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INVESTIGATION OF LIMESTONE DEPOSIT AT OJIRAMI MIXED SECONDARY SCHOOL, OJIRAMI, AKOKO EDO LOCAL GOVERNMENT AREA, EDO STATE USING ELECTRICAL RESISTIVITY IMAGING METHOD

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Abstract

Geophysical investigation was carried out at Ojirami Mixed Secondary School, Ojirami, Edo State. This was done with a view to target an essential mineral like limestone. Electrical Resistivity Tomography (ERT) method was used for this survey.
Preliminary investigation was done in the location at Ojirami, Akoko Edo Local Government Area, Edo State by carrying out reconnaissance survey to ascertain the extent of outcrop of this very important mineral. A series of 2D apparent resistivity data were then acquired by using Wenner-Alpha electrode configuration. Electrode separation of (a) = 10m, 20m, 30m, 40m, 50m, 60m for each profile line was obtained. The total length of investigation was taken as 200m. The 2D data sets were inverted separately using RES2DINV software producing 2D model for each line. The total depth attained for the four profile lines was 39.6m.
The minerals that fall within the resistivity range 86.4-2609 Ωm observed from the models are, Clay, Clayey Sand, Limestone and Sandstone. The resistivity obtained for profile 1 was 113.7-372 Ωm at a depth of 18.85-30.9 m indicative of limestone. The resistivity obtained for profile 2 was 111-386 Ωm at a depth of 0-21.9 m indicative of limestone. The resistivity obtained for profile 3 was 118-393 Ωmat a depth of 0-24.9m indicative of limestone. The resistivity obtained for profile 4 was 118.9-429Ωm at a depth of 0-32 m indicative of limestone. It is observed that limestone is the predominant mineral in Ojirami and its environs from both its presence in substantial amount as outcrop and even deep to the earth subsurface.

Keywords: Tomography, limestone, resistivity, wenner configuration, outcrop.

1.0 INTRODUCTION

Geophysics as the name indicate, has to do with the physics of the earth and its surrounding atmosphere.The science of geophysics is an applied branch of physics which employs physical methods such as seismic, magnetic, gravitational, electrical and electromagnet at the surface of the earth to measure the physical properties of the earth's surface, along with anomalies in those properties. It is mostly used to detect the presence and position of useful geological deposits such as fossil fuels, ground water reservoirs and minerals like limestone [1].
Limestone is a sedimentary rock that has a large composition of calcium Carbonate (aragonite and calcite), dolomite and other minerals and impurities.
Limestone is considered to be one of Nigeria's strategic minerals. The biggest and purest limestone deposits can be found around middle and southwest belt region of Nigeria. There are 31 million metric tons of limestone and because of this, Nigeria is considered to have the richest limestone deposits in West Africa.
When organisms in water body die, their shells accumulate on the seafloor. The soft part decays leaving only the hard shells (exoskeletons or tests), which typically become broken down by current action and biological predators. Over long periods of time, the loose skeletal "sediments" are transformed into "bioclastic limestone" by the addition of chemically precipitated carbonite cement between the shell fragments [2]. In the warm low–latitude waters of the tropics, these are called tropical bioclastic limestone, while in the cooler waters, at mid to high latitudes, they are known as temperate

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bioclastic limestone. In the case of large congregations of tropical marine organisms, like reef building corals, the normally vary large structure remains intact as it is transformed into tropical limestone reef rock. The constituents of limestone are aragonite, calcite and dolomite

The economic importance of limestone includes;

1. Paint pigments and filler: Whiting is used as pigment and/or filler in paints.
2. Glass: Limestone or dolomite in the raw state, or burned to lime, is an important constituent of the “batch" from which glass is made.
3. Paper: In the manufacture of chemical wood pulp for making paper in the tower system of the sulfite process, limestone in concrete towers is reacted with sulfur dioxide gas in the presence of water to form calcium bisulfite, $Ca(HSO_3)_2$ [3].
4. Agricultural Limestone: Limestone and dolomite are applied to soil to correct soil acidity.
5. Limestone is often used as a building material. It is one of the main components of cements.
6. Crushed limestone provides a base for roads and asphalt concrete, as well as ballast for railroads.
7. Limestone creates geological formations that are perfect for storing petroleum.
8. Limestone is a reagent in desulphurization of flue gas. It reacts with limestone and controls air pollution.
9. It is a great source of calcium, which is why purified limestone is added to cereals and bread.
10. It is used to demineralized purified water which restores the nutrient levels and prevents pipe corrosion.

Electrical resistivity imaging (2-D) was used for mapping the subsurface layers at Ekiugbo (Uhunmwode Local Government Area) in Edo State, Nigeria [4]. The research gave resistivities of the various lithological profile ranges of 138 Ωm-54938 Ωm, lateral spread from 50 m- 180 m and thickness of 33.7 m with very high resistivity values of 23154 Ωm and 54938 Ωm respectively.

Electrical Resistivity Tomography (ERT) data were also acquired within Agbabu, Southwestern Nigeria using wenner-schlumberger configuration to search for bitumen [5]. The results obtained indicate that bitumen is characterized by good lateral continuity and is sufficiently thick for commercial exploitation.

2.0 LOCATION OF STUDY AREA

Ojirami mixed secondary school is located in Ojirami Town of Akoko Edo Local Government Area of Edo State.

The major economic activity in Akoko–Edo is Agriculture which provides employment for about 83.1% of the working population. About 8.8% are traders while 4.1% are educationist and the rest 4.0% are health care providers.They have a favourable climate, fertile soil and a high potential for Agricultural development. The major agricultural products are Yam, Cassava, Plantain, Maize, Cocoyam, Livestock and cash crops like Cocoa Kolanut, Oil palm and coffee.

3.0 GEOLOGY OF STUDY AREA

Akoko Edo is geologically characterized by deposits laid basically during tertiary and cretaceous periods [6].

The geology of the study area reveals that the entire community is underlain by sedimentary rocks. It consists of the crystalline basement rocks in the hilly and dissected zone in the north followed southwards by residual lateritic soils of the well-drained dry lands at Auchi, Agbede and Afuze [7].

The geographical coordinates of Ojirami are $7^o\,18'0''$North, $6^o11'0''$ East.

4.0 THEORY

For a single current electrode implanted at the surface of a homogeneous medium of resistivity *p*, current flows away radially (Fig 1).

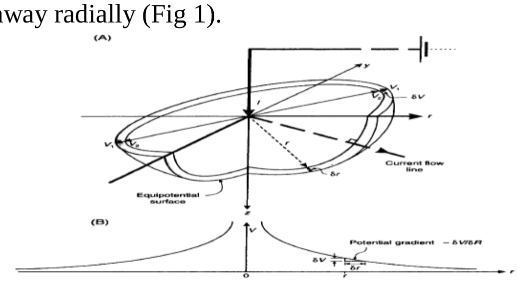


Fig 1 (A) Three-dimensional representation of a hemispherical equipotential shell around a point electrode on a semi-infinite, homogeneous medium. (B) Potential decay away from the point electrode

The voltage drop between any two points on the surface can be described by the potential gradient $(-\delta V/\delta x)$, which is negative because the potential decreases in the direction of current flow. Lines of equal voltage ('equipotentials') intersect the lines of equal current at right-angles. The current density *(J)* is the current (*I*) divided by the area over which the current

is distributed (a hemisphere; $2\pi r^2$), and so the current density decreases with increasing distance from the current source. It is possible to calculate the voltage at a distance *(r)* from a single current point source.
The potential difference (δV) across a hemispherical shell of incremental thickness δr is given by:

$$\frac{\delta V}{\delta r} = -\rho . J = -\rho \frac{I}{2\pi r^2} \qquad (1)$$

Thus the voltage V_r at a point r from the current point source is:

$$V_r = \int \delta V = -\int \rho \frac{I}{2\pi r^2}\, \delta r = \frac{\rho I}{2\pi} . \frac{1}{r} \qquad (2)$$

If, however, a current sink is added, a new potential distribution occurs (Fig 2)

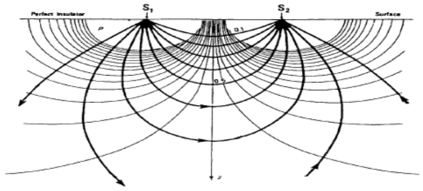


Fig 2 Current and equipotential lines produced by a current source and sink [8].

For a current source and sink (Fig 2), the potential V_P at any point P in the ground is equal to the sum of the voltages from the two electrodes, such that:

$$V_p = V_A + V_B \qquad (3)$$

Where V_A and V_B are the potential contributions from the two electrodes, $A(+1)$ and $B(-1)$.

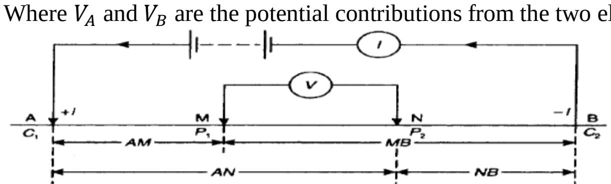


Fig 3 Generalized form of electrode configuration in resistivity surveys

The potentials at electrode M and N as shown in figure 3 are:

$$V_M = \frac{\rho I}{2\pi}\left[\frac{1}{AM} - \frac{1}{MB}\right], \quad V_N = \frac{\rho I}{2\pi}\left[\frac{1}{AN} - \frac{1}{NB}\right] \qquad (4)$$

However, it is far easier to measure the potential difference,

$$\delta V_{MN} = V_M - V_N = \frac{\rho I}{2\pi}\left\{\left[\frac{1}{AM} - \frac{1}{MB}\right] - \left[\frac{1}{AN} - \frac{1}{NB}\right]\right\} \qquad (5)$$

Rearranging this so that resistivity ρ is the subject:

$$\rho = \frac{2\pi \delta V_{MN}}{I}\left\{\left[\frac{1}{AM} - \frac{1}{MB}\right] - \left[\frac{1}{AN} - \frac{1}{NB}\right]\right\}^{-1} \qquad (6)$$

Electrode Configurations and Geometric Factors

Equation 6 has two parts, namely a resistance term *(R;* units Ω) and a term that describes the geometry of the electrode configuration being used and which is known as the geometric factor *(K;* units m).
The geometric factor (K) is defined by the expression:

$$K = 2\pi\left[\frac{1}{AM} - \frac{1}{MB} - \frac{1}{AN} + \frac{1}{NB}\right]^{-1} \qquad (7)$$

Where the ground is not uniform, the resistivity so calculated is called the apparent resistivity (ρ_a)

$$\rho_a = RK, \quad where\ R = \delta V/I$$

In reality, the sub-surface ground does not conform to a homogeneous medium and thus the resistivity obtained is no longer the 'true' resistivity but the apparent resistivity (ρ_a) which can even be negative. It is very important to remember that the apparent resistivity is not a physical property of the sub-surface media, unlike the true resistivity. Consequently, all field resistivity data are apparent resistivity while those obtained by interpretation techniques are 'true' resistivity.

5.0 METHODOLOGY

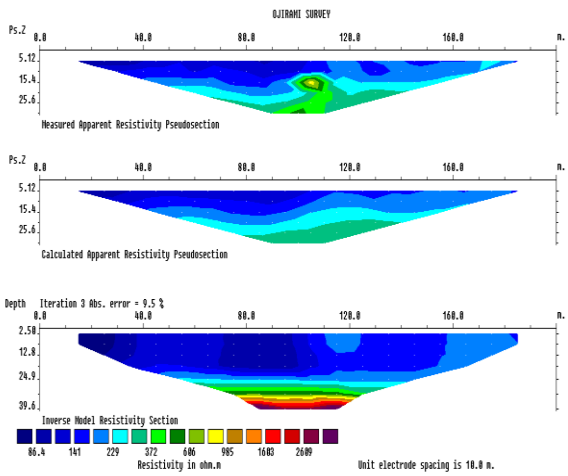
Fig. 4 Basic field equipment for this research, Pasi Terrameter, Metal Electrodes, Cables, Cutlass, Hammer, Compass and clips.

The greatest limitation of the resistivity sounding method is that it does not take into account horizontal changes in the subsurface resistivity. A more accurate model of the subsurface is a two-dimensional (2-D) model where the resistivity changes in the vertical direction, as well as in the horizontal direction along the survey line. In this case, it is assumed that resistivity does not change in the direction that is perpendicular to the survey line. In many situations, particularly for surveys over elongated geological bodies, this is a reasonable assumption [9].

Reconnaissance survey was carried out to ascertain the extent of outcrop of this very important mineral and also to familiarize with the local inhabitants. A series of 2D apparent resistivity data were then acquired by using Wenner-Alpha electrode configuration. Electrode separation that begins with 10 m and ends with 60 m were obtained. The total length of investigation was taken as 200m. With the terrameter and researchers in position, accurate readings were obtained by sending a current of 2A into the earth which is received on the instrument as resistance values. The 2D data sets were inverted separately using RES2DINV software producing 2D model for each line. The total depth attained for the four (4) profile lines was 39.6m.

4.0 DISCUSSION OF RESULTS

Results obtained in Line 1

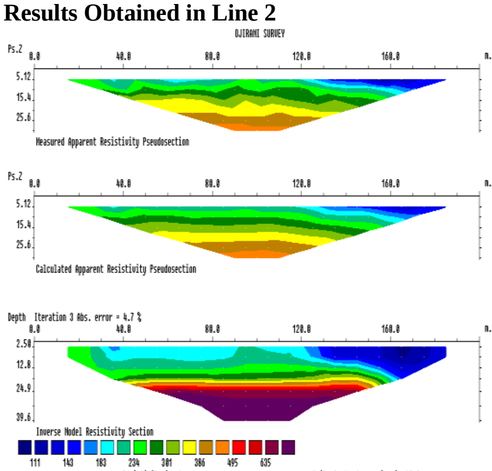


Survey line no./orientation: L1/200m/N-S	Equipment used: Pasi Terrameter
Site Description: Ojirami Mixed Secondary School	Begin/end coordinates: N06˚10'06.1"/E07˚18'25.8"/ N06˚10'10.5"/E07˚18'30.7"/
State/town/LGA :Edo/Ojirami/ Akoko Edo	Array/software used: Wenner-Alpha/RES2DINV

Fig. 5. Traverse for profile 1

From 0-18.85m down the earth, we have Clay with resistivity ranging from 86.4-113.7Ωm, and lateral spread from 15-118m. Clayey sand is present from 0-32m down the earth with resistivity ranging from 141-606Ωm and lateral spread from 53-185m. That of Limestone is down the earth and between 18.85-30.9m with resistivity of 113.7-372Ωmwith lateral spread from 32-185m. Sandstone has resistivity of 372-2609Ωm, depth of 24.9-39.6m and lateral spread of 65-125m.

Results Obtained in Line 2



Survey line no./orientation: L1/200m/N-S	Equipment used: Pasi Terrameter
Site Description: Ojirami Mixed Secondary School	Begin/end coordinates: N06˚10'04.8"/E07˚18'27.0"N06˚10'08.8"/E07˚18'32.2"
State/town/LGA :Edo/Ojirami/ Akoko Edo	Array/software used: Wenner-Alpha/Res2DIN

Fig. 6. Traverse for profile 2

Clayey sand is present from 21.5 m down the earth with resistivity ranging from 386-495Ωm and lateral spread from 40-155m while that of limestone is down the earth 0-21.9m with resistivity of 111-386Ωm with lateral spread from 52-185 m. There is the presence of sandstone with resistivity of 495-635 Ωm and depth 24-39.6m and lateral spread of 45-150m. No clay present.

Results Obtained in Line 3

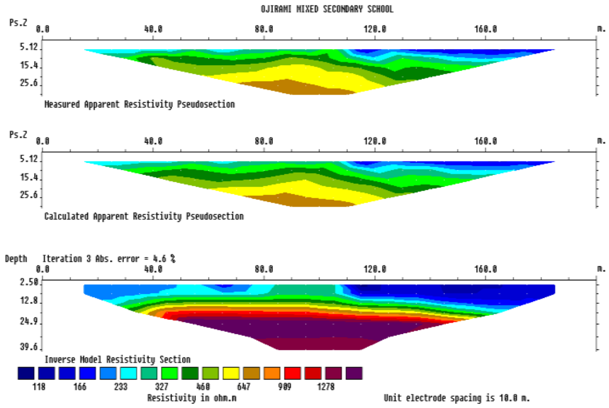
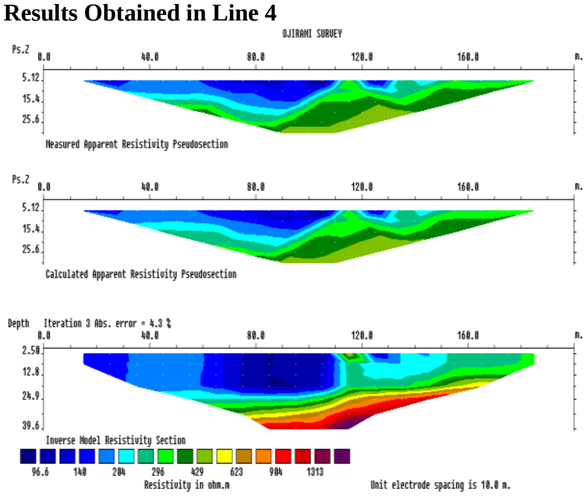


Fig. 7. Traverse for profile 3

Survey line no./orientation: L1/120m/N-S	Equipment used: Pasi Terrameter
Site Description: Ojirami Mixed Secondary School	Begin/end coordinates: N06˚10'06.1"/E07˚18'25.8"/ N06˚10'10.5"/E07˚18'30.7"/
State/town/LGA :Edo/Ojirami/ Akoko Edo	Array/software used: Wenner-Alpha/RES2DINV

Clayey sand is present from 12.8-18.8m down the earth with resistivity ranging from 393-550Ωm and lateral spread from 32-160m, while that of limestone is down the earth 0-24.9 m with resistivity of 118-393Ωm,with lateral spread from 15-185 m. There is Sandstone with resistivity of 550-1278 Ωm, lateral spread of 35-155m and depth of 13-39.6m. No clay present here.

Results Obtained in Line 4



Survey line no./orientation: L1/120m/N-S	Equipment used: Pasi Terrameter
Site Description: Ojirami Mixed Secondary School	Begin/end coordinates:N06˚10'10.8"/E07˚18'29.5" /N06˚10'04.2"/E07˚18'29.0"
State/town/LGA: Edo/Ojirami/Akoko Edo	Array/software used:Wenner Alpha/RES2DINV

Fig. 8. Traverse for profile 4

From 0-18.9m down the earth, we have clay with resistivity ranging from 96.6-118.3Ωm, and lateral spread from 74-102m, clayey sand is present from 12.8-34m down the earth with resistivity ranging from 429-526Ωm and lateral spread from 15-185m while that of limestone is down the earth 0-32m with resistivity of 118.9-429Ωm, with lateral spread from 15-185m. Sandstone is present with resistivity of 526-1313 Ωm, lateral spread of 77- 168m and depth of 18.8-39.6m down the earth.

5.0 CONCLUSION

The Wenner-Alpha Array methods were employed in this work and have revealed the possible location of limestone at Ojirami, Edo State, Nigeria. The investigation showed that crystals of limestone could be found in association with the dominant clay/clayey sand formation within the area. It was discovered that limestone may be found within a depth range of 18.85-30.9m, 0-21.9m, 0-24.9m, 0-32m for the first, second, third and fourth profile lines respectively.

From this research, we have been able to obtain the resistance and resistivity values of sub-surface minerals from the area. Limestone deposits were determined based on its standard resistivity value. The major suspected minerals deposits in the study location are clay, clayey sand and limestone. Purer forms of limestone are formed as we go deeper down the earth.

This research has acknowledged the fact that limestone can be found in large quantity in Ojirami community along with other materials like clay and clayey sand. This research has also provided reliable procedures (2-Dimensional electrical resistivity tomography) to locate mineral deposits in Akoko-Edo, Edo State, Nigeria.

Longer spread should be used and shorter electrode spacing like 5m to get a better picture of the earth sub-surface.

As an extension to this study, 3-D electrical resistivity tomography survey need to be carried out on those resistivity anomalies interpreted as limestone.

Further research on 2D-electrical resistivity imaging should be carried out in other locations within the local government area to ascertain other types of minerals and aggregates that can be found in the environment and also to compare with limestone that has already been determined.

REFERENCES

[1] Telford, M.W., Geldert, L.P. and Sheriff, R.E. (2001). Applied Geophysics Second Edition, Cambridge University Press, 343.

[2] Linsley C. M. (1954). "Limestone, how to use it, when to use it, where to use it" University of Illinois, Agriculture Extension Circular, 721. pp 6.

[3] Cadigan, A. M. (1942). "Limestone and lime in the chemical pulp industry" Pit and Quarry, v. 35, no. 5, pp 74-78.

[4] Aigbogun, C. O., Alile, O. M. and Egbai, J. C. (2017). Geoelectrical imaging for shallow site investigation at Ekiugbo in Uhunmwode Local Government Area of Edo State, Nigeria. Journal of Applied Science and Management. Vol 21 (5) 873-876.

[5] Ogunlana, O. F., Alile, O. M. and Airen, O. J. (2019). Two-dimensional Electrical Resistivity Tomography of Bitumen Occurrence in Agbabu, Southwest Nigeria. Current Journal of Applied Science and Technology. 36(1). 1-9.

[6] Reyment, R.A (1965). Aspects of Geology of Nigeria. Ibadan University press Ibadan Nigeria.

[7] Shettima, B., Abubakar, M., Kuku, A. and Haruna, A. (2018). "Facies analysis, depositional environments and paleoclimate of the Cretaceous Bima Formation in the Gongola Sub Basin, Northern Benue Trough, NE Nigeria", Journal of African Earth Sciences, 137, pp193-207.

[8] Reynolds, J.M., (1998). An Introduction to Applied and Environmental Geophysics 36, 943-959.

[9] Loke, M. H (2014). 2-D and 3-D electrical imaging surveys pg 1-2.