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Geophysical Exploration of Gravel Deposits in Abudu Area of Edo State, Nigeria.

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Abstract

The need to prospect for gravel deposit in Abudu area of Edo State, Nigeria became inevitable in view of the fact that it has greatly aided many developed and developing nations of the world commercially. The geophysical study was carried out using vertical electrical sounding (VES) of electrical resistivity method, employing Schumberger configuration techniques based on six (06) points per decade operation to justify the study of assembling resistivity data.

Ten (10) fairly distributed VES in eight (08) different stations of Abudu Area was carried out to investigate the subsurface Lithologies or rock types. So as to detect gravel deposits.

The software or package IP12WIN utilizing computer iteration was used for interpretation of apparent resistivity data.

The result of the geophysical survey showed that gravel deposit was intercepted at a depth varying from about 25.0m to 140.0m below sea level while its thicknesses varied from about 2.0m to 120.0m. The resistivity of the detected gravel deposit varied from about 1000 0hm-m to 7000 0hm-m.

Area of probable gravel deposits formations and their thicknesses have been identified especially for commercial purposes.

1.0 Introduction

Geophysical exploration is usually conducted to locate significant accumulation of gravel deposits, limestone deposit, sandstone deposits, clay deposit, oil, natural gas and other minerals, including ground water which are of economic importance to Nigeria as a nation in particular and the world in general because of their commercial values [1]. The use of gravel as a commercial product with a number of applications has added many developed and developing nations of the world such as Nigeria, U.S.A, U.S.S.R etc e.g. man roadways are surfaced with gravel, especially in rural areas where there is little traffic. Globally, far more roads are surfaced with gravel than with concrete or tarmac, U. S. S.R alone has over 400,000 km of gravel- surfaced roads. In fact, both sand and small gravel are also vital for the manufacture of concrete [2],[3].

Gravel is formed as a result of the weathering and erosion of rocks. The action of rivers and wave tends to pile up gravel in large accumulation.s This can some times result in gravel becoming compacted and concreted into the sedimentary rock called conglomerate [3]. Where natural gravel deposits are inadequate for human purposes, gravel is often produced by quarrying and crushing hard-wearing rocks such as sandstone, limestone, or basal [3], [4].

This research paper tends to estimate the thickness quantity and distribution of gravel deposits in the Abudu area using geophysical survey method with the intention of providing detailed documentation of known gravel deposits and recommend possible set up of an industry/factory in Abudu that rely on gravel for manufacture purposes.

2.0 Brief Geology and Hydrogeology of the study area

The research area was Abudu and is underlained by Benin formation which is linked with Niger Delta basin [5]. Abudu has approximately on latitude of about $6^o17'$N and longitude of about $6^o03'$E. Abudu is hilly and has little natural topographical variations. The terrain is generally low with gentle slope [6].

3.0 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], [9], [10] [11].

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

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Measurements were taken at increasing current electrode distance such that the electric current passed into the earth's surface penetrates greater depths. He 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 [7], [8], [9], [10] [11].

4.0 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 resisitivity 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, inhomogenous 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 is have been documented in previous research work, the observed apparent resistivity is such that

$$\ell_a(r) = r^2 \int_\circ^\infty \lambda T\left(\lambda\right) J_1\left(\lambda r\right) d\lambda \qquad (4.1)$$

Where the kernel function is given as

$$T(\lambda) = \int_\circ^\infty \frac{1}{T} \ell_a \left(r\right) J \left(\lambda r\right) d\lambda \qquad (4.2)$$

J_1 represent Bessel function of first order, first kind ant T (λ) is the transformed resistivity data.

However, when the earth is approximately composed of horizontally stratified isotropic, and homogenous media such that the change of resisitivity 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 [7] [8] (9) (10) (11) (12).

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 ($\left(\ell_a\right)$ according to Schlumberger array condition of AB≥5MN is

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

AB = Current electrode spacing in meter
MN = potential electrodes spacing in meter
ΔV = Potential difference volts, 1 = electric current in Amperes, π= 22/7

5.0 Results and Discussion

Geophysical survey results employing electrical resistivity method are presented as field curves/computer iterated curves shown in figures 1-8. Their corresponding surface Lithologies are shown in table 1 for VES vertical (electrical sounding) stations 1 -8.

Results of the VES interpretation showed that high resistive layers are present in all the stations indicating gravel deposit and hard rock deposit such as lime stone. The Benin formation is exposed, in all the VES stations consisting of the Lithologies top soil, laterite, clay sandy clay, clayey sand, sand, fine sand and coarse sand/sandstone/gravel [5].

A close examinations of all VES station, revealed gravel existence. Gravel occurred in VES station two (2) at a depth of about 137.9m below sea level, with a thickness of about 116.8m. This VES station exhibited the thickest quantity of gravel deposit which can be of a high economic value, commercially. VES station three (3) revealed that gravel occurred at a depth of about 1.46m below sea level, with a thickness of about 1.46m. Also VES station four (4) revealed that gravel occurred at a depth of about 24.7m below sea level, with a thickness of about 20.0m. In VES station six (6), gravel occurred at a depth of about 52.32m, below sea level with a thickness of about 27.47m. In VES station seven (7), gravel occurred at a depth of about 4.1 below sea level, with a thickness of about 3.44m. The thinnest quantity of gravel occurred in VES station eight (8), with a thickness of about 3.44m. The thinnest quantity of gravel occurred in VES station eight (8), with a thickness of about 0.75m at a depth of about 0.75m below sea level. The results obtained above agreed very well with available borehole record of the area [13], which is also confirmed by standard table of approximate resistivities[14].

The thickest quantity of gravel occurred in VES station two (2) and hence can be exploited commercially with a view to improving the economy of Abudu in particular and Edo State in general.

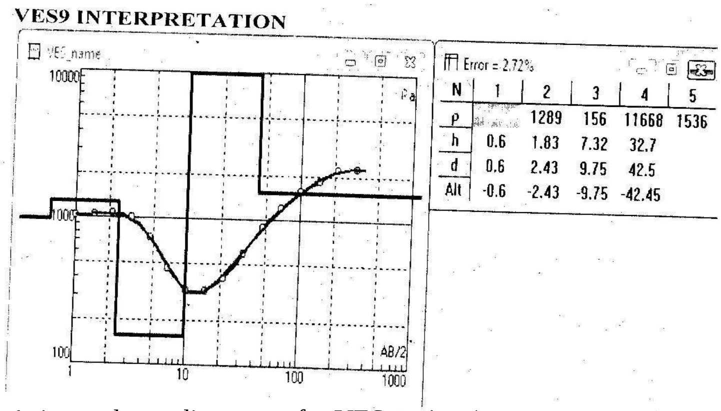

Fig 1: iterated sounding curve for VES station 1

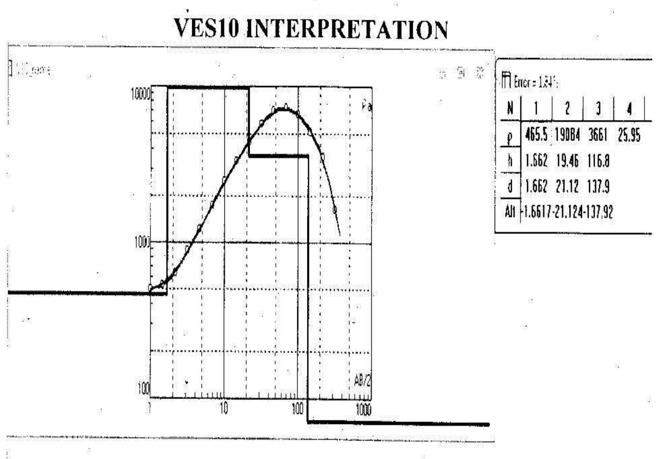

Fig 2: iterated sounding curve for VES station 2

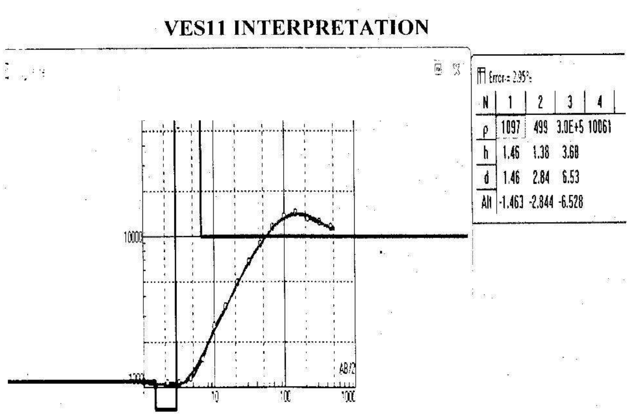

Fig 3: iterated sounding curve for VES station 3

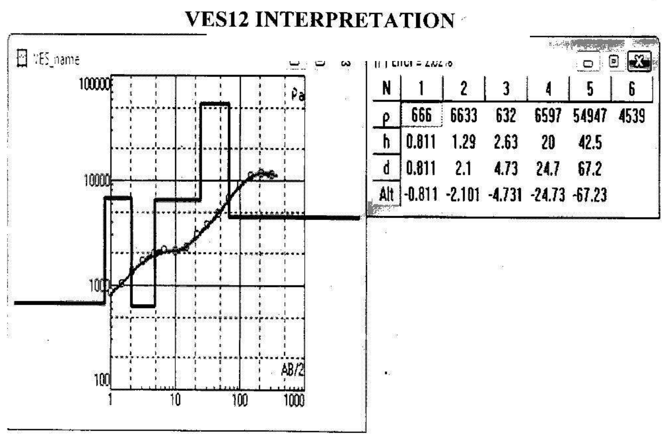

Fig 4: iterated sounding curve for VES station 4

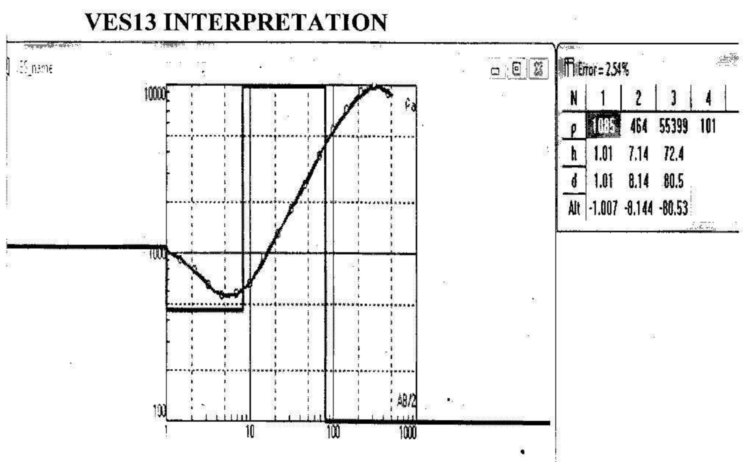

Fig 5: iterated sounding curve for VES station 5

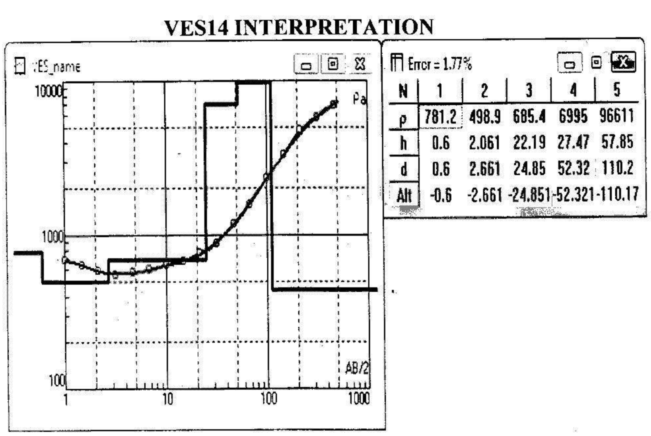

Fig 6: iterated sounding curve for VES station

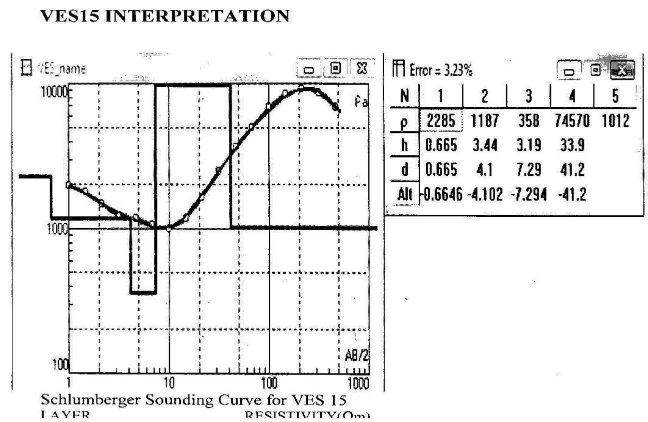

Fig 7: iterated sounding curve for VES station 7

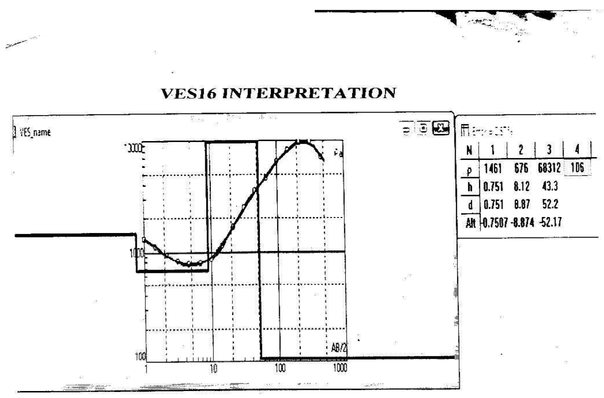

Fig 8: iterated sounding curve for VES station 8

Table 1: lithologies for all the VES stations

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		
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		
3	1	1097	Gravel	1.46	1.46
	2	499	Wet sand/laterite	1.38	2.84
	3	300000	Hard rock	3.68	6.53
	4	10061	Hard rock		
4	1	666	Moist silt	0.811	0.811
	2	6633	Dry coarse sand/coarse	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		
5	1	1085	Laterite	1.01	1.01
	2	464	Silty sand	7.14	8.14
	3	55399	Hard rock/dense lime stone	72.4	80.5
	4	101	Clay/clayey sand		
6	1	781	Laterite	0.6	0.6
	2	498	Silty sand	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		
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		

CONCLUSION

Geophysical exploration techniques based on the notion of vertical electrical sounding (VES) have demonstrated its usefulness for achieving reliable results that enable the researcher to delineat sequence of gravel deposits in all the VES stations area of Abudu.

The various gravel deposits were intercepted at a depth varying from about 25.0m to 140.0m below sea level while its thicknesses varied from about 2.0m to 120.0m. The resistivity of the detected gravel deposits varied from about 1000 ohm – m to 7000 0hm-m formation.

Area of probable gravel deposits and their thicknesses have been identified especially for commercial purposes. Hence industry can be cited in Abudu to aid construction of roads both in the urban and rural areas.

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