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The Generic Relationship among Oils from the Greater Ughelli Depobelt of the Niger Delta Basin

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Abstract:

The genetic relationship of oils from three fields in the Greater Ughelli depobelt of the Niger Delta Basin Nigeria was evaluated . This involved the geochemical analyses for generic hydrocarbon ratios derived from the GC fingerprint profile. Ratios such as Pr/Ph (Pristane/Phytane), Pr/nC_{17}, Ph/nC_{18} and Carbon Preferential Index (CPI) of the crude oils were determined in respect of their organic matter source, thermal maturity and environment of deposition. The samples were coded KZ1, KZ2 and KZ4. Pr/Ph ratio, Pr/nC17 versus Ph/nC18 and CPI versus Pr/Ph plots revealed that samples KZ1 and KZ2 were derived from organic matter of dominant terrestrial origin while KZ4 is of significant marine contribution. The CPI of all the three samples were approximately 1.0 implying that all the samples are thermally mature. Gas chromatogram fingerprint of the three samples showed that samples KZ2 and KZ4 had undergone a significant degree of biodegradation when compared to KZ2 The GC envelope (profile) KZ2 and KZ4 indicates a possible petroleum recharge of the reservoir or invasion of bacteria through the metreoric waters.

Key words: ***Geochemical analyses, Thermal maturity, oil to source linkage, depositional environment, Gas chromatogram, Carbon Preference Index (CPI)***

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I. INTRODUCTION

The analyses of the generic relationship between crude oils between fields is vital in petroleum exploration and production as it aids in highlighting the similarities as well as contrast in oils intra and inter fields. This is based on the fact that crude oil differs greatly in appearance and viscosity from field to field leading to international price differentials per barrel and thus its classification and source identification from various fields is however necessary. One key method of identifying the intra and inter field variation in crude oil composition is by analysing the saturated hydrocarbon fractions using Gas Chromatography fingerprinting leading to a form of fingerprinting which is often used for evaluating the compositional distribution of hydrocarbons in crude oils (Onojake et al, 2012).

The Niger Delta Basin in Nigeria is a one of the very productive hydrocarbon provinces in the world. It is composed of six depobelts which portrays its structurally and stratigraphically most dynamic portion at each phase of the Niger Delta Basin evolution.

The development of these depobelts progressed from north to south having Northern (as the oldest), Greater Ughelli, Central Swamp, CoastalSwamp and Shallow Offshore (the youngest) and Deep Offshore. Each depobelt is believed to be a more or less independent unit (Doust and Omatsola, 1990) and are about 30-60 km wide with regular differential time interval of 5MA .
This study is focused on identifying the generic relationships between the oils in the Greater Ughelli Depobelt using samples from three wells by recognising their unique signatures which is a reflection of the prevalent depositional environment, organic matter source and thermal maturation. This will foster oil to oil/source correlation in environmental pollution studies, production comingling and will serve as a reliable tool for modular (small scale) refineries targeting a particular oil type.

MATERIALS AND METHODS

Three (3) crude oil samples (KZ1, KZ2, KZ4,) were obtained for this research work . The samples were collected from three different wells in different fields in the Greater Ughelli Depobelt of the Niger Delta Basin (Fig. 1).

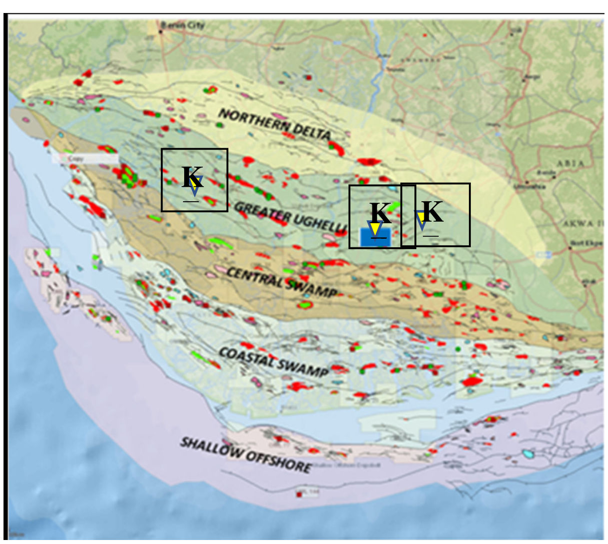

Fig 1: Map showing the sample locations within the Greater Ughelli Depobelt (Modified from Reijers, 2011)

Oil samples Analyses

The three crude oil samples were subjected to GC–FID analysis, using Gas Chromatogram instrument which can separate crude oil samples into various components, which are key for oil to oil correlation.

Prior to the GC–FID analysis, samples were fractionated into saturated hydrocarbons, aromatic hydrocarbons and resins by using hexane, toluene and methanol, respectively, by means of column chromatography (Eneogwe et al. 2002). The obtained fractions were reduced with a stream of nitrogen gas. The GC–FID analysis of the aliphatic/saturated fraction was performed using a Hewlett Packard 5890 series II Plus chromatograph equipped with a 50 m x 0.2 mm x 0.5µm film thickness (DB-1) column with a flame ionization detector (FID). Hydrogen (H_2) was the carrier gas and was allowed to flow at a flow rate of 300 ml/sec and the oven was programmed from 30^{o}C to 305^{o}C at 5^{o}C/min.

The peak areas integration and identification were based on retention times and comparison with standards. The integrated peaks were later compared and it was discovered that HIRES software gave a better peak resolution.

RESULTS AND DISCUSSION

The gas chromatographic fingerprints (Fig.3) of all the analysed crude oil samples were used to generate geochemical ratios for the identification, based on generic similarities for oil to oil/source correlation, depositional environment and thermal maturity.

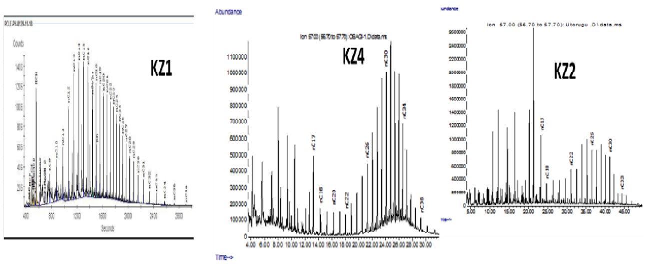

Fig.2: Profiles of analysed crude oil samples showing the normal alkanes (n-Alkanes) and Isoprenoids distribution

The fingerprints of samples KZ2 and KZ4 have similar signatures, their middle molecular weight hydrocarbons are nearly depleted and are different from KZ1. This could imply that KZ2 and KZ4 samples have undergone a mild degree of biodegradation / water washing than sample KZ1, though the hump in KZ4 fingerprint indicate more biodegradation. Additionally, the light end molecular weight hydrocarbon are seen to be more pronounce in KZ2 and KZ4 than the middle end molecular weight hydrocarbon. This is quite an unusual observation as the lower ends are expected to be more susceptible to degradation (evaporation) than the middle weight molecular hydrocarbons. This observation could be an indication of hydrocarbon recharge into the reservoir rocks of these two samples.

Normal Alkanes and Isoprenoids distribution of the analysed crude oil samples

The ratios of isoprenoids to n-paraffin are employed in oil- source correlation, maturation and biodegradation studies (Onojake et al , 2012).

The geochemical ratio of the three (3) oil samples used in this study are outlined in Table 1. The Pristane/nC_{17}, Phytane/nC_{18}, Pristane/Phytane (Pr/Ph) ratio and Carbon Preference Index (CPI), values were generated from the Gas Chromatogram data and several cross plots made.

The API gravity of the three crude oil samples was also determined using the formula **API =** (141.5 / SG) - 131.5, where API = Degrees API Gravity and SG = Specific Gravity (at 60^{o} F or 15.5^{o}) (Saliu et al, 2013).

API Gravity

The API gravity of crude oils determines its grade or quality (Dickson and Udoessien, 2012). Sample KZ1 appeared to be lighter (of better quality) than KZ2 and KZ4 because, the lighter the oil, the greater the API.

Table 1: Geochemical parameters extracted from Gas chromatogram (GC)

	Pr/Ph	Pr/nC17	Ph/nC18	TAR	CP1	W
KZ1	**4.71889**	**6.04576**	**0.813366**	**0.30336**	**1.02583**	**1.**
KZ2	**3.83619**	**3.14955**	**0.949239**	**0.13937**	**1.15711**	**7.**
KZ4	**0.95722**	**1.00346**	**1.004976**	**0.7395**	**1.03015**	**2.**

Abbreviations: Pr – Pristane, Ph – Phytane, TAR – Terrestrial/algae ratio = [nC_{17}+nC_{18}+nC_{19}/ nC_{27}+nC_{28}+nC_{29}]; Waxiness = [nC_{21}+nC_{22}+nC_{23}/ nC_{24}+nC_{27}+nC_{26}+ nC_{27}+ nC_{28} nC_{29}+ nC_{29} +nC_{30}/ nC_{15}+nC_{16}+nC_{17}+nC_{18}+nC_{19}+nC_{20}];Carbon Preference Index (CPI)= ½ [(nC_{25} + nC_{27} + nC_{29} + nC_{31} + nC_{33})/ (nC_{24} + nC_{26} + nC_{28} + nC_{30} + nC_{32}) + (nC_{25} + nC_{27} + nC_{29} + nC_{31} + nC_{33})/ (nC_{26} + nC_{28} + nC_{30} + nC_{32} + nC_{34})]

The major factors responsible for differences in crude oil composition are source (organic matter), migration, maturation (thermal maturity) and biodegradation (Onojake et al, 2012).

Paleo-environment of Deposition of organic matter

The Pristane/Phytane (Pr/Ph) values of the three analysed samples showed that samples KZ1 and KZ2 have high Pr/Ph ratios of 4.7 and 3.8 respectively (Fig.2) which suggest that these oils were generated from source rock with a significant terrestrial contribution and deposited in an oxic paleoenvironment while low Pr/Ph ratio was observed for sample KZ4 indicates that the oil was derived from a source rock with substantial marine input .

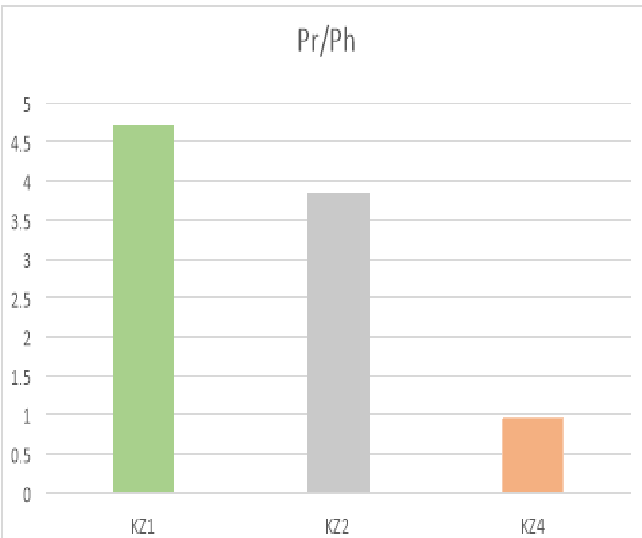

Fig. 3 A plot of Pr/Ph ratios

A plot of Pr/n-C17 versus Ph/n-C18 has occasionally been used by authors to classify oils and rock extracts based on kerogen type, depositional environment and source of organic matter in the source rock as shown in Fig.4. The Pr/n-C17 and Ph/n-C18 decrease with maturation as a result of increasing prevalence of the n-paraffin. All the analysed samples are seen to be thermally mature. This plot also revealed that samples KZ1 and KZ2 are of terrestrial organic matter while KZ4 is from a source rock with significant marine organic matter (Fig.3) as previously shown in Pr/Ph plot.

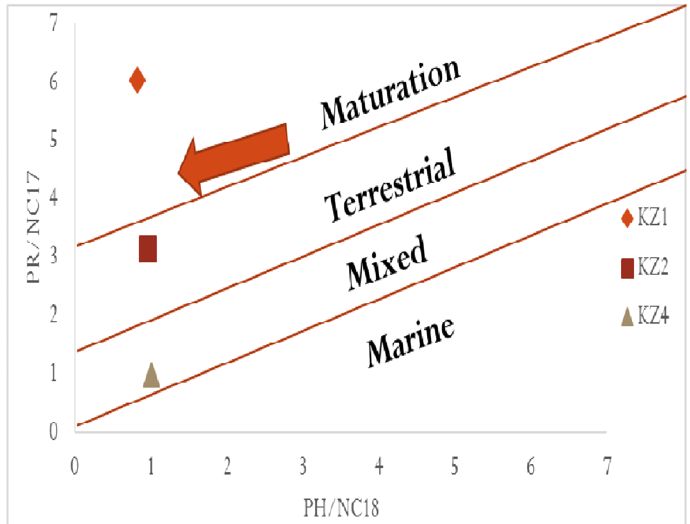

Fig. 4. A plot of Pr/nC_{17} and Ph/nC_{18} of Greater Ughelli depobelt of Niger Delta oils

Thermal maturation

The f generic maturity indicator applied to crude oils is Carbon Preference Index (CPI) Carbon Preference Index was (Peters et al 1996). It was observed by many researchers that immature rocks often had high CPI values less than 1.5 (>1.5), while those of mature oils were mostly below 1.0. In Table 1, the calculated values of CPI of the three crude oils samples are close to1.0, which shows the oils are mature. A further evaluation of the environment of deposition using the cross-plot of CPI versus Pr/Ph (Fig. 5) shows that KZ1 and KZ2 oil samples were derived from terrigenous organic matter while KZ4 is from marine organic matter.

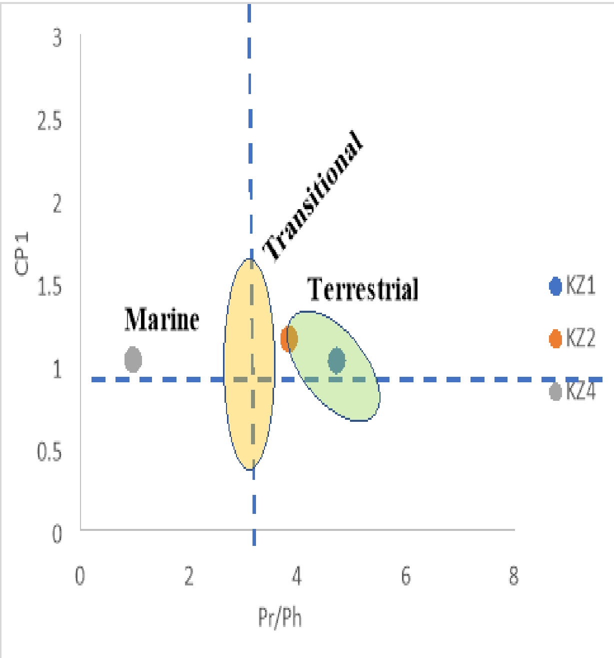

Fig 5. A plot of CPI against Pr/Ph of oils from Greater Ughelli depobelt of Niger Delta

CONCLUSIONS

The chromatogram of the analysed samples revealed that samples KZ2 and KZ4 have similar fingerprints different from KZ1 and this was used to infer the degree of degradation these oils have undergone. Samples KZ2 and KZ4 seemed to have undergone a mild to moderate degree of degradation than sample KZ1.

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REFERENCES

[1] Akinlua, A., Ajayi, T. R. and Adeleke, B. B., 2005. A re-appraisal of the application of Rock-Eval pyrolysis to source rock studies in the Niger Delta. *Journal. Petrol. Geol.* **28** (1), 39–48.

[2] Dickson UJ, and Udoessien EI, 2012: Physicochemical studies of Nigeria's oil blends. Petroleum and Coal, 54 (3):243-251

[3] Doust, H. and Omatsola, E., 1990. Niger Delta. In: Divergent/Passive margin basins. In: J.D. Edwards and P.A. Santogrossi (Eds), *AAPG Memoir* **48,** 201–238.

[4] Ejedawe, J.E., 1981. Patterns of incidence of oil reserves in Niger Delta Basin. American Association of Petroleum Geologists Bulletin **65**, 1574–1585.

[5] Eneogwe, C. and Ekundayo, O., 2003. Geochemical correlation of the crude oils in the NW Niger Delta, Nigeria. *Journal. Petrol. Geol.,* **26**, 95–103.

[6] Evamy, B. P., Haremboure, J., Kamerling, P., Knoop, W.A., Molly, F. A. and Rowlands, P. H., 1978. Hydrocarbon habitat of tertiary Niger Delta. *AAPG Bulletin,* **62,** 1–39.

[7] Knox, G.J. & Omatsola, M.E., 1987. Development of the Cenozoic Niger Delta in terms of the escalator regression model. [In:] Proceedings of the KNGMG Symposium 'Coastal Lowlands – Geology and Geotechnology'. Kluwer Academic Publishers, 181–202

[8] Onojake, M.C. Oforka, N.C., Osuji L.C. 2015. Petroleum hydrocarbon fingerprinting of crude oils from umutu/bomu oil fields in Niger Delta, Nigeria, v Scholars Research Library , Archives of Applied Science Research, 2012, 4 (1):246-253.

[9] Peters, K.E., Walters C.C, and Moldowan J.M. 1996. The Biomarker Guide: Interpreting Molecular Fossils in Petroleum and Ancient Sediments. 1999, Cambridge: Cambridge University Press.

[10] Reijers, T.J.A. 2011. Stratigraphy and sedimentology of the Niger Delta. Geologos, 17 (3): 133–162

[11] Reijers, T.J.A., Petters, S.W., Nwajide, C.S., 1997. The Niger Delta Basin. [In:] R.C. Selley (Ed.): African basins. Sedimentary Basins of the World (Elsevier, Amsterdam) 3, 145–168.

[12] Salih M.A , and HebaSadoon A. (2013). Statistical Analysis of the Relations between API, Specific Gravity and Sulfur Content in the Universal Crude Oil International Journal of Science and Research (IJSR) ISSN (Online): Vol. 4.

[13] Salisu N., Nasir M. A., Ali A.S. and Geoff A. 2015. Geochemical Applications and Limitations of Pristane to Phytane ratio in determining the Redox Condition of North Sea Oil and Kimmeridge Source Rocks' Paleoenvironment of Deposition. Dutse Journal of Pure and Applied Sciences 96 – 103.

[14] Udo, O. T. and Ekweozor, C. M., 1990. Significance of Oleanane occurrence in shales of Opuama Channel Complex. Niger Delta. *Energy and Fuels*, **4,** 248 – 254.

[15] Wang, Z., & Fingas, M. F. (2003). Development of oil Hydrocarbon Fingerprinting and Identification Techniques. Marine Pollution Bulletin, 47, 423–452.

