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Research Article

GENERIC EVALUATION OF OILS FROM GREATER UGHELLI AND CENTRAL SWAMP DEPOBELTS OF NIGER DELTA BASIN

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ABSTRACT

The geochemistry of (21) oil samples and (4) reservoir core samples collected from the Obiafu, Obagi, and OML 61 in the Greater Ughelli and Central Swamp, depobelts of the Niger Delta Basin were investigated. Whole oil analysis using GC-MS was carried out with reference to source organic matter, deposition environment, maturity, biodegradability profile, and reservoir structure to identify generic and genetic features of the oils. All of the oils tested contained oleanane, a diagnostic biomarker for organic matter found in vascular plant materials and oils from the Cretaceous period and younger. A cluster of oils was discovered in the plot of Oleanane/C30 Hopane vs Waxiness, indicating that terrigenous and small algal contributions are significant. The presence of Oleanane and a high Pr/Ph ratio in the oils, as well as the DBT/P vs Pr/Ph ratio, indicate that the Paleo depositional environment was deltaic. The Ts/(Ts+Tm) and C31Hopane maturity isomerization ratios were not significantly different between Obiafu, Obagi, and OML 61 oils. The organic precursors were delineated to be vascular plant material for some Obiafu oils and algal materials for some Obagi oils while the OML oils were shown to have mixed precursors. Kerogen typing for the oils also show type II for Obagi oils and type III for Obiafu Oils.

The biomarkers in the oils are arranged in a star pattern, implying fluid connectivity and a consistent reservoir structure across the fields. According to PC analysis of the oils tested, Obagi and OML oils are end member oils, but Obiafu is thought to be a blend of Obagi and OML 61 contributions. The consistency of crude oil content suggested a single large reservoir split by fault lines rather than multiple independent reservoirs developed over time.

Keywords: Pristane/phytane ratio, biodegradation, biomarkers, maturity, Niger Delta.

INTRODUCTION

A diagenetic pathway for source organic matter within petroleum generation explains the transformation of source organic matter to petroleum (Tissot and Welte, 1984). For accumulation of petroleum to economic quantity, favourable geologic development, features and factors must be present at the appropriate time and space (Magoon and Beaumont, 1999). In other to generate hydrocarbons within a Formation , it is required that kerogen receives an ample amount of heat transmission necessary for diagenesis. The temperature is attained by subsidence and burial through the overburden rock. When the hydrocarbon is generated from the sedimentary rock it migrates into vastly permeable strata (vast sandstone) in some cases via faults line.

Accumulation develops merely after large porosity strata (sandstone/limestone) are filled of migrating hydrocarbon which had been restrained from further migration. The entrapments architecture results from changes in structure and stratigraphy of the sedimentary rock caused by several processes which may include tectonics. This architecture leads to constrain of hydrocarbon migration especially when the porous strata is underlain by sealing strata. Ordinarily this geologic element (factors) availability alone may not be adequate for the preservation of hydrocarbon reserves. The timing must be proper which entails, the availability of the traps during hydrocarbon migration. Guarantee of its seal's cohesion is essential once a reservoir is charged. Petroleum System is defined by these elements (figure 1).

Aim of Research:

The aim of this research is to unravel the biomarker geochemistry of Obiafu, Obagi and OML 61 fields and using generic biomarkers as a tool to delineate the paleo-depositional settings of the source-organic matter that produces the oil as well as depict its thermal maturation.

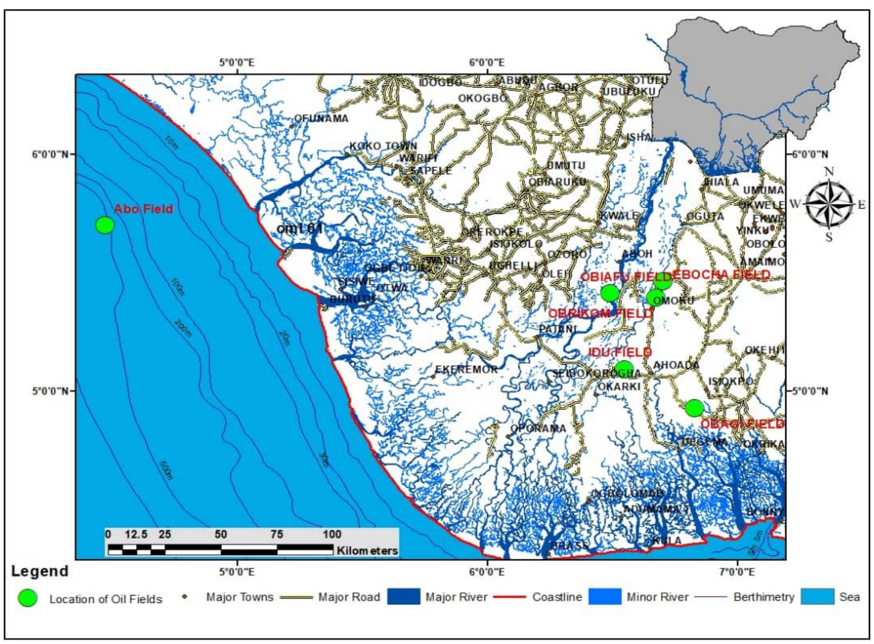

Figure 1: A topographic map showing the fields under the study area

MATERIALS AND METHODS

The suite of oils and core samples were subjected to lithologic, biomarker, and kerogen examination. A total of twenty one crude oil and six core samples were collected from seven wells each, spanning three fields: Obagi, Obiafu, OML 61, and Abo. The fields also cut across three depobelts namely Greater Ughelli depobelt, Coastal swamp and offshore depobelts. These samples were taken from well heads and placed in a sample vial with Teflon caps before delivery to the laboratory for analysis.

Methods:

This study's analytical methodologies comprised gas chromatography/mass spectroscopy which was used to determine biomarkers in all twenty-one oil samples and four core samples.

Full scan GC-MS data (m/z 57, 178, 184, and 217) were obtained. Aromatics and saturates are detected using GC-MS. This was done for all of the oil samples in the collection.

To extract the organic matter components from the core samples, the optical methods employed this study are typical palynological techniques. Kerogen analyses were performed on a portion of the remaining core samples collected after palynological preparations. The following are the steps that were taken

Dissolution of carbonates: The samples are subjected to treatment with Hydrochloric acid (HCl_{aq}) to dissolve any carbonate. The samples are at that point completely washed with condensed water after emptying the HCl_{aq}.

Dissolution of silicates: The addition of Hydrofluoric acid (HF_{aq}) to the treated samples used to break down the silicates. The samples are mixed at standard ratios with a plastic or nickel bar and then cleared out overnight. Samples are completely washed with condensed water after tapping the HF_{aq}.

Removal of fluoride gels: The samples are at that point treated with warm 36% HCl_{aq}, and after thatcoldHCl_{aq} to dissolve fluoride gels and washed with condensed water.

Residue Separation: The following strategy is to wash with 0.5% $HCl_{aq}$and after that exchange the tests into little 15cc. Centrifuge tubes. The 0.5% HCl_{aq} is tapped after centrifuging and the Zinc bromide (s. G.2.2) is included and mixed with glass bar. After centrifuging, the drifting portion comprising of is tenderly emptied into another tube. That residue will be tapped into another tube and then washed withdistilled water.

Neutralisation of acids: Warm Potassium hydroxide (KOH_{aq}) is included to the residues and kept for around 5 minutes. It is centrifuged and the KOH_{aq}tapped. The residue is washed approximately 2 or 3 times with distilled and deionized (D&D) water in orange to guarantee that all KOH_{aq} is washed out. The residue is at last washed twice with alcohol.

Preservation of residues: The residues are protected by including a drop of glycerol/glycerin to each of the well-labeled phials. They are then stored in water.

Preparation of microscopic slides: In the center of a clean slide, a small amount of mounting medium is placed, and a small amount of organic residue is added and warmed. The mixture is equally spread out on the slide, which is then covered with a cover slip and labeled with sample location names.

RESULTS AND DISCCUSSION

The results of the lithologic, biomarker and kerogen analysis carried out on the suite of oils and core samplesare discussed as follows.

Lithologic Description:

The description and identification of Samples was carried out using observable physical . cores were however not sampled for Obiafu wells.

Wells	Depth	Lithology	Mud	Sand						Gravel				Texture	Lithofacies	Shale/Sand	Formation
			Shale	Silt	Very fine	Fine	Medium	Coarse	Very coarse	Granule	pebble	Cobble	boulder				
Oml 61-2	3060													Light brown colour, veryfine to medium grain, subangular to subrounded, moderately to wellsorted, sediments with fossil content	Silty Sandstone	40% 60%	Agbada

Figure 2: Lithofacies analysis of samples from OML 61 well 2, Central Swamp Depo belt.

Wells	Depth	Lithology	Mud	Sand						Gravel				Texture	Lithofacies	Shale/Sand	Formation
			Shale	Silt	Very fine	Fine	Medium	Coarse	Very coarse	Granule	pebble	Cobble	boulder				
Oml61-7	3335													Grey colour, very fine to clay subrounded to moderately rounded indurated sample with fossil content	Sandy Clay	80% 20%	Agbada

Figure 3: Lithofacies analysis of samples from OML 61 well 7, Central Swamp Depo belt.

Wells	Depth	Lithology	Mud	Sand						Gravel				Texture	Lithofacies	Shale/Sand	Formation
			Shale	Silt	Very fine	Fine	Medium	Coarse	Very coarse	Granule	pebble	Cobble	boulder				
Obagi 2	3335													Dark grey colour, friable, very fine to clay subrounded to moderately rounded sample withfossil content	Sandy Clay	80% 20%	Agbada

Figure 4: Lithofacies analysis of samples from Obagi well 2, Coastal Swamp Depo belt.

Wells	Depth	Lithology	Mud	Sand						Gravel				Texture	Lithofacies	Shale/Sand	Formation
			Shale	Silt	Very fine	Fine	Medium	Coarse	Very coarse	Granule	pebble	Cobble	boulder				
Obagi 7	3415													Lightgrey colour, friable, fine to clay grain, subrounded to moderately rounded, sample without fossil content	Sandy Clay	85% 15%	Agbada

Figure 5: Lithofacies analysis of samples from Obagi well 7, Greater Ughelli Depo belt.

WELLS	Ts/Ts+Tm	S/S+RαβC31Hopane	S/S+RαβC32Hopane	Oleanane/C30Hopane	P/DBT	Pr/Ph	Pr/nC17	Ph/nC18	TAR	WAXINESS	CPI	DBT/P
OBIAFU 1	0.45	0.56	0.6	0.46	10.91	3.04	3.26	0.96	0.33	7.1	1.04	0.09
OBIAFU 2	0.48	0.53	0.59	0.47	15.74	3.12	3.29	0.95	0.26	3.65	1.09	0.06
OBIAFU 3	0.51	0.57	0.57	0.48	11.44	3.08	3.05	0.9	0.33	4.02	1.06	0.09
OBIAFU 4	0.47	0.54	0.59	0.48	11.68	3.14	3.05	0.91	0.21	5.1	1.12	0.09
OBIAFU 5	0.49	0.52	0.58	0.51	10.6	3.46	3.18	0.96	0.23	5.89	1.11	0.09
OBIAFU 6	0.49	0.54	0.58	0.47	13.07	3.4	3.21	0.92	0.4	5.17	1.07	0.08
OBIAFU 7	0.45	0.55	0.59	0.48	12.38	3.07	3.2	0.94	0.29	6.39	1.09	0.08
OML 61 -1	0.48	0.58	0.6	0.41	3.84	3.88	2.81	0.91	0.01	6.78	1.12	0.26
OML 61 -2	0.5	0.57	0.59	0.47	7.24	2.87	2.62	0.87	0.7	4.17	1.03	0.14
OML 61 -3	0.47	0.55	0.58	0.46	6.38	2.97	2.84	0.9	0.22	4.17	1.1	0.16
OML 61 -4	0.46	0.55	0.59	0.51	6.33	3.41	2.78	0.92	0.31	5.54	1.07	0.16
OML 61 -5	0.49	0.53	0.58	0.49	3.73	3.4	2.6	0.9	0.06	7.23	1.16	0.27
OML 61 -6	0.47	0.52	0.56	0.44	5.72	2.93	2.61	0.9	0.26	4.72	1.1	0.17
OML 61 -7	0.48	0.54	0.58	0.45	6.04	2.94	2.7	0.89	0.28	4.84	1.06	0.17
OBAGI 1	0.47	0.53	0.58	0.48	6.68	3.84	3.15	0.95	0.06	8.57	1.21	0.15
OBAGI 2	0.47	0.56	0.6	0.47	8.02	3.51	2.97	0.97	0.1	7.22	1.21	0.12
OBAGI 3	0.41	0.57	0.61	0.46	22.08	2.83	3.04	0.92	0.14	8.1	1.13	0.05
OBAGI 4	0.42	0.51	0.6	0.5	17.42	2.86	3	0.95	0.21	6.97	1.02	0.06
OBAGI 5	0.41	0.53	0.61	0.62	32.62	2.59	2.79	0.99	0.32	5.9	1.1	0.03
OBAGI 6	0.42	0.52	0.58	0.47	16.59	2.97	2.85	0.97	0.12	7.77	1.07	0.06
OBAGI 7	0.44	0.53	0.6	0.61	11.46	3.57	2.84	0.97	0.08	8.21	1.24	0.09

Table 1: Biomarker Ratios

DISCUSSION

The lithologic analysis of the samples indicated that OML 61 samples are indurated and with much less shale/sand. Shaliness expanded downwards. Obagi samples had been friable with an expanded shaliness. The extra shale /sand indicate deposition underneath high energy figure 2-5.

The results from the geochemical analysis were used to generate some diagnostic ratios. Plots of the ratios was used for the generic characterization of the fields as follows:

Biodegradation Status:

In contrast to biodegradation, n- alkanes are produced faster than isoprenoids as maturity increases (Waples, 1985), Nwadinigwe and Alumona, 2018). Biodegradation status inferred from figure 6 indicates that Obiafu oil is most degraded, while the OML-61 oil is least degraded**,** the Obagi oils are averagely degraded, the degradation of oils in the reservoir is fostered by the availability of nutrients, which in this case are minerals and oxygen, oxygen is available in the form of oxides and sulphate and nitrates. The profile of degradation may suggest that the orientation of the reservoir may be that of a tilted reservoir, whereby water may be much more available in one end relative to the other (Abrakasa and Nwankwo, 2019).

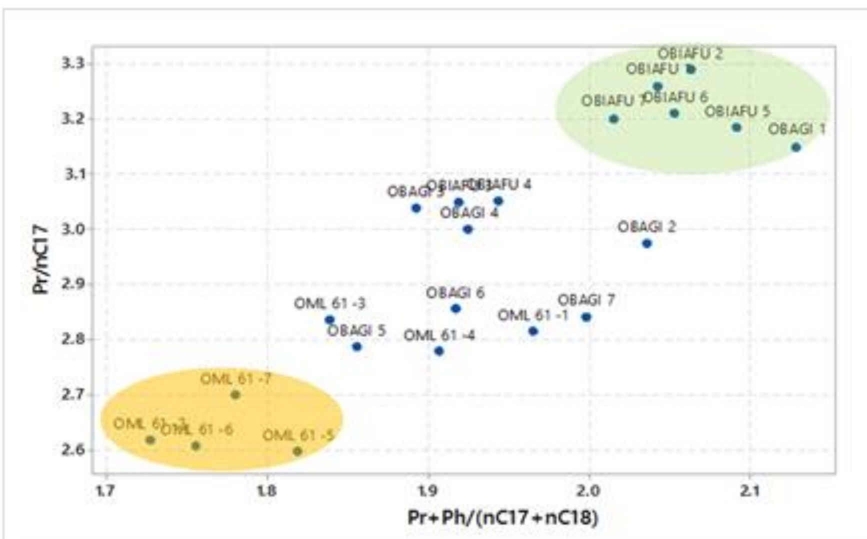

Figure 6: plot of Pr/nC$_{17}$ against Pr+Ph/(nC$_{17}$+nC$_{18}$)

Organic Precursors:

Figure 7, which is a plot of Pr/nC$_{17}$ against Ph/nC$_{18}$show that most of the samples are clustered along the diagonal, however, that Obagi wells 5,6,7 oils show dominant algal contributions relative Obiafu wells 3,4,6 with terrigenous contributions for their source organic matter. Also figure 8, the Pr/Ph versus the Terrigenous Algal Ratio show that the Obiafu oils are more terrigenous compared to the Obagi oils. This observation implies that the Obiafu oils were derived from organic matter that are dominant in plant materials while the Obagi oils were soured from organic matter with more algal materials.

The OML oils are in between inferring equal contribution of terrigenous and algal materials in their organic matter.

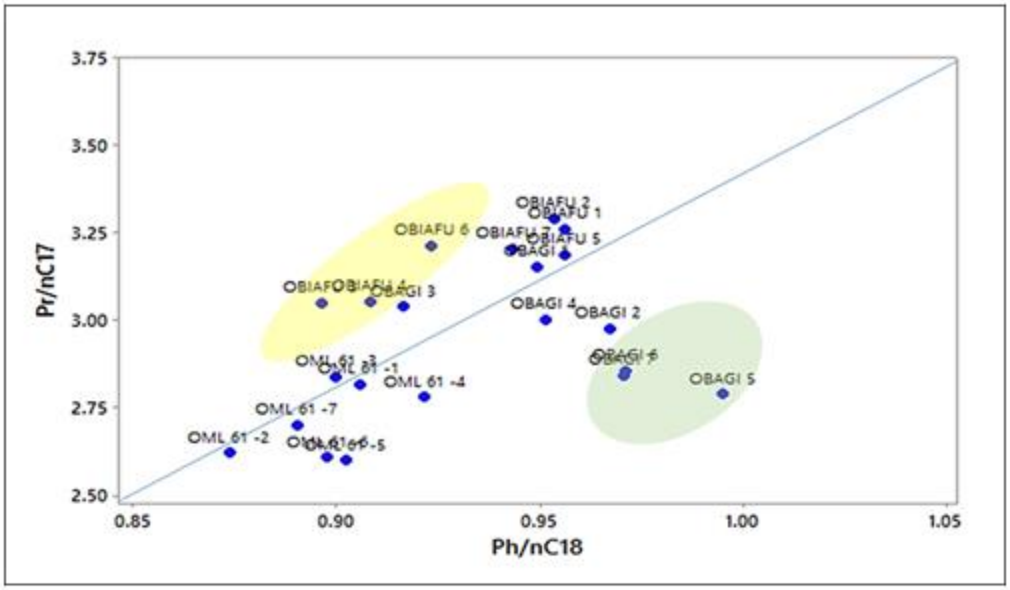

Figure 7: plot of Pr/nC_{17} against Ph/nC_{18}

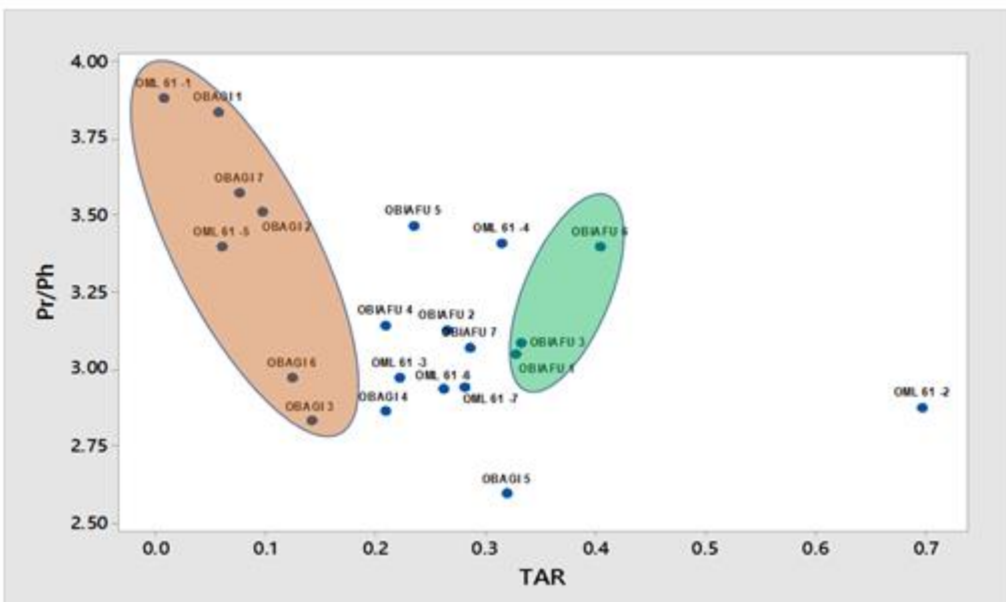

Figure 8: Plot of Pr/Ph and Terrigenous Algal Ratio

Figure 9 is the plot of Waxiness against TAR, it shows that Obagi oils has more Algal contributions and higher waxiness relative to Obiafu oils, waxiness infers the presence of higher molecular weight hydrocarbons (higher than C_{35}). Higher molecular weight hydrocarbons are normally derived from marine algae or lacustrine algae (Moustafa and Morsi, 2012)

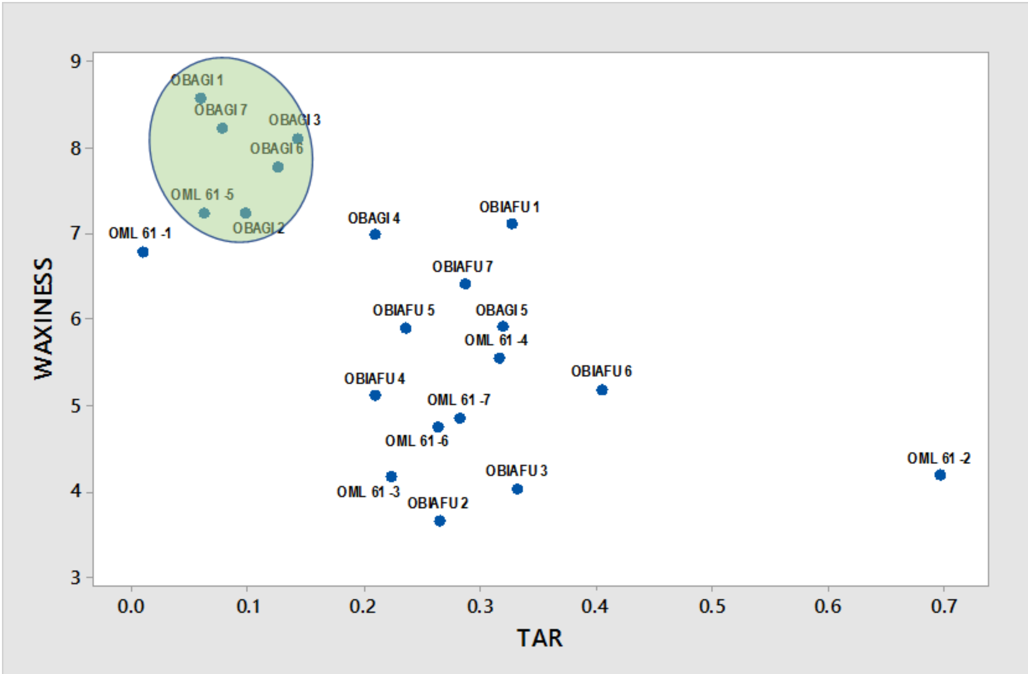

Figure 9: Plot of TAR against Waxiness

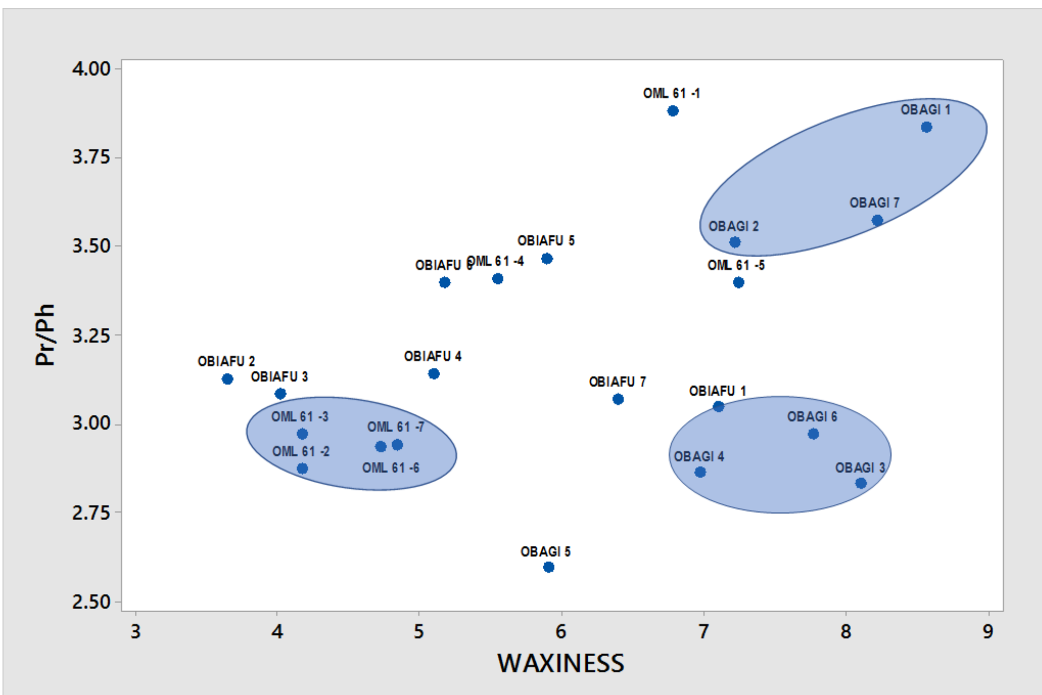

Figure 10: Plot of Pr/Ph against Waxiness

Figure 10 show that OML oils are lower Pr/Ph values while the Obagi oils have higher values of Waxiness ratio. This implies that the OML oils of less oxic environment show less Waxiness, while Obagi oils of moderate to high oxic condition have high waxiness. Moderate to high waxiness entails more terrigenous conditions, more contribution of vascular plant materials that are rich in longer hydrocarbon chains i.e., $C_{38.}$ The OML oils with lower values show shorter carbon chains i.e., C_{28} and lower waxiness.(Killops, 2005).

Maturity of the Oils:

The CPI (carbon preference Index) represent the change in distribution of hydrocarbon chain during maturation, the oil in early stage is always immature with a lot of Odd over Even Preferences (CPI >>1) as maturity ensures the differences smoothens off such that OEP become CPI= 1.The observation occurs as a result of random cleavage of alkyl groups while generating oils and loss of the component that have odd preference during generation and expulsion. (Killops, 2005). According to, CPI value of unity and above is an indicator of maturity (Tissot and Welte 1984), Jihad, et al, 2019). For all three fields, a CPI value of 1 was recorded which in turn confirms source organic matter's maturity thus, CPI of 1 indicates mature oil. Figure 11 is a plot of Pr/Ph and CPI, the plot does not show any particular trend, the oils are mixed up. Less oxic condition goes with lower CPI while, higher Oxic condition goes with higher CPI (Killops, 2005).

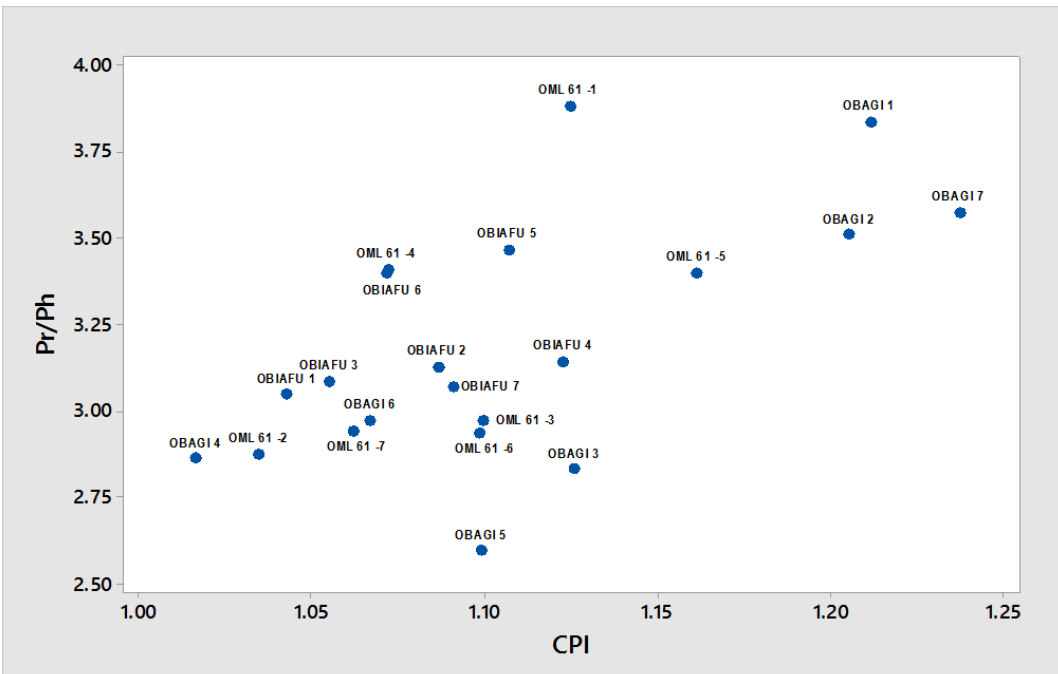

Figure 11: Plot of Pr/Ph and CPI.

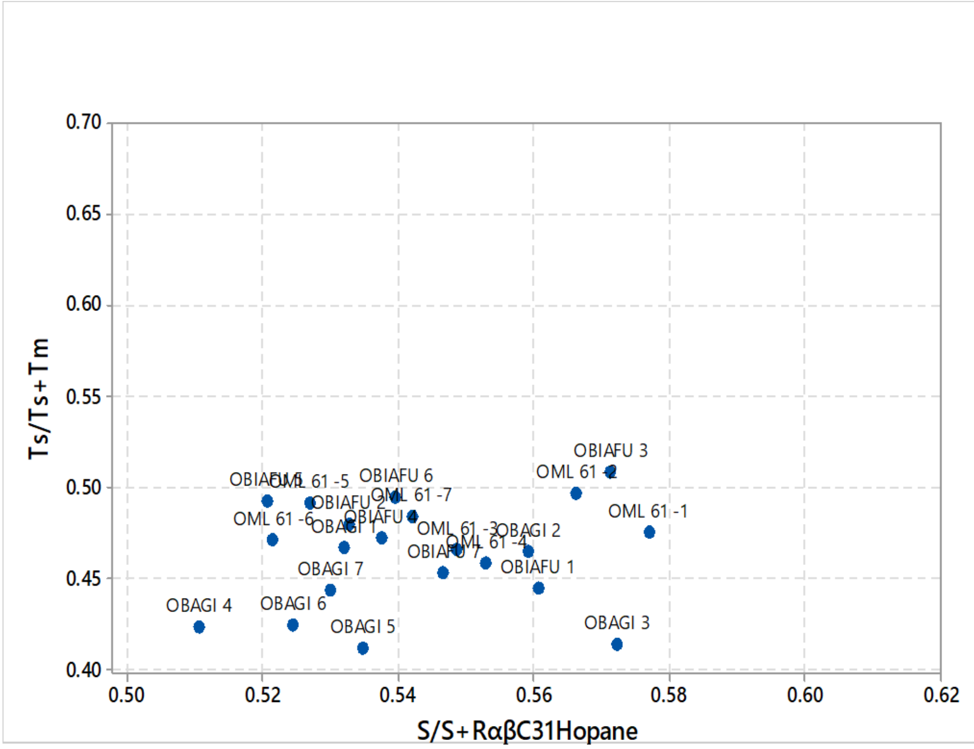

Figure 12: of Ts/Ts+Tm against S/S+RαβC31

Ts/Tm ratio decreases quite late during maturity (Van Graas, 1990), (El Nady & Mohammed, 2014).Ts / (Ts + Tm) against S/(S+R) αβC31 Hopane plot from figure 12, for maturity did not show any significant difference between oils from Obiafu, Obagi and OML 61. The oils are within similar maturity range and represents oils source from same or similar source rock, (Zhang, 2017). The observed gradient can be used to deduce the direction of petroleum emplacement

Environment of Deposition:

The paleo environment is the ancient where the precursors were incorporated in the rock formations. Figure 7, show that the Obiafu oils displayed some deltaic condition, while the Obagi oils show marine characteristics. The OML oils are clustered within the diagonal which implies near-shore or coastal environment (Hanson et al., 2000).

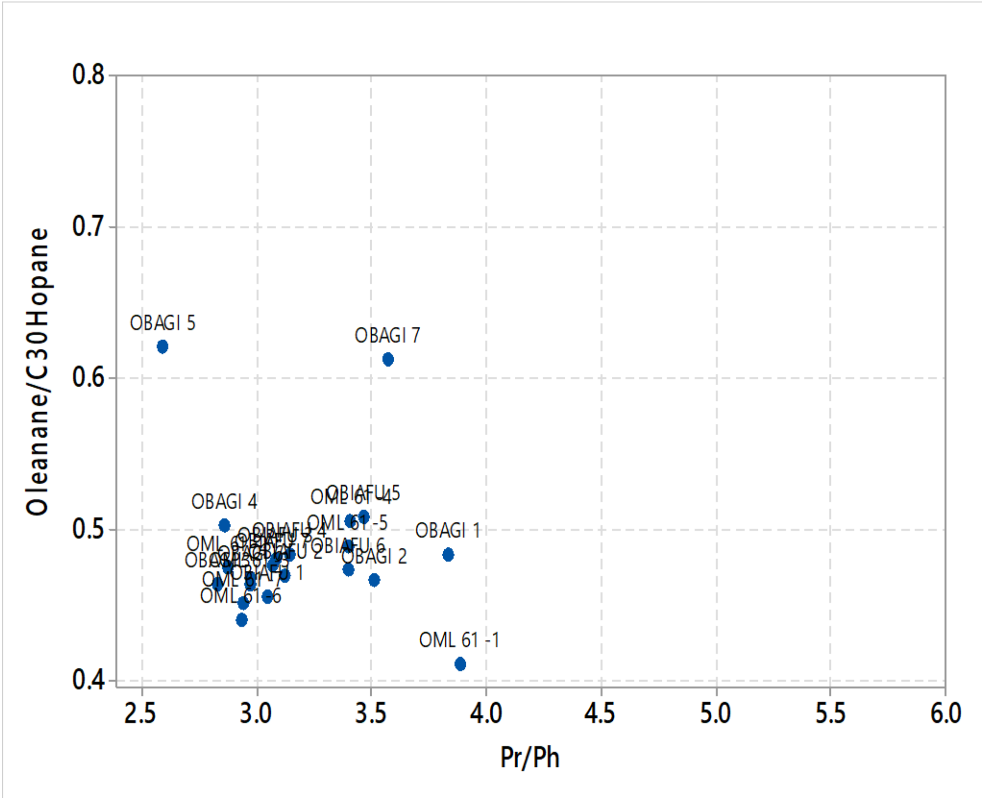

Figure 13: Oleanane/C30 Hopane against Pr/Ph for the suite of oils

According to Hunt, (1996) and Zhang, (2017), a Pr/Ph ratio of 1- 3 indicates an oxidising depositional environment . A Pr/Ph ratio of 2-4 indicates a deposition environment of river marine and coastal swamps (Lijmbach, 1975). From figure 13 as shown the source organic matter that formed the spectrum of oils was thus believed to have come from a deltaic paleo-environment.

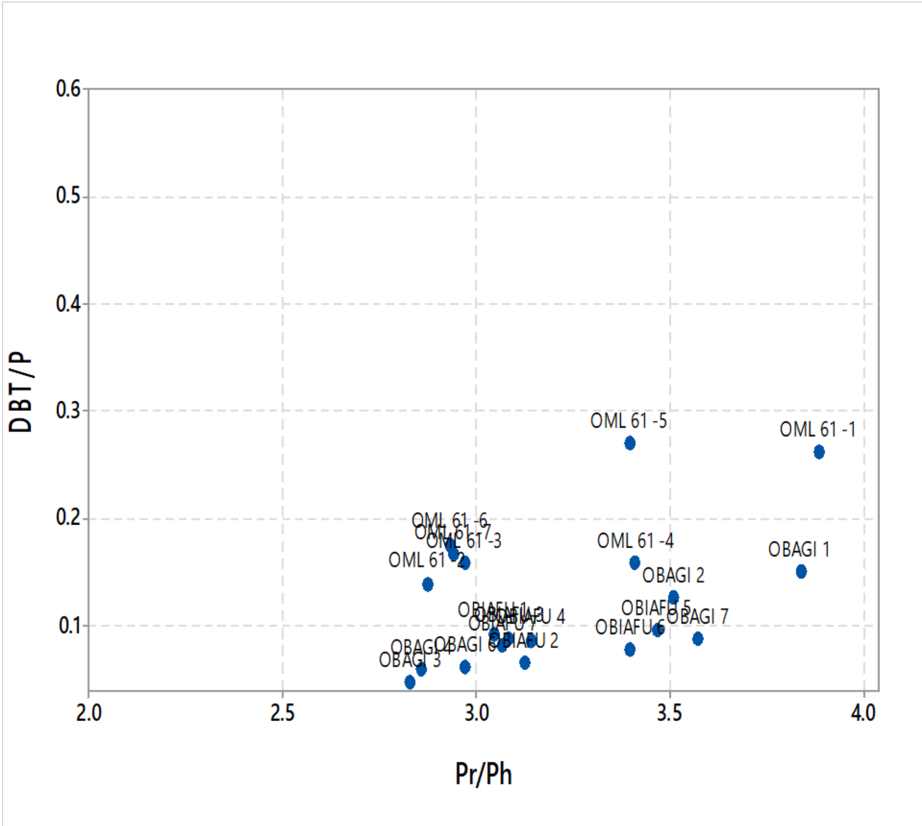

Figure 14a: DBT/P against Pr/Ph for the suite of oils

Figure 14a show plot of DBT/P against Pr/Ph ratio, which further confirms the organic matter for the suite of oils as fluvio deltaic. They all plotted in Zone 4 of (Hughes et al, 1995), (Aboglila et al, and 2010) as seen in figure 14b below.

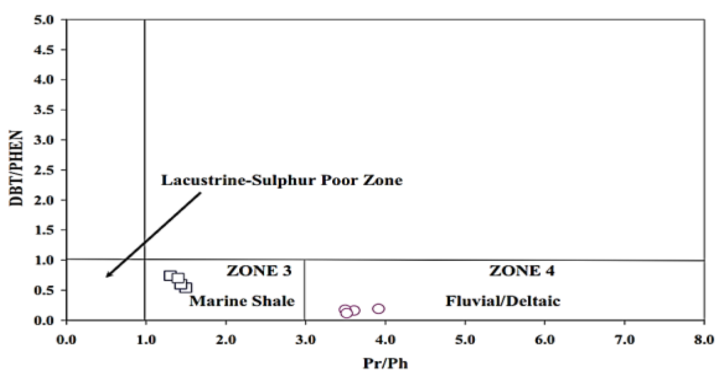

Figure 14b: DBT/P Vs Pr/Ph Hughes et al 1995

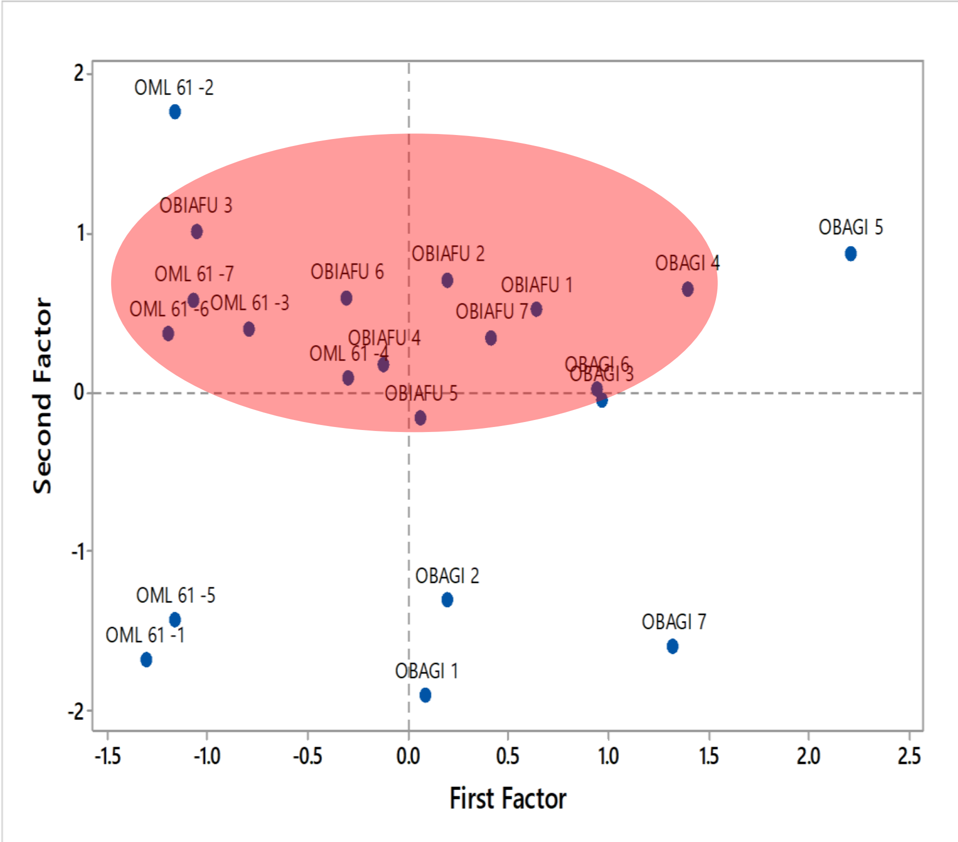

Figure 4.35: A Principal Component Analysis for the suite of oils

The chromatograms are de-convoluted using principal component analysis, which produces better results than fingerprinting (Moustafa and Morsi, 2012). From figure 15 the Obagi and OML oils are End Member oils, according to the Principal Components analysis of the suite of oil. Obagi and OML 61 oils are thought to have contributed to the Obiafu oils.

Kerogen Typing:

Kerogen typing refers to the composition of kerogen that will be formed as the biological molecules converts to geological molecules from which oil is generated. The composition of the kerogen depends on the composition of the contributing organic matter. Figure 7 is a composite figure that can be used for preliminary studies, the plot show that Obiafu Oils for wells 3,4and 6 is generated from type III kerogen while Obagi oils for wells 5, 6 and 7 by virtue their positions in the figure 7 are generated from type II kerogen. Type II kerogens generate and expel oils with high fuel value and are dominant (Hanson et al, 2000).

CONCLUSION

The suite of samples studied showed that Obiafu oils are the most degraded while Obagi oils are moderately degraded and the OML oils are the least degraded. The CPI values shows that the oils are slightly mature to moderately mature, while environment of deposition has been evaluated to be nearshore to coastal environments. The kerogen typing for the suite of oils is type III for Obiafu oils and type II for Obagi oils. The organic precursors of the oils are delineated to be vascular plant materials for Obiafu oils and algal material for Obagi oils, most of the OML oils are shown to be generated from kerogen that consist of both vascular plant materials and algal materials.

REFERENCES

1. Aboglila, S., Grice, K., Trinajstic, K., Dawson, D., & Williford, K.(2010). *Use of biomarker distributions and compound specific isotopes of carbon and hydrogen to delineate hydrocarbon characteristics in the East Sirte Basin (Libya). Organic geochemistry 41(2010) 1249-1258 .Retrieved from www.elsevier.com/locate/orggeochem.* Journal for spreadsheets in education (ejsiE), *7(2)*, 3.
2. Abrakasa, S. and Nwankwo, C. 2019. Journal of Research in Environmental and Earth ScienceVolume 5~ Issue 1 (2019) pp: 27-35
3. El Nady., & M, Mohammed, S. (2014). Biomarker characteristics of crude oils from Ashrafi and GH oilfields in the Gulf of Suez, Egypt: An implication to source input and paleoenvironmental assessments.Egyptian journal of petroleum, 23(4),455-459.
4. Farrimond P, Stoddart DP and Jenkyns HC (1994) An organic geochemical profile of the Toarcian anoxic event in northern Italy. Chemical Geology 111(1–4): 17–33.
5. Jihad, W., Naqshabandi, F.,& Al-Jaboury, Kh.(2019). *Practical Hydrocarbon Generation Potential of Chia Gara Formation in Three Selected Wells, Northern Iraq. DOI: 10.1515/geo-2019-0007.*
6. Hanson A.D, Zhang S.C, Moldowan J.M, Liang D.G, Zhang B.M (2000) Molecular organic geochemistry of the Tarim Basin, Northwest China. AAPG Bull 84(6):1109–1128
7. Hughes, W. B., A. G. Holba, and L. I. P. Dzou (1995) The ratios of dibenzothiophene to phenanthrene and pristane to phytane as indicators of depositional environment and lithology of petroleum source rocks: *Geochimica et Cosmochimica Acta*, v. 59, p. 3581-3598.
8. Hunt, J. (1996). Using Petroleum geochemistry and geology, 2nd ed., Freeman and company, Newyork, 743.
9. Killops, S. K. V. (2005). Introduction to Organic Geochemistry Blackwell: England
10. Lijmbach, G. (1975). On the origin of petroleum: proceedings of the 9th world petroleum congress, *Applied science publishers*, London, Vol. 2, 357-369.
11. Magoon, L.B. and Beaumont, E.A, (1999). Petroleum Systems: Exploring for oil and gas traps. Treatise of Petroleum Geology, Handbook of Petroleum Geology, Retrieved from
12. Moustafa, M. and Morsi, E.,(2012). Biomarkers. Egyptian petroleum research institute, Egypt.

13. Nwadinigwe., C. and Alumona., T. (2018). Assessmment of n-alkanes and acyclic isoprenoids (geochemical markers) in crudes: A case study of Iraq and Niger delta, Nigeria. Egyptian journal of petroleum, 27(1), 111-116.

14. Tissot, P.andWelte, D. (1984). Petroleum formation and occurrence ,2nd ed, Springer Verlay, Berlin, 699.
15. Van Graas, G. (1990). Biomarker maturity parameters for high maturities: Calibration of the working range up to the oil/condensate threshold, organic geochemistry, vol.16, 1025-1032.
16. Zhang, X. (2017). Teacher Geochemical characteristics and origin of the crude oil of Triassic Yanchang Formation in Southwestern Yishan slope, ordos Basin. International journal of analytical chemistry, vol. 2017.