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Research Article

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Hopanoid Study of Intra-Coastal Swamp Depobelt Oils, Niger Delta Basin

Selegha ABRAKASA[1], Emmanuel OYIBO[2], Embilakpo Michelle NABENA[3]

[1]Reader in Petroleum/Organic Geochemistry, Geology Department, University of Port Harcourt.
[2]Lecturer with Delta State Polytechnic.
[3]Senior Officer Training in Petroleum Engineering and Geosciences Department, Petroleum Training Institute, Effurun.
Corresponding Author's E-mail: selegha.abrakasa@uniport.edu.ng

Abstract: The intra depobelt study was undertaken to delineate possible verities of oils that could be observed within a depobelt and potential explanation for the observation, oil samples were obtained and analysis done via GC-MS and peak areas of interest were obtained from the percent report with which various parametric ratio were calculated. The study unraveled the fact that oils from Coastal Swamp depobelt showed significant differences and close similarities. The Nembe and Odeama Creeks Oils in the Eastern part of the depobelt showed very close similarities, while Clough Creek and Tebedaba oils in the Western part of the depobelt showed significant differences. The implication is that different facies generating different oils could be present within the same formation.

Keywords: Biomarker; Coastal swamp depobelt; Hopanoid.

1. Introduction

The Nigerian Niger Delta basin is prolific in petroleum exploration, basically due to favorable depositional environment and organic precursors with higher petroleum generation potential [5]. The formation of the Niger Delta has its origin from an alacogen that results in a failure arm of a triple junction during the opening of the Southern Atlantic, the failed arm is the Benue Trough that propergates into the continent [5].

Three petroleum systems have been identified in the Niger Delta basin, the first is a lacustrine system with a Neocomian source rock of the Aptian–Cenomanian age. The second is a marine system that corresponds to the Late Jurassic – Early Cretaceous age, while last is the Akata–Agbada Tertiary petroleum system, which is gas prone with little oil and is the most active [9]. The popular concept is that the Niger Delta basin was deposited as a process of continental runoff such that the sediments will accumulate at the edge until the angle of repose is exceeded and it will slide down into the continental slope [5]. Where the rate of deposition is faster than that of subsidence (burial), there will occur ineffective dewatering and the overburden that is bored by the grain to grain contact, over time will be bored by the interstitial water, thus ensuing the overpressure that is observed in the Niger Delta basin [12].

The Niger Delta has been described to be deposited in the form of megasequencies, which is repeated every 5Ma to 10Ma. Each magesequence has a width of about 30km to 60km, and invariably a depobelt [7].

Geological and geochemical data indicates that the geo-thermal gradient is about 3ºC/100m, which is equivalent to 30ºC/Km. The top of the oil window, has been reported to vary from 115ºC to 140ºC, this corresponds to 3.0Km to 5.2Km. thus generation of hydrocarbon (petroleum) commences approximately at the depth of 3.0Km in the Niger Delta basin [7].

Biological Markers (Biomarkers) also known as Molecular Markers compounds are present in petroleum and are derived from their respective organic precursors that consist the organic matrix from which the petroleum is generated [10]. These compounds earlier exist as biological polymers, they become modified and defunctionalized and existed as geopolymers basically kerogen. Biomarkers are actually the custodians of paleo information on maturity of oils, organic precursors of the oils, paleo–environment of deposition, age of the oil and biodegradation status.

The intra-depobelt study of oils implies characterization of oils from same depobelt for potential differences, otherwise by implication the same depobelt should present oils of similar or near similar characteristics.

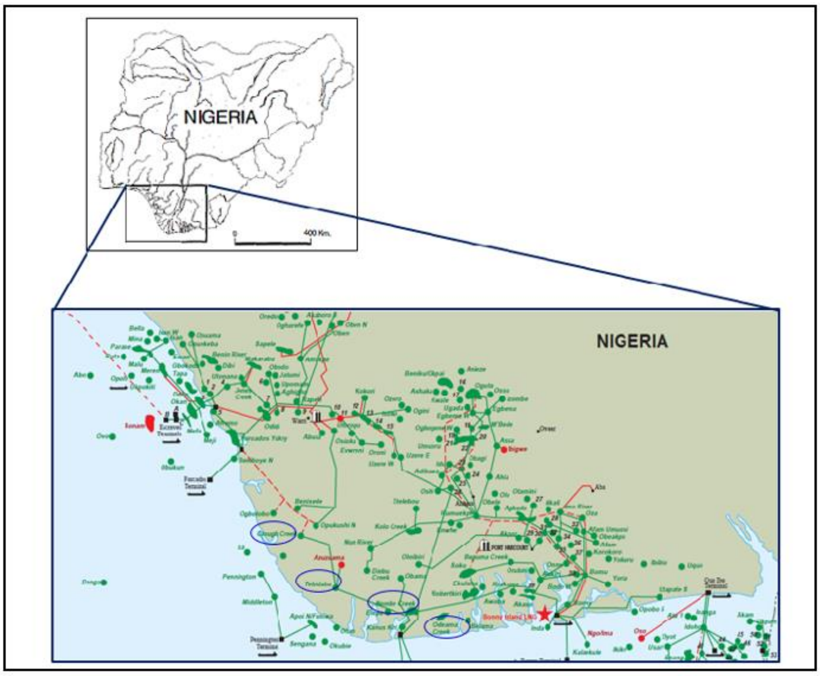

Fig. 1.

2. Samples and Sampling

Samples were crude oils generated from organic matter that has been incorporated into the source rock during deposition and diagenesis. The samples were obtained from the well-head of various wells in the oil fields. These samples are representative of the bulk in the reservoir. The sampling was done during well testing, while on well maintenance. Samples were subsampled into sample glass vials with Teflon caps. The samples were preserved in a chest of ice and were later stored in a refrigerator until analysis were performed. Chain of custody was not broken until analysis was per-formed.

3. Gc–Ms Analysis

The analytical subsamples were prepared by diluting 2mg by 2mL of hexane (AnalaR Grade) to obtain a 1µg/1µL con-centration, which is the recommended concentration for injection into the GC–MS equipment. [10]

GC-MS analysis for whole oil was performed and for monitoring of some fragment ions of biomarker compounds on a Hewlett-Packard 5890 GC model having both split and split-less injector. This was linked to a Hewlett-Packer 5972 MSD model having an electronic voltage of 1600V and interface temperature of 300C. The acquisition was controlled by a HP Vectra 48 PC ChemStation computer in full scan. The separation was performed on a fused silica capillary column (30x0.25 i.d.) coated with 0.25um, 5% phenyl methyl silicone (HP-%) which was supplied by HP which currently Agilent UK.

The data from analysis was obtained from ChemStation software, the EICs (extractable ion cheromatogarm) were extracted for m/z=191, which are the hopanes. The peak areas were extracted from the percent report, the peak areas served as the main data from the derivation of the various parametric ratios used in this study.

4. Results and Discussion

Table. 1. Parametric ratios in the study.

WELLS	1	2	3	4	5	6	7	8	9	10	11	12	13
Clough Creek	0.53	0.56	1.28	0.17	0.18	0.38	0.14	0.23	3.17	1.09	0.44	0.18	0.29
Tebedaba	0.49	0.49	1.85	0.28	0.23	0.97	0.48	0.26	3.67	1.64	0.68	0.27	0.79
Nembe Creek	0.45	0.56	1.00	0.14	0.12	1.14	0.10	0.18	2.31	0.52	0.32	0.16	0.13
Odeama Creek	0.45	0.55	0.78	0.16	0.12	0.34	0.20	0.19	2.58	0.73	0.35	0.11	0.17

1 Ts/(Ts+Tm)
2 S/(S+R)αβC31Hopane
3 Oleanane/C_{30}Hopane
4 Moretane/Moretane + C30αβHopane
5 Ts/Ts+αβC30 Hopane
6 Diahopane/αβC29Ts
7 αβC33-αβC35Hopane/αβC31-C35Hopane
8 αβC31R/αβC30 Hopane
9 Pr/Ph
10 Pr/nC17
11 Ph/nC18
12 αβC28 bisnorhopane/C29
13 αβC29 Nor-25-hopane/C29

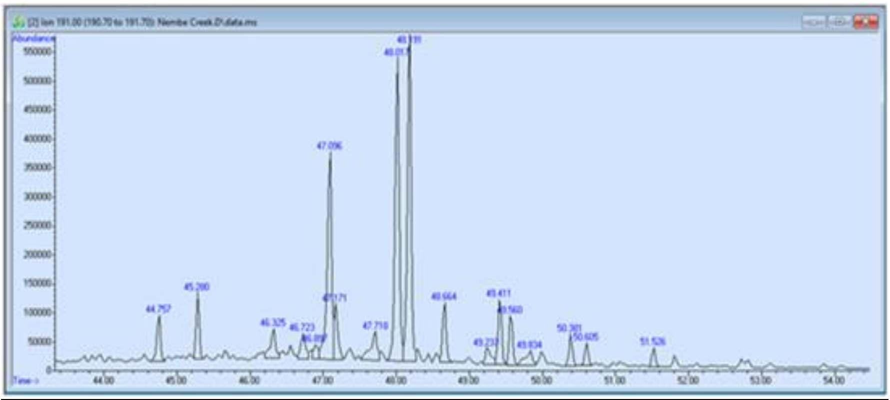

Fig 2. *EIC of m/z 191 for Nembe Creek Oil*

The chromatogram on fig.2. indicates that the homohopane are limited to C_{33} homohopanes. Hopanes are derived from bacteriohopanetetrol, which are lipids found in bacteria. They are modified via the process of diagensis into C_{27} hopanes to C_{35} homohopanes, the number of carbon atoms depends on the environments.

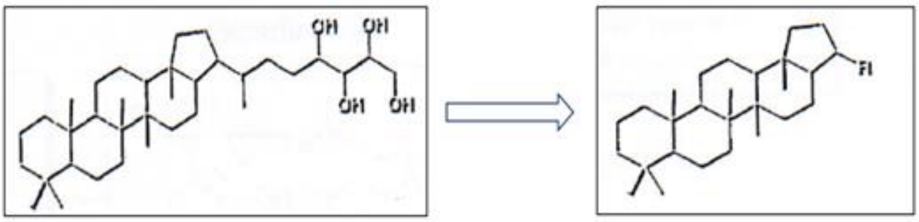

Fig. 3. *Conversion of hopanetetrapolyols to hopane*

Depositional Environment

The paleo depositional environment describes the ancient environment where the organic matter that generated the oils were incorporated into the source rock matrix. A plot of Pr/nC_{17} and Ph/nC_{18} as presented in fig.4. had been used as a preliminary tool for this assessment [6].

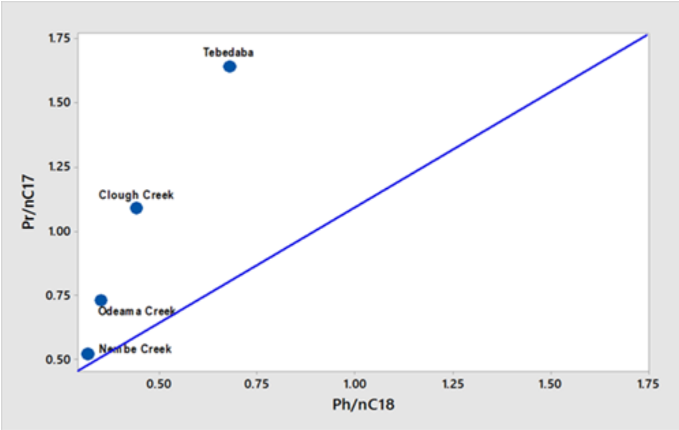

Fig. 4. *Plot of Pr/nC$_{17}$ and Ph/nC$_{18}$*

The plot show that the oils varies in their depositional environment from suboxic for Nembe and Odeama Creeks oils to oxic for Clough Creek and Tebedaba oils. Suboxic environments means a bit of marine settings. The plot has been used to delineate organic precursors and kerogen types.

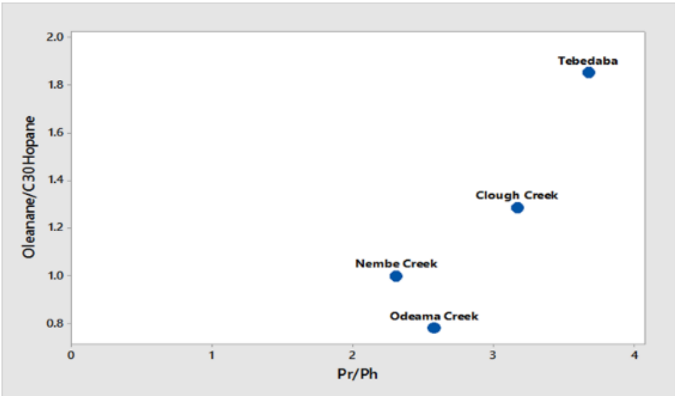

Fig. 5. *Plot of Oleanane/C$_{30}$ Hopane and Pr/Ph*

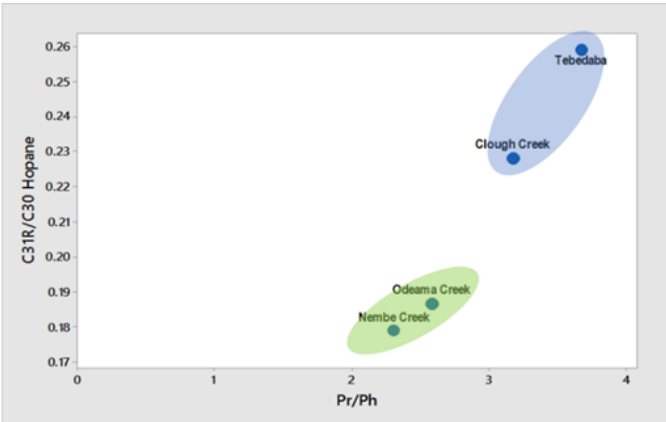

Fig. 6. *Plot of C$_{31}$R/C$_{30}$ hopane and Pr/Ph*

The presence of Oleanane in oils is diagnostic of deltaic environment with terrigenous materials consisting of landplants, the plot of C$_{31}$R/C$_{30}$ hopane and Pr/Ph as in fig.6. assesses the possible presence of lacustrine precursors in the matrix of the organic matter that generated the oils in this study. Low values of C$_{31}$R/C$_{30}$ hopane ranging between 0.10 to 0.25 has be used to indicate lacustrine contributions [10]. However, in this study, there seems to be some contributions but could be attributed to initial lacustrine environment that existed before the opening of the Southern Atlantic and eventual incursion of marine waters [2]; [3].

Organic Precursors.

The organic precursors are the organic matter from which the oils were generated, there exist classes of organic precursors depending on the environment in which they existed and were deposited, these ancient former living organisms are specific for certain environments and inherit specific traits. Oleanane is derived from angiosperms that is present in flowering plants of the land plant family [4], which be-came dominant in the Cretaceous. Its presence in oil implies that the oil is source from flowering land plants materials. Fig.5. indicates that Oleanane/C_{30} hopane ratio, which is also referred to as Oleanane index is high in Tebedaba and Clough Creek oils relative to Nembe and Odeama Creeks oils, this observation could be attributed to the shallowness of the Western Coastal Swamp depobelt relative to the East-ern [11], allowing for more terrigenous contributions as continental runoffs.

Fig.6. a plot of $C_{31}R/C_{30}$ hopane and Pr/Ph indicates that Nembe and Odeama Creeks oils have lower values implying more lacustrine contributions relative to Tebedaba and Clough Creek Oils.

Age.

The age of oils could also be assessed espcially for those that are of cretaceous age and earlier. More specifically, if the Oleanane index is greater than 20%, then the age is tertiary, in this study, the Oleanane index is greater than 20% for all oils, thus the suite of oils used in this study are all of Tertiary age [10].

Maturity.

Maturity can be defined as the totality of diagenetic processes an organic matter undergoes to enable the generation of oil, from a biopolymer to a geopolymer and to kerogen and the eventual break down of kerogen via cracking. Maturity can be accessed via transmitted or reflected white light micros-copy, rock eval pyrolysis, or molecular marker isomerization ratios [10].

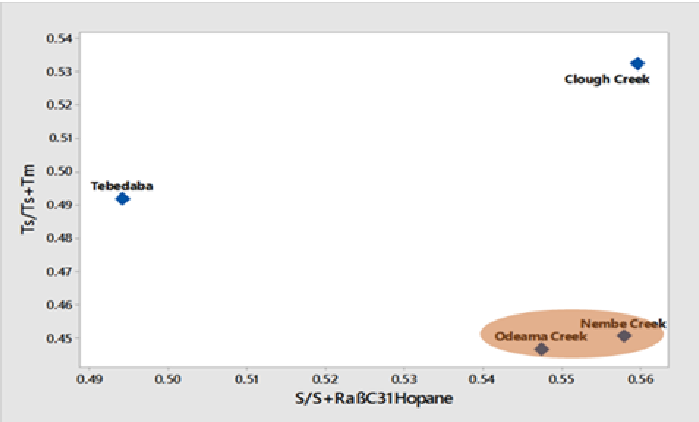

Fig. 7. *Plot of Ts/Ts+Tm and S/(S+R)αβC_{31} hopane*

In this study, Ts/(Ts+Tm) and S/(S+R)αβC_{31}hopane has been evaluated which are normally used as maturation parameters and the plot of Ts/Ts+Tm and S/(S+R)αβC_{31} ho-pane as in fig.7, indicates that Nembe and Odeama Creeks oils show close maturity values for Ts/Ts+Tm and S/(S+R)αβC_{31}hopane

This observation implies that the Nembe and Odeama Creeks oils are generated from the same source rock and by maturity values, they are moderately mature. However, the Tebedaba and the Clough Creek oils show very significant difference, even though they are in the Western part of the Coastal Swamp depobelt. The implication is that the oils are generated by slightly different facies within the same source rocks

5. Conclusion.

In this study, how variable oils could be within a depobelt was evaluated and in the Coastal Swamp depobelt of the Niger Delta basin, the suite of oils show some differences and similarities, this implies that there exist source rock with different facie combination within a formation and in this case a depobelt with different maturity profile.

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