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Tomographical Evaluation of Subsurface Mineral Composition in Ozalla, Edo State Nigeria

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ABSTRACT: The subsurface is made up of distinct geologic materials existing at various depths. In a basement complex terrain, the lithologic unit that can be noticed is made up of the weathered layer, weathered/fracture basement and fresh basement. This research work was carried out at Ozalla community in Owan West Local Government Area of Edo State Nigeria, The study area is a basement complex area with some parts as transition zone, two dimensional geoelectrical resistivity survey was use to determine the subsurface resistivity distribution of the subsurface and interpreted with Res2Divn software to determine the subsurface Lithology and the mineral composition of the study area. The result from the study shows some buried subsurface minerals from the tomography images of the subsurface shows that at a depth between 10 m to 12 m reveals the composition of Alluvium soil, Shale, Slate, Sandstone, while at a depth between 13 m to the last depth of investigation reveals Quartz, Marble, Basalt, and Granite with apparent resistivity values ranging from 50 Ωm to 1500 Ωm. From the obtained results, slightly weathered/schist formation are the aquifer zone which shows that borehole drilling in this area is achievable at the depth of 40m, which allow big reservoir within the aquifer unit and overburden is thick enough for aquifer to accommodate high ground water potential due to presences of permeable rock.

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Nigeria consists of two broad geological terrains, namely: the basement complex and sedimentary terrain. The basement complex regions of Nigeria are made up of crystalline igneous and metamorphic rocks. These rocks exist either directly exposed or covered by shallow mantle of superficial deposit (Rahaman, 1988). The basement lies between the West Africa and Congo cartons. According to (Rahaman, 1976), the crystalline basement rocks were broadly classified into five major lithological groups, which are: Magmatic-gneiss complex, Meta sedimentary and metavolcanic rocks, Charkonite rocks, older granite, and Unmetamorphosed dolerite dykes. The subsurface is made up of different geologic materials occurring at varying depths. In a basement complex terrain, the lithologic unit that can be observed comprises of the weathered layer, weathered/fracture basement and fresh basement (Odusanya et al., 1999). The porosity and permeability capacity of these subsurface lithologies depends on the type of geologic material occupying them (Olorunfemi et al., 1999). Weathered layer with clay would have less porosity while a highly weathered/fracture basement is highly porous and permeable (Omeje et al., 2014). Sub geophysical surface geologic sequence and concealed geological structures can be mapped by geophysical methods (Orellana et al., 1996, and Omosuyi et al., 2007) hence; geophysics is quite relevant in map subsurface lithologic units. This geophysical survey of the subsurface involves the measurement/establishment of geoelectric parameters such as layer resistivity (pa), thickness and depth for each lithologic unit, geoelectric parameters can be used to describe the hydrological condition of the subsurface. In order to effectively map and characterize lithologic units within the subsurface, the knowledge of the various lithological units, their distribution and characteristics must be put into consideration (Zohdy, 1965) The degree of saturation (for weathered layer) and fracturing (for fresh basement) is relative to porosity and permeability. In the basement complex, the relative depth and degree of weathering depends on the mineral grain, size of the crystalline rocks, their intensity of fracturing (Ringstad et al., 2000, and Oladapo et al., 2008). This research applied geophysical method by using two dimensional geoelectrical resistivity surveys to determine the subsurface resistivities distribution of the subsurface,

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from the resistivity of the study area, the mineral composition can be inferred by comparing the subsurface resistivity to standard resistivity for different mineral composition. It is also possible to deduce the subsurface conduction, deducing information such as overburden thickness, fractured zones, lithologic distribution, aquifer characteristics which are relevant in evaluating the groundwater potential of the area. The objective of this paper is to evaluate the mineral composition to establish the reliability of using geophysical geoelectrical method in investigating subsurface minerals in Ozalla, Edo State, Nigeria.

MATERIALS AND METHODS

Location And Geological Setting Of The Study Area: The study was carried out in Ozalla community Owan West local government Area of Edo State, Nigeria.

Fig 1: Aerial View of Ozalla Town (Source Google Earth)

Edo State is an inland State in central southern Nigeria. Its capital is Benin City. It was created from the defunct Bendel State on the 27th of August 1991 and is located in the rain forest belt of Nigeria between Longitude 5” 42’ and 6o 45’E and Latitude 5” 45’N and 7” 35’N. It is bounded by Kogi State to north; to the east by both Kogi and Anambra States; to the South by Delta State and by Ondo State to the west. It has a total land mass/area of 19,281.93 square kilometers ad eighteen (18) Local Government Areas that make up the three (3) Senatorial Districts, namely Edo South, Edo Central and Edo North. Natural resources abound in the state and these include: hardwood and timber, limestone, marbles lignite crude oil, gold, clay, Kaolin, granite, amongst others. The State is generally low-lying except in the northern part that is characterized by undulating hills. The geology of the study area is described in the geology of Niger delta. Niger delta is one of the ten major sedimentary basins of Nigeria. The others are Abakaliki basin, Anambra Basin, Benue trough, Bida basin, Bornu-Chad basin, Dahomey basin, Gongola basin, Sokoto basin and Yola trough. These onshore basins occupy about half the total area of Nigeria (Whiteman, 1982). The basins are delineated by three main areas of basement complex. These are Western end of the Cameroun volcanic zone, Northern Nigeria massif and the eastern end of West African massif. The Niger Delta complex basin is situated on the Gulf of Guinea on the west coast of Central Africa.

Experimental: Electrical Resistivity Tomography (ERT) survey was carried out using the Wenner array to obtain the apparent resistivity of the various survey site because of its relativity sensitivity to vertical variations in the subsurface resistivity, moderate depths of investigation and general strong signal strength which is a preferred choice for the survey in a noisy site. A minimum electrode separation of (5 m) and inter-lines spacing 10 m were used. In each site of investigation, the field survey was in a square grid format, such that the parallel lines are all the same of 100 m each. The 2D apparent resistivity data for each of the Wenner arrays were interpreted using the RES2DIVN software.

RESULTH AND DISCUSSION

Figures 2 – 10 shows the 2D inverted imaging model obtained from the study area. The subsurface images from the 2D model reveals more than ten distinct subsurface layers ranging from Alluvium soil, Shale, Slate, Sandstone , Quartz, Marble, Basalt, and Granite with apparent resistivity values ranging from 50 Ωm to 1500 Ωm. The delineated subsurface Lithology materials extend to a depth of 15 m below the surface towards the end of the depth of investigation. It will be observed, that there is an increase in the coarse nature of the Lithology rocky materials which is reflection from the increase in resistivity of the rock types as we go deeper into the earth subsurface of the study area in all the profiled lines. In figure 2, at a resistivity of 1475 Ωm at a depth of 13 m, Basalt, Slate and Limestone can be inferred

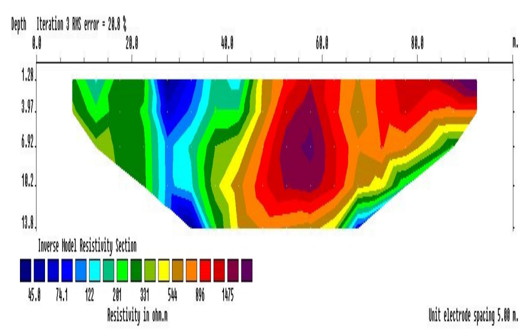

Fig 2: Inverted 2-D resistivity imaging model obtained from Ozalla community profile one

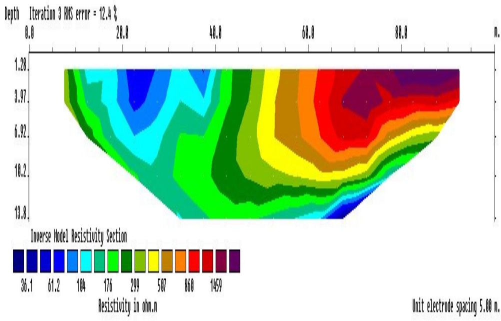

Fig 3: Inverted 2-D resistivity imaging model obtained from Ozalla community profile two.

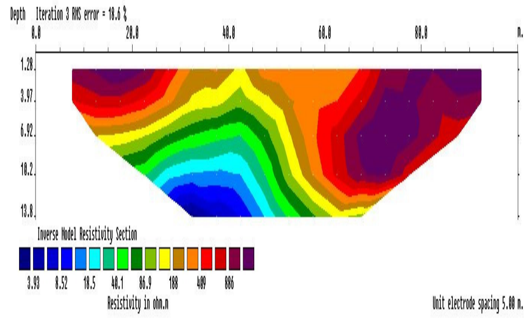

Fig 7: Inverted 2-D resistivity imaging model obtained from Ozalla community profile six.

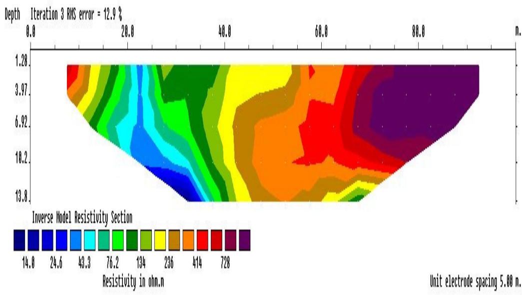

Fig 4: Inverted 2-D resistivity imaging model obtained from Ozalla community profile three.

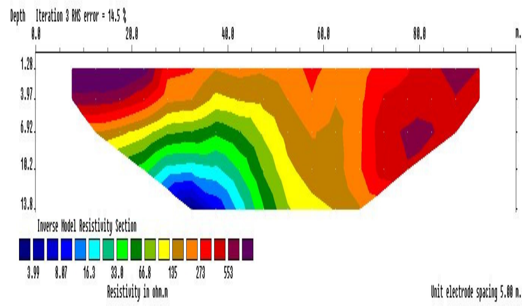

Fig 9: Inverted 2-D resistivity imaging model obtained from Ozalla community profile seven

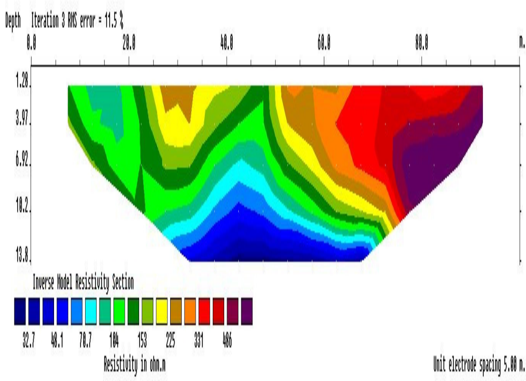

Fig 5: Inverted 2D resistivity imaging model obtained from Ozalla community profile four

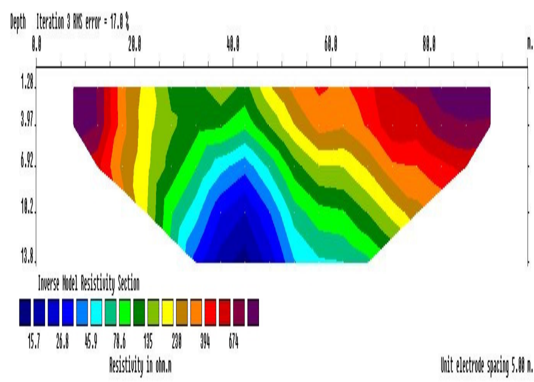

Fig 10: Inverted 2-D resistivity imaging model obtained from Ozalla community profile eight.

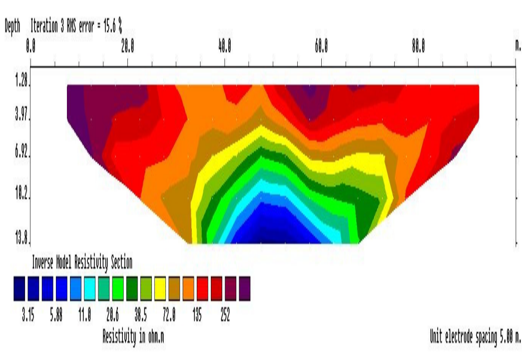

Fig 6: Inverted 2-D resistivity imaging model obtained from Ozalla community profile five

Figure 3 also shows similar presence of Basalt, Slate and Limestone at a depth of 12 m with a resistivity value of 728 Ωm – 1400 Ωm. Figures 4 and 5 were collected in the same place having resistivity values 700 Ωm above, the minerals found are Sandstone, Quartz and limestone at a depth of 10 m. The rest profile from Figure 6 – 10 all show similar deposition of Igneous, Metamorphic and sedimentary rocks which comprises of Shale, Slate, Sandstone, Quartz, Marble, Basalt, and Granite with resistivity ranging from 300 Ωm – above 1000 Ωm with moderate depth of 13 m. The various depth and minerals delineated is compared with the standard resistivity table for various minerals in table 1.

Table 1: Resistivity Values of Some Common Rocks, Minerals and Chemicals. (Source: Keller and Frischknecht, 1966)

Material	Resistivity (Ω•m)	Conductivity(Siemen/m)
Igneous and Metamorphic Rocks		
Granite	$5x10^3$ - 10^6	10^{-6} - $2x10^{-4}$
Basalt	10^3 - 10^6	10^{-6} - 10^{-3}
Slate	$6x10^2$ - $4x10^7$	$2.5x10^{-8}$ - $1.7x10^{-3}$
Marble	10^2 - $2.5x10^8$	$4x10^{-9}$ - 10^{-2}
Quartzite	10^2 - $2x10^8$	$5x10^{-9}$ - 10^{-2}
Sedimentary Rocks		
Sandstone	8 - $4x10^3$	$2.5x10^{-4}$ - 0.125
Shale	20 - $2x10^3$	$5x10^{-4}$ - 0.05
Limestone	50 - $4x10^2$	$2.5x10^{-3}$ - 0.02
Soils and waters		
Clay	1 – 100	0.01 – 1
Alluvium	10 – 800	1.25 $x10^{-3}$ - 0.1
Groundwater (fresh)	10 – 100	0.01 -0.1
Sea water	0.2	5
Chemicals		
Iron	$9.074x10^{-8}$	$1.102x10^7$
0.01 M Potassium chloride	0.708	1.413
0.01 M Sodium chloride	0.843	1.185
0.01 M acetic acid	6.13	0.163
Xylene	$6.998x10^{16}$	$1.429x10^{-17}$

Conclusion: The geoelectrical investigations performed at Ozalla has helped to delineate the subsurface Lithology and mineral composition of the study area. It is evident from the result of the modeled 2D images that the Lithology is rich in some buried rocks materials and minerals, at a depth between 10 m to 12 m reveals the composition of Alluvium soil, Shale, Slate, Sandstone, while at a depth between 13 m to the last depth of investigation reveals Quartz, Marble, Basalt, and Granite. The study area is a basement complex area which is rich in the minerals delineated.

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