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Geophysical Determination of Sand Deposits Using 2-Dimensional Electrical Resistivity Imaging in Ologbo Area of Edo State, Nigeria.

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Abstract

Subsurface earth's imaging was carried out in Ologbo area of Edo State using Electrical Resistivity method in order to determine deposits of sand. The equipment employed for taking the Electrical resistivity imaging data was the PZ-02(D.C.) Earth Resistivity meter using the Wenner-Schlumberger array with maximum current electrode separation fixed at 100m in the sites investigated. The data obtained were interpreted using ZONDRES2D computer software. The results from the two profile lines investigated in the area, showed sand deposits with probable depth from top ranging between 0.6m – 5.5m and thickness between 2.3m - 4.5m with resistivity varying between 300Ωm -1000Ωm. The interpreted result correlated well with geologic and lithologic data/logs acquired from the survey area.

Keywords: Gamma radiation, absorbed dose, Geiger-Muller tube (GMT).

1.0 Introduction

The aim of this study is to obtain information about the spatial distribution of subsurface electrical properties of earth's materials that can be used to determine sand deposits in Ologbo Area of Edo state, using 2-dimensional electrical resistivity imaging.

Electrical Resistivity Imaging (ERI) is a rapidly developing geophysical imaging technique that is increasingly being used in site and environmental investigations, and routinely applied by the minerals industry to sand and gravel deposit assessment and quarry planning [1,2]. It is a cost-effective non-invasive method, which employs highly portable lightweight field equipment that can provide fully 2D spatial and 3D volumetric models of the subsurface throughout the full region of interest. The technique complements though it contrasts intrusive sampling methods, which typically provide information only at discrete locations. ERI is sensitive to compositional variations in the subsurface, and can therefore be used to distinguish between different lithologies.

The amount of data that will be required to obtain an adequate interpretation is determined to some extent by the economics of the situation. Satisfactory interpretation can only be achieved when the structures are relatively simple [3].

2.0 The Study Area

Ologbo is a border town located between Edo and Delta states of southern Nigeria, approximately 3km from Benin City, with geographical coordinates of about, 6° 3' North, 5° 40' East.The geology of the study area is characterized by deposits laid during the tertiary and cretaceous periods. The area is underlain by sedimentary rock constituting part of the Benin formation which is made up of over 90% massive, porous, coarse sand with clay/shale interbeds having high groundwater retention capacity. The topography of the area is generally flat [4].

3.0 Theory

Resistivity imaging technique depends on Ohm's law, which states that the electric current I in a material is proportional to the potential difference V across it.

Generally the four electrode configuration for resistivity survey is as shown below with P_1 and P_2,the potential electrodes while C_1 and C_2 the current electrodes.

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The fundamental equation governing direct-current electrical prospecting is

$$\rho = K \frac{\Delta V}{I} \qquad (1)$$

Where

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

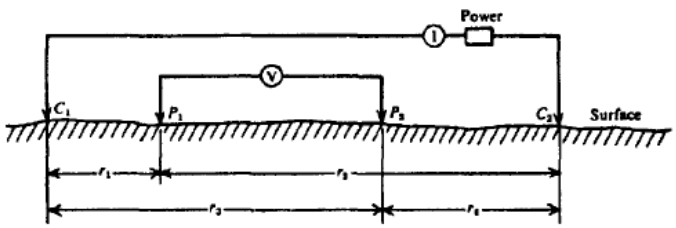


Figure 1: Four electrode spread consisting of two current electrodes and two potential electrodes.

K is the geometric factor that depends on the arrangement of electrodes and type of subsurface structure. Thus, by measuring Δ V and *I* (whose ratio gives resistance), and knowing the electrode configuration, we obtain resistivity, ρ_a known as the *apparent resistivity*, for an inhomogeneous earth. Comprehensive overview of resistivity methods exists in the literature [5-7].

Resistivity data are typically collected at earth's surface as a response of the earth to an active or passive electric signal. True resistivity can be calculated from apparent resistivity with the use of computer software that uses numerical methods (Inversion) to estimate true resistivity and plot a 2D image [8, 9].

The results obtained from the pseudo-section after inversion are further interpreted by describing the resistivity of each layer as compared with the standard resistivity of rock types, geological structures are then drawn out and described according to their measured thickness, length and width. This description provides the lead for a reconstruction of the geological and depositional history of the area. The field technique involved in 2D electrical imaging of three dimensional structures is extensively discussed by Aizebeokhai [10].

4.0 Methodology

The electrical resistivity survey was carried out along two profiles in Ologbo Area, Ikpoba Okha in Edo State. A total of six levels of data were acquired for each profile, using manually operated switching units. The PZ-02(DC) Earth Resistivity Meter was used to acquire accurate and reliable resistivity data using the Wenner-Schlumberger array in the survey area with the profile line being 100m. This array type was chosen because it provides greater depth of penetration and high image resolution as compared to other array types. The system injects current into the surface with the use of two electrodes that read the potential difference between two other electrodes. It is a digital and microprocessor-based resistivity meter that calculates the resistance by dividing the measured potential difference, ΔV by the observed current, I. The apparent resistivity was computed from resistance values using

$$K = \pi n\,(n+1)\,a, \qquad (3)$$

as the geometric factors and later imported onto the Zondres2d software designed by A.E. Kaminskly.

The depth of investigation for the study area was calculated as 14.105m (which is approximately 20% of the profile length).

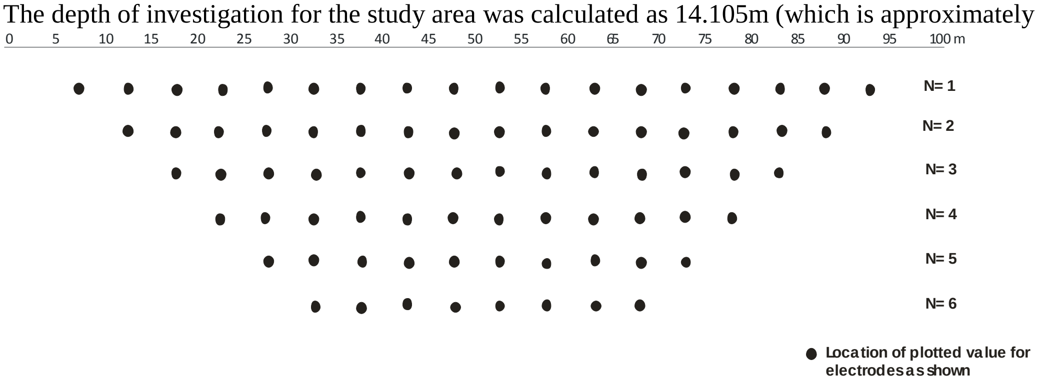


Figure 2: Pseudo-section for 6-data levels obtained for Wenner-Schlumberger surveys with 21 electrodes (0, 5, 10, ..., being electrode positions).

5.0 Results and Discussion

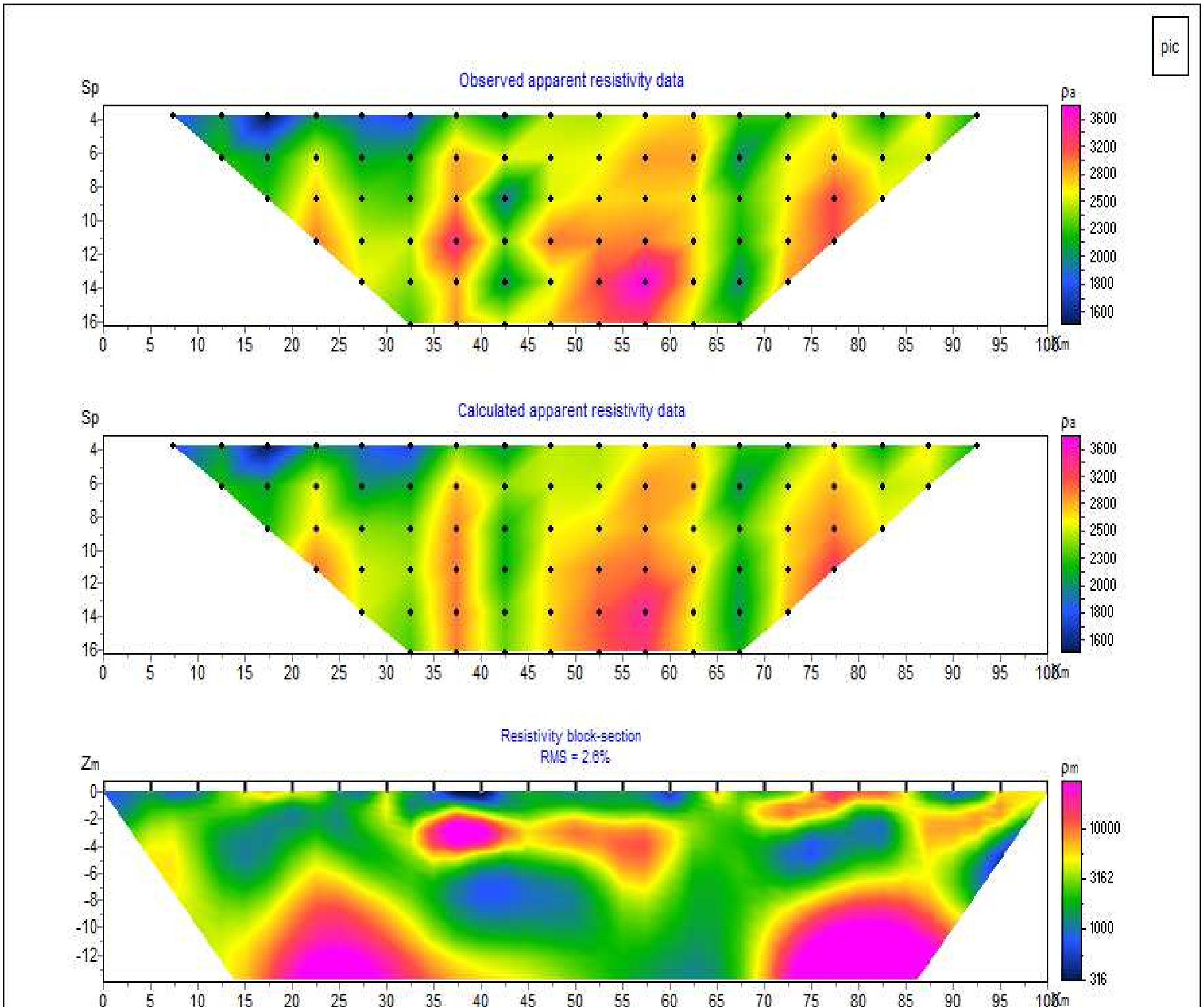
The field results of this study are used to create 2D images using ZONDRES2D software, (Figure 3 and 4). The field data were processed such that error tolerance within 0 - 10% are obtained after ten iterations were taken using focused inversion scheme.

The observed apparent resistivities (upper part), computer generated apparent resistivities (medium part)and interpreted electrical resistivity image (lower part) were displayed in the form of pseudo sections, which shows distorted pictures of the subsurface. The colour in the images indicates the resistivity values of the substructure of the study area, with the shapes of the contours depending on the type of array used as well as the true subsurface resistivity [8].

The 2D resistivity images were interpreted geologically using knowledge of local geology of the survey area, resistivity of sediments, rocks and minerals available in literatures [7], to identify deposits of sand, based on the resistivity values.

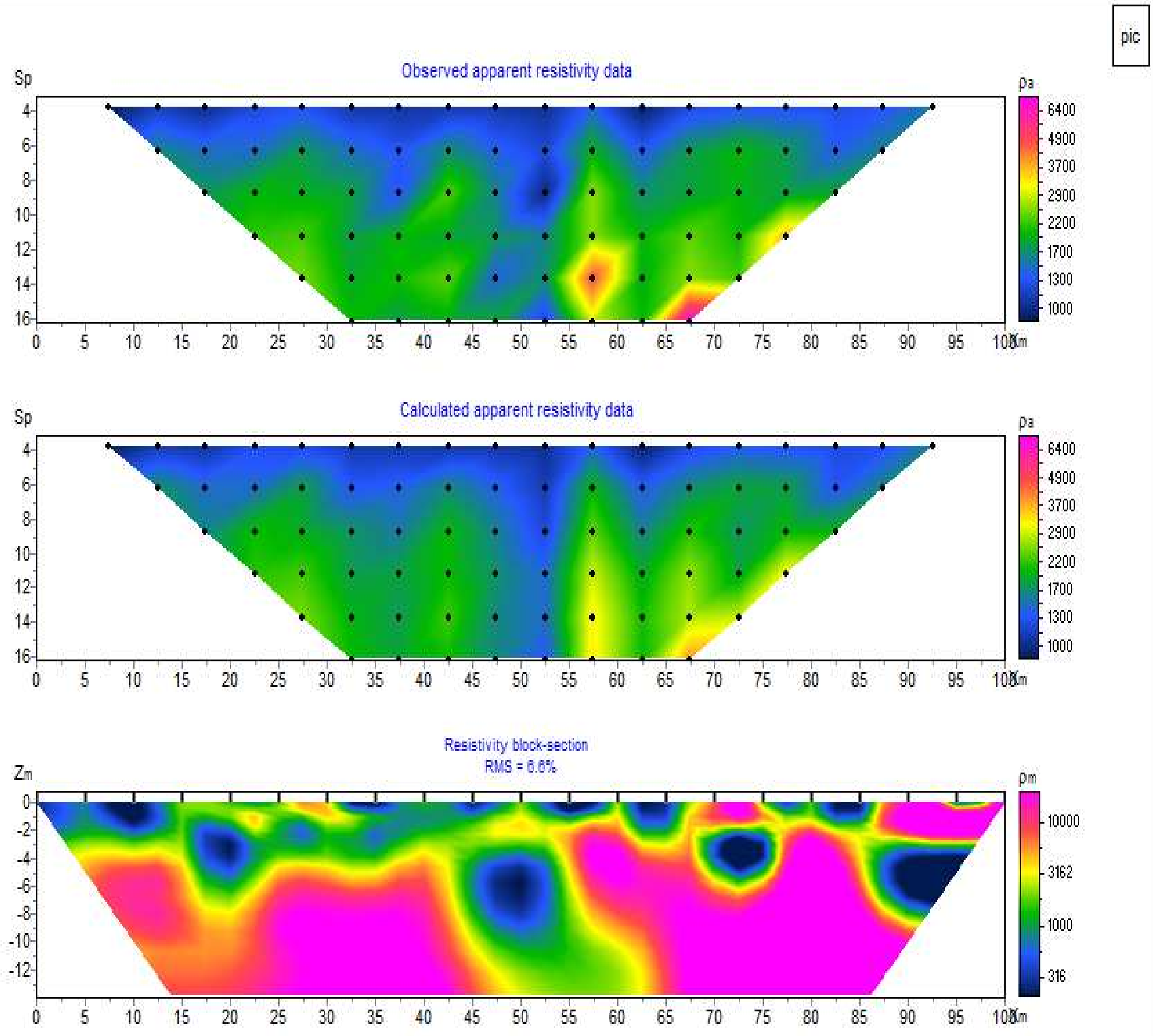
The result shows that profile1 which runs S-W has three isolated resistivity bodies 600-1000Ωm, which may be interpreted as sand bodies (fine). The first sand deposit depth from top of 1.5m with thickness 4.5m and lateral extent of 12.5m. The second sand deposit depth from top of 5.5m with thickness 4m and lateral extent of 15m. The third sand deposit depth from top of 1.8m with thickness 4.2m and lateral extent of 15m. The other earth's materials are laterite.

Also profile2 which runs N-E has well defined two isolated resistivity bodies 300-1000Ωm, which may be interpreted as clayey sand. This clayey sand is within the sand bodies. The first sand deposit depth from top of 0.6m with thickness 4.2m and lateral extent of 6.0m. The second sand deposit depth from top of 4.8m with thickness 4m and lateral extent of 8m. A third clayey sand deposit(resistivity less than 300Ωm) with depth from top of 2.0m with thickness 2.3m and lateral extent of 7.5m was also observed.



Survey Aim:	**Survey Date**: 1/04/2014
Survey Line No./ Length/Direction: L2/100m/S-W	**Equipment Used:** Petrozenith Earth Resistivity Meter
Site Description: Off Imasabor Primary School Road	**Array/Software Used:** Wenner-Schlumberger/Zondres2d
State/Town/LGA: Edo/Ologbo/Ikpoba Okha	**Begin/End Coordinates:** N6.056°,E5.657°/N6.088°,E5.658°

Figure 3: Resistivity Pseudosection for Profile1.



Survey Aim:	Survey Date: 2/04/2014
Survey Line No./ Length/Direction: L4/100m/N-E	**Equipment Used:** Petrozenith Earth Resistivity Meter
Site Description: Lower Oshiomo Road, Off NNPC Road	**Array/Software Used:** Wenner-Schlumberger/Zondres2d
State/Town/LGA: Edo/Ologbo/Ikpoba Okha	**Begin /End Coordinates:** N6.086°,E5.658°/N6.087°,E5.659°

Figure 4: Resistivity Pseudosection for Profile2.

6.0 Conclusion

The results of subsurface earth's imaging carried out in Ologbo area of Edo State, using electrical resistivity method shows sand deposits with depths from top ranging between 0.6m – 5.5m, thicknesses between 2.3m - 4.5m. These observed depth of sand deposits obtained from the two profiles correlates well with borehole logs, obtained from the area of between 1m-3m for silty clay (clayey sand), and between 3m-10m for sand from the earth's surface. Other subsurface lithology in the area includes laterite and gravel.

7.0 References

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