Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 3159-0040
Vol. 3 Issue 2, February - 2016

Conceptual Models Of Origin For Nigerian Frontier Basin Deposits: An Interdisciplinary Case Study Of Oil Seepages In Kwara State Nigeria.

Alao,D.A[1] Johnson, L.M.[2] and Abdulazeez Tajudeen[3]
Footnotes
[1]Alao , D.A.-Lead and corresponding author
CEO,Folaina Nigeria Limited, 14 Dasuki Road Tanke GRA Ilorin Kwara State Nigeria
Email-davidalao2012@gmail.com
[2] Johnson,L.M
Doctoral Candidate, Curtin University Australia. Email-mobolajijay@gmail.com
[3]Abdulazeez Tajudeen
Energy Commission of Nigeria, Plot701c Garki Abuja FCT Nigeria. Email -Teejay4show@yahoo.com

***Abstract*—Fossil fuels shall continue to be relevant globally for at least another fifty years. Nigeria, the most populous African nation with rapid population growth shall continue to need fossil fuels(coal, oil and natural gas)as energy source for her socio-economic development in forseeable future.Like a wakeup call, unconventional hydrocarbons oozed out of a hillside at a rural settlement(Aran-Orin) in Kwara State Nigeria a few years ago.The site of the seepage is now classified as part of Nigerian Inland Frontier basins(1,2).**

The Frontier basins in Nigeria are found within the preCambrian basement complex of Southwestern Nigeria. These Inland basins have no direct linkage with the Niger Delta,the Atlantic Ocean,or the Illumeden Basin in the Northwest. Furthermore, they have no linkages with the tars-sands belt also in the southwest.

Accidental discovery of hydrocarbon in Kwara State,propelled this research, which has come up with three competing models of origin of the crude oil find in the State. We have provided data from preliminary investigation to call for funded systematic research on the source of crude oil seepages in Kwara State Nigeria. This paper concludes with a recommendation for an interdisciplinary scientific research approach based on the apparent significant contribution of ArcGIS at this initial stages of petroleum exploration in the state.

Keywords—Frontier, Inland basins, geotectonic models, seepage, palaeo-channels, Hydrothermal and depo-centers.

INTRODUCTION

Accidental discovery of hydrocarbons in Kwara State Nigeria went viral on the print and electronic media following the announcement by the State Governor a few years ago.

Collation of available data from memorabilia led to site investigation and interaction with key community leaders in the area (Figure 1) where oil and natural gas seepage had occurred.

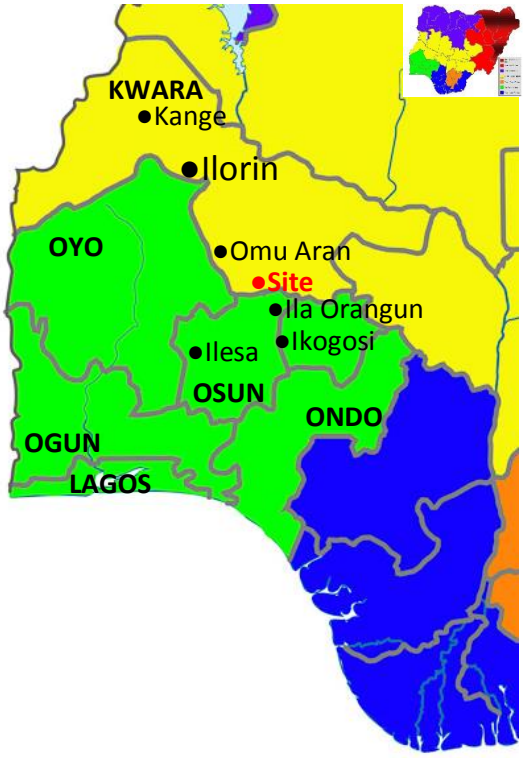

Figure 1: Map of Nigeria, showing the south western states in relation to the site of seepage

Field and limited laboratory data were used to develop three Conceptual models namely, a thermo-igneous model, a sedimentary model and migration and accumulation of hydrocarbons from several depocenters. With these concepts, we have tried to foster a road map for future studies of Inland basins

similar to the site of seepage of hydrocarbons in Kwara State.

PREVIOUS WORKS

The previous works may well be a labyrinth of research activities dating back to the colonial era before the country gained independence from the United Kingdom. The reports of the works of British Geologists namely (3,4) are relevant to subsequent researchers in Southwestern Nigeria. More recent activities include (5,6,7);Many of these research reports(8,9,10) did not focus on petroleum geology until very recently(11,12).

Therefore researchers have had to review previous works in the light of the ubiquitous exposures of outliers of sedimentary vestiges (13) within the basement complex of Kwara State. The recent report of hydrocarbons seepages in Kwara State led to reevaluation of previous research reports. This move has brought to the fore, the importance of tectonic bifurcation of the Niger River at Jebba in the mid to late Mesozoic.This tectonic episode formed paleo-channels and depo centers like Elebu. Following this are the careful studies of the Bida Basin by several workers which led to discovery of depocenters where marine sediments with macro and micro fauna were found(14).Elebu, in Moro LGA of Kwara State features prominently in the geology literature since the colonial era,(15) and a few others have documented the Elebu Limestone /Marble deposit. Of recent however, limestone/marble and other marine sediments (mudstone,calcareous marl.shale and carbonaneous limestone,have been found at Eleja,Biribiri,Babanloma and Fufu in Ilorin South LGA. The database has added support for theorizing about how the recent oil seepage came about. We subsume there must be some kind of entrapment of the crude oil below the surface before the seepage mechanism was initiated (16).

The marine sediments found in depocenters like the one at Elebu were found to contain macrofossils(Algeas, Gastropods, Brachiopods and Pelecepods).The sediments also revealed evidence of gravity tectonics(17). Furthermore, the marine sediments also contain macrofossils(foraminefera-showing the presence of Ammobaculites Sp.,Haplopgragmoides Sp.,Ammotium Sp., and Milliolina Sp.(18)Uniformly recrystallized micrite was also observed in the sediment as well as the absence of plankton foraminefera suggesting a shallow intertidal environment,where the muds are protected from wave action(19) Some studies (20) reported TOC (Total Organic Carbon), and SOM (Soluble Organic Matter) for some sediments in the Cretaceous outliers at the Elebu depocenter.Some of the limestone had flame structures and load casts. This as well as the presence of convolute bedding suggests plastic deformation of partially liquefied sediments(20). The TOC and SOM values for the recrystallized limestone range between 0.06-0.21%wt and 100- 360ppm respectively. The shales values are 1.20%wt for the TOC and 2090 ppm for the SOM.These values make the shale most promising in terms of hydrocarbon generating potential. The minimum threshold for this as given in the geology literature (21) is TOC of 0.5%wt and 150 ppm for SOM. It is noteworthy to observe that a shale-like material was found at the base of the quartzite ridge where the seepage had occurred.

CURRENT RESEARCH METHODS

The preliminary site investigation covered measurements of target points in the vicinity of a seepage point among six or seven that were reported by using a GPS to document the longitudes and latitudes. We also measured the elevation of the prominent quartzite ridge at the base of which the seeped crude oil was collected in containers of varying sizes. Several drums(200 liter capacity) shipped to states in the far north and the Southwest. Journalists and educated public passed the seepage for a result of vandalism on pipelines) in which the AGO namely, Associated Gas Oil spilled. There are no pipelines close to the seepage site, of course those who used the crude as diesel engine oil suffered significant losses as their vehicles knocked.

However, our guides who are local landowners had arranged for the analysis of the seeped oil sample in a standard laboratory (see Table 1).

The community leaders gave us some sample of the crude oil. Our team of investigators also collected soil and rock specimens for analysis in a laboratory in the UK.

The enthusiasm of the State Governor did not flag, rather some groups were encouraged to advance research efforts.

We therefore prepared an interdisciplinary research approach summarized below.

From the data gathered from a labyrinth of research data over a period of fifty years or more, we conjectured three conceptual models of origin for the seeped crude oil at Aran-Orin in Kwara State. First is, a thermo-igneous origin,a sedimentary origin, migration and subsequent accumulation of oil and gas from several depocenters within a 300 km radius(22) with the point of seepage center of the circle.

Paucity of data would call for detailed geological mapping of the seepage site. We also propose the following namely, earth resistivity, ArcGIS, and acquisitions and interpretation of aeromagnetic data of the target area.

PRESENTATION OF PRELIMINARY RESEARCH DATA.

Site description, quality control analysis of seeped oil, and geospatial analysis of the vicinity of the target area are presented in this section. Also presented is the laboratory analysis of the raw sample sent to a standard laboratory.

We noticed that the nearby stream flowed swiftly almost parallel to the base of the Ridge where seepage had occurred some twelve months before our visit .There was no sign of aquatic life in the stream.

The water appeared clear with no animals or even insects, no tadpoles which are common in the tropical rainforest zones.

This is odd, perhaps the exuding hydrocarbons had killed animal life forms with the exception of trees, ferns, and shrubs. This stream should be traced for some distance northwards to see if it will host living things like tadpoles frogs and fishes away from this site.

The chemical assays of the seepage is presented below.

Table 1. Report on crude oil sample characteristic

Report on Quality Control Analysis					
Sample: Crude Oil			Reference No: ICBLGL/PET/628/2011		
Source: Aran Orin, Kwara State. Nigeria			Client: Abmak Nigeria Enterprises		
Sampling Method:			Sample Drawn by: Afolarin A. Joshua		
Date of Sampling			Name of Chemist: A Imomoh		
Date of Reciept					
Date of Reporting					
Test	Unit	Method		Specification	Result
		ASTM	1P		
Density @ 15°C	g/ml	D 1298	160		0.9021
Flash Point	°C	D 93	34		115
API Gravity	60°F	D 1298	160		25.36
Pour Point	°C	D 979	15		+18
Water Content	% Vol	D 4006-07			0.15
Sediment by EXT	% Vol	D 473	53		0.06
Sulphur Content	% Wt	D 4294			0.222
Kin Viscosity @ 50°C	CST	D 445	71		17.8
Note: Analysis indicates the sample as low pour fuel oil. All the characteristics it exhibits is of residual oil and not crude oil.					

Oil pools and tar deposits often can be detected directly by remote sensing. Microseeps are more difficult to study using remote sensing, but they give rise to vegetation stress, and cause geochemical alterations in soil and rocks, which can be studied indirectly using hyperspectral sensors(USGS)

The Geospatial approach for the site investigation was an indirect method using hyperspectral sensor. Oil seapages will have effect on vegetation, causing vegetation stress. The NDVI (Normalize difference vegetation index) was used to analyze the USGS provided Landsat TM 5 in TIFF format and this data was converted to a format using ArcGIS for image processing using a USGS software. Our study area is under path 190 and row 54. These is in the south western part of Nigeria. each Landsat Scene has a unique identifier, our Landsat scene has an identifier L71190054_05420001113. all information about the landsat data is summarized in the table below.

Table 2.Summary of Landsat data for our site 5TM.

Data Set Attribute	Attribute Value
Entity ID	L71190054_05420001113
WRS Path	190
WRS Row	54
Acquisition Date	2000/11/13
Satellite	Landsat7
Map Projection	UTM
UTM Zone Number	31
Datum	WGS84
Ellipsoid	WGS84
Resampling Option	MTF
Orientation	NOM
File Size	291050065
Band Combination	123456678
Sun Azimuth	138.3480046
Sun Elevation	54.1329657
Center Latitude	8°40'55.34"N
Center Longitude	5°13'59.28"E
NW Corner Lat	9°39'28.27"N
NW Corner Long	4°21'51.23"E
NE Corner Lat	9°22'08.13"N
NE Corner Long	6°20'45.15"E
SE Corner Lat	7°42'28.53"N
SE Corner Long	6°05'53.13"E
SW Corner Lat	7°59'36.44"N
SW Corner Long	4°07'27.62"E
Center Latitude dec	8.6820401
Center Longitude dec	5.2331338
NW Corner Lat dec	9.6578532
NW Corner Long dec	4.3642316

landsat 5TM has 7 different bands. Below are details of band designation for Landsat 5 TM.

Table 3. Details of Landsat 5TM.

Band	Spectral Bands[1]	Wavelength (micrometers)	Potential Information Content	Resolution (meters)
Band 1	Blue	0.45 - 0.52	Discriminates soil and rock surfaces from vegetation. Provides increased penetration of water bodies	30
Band 2	Green	0.52 - 0.60	Useful for assessing plant vigor	30
Band 3	Red	0.63 - 0.69	Discriminates vegetation slopes	30
Band 4	Near IR	0.76 - 0.90	Biomass content and shorelines	30
Band 5	Mid IR	1.55 - 1.75	Discriminates moisture content of soil and vegetation; penetrates thin clouds.	30
Band 6	Thermal IR	10.40 - 12.50	thermal mapping and estimated soil moisture	120
Band 7	Mid IR	2.08 - 2.35	Mapping hydrothermally altered rocks associated with mineral deposits	30

NDVI is computed using the following formula: NDVI= NIR-RED/NIR+RED. RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared regions of electromagnetic spectrum, respectively. NDVI takes the value from -1 to 1. The higher the NDVI, higher the fraction of live green vegetation present in the scene.

The NDVI image is shown below.

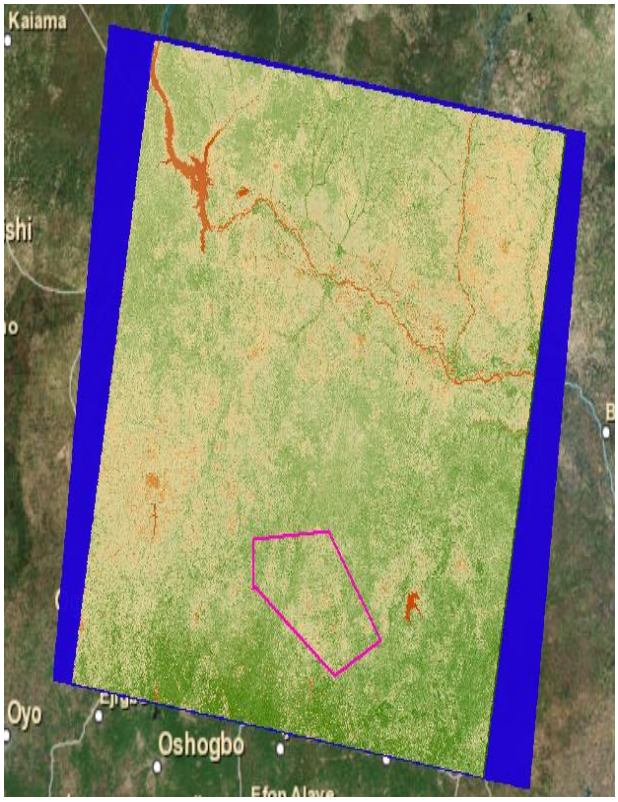

Figure 2.NDVI Image of Site.

The vegetation in the study area shows some indication of stress which was caused by the microseeps of hydrocarbons in the area.

CONCLUSION AND RECOMMENDATION

The quality of the oil sample analyzed is poor,nonetheless it confirmed the liquid collected

from the site is petroliferous. Secondly,we observed total absence of aquatic life in the nearby stream.Naturally one would expect to see small animals like frogs and small fishes in the swamp and in the river channel. Thirdly the geospatial data confirmed the impact of micro -seeps of hydrocarbons at the site of the seepage in Kwara State.

We therefore strongly recommend that a systematic study of the site using interdisciplinary approach like the one used here would solve the mystery of petroleum occurrence in Kwara State,which is part of the Nigerian Frontier Inland Basins.

ACKNOWLEDGEMENT

The authors will like to recognize the assistance of a number of organizations and people who assisted to make this publication a reality. These include Brock Adams of Appolo Mapping of Colorado,the USGS for granting free access to the Arc GIS Database used in this report.

References

1.Adegoke,S.O.(2013) Classified Government(Kwara) Document-Unpublished.

2.Alao,D.A.(2013)Classified Government(Kwara) Document -Unpublished.

3.Alao D.A. 2011. Oil discovery in Kwara: A geological appraisal. Unpublished

4.Hockey,R.D.and Jones,S.H.A. (1964).The Geology of part of south western Nigeria. Geological Survey of Nigeria Bulletin No 31 Vol 26,pp 1-47 .

4.Alao, D.A. and Annor A.E. 2001. Primary sedimentary features in Elebu Carbonates within the Precambrian Basement Complex of Nigeria.

5.Jones,H.A. (1955) The oolitic ironstone of Agbaja Plateau, Kabba Province . Record of Geological Survey of Nigeria, pp 20-43.

6.Annor,A.E (1986).A structural classification of the Precambrian basement complex of Nigeria. Nigerian Jour. Of pure and Applied Sciences,1,84-99.

7.Okonkwo,C.T. (1992)Structural Geology of basement complex rocks of Jebba Area, Nigeria Jour.Min.and Geol.28,203-209.

8.D.A. and Adekeye O.A. 2001. Paleoenvironmental Interpretation of Limestone occurrence at Elebu, Bida Sub-Basin, SW Nigeria. Dept. of Geology and Mineral Sciences, University of Ilorin, p 7-15

9.Alao,D.A. and Annor, A.E. (2001) Primary Sedimentary features in Elebu Carbonates within the Precambrian Basement Complex of Nigeria. NMGS Annual Int Conference Jos Bk of Abstract p.4

10.Alao D.A. and Adeniyi H.A. (2002) Source rock potential of limestone and shales of Basin at Elebu, southwestern Nigeria. NAPE Annual Meeting, Conference and Exhibition, Lagos, Nigeria. Bk. Of Abstract p A2

11.Alao,D.A et al (2001).

12.Alao,D.A et al (2002).

13.Alao,D.A.(2011).Oil discovery in Kwara :A geological appraisal Unpublished.

14. Alao,D.A. et al (2001).

15.Hockey R.D. and Jones S.H.A. (1964).

16. Alao,D.A. et al (2002).

17.Alao,D.A and Annor,A.E. (2001).

18.Alao,D.A. et al(2001).

19.Alao,D.A. et al (2002).

20.Gebhart H., 1997. Cenomanian to Turonian foraminifera from Ashaka NE Nigeria Quantitative analysis and Paleoenvironment interpretation. Cretaceous Resh. V. 18, pp. 17-36.

21. Tissot, B.P. and D.H. Welte, 1984. Petroleum Formation and Occurrence. 2nd Edn., Springer-Verlag, Berlin, ISBN: 0387132813

22.Hunt,J.M.(1979-Geology Book Series)Petroleum Geochemistry and Geology 743 pp.

Publisher W.F,Freeman & Co.Ltd.