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Research Article

GEOCHEMICAL ANALYSIS OF X-WELL, AGBADA FORMATION, NIGER DELTA, NIGERIA

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ABSTRACT

Ditch cuttings from a well in OML 85 in of Agbada Formatio Niger Delta were subjected to geochemical analysis to determine the TOC and SOM values. The TOC values varied from 1.58w% - 1.90w% with an average of 1.74w%, while the SOM values ranged from 0.012% - 0.2184% with an average of 0.563%. The above results show that the TOC values fall above the minimum threshold for hydrocarbon generation potential. The minimum threshold value for TOC in the Niger Delta is 0.5%. The average SOM value of 0.563% 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 0.27 against the minimum threshold value of 0.16. The implication, therefore, is that the sediments from the studied depth slice can be regarded as good source rock for hydrocarbon generation.

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.

Geology of the Study Area:

The stratigraphy of the Niger Delta is intimately related to its structure. The development of each being dependent on interplay between sediment supply and subsidence rate. Short and Stauble (1967) recognized three subsurface stratigraphic units in the modern Niger Delta. The delta sequence is mainly a sequence of marine clays overlain by parallic sediments which were finally capped by continental sands.The stratigraphy of Niger Delta Basin are as follows:

Benin Formation: The formation comprising over 90% sandstone with shale intercalations extends from the west across the entire Niger Delta area and southward beyond the present coast line. The thickness though variable is estimated at about 6000fts. It is coarse grained, gravelly, poorly sorted, sub-angular to well rounded and bears lignite streaks and wood fragment. The formation is characterized by structural units such as channel fills, point bars etc which indicate variability of the shallow water depositional medium. The Benin formation with very little hydrocarbon accumulation ranges in age from Oligocene to Recent.

Agbada Formation: The formation is a sequence of sandstones and shales with sandstone dorminant in the upper unit and thick shales in the lower unit. It is very rich in microfauna at the base decreasing upwards suggesting an increase in the rate of deposition at the delta front. The grains are coarse and poorly sorted indicating a fluvatile origin.The Agbada formation covers the entire subsurface of the delta and may be continuous with the Ogwashi-Asaba and Ameki formations of Eocene- Oligocene age. It is over 10,000ft thick and are the major hydrocarbon bearing unit in the delta.

Akata Formation: The formation underlies the entire delta and forms the lower most unit. It is a uniform shale development consisting of dark grey sandy, silty shale with plant remains at the top. The Akata formation is typically overpressured and believed to have formed during lowstands when terrestrial organic matter and clays were transported to deep water areas characterized by low energy conditions and oxygen

deficiency (Statcher 1995). It is over 4000ft thick and ranges in age from Eocene to Recent and is believed to have been deposited in front of the advancing delta.

Location of Study Area: The studied samples were recovered from an interval of an appraisal well within the X-Well of the Agbada Formation Niger Delta Basin.

Aim of Study: The aim of present study is to carry out geochemical characterization of a sedimentary section from a depth slice within OML 85, in the X-Well of the Agbada Formation, Niger Delta. The characterization involves analysis and interpretation of source rock parameters in order to determine the hydrocarbon source potential of the studied sediments.

METHODOLOGY

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

Sample number	**Depth Intervers**(metres
1	3050-3055
2	3055-3060
3	3060-3065
4	3065-3070
5	3075-3080
6	3080-3085
7	3085-3090
8	3090-3095
9	3095-3100
10	3100-3105
11	3105-3110
12	3110-3115

Table 1: Selected Sample Interval

EVALUATION TECHNIQUES:

The 12 drill cuttings 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 ($K_2Cr_2O_7$).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.

(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.

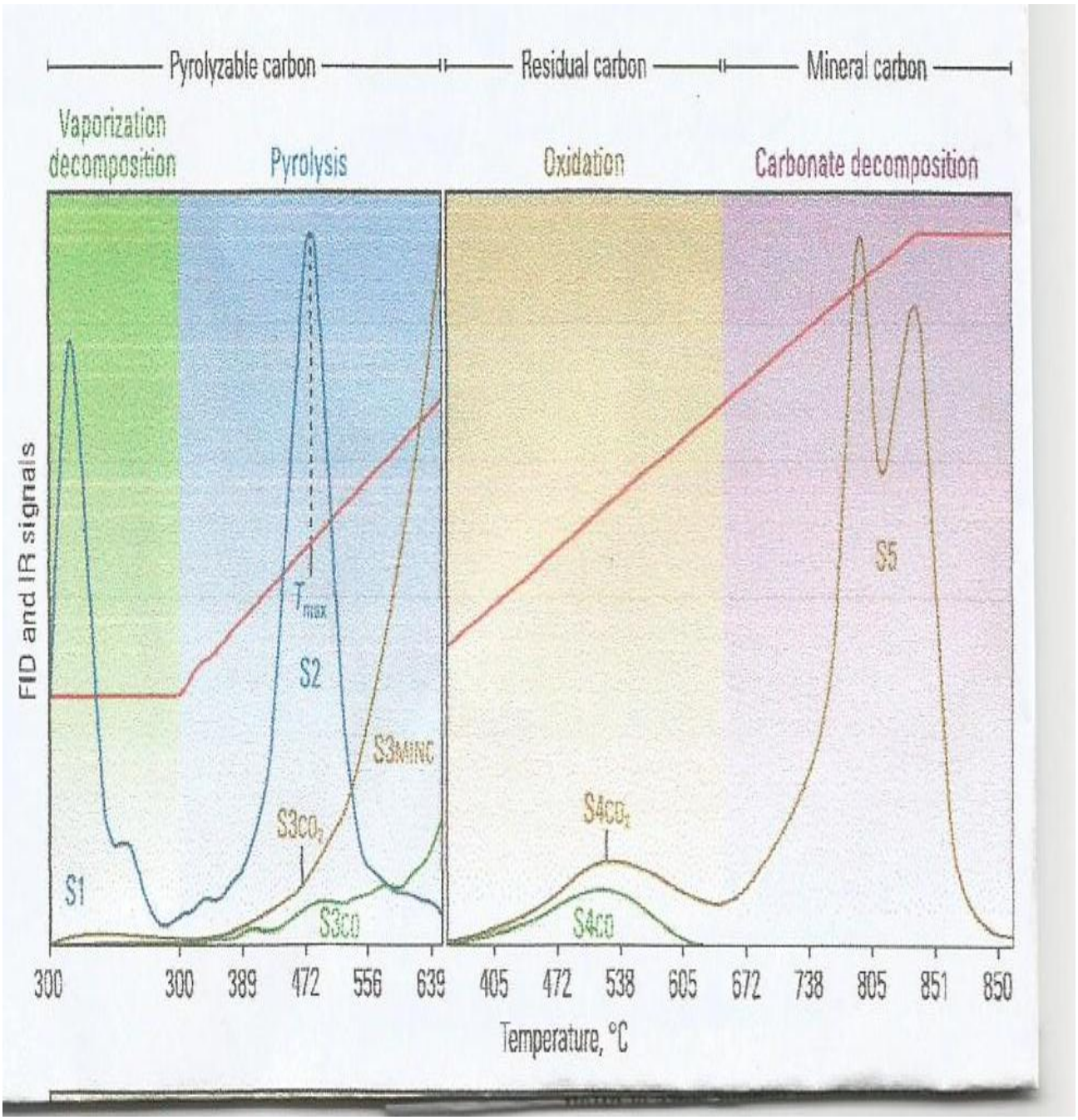

Figure 3: Response of Organic Carbon to controlled heating during pyrolysis

(Adapted fron Vinci technology, 2011)

PRESENTATION OF RESULTS

The total organic carbon content: (TOC) of the twelve (12) analyzed samples varied from 1.58wt% - 1.90wt%, with an average of 1.74%. Table 2, shows the end point and TOC values obtained.

Sample number	Depth Intervers	End Point Values	TOC	Rating
1	3050-3055	1.93	1.90	Good
2	3055-3060	1.94	1.68	Good
3	3060-3065	1.75	1.71	Good
4	3065-3070	2.29	1.59	Good
5	3075-3080	2.29	1.60	Good
6	3080-3085	2.20	1.60	Good
7	3085-3090	2.04	1.66	Good
8	3090-3095	2.03	1.68	Good
9	3095-3100	2.09	1.62	Good
10	3100-3105	2.04	1.61	Good
11	3105-3110	2.00	1.60	Good
12	3110-3115	1.98	1.58	Good

Table 2: Total organic carbon content of the study area.

Sample number	Depth Intervers	Weight of sample	Wt of extract	SOM
1	3050-3055	25	0.2180	6426
2	3055-3060	25	0.1265	6314
3	3060-3065	25	0.0048	272
4	3065-3070	25	0.0038	785
5	3075-3080	25	0.0071	382
6	3080-3085	25	0.0045	218
7	3085-3090	25	0.0041	232
8	3090-3095	25	0.0026	123
9	3095-3100	25	0.0051	296
10	3100-3105	25	0.0015	2846
11	3105-3110	25	0.0013	2890
12	3110-3115	25	0.0012	2895

Table 3: Values obtained for the soluble organic matter (SOM)

The extractable soluble organic matter (SOM) showed a pattern similar to that of the total organic carbon content. The SOM values increased with depth of burial (Table 3). The value of SOM ranges from 0.012% to 0.2184% with an average of 0.563%. Deroo et al (1977) have shown that soluble organic matter content in the range of 0.15% - 3.36% is high. The average SOM value for analyzed well samples falls within this range, and is interpreted to be high.

Transformation Ratio*:* The transformation ratio, which serves as a quantitative analysis is an index of maturity. It is investigated as a comparative measure

Average transformation ratio is 0.27

According to Deroo et al (1988) values of transformation ratios between 0.002 – 0.016 indicate no hydrocarbon generation, that is, the standard threshold value of transformation ratio is 0.18. From the table, the average TR value for the samples is 0.27; this is far above the standard threshold value required for hydrocarbon generation. This implies that the sediments are good source rocks.

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 1.58w% - 1.90wt% with an average of 1.74%. This implies that they are very good, and fall within the range expected in the Niger Delta area (Ekweozor et al, 1984). The extractable organic matter also tends to increase as the depth of burial increases. The values obtained were interpreted to be high (SOM values is 0.012% to 0.2184, average of 0.563%). 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 value is obtained at 3050m-3055m depth. 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, although initial high values at 3100m-31055m were recorded, this decreased and then rose sharply at 3050m-3055m, suggesting that the sediment penetrated probably vary from immature at the top to mature at depth. Deroo et al (1988) has stated that values of 0.002-0.016 indicate no hydrocarbon generation. The average value of TR for the studied samples exceeds this threshold. Therefore, the samples can be said to be fairly mature and hence good source rock material.

CONCLUSION

The result of the various geochemical analyses carried out within the studied sedimentary section shows that the samples exhibited the qualities of good source rock.

The TOC values range from 1.58w% - 1.90wt% with an average of 1.74%. According to Bordenare 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 average TOC value for the studied samples is in agreement with the 0.4-4.4% range reported by Ekweozor and Okoye (1985) for the Niger Delta 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 sampled section has the optimum Kerogen concentration to produce petroleum. This view is reflected in the extractable soluble organic matter values. The maturity status of the sediments show a fairly good agreement with the views of Short Sand Stauble (1965), and Frankl and Cordry (1967) that the shales of the parallic Agbada Formation are source rocks in the Niger Delta. However, this differs with the views of Weber and Daukoru (1975) and Ekweozor and Daukoru (1984) that in most parts of the delta, the Agbada Formation is immature as to be the source rock.

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