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The Usefulness Of Bimarkers In Understanding The Nature Of Compartmentalized Reserviors In An X-Field, Niger Delta Basin, Southern Nigeria

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ABSTRACT
This research work was carried out in order to reveal the usefulness of biomarkers in understanding the nature of compartmentalized reservoirs in an X-field, Niger Delta basin. In order to achieve the set goals, four crude oil samples from an X-field in Niger Delta basin was subjected to standard laboratory analysis and techniques. The results obtained from the analysis of the oil samples were reflected as Gas Chromatogram (GC) and interparaffins values plotted on a star/stiff plot which shows that the wells are compartmentalized. The geochemical finger printing of the oils convey information from two different aspects namely Gas Chromatogram and interparaffins. The GC envelopes which is the profile of the peaks of the chromatogram had some minor differences at a time interval of between 10 to 12 seconds and an abundance of between 3000 to 5000 but generally showed similar trends of the GC envelope. The interparaffins show differences in the values of the peak ratios, thus expressed graphically in the form of a star/polar plots. The star plot showed differences in profile of each oil compared amongst each other indicating compartmentalization. A synergy of these results means compartmentalization.
Keywords: *Biomarkers, Compartmentalization, Reservoirs, Organic matter*

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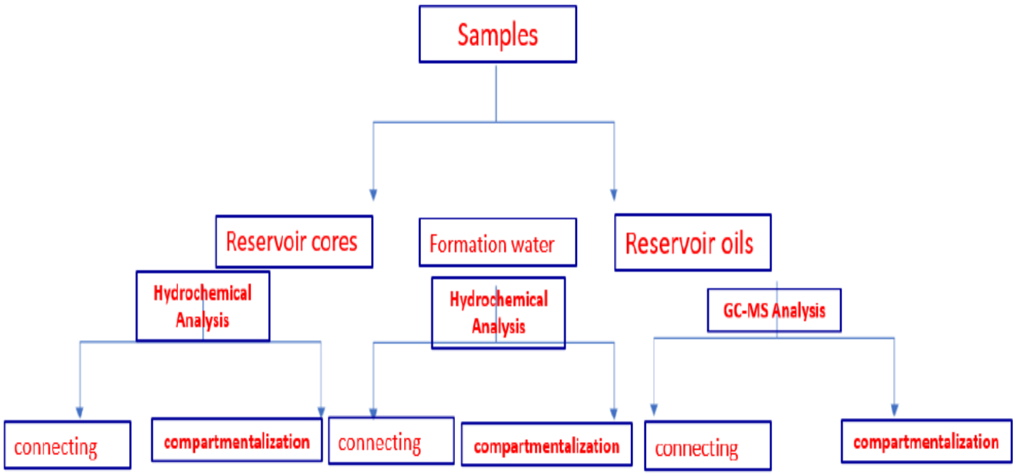
I. INTRODUCTION

Biomarkers are organic compounds in the oil (geosphere), whose structures suggest an unambiguous link with a known natural product in the biosphere (source organic matter), (Kaufman *et al*., 1990; Hwang *et al*., 1994). The compounds can be used to correlate oils co-existing in oil fields for their homogeneous or heterogeneous compositional distribution, which could be used to infer the same or different genetic origins (Hwang *et al*., 1994). Compartmentalization is defined as the existence of petroleum accumulations in discrete individual compartments in the reservoir (Jolley *et al*., 2010).The two basic types of boundaries that can cause compartmentalization are static and dynamic seals. Static seals can prevent fluid flow over geological time scale, but dynamic seals can prevent fluid flow during only production timescale. Dynamic seals include baffles and barriers (Jolley *et al*., 2010). Overtime as production continues the characteristic indicators of compartmentalization are fluid contacts, oil saturations, pressures data and biomarker compositional distribution and formation water chemistry (Smalley & Hale 1996). A variety of compartmentalization has been unraveled; there have been occasions of false negatives, where compartments were assumed absent due to the homogeneous nature of the fluid properties while equilibration was possible in the presence of compartments. False positives are where fluid differences were assumed as indicator of compartmentalization, while they are still in the process of equilibration as a reservoir process during infilling (Smalley & Muggeridge, 2010). Reservoir compartmentalization has been attributed to structural configuration, depositional architecture and fault juxtapositions, these are conditions that determine the plumbing system of the reservoir (Ainsworth, 2006; Jolley *et al*. 2007). Wider understanding of compartmentalization has been related to faulted juxtapositions. Sealing and baffling of fluid flow has been controlled by juxtapositions between reservoir and non-reservoir rock across a fault. The clay content of the faults has been a point of interest, where Shale-Gouge ratio or Clay smear potential, or shale smear potential had been used as a tool for evaluating and ranking seals and had also been used as a proxy for clay content (Jolley *et al*., 2010).

Clay content or shale gouge ratio has been used together with Oil water contact (OWC) and pressure differential to study efficiency of the sealing faults expressed as sealing fault capacity. The faulted zone may show some type of heterogeneity which may translate to variation in Oil Water Contact (OWC), saturations, formation water chemistry, and biomarker compositional distribution.

AIM & OBJECTIVES OF STUDY



II. MATERIALS AND METHOD OF STUDY

Biomarkers are biological marker compounds that are present in oils, biomarker are the custodian of paleo information on the origin of the oils, their maturities, their depositional environments, and their corresponding organic matter precursors. Parametric ratios for the compositional distribution of the oils will show close similarities in their profile if it is applied in a radar/star plot. This observation will infer oils from reservoirs that are communicating (Kaufman et al., 1998; Kaufman et al., 2000; Hunt, 1996). Samples for this study is a suite of oil samples obtained from oils fields (figure 1) in the Niger Delta basin. The samples were obtained randomly of different levels of degradation. Samples were obtained from well heads in a sample vial with Teflon caps, samples were further stored in a chest of ice to preserve sample compositional integrity (Giles & Mills, 2010). Samples were prepared by appropriately measuring 0.2mg into 0.2mL of hexane to achieve 1µg/µL which is the recommended concentration that was injected into GC–MS for full scan analysis. The GC-MS analysis was done using a HP5890 II GC with a split/splitless 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 carrier gas was Helium (flow rate 1ml/min., pressure of 50kPa, slit at 30ml/min). The ionization and identification were carried out in the HP 5972 MSD, which was equipped with electron voltage of 70 eV, filament current of220µA, 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 35mdwell). HP is currently known as Agilent, UK. Peak integration was done using the RTE integrator. Data was obtained from the percentage report from the Enhanced MSD ChemStation 2011 software by AgilentTechnologies (Peters et al., 2005).

III. RESULTS

The results for oil fingerprinting are presented in two aspects namely the EICs profiles and the interparaffins ratios. Figure 4.19 presents the chromatograms for MZ 71 for the alkanes showing the profiles. Figure 4.18 presents the polar plots of the interparaffins ratio, the polar plots show different profile for each of the four wells.

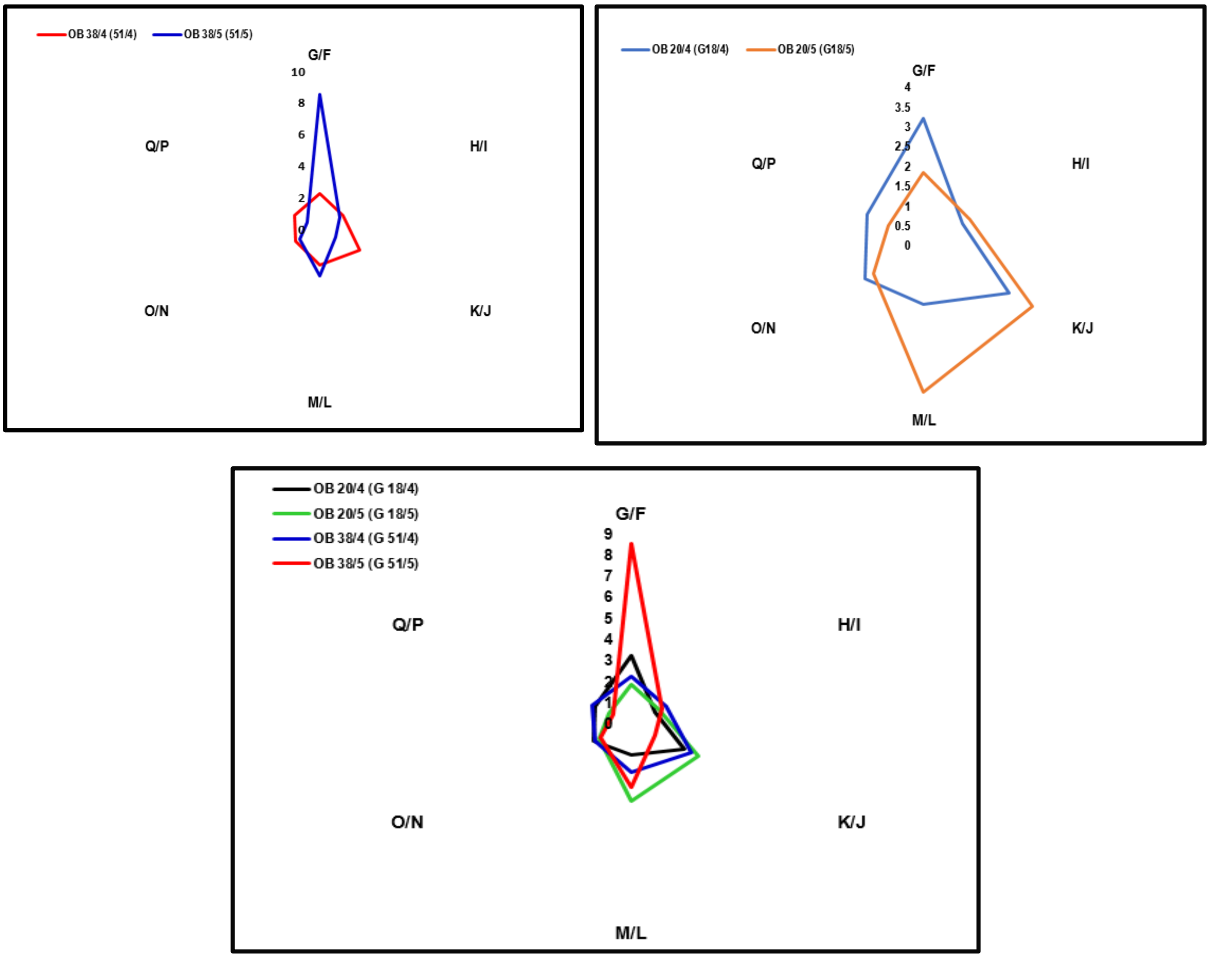


Figure 4.18. The polar plots of the interparaffins, indicating compartmentalization (a, b and c)

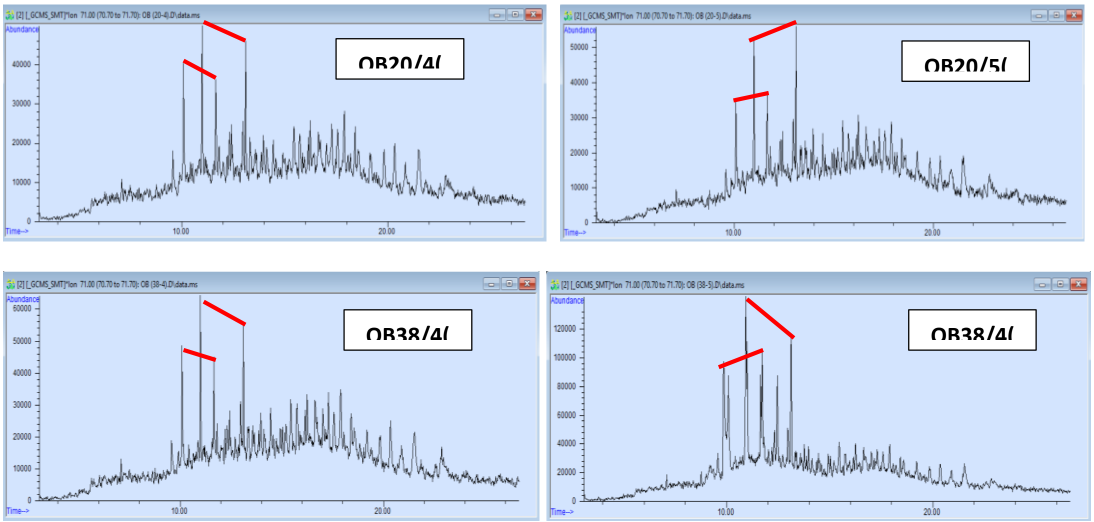


Figure 4.19. The EICs (Extracted ion Chromatograms) of the reservoir oil samples. The Well names are inscribed on the chromatograms

Table 4.6. Table of ratios of interparaffins used for the polar plot.

WELLS	G/F	H/I	K/J	M/L	O/N	Q/P
OB 20/4 (G 18/4)	3.22	1.09	2.40	1.48	1.66	1.59
OB 20/5 (G 18/5)	1.84	1.30	3.06	3.69	1.40	1.00
OB 38/4 (G 51/4)	2.20	1.61	2.77	2.33	1.61	1.72
OB 38/5 (G 51/5)	8.49	1.40	1.13	3.02	1.36	0.81

IV. INTERPRETATION AND DISCUSSION

Oil Fingerprinting.

Oil fingerprinting is trending technique that has been applied in the petroleum industry in different aspects towards proffering solutions to problems such as delineating leakage, comingled production, compartmentalization (Hwang *et al*, 1994). In the study of compartmentalization oil fingerprinting is a reliable tool on the premise that where reservoirs are connecting, oils in each of the reservoir should have the same or similar compositional distribution, some case studies where fingerprinting on oil compositional distribution were used for solving problems includes, Hwang *et al*., (1994) which delineated the Sudan Unity Field for reservoir continuity, Rajasingam and Freckelton (2004) applied the used oil fingerprinting to delineate the diversely complex reservoir systems of the Na Kika's Oil Field. The study by Xing *et al*., (2019) used oil fingerprinting for production allocation and production optimization, Kaufman, *et al*., (1998) applied oil fingerprinting technique in in studying the Greater Burgan Oil Field in Kuwait. Al–Amrie *et al*., (2016) used oil fingerprinting as a tool to allocate production between reservoirs of different oil and different oil signatures. Wilhelms *et al*., (2001) used oil fingerprinting technology to delineate compartmentalization in horizontal wells.

In this study, oil fingerprinting is employed as tool for delineating compartmentalization of reservoir sections in the G oil field. The precept is on the hypothesis that oils in connecting reservoir will tend to have similar compositional distribution of the compounds that constitute the oils. Hence if a GC–MS or GC–FID is performed on all the oils the signature known as the TIC (Total Ion Chromatogram) will look alike much more specifically, the interparaffins could be applied for a more robust evaluation. The signatures of oils migrating into the reservoir at the initials time may be heterogenous however, the fact that the reservoir is connecting provides for the mixing and eventual equilibration of the oils establishing the same signature. The reason for this observation is the presence of a high permeability interface between the reservoirs allowing the mixing of oils, in the form of faults, fractures and extensive sand body. The depositional architecture of the sandstone could also provide for fissures and fractures that could exist.

GC Envelope.

The GC envelope refers to the trend of the peak on the chromatogram, generally the trend is that of high lighter peaks and low heavier peaks. The envelope seems to show similarity of the oils base on the Extracted Ion Chromatogram (EICs), however orientation of the peaks when compared one to another amongst the chromatograms, shows some differences. These differences averagely infer a tat the oils are not similar hence there is no connectivity of the reservoir cross sections in the suite of wells studied. The absence of connectivity indicates the presence od a low permeability and a high entry capillary pressure interface between the reservoirs serving as a seal not a baffle or barrier. Baffles and barriers do not absolutely restrict fluid flow, but seals do restrict fluid flow for all geological time frame. The differences in compositional distribution as observed also indicates that the oils did not undergo the same diagenetically processes.

Interparaffins

The interparaffins are mostly isoprenoids they have greater resistance to biodegradation, since they are of greater resistance, preferably they are used for delineating differences in peak orientation for a given suite of oils, to understand how related the oils could be. Figure 4.19 is an example of the data used. Pairs of the interparaffins are established and ratios are obtained and compared amongst the suite of oils studies. The ratios are later expressed graphically as star plot. The star or polar plot will show oils are similar to have similar profile on the star or polar plots while oils that are not similar will have different profiles. That has been the mode of use of interparaffins (Hwang *et al*, 1994).

In this study, figure 4.19 shows that the oils are all different from one another, based on the orientation of the peaks and eventually the peak ratios. The peaks were used for expressing the relationships between the oils graphically with star or polar plots. Figure 4.18 showed the graphical expressions of the relationships between the oils.

The polar/star plots in 4.18a shows that of OB38/4 (G51/4 and OB38/5 (G 51/5), as it can be observed the profile for both oils are out of phase, they do not correspond to any each other, nonetheless, the reservoirs are stack in G Well 51, this means that the reservoirs namely OB38/4 (G51/4 and OB38/5 (G 51/5), are compartmentalized both vertically and horizontally.

Figure 4.18b is the polar/star plot for OB 20/4 (G 18/4) and OB 20/5 (G 18/5) it also infers that the reservoir is stack in G Well 18 and that the compositional distribution of the oils are out of phase. It also implies that G Well 18 has stack reservoirs that are vertically and horizontally compartmentalized. This can also be validated by the fact that long and short are used for production of the reservoir oils. The major reason for compartmentalization is that the reservoirs are partitioned by seals which can restrict over geological time frame. Seals are very low permeability and very high capillary pressure interface. The main reason for the occurrence of seals is as a result of their depositional architecture, though it has been accepted that compartmentalization is majorly caused by stratigraphic depositions. (Jolley *et al*., 2010). The fact that the reservoir sections are not connecting in G Well 51 using the interparaffins data expressed by the star/polar plot can be validated by the pressure data in figure 4.15. The fact is that pressure may not be able to detect barriers and baffle validates the fact seals exist between the reservoir cross sections. Thus the reservoirs have significantly different pressure orientations which is also reflected by the biomarker data on the reservoir oils.

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