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Research Article

HYDROCARBON POTENTIAL ASSESSMENT OF BENDE AREA, AFIKPO SOUTH EAST, NIGERIA

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ABSTRACT

Geochemical analyses were carried out on shale samples obtained from a well in the Bende Area, Afikpo Basin, to determine the TOC and SOM values. The TOC values varied from 0.88wt% - 1.40wt% with an average of 1.07wt%, while the SOM values ranged from 30ppm – 470ppm with an average of 130.5 ppm. 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 of 130.5 ppm which is higher than the minimum value which is 50 ppm is also indicative of good source rock potential for the studied samples. The transformation ratio which serves as a quantitative analysis to determine the level of maturity shows an average value of 12.6 which indicate that studied samples of the area are immature. The implication, therefore, is that the sediments from the studied depth slice can be regarded as immature sediment in predominantly gas prone enviroment.

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. It is in this regard, that the present work is aimed at evaluating the source rock qualities of the study area , with a view to further understanding the petroleum prospects of the Afikpo Basin.

(i) Location of study Area: The studied samples were recovered from an interval of an appraisal well in Bende Area in Afikpo Basin, southeastern Nigeria which lies within Latitude 52 30' and Longitude 80 .60' in southeastern Nigeria .

(ii) Aim of the Study: The aim of this research work is to carry out petroleum potential assessment of a sedimentary section of Bende Area in Afikpo Basin. The Characterization involves analysis and interpretation of source rock parameters in order to determine the hydrocarbon source potential of the studied sediments

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: The Asu River Group consists of shales, sandstones and limestone. It is the oldest lithostratigaphic unit in the study area, and was deposited during the Albian transgressive phase. It is also the oldest dated sedimentary rock unit in Southern Benue Trough. According to Reyment (1965), the Albian sediments were moderately folded in many places with the fold axis trending NE-SW. Ukaegbu and Akpabio (2009) have differentiated the Asu River Group northeast of the Afikpo Basin. According to them, the Asu River Group consists of alternating shale, siltstone with occurrence of sandstone. The maximum thickness of Asu River Group is 1000m, Albian in age and rich in ammonites as well as foraminifera, radiolarian and pollens. The shale, Asu River Group is characterized by species of *Monticeras* and *Elobiceras* which are

ammonites (Offodile, 1976).

Ezeaku Formation: The typical locality of the Eze Aku Group is the Eze Aku River valley in southeast of Eze Aku. Murat (1972) was of the view that the Eze-Aku shale shows deposits of marine conditions in a tectonically controlled Basin. He believed that sandstone deposits mark a period of regression, while the shale deposits indicate a period of transgression.

Agwu Shale: The Agwu shale overlies the Eze-Aku Formation conformably. The lithology is a blurish-grey well bedded shale interbeded with fine grained yellow calcareous sandstone and shaly limestones, with a total thickness of about 900meters.

Nkporo Shale: In Southeastern Nigeria, Campanian sediments probably belong to the base of the Nkporo Formation. No typical Campanian Ammonites have been found in Nigeria but it is probably that the base of the Nkporo Formation and its lateral equivalents, are Campanian in age (Ukaegbu *et al*., 2009). The major part of the Formation is Meastrichtian. The Campano-Maastrichtian sediments in Southeastern Nigeria have dark grey shale, which is often friable. This part of the sequence belongs to the Nkporo Formation. The Owerri sandstone and Enugu shale are lateral equivalents of the Nkporo Formation.

Mamu Formation: It is stratigraphically synonymous to the lower coal measures and is of Lower-Middle Maastrichtian in age. Cross stratification is rare and of very low angle when present. There are fragment interbeds of carbonaceous shales with a sparse arenaceous micro fauna and coal beds. The lithology of Mamu Formation in the subsurface is similar to that on the surface except that the more continuous and thicker subsurface sections show that there are numerous fairly thick shale interbed in the sequence.

Ajali Formation: The Ajali Formation is the middle coal measure and is of Middle-Late Maastrichtian in age. Fresh rock exposures are rare because the Formation is often overlain by a considerable thickness of weathered red earth. Trough stratification, herringbone cross bedding tidal bundles, back flow ripples and reactivation surfaces occur in the section. This formation exhibits variation in topography from less than 300m to more than 1000m above sea level and is mineralogically highly mature. Ajali Formation consists of coarse grained, moderate to poorly sorted sandstone. These sandstones usually occur as thick friable strong cross-stratified units. However, the Ajali sandstone consists of white, cross-bedded sandstone with thin beds of white mudstone near the base. Escape burrows, ophiomorpha and skolitos are the organic structures present. The environment is of shallow marine/tidal (sand) waves. Reversal of direction of tidal current is demonstrated by the sedimentary structures.

Nsukka Formation: The Nsukka Formation is stratigraphically synonymous with the upper coal measures (Murat, 1972). There are brown and grey shales and sandy shales and mudstones with numerous coal seams at various horizons. Much of the sections that have no coal seam are rich in fragmentary plant remains. The lithology is similar to that of the Mamu Formation except that Nsukka Formation is generally less sandy and

carries fewer coal seams

MATERIALS AND METHODS

Sample Preparation: Selected sample interval (Table 1) the samples were oven dried properly after which they were ground individually.

SAMPLE NO	*DEPTH(METRES*
1	***0-5***
2	***6-10***
3	***10-15***
4	***15-20***
5	***25-30***
6	***30-35***
7	***35-40***
8	***45-50***

Table 1: Selected sample interval

EVALUATION TECHNIQUES: The Eight shale samples were subjected to a geochemical analysis in order to characterize their petroleum generation potential

The analytical methods involves are:

(a) Extraction and Fractionation of soluble organic matter (SOM) from the samples and

(b) Determination of total organic carbon (TOC) content

(a) 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 (K2Cr2O7).After complete oxidation from the heat of solution and external heating, the unused or residual K2Cr2O7 (in oxidation) is titrated against ferrous ammonium sulphate. The used K2Cr2O7, the difference between added and residual K2Cr2O7 gives a measure of organic content of sediment.

(b) 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,Ejedawe et al. (1979).

RESULTS

The total organic *carbon content* (TOC) of the ten (8) analyzed samples varied from 0.88wt% - 1.40wt%, with an average of 1.07%. Table 2, shows the end point and TOC values obtained .It has been established from various studies that TOC of 0.5% is the standard minimum threshold value for source rock to generate hydrocarbon, Frankyl (1967)

SAMPLE NUMBER	END POINT VALUES	RATING	TOC	DEPTH
1	1.88	GOOD	1.10	0-5
2	1.30	GOOD	1.40	5-10
3	1.60	GOOD	0.98	10-15
4	1.90	GOOD	0.96	15-20
5	2.10	GOOD	0.90	20-25
6	2.20	GOOD	0.88	25-30
7	1.50	GOOD	1.10	35-40
8	1.80	GOOD	0.97	45-50

Table 2: Total organic carbon content of the study area

Therefore an average TOC value of 1.07 wt% for samples studied is well above the minimum threshold for hydrocarbon generation. Ronov [17] states that the ability of a rock to generate and expel hydrocarbon is dependent on the quantity of organic matter present. The quantity of organic matter present in a rock can be evaluated and classified using the total organic carbon content as indicated below,
Ekweozor et al. (1984)

TOC (WT %) Grade of Source Rock

< 0.5% Poor

0.5% - 1.0% Fair

> 1.0% Good

From the data above, it can be inferred that the analyzed samples which yield organic carbon values are greater than the threshold value (0.5%). The organic carbon rating of the source rock can be said to be good, Evamy et al (1978).

Extractable Soluble Organic Matter (SOM): The samples were subjected to extractable soluble organic matter analysis (SOM), the values were shown (see Table 3)

SAMPLE NUMBER	RATING	TOC	DEPTH	Wt of sample (g)	Weight of extract	SOM
1	GOOD	1.10	0-5	10	0.016	0.030
2	GOOD	1.40	5-10	10	0.038	0.040
3	GOOD	0.98	10-15	10	0.270	0.020
4	GOOD	0.96	15-20	10	0.083	0.131
5	GOOD	0.90	20-25	10	0.017	0.188
6	GOOD	0.88	25-30	10	0.019	0.08
7	GOOD	1.10	35-40	10	0.067	0.49
8	GOOD	0.97	45-50	10	0.280	0.15

Table 3: Values obtained for the soluble organic matter (SOM) of well samples by Soxtec extraction method

The extractable soluble organic matter (SOM) showed a pattern similar to that of the total organic carbon content. The SOM values increases from depth interval 0-5m to 15-20m with depth of burial and then flunctuate for the rest of the depth interval (Table 3). The value of SOM ranges from 20ppm to 480ppm with an average of 120.5ppm. Deroo et al (1967) from the Source rock classification scheme of the soluble organic matter (SOM). The average SOM value for analyzed well samples falls within this range, and is interpreted to be good source rock. However, the concentration of soluble organic matter of less than 7000PM as in the case of the study area, is incomparable to the prolific petroleum source rocks of the world.

Transformation Ratio*:* The transformation ratio serves as a quantitative analysis is an index of maturity. It is investigated as a comparative measure between the values of SOM and those of TOC.

Average transformation ratio is 12.6:

According to Deroo et al [1967] values of transformation ratios between 1.7-49.5 indicate that the sediments are immature, base on these immature status , the estimated vitrinite reflectance values of most of the samples are indicative of an immature bed that may be capable of generating oil and gas when matured, the resultant maturity status is confirmed by relatively low vitrinite reflectance. The initial oil generation begins in sedimentary rocks at vitrinite reflectance value (VRO) 0.6% while oil generation terminate at vitrinite reflectance value (VRO)= 1.3%, Frankyl [10], and this concides with the beginning of maximum gas generation . According to Reyment [16] the Anambra/Afikpo basins has sediments that are within the gas generating range., the average TR value for the samples is 12.6 which indicates that sediment in the study area are immature.

DISCUSSION

Hydrocarbon source rock evaluation of the samples from study area was carried out to determine whether they are good or poor source rocks. In the study, two criteria were used, namely, organic richness and degree of maturation. The determination of organic richness was based on the amount of organic carbon content and extractable organic matter. The total organic carbon content ranges from 0.88w% 1.40 wt% with an average of 1.07%. This implies that they are very good, and they exceed the minimum threshold value for a petroleum source rock (0.5wt%). The extractable organic matter also tends to increase initially and then flunctuate as the depth of burial increases. The values obtained is interpreted as an indicative of good source rock (SOM values of 20ppm- 480ppm, average of120.5ppm).

The level of maturity of the sediment to produce hydrocarbon was determined using the transformation ratio (TR). This is a ratio of the extractable soluble organic matter to total organic content (SOM/TOC). The values tend to fluctuate. The highest being 47.8. The ratio of SOM/TOC contained in sediments is a measure of the transformation of kerogen into hydrocarbon. It is low in immature sediments, but increases sharply in mature ones , Cavaliere,[1978]. In this study,. Deroo et al [1967] has stated that values of less than 70(<70) indicate no hydrocarbon generation. The average value of TR 12.6 for the studied samples does not exceeds this threshold. Therefore, the samples can be said to be immature.

CONCLUSION

The result of the various geochemical analyses carried out within the studied sedimentary section shows that the samples indicates that the study area is predominantly gas prone. The TOC values range from 0.88wt% -1.40wt% with an average of 1.07wt%. According to Bordenave et al [1993], the TOC of a sediment is the basic parameter which is required to interprete any other geochemical information obtained by other methods. Therefore, good source rocks have high TOC values The maturity status of the sediments is an indicative of immature source rocks It is generally accepted that good shaly source rock of liquid petroleum should normally have a minimum average TOC of 1 – 2wt%. Therefore, it is reasonable to conclude that the level of organic richness as indicated by TOC and extractable organic matter as measured by SOM and as well as maturity assessment that the study section consist of immatured sediments in a predominantly gas prone environment.

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