# Geophysical Survey of the Occurrence of Oil Sand Deposit in Usen, Ovia South West Local Government Area, Nigeria.

BY

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**ABSTRACT**

Oil sands are known to be an alternate source of energy and of great economic value, to delineate the deposit of oil sand in Usen, South west of Edo State, Electrical Resistivity survey was used. Vertical Electrical Sounding (VES) was done on one profiles using Schlumberger Configuration, acquiring 1- Dimensional apparent resistivity data. to determine the depth extent of the deposit. This was preceded by 2-Dimensional Electrical Resistivity Tomography (ERT) (image) at four locations which were at Edo State Polytechnic field environ, Science Laboratory environ, Elawure Grammar School environ and the Quarry Site environ all in Usen, to determine the spread extent of this deposit. The 1-D Data was processed and interpreted using IP2WIND software to delineate depth of the oil sand deposit which was about 2.67m - 19.1m with 6 geo- electric layers having resistivity range of value of 295Ωm - 5943Ωm and RES2DINV software was used to processed and interpreted the 2-D data with model resistivity range of values 383 Ωm- 18765 Ωm, 4.28 Ωm - 1568 Ωm, 198 Ωm - 1217 Ωm and 128 Ωm - 53639 Ωm delineating the spread of the deposit. The ERT results bearing oil sand at the depth within 6.0m – about 13.4m and other subsurface aggregate also present at the surveyed locations. It was observed that the bitumen is not characterized by good lateral continuity and not sufficiently thick for commercial exploitation.

**Keywords**: Oil Sand, Vertical Electrical Sounding, Electrical Resistivity Tomography, Geo-Electric, Delineate.

## 1.0 INTRODUCTION

Oil sand is a mixture of sand, water, clay, and a highly viscous dark and tar like petroleum substance called Bitumen. It is made up of polycyclic aromatic hydrocarbon which has been used in the tailing of roads in Nigeria. Nigeria is known to have enormous reserves of oil sands within a belt that cut across Ogun, Ondo and Edo states, covering a distance of approximately 10 km. [1] described the nature and occurrence of the Nigerian oil sand and remarked that it is made up of sand (84%), bitumen (17%), clay (2%) and water (4%). He also studied the porosity of tar sand using quite a number of techniques and observed that the porosity of tar sand ranges from 16 to 35%.

In the world today, United States, Canada and Venezuela are the world largest explorer and exploiter of oil sand. There are about 1.7 trillion barrels of reserves in Athabasca oil sand (Canada) and 1.8 trillion barrels of extra heavy crude in the Venezuelan oil Orinoco oil sands.

In fact, the oil sands account for about 68% of the world total oil reserve, accounting to the energy business reports published in 2008.

According to [2]. The country has a reserve estimate of 30-40 billion barrels (bbls) with potential recovery that may result from the exploitation of this resource [3] makes its delineation an important concern.

Over 80% of the country's revenue comes from export and domestic sales of oil and gas. As the hydrocarbon potentials of the prolific Niger Delta becomes depleted or in the near future may be exhausted due to continuous exploitation, attention needs to be shifted to other source of revenue. Bitumen which is known as asphalt or tar sand is the heavy oil in the bituminous sand which is a very dark coloured, sticky and highly viscous liquid or semi-solid form of petroleum.

Electrical Resistivity Tomography (ERT) is one of the most popular techniques for the shallow subsurface applications and is applied for hydrogeological, engineering, or agricultural problems [4].

## 2.0 RELEVANT LITRATURE

[5] did a 2D Electrical Resistivity Tomography of Bitumen Occurrence in Agbabu, Southwest Nigeria. PASI 16GL-N Earth Resistivity Meter instrument was used to acquire data along five (5) traverses with 5m electrode spacing and traverse length of 150m. In their

survey, it was observed that oil sand lies within a depth of 0 m to about 18m. The results indicate that the bitumen is characterized by good lateral continuity and is sufficiently thick for commercial exploitation. [6] used Integrated Electrical Resistivity and Magnetic methods to explore for oil sand in Agbabu, Southwestern Nigeria. While [7] applied electrical resistivity survey to investigate the role of fault as a barrier of conduit for bitumen seepages found in Imeri, Southwestern Nigeria.

## 3 .0 GEOLOGICAL SETTING

Usen Community in Ovia South West Local Government Area of Edo State which is located within longitudes $6^0\,44'$, $6^0 45'$ East and latitudes $5^0\,20'$, $5^0 22'$ North. The study area is defined by sedimentary formations comprising of top reddish clayey sand capping, bearing loose pebble sandstone with clay overlying a thick lateritic hard pan. This in turn overlies series of shale and clayey sand inter-beds which is believed to support the head springs of the existing streams and streamlets. The surface material exposed at Usen and environs are mapped as the western extension of the hitherto false bedded sandstone and Upper coal measure formation of the Anambra basin. The characteristic rock units include false bedded sandstone, shale and coal of cretaceous (santonia) age. Elsewhere, the false bedded sandstone is known to be prolific with occasional artesian behavior where favorable conditionsexis



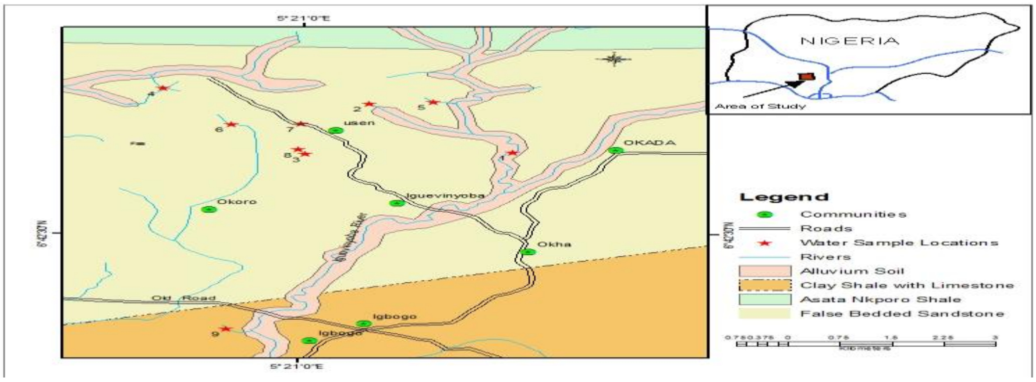


Figure 1: Geological map of Usen and environs [8].

## 4.0 METHODOLOGY

1D VES was carried out at Usen market environ and 2D ERT survey were carried out at Edo State Polytechnic field environ, Edo State Polytechnic SLT environ, Elawure Grammar School environ and the Quarry Site environ. All located within Usen Community in Ovia South West Local Government Area of Edo State which is located within longitudes

$6^0\,44'$ , $6^0 45'$ East and latitudes $5^0\,20'$ , $5^0 22'$ north. Wenner-Schlumberger array was used for this survey. This is a new hybrid between the Wenner and Schlumberger arrays [9]. The classical Schlumberger array is one of the most commonly used array for resistivity sounding surveys. The “n” factor for this array is the ratio of the distance between the $C_1 - P_1$ (or $P_2 - C_2$) electrodes to the spacing between the $P_1 - P_2$ potential pair. The sensitivity pattern for the Schlumberger array is slightly different from the Wenner array with a slight vertical curvature below the centre of the array, and slightly lower sensitivity values in the regions between the $C_1$ and $P_1$ (and also $C_2$ and $P_2$) electrodes. There is a slightly greater concentration of high sensitivity values below the $P_1 - P_2$ electrodes. This means that this array is moderately sensitive to both horizontal and vertical structures. The median depth of investigation for this array is about 10% larger than that for the Wenner array for the same distance between the outer ($C_1$ and $C_2$) electrodes [10]. For the Wenner- schlumberger array shown on (figure 2), an inter – electrode spacing of 5 m along the survey line of a total length 60m for the first three ERT locations and 300m for the last location. A high resolution Wenner Schlumberger survey will start with the “a” spacing (which is the distance between the $P_1 - P_2$ potential dipole) equal to 5 m and repeat the measurement with “n” value of 1, 2, 3, 4 and 5. “a” spacing was keep constant as 5m.

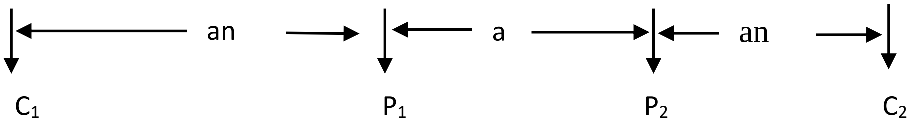


Figure 2: Wenner Schlumberger Array showing arrangement of electrodes

## 5.0 RESULTS AND DISCUSSION

The apparent resistivity data got over the 1D and 2D profiles were inverted using IP2WIND software and RES2DINV inversion code [11] to produce 1D and 2D models respectively for each profile. The RES2DINV computer program uses a nonlinear optimization technique which automatically determines a 2D resistivity model of the subsurface for the input apparent resistivity data [12]. The program divides the subsurface into a number of rectangular blocks and then calculates the apparent resistivity values that agree with the measured values using a forward modeling routine. The arrangement of the rectangular blocks is loosely tied to the distribution of the data points in the pseudosections. The 1D VES with resistivity range of values of 295Ωm - 5943Ωm, and depth of the oil sand deposit exiting at about 7.14m – 19.1m. The ERT 2D models with resistivity range of values 383 Ωm- 18765 Ωm, 4.28 Ωm - 1568 Ωm, 198 Ωm - 1217 Ωm and 128 Ωm - 53639 Ωm bearing oil sand (bitumen) at the depth within 6.0m – about 13.4m and other subsurface aggregate like lateritic soil, sand, sand clay/ clayey sand, consolidated shale, clay and sandstone.

## 5.1 Market Environ 1D

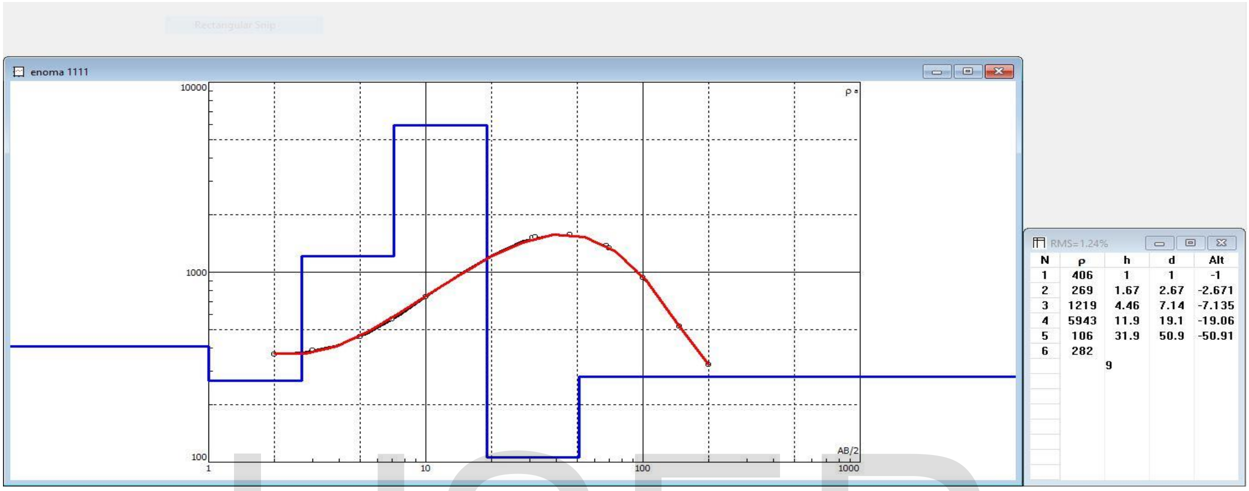


Figure 3: 1D VES showing the 6 (six) different geo-electric layers



Figure 3, showthe 1D VES result with 6 geo-electric layers this survey was done near the market environ in Usen. The second to fourth geo-electric layer with resistivity range 269Ωm to 5943Ωm with depth level 2.67m to 19.1m probably bears the oil sand or bitumen.

## 5.2 Edo State Polytechnic Field Environ, 2D Models.

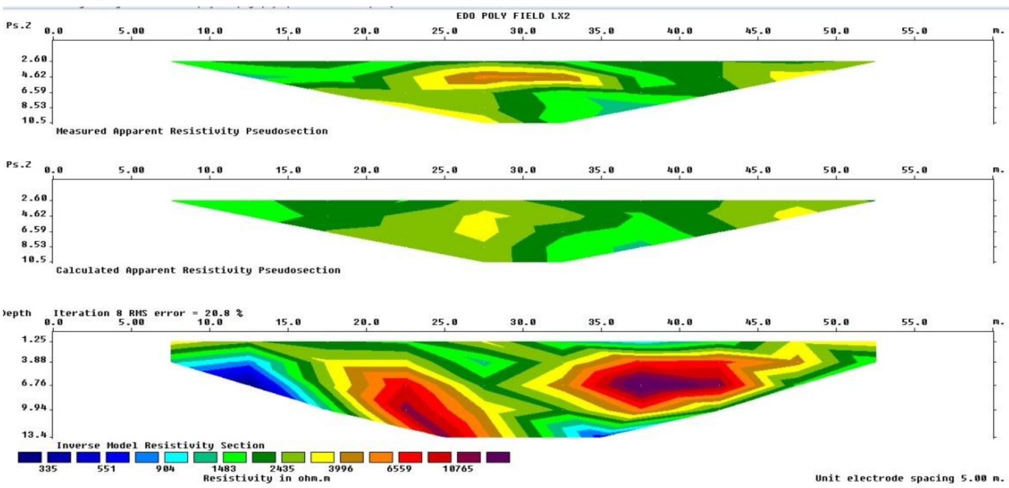

**Figure 4:** Edo State Polytechnic field line L1; 2D smoothness constrained inversion model resistivity section

Figure 4 shows Edo State Polytechnic field line L1 2D inversion model with total depth of 13.4m which has the top layer to depth of 6.79m with resistivity 984 $\Omega m$-3996$\Omega m$ is suggested to be composed of lateritic soil while depth 6.79 m -13.4m with resistivity 335 $\Omega m$-18765$\Omega m$ suggested to be composed of sand, sandstone and bitumen.

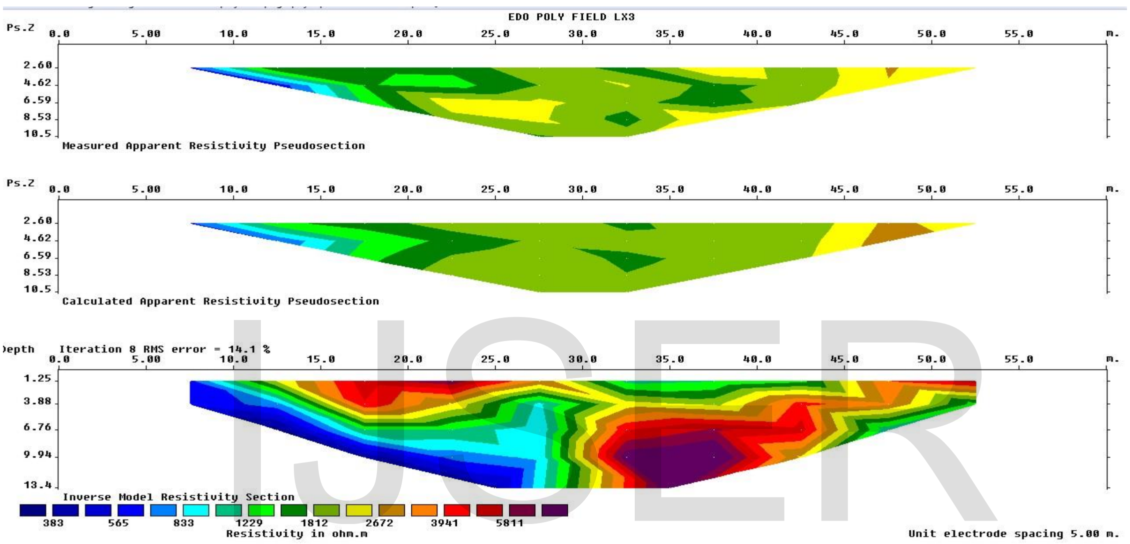


**Figure 5:** Edo State Polytechnic field line L2; 2D smoothness constrained inversion model resistivitv section

Figure 5 shows Edo State Polytechnic field line L2 2D inversion model with total depth of 13.4m which has the top layer to depth of 6.76m have resistivity range of value of about 2697$\Omega m$ to 3941 $\Omega m$ is suggested to be composed of lateritic soil. This is followed by depth range between 6.76m to 13.4m with 383 $\Omega m$ to 5811 $\Omega m$ this is suggested to be composed of laterite, clay, sandstone, bitumen.

## 5.3 Edo State Polytechnic Science Laboratory Environ 2D Models.

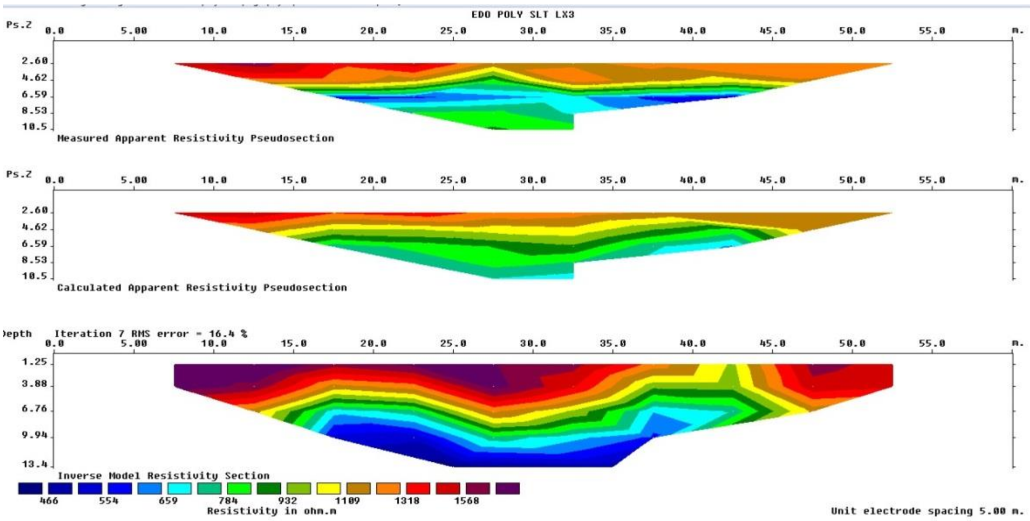


**Figure 6:** Edo State Polytechnic SLT field line L3; 2D smoothness constrained inversion model resistivity section



Figure 6 shows Edo State Polytechnic SLT field line L3 2D inversion model with total depth of 13.4m which has the top layer to depth of 6.76m with resistivity range of value of about 784 $\Omega m$ to 1568 $\Omega m$ is suggested to be composed of sandstone. This is followed by depth range between 6.76m to 13.4m with resistivity range 466 $\Omega m$ to 784 $\Omega m$ this is suggested to be composed of wet clay, and shale.

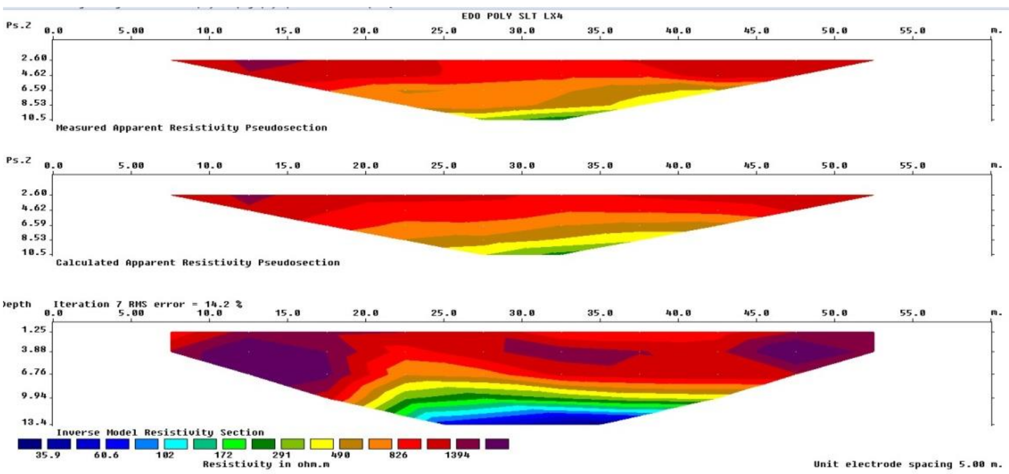


**Figure 7:** Edo State PolytechnicSLT field line L4; 2D smoothness constrained inversion model resistivity section

Figure 7 shows Edo State Polytechnic SLT field line L4 2D inversion model with total depth of 13.4m which has the top layer to depth of 9.94m with resistivity range of value of about 498 $\Omega m$ to 1394 $\Omega m$ is suggested to be composed of sandstone. This is followed by depth range between 9.94m to 13.4m with resistivity range 36.9 $\Omega m$ to 498 $\Omega m$ this is suggested to be composed of wet clay, and shale.

### 5.4 Elawure Grammar School Environ

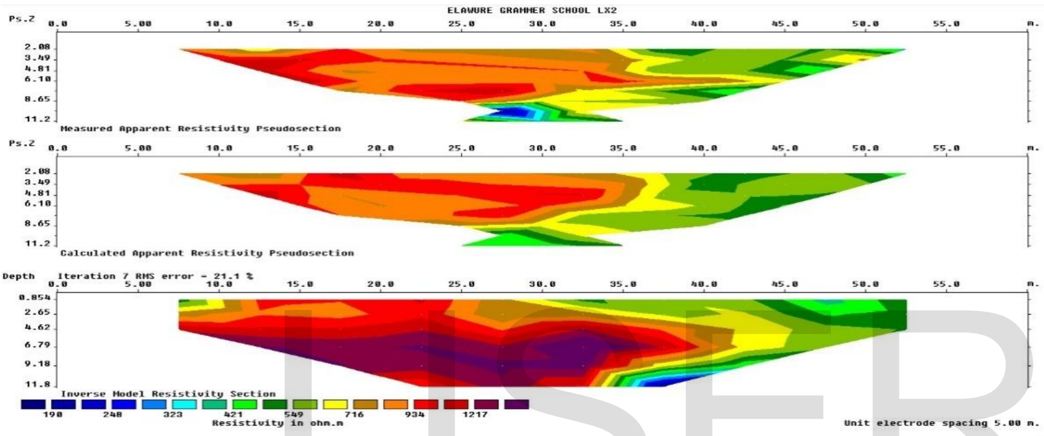


**Figure 8:** Elawure line L5; 2D smoothness constrained inversion model resistivity section

Figure 8 shows Elawure L5 2D inversion model with a total depth of 11.8m which has the first half of the profile from 0 m to 30 m with depth 0 m to 6.79 m is suggested to contain lateritic soil, while 30m and above along the profile is suggested to contain wet lateritic soil, sand and depth 6.72m to 11.8m suggest to contains sandstone.

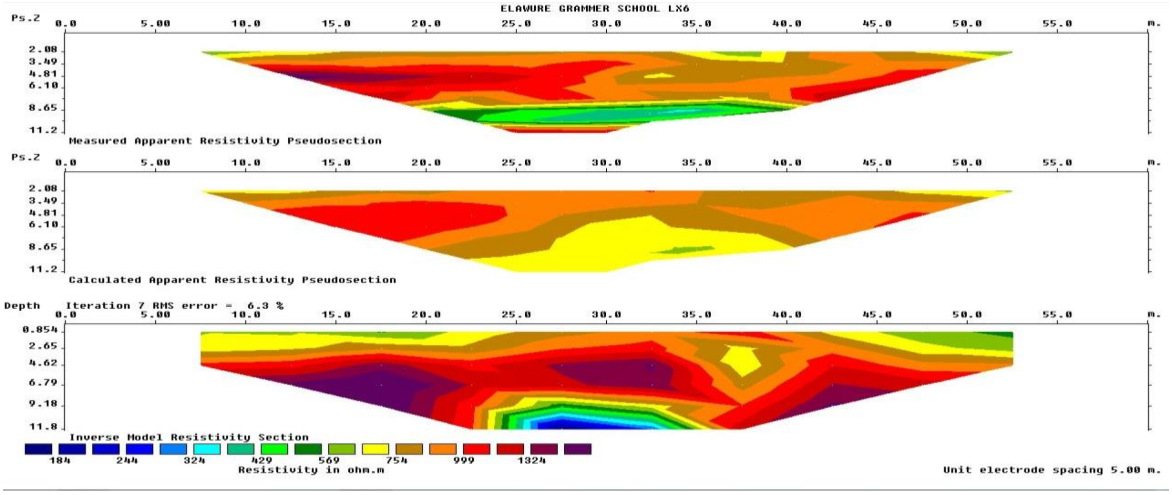


**Figure 9:** Elawure line L6; 2D smoothness constrained inversion model resistivity section

Figure 9 shows Elawure L6 2D inversion model with total depth of 11.8m which has the top layer to a depth of 4.62m have a lower resistivity range of value of about 184 $\Omega m$ to 324 $\Omega m$ is suggested to be composed of laterite. This is followed by depth range between 4.62m to 9.18m with 754 $\Omega m$ to 1324 $\Omega m$ this is suggested to be composed of sandstone. Below this depth 9.18 m to 11.8 m having resistivity of 184 $\Omega m$ to 324 $\Omega m$ which suggest that this depth contains lateritic soil clay and bitumen.



## 5.5 Quarry Site Environ

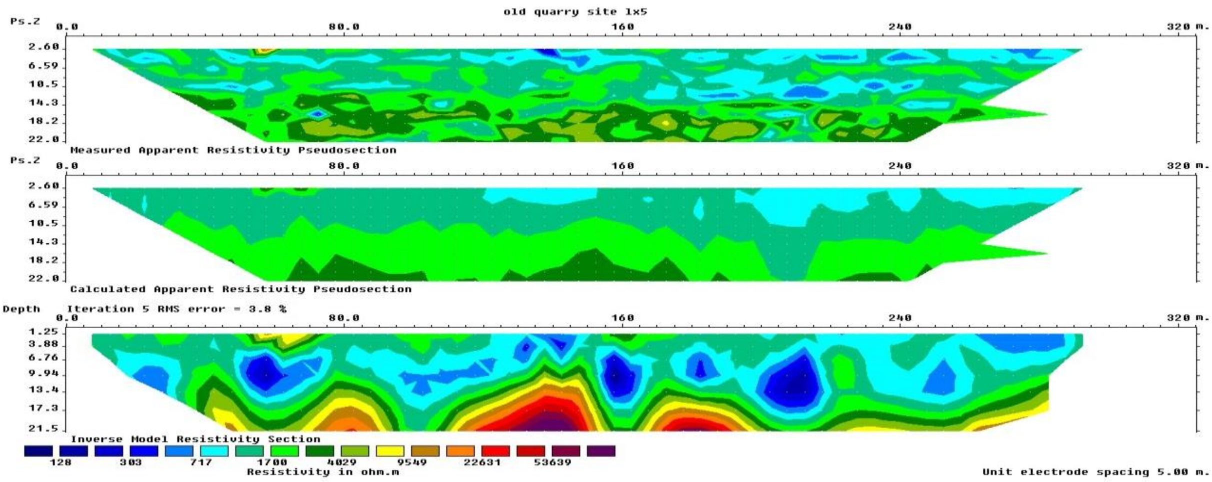


Figure 10: Quarry Site Environ; smoothness constrained inverse model L7 for 300 m.

**Figure 10:** shows Quarry site inverse model L7 for 300 m survey length with 5 iterations, percentage error of 3.8 %. Having measured apparent resistivity section, calculated

apparent resistivity section and the inverse model, showing the total depth as 21.5 m with resistivity range 128 $\Omega m$ to 53629 $\Omega m$ is suggested to be probably composed of lateritic soil, sand, clay, shale sandstone and bitumen.

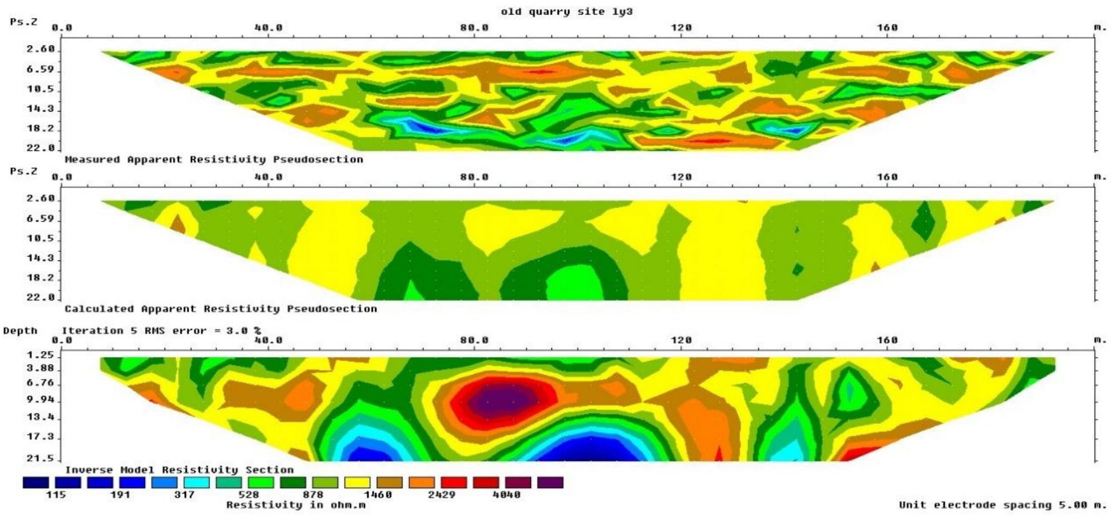


**Figure 11:** Quarry Site line L8; 2D smoothness constrained inversion model resistivity section

**Figure 11:** shows Quarry site inverse model L8 for 300 m survey length with 5 iterations, percentage error of 3.8 %. Having measured apparent resistivity section, calculated apparent resistivity section and the inverse model, showing the total depth as 21.5 m with resistivity range 115 $\Omega m$ to 4848 $\Omega m$ is suggested to be probably composed of lateritic soil, sand, clay, shale sandstone and bitumen.

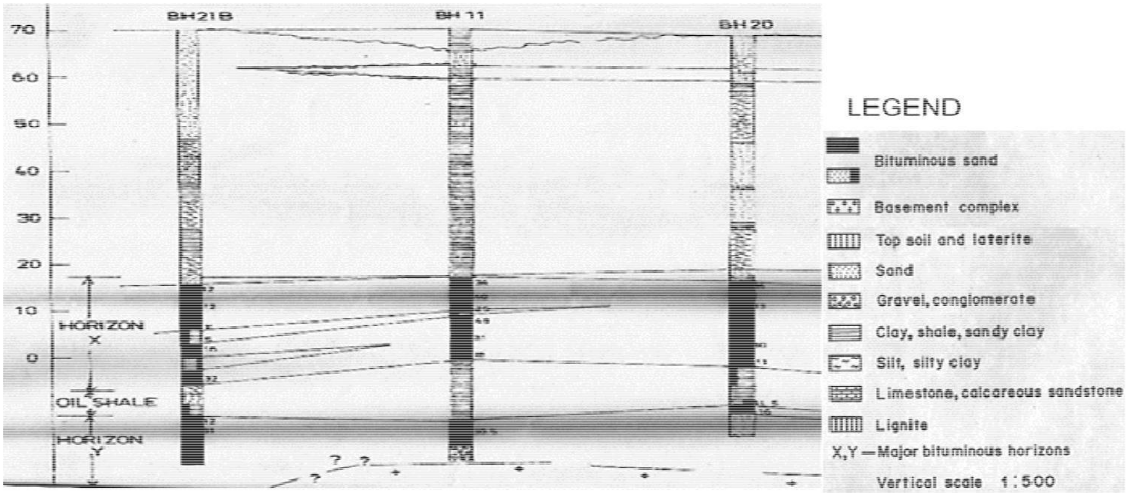


**Fig. 12: Lithofacies / bitumen saturation correlation panel of the study area** *[13]*

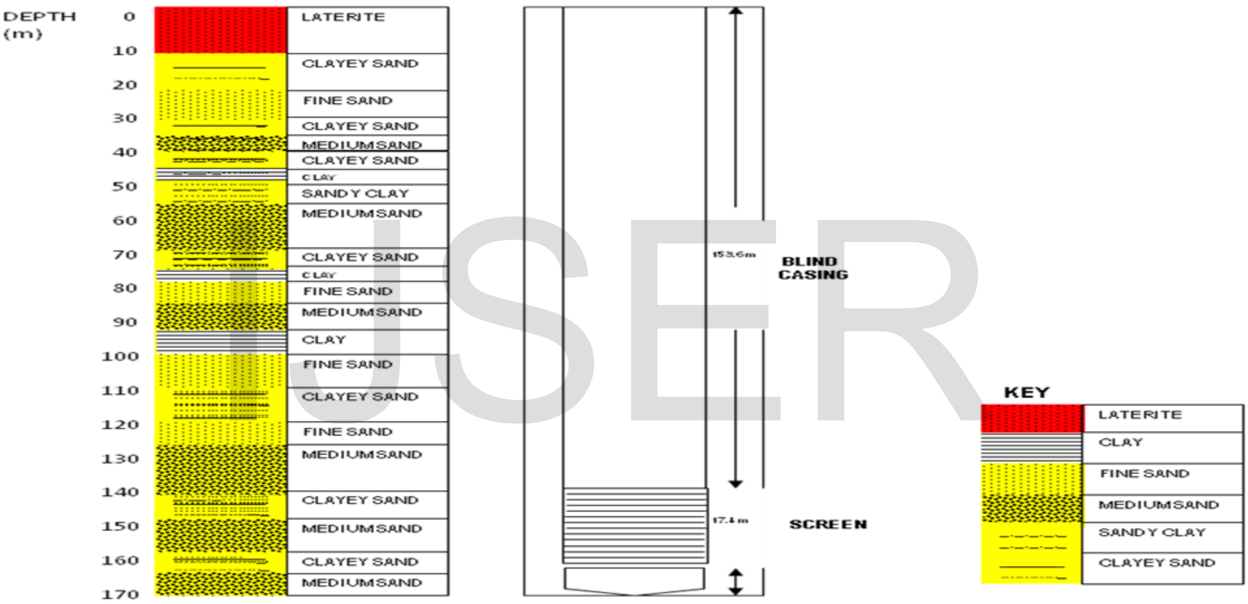


**Figure 13**: lithological section of drilled borehole at Usen community. (Benin owena river basin)

Confirming from the lithofacies / bitumen saturation correlation panel of the study area on figure 12 and the drilled borehole log within the quarry site location shown on figure 13. The layers are composed of lateritic soil, sand, sand clay/ clayey sand, gravel, consolidated shale, clay sandstone and bitumen.

## 6.0 CONTRIBUTION TO SCIENTIFIC KNOWLEDGE

1. This research reveals the presence of aggregates like lateritic soil, sand, sandstone, shale, clay and bitumen.

2. These aggregates can also be termed mineral which can be mine for other purpose.

3. Increasing the survey length also increases our depth of probe as observed on the fourth location to get more detailed information about the subsurface.

4. It is observed that the bitumen is not characterized by good lateral continuity and not sufficiently thick for commercial exploitation.

## 7.0 CONCLUSION

This study showed that the use of wenner schlumbeger arrays proved to be cost effective and efficient methods for the investigation of the sub-surface structure

in any survey location. Revealing subsurface features in depth and good resolution.

## 8.0 ACKNOWLEDGEMENT

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