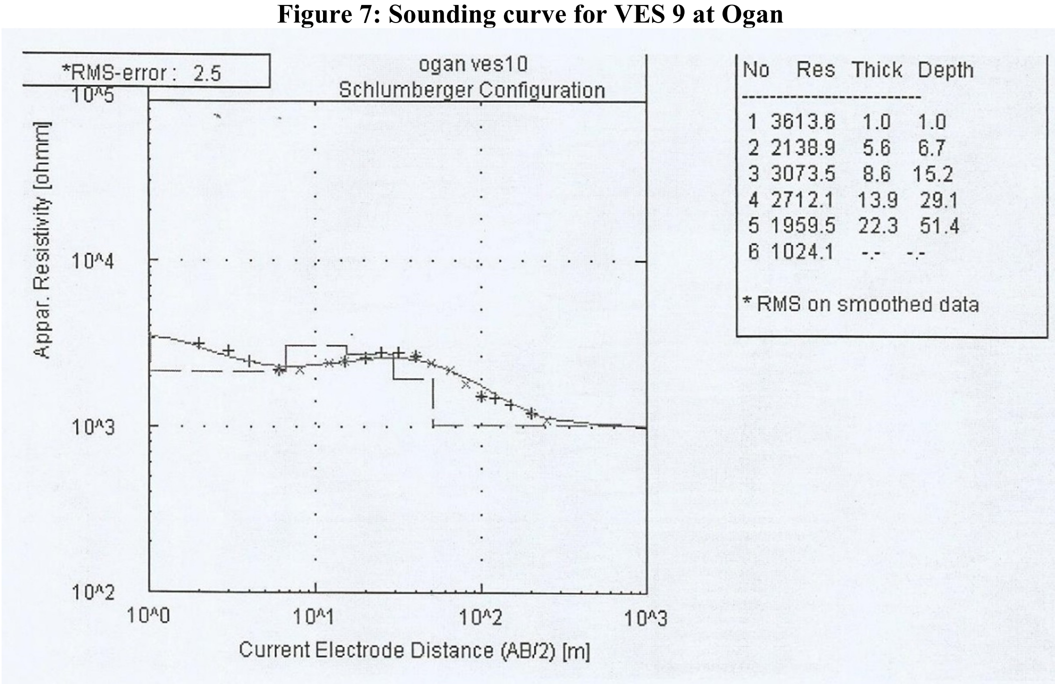

Figure 8: Sounding curve for VES 10 at Ogan

RESULT AND DISCUSSION

Geophysical survey was carried out at Ogan to study and quantify sand deposit with a view to ascertain whether it could be mined commercially. Eleven vertical electrical soundings (VES) have been conducted at Ogan and the result shown in Table 1. The result of the electrical resistivity curves show six layers earth. The subsurface resistivity layer parameters of the eleven vertical geoelectrical soundings are analysed to determine the thickness of sand in the study area.

The analyses of the lithology of the area consists of lateritic topsoil, clayey-sand, fine-medium sand, medium sand, medium to coarse sand and coarse sand. Table 1 shows the resistivity values and the thickness of each layer. Figures 3-8 show some of the resistivity sounding curves.

The topsoil is lateritic with resistivity ranging from 68.7Ωm to 3086.2 Ωm with thickness varying from 0.9 to 1.6m. The second layer is layer is clayey sand with resistivity ranging from 187.0 to 2355.7 Ωm with a thickness varying from 3.9m to 6.2m. The third layer is fine to medium sand with resistivity values ranges from 68.1 to 5306.3 Ωm with thickness varying from 4.5m to 17.9m. The fourth layer consists of medium sand with resistivity ranging from 180.5 Ωm to 4611. Ωm while the thickness of this layer varies from 11.8 to 23.1m. The fifth layer is made up of medium to coarse sand with resistivity values ranging from 314.8 to 3022.1 Ωm and thickness varying from 11.9 to 33.9m. The sixth layer is made of coarse sand except VES 6 and 8. The resistivity of this layer ranges from 877.4 to 3058.2 Ωm. The thickness of this layer cannot be determined as the current electrodes terminated in this layer. The survey shows that from the third layer down to the fifth layers is mostly sand indicating a considerable quantity of sand which can be mine in the area of study.

Calculation of Building Sand Quantification

The VES within the area of study is of triangular shape as shown in the figure 9

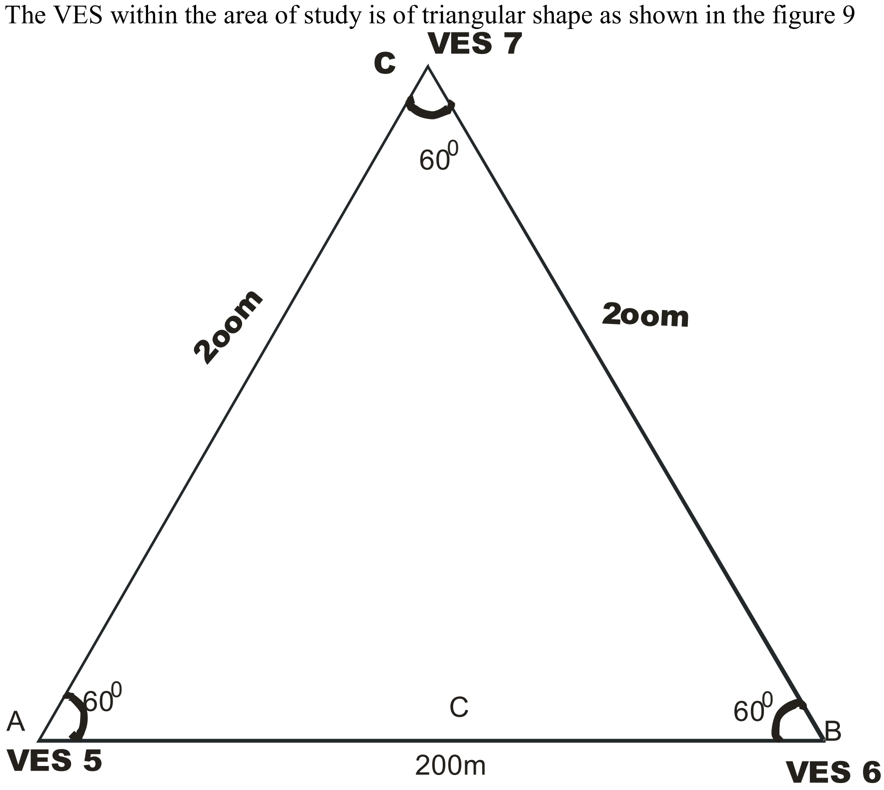

Fig. 9: Triangular shape of study area

Area of triangle = $\frac{\pi}{2}\ abSinC$

where C = 60, a = 200 and b 200m

$A = \frac{1}{2} \times 200 \ \times 200 Sin\ 60^0$

$= 17320.50m^2$

Depth of the layer is taken as the total thickness

Average depth of the three VES $= \frac{60.0 + 47.6 + 57.0}{3}$

= 54.8m

Volume of the triangle

= Area x thickness

= 17320.5 x 54.8

= 949163.40m^3

Mass = Density x volume

Density of building sand= 1.602gcm^{-3}

Density = 1.602 x 1000 = 1602kgm $^{-3}$

Mass = 1602 x 949163.40kg

= 1520559767kg

= 1520559.8 tonnes

Hence the quantity of sand plus over burden in the mapped area is 1520559.8 tonnes.

VOLUME ESTIMATION OF OVERBURDEN FROM VES VALUES FOR OGAN

Area of Triangle = 17320.m^2

Density of lateritic topsoil (D_L) = 1.25gcm^{-3}

Density, D_L = 1.25 x 1000kgm^{-3}

=1250 kgm^{-3}

Density of clayey sand (D_C) = 2.60 x 1000 kgm^{-3}
Average thickness of Lateritic topsoil = (1.6 + 1.4 +1.1)/3
= 1.367m
Average thickness of clayey sand = (3.9 + 4.6 + 5.1)/3
= 4.53m
Volume of lateritic topsoil = Area x thickness
= 17320.5 x 1.367m^3
Mass of lateritic topsoil = Volume x density
= 17320.5 x 1.367 x 1250
= 29596404.38kg
= 29596.40 tonnes
Volume of clayey topsoil = Area x thickness
= 17320.5 x 4.53m^3
Mass of clayey sand = 17320.5 x 4.53 x 2600
= 204000845kg
= 204000.8 tonnes
Total mass overburden = mass of lateritic topsoil + mass of clayey sand
= Ml + Mc = 29596.4 + 204000.8 tonnes
= 233597.2 tonnes.
Mass of building sand = 1520559.8 – 233597.2
= 1286962.6 tonnes.

CONCLUSION

Geophysical survey has been conducted in Ogan to quantify building sand deposits. Eleven VES were carried out with resistivity curves obtained showing six geoelectric layers. The survey shows that from third layer down to the fifth layer is sand indicating that considerable quantity of sand can be mined in the area. The result obtained was very reliable when compared with the driller's log obtained from the community. The reserve of the building sand deposit within the area of study is estimated to be approximately 1286962.6 tonnes while the mass of overburden is 233597.2 tonnes. The result shows that the building sand deposits can be mined economically for domestic and building purposes. Results show that there may be building sand deposits beyond the area studied. Further investigation is highly recommended to study building sand deposit beyond the surveyed areas.

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