Comparative Study of Oils from Greater Ughelli and Coastal Swamp Depobelts

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Abstract: ***An inter-depobelt camparative study of a suite of oils was carried out based on the generic properties of oils; the oils are from Utorugu and Agbada in the Greater Ughelli depobelt and Clough Creek and Nembe Creek from Coastal Swamp depobelt. Oils were subjected to GC-MS analysis and EICs of m/z 57, were used to derive various generic parametric ratios for the study. The study showed Clough and Nembe Creeks are immature relative to Agbada and Utorugu oils, and it corresponds to differences in geological time frame for the deposition of the depobelts. Agbada and the Nembe Creek oils in the Eastern Niger Delta show less oxic origin compare to Utorugu and Clough Creek oil of the Western Niger Delta. The oils showed similar characteristics for waxiness and Terrigenous-aquatic ratio. The radar plot showed that Nembe and Clough Creeks oils have close profiles for the various parametric ratio, implying the same source, the PCA score plot describes the variableness that showed close variability of the Nembe Creek and Agbada oils based on organic precusors relative to the Nembe and Clough Creeks oils based on all generic parameters used. The study also highlights the fact that oils from same depobelt can be significantly different.***

Keywords: Agbada, Clough Creek, generic, inter-depobelts, Nembe Creek, Niger delta basin, Oils, Utorugu

1. Introduction

The Niger Delta Basin was developed by continental runoff fostered by turbidity currents down the slopes of the continental margin. When the sediment's angle of repose is exceeded as a result of progressive accumulation of material on the slope the materials slides down giving rise to high density current.

The hypothesis on which this study rest is that though the Niger Delta Basin was deposited from runoff sediments from the Anambra basin with the Imo Shale and the Ameki Group as the subsurface equivalents of Akata and Agbada formation in the Niger Delta Basin [8] and there also exsit major depositional centres known as depobelts [5], [4]. Concurrently, it has also been postulated that the Niger Delta Basin was deposited in mega sequences, which were formed over time intervals of 5Ma these mega sequences are link into depobelts. Each of the depobelts is about 30-60km wide, with the oldest inland and the youngest offshore [11].

The fact that the deposition of the sequences lasted intervals of 5Ma, invariably means the depositional environment for corresponding source rocks should be variable which will be systematically figured into the inherient characters of the oils.

Biomarkers are chemical fossils that are derived from the organic matter that generated the oils; these are transformed defunctionalized compounds due to loss of functional groups, which is a function of the environment of deposition, organic matter type/precusor and stage of biodegradation. Biomarkers have been classed as the custodians of paleoinformation. Since oils are generated from organic matter, the organic matter that was deposited in the different megasequences will be a reflection of the different depositional environment in existence as at the time of the deposition of the megasequences [6]. How different the oils are is the objective of this study.

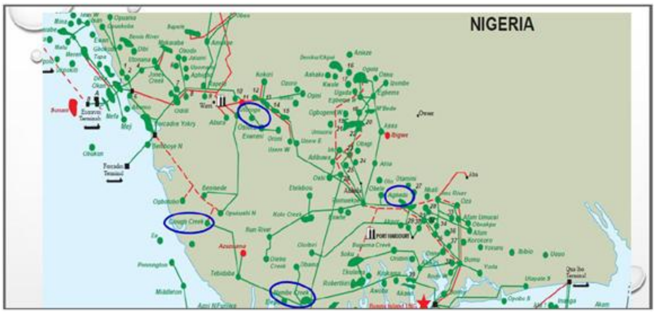

Figure 1: Location of samples used in the study

2. Samples and Sampling

Samples for this study are oils. Oils were obtained though in limited quantity from the different depobelts concerned in the study specifically samples were obtained from Utorogu oil field and Agbada oil field in the Greater Ughelli depobelt and from Nembe and Clough Creeks oils fields in the Coastal Swamp depobelt, samples were obtained in 5mils glass vials with Teflon caps, the samples are representatives of the bulk oil in the reservoirs.

Samples were initailly kept in a chest of ices to preserve the lighter fractions untill they were properly stored in a refrigerator, untill they were analyzed. The chain of custody was unbroken untill finally stored in the refrigrator.

3. Sample Analysis

The samples were prepared by diluting 0.2mg of oil with 0.2mils of hexane to achieve 1µg/µL concentration which is the recommended standard for GC-MS analysis; the samples were subjected to full scan for whole oil analysis [10].

4. GC-MS Analysis

The GC-MS analysis was done using a HP5890 II GC with a split/spiltless injector linked to a HP 5972 MSD (Mass Selective Detector). The GC was temperature programmed for

40ºC-300ºC at 4ºC per minute and held at final temperature for 20 min. The gas was Helium (flow rate 1ml/min., pressure of 50kPa, slit at 30ml/min).

The ionization and identification was carried out in the HP 5972 MSD, which was equipped with electron voltage of 70 eV, filament current of 220µA, source temperature of 160ºC, a multiplier voltage of 1600V and interface temperature of 300ºC. The acquisition was monitored by HP Vectra 48 PC chemstation computer in both full scan mode (30ions 0.7 cps 35m dwell). HP is currently known as Agilent, UK. Peak integration carrier was done using the RTE integrator. Data was obtained from the percentage report from the Enhanced MSD ChemStation 2011 software by Agilent Technologies [9].

5. Treatment of Result

The result obtained from the GC-MS was presented as percent report for m/z 57 capturing the generic class of chemical fossils present in the oils.

The EICs for m/z 57 were extracted covering the generic parameters of oils.

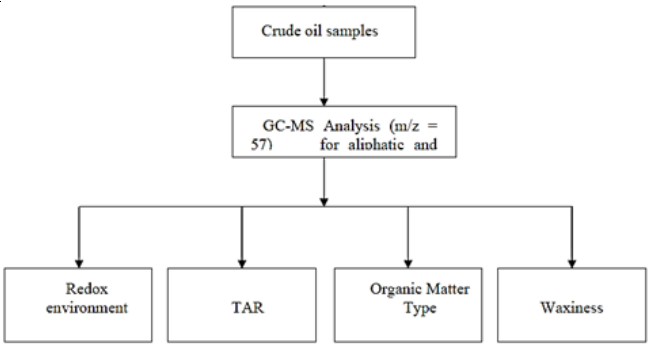

Figure 2: Workflow for the anaysis of Samples

Table 1: Table of Generic parameters of Oils

Oils	Pr/Ph	Pr/nC_{17}	Ph/nC_{18}	TAR	Waxiness	CPI
Agbada	1.99	2.00	3.69	0.31	0.91	1.42
Clough Creek	6.84	1.10	0.21	0.26	0.74	1.68
Nembe Creek	2.77	0.59	0.30	0.32	0.84	1.53
Utorugu	4.72	6.21	0.83	3.14	2.34	1.38

*TAR = Terrigenos Aquatic Ratio; CPI = Carbon Preference Index

6. Results and Discussion

The generic characteristic of the oils are inherent traits from organic precusors of the oils, these will be discussed under depositional environment, maturity, organic matter precusors, and biodegradation status.

6.1 Depositional Environment

This refer to the paleoenvironment where the organic matter was deposited, the Pristane (Pr) - Phytane (Ph) ratio had be used to delineate the paleoenvironment, [6, where the Pr/Ph ratio is above 1, it implies that organic matter was depossited in oxic environment, where it is the reverse, it implies organic matter was deposited in anoxic environment.

Table 1 shows Pr/Ph values greater that 1, infering that the organic matter that generated the oils were deposited in oxic environment with sufficient oxygen, such environmnet could be coastal, nearshore, even deltaic environments. Corroborating table 1 and figure 1 shows that Clough Creek and Utorugu oil fields are on the Western side and have higher values while, Agbada and Nembe Creek oil fields are on the Eastern side with relatively lower values, it could be suggested to be due to the fact that wells in Western Niger Delta are more shallow compare to the wells in Eastern Niger Delta [12].

6.2 Maturity

The generic parameter for assessing maturity is the CPI, carbon prefrence Index; this is used to express the odd carbon numbers over even carbon numbers distributions in the oil. As maturity sets in the odd carbon fades off and the even carbon sets in. CPI higher than 1 are immature but CPI of or lower than 1 is mature. Table 1 shows that Agbada and Utorugu oils are more mature compare to Nembe and Clough Oils.

The Agbada and Utorogu oils are of Greater Ughelli depobelt that was deposited about 10Ma before Coastal Swamp Depobelt of which the Nembe and Clough Oils belong.

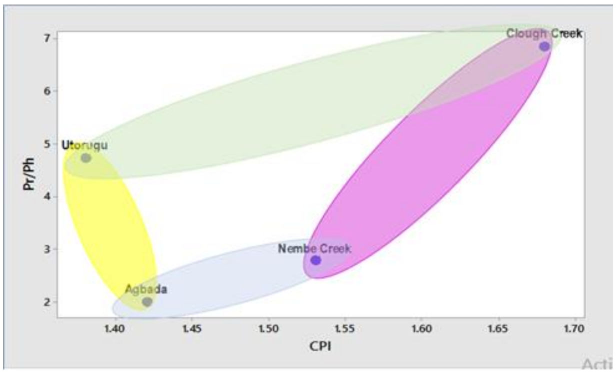

Figure 2: Plot of Pr/Ph versus CPI

Figure 2 shows Utorugu and Agbada with lower CPI infering maturity and Clough and Nembe Creeks with higher CPI infering immaturity, also Utorugu and Clough Creek with higher Pr/Ph ratios.

6.3 Organic Precusors

Organic Precusors refer to the type of organic matter that generated the oils, in this context a plot of Pr/nC_{17} versus Ph/nC_{18} had been used for this purpose [7].

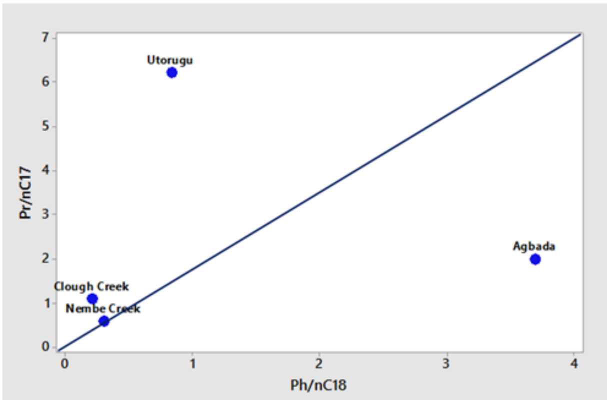

Figure 3: A plot of Pr/nC_{17} versus Ph/nC_{18}

Figure 3 shows that the Clough and the Nembe Creeks oils are of mixed organic matter; this infers mixed contributions of higher land plant materials and algal organic matter. However, the Utorugu and Agbada Oils show significantly diverse contributions, the Utorugu oils show more of higher land plants and vascular plant materials while the Agbada oil show more of algal contributions, but both oils portary a mildly biodegraded nature.

The organic matter type of Clough and Nembe Creeks oils by virtue of their contributions is that of mixed type II and III, while Utorugu is type III and Agbada is of mixed type II and III due to the fact that it's a deltaic oil but notice algal contributions.

6.4 Waxiness

Waxiness is the expression of the presence of higher moleular weight hydrocarbon from C_{30} to C_{45} [2]. One of the simplest expression for waxiness is $(nC_{21}\text{-}nC_{31}) / (nC_{15}\text{-}nC_{20})$, higher values of the ratio indicate major contributions from land plants and vascular plant materials, infering that the organic matter generating the oils are mainly land plants and vascular plants materials containing higher molecular weight hydrocarbons. High waxiness values also indicate low fuel values while low waxiness indicates high fuel value [2].

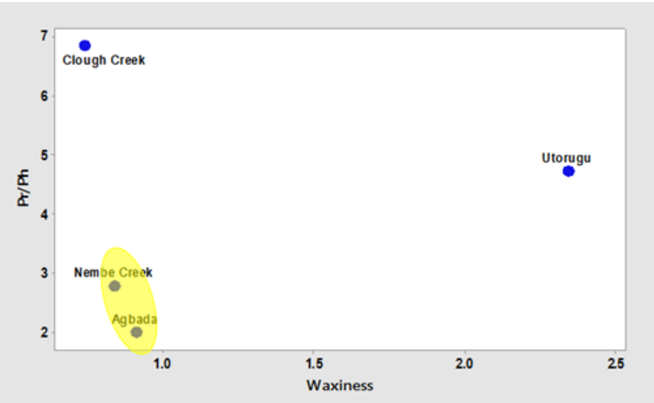

Figure 4: A plot of Pr/Ph versus Waxiness

Figure 4 shows that Nembe Creek oil and the Agbada oil have near similar Pr/Ph and waxiness ratios, this similarity could be attributed to oils from same source rock, however, the Utorugu oil is significantly different with a very high waxiness value.

Greater Ughelli was deposited during rising sea level, so continental debris (lans plant and vascular plant materials) were trap and sedimented resulting in source rock that generate high waxy oils. The implication is that the oils are generated by slightly different source rocks, hence the pronouced differece in waxiness.

6.5 Terrigenous-Aquatic Ratio (TAR)

The ratio TAR expresses the dorminant contributing organic matter in a sample of source rock [2], TAR is calculated using the data obtained from the EICs of m/z 57. The ratio for the expression of TAR is $(nC_{27}\text{-}nC_{31}) / (nC_{15}\text{-} nC_{19})$ [2], the $nC_{15}\text{-}nC_{19}$ expresses the algal organic matter, which is majorly from marine or shallow marine settings, the $nC_{27}\text{-}nC_{31}$ expresses the terrigenous organic matter which are basically derived from land plant and vascular plant materials and indicated nearshore or coastal shallow marine settings. Higher TAR values indicate land plant and vascular plant contributions, while lower TAR values indicate higher algal contributions.

Table 1, show that TAR values ranges from 0.26 to 3.14, with Utorugu having the highest value.

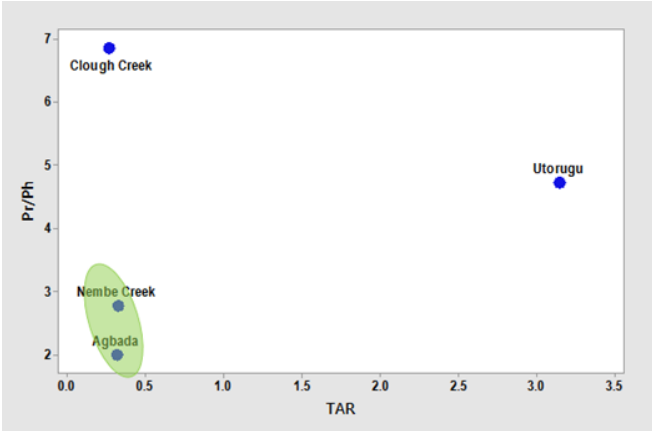

Figure 5: A plot Of Pr/Ph Versus Tar

Figure 5 show very close similarity with figure 4, probably due to the fact that similar peaks are involue in the expressions of these parametric ratios. The Nembe, Clough Creeks and the Agbada oils show close similarities in the Pr/Ph and TAR ratios, infering similar paleoenvironment of deposition and similar type of algal contributions in the source rock that generated the oils. However, Utorugu oil has a significantly higher TAR value indicating significant contribution from higher land plants.

Figure 6 is a plot of TAR and Waxiness and it shows similarity of three oils namely Agbada, Nembe and Clough Creeks on the bases of their waxiness and terrigenous-aquatic ratio. An overall comparative assessment for the set of oils studied was perform using the profiles of the oils in Figure 7, which is a radar plot. The profiles showed close similarities for Nembe and Clough Creeks oils, while those for Utorugu and Agbada oils were significantly different, the profiles represent the inherent traits of the oils, similar traits implies similar or same organic precusors and similar or same source rocks.

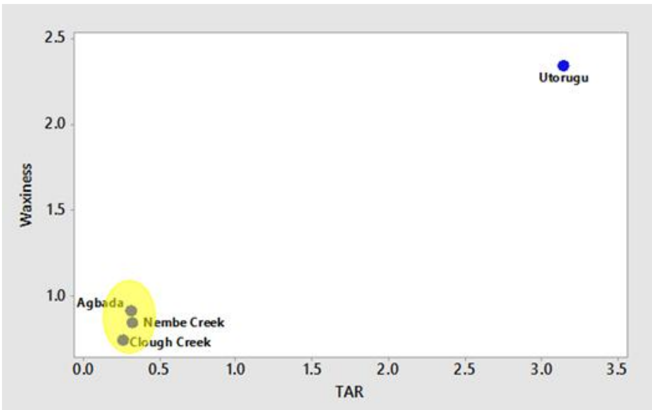

Figure 6: A plot of TAR versus Waxiness

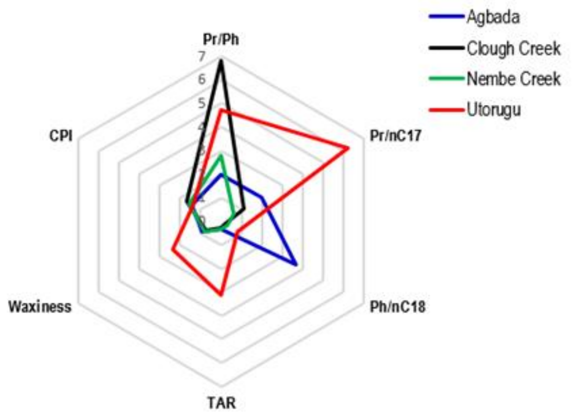

Figure 7: A radar diagram show the profile for each Oil

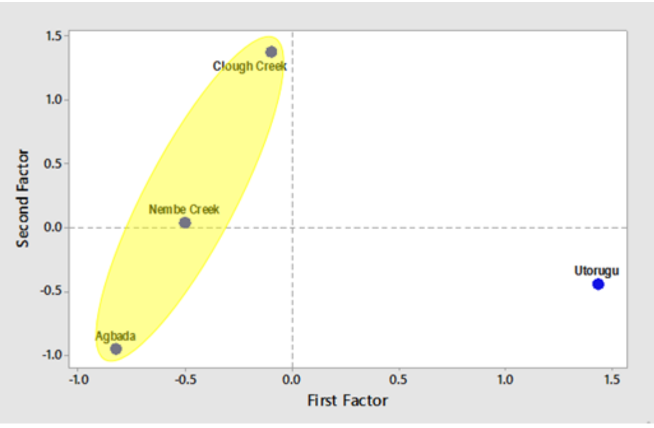

Figure 8: A Principal Component Analysis Score Plot

Figure 8 is the score plot for the principal component analysis for the suite of oils studied. The plot showed that the Nembe and Clough Creeks oils are in the same quadrant while the Agbada oil is in the negative quadrant of the second factor which explains 38% of the variation, meaning that there is not much variation with the Nembe Creek but the Clough Creeks oil is more variable. The Utorugu oil is in the positive quadrant of the first factor which explains about 62% of the variation showing significant variation from the other oils.

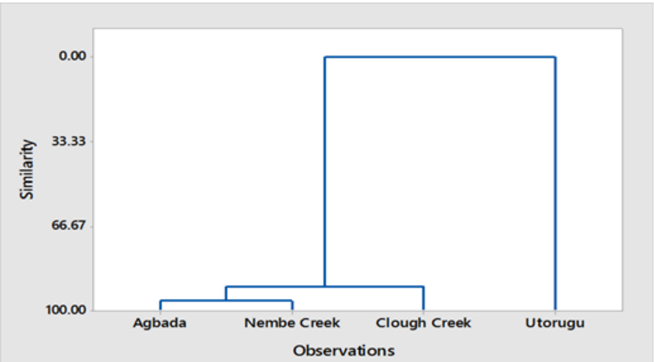

Figure 9: A dendrogram for hierarchical cluster analysis

Figure 9 is the dendrogram for hierarchical cluster analysis, it shows that Nembe and Agbada oils has 96% similarity, while Clough Creek had 91% similarity with Nembe Creek oil and Utorugu had 0% similarity with other oils.

7. Conclusion

The study is an inter depobelt study, the Clough and Nembe Creeks oils show some similarity based on Waxiness, TAR, organic matter type, pale-environment of deposition and this observation implies same source rock. However, the Agbada and Nembe Creek oil showed very close (90%) similarity based on Waxiness, TAR and CPI and is explained by the organic precusors, implying variability in environment of deposition. The study also brings to light the fact that two oils from the same depobelt can be significantly variable.

References

[1] Akinlua, A., & Ajayi, T. R. (2009). Geochemical Characterization of Central Niger Delta oils. *Journal of Petroleum Geology*, 373-382.

[2] Barakat, A. O., Mostafa, M. S., El-Gayar, M., & Rollkotter, J. (1997). Source-dependent biomarker properties of five crude oils from the Gulf of Suez, Egypt. *Organic Geochemistry*, 441-450.

[3] Demaison, G., and Huizinga, B. J. (1994). Genetic classification of petroleum systems using three factors: charge, migration, and entrapment, *in*, Magoon, L. B., and Dow, W. G., eds., The Petroleum System--From Source to Trap, AAPG Memoir 60: Tulsa, American Association of Petroleum Geologists.73-89.

[4] Ekweozor, C. M., and Daukoru, E. M. (1994). Northern delta depobelt portion of the Akata-Agbada petroleum system, Niger Delta, Nigeria, *in*, Magoon, L. B., and Dow, W. G., eds., The Petroleum System--From Source to Trap, AAPG Memoir 60: Tulsa, American Association of Petroleum Geologists.599-614.

[5] Evamy, B. D., Haremboure, J., Kamerling, P., Knaap, W. A., Molloy, F. A., & Rowlands, P. H. (1978). Hydrocarbon Habitat of Tertiary Niger Deita. *The American Association of Petroleum Geologists Bulletin*, 1-39.

[6] Haack, R. C., Srindararaman, P., Dedjomahor, J. O., Xiao, H., Gant, N. J., May, E. D., & Kelsctu, K. (2000). Niger Delta Petroleum Systems, Nigeria.273-231.

[7] Hanson, A. D., Liang, D. G., Zhang, B. M., Zhang, S. C., Moldowan, J. M., & . (2000). Molecular Organic Geochemistry of the Tarim Basin, Northwest China. *AAPG Bulletin*, 1109-1128.

[8] Magoon, L. B., & Dow, W. G. (1994). The Petroleum System. In L. B. Magoon, & W. G. Dow, *The Petroleum System-From Source to Trap* (pp.1-34). Tulsa, Oklahoma: The American Association of Petroleum Geologists.

[9] Nwachkwu, J. I., Oluwole, A. F., Asubiojo, O. I., Filby, R. H., Grimm, C. A., and Fitzgerald, S. (1995). A geochemical evaluation of Niger Delta crude oils, *in*, Oti, M. N., and Postma, G., eds., Geology of Deltas: Rotterdam, A. A. Balkema, . 287-300.

[10] Peters, K. E., Walters, C. C., & Moldowan, J. M. (2005). *The Biomarker Guide II. Biomarkers and Isotopes in Petroleum Systems and Earth History.* New York: : Cambridge University Press.

[11] Reijers, T. J. (2011,). Stratigraphy and sedimentology of the Niger Delta. *Geologos*, 133-162.

[12] Stacher, P. (1995). Present understanding of the Niger Delta hydrocarbon habitat, *in*, Oti, M. N., and Postma, G., eds., Geology of Deltas: Rotterdam, A. A. Balkema.257-267

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