Paper Title* 2-D Electrical Resistivity Imaging of Tar sands Seepages in Ilubirin, Southwestern,Nigeria.

1 Olayinka, A.I, 2 Oladunjoye, M, 3,4 Korodele, A.O

1 Department of Geology, University of Ibadan, Oyo State, Nigeria.
2 Department of Geology, University of Ibadan, Oyo State, Nigeria.
3 Department of Geology, University of Ibadan, Oyo State, Nigeria

Email: korodelesesan@yahoo.com

ABSTRACT

Non-destructive geophysical investigation techniques comprising eight 2-Dimensional electrical resistivity imaging were taken with Wenner Configuration at Ilubirin, Southwestern, Nigeria. The Electrical Resistivity Imaging has a maximum electrode spacing (AB) of 150m. Two Electrical Resistivity Imaging profiles were taken very close to the contaminated hand dug well along the area where tarsands seepages were sighted. The results obtained geologically deduced that tar sand seepages were witnessed within the study area from traverse 1 to traverse 8 with a resistivity value ranging from 40Ωm - 100Ωm. The thickness of occurrence of the tarsands bearing zone within the study area varies from the top surface to infinite depth.

Keywords: Traverse; Tar sand; Resistivity; Seepages

Introduction:

Occurrence of tarsands deposits over the Okitipupa ridge in the Dahomey basin provided the initial impetus for oil exploration in Nigeria. The Occurrence of these deposits has been known since last century, however, intense investigations commenced from mid 70’s till now. Most of the Nigerian tarsands deposits are located in the eastern Dahomey basin. The stratigraphy of the basin was studied by [5] but was reviewed by [17] on the basis of new subsurface data. Ilubirin, is located at the Okitipupa ridge of the Dahomey basin. The Dahomey basin is a coastal sedimentary filled with over 2500m of cretaceous and younger sediments unconformably overlying the block faulted basement complex rock. Tarsands deposits with large reserves occur within a belt that cuts across Ogun,
Ondo, Edo, and Bendel states of Nigeria. Tarsands are mixture of sand, water, clay and crude bitumen. Each tarsand grain has three layers: an ‘envelope’ of water surrounding a grain of sand, and a film of bitumen surrounding the water. Heavy oil and bitumen (the primary hydrocarbon component of tarsands) are the types of crude oil, naturally occurring petroleum. In the raw state, tarsand is sticky, viscous, black substance. Bitumen is a viscous mixture of hydrocarbon that contains about 83% carbon, 10% hydrogen, 5% sulphur, 1% oxygen, 0.4% nitrogen, and trace quantities of methane, hydrogen sulphide and metals [6]. Tarsands have a similar composition as the light crude. They are believed to have formed from biodegradation and water-washing of light crude due to lack of caprock.

2-D Electrical Resistivity Imaging faithfully identifies contacts and true bulk resistivities of the imaged lithologies which provides broad a view of the spatial distribution of the McMurray Formation bitumen impregnated sands of the Athabasca oil sands, Canada [6]. Also, 2-D Electrical Resistivity Imaging produces high-resolution images of the subsurface, which are useful for groundwater resources assessment. The resistivity results provide a clear view of the thickness of the weathered regolith and of the distribution of the various lithological units at the Harare Greenstone belt [18]. As a result, 2-D Electrical Resistivity Imaging was carried out at Ilubirin, southwestern, Nigeria to delineate tarsands seepages within the area.

**Geological Setting and Geophysical Investigation on the studied area:**

The Dahomey Basin, Southwestern Nigeria is in the Gulf of Guinea, West Africa. The Eastern Dahomey Basin, a wrench modified basin, is an extensive sedimentary basin [7], containing rocks ranging from Cretaceous-Recent [13]. The basin extends from Southeastern Ghana (Volta Delta) in the west, to the western flank of the Niger Delta in the east [14], [17]; [24]. The basin is bounded by the Okitipupa Ridge to Niger Delta (Fig.1). It is a marginal pull apart basin or marginal sag basin [17] which was initiated in
the Mesozoic era (Late Jurassic to Early Cretaceous tectonics) and it is characterized by both block and transform faulting superimposed across an extensive Paleozoic basin during the breakup of the African, North American and South American paleocurrents [23]. This led to the formation of continental margin and coastal margin which was filled up by Cretaceous and Tertiary sediments [24].

Fig 1: Geological Map of Dahomey Basin (After Billman, 1976)

Fig 2: Geological Map of Southwestern Nigeria showing tar sands outcrop belt (after Enu, 1985)

Fig 3: Tectonic model for evolution Of the Dahomey Basin (After Omatsola and Adegoke, 1981)

Fig 4: East-West geological section showing position, extent, and sediment thickness variation in the onshore Dahomey Basin and upper part of Niger Delta (Whiteman, 1982)
The stratigraphy of the Eastern Dahomey Basin has been studied by several workers including [14],[19],[15],[1],[5],[17],[2],[9],[13],[16],[10], have all described in an understandable and detailed way the stratigraphy setting of the Eastern Dahomey basin in the Southwestern Nigeria based on respective analytical study. However, there are still controversies on age assignment and nomenclature of the different lithosection. The lithostratigraphy formation range from Cretaceous to Tertiary ages as reported by these authors is shown in fig 5 below. The successions from youngest to oldest include:

- Benin formation (Oligocene-Recent)
- Ilaro formation (Eocene)
- Oshosun Formation (Eocene)
- Akinbo Formation (Late Paleocene- Early Eocene)
- Ewekoro Formation (Paleocene) and
- Abeokuta Group (Cretaceous ); Ise, Afowo, and Araromi

Fig.5 : Stratigraphy of the Eastern Dahomey Basin (after Omatsola and Adegoke, 1981).
To convert the resistivity picture into a geological interpretation, one requires some knowledge of the typical resistivity values for the different types of subsurface materials and geology of the studied area. 2-D Electrical Resistivity Imaging, a non-invasive geophysical methods assimilate hundreds of individual resistivity measurement collected over the line of sections into a two dimensional image of the subsurface. This method provides extensive application for exploration of tarsands in a definitive and in a cost-effective fashion.

Discussion of Results:

Ilubirin Traverse 1: The subsurface resistivity distribution of the area is shown in the fig. 8. The top part shows a resistivity values ranging from 143Ωm to 150Ωm and the bottom part of the image gives a resistivity values ranging from 100Ωm to 171Ωm. The resistivity value between 500Ωm and 1700Ωm is geological described as laterite [21] with red to purple coloration. This formation occurs at a depth of 4m along 75m and 95m of traverse. The geological interpretation of resistivity section of the 2-D resistivity imaging with yellow to light brown coloration indicate the presence of sandy-clay with subsurface resistivity value between 101Ωm and 171Ωm [20] in the northeastern part with thickness varying between 20m to 25m spanning over some 30m where the traverse

Fig. 6 : Location Map of Studied area showing traverses and VES points.

Fig 7: Tar sand seepage
begins extending to the southwestern area of the traverse. This geological formation can be described as aquitard which does not yield water freely due to less permeability, although seepage is possible through it. Tar sand occurs at the flank and bottom part of the model with true resistivity ranging from $45\Omega m$-$100\Omega m$ [3]. It occurs at surface to a depth of about 25m. The central part through to the top of the southwestern portion of traverse is covered by clayey sand. The resistivity value of the clayey sand formation ranges from $170\Omega m$ to $350\Omega m$ [12] indicated by light brown to brow coloration. This can serve as good aquiferous zone for groundwater development in the survey area. The thickness of this geological formation ranges from 1 to 25m.

Ilubirin Traverse 3: There was high resistivity region occurring from the west to the east at the top of the model. The resistivity value ranges from $604\Omega m$ to $1075\Omega m$ [22] which was delineated to be high resistive zone occurring at a depth of 1m to 5m. The top lateritic cover is directly underlain by a clayey sand geological formation with resistivity varying from $191\Omega m$ to $480\Omega m$. This geological formation occurs at a depth of 4m extending to about 25m within the subsurface model. Materials having resistivities between $19\Omega m$ and $60\Omega m$ referred to tar sand bearing horizon [3]. The low resistivity part $1\Omega m$ and $19\Omega m$ is interpreted as clayey soil/shale situated at the lower left part of the image occurring at the eastern portion of the surveyed area. Overlying the low resistivity layer is the sandy clay formation with the resistivity of $60\Omega m$. 

Fig 8: 2-D Resistivity Distribution of traverse 1.
Ilubirin Traverse 7: A 150m electrical resistivity survey was carried out. The topsoil reveals high resistivity 1026Ωm from the west to east occurring at a depth of 3m. This resistivity value corresponds to a geological formation known as laterite. A thin layer of clayey sand with resistivity of 431Ωm occurs underneath the superficial topsoil formation. The depth of the occurrence is at 4m. This extends from the west to the east of the survey area. A layer with a resistivity of 161Ωm is geological described as sandy clay with thickness of 2m. Underlying the sandy clay is a formation with true resistivity ranging from 40Ωm to 75Ωm is described as tar sand. The thickness of this biodegraded geological formation is 6m. The horizon of the tar sands bearing is continuous indicating that is stratigraphically controlled. The geological formation having the resistivity ranging from 0Ωm to 32Ωm is referred to clay/shale. It occurs at the bottom of the model.
Ilubirin Traverse 8: The area surveyed consists of laterite with very high resistivity values between 626Ωm and 967Ωm which constitutes the superficial portion or the topsoil formation extending from the west to the east of the image model. The depth of occurrence ranges from 1m to 4m. A thin layer of clayey sand was found at a depth of 5m extending to a depth of 7m with soil resistivity ranging from 263Ωm and 406Ωm. Also, sandy clay was found stretching from the west to the east of the surveyed area which occurs as thin layer with resistivity value of 110Ωm and 170Ωm with thickness of 2m. The resistivity of the unconventional hydrocarbon (tar sand) ranges from 40Ωm and 100Ωm. The tar sands bearing horizon is also found to be continuous from the west to the east which indicates that they are startigraphically controlled. A low resistivity value between 0Ωm and 46Ωm is found at the bottom flanks of the west and east portion of the inverted subsurface model. This low resistivity value corresponds to a geological formation known as clay/shale. The depth of occurrence is from 9m extending to 35m.

![Fig 11: 2-D Resistivity Distribution of traverse 8.](image)

Conclusion: 2-D Electrical Resistivity Imaging reveals the spatial distribution and the presence of tar sand at the surveyed area. Tar sands bearing horizon was seen occurring from the surface to infinity given an indication that it was a shallow occurrence which can easily seep to the surface. This study will help in the construction of groundwater development within the area.
References:


