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Organic Geochemical Evaluation for Source Rock Potentials of Mamu Formation Exposed at The Benin Flank of Anambra Basin

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ABSTRACT

Organic matter quantity, quality, maturity studies were carried rock exposures at Benin flank of the Anambra Basin to assess its source rock potential using organic geochemical analysis such as Rock Eval pyrolysis, Total organic carbon content (TOC) analysis, Total Sulphur content (TS) analysis and Soluble organic matter (SOM) analysis. The analytical results of the studied samples reveals that the Total organic carbon content (TOC) and Hydrogen Index (HI) ranged from 1.08 – 3.81wt% and 260 – 1005 mgHC/g respectively indicating that the samples are fair to good source rocks and are of type II/III kerogen based on the criteria for source rock evaluation. Type of Organic matter using cross-plot of HI/OI indicates that they are predominantly of Type III/II kerogen; Maturity studies present them as immature. TSC/TOC cross-plot indicates that they are of normal marine environment, while cross-plot of HI/TOC and TOC/GP shows that they are good potential source rocks and have moderate to very good organic richness. The study area is therefore considered to be of good petroleum potential.

Keywords: Organic geochemistry, Source rock, Rock eval pyrolysis, Kerogen and Organic richness.

1. Introduction

Availability of viable source rocks constitutes a major factor governing the accumulation of hydrocarbon[2]. One of the essential steps in hydrocarbon exploration and exploitation is to understanding the source rock evolution. Organic geochemical characterization of source rocks entails assessing the hydrocarbon generation potential of sedimentary rocks by taking a look at the sediments capacity for hydrocarbon generation, type of organic matter, type of hydrocarbon that is expected to be generated and the sediments thermal maturity[3]. It provides valuable information relating to concentrating exploration activities in particular places and reducing risks and costs.

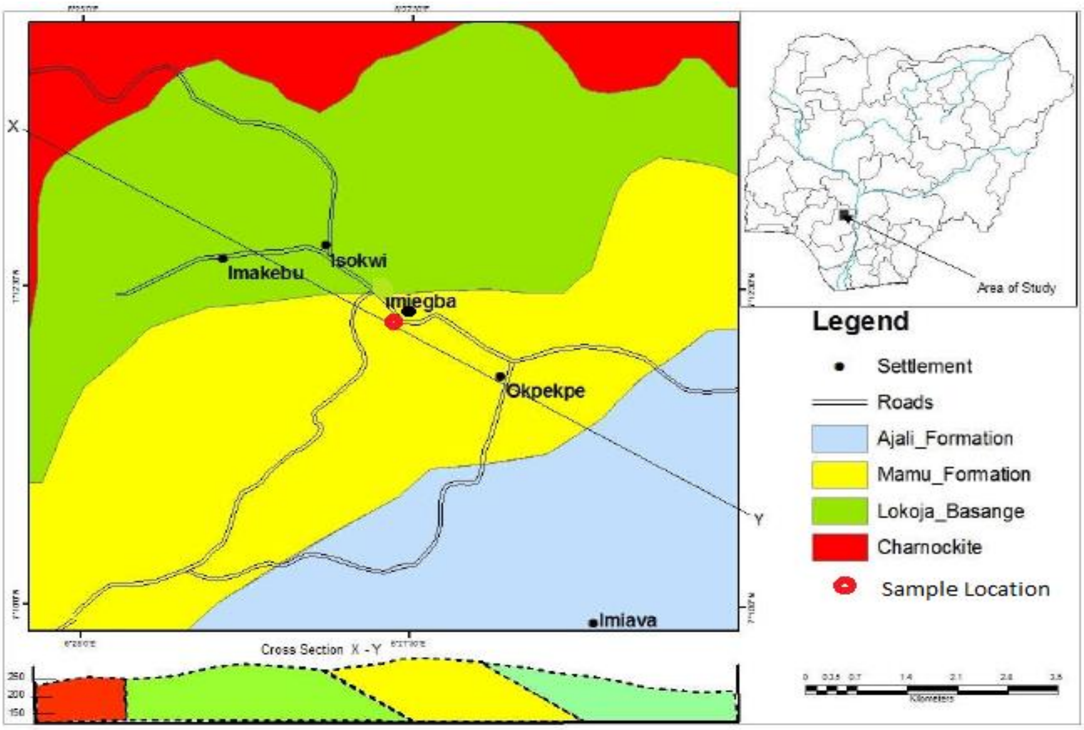

Fig.1: Map showing the Geology of the study area [5]

The objective of this study is to characterize the hydrocarbon generative potentials of the source rocks at Imiegba, Benin flank of the Anambra Basin by assessing its organic richness, type and quality of organic matter, paleodepositional environment and thermal maturity through Organic geochemical analysis.

1.1. Location and geological settings of the study area

The sampled location is at Latitude N07° 11' 28.3" and Longitude E006° 26' 48.1" of the Greenwich Meridian. It falls within the Benin flank of the Anambra Basin.[4]. The sediments of the Benin Flank include the Ajali Formation and the Mamu Formation (Coal Measure) represents a major regression of the Late Cretaceous Sea[9]. The study area is an exposed section of Mamu formation which occurs as a road cut along Imiegba (Fig.1).

2. MATERIALS AND METHODS

The collected samples are summarized in Table 1. Laboratory studies of the samples were based on organic geochemical analysis such as Rock-Eval pyrolysis, Total sulphur content (TS) analysis, Total organic carbon content (TOC) analysis and Soluble organic matter (SOM) analysis.

Table 1: Samples lithologies and the elevations at which they were taken.

SAMPLE	LITHOLOGY	ELEVATION
5	Claystone	159m
4	Grey Shale	156 m
3	Grey Shale	153 m
2	Coaly Shale	152 m
1	Coal	151 m

3.RESULTS AND DISCUSSIONS

Results of the organic geochemical study are presented in Table 2 below.

Table 2: Results of organic geochemical analysis of the studied samples

SAMPLES	TOC	S_1	S_2	S_3	TS	T_{max}	PI	HI	OI	SOM
1	3.82	0.258	0.99	0.82	0.79	332	0.21	260	213	2450
2	2.62	0.663	0.98	0.69	0.35	308	0.40	376	263	2340
3	2.97	0.581	1.32	0.68	0.22	319	0.31	443	229	1620
4	3.64	0.013	3.66	0.049	2.01	423	0.0033	1005	13	1820
5	1.08	0.011	0.46	0.043	2.90	411	0.023	428	40	1101

. TOC, TC, TS and SOM are in (wt.%), while S_1, S_2, S_3 and HI are in mgHC/g

T_{max}: Maximum temperature (°C) TOC: Total Organic Carbon

PI: Production Index HI: Hydrogen Index

OI: Oxygen Index ($mgCO_2/g$) TC: Total Carbon content

TS: Total Sulphur content SOM: Soluble Organic Matter

mgHC/g: Milligram Hydrocarbon per gram Wt%: Weight Percent

$mgCO_2/g$: Milligram Carbon dioxide per gram

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3.1 Quality of organic matter

[11], gave 0.5wt% as the minimum threshold value required for a rock to be regarded as a petroleum source rock. As shown in Table 2, the Total organic content (TOC) of the samples range from 1.08 to 3.64 w.t% (2.83wt.% average), which exceeds the threshold value of 0.5wt.%. This suggests that the samples are good to very good source rocks. A plot of HI versus TOC (Fig. 2.) shows that the samples have good potential to generate Hydrocarbon.

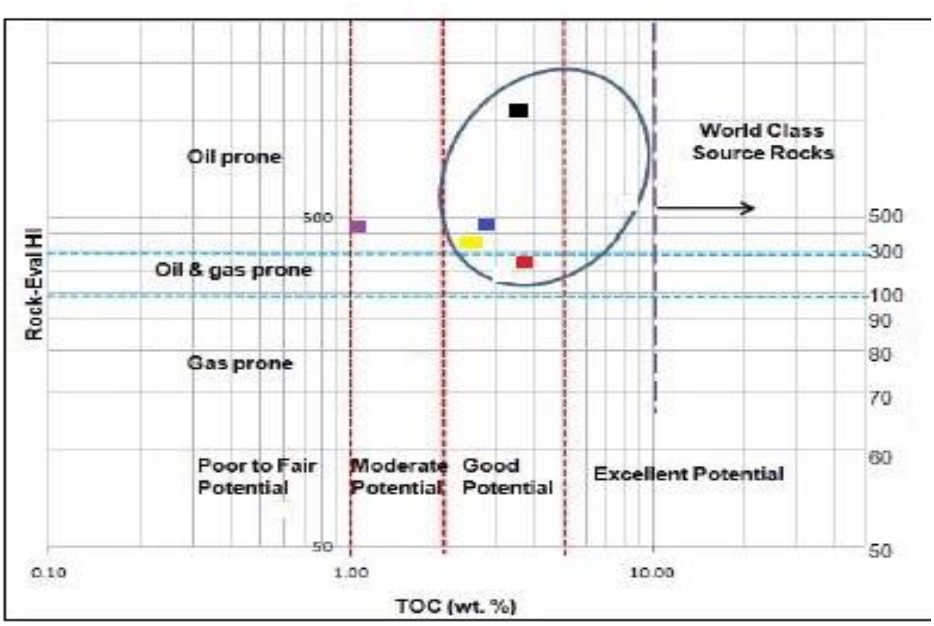

Fig. 2: Plot of Hydrogen index against TOC modified showing the generative potential modified after[1]

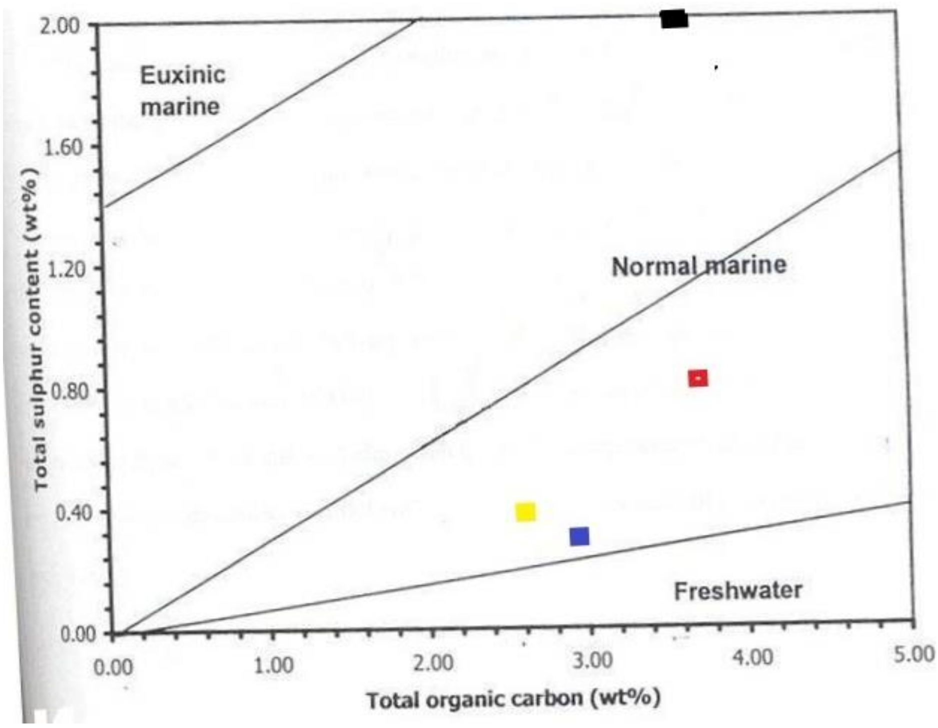

Fig.3: Plot of TS against TOC indicating various conditions of deposition (modified after [7])

3.2 Paleodepositional environment

The paleodepositional environment of the samples taken gives an insight to the type of organic remains that the samples are expected to contain. The Total Sulphur content of the organic matter in the studied samples ranges from 0.22 to 2.90 wt.% (1.25 wt.% average). The TS versus TOC plot in Fig.3, exclusively shows a normal marine depositional environment for most of the samples with sample 5 indicating a deep marine environment and sample 1 tending towards a terrestrial environment.

3.3. Kerogen type

[6] proposed that source rocks with HI greater than 600 mgHC/g will generate oil, while those with HI between 200 and 600 mgHC/g will generate wet gas (oil and gas). Rocks with HI values between 50 and 200 mgHC/g will generate gas and those with HI values less than 50 mgHC/g are inert. The HI values for the samples ranges from 260 to 1005 mgHC/g (502 mgHC/g average). HI versus OI plot in Fig.4. Suggest that the studied samples are dominated by type III/II kerogen. This implies that the samples are oil-gas prone source rocks.

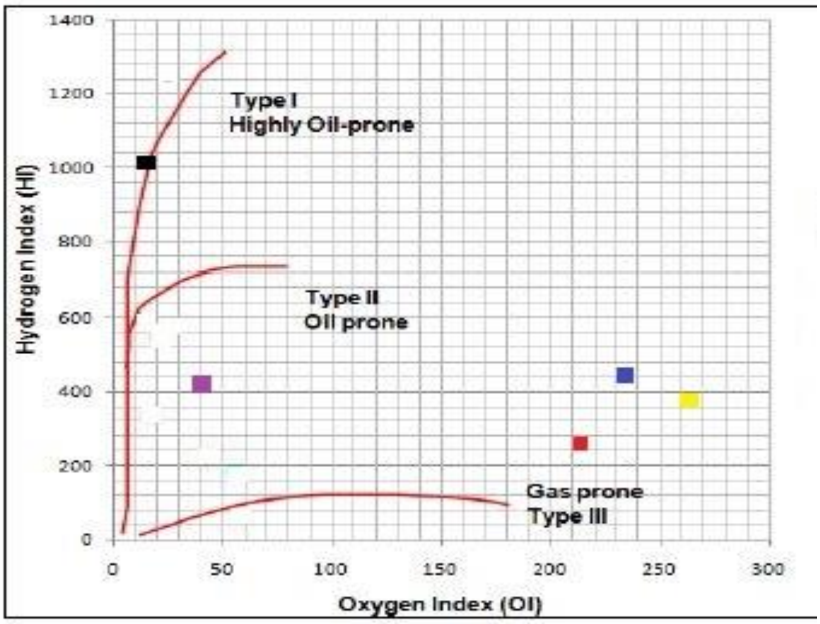

Fig.4: Plot of Hydrogen index against Oxygen index modified showing the organic matter types on modified from Van Krevelen diagram[1]

3.4 Thermal maturation

Maturation is the process of chemical change in sedimentary organic matter, induced by burial, i.e. the action of increasing temperature and pressure over geological time [8] . [10] proposed that source rocks with Tmax values of less than 435oC are Immature, while those with Tmax value of between 435 - 470oC are Mature and those above 470oC are post mature. In this present study, the Tmax ranges from 328 to 423oC (358.6oC average). This suggests that the samples are immature source rocks.

4. CONCLUSION

Organic geochemical assessment and palynological analysis of the studied samples indicates that the samples have good generative potential and are capable of generating hydrocarbons. Paleodeopositional and hydrocarbon origin studies show that the organic matter present was deposited in a terrestrial environment to normal marine environment, they are petroleum source rocks and characterized by indigenous (autochthonous) hydrocarbons. Type of kerogen evaluation shows that they are predominantly of Type III/II Kerogen, as such are capable of generating gas and wet gas. Maturity studies on the kerogen presents their status as immature. Thus, the samples are good potential source rocks. A Maastrichtian age has been assigned to the samples and the exposure as a whole due to the presence of certain diagnostic palynomorph forms present in the samples.

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