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Evaluation of Crude Oil Thermal Maturity from Some Oil fields in Niger Delta, Nigeria

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ABSTRACT

Niger Delta region of Nigeriais is a hub for huge deposits of hydrocarbons. Five crude oil samples collected from Azuzuama, Clough creek and Tebidaba oil fields were analyzed to ascertain their degrees of thermal maturity. The studied oils were fractionated by column chromatography into saturated hydrocarbon and aromatic compounds. Gas chromatography-mass spectrometery (GC-MS) was used to analyze the saturated/aliphatic hydrocarbons. Hopane and sterane ratio results indicated that ααα C_{29} isomerization ratios ranged from 0.33 – 0.40 which was evidence of thermal maturity. There is also a similar maturity trend for Ts/Ts+Tm ratios ranging from 0.40- 0.55 and C_{31} Hopane Isomerization ratio range of 0.50 – 0.60, which also was evidence of oil generation from an early-mature to mature source rock. The C_{29}ααα Steranes and Ts/Ts+Tm ratio supports a moderate maturity levels for the five sampled oils.

Keywords: Biomarker, crude oil, hopanes, Niger Delta, steranes, thermal maturity.

INTRODUCTION

Biomarker parameters are useful in assessing the thermal maturity of crude oils and this thermal maturity points to the thermal history of oils [1,2]. Hopanes and steranes are used as maturity assessment parameters [2, 3].

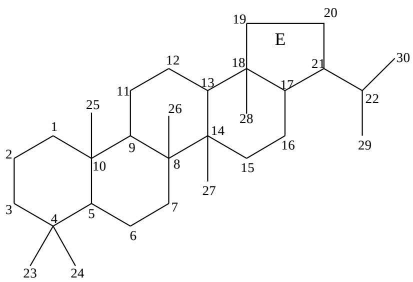
Terpanes, hopanes and steranes are characteristic organic matter fingerprints [4, 5]. This further shows the practical application and usage of biomarkers in interpreting the thermal maturity for organic source matter [3, 6].

Farrimond *et al* [7] stated that before an oil window onset, the maturity parameters approach their equilibrium level and often substantiate a high maturity level inversions and this disqualifies them as maturity indicators. According to Radke [8], maturity parameters of aromatic hydrocarbons are sensitive to changes in maturity especially in the mid- to- late parts of the generation window.

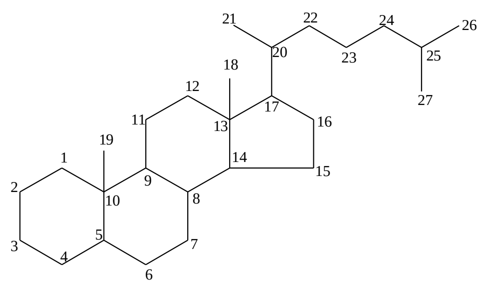
Living organisms were counted as the biological origin of biomarkers. They are resident in rocks whose carbon structure is connected to a formerly living organism. Biomarkers are termed "biological markers". Petroleum geochemists have been utilizing biomarker fingerprinting in the crude oil characterization for correlation of oils with their environment of deposition, organic source input, crude oil thermal maturity and biodegradation levels [3].

This paper examines the geochemical parameters of three oil fields (five crude oil samples) within Bayelsa State, Nigeria to characterize and deduce their maturity levels.

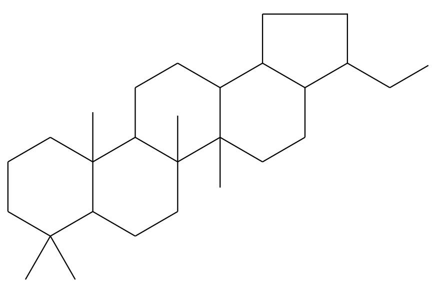
Given below are the structures of some biomarkers found in crude oil.



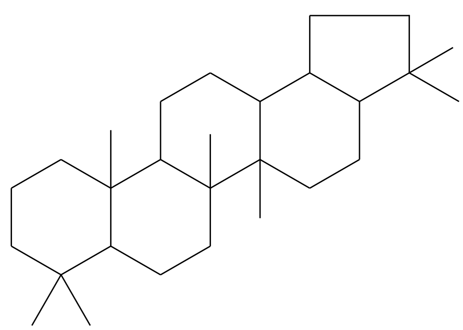
Hopane



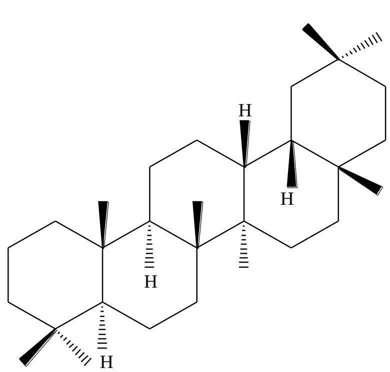
Cholestane C_{27}



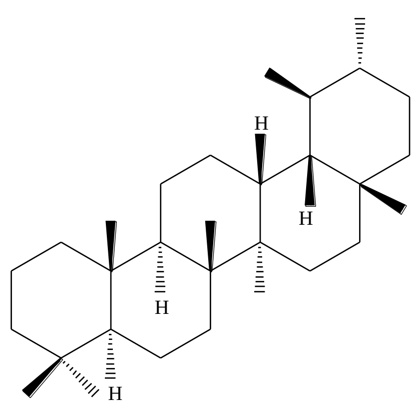
28, 30-Bisnorhopane



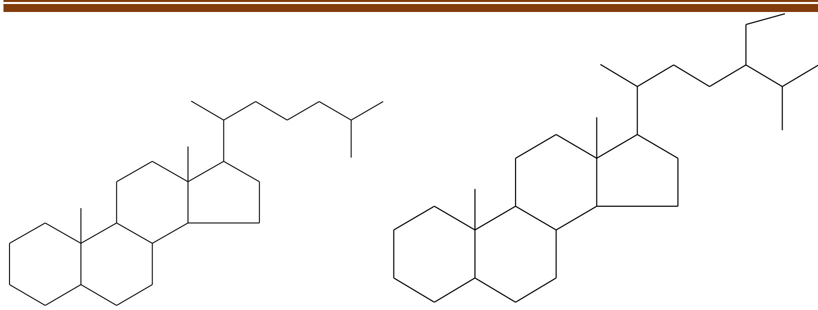
Gammacerane



Olenane



Ursane



Ergostane C_{28} Sigmastane C_{29}

Figure 1: Molecular structures of some biomarkers found in crude oil

MATERIAL AND METHODS

Sample Collection

The studied samples were collected from well heads at Azuzuama, Tebidaba and Clough Creek fields in Bayelsa State, Nigeria (Figure 2) and are representatives of the oil bulk.

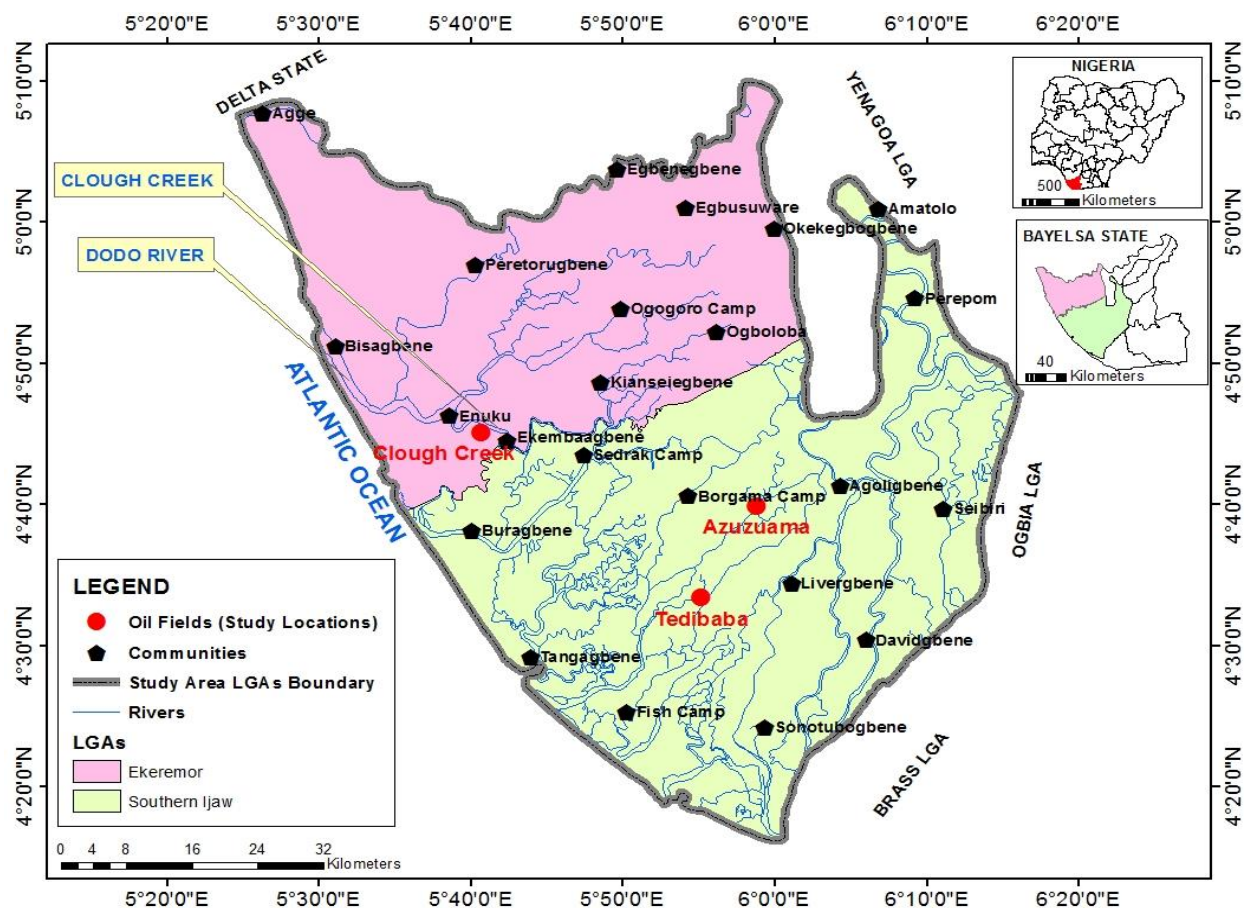


Figure 2: Map showing oil fields where crude oil samples were obtained

The samples were collected from Azuzuama, Clough Creek and Tebidaba fields and were labeled: AZU ST, WELL 2, TEB 12, TEB 08 and CCST. These samples were retained in a glass vials and stored in a refrigerator for preservation till when needed for analysis.

Samples Preparation

30 mg of the oil sample was transferred to a 2 ml bottle with Teflon lined plastic cork, and diluted with 1 ml dichloromethane. The oil samples were fractionated and subjected to Gas Chromatography-Mass Spectrometry analysis. Abrakasa [9] outlined the procedures used for the fractionation of oil samples and these were followed in the study.

The saturated fractions were subjected to Gas Chromatography analysis using HP389OGC serial II, separation performed in a silica capillary column (30 m x 0.25 mm id.) coated with 0.25 µm, 5 % phenyl methyl silicone (HP—5) by HP (Agilent HP389OGC, United Kingdom). Hydrogen gas was used as carrier gas at 2 ml/min with a spilt/splitless injector, the temperature at 50 °C for 2 mins then progressed at 4 °C/min to 300°C at which it was held for 20 mins.

Procedures and conditions for the GC-MS analysis were carried out as outlined by [10] at Giolee Global resources Limited.

RESULTS AND DISCUSSION

Table 1: Thermal maturity parameters in the studied oils using Gas chromatography- aass spectrometry

WELLS	C_{29}/Tot.Sterane	$\alpha\alpha\alpha C_{29}$S/S+R	S/S+R$\alpha\beta C_{31}$Hopane	Pr/nC_{17}	Ph/nC_{18}	Ts/Ts+Tm
AZU ST	0.45	0.33	0.56	1.52	0.69	0.40
CCST	0.54	0.40	0.56	1.09	0.44	0.53
TEB 12	0.59	0.39	0.60	1.64	0.68	0.49
TEB 08	0.49	0.33	0.49	1.04	1.01	0.47
WELL 2	0.51	0.36	0.56	0.73	0.52	0.43

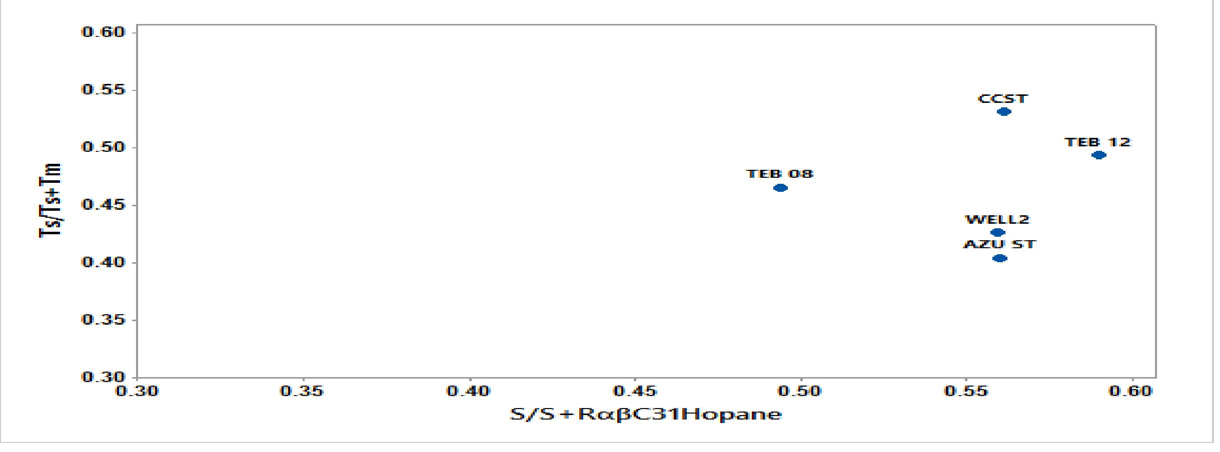


Figure 3: Cross plot of Ts/Ts+Tmvs S/S+R$\alpha\beta C_{31}$Hopane indicating Maturity of the crude oils

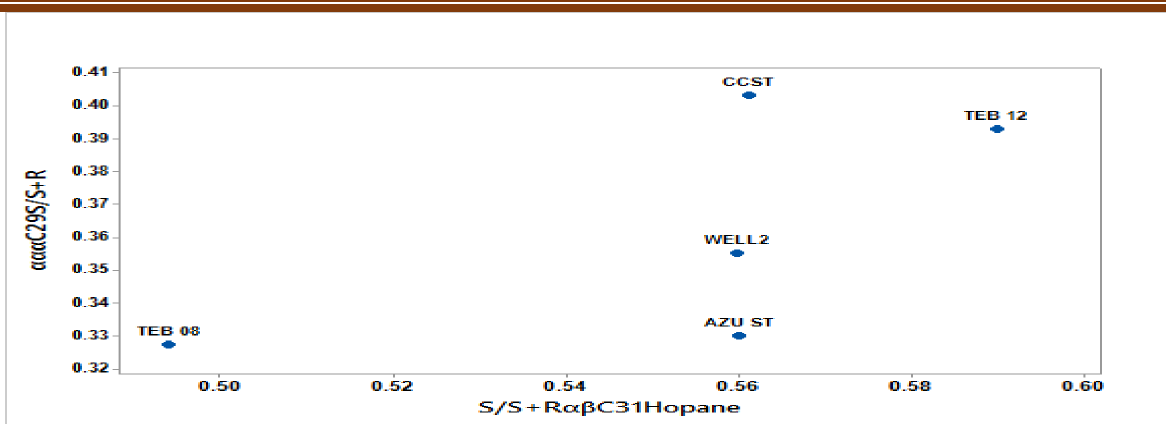


Figure 4: Cross plot of $\alpha\alpha\alpha C_{29}$S/S+R Vs S/S+R$\alpha\beta C_{31}$Hopane

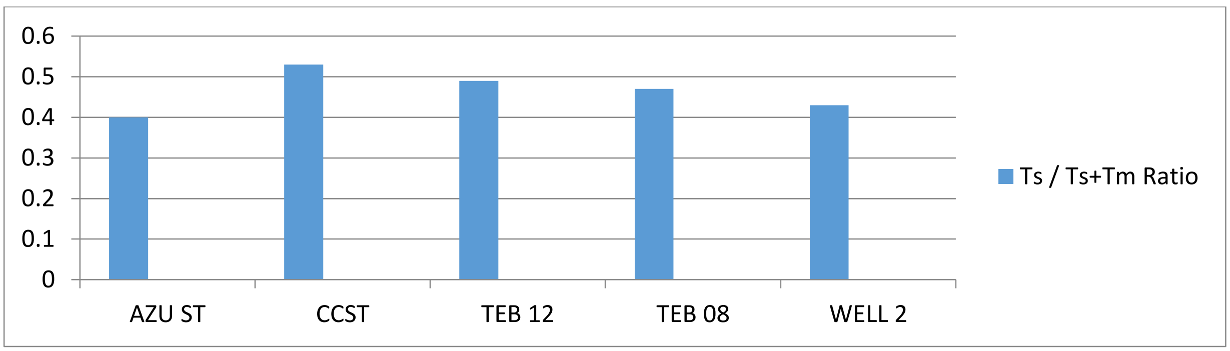


Figure 5: Chart showing Ts/ Ts+Tm distribution in the studied oils

Several biomarker parameters have been examined to estimate the thermal maturity of the studied samples (Tables 1), and to assess the effect of oil-oil correlations tothermal maturation.

In petroleum geochemistry, one of the widely applied maturity parameters is C_{29} αααsteranes. The ααα C_{29} isomerization ratio range from 0.33 – 0.40 (figure 4) of the studied samples show evidence of thermal maturity (evidence of peak oil generation onset). The studied oils are generated from an early-mature to mature source rock [3]. In contrast, low steranes and sterane/hopane ratios are more indicative of terrigenoussource organic input[11] showing the same level of maturation for the organic matter in the samples, a crude oil early-mature to mature window.These relationship and values of C_{29} sterane isomer support a moderate maturity levels for studied samples.

Though Ts/Tm is not appropriate for determining crude oil thermal maturity [12] but during maturation, it starts todecrease very late [13]. The studied samples (CCST & TEB 12) have a predominance of Trisnorneohopane (Ts) over Trisnorhopane (Tm). The predominance of Ts over

Tm is less pronounced in the AZU ST (Figure 5). Obviously, Ts/Ts+Tm ratios display maturity trends similar to S/(S + RαβC_{31}) hopane ratios. The studied samples have Ts/Ts+Tm ratios range from 0.40- 0.55 and C_{31} Hopane Isomerization ratio range from 0.50 – 0.60 (figure 3) showing that the studied samples are moderately mature.

Pr/n-C_{17} and Ph/n-C_{18} are widely used source maturation indicators [3]. Due to increased prevalence of normal alkanes, the ratios of Pr/n-C_{17} and Ph/n-C_{18} decrease with maturation. Thermal cracking causes a decrease in the isoprenoid/n-alkane value with maturation. This results in the elimination of pristane and phytane and production of n-alkanes [14]. Pr/n-C_{17} and Ph/n-C_{18} ratios in the studied samples are displayed in Table 1. These values show the moderate maturity levels for the studied samples.

CONCLUSIONS

The geochemical appraisal of crude oil samples from different producing fields based on their component biomarkers were investigated and characterized. The thermal maturity of these oil samples were assessed using fingerprints generated from steranes and isoprenoids of aliphatic biomarkers. Thermal maturity parameters such as Ts/Ts+Tm, C_{29}ααα Steranes and C_{31}hopanes in the studied samples showed an evidence of thermal maturity. Maturity estimates based on biomarker trends (Sterane /Hopane Isomerisation ratio) indicate that the studied samples are moderately mature.

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