ORGANIC GEOCHEMICAL STUDIES OF CRETACEOUS SOURCE ROCKS OF AFIKPO BASIN, SOUTHEASTERN, NIGERIA

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Abstract: *Ten shales* samples obtained in X-Formation, Afikpo Basin and were subjected to geochemical analysis to determine the TOC , SOM and Rock eval pyrolysis. The TOC values varied from 0.6-7.36 % 1.60w% - 1.80w% with an average of 1.66w%, while the SOM values ranged from 100-380 % . Tmax range from 442-462 . The above results show that the TOC values fall above the minimum threshold for hydrocarbon generation potential. The minimum threshold value for TOC is 0.5%. The average SOM value is also indicative of good source rock potential for the studied samples. The Tmax values in the study area shows that the sediments are immature and have not reached the oil generation phase, but are within the gas phase. The organic matter quantity is adequate for sediments to yield hydrocarbon whereas the organic matter quality is inadequate to expel hydrocarbon.

Key Words: Afikpo Basin, geochemical, threshold, hydrocarbon.

1. INTRODUCTION:

Most people now believe that oil and gas are formed when the remains of dead animals and plants are mixed with sediments, buried and formed into rocks and then heated deep underground. The oil and gas then seep out through porous rocks where they may or may not collect in an oil or gas field. Geochemistry, particularly organic geochemistry tries to find if the rocks in an area are of the right sort and the right amount to form oil or gas.
The mechanism of the transformation of the sedimentary organic matter into oil and gas is known as pyrolysis. These transformations take place in a sedimentary rock usually called a SOURCE ROCK. It is important, therefore, to recognize these rocks in the early stages of petroleum exploration, for their evaluation. The presence of more than one source rock in an area makes it more attractive. An estimate of how prolific the source has been and some indication of the nature of the hydrocarbon products (oil or/and gas) is valuable for effective exploration of petroleum.

Location of Study area. The study area is located X-Formation in Afikpo Basin, Southeastern part of Nigeria, (But the actual locations of the wells with respect to latitude and longitudes are concealed for proprietary reasons)

2. AIM AND OBJECTIVES OF STUDY:

The aim of present study is to carry out geochemical characterization of the study area. The characterization involves analysis and interpretation of source rock parameters in order to determine the hydrocarbon source potential of the studied sediments.

3. STRATIGRAPHIC EVOLUTION

Murat, (1972) described the stratigraphy of the Afikpo Basin and noted that the sedimentation was controlled dominantly by transgressions and regressions episodes. The Afikpo Basin in the Southern Benue Trough has the following lithostratigraphic divisions;

Asu River Group: This is a sequence of marine shales occupying the core of the Abakaliki Anticlinorium. It has a thickness of about 6000ft, embedded with shale and micaceous sandstone and the shales are deeply weathered and contains radiolarian echinoids, pelecypods and gastropods . The Age is Albian.

Eze-Aku Shale Group: The Eze Aku Shale group consist of hard grey to black shale having thick flaggy calcareous and non-calcaroeus shale. The Eze-Aku Formation represents a shallow water deposit. The fossils consist of mainly pelecypods, gastropods, echinoids, e.t.c which indicate basal Turonian age .

Agwu Shale: The Agwu Shale overlies the Eze Aku shale conformably and is between Agwu and Ndeaboh in Southern eastern Nigeria.The lithology is a bluish-grey well-bedded shale interbedded with fine yellow calcareous sandstone and shaly limestone with a total thickness of 900m,the strata are greatly folded and contain oil seeps.

Nkporo/Enugu shale and Owelli sandstone: Nkporo shale of Late Campanian age the central and northern parts of the basin. The lithology of Enugu shales consists mainly of carbonaceous shales and coals within the upper half deposited in lower flood plain and swampy environments. The sediments are normally associated with siderites and pyrites which are early diagenetic minerals.

The Owelli sandstone is the major sand member of the Enugu shale formation and forms and elongate shoestring sand body elongated to the NE defining a meander belt of a fluvial/distributary channel system. Sedimentary structures of the channel sand exposed at the junction, for instance demonstrates possible tidal processes coupled with a few gastropod shells recovered, suggesting marine incursions into these distributary channel systems .

Mamu Formation: The Mamu Formation overlies the upper Campanian lateral facies associations described above. The age ranges from lower to middle Maastrichtian from south to north. Both vertical and lateral facies changes are observed, formation thickness ranges from 100m to 1000m across the basin and lithology includes shales and sandstones, with some limestones in the south and coal seams in the central to upper parts of the basin. Depositional

environments include distributary/estuarine channels, barrier foot, swamp and tidal flats,.

The Ajali Sandstones: The Ajali sandstone consists of mineralogically much matured, medium to coarse grained, moderately well sorted quartz grains, and intercalations of thin laterally extensive clay beds of normally less than 1m also occur. The formation thickness is about 300m extending across the entire basin and into the middle Niger Basin and slightly diachronous, ranging from Middle to Late Maastrichtian from south to north.

Nsukka Formation : The Nsukka Formation (Upper Coal Measure) lies conformably on the Ajali Sanstone. It occurs from the north of Awka to the Upper Ankpa sub-basin, with lithology of mainly shales, siltstones, sands and coals and lateritic cover. Age of the formation is from upper Masstrichtian to Danian, and depositional environment is similar in many respects to the Mamu Formation (lower coal measures), consisting

4. MATERIALS AND METHODS:

(A) FIELD STUDY

Sample collection The spot sampling (Davies *et al*, 1973) method was adopted for data collection during the field work. 10 samples were collected using steel hand-auger at different depths for vertical delineation of change in organic matter content as observed visually. All samples were put inside cellophane bags and labeled properly to avoid mix-up.

(B) LABORATORY METHODS

Standard laboratory methods as applied in petroleum potential studies were adopted. This involved analysis for Total Organic Carbon (TOC), Soluble Organic Carbon (SOM), Pyrolysis temperature (Tmax) and Free hydrocarbon (S1).The number of samples evaluated were ten

Total Organic Carbon (TOC): TOC determination is done to estimate the quantity of organic matter in each sample. The basic principle behind this is that organic carbon is determined by a mixture of hydrogen tetraoxosulphate (iv) acid and aqueous potassium dichromate $K_2Cr_2O_7$.After complete oxidation from the heat of solution and external heating, the unused or residual $K_2Cr_2O_7$ (in oxidation) is titrated against ferrous ammonium sulphate. The used $K_2Cr_2O_7$, the difference between added and residual $K_2Cr_2O_7$ gives a measure of organic content of sediment.

Soluble Organic Matter (SOM): To determine source rock potential, maturity and depositional environment. The significance of this is that extraction and the determination of yield of soluble organic matter (SOM) allow for identification of hydrocarbon rich sediments, while the ratio of soluble organic matter (SOM) to the total organic carbon (TOC) gives an indication of the maturity status of hydrocarbon generative potential of the source rock.

Rocks-eval pyrolysis/Toc analysis Rock-Eval pyrolysis technique was applied in this work and is based on the methodology described by Espitalié *et al* (1977.This technique provided data on the quantity, quality, and thermal maturity of the associated organic matter.

5. RESULTS AND DISCUSSION:

The results of the geochemical analysis are presented in Tables 1 below

SAMPLE No	Lithology	Location	Formations	Depth (m)	TOC (wt%)	SOM(ppm	T(Max
1	Shale	A	Mamu	15	7.46	400	425
2	Shale	A	Nsukka	0.4	0.69	140	426
3	Shale	B	Nsukka	1.1	0.78	170	428
4	Shale	B	Nsukka	1.0	0.66	380	447
5	Shale	C	Nsukka	5.8	0.73	380	429
6	Shale	C	Mamu	4.6	0.64	350	366
7	Shale	D	Mamu	4.0	0.61	380	365
8	Shale	D	Nsukka	1.4	0.63	160	356
9	Shale	E	Nsukka	1.8	7.51	130	426
10	Shale	E	Nsukka	0.7	7.56	160	462

(a) Total organic carbon (TOC) The Total Organic Carbon (TOC) is a direct measure of the organic matter present in the rock. It is indicative of the organic matter available for the formation of hydrocarbon. The results of the TOC are present in Table 1. The TOC values varied from 0.69-0.7.46wt% for samples collected from A area, 0.66-0.78 wt% for samples collected from B area, 0.64-0.73wt% for samples collected from C area, 0.61-0.64 wt% and 7.56wt% for samples collected from D and E areas respectively. These values are indicative of good organic matter richness for hydrocarbon generation. The results suggest that only one sample collected from E area is capable of expelling hydrocarbon even at minimal maturity.

(b) Soluble organic matter Ten shale samples yielded organic extract in the range of 100ppm-380ppm with an average value of 210ppm for all the samples analyzed. The results showed that the SOM value varied from 100-200ppm for samples collected from A area, 300-380ppm for samples collected from B area, 380ppm for samples collected from C area, 150-160ppm and 350ppm for samples collected from D and E sections respectively. The work of Deroo *et al* (1977), relates the SOM contents to source rock potential. These values are greater than 50ppm and it indicates that the source rocks have adequate organic matter to generate hydrocarbon.

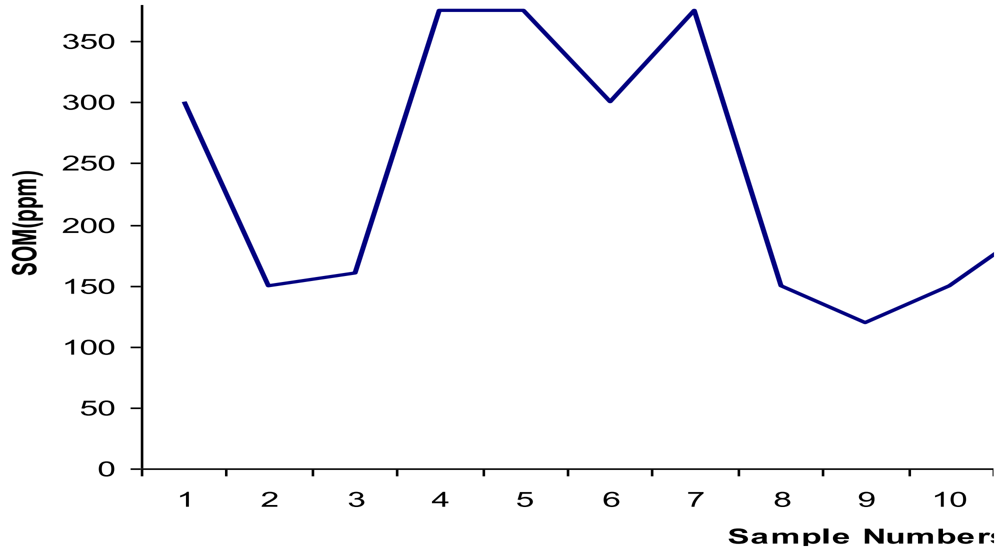

Figure 1 Geochemical log for extract yield (SOM) versus sample numbers

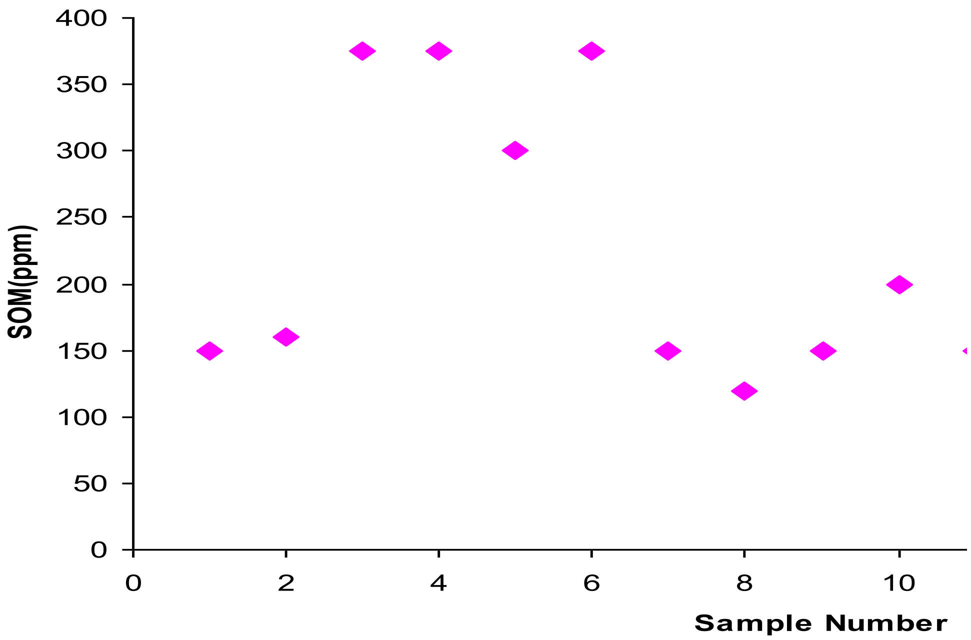

Figure 2 Varriation of SOM (ppm) with sample intervals

(d) Pyrolysis temperature (Tmax). In this study, Tmax value is used as a simple measure of the samples' level of thermal maturity. Thermally matured samples in the study area displayed Tmax value of at least 365^0C, with an average value of 418^0C for all the samples analyzed. This is in line with minimum maturity threshold of 435^0C, Peters *et al* (1986). Tmax values range between $425\text{-}426^0$C for samples collected from A area indicating early to peak maturity. Tmax values for samples collected from B area varied from 428- 447^0C indicating thermal immaturity. Samples collected from C area varied from 366- 429^0C indicating immature to early thermal maturity.

6. CONCLUSION:

Based on the results of geochemical analysis, the organic matter content of the samples is adequate for hydrocarbon generation. The samples analyzed from A, B, C and D are classified as poor, while the sample analyzed from E area is classified as very good. There is contrasting levels of thermal maturity in the study area. Maturity variation in the study area is due to presence of high temperature associated with tectonism. The results indicate an oil and gas source possibility in the study area while some part of the area has potential for gas only.

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