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2D ELECTRICAL RESISTIVITY TOMOGRAPHY FOR THE ASSESSMENT OF MINERALS' OCCURRENCES IN UGONEKI, EDO STATE, SOUTH-SOUTH, NIGERIA

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ABSTRACT

Geophysical investigation using the 2D Electrical Resistivity Tomography (ERT) was carried out to assess the subsurface of Ugoneki and its environs in order to investigate for minerals. A total of six (6) traverses, 200 m long each, three (3) transverse lines were in the North-South direction and the other three (3) traverses in the West-East direction using the Wenner electrode configuration. 2D Wenner resistivity data were acquired along each traverse. The data were inverted to reveal a spatially continuous resistivity distribution in 2D within the study area. The 2D results reveal a depth of 39.6 m across each traverse. Resistivity values vary from 87.1 – 3423 Ωm in the entire study area. From the standard resistivity table, the following solid and non-metallic type of minerals can be delineated in the study area which is representative of sandy clay, lateritic clay sand, sandstone and limestone with resistivity values that range from 87.1 – 89.9 Ωm, 1201 – 1462 Ωm, 2069 – 3423 Ωm, and 2069 – 3423 Ωm respectively. The implication of this research is to know the type and the particular location where these non-metallic solid minerals are located in the subsurface for future exploration. The results of resistivity values are compared with those in the literature and are found to be in good agreement. In order to quantify these minerals, it is also recommended to use higher dimension (3D) of resistivity method (ERT) in the study area.

Keywords: Mineral exploration, Resistivity, RES2DINV, Wenner array

INTRODUCTION

Mineral exploration in Nigeria dates back to the geological expeditions by the colonial masters in the early part of the 19th century and this has resulted in economic development and has generated revenue. Also, in the early years of twentieth century, the continued efforts by explorers to look for more effective, less risky and more economical technique of sub-surface exploration led to the advent of geophysical exploration (Idowu, 2006). The commercial value of Nigeria's solid minerals has been estimated to run into hundreds of trillions of dollar (Ajakaiye, 1985). With the dwindling of the price of petroleum products in recent times, and the abundance of economic solid minerals in Northern Nigeria, the search for mineral deposits, its exploitation, and processing as well as marketing to generate income by small scale miners is wide spread in Nigeria. Solid mineral exploitation is an everyday activity in the southern part of Nigeria, most especially in the northern part of Edo State. However, Nigeria is endowed with abundant mineral resources, which have contributed immensely to the nation's wealth with associated socio-economic benefits (Orazulike (2002)).

Alisa (1990) grouped minerals into four categories which include: metallic minerals (Iron, zinc, aluminum, gold etc); non-metallic minerals (sandstone, limestone, gypsum, gravel etc,); liquid minerals (oil, water etc); and gaseous minerals (gasses in buried cavity). To improve minerals' exploration and quarry design, a number of novel approaches are beginning to be considered (Telford *et al.* 1990). This includes the use of non-invasive geophysical imaging techniques, which have the potential to map subsurface property distributions that are linked to variations in density, porosity, moisture or mineralogy (Luodes, 2008). To-date, the most commonly applied geophysical approach in hard rock exploration is ground penetrating radar (GPR), which employs electromagnetic waves propagating through the rock that are reflected at discontinuities in the electromagnetic properties of the rock, e.g., at fractures or joints (Luodes *et al.*, 2015, Rey *et al.*, 2015).

Alile *et al*. (2016) carried out experimental approach of two-dimensional (2D) geoelectrical resistivity imaging in which the resistivity is allowed to vary both laterally along and vertically beneath the survey line, series of 2D apparent resistivity data were generated and the survey revealed lateritic soil, sand, sandstone, shale, limestone, clay, dolomite with resistivity values ranging between 259 W*m* to 2159 Wm. Olaseni and Airen (2021) also did research using 3-D ERT to investigate the type of minerals' deposit that can be found in Ugonoba village and the research revealed that at the depth range between 25 m and 33.7 m, the following were found: sand-clay, lateritic sand, sandstone and limestone with high resistivity values ranging from 6001 Ωm to 14376 Ω m. Depending on the chosen geophysical method, operating any method with GPR can achieve high resolution (a few cm) to a depth of a few metres, as attenuation of the electromagnetic waves is comparably small in highly resistive hard rock environments as claimed by Rey *et al.* (2017) and Elkarmoty *et al.* (2017).

Here, we consider another potentially useful geophysical exploration technique, electrical resistivity tomography (ERT). The study area of Ugoneki community, Uhunmwonde Local Government area of Edo State has been seen with presence of outcrops over years. Identifying potential minerals' deposits that are essential for industry and economic growth of the nation, the study area (virgin area) was selected for geophysical investigation. Also, the presence of some minerals in form of outcrops that are sparsely distributed in the study area during reconnaissance survey, (Olaseni and Airen, 2021) formed part of the motivation for this research. Hence, this informs the application of 2-D ERT to assess the subsurface information in the study area with view to exploration for mineral.

Location and Geology of Study Area

The study area, Edo State, south-south Nigeria falls within the Niger Delta Basin. The basin is an extensive continental margin basin situated in the Gulf of Guinea built out into the Central South Atlantic Ocean at the mouths of the Niger-Benue and Cross River systems during the Eocene [Fig.1(a)]. Edo State is situated in Southern part of Nigeria. It is an important sedimentary basin in Nigeria due to the closeness to the oil fields within the Niger-Delta region.

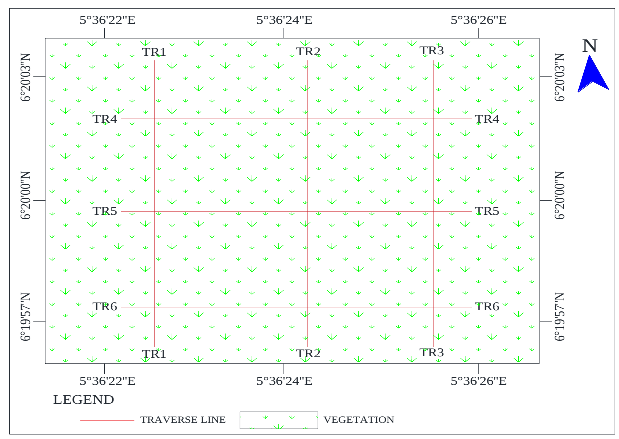
Ugoneki community (red point in fig 1(a)) is located at Uhunmwonde Local Government Area of Edo State, South-South Nigeria and is defined by sedimentary formations comprising of top reddish clayey sand bearing loose pebble sandstones with clay overlaying a thick lateritic hard pan. It lies between latitudes $6^0 19'57''$ N to $6^0 20'03''$ N and longitudes $5^0 36'22''$ E to $5^{0}{}'36'26''$ E (Fig. 1(a))

METHODOLOGY

Data Acquisition

Six (6) traverses were acquired using Abem resistivity meter and Wenner electrode array configuration was applied in the study area and the base map shown in fig 1b displayed how sets of data were acquired in grid formats. This electrode configuration was suited for constant separation data acquisition so that many data-points can be recorded simultaneously for each current injection. On each traverse, measurements were made at sequences of electrodes at 10, 20, 30, 40, 50 and 60 m interval using four (4) electrodes spaced at 10 m with a maximum length of 200 m each.

Fig. 1(a): Location map the study area
(Source: Ministry of Lands and Survey, Benin City 2009).



(b) Base map of the study area

Data Processing and Interpretation

RES2DINVERSION geophysical software was used for the inversion of the 2D apparent resistivity data. The measured and calculated resistivities were processed and inverted to obtain the 2-D Inverse Resistivity structure or model. Varying anomalous features along each profile were delineated from the distribution of areas of low, moderate and high resistivities. The model also exhibits gradational change in resistivity with depth, and with varying subsurface topographies.

The geophysical software used generated six (6) images/models (see figures 2 and 3) from the six traverses acquired from field and these models were interpreted and used to ascertain and identify the true resistivity, lithologic formation and depth extent to any buried mineral deposited in the study area.

PRESENTATION AND DISCUSSION OF RESULTS

The images display below are the 2D models generated from the geophysical software

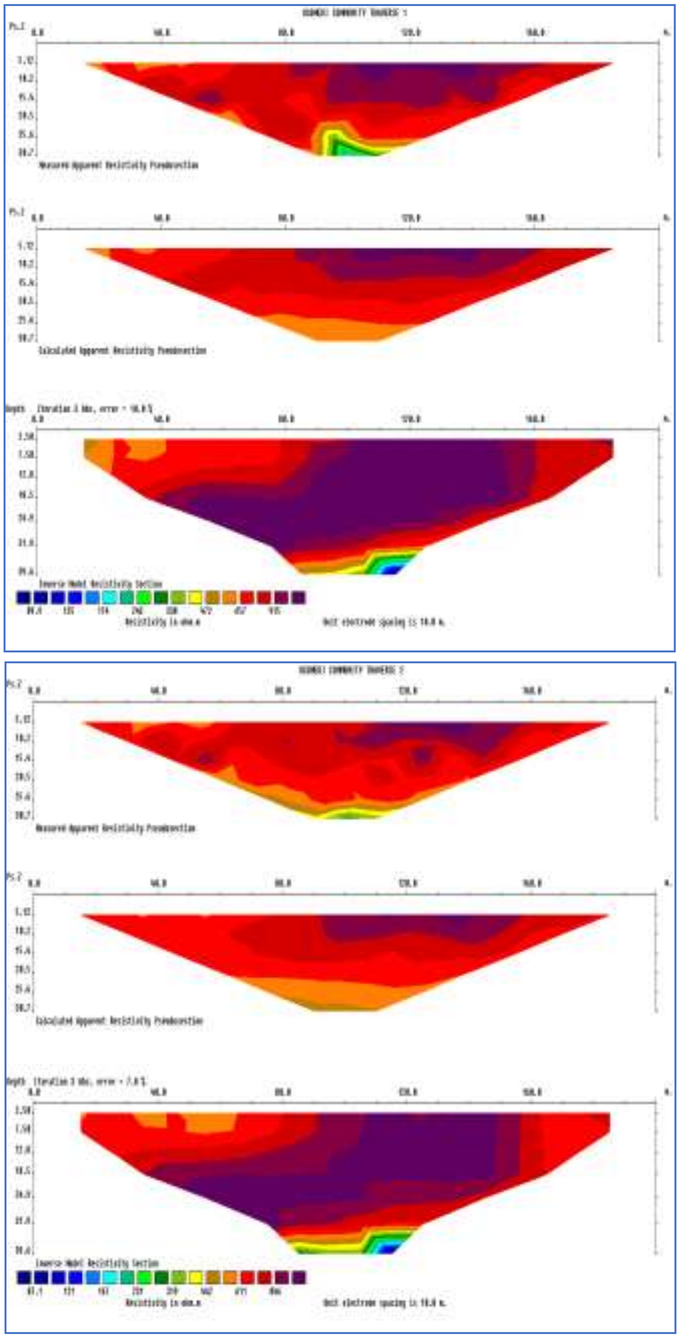


Fig. 2(a): 2D ERI sections along traverse 1 - 2

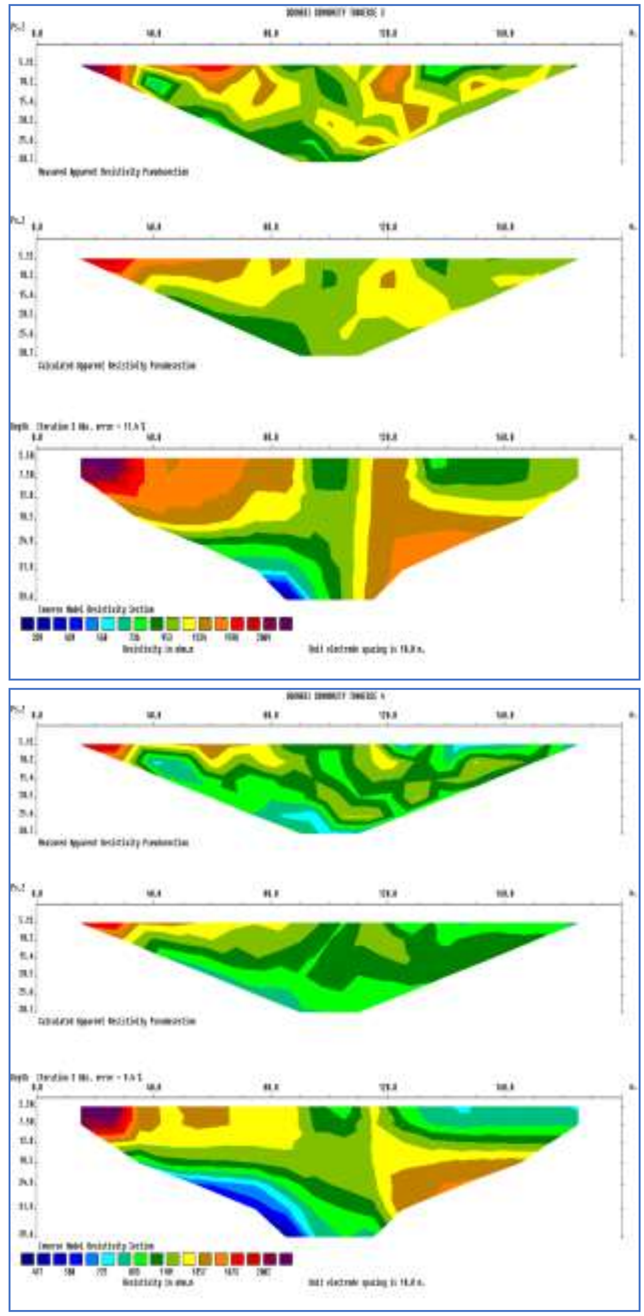


Fig. 2(b): 2D ERI sections along traverse 3 - 4

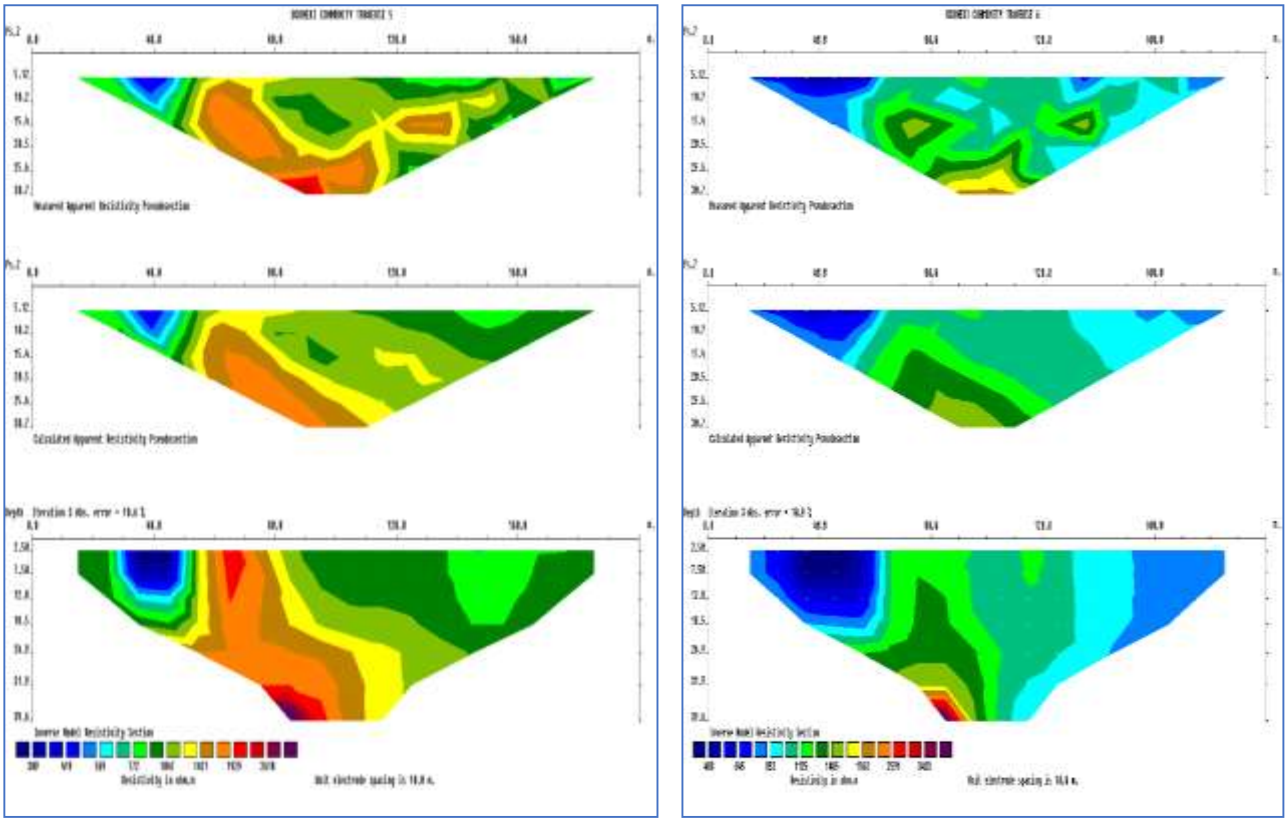


Fig. 3: 2D ERI sections along traverse 5 - 6

Table 1: Resistivities of some common solid minerals and rocks Reference: (Telford *et al.*, 1990)

	Typical Ranges of Resistivities for Common Materials/Minerals/Rocks	
	Rock/Minerals Type	Resistivity Range (Ωm)
	Rock/Minerals Type	**Resistivity Range (Ωm)**
1	**Alluvium**	1 - 1,000
2	**Basalt**	10 - 1.3x10^{7} (dry)
3	**Lateritic Clay**	120 -1500
4	**Cobalt**	5.6x10^{-8}
5	**Copper**	0.0000002 (native) - 1.7x10^{-8}
6	**Drill Mud or Hydraul-EZ**	4.5
7	**Fresh Water**	10 – 100
8	**Gabbro**	10^{3} - 10^{6}
9	**Gold**	2.4x10^{-8}
10	**Gravel**	100 - 10,000
11	**Igneous**	10000 - 1,000,000
12	**Limestone**	100 - 10,000
13	**Marble**	10^{2} - 2.5x10^{8} (dry)
14	**Mica**	9x10^{2} - 10^{14}
15	**Nickel**	7x10^{-8}
16	**Salt Water**	0.1 – 1
17	**Sand (Both dry and wet)**	1 - 10,000
18	**Sandstone**	100 - 10,000
19	**Schist (Calcareous and Mica)**	20 – 104
20	**Graphite (Schist)**	10 -102
21	**Silver**	1.6x10^{-8}
22	**Soil**	1 – 10
23	**Shale**	2x10^{2} –2x10^{3}

The table 1 above shows the standard resistivity values which were used as a reference to infer the type of minerals or rocks in the study area.

DISCUSSION

Figs.2 (a), 2(b) and 3 represent the 2D resistivity structures along traverse 1 – 2, 3 – 4 and traverse 5 – 6 respectively. The horizontal distance of 200 m was covered and a depth of 39.6 m was imaged across each of the six traverses. Resistivity values vary from 87.1 – 3423 Ωm in the entire study area. All these images are displayed as cross sections of the true resistivity distribution of the subsurface with depth along each of the profiles and are validated based on the standard resistivities of some common solid minerals and rocks as referenced by Telford *et al.* (1990).

Five resistivity structures, [Figs 2(a), (b) and 3] are delineated from the images and from the Table 1, it can be inferred that these regions are representative of sandy clay, lateritic clay sand, sandstone and limestone with resistivity values that range from 87.1 – 89.9 Ωm, 1201 – 1462 Ωm, 2069 – 3423 Ωm, and 2069 – 3423 Ωm respectively. Based on the standard resistivity values in Table 1, serial numbers 3, 12, 17 and 18 are in conformity with the ranges of resistivity values for lateritic clay sand, limestone, sandy clay and sandstone respectively.

Similarly, the suspected mineral deposits that lie within the resistivity range (2069 Ωm to 3423 Ωm) observed on traverse 1, 2, 3 and 6 in the study location are sandstone, gravel, consolidated-shale, alluvium, gabbro, basalt, marble and dolomite. Also, from the standard resistivity table, the resistivities values for serial numbers 1, 2, 8, 10, 12, 13, 18 and 23 for respective alluvium, basalt, gabbro, gravel, dolomite (limestone), marble, sandstone and consolidated-shale were in very good agreement with those in literature. The geophysical signature of high resistivity of this type of mineralization is attested to in several studies on mineral exploration apart from Tetfold *et al.* (1990).

CONCLUSION AND RECOMMENDATION

A geophysical investigation was conducted at Ugoneki, Edo State, South-South, Nigeria, to delineate and assess the type of minerals occurrences within the study area. The application of 2D Electrical Resistivity Tomography (ERT) survey was deployed to achieve these objectives and the 2D results show significant areas of minerals' occurrences in the area of study.

It can be seen that from all the 2D images generated, the study has identified the fact that the investigated area is composed of the non-metallic and solid type of minerals resources and these minerals zone occur at lateral distance of 55 to 120 m at depth ranging from 2.5 to 39.6 m across the area of investigation. However, it is recommended that higher dimension of electrical resistivity methods such as 3-Dimensional (3D) Electrical Resistivity Tomography should be carried out in a grid form in order to determine the volume and extent of mineralization.

REFERENCES

Ajakaiye, D.E. (1985). Environmental Problems associated with Mineral Exploration in Nigeria. A Paper Presented at the 21st Annual Conference of the Nigeria Mining and Geosciences Society held at Jos, Nigeria.

Alile, O.M., Ujuanbi, O. and Evbuomwan, I.A. (2011). Geoelectric Investigation of Groundwater in Obaretin-Iyanomon Locality, Edo state, Nigeria. J of Geol Min Res.; 3(1): 13-20.

Alile, O.M., Enoma, N., Ojo, K.O. and Osuoji, O.U. (2016). 2-Dimensional Electrical Resistivity surveying for mineral deposits in Eguare, Igueben L.G.A South-South, Nigeria. *Journal of Scientific Research in Allied Sciences,* 68, pp. 67-81.

Alisa Allaby, M. A. (1990). "Telluric Current" A dictionary of Earth Sciences Ed. Oxford

Elkarmoty, M., Colla, C., Gabrielli, E., Bonduà, S. and Bruno, R. (2017). A Combination of GPR Survey and Laboratory Rock Tests for Evaluating an Ornamental Stone Deposit in a Quarry Bench. *Procedia Eng.*, 191, 999–1007.

Idowu, T.O. (2006). Prediction of gravity anomalies for geophysical Exploration *FUTY Journal of the Environment,* Volume 1, Issue1.

Luodes, H. (2008). Natural stone assessment with ground penetrating radar. Est. J. Earth Sci. 2008, 57, 149–155.

Luodes, H.; Sutinen, H.; Härmä, P.; Pirinen, H. and Selonen, O. (2015). Engineering Geology for Society and Territory — Volume 5: Urban Geology, Sustainable Planning and Landscape Exploitation; Springer International Publishing: Cham, Switzerland; Volume 5, pp. 243–246.

Ministry of Lands and Survey, Benin City 2009

Olaseni V.B and Airen J.O. (2021). A 3-D Geoelectric model over mineralized zone of Ugonoba, Edo State, Nigeria. *Scientia Africana* Vol 20 (1): 141-151.

Orazulike, D.M. (2002). The solid mineral resources of Nigeria: maximizing utilization for industrial and technological Growth. A lecture delivered at Abubakar Tafawa Balewa University, Bauchi, Nigeria on 11th September, 2002.

Rey, J., Martinez, J., Montiel, V., Canadas, F. and Ruiz, N. (2017). Characterization of the sedimentary fabrics in ornamental rocks by using GPR. Near Surf. Geophys., 15, 457–465.

Rey, J., Martínez, J., Vera, P., Ruiz, N., Cañadas, F. and Montiel, V. (2015). Ground-penetrating radar method used for the characterization of ornamental stone quarries. *Constr. Build. Mater*, 77, 439–447.

Telford, W.M., Geldart, L.P. and Sheriff, R.E. (1990). *Applied Geophysicis*. 2nd Edition, Cambridge University Press, Cambridge, 770.