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Full Length Research Article

PRELIMINARY ESTIMATE OF GYPSUM DEPOSIT BASED ON WENNER AND SCHLUMBERGER ELECTRICAL RESISTIVITY METHODS AT IKPESHI, EDO STATE, NIGERIA

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ABSTRACT
The Wenner and Schlumberger electrical resistivity methodswere employed at spread lengths of a=1m, a=3m, a=6m and a=9m across the entire area, after which a total of twelve vertical electrical sounding (VES) points were sounded at appropriate locations with a maximum spread of 100 meters in the area at Ikpeshi, Etsako Local Government Area of Edo State,with the aim of locating and estimating the quantity of some possible deposits of gypsum. Just like any other solid mineral, it is uniquely difficult to locate gypsum in isolation, however, gypsum could possibly be found in association with some other geological formations.The common formation identified in this work was limestone, which possess a very wide range in resistivity values (1 – 104 Ω-m).The surveyed area shows the presence of some traces/crystals of gypsum at depths of between 3m and 9mand a resistivity range of 1 to 3000Ω-mspread around the investigated area. The gypsum reserve deposit was estimated to be about seventeen million tons.

Keywords: Estimate for Gypsum Deposit, Wenner and Schlumberger Methods, Ikpeshi, Edo State, Nigeria.

INTRODUCTION
Crime is one of the continuous problems that bedevil the Gypsum is an evaporate mineral most commonly found in layered sedimentary deposits in association with halite, anhydrite, sulphur, limestone or calcite and dolomite. The chemical composition of gypsum is $CaSO_4.2H_2O$ and is very similar to anhydrite, CaSO4. The chemical difference between the two is that gypsum contains two waters while anhydrite is without water, since gypsum is a mineral consisting of the hydrated calcium sulphate, when calcined, it forms plaster of paris(Robert, 2016).Gypsum occurs in a variety of forms, both crystalline (a solid composed of an array of atoms or molecules possessing long – range order and arranged in a pattern which is periodic in three dimensions or a piece of glimmering, shining mineral resembling ice or glass) and amorphous (lacking a definite form or clear shape).
Mineral exploration in Nigeria dates back to the geological expeditions by the colonial masters in the early part of the 20^{th} century (Ajakaiye, 1985; Chuku, 1988). It has resulted in revenue accruing earnings and economic development. In the southern part of Nigeria, especially the Northern part of Edo State, solid mineral exploitation is an everyday activity that is currently going on, but, on a ‘wild cat’ basis. The mining industry in Edo State is of great potential which has the capacity to contribute to local and foreign exchange earnings as well as the attraction of foreign direct investment thereby boosting the country’s economy (Ndinwa and Ohwona, 2014; Dogara and Aloa, 2017).

Exploitation of mineral resources has assumed prime importance in several developing countries including Nigeria (Aigbedion and Iyayi, 2007). Nigeria is endowed with abundant mineral resources, which have contributed immensely to the nations wealth with associated socio-economic benefits. Mineral resources are an important source of wealth for a nation, but before they are harnessed, they have to pass through the stages of exploration, mining and processing (Brooks, 1974; Ndinwa and Ohwona, 2014). This paper is aimed at using the Wenner and SchlumbergerElectrical Resistivity methods to preliminarily locate and use the information obtained therefrom to estimate the quantity of gypsum at Ikpeshi, Edo State, Nigeria.

Location and Geology of the Area
The Wenner and Schlumberger electrical geophysical exploration methods were carried out at the Auchi-Agenegbode road, Edo State, near a part of the Ajaokuta – PortHarcourt railway line (Fig. 1). The area falls within the standard topographic sheet 267 Idah of 1:100,000. The area is located at Iviari-Weppa, Ikpeshi, Etsako East Local Government Area of Edo State. The site is about 30 km away from Auchi town. The site is defined by the geographical coordinate of latitude and longitude of 007° 02.666' N to 007° 02.111' N, and 006° 31.904' E to 006° 31.259' E respectively. The location covers a total landmass of 800,000 square meters and the average height is 56 m above the mean sea level. Auchi town is within the Anambra hydrogeological Basin. The basin comprises an almost triangular shaped embayment covering an area of about 30,000km^2. It stretches from the area just south of the confluence of the River Niger and Benue across to areas around Auchi, Okene, Agbo and Asaba, west of the river, and Anyangba, Idah, Nsukka, Onitsha and Awka area, east of the river. The site is drained by both surface water and groundwater. The relief of the area is characterized by undulating plain, gentle slopes, and consists of peneplains with eroded flat tops, often capped by top layers of laterites (Abdullah, etal., 2013) (Fig. 1)..

Fig. 1: Googled Map of the Investigated Area

The local geology of the studied area lies in the post deformational cretaceous Anambra Basin and stratigraphically positioned within the Ajali Formation. The Ajali Formation is conformably overlain by the Nsukka Formation and underlain by the Manu Formation. The stratigraphy succession in the area is in the age sequence of Santonian/Paleocene to Maestrichitian/Campanian (NMCO, 2016).The regional geology is that of the sedimentary cycle in Southern Nigeria which began with the deposition of thick series of marine shales with subordinate sandstones and limestones ranging in age from Middle Albian to Uppermost Albian and in few places to Cenomanian. The regression of the sea, however, led to very slow deposition and final cessation of deposition. These sediments were subsequently strongly folded. In the Turonian time, the sea again invaded large areas and marine sedimentation continued well into the Senonian. This was also followed by renewed folding and erosion in certain areas of the region (NMCO, 2016).

The Theory of Electrical Resistivity Methods

Electrical resistivity method measures both vertical and horizontal variation of resistivity (Parasnis, 1986). This is achieved based on the assumption that the surface is to be homogeneous and isotropic (Abdullahi and Udensi, 2008). From Ohm's law, the current I and the potential V in a metal conductor at constant temperature are related as follows:

$$V = IR \qquad (1)$$

Where R is the constant of proportionality known as resistance, measured in ohms. The resistance R, of a conductor is related to its length L and cross sectional area A, by

$$R = \frac{\rho L}{A} \qquad (2)$$

Where ρ is the resistivity, and it is a property of the material considered. From (1) and (2),

$$V = \frac{I\rho L}{A} \qquad (3)$$

Using the configuration in the works of Dogara and Aloa (2017), the surface area will be $2\pi L^2$, where L is the radius of the sphere. Thus,

$$V = \frac{I\rho}{2\pi L} \qquad (4)$$

and

$$\Delta V = \frac{I\rho}{2\pi}\left[\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \left(\frac{1}{r_3} - \frac{1}{r_4}\right)\right] \qquad (5)$$

$$\Rightarrow \rho = \frac{2\pi\Delta V}{I}\left[\frac{1}{\left(\frac{1}{r_1}-\frac{1}{r_2}\right)-\left(\frac{1}{r_3}-\frac{1}{r_4}\right)}\right] \qquad (6)$$

If the body is inhomogeneous like the study area, apparent resistivity (ρ_a) is considered,

$$\rho_a = K\left(\frac{\Delta V}{I}\right) \qquad (7)$$

Where $\rho_a$is apparent resistivity in ohm-metre, and

$$K = 2\pi\left[\frac{1}{\left(\frac{1}{r_1}-\frac{1}{r_2}\right)-\left(\frac{1}{r_3}-\frac{1}{r_4}\right)}\right] \qquad (8)$$

K is called the geometric factor whose value depends on the type of electrode array used.

For Schlumberger array, $\mathrm{MN} = 2\mathrm{b}$ and$\frac{AB}{2} = L$, then,

$$K = \pi\left(\frac{L^2}{2b} - \frac{b}{2}\right)$$

For the Wenner array, $r_1 = r_4 = 2b$

Therefore, K = πb

In this survey, the two electrical resistivity methods were used to study both the lateral and vertical variation of resistivity with respect to subsurface formation.

MATERIALS AND METHOD

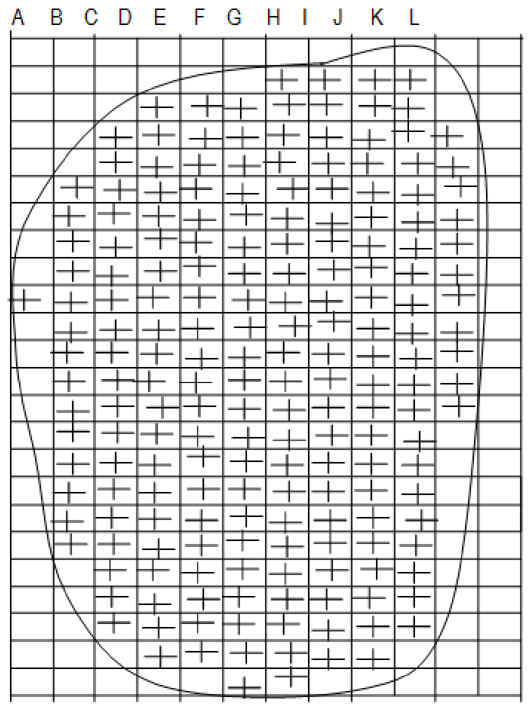
The geophysical exploration method carried out at the site was the electrical resistivity sounding technique with Schlumbeger Array for studying vertical variation and Wenner Array was used for lateral variation. Ohmaga Resistivity Tarrameter and its accessories was used to obtain geoelectrical properties of the site. Geographical coordinates were obtained from a Global Positioning System (GPS) device. In this survey the Constant Separation Traversing (CST) technique was employed at spread lengths of a=1m, a=3m, a=6m and a=9m across the entire area, after which a total of twelve vertical electrical sounding (VES) points were sounded at different locations within the study area with a maximum spread of 100 meters.

The density of the gypsum was determined by weighing a sample of the gypsum obtained from the field using the KERRO Electronic/Digital Balance Scale and the mass was taken. A well calibrated beaker was filled with water to a certain level and the mark was noted. The gypsum was then lowered into the beaker containing the water using a thin negligibly weighed thread. The change in the volume of the water in the beaker, which is equal to the volume of the gypsum was taken. The density of the gypsum was then calculated by dividing the mass of the gypsum by the change in the volume of the water on immersion of the gypsum (table 1).

Table 1: Estimated Density of Gypsum

Gypsum Sample	
Mass	23.69 g
Volume	68.0 – 79.5 = 11.5 cm^3
Density	$\frac{Mass}{Volume} = \frac{23.69}{11.5}$ = 2.06 g/cm^3 = 2060 kgm^{-3}

The estimated total reserve of the gypsum deposit was determined using the block methods of Onimisi, *et, al*. 2015 and Po, 1966. The surface extent of mass (Figure 2) was divided into blocks of regular grids and then summing up the area of the entire blocks. The result of the mass of the gypsum deposit was obtained by multiplying the area of the suspected gypsum deposit (m^2) by the thickness of the gypsum layer obtained from the geophysical interpretation (m) and then by the density of the gypsum (kgm^{-3}).



1:7,500
Figure 2: The Gridded Area

Data Interpretation

The *Res IDversion 1.00.07 Beta* software for resistivity curve were used for the interpretation of the apparent resistivity data and the Surfer version 11 was used for contouring surface plots of various Wenner Array surfaces. Figure 3a, shows a typical resistivity curve and the model parameters after quantitative interpretation while Figure 3b shows the geoelectric/geologic section under the same VES point. All the interpreted resistivity curves are of the Q-Type.

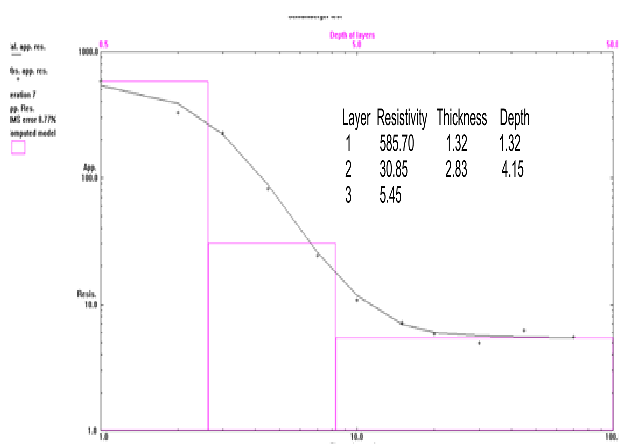


Fig. 3a: Typical Resistivity Curve for VES Station $F_{1,2}$

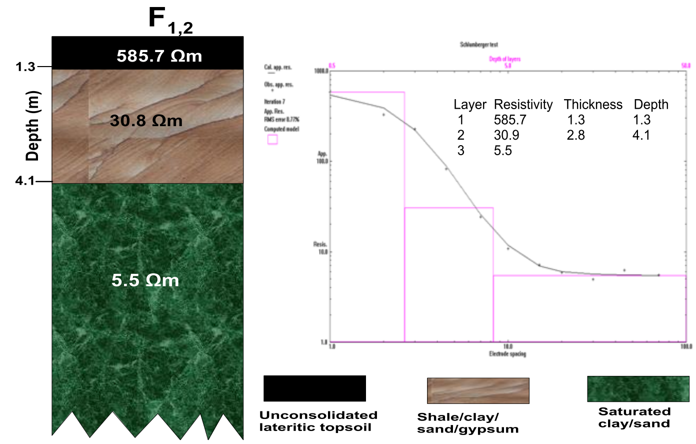


Fig. 3b: Geoelectric/geologic section of other VES $F_{1,2}$

RESULTS AND DISCUSSION

Two profiles were carefully chosen from which the geoelectrical parameters were used for the preparation of the geoelectric/geologic sections (Figs. 4 and 5). These figures, show the geoelectric/geologic sections of profiles from $F_{3,1}$ to $F_{3,5}$, and that of profile $F_{3,4}$ to $F_{6,2}$. The first layer of the profiles is indicative of the general surface resistivity along the profile which is considered to be a mixture of laterite, clay and sand and is termed in this work as the unconsolidated lateritic topsoil with a resistivity range of 288 ohm-m to 914 ohm-m.

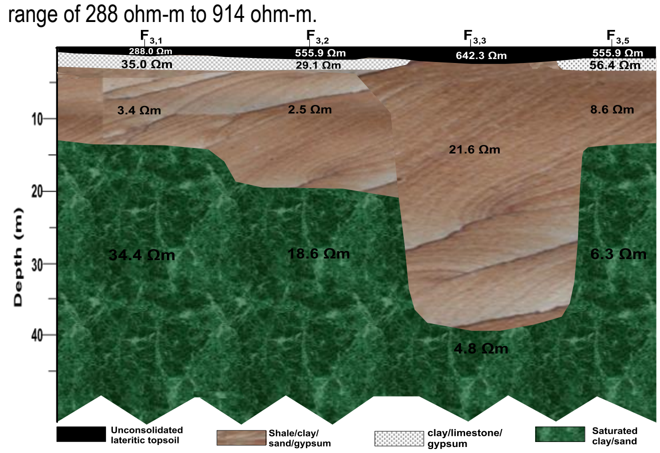


Fig. 4: Geoelectric/geologic Sections of Profile from $F_{3,1}$to $F_{3,5}$

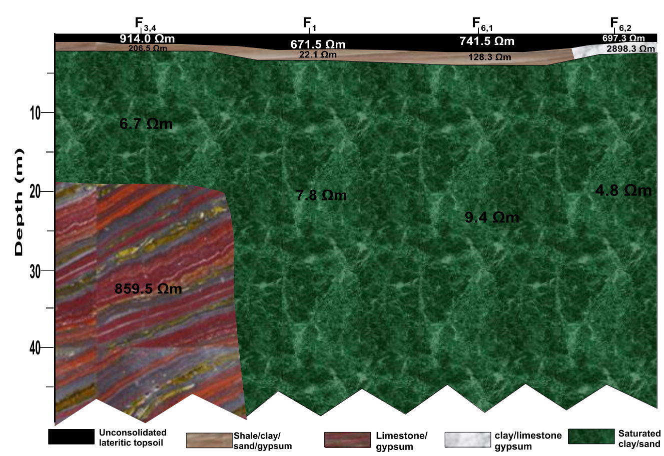


Fig. 5: Geoelectric/geologic Sections of Profile from $F_{3,4}$to $F_{6,2}$

The second layer has a resistivity range of 22.1 Ohm-m to 2898.3 Ohm-m which gypsum falls within the resistivity range. It is this layer that the mineral of interest is most likely suspected to be deposited. The third and fourth layer in some cases has the average lowest resistivity of 12.5 Ohm-m. This is suspected to be weathered clay with sand and possible crystals of gypsum scattered within the layers. It is very clear from the resistivity curves that we are not near the basement surface. In the search for gypsum,the topsoil thickness showing the extent of laterization of the layer being thickest at about 2.2m and shallowest at 0.4m is expected to be excavated entirely with rare possibility of gypsum.

The idea of using the Wenner Array that is CST is to profile the area of interest at a particular depth, hence, four different electrode spacings which are representative of approximately equivalent depths were chosen. The first is profiling at a=1m, followed by a=3m, then a=6m and finally a=9m. All maps (Figs. 6, 7, 8 and 9) exhibit a common trend having higher resistivitiestowards $F_{6,2}$ which is indicative of the possible existence of the mineral of interest, more so, that the electrical resistivity of the area falls within the electrical resistivity of gypsum and limestone ranging between 10 Ohm-m to 10^4 Ohm-m (Lowrie, 1997). Evidently, it could be seen that there exist a strong resistivity anomaly. However, in geophysics it could only be determined with a great level of confidence if other confirmatory geophysical techniques are employed and a similar.

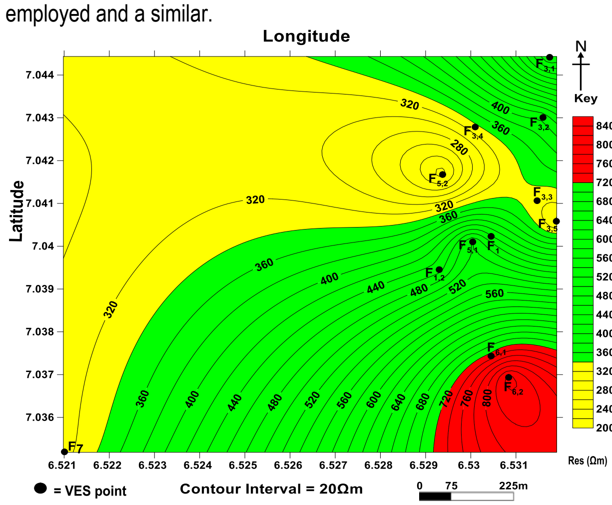


Fig. 6: Map of CST at a=1m

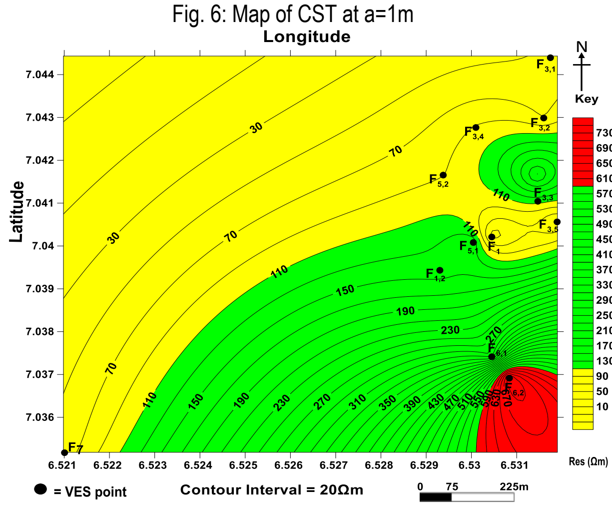


Fig. 7: Map of CST at a=3m

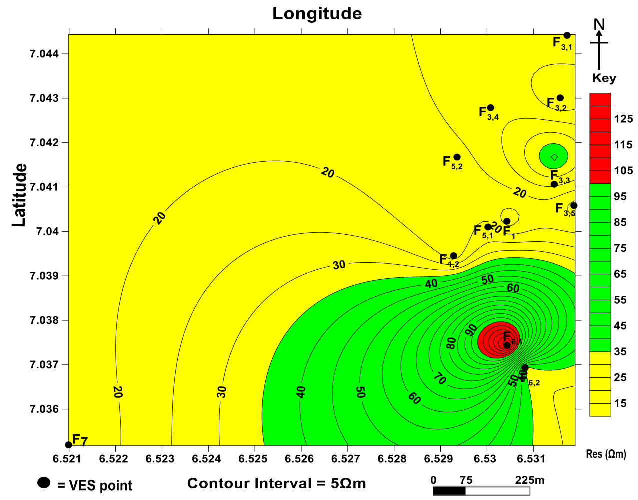


Fig. 8: Map of CST at a=6m

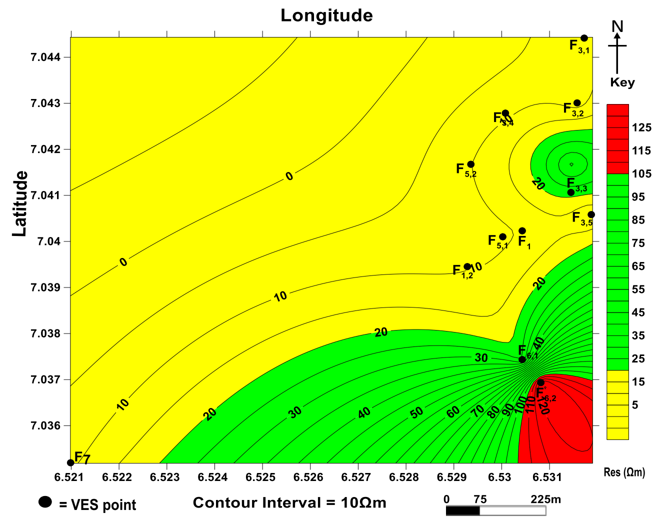


Fig. 9: Map of CST at a=9m

anomaly of the geophysical parameters of the method used are equally noticed. This is so because target detection is usually impossible using a single geophysical method, since identical geophysical anomalies may be related to an anomaly source with different physical properties, mode of occurrence pattern and nature (Boris, 2005; Olowofela, 2010). Also, the resistivity method suffers from a number of limitations. Interpretations are ambiguous, consequently, independent geophysical and geological controls are necessary. The depth of penetration of the method is limited by the maximum value of $\frac{AB}{2}$ used in Schlumberger Array and the value of 'a' used in the Wenner Array (Philip, etal. 2002). These, limitations, though obvious but there is inherent need for the computation of the reserved mass hence the consideration of the gridded area as shown in figure 2 which has led to viable information derived for the area covered by the gypsum shown in table 2 and table 3 shows the thickness of the gypsum reserve.From tables 2 and 3, the Total Volume of Gypsum Deposit = Area x Thickness= 282656.25 m^2 x 29.2 m= 8253562.5 $m^3$and the Total Reserve Mass of the suspected Gypsum Deposit = Volume x Density= 8253562.5 m^3 x 2060 kgm^{-3} = 17002338750 kg≈17 Million Tones..

Table 2: The Area Covered by Suspected Gypsum Deposit

	A	B	C	D	E	F	G	H	I	J	K	L	
Full	1	14	19	21	21	22	23	22	22	21	11	0	
Half	13	5	3	2	2	1	0	2	2	3	11	8	
Total	7.5	16.5	20.5	22	22	22.5	23	23	23	22.5	16.5	4	201
Area covered = $(1/2)^2 \times 201 \times (7500/100)^2$ = 282656.25 m^2													

Table 3: The Thickness of Gypsum Deposit

Digitised Stations	F1	F3,1	F3,2	F3,3	F3,4	F3,5	F5,1	F5,2	F6,1	F6,2	F1,2	Total
Thickness	2.2	4.1	2.6	3.5	1.8	1.9	2.2	1.8	3.8	1.2	4.1	29.2m

Conclusion

The Wenner and Schlumberger Array methods were employed in this work and have revealed the possible location of gypsum at Ikpeshi,Edo State, Nigeria. The investigation showed that crystals of gypsum could be found in association with the dominant limestone/clay/shale formation within the area. It was discovered that gypsum may be found within a depth range of 3m to 9m, and this falls largely in the second layer and possibly beyond and the estimated reserve deposit was calculated and found to be about 17 million tones within the studied area.

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