International Journal of Oil, Gas and Coal Engineering
2014; 2(2): 19-27
Published online May 30, 2014 (http://www.sciencepublishinggroup.com/j/ogce)
doi: 10.11648/j.ogce.20140202.12

Geochemical characterization of potential source rock of the Central (Saltpond) Basin, Ghana

S. Bansah[1, 3, *], E. K. Nyantakyi[2, 4], L. A. Awuni[3, 5], J. K. Borkloe[2, 4], Gong Qin[2]

[1]Department of Geological Sciences, University of Manitoba, 240 Wallace Building, Winnipeg, Canada, MB R3T 2N2
[2]School of Earth Sciences, Yangtze University, Caidian Wuhan, 430100, Hubei, China
[3]Geological Engineering Department, KNUST, Kumasi-Ghana, 03220
[4]Civil Engineering Department, Kumasi Polytechnic, P.O. Box 854, Kumasi-Ghana, 03220
[5]Ghana National Petroleum Cooperation, PMB, Petroleum House, Tema

Email address:

bansero@hotmail.com (S. Bansah), emmanuelkwesinyantakyi@yahoo.com (E. K. Nyantakyi), laawuni@gmail.com (L. A. Awuni), juliusborkloe1@yahoo.com (J. K. Borkloe), cdgongqin2007@126.com (Gong Qin)

To cite this article:

S. Bansah, E. K. Nyantakyi, L. A. Awuni, J. K. Borkloe, Gong Qin. Geochemical Characterization of Potential Source Rock of the Central (Saltpond) Basin, Ghana. *International Journal of Oil, Gas and Coal Engineering.* Vol. 2, No. 2, 2014, pp. 19-27.
doi: 10.11648/j.ogce.20140202.12

Abstract: This research characterized the potential source rock of 3 exploratory wells from the Central (Saltpond) Basin, Ghana. Ten (10) samples each of the drilled cuttings from the three key exploratory wells were geochemically characterized for total organic carbon contents (TOC), rock-eval pyrolysis techniques and vitrinite reflectance measurements (Ro). The results revealed that they have fair to good total organic carbon (TOC) contents, suggesting that there might exist conditions in the Saltpond Basin that favour organic matter production and preservation. The rock-eval results showed that all the samples from the 3 exploratory wells contain predominantly types II and III kerogen with a capacity to generate gas-oil and gas respectively. They have good generation potential. Results of the vitrinite reflectance measurement also reveal that all the samples from the 3 exploratory wells have poor to low source-rock grade. The Saltpond Basin can be regarded as having fair petroleum source rocks and could be part of a petroleum system if sufficient burial and maturation have occurred.

Keywords: Central (Saltpond) Basin, Core Samples, Total Organic Carbon Content, Rock-Eval, Vitrinite Reflectance

1. Introduction

The Saltpond Basin is amongst one of the hydrocarbon provinces in Ghana. The basin has been exposed to some level of exploration activity since the 1970's. From the exploration activities and reservoir assessment done on the basin, it had been described as a poor prospect for petroleum accumulation [1].

The Saltpond Basin is a Paleozoic wrench modified pull-apart basin centrally located between the Tano-Cape Three Points and Accra-Keta basins. It covers an area of approximately 12,294 km^2. Sediments in the basin were deposited in non-marine to coastal marine environments, and range in age from Ordovician to Cretaceous. The basin has been stratigraphically divided into formations based on lithofacies and depositional environments [2]. These are from oldest to youngest: Elmina Sandstone (Late Ordovician-Early Silurian), Takoradi Sandstone (Devonian), Takoradi Shales (Middle Devonian-Early Carboniferous), Efia Nkwanta Beds (Late Carboniferous-Permian), Sekondi Sandstone (Triassic-Early Jurassic) and the Lower Cretaceous sediments. The structure of the basin is characterized by multiple faulting, which has resulted in a complex set of horsts and grabens.

The only known and proven petroleum system in the Saltpond Basin is the Lower Paleozoic Petroleum System. This system has Devonian source rocks and Devonian to Carboniferous reservoirs. The two main source rocks are the Lower and Upper Takoradi Shales. These are dark grey shales with predominantly Type II kerogen and moderate to good TOC and HI values. The reservoirs are sandstones of the Takoradi Sandstone Formation. Trapping is both structural (fault-bounded blocks) and stratigraphic (sandstones interfingering into shales) with sealing provided by the Takoradi Shale Formation. Burial history reconstruction and geochemical analysis indicate the source rock was mature for hydrocarbon generation in the Middle Cretaceous.

The Saltpond Field was discovered in 1970 by the Signal-Amoco 10-1 well. The well recovered light crude oil from the Devonian Takoradi Sandstones. The maximum production attained was 4800 bopd from 1978 to 1984. Production declined from 4,800 bopd and by 1985 the field was no longer economical to produce and operations were stopped. In 2000, the Ghana National Petroleum Corporation (GNPC) and Lushann-Eternit Energy Ltd entered into a joint venture to form the Saltpond Offshore Producing Company Ltd (SOPCL). This venture enabled them attract the needed investment to redevelop the field and provide for its decommissioning. The current production average is 300 bopd from 2 wells.

The geology of the coastal region and continental shelf of Ghana is part of the geology of the Gulf of Guinea Province of West Africa**.** The Gulf of Guinea Province includes the Ivory Coast, Tano, Saltpond, Central, Keta, and Benin Basins and the Dahomey Embayment in the northwestern part of the Gulf of Guinea. These basins share common structural and stratigraphic characteristics, in that they are wrench-modified basins [3] and contain rocks ranging in age from Ordovician to Holocene [4]; they are therefore grouped together as one province.

It is primarily the particulate remains of phytoplankton that form organic matter in most marine and many aquatic sediments. As sedimentary organic matter is buried, it experiences progressively higher temperatures and pressures. In most sedimentary basins, the onset of petroleum generation begins at approximately 60°C to about 120°C, at depths greater than 1 km [5].

The most basic question in the exploration of an area is whether petroleum-source rocks are present and whether their quality and quantity are sufficient to have generated commercial volumes of oil and or gas. Recent developments in geochemistry have made the identification and evaluation of source rocks more precise and more operational.

The aim of the study was to characterize geochemically potential source rocks for Central (Saltpond) Basin, Ghana. The wells used in the study were PFI 13-A7, PFI 13-C1, SIGNAL 13-1. The objectives of the study were to determine total organic carbon content, identify organic matter type and determine the maturity of organic matter (Ro). Figure 1 shows the location map of Saltpond Basin.

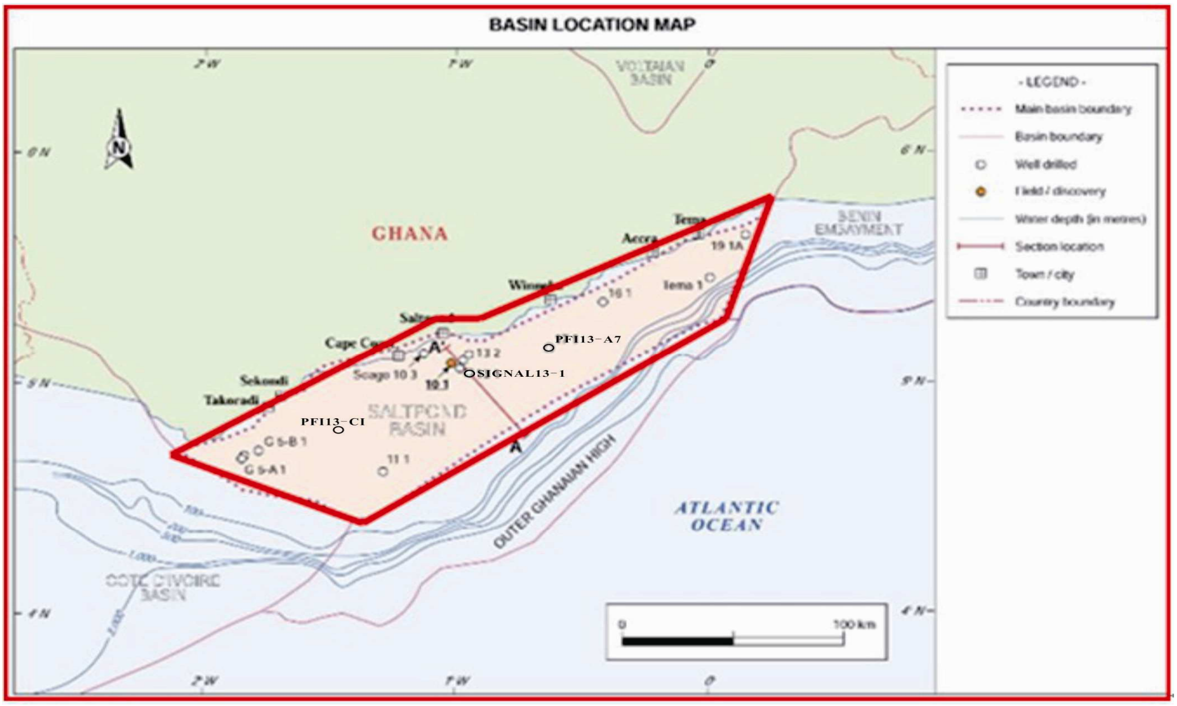

Figure 1. *Location map of Saltpond Basin showing the 3 exploratory wells [6]*

1.1. Location of the Study Area

Saltpond Basin (Figure 2) is found along the Atlantic coastline of the Central region of Ghana. It is located between 0° to 2°W and 4°N to 5°N and extends from the coastal areas of Winneba in the east to the vicinity of Sekondi-Takoradi in the west. Saltpond is situated 328 km south (162°) of the approximate center of Ghana and 102 km west (248°) of the capital, Accra. Saltpond and its surrounding areas have an average elevation of 62 m above sea level. The Saltpond Basin falls in the jurisdiction of the Mfantseman Municipal District. Some nearby towns are Abandze, Ankaful, Kete, Aga Point, and Anfeo.

1.2. Regional Geological Setting

The coastal basin offshore Ghana, located along the equatorial Atlantic Margin in the Gulf of Guinea, West Africa, was developed as a result of the events which led to the break up and pull-apart of South America from Africa.

The basin and sub-basins off south and southwestern Ghana form a part of this complex. From west to east, the coastal basin of Ghana is divided into three district provinces namely Tano-Cape Three Points – Dixcove Basin, Takoradi Arch (Saltpond Sub-basin) and Accra-Keta Basin.

The Saltpond Basin is situated on the Takoradi Arch, located on the northern up-thrown side of the Ivory Coast Fault, immediately West of its intersection with the Accra Fault. The Fault runs westward parallel to the coast for a distance of more than five hundred miles, offshore western Ghana and the Ivory Coast, and forms the northern flank of a thick upper Palaeozoic-Mesozoic sedimentary basin [6]. Saltpond is on the landward shelf which is covered by a relatively thin veneer (9000 ft) of these sediments, resting unconformably on the Devonian Elmina Sandstone. This sandstone outcrops onshore in the coastal areas between Cape Coast and Sekondi, and in a small area of Accra. The upper Palaeozoic-Mesozoic section above the Elmina sandstone thickens abruptly seaward to the Saltpond area, probably across a near shore fault system, and then again thickens seaward across the Ivory Coast Fault.

1.3. Geology and Geochemistry of Central (Saltpond) Basin

The Saltpond Basin is one of the four sedimentary basins and situated in the central offshore Ghana. The total size of the basin is approximately 12,294 km^2 with 205 km^2 onshore and the remaining 12,089 km^2 offshore with about 95% of it lying in shallow water. The basin has been classified as an offshore sedimentary basin, comprising precisely offshore Takoradi, Saltpond and West of Accra [7].

The Basin is limited to the north by the Precambrian Basement; to the east, a hinge line separates it from the Benin Embayment whilst the western limit between the Cote d'Ivoire and Saltpond Basin appears to be an easterly or lateral sedimentary onlap. The Saltpond Basin is one of several pull-apart basins developed in the West Africa coastal area [1]. The basin consists of Palaeozoic to recent deposits, which were influenced by two major tectonic events: the Pan-African Orogeny and the event related to the rifting, break-up and drifting of the African and South American continental plates. Ordovician-Silurian rocks were deposited on the Precambrian basement overlain by Devonian and younger shallow marine sandstones and shales. Sediments in the Saltpond basin range from Palaeozoic to Cenozoic in ages. The stratigraphic sequence of the Saltpond basin beginning from the oldest to the youngest is as follows; Ajua shale, Elmina sandstone-Silurian, Takoradi formation- Lower Devonian to Lower Carboniferous, Efia Nkwanta formation- Carboniferous to Triassic, Sekondi sandstone-Triassic to Jurassic, and Interbedded sand or shale sequence (Barremian)–Albian.

Geochemical data indicate that the Takoradi Shale Member, Lower Cretaceous and Upper Cretaceous have source rocks potential. The Total Organic Carbon (TOC) values range from 0.5% to 2.0%. The organic matter is of Type II kerogen in the Takoradi Shale Member and Type III in the Aptian shales. Sandstones of the Devonian-Lower Carboniferous Takoradi Formation are the only proven reservoir rocks in the basin to date [1], and produce oil in the Saltpond field.

Two petroleum systems have been identified in the Saltpond Basin [1]. The Takoradi - Takoradi Hypothetical Petroleum System is based on the interpretation that the hydrocarbons found in the Saltpond field have been generated from the Takoradi Shale Member (Takoradi Formation). The Cretaceous-Cretaceous Speculative Petroleum System is based on the assumption that the Lower and/or Upper Cretaceous shales form the source rocks.

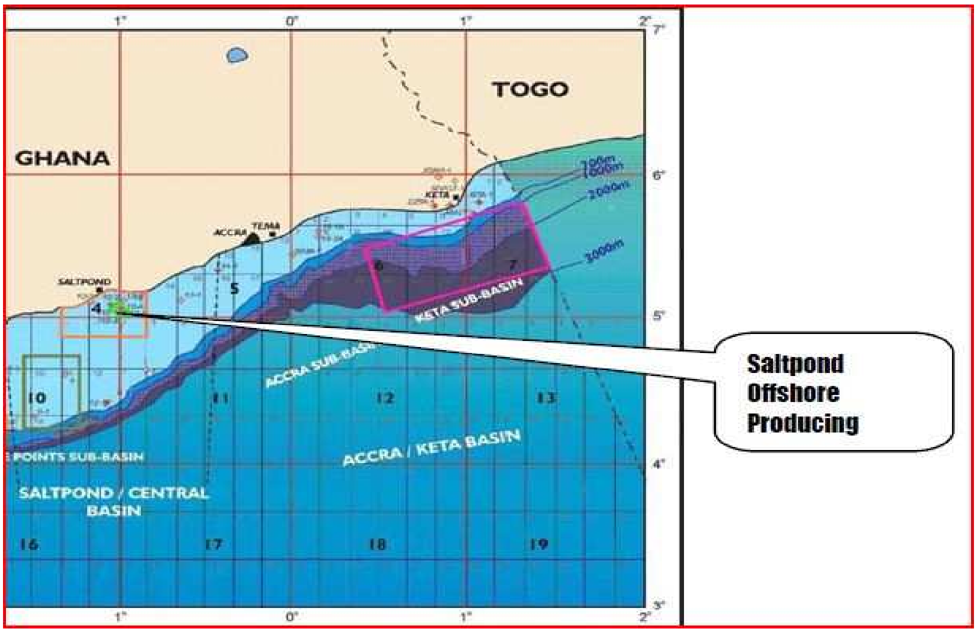

Figure 2. *A map showing the location of the Saltpond Field (modified from [6])*

2. Methodology

2.1. Samples

The core samples were recovered from an interval of the 3 exploratory wells within the Saltpond Basin, Ghana. The wells and their depth details are summarized in Tables 1, 2 and 3. The core samples were taken to the Organic Geochemistry Laboratory, Ghana National Petroleum Corporation (GNPC), Tema-Ghana, where they were oven-dried overnight at 110°C, and pulverized with the aid of pestle and mortar. The crushed rock samples were analyzed geochemically by TOC contents, Rock-Eval pyrolysis techniques. The samples were geochemically investigated in order to determine the total organic compound, identify organic matter type, determine the maturity of organic matter (Ro) and hence characterize their petroleum generation potential.

2.2. Total Organic Carbon (TOC) Contents and Rock-Eval Analyses

The pulverised rock samples submitted to Organic Geochemical Laboratory, GNPC, Tema-Ghana, were analysed for TOC contents, hydrogen index (HI), the oxygen index (OI) and T_{max} (temperature of maximum kerogen pyrolysate yield), using Rock-Eval II instrument. The oven was initially kept isothermally at 300°C for 3 minutes during which time the free hydrocarbons were volatilized and the S_1 peak was measured with a flame ionization detector (FID). Pyrolysis of organic matter was later performed at 300–600°C with a temperature rise of 25°C/min. This is the phase of volatilization of the higher carbon number hydrocarbons compounds ($>C_{40}$) as well as the cracking of non-volatile organic matter. The hydrocarbons released from this thermal cracking were measured as the S_2 peak (by FID). The temperature at which S_2 reached its maximum depended on the nature and thermal maturity of the kerogen and this was measured as T_{max}. The CO_2 produced from kerogen cracking was trapped in the 300–390°C range. The trap was heated, and CO_2 was released and detected with a thermal conductivity detector (TCD) during the cooling of the pyrolysis oven (S_3 peak). The HI was determined as the yield of reduced products of pyrolysis (S_2) relative to the TOC (mg HC/g TOC) and oxygen index (OI) was the yield of the oxygen and bound organic carbon (S_3).

2.3. Vitrinite Reflectance

Vitrinite reflectance (Ro) was measured on samples with C_{org} more than 0.4%. In this study, C_{org} values were all above 0.4%. For microscopic studies, the samples were embedded in an epoxy resin, and a section perpendicular to bedding was polished [8]. The polished blocks were investigated at a magnification of 500× in incident white light and in incident light fluorescence mode, excited by ultraviolet and violet light. The Ro measurements were conducted using a Zeiss Axioplan incident light microscope at a wavelength (l) of 546 nm with a Zeiss Epiplan-Neofluar 50×, 0.85 oil objective. An yttrium aluminum garnet standard was used, with an Ro of 0.889%.

3. Results and Discussions

The TOC contents and Rock-Eval data results for the studied samples of the 3 exploratory wells are presented in Tables 1, 2 and 3. The TOC values versus depths for the 3 exploratory wells plot is generated and presented in Figure 3.

In order to characterize the organic matter type (kerogen type) of the samples, the modified Van Krevelen diagram (HI versus OI) is displayed in Figure 4. Graphs of genetic potential (PG) against TOC [9] and the Rock-Eval HI versus TOC [10] were plotted and shown in Figures 5 and 6 respectively in order to evaluate the hydrocarbon generation potential.

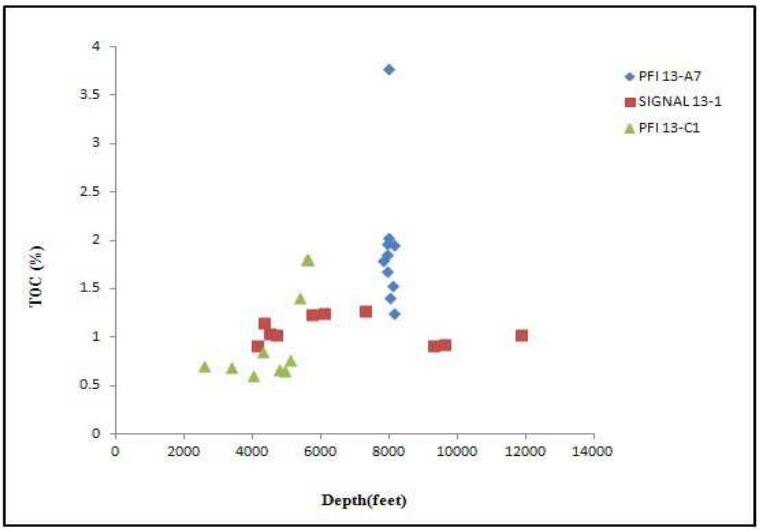

Figure 3. *TOC values (%) versus Depth (feet) in the 3 exploratory wells*

Table 1. *Rock-Eval Analysis of samples from SIGNAL 13-1 well, Central (Saltpond) Basin, Ghana*

SIGNAL 13-1											
Sample Numbers	**Depth (feet)**	**TOC (%)**	**S_1**	**S_2**	**S_3**	**T_{max} (°C)**	**PG (S_1+S_2)**	**OI**	**HI**	**PI (S_1/(S_1+S_2)**	**Ro (%)**
1	4120	0.90	0.1	1.0	1.2	439	1.1	133	111	0.09	0.43
2	4330	1.14	0.2	1.7	0.9	437	1.9	79	149	0.11	0.46
3	4470	1.03	0.15	1.1	0.8	435	1.25	78	107	0.12	0.43
4	4680	1.02	0.1	1.3	0.4	440	1.4	39	127	0.07	0.44
5	5740	1.23	0.5	1.1	1.1	434	1.6	89	89	0.31	0.49
6	6070	1.24	0.2	1.4	1.3	435	1.6	105	113	0.13	0.48
7	7290	1.27	0.1	1.6	0.4	442	1.7	31	126	0.06	0.47
8	9300	0.91	0.4	1.1	1.4	438	1.5	154	121	0.27	0.53
9	9610	0.92	0.4	1.3	1.3	438	1.7	141	141	0.24	0.50
10	11840	1.02	0.3	1.9	0.5	439	2.2	49	186	0.14	0.52

Table 2. *Rock-Eval Analysis of samples from PFI 13-A7 well, Central (Saltpond) Basin, Ghana*

PFI 13-A7											
Sample Numbers	**Depth (feet)**	**TOC (%)**	**S_1**	**S_2**	**S_3**	**T_{max} (°C)**	**PG (S_1+S_2)**	**OI**	**HI**	**PI (S_1/(S_1+S_2)**	**Ro (%)**
1	7820	1.78	0.4	3.5	0.7	432	3.9	39	197	0.10	0.45
2	7920	1.85	0.5	3.9	0.7	432	4.4	38	211	0.11	0.52
3	7930	1.67	0.6	3.1	0.5	429	3.7	30	186	0.16	0.53
4	7950	1.96	0.4	4.0	0.6	429	4.4	31	204	0.09	0.56
5	7960	3.77	1.7	13.9	0.7	429	15.6	19	369	0.11	0.41
6	7990	2.02	0.7	4.5	0.5	430	5.2	25	223	0.14	0.48
7	8010	1.40	0.3	3.0	0.6	435	3.3	43	214	0.09	0.52
8	8090	1.53	0.3	4.0	0.5	432	4.3	33	261	0.07	0.53
9	8120	1.24	0.3	2.9	0.6	435	3.2	48	234	0.09	0.48
10	8130	1.95	0.5	8.1	0.5	435	8.6	26	415	0.06	0.59

Table 3. *Rock-Eval Analysis of samples from PFI 13-C1 well, Central (Saltpond) Basin, Ghana*

PFI 13-C1											
Sample Numbers	**Depth (feet)**	**TOC (%)**	**S_1**	**S_2**	**S_3**	**T_{max} (°C)**	**PG (S_1+S_2)**	**OI**	**HI**	**PI (S_1/(S_1+S_2)**	**Ro (%)**
1	2550	0.69	0.1	0.4	0.4	429	0.5	58	58	0.2	0.52
2	3350	0.68	0.1	0.8	0.4	432	0.9	59	118	0.11	0.43
3	4010	0.60	0.2	0.5	0.8	429	0.7	133	83	0.29	0.45
4	4270	0.85	0.6	1.0	1.6	427	1.6	188	118	0.38	0.45
5	4750	0.66	0.1	0.9	0.3	435	1.0	45	136	0.08	0.46
6	4930	0.64	0.1	0.5	0.3	433	0.6	47	78	0.10	0.47
7	5100	0.76	0.2	1.1	0.3	436	1.3	39	145	0.15	0.44
8	5370	1.40	0.2	2.0	0.3	436	2.2	21	143	0.09	0.44
9	5580	1.80	0.2	4.7	0.3	439	4.9	17	261	0.04	0.43
10	5610	1.80	0.2	2.9	0.3	439	3.1	17	161	0.06	0.44

*S_1 and S_2 are in mg hydrocarbon / g rock, S_3 is in mg CO_2; Rock-Eval hydrogen index (HI = [S_2 / TOC] *100); Rock-Eval oxygen index OI, (OI = [S_3 / TOC] *100); TOC, Total organic carbon (wt %), Potential of Generating Hydrocarbon (PG = S_1+ S_2), PI, Rock-Eval production Index (PI = S_1/(S_1+ S_2) and T_{max} (heating temperature at which peak of S_2 Occurs), and vitrinite reflectance data of samples from the Central Basin

3.1. Organic Matter (Kerogen) Type

The organic matter type is an important parameter in evaluating source rock potential and has important influence on the nature of the hydrocarbon products ([11]; [12]; [13]). [14] proposed that, for mature source rock, HI for gas-prone organic matter is less than 150, gas-oil-prone organic matter ranges between 150 and 300, whereas the oil-prone organic matter is more than 300 HI. Thus, it is very important to determine the kerogen types of the source rocks as they have a first-order control on the hydrocarbon products after maturation.

The results from this study showed that for SIGNAL 13-1 well, samples 1-9 have HI values less than 150 which indicate gas-prone organic matter (Table 1). Also sample 10 for the same well has an HI value between 150-300, which indicate gas-oil prone organic matter.

For PFI 13-A7 well, samples 1-4 and 6-9 have HI values between 150 and 300 which indicate gas-oil prone organic matter. Similarly samples 5 and 10 for the same well have HI values greater than 300 (Table 2) which indicate oil-prone organic matter.

For PFI 13-C1 well, samples 1-8 and 10 have HI values less than 150 which indicate gas-prone organic matter. Similarly sample 9 for the same well has HI value between 150 and 300, indicating gas-oil prone organic matter (Table 3).

[12] proposed a genetic potential (PG = S_1 + S_2) for the classification of source rocks. According to their classification scheme, rocks having PG of less than 2 mg HC/ g rock correspond to gas-prone rocks or non-generative ones, rocks with PG between 2 and 6 mg HC/ g rock are moderate source rocks, and those with PG greater than 6 mg HC/ g rock are good source rocks.

Based on the above criteria, samples 1-9 for SIGNAL

13-1 well have PG values less than 2mgHC/g and are gas-prone rocks or non-generative rocks. Similarly, sample 10 for the same well has a PG value between 2 and 6mgHC/g, meaning that it is a moderate rock.

For PFI 13-A7 well, samples 1-4 and 6-9 have PG value between 2 and 6mgHC/g, meaning that they are moderate rocks. Similarly, samples 5 and 10 have PG values greater than 6mgHC/g meaning they constitute good source rocks at sufficient depths.

For PFI 13-C1 well, samples 1-7 have PG values less than 2mgHC/g and are gas-prone rocks or non-generative rocks. Again samples 8-10 have PG value between 2 and 6mgHC/g, meaning that they are moderate rocks.

The modified Van Krevelen diagram (HI versus OI) (Figure 4) shows that almost all the samples from the 3 exploratory wells consist predominantly of Types II and III kerogens, which are capable of generating gas-oil and gas respectively at suitable temperature in depth. Only 2 samples from PFI 13-A7 well consist of type I and are capable of generating oil.

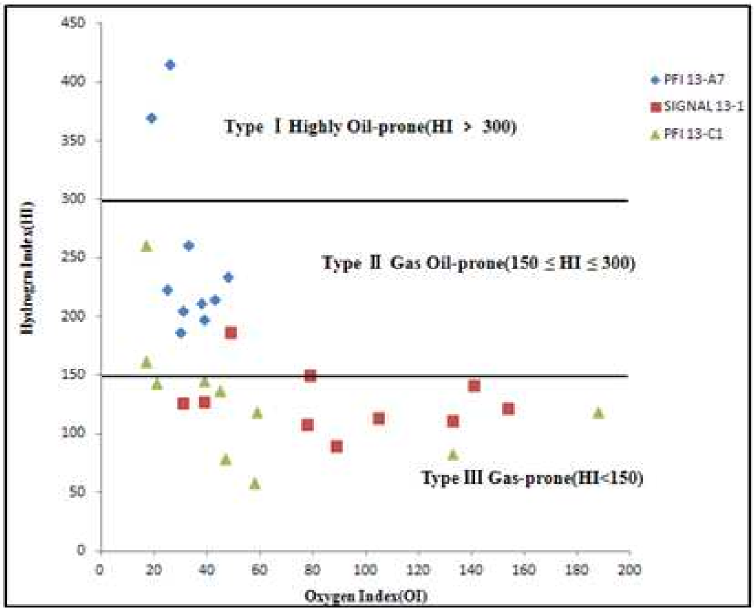

Figure 4. *Modified Van Krevelen diagram showing the organic matter types of the studied samples*

3.2. Kerogen Type and Generation Potential

The organic matter richness of source rocks is determined usually using the total organic carbon content, which is the total amount of organic material (kerogen) present in the rock, expressed as a percentage by weight (TOC wt.%). The higher the TOC value, the better the potential for hydrocarbon generation. According to [14], the TOC values between 0.5% and 1.0% indicate a fair source-rock generation potential, TOC values varying from 1.0 to 2.0% reflect a good generation potential, TOC values between 2.0 and 4.0% refer to a very good generation potential, and rocks with TOC higher than 4.0% are considered to have excellent generation potential.

Based on this criterion, the TOC results of rock samples in this study reveal that for SIGNAL 13-1 well, samples 1, 8 and 9 (Table 1) have fair generation potential source rocks because their TOC values fall between 0.5%-1.0%. Again samples 2-7 and 10 from the same well have good generation potential source rocks because their TOC values fall between 1.0-2.0%. (Table 1)

For PFI 13-A7, samples 1-4 and 7-10 (Table 2) have good generation potential source rock because their TOC values fall between 1.0% and 2.0%. Again samples 5 and 6 for the same well have very good generation potential source rock because their TOC values fall between 2.0% and 4.0%.

For PFI 13-C1, samples 1-7 (Table 3) have fair generation potential source rocks because their TOC values fall between 0.5%-1.0%. Similarly samples 8-10 for the same well have good generation potential source rock because their TOC values fall between 1.0% and 2.0%. This is demonstrated in the plot of the Rock–Eval HI versus TOC (Figure 4). The poor to fair and moderate generation potential of all the samples in particular is supported by the presence of type II & III kerogens though only two samples from PFI 13-A7 indicate type I kerogen (Figure 4). Figure 6 shows the generation potential for the studied samples. It is also worth pointing out that almost all the samples from the three exploratory wells fall within the field of typical gas prone and gas-oil prone source rocks [10] as shown in Figure 4.

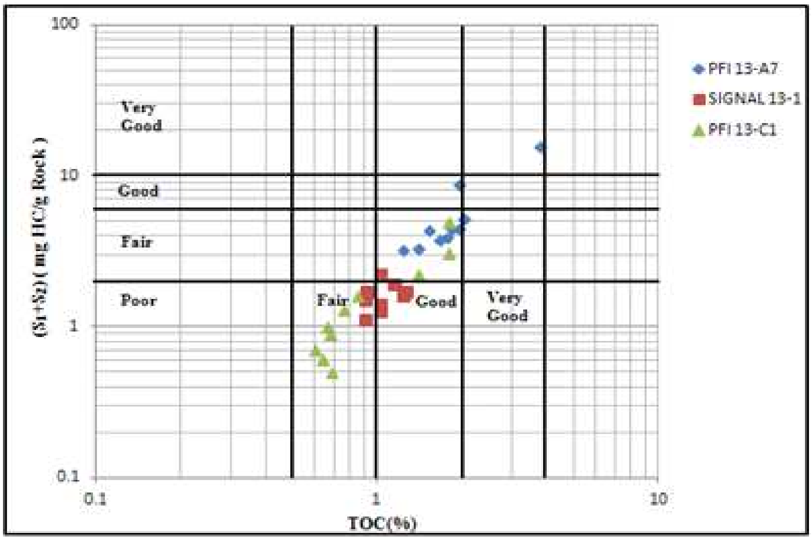

Figure 5. *Generation potential for the studied samples (after [9])*

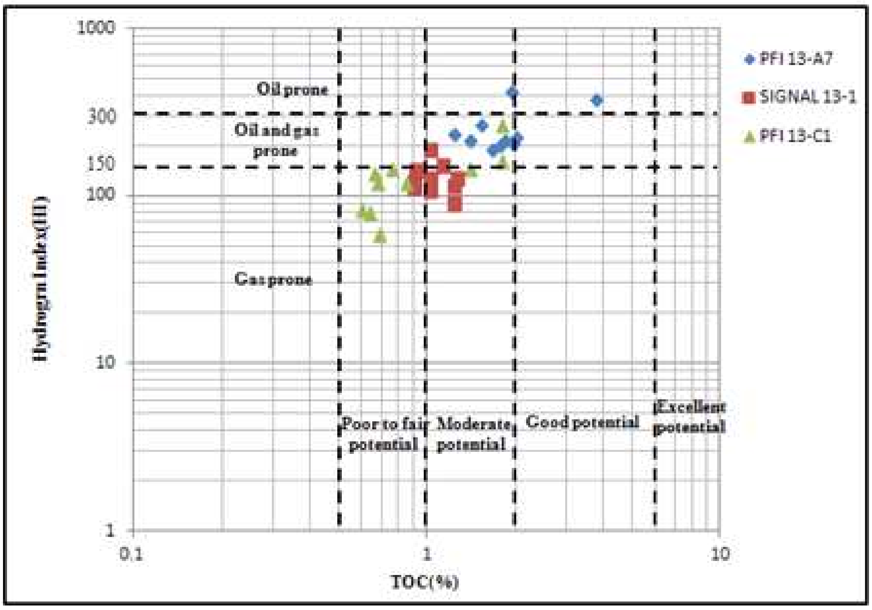

Figure 6. *Generation potential of potential source rocks of the Central (Saltpond) Basin*

3.3. Maturity of Organic Matter (R_o)

An overview of maturity distribution is provided by Ro data, which is considered to be the most reliable and most commonly used maturity indicator ([15]; [16]). According to them, the Ro values between 0.5 and 0.7% indicate low source-rock grade, Ro values varying from 0.7 to 1.0% reflect a moderate source-rock grade, Ro values between 1.0 and 1.3% refer to a high source-rock grade. Based on the above criteria, for SIGNAL 13-1 well, samples 1-7 have poor source rock grade because their Ro values are lower than 0.5%. Similarly samples 8-10 for the same have low source rock grade because their Ro values fall between 0.5% and 1.0%. (Table 1)

For PFI 13-A7 well, samples 1, 5-6 and 9 have poor source rock grade because their Ro values are lower than 0.5%. Similarly samples 2-4, 7-8 and 10 for the same well have low source rock grade because their Ro values fall between 0.5% and 1.0%. (Table 2)

For PFI 13-C1, samples 2-10 have poor source rock grade because their Ro values are lower than 0.5%. Similarly sample 1 for the same well has low source rock grade because its Ro value falls between 0.5% and 1.0%. (Table 3)

The Ro values of all samples for the 3 wells are plotted against the depth in Figure 7. From the figure below, all the samples are concentrated between Ro values of between 0.4% and 0.55% and the depths values between 3000ft and 11,000ft. It shows a fairly distributed plot.

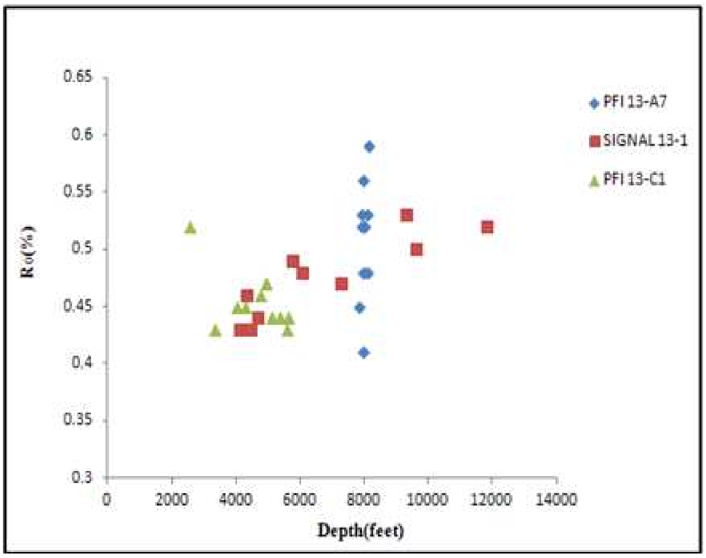

Figure 7. *Maturity, R_o (%) versus Sample Depth Interval (feet)*

4. Conclusions

The results revealed that the three exploratory wells in the Saltpond Basin, Ghana have fair to good total organic carbon (TOC) content, suggesting that there might exist conditions in the basin that favour organic matter production and preservation. The rock-eval results showed that all the samples from the 3 exploratory wells contain predominantly Types II and III kerogens with a capacity to generate gas-oil and gas respectively. They have good generation potential. Results of the vitrinite reflectance measurement also reveal that all the samples have poor to low source-rock grade. The Saltpond Basin can be regarded as having fair petroleum source rocks and could be part of a petroleum system if sufficient burial and maturation have occurred.

Acknowledgement

The authors would like to acknowledge the management of Ghana National Petroleum Corporation (GNPC), Ghana, for providing data to undertake this study. Special thanks go to Mr. Eben Apesegah for providing valuable guidance and information when needed.

References

[1] IHS (2010) IHS Energy Group, 2003 [includes data current as of December 2003], International petroleum exploration and production database: IHS Energy Group; database available from IHS Energy Group, 15 Inverness Way East, Englewood, CO 80112 U.S.A.

[2] Asiedu, D.K., E. Hegner, A. Rocholl, and D. Atta-Peters, (2005) Provenance of late Ordovician to early Cretaceous sedimentary rocks from Southern Ghana as inferred from Nd isotopes and trace elements: J. African Earth Sci., v. 41, p. 318-319.

[3] Clifford, A.C. (1986) African oil—Past, present, and future, in Halbouty, M.T., ed., Future petroleum provinces of the world, Proceedings of the Wallace E. Pratt Memorial Conference, Phoenix, December 1984: American Association of Petroleum Geologists Memoir 40,

[4] Kjemperud, A., Agbesinyale, W., Agdestein, T., Gustafsson, C., and Yükler, A. (1992) Tectono-stratigraphic history of the Keta Basin, Ghana with emphasis on late erosional episodes, in R. Cumelle, (ed.), Geologie Africaine -1st Coloque de stratigraphie et de paleogeographie des basins sedimentaires ou est-Africans, 2nd Colloque Africain de Micropaleontologie, Libreville, Gabon, May 6 – 8, 1991: Elf Aquitaine Memoir 13, p. 55-69.

[5] Seewald, J. S. (2003) Organic-inorganic interaction in petroleum-producing sedimentary basins. Nature 426, 327–333.

[6] Ghana National Petroleum Corporation (2007) Hydrocarbon potential report of the Central (Saltpond) Sedimentary Basin, vol. 2, Saltpond Project Unit, Tema-Greater-Accra. Web accessed November 11, 2013. http://www.gnpcghana.com

[7] Acres International Limited, unpublished report

[8] Taylor, G. H., Teichmüller, M., Davis, A. (1998) Organic petrology: Berlin, Borntraeger, 704 pp.

[9] Ghoria, K. A. R. (1998) Petroleum Source-Rock Potential and Thermal Maturity of the Officer Basin [J]. *Geological Survey of Western Australia.* 1, pp. 52-53.

[10] Walters, C. C. (2006) The Origin of Petroleum, in Practical Advances in Petroleum Processing, Volume 1, Springer Science and Business Media Inc, New York, pp. 79-97

[11] Hunt, J. M. (1996) Petroleum Geochemistry and Geology, W. H. Freeman, San Francisco, 743pp.

[12] Tissot, B.P. and Welte D. H. (1984) *Petroleum Formation and Occurrence* [M]. Springer Verlag, New York, ISBN 9783642878152, 702pp.

[13] Barker, C. (1996) T*hermal Modelling of Petroleum Generation: Theory and Applications [M]* Elsevier, New York, 1996, 512pp.

[14] Peters, K. E. (1986) Guidelines for evaluating petroleum source rock using programmed analysis [J] *The American Association of Petroleum Geologists Bulletin*. 70, pp. 318-329.

[15] Dow, W. G. (1977) Kerogen studies and geological interpretations: Journal of Geochemical Exploration, v. 7, p. 77– 99, doi:10.1016/0375-6742(77)90077-2.

[16] Waples, D. W., H. Kamata, and M. Suizu. (1992) The art of maturity modeling: Part 1. Finding a satisfactory geological model: AAPG Bulletin, v. 76, p. 31–46.