Unconventional Source and Shale Oil Potential of Upper Cretaceous Rakb Group in The NC84 East Sirte Basin, Libya

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المصدر غير التقليدي والنفط الصخري المحتمل لمجموعة راكب الكريتاسي العلوي في امتياز84 شرق حوض سرت، ليبيا

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Abstract

This study focused on geochemical analysis of the Rakb group from two wells A2 and B2 in the NC84 east Sirte basin, where deal with this rocks as unconventional source, the samples were analysis by used Rock Eval pyrolysis. The results of this research showed total organic matter range from 0.4% to 2.6% categorized as fair to good source, and organic matter are Type II and type III kerogen. The maturity of the Rakb group are in mature zone (oil window). Oil saturation OSI of the samples range from 20 to 482 mg HC/g TOC that lead to the Rakb rocks have capacity to produce shale oil.

Keywords: *Organic geochemistry, Rakb group, Sirte basin, Shale oil, Unconventional source.*

الملخص

هذه الدراسة تركزت على التحليل الجيوكيميائي لمجموعة راكب من اثنين آبار A2 وB2 ضمن امتياز 84 شرق حوض سرت، حيث تم اعتبار هذه الصخور كمصدر غير تقليدي، العينات تم تحليلها بواسطة جهاز Rock Eval، وكانت النتائج أن كمية المادة العضوية تتراوح من 0.4 إلى 2.6% مصنف كمصدر مقبول إلى جيد، ونوعية المادة العضوية type II و type III كيروجين. النضوج لمجموعة راكب يكون في مرحلة النضج في نطاق oil window. مقدار التشبع بالنفط للعينات يتراوح من 20 إلى 482 mg HC/g TOC، وهذا يشير إلى أن صخور الراكب ذات مقدرة لإنتاج النفط الصخري.

الكلمات الدالة: النفط الصخري، الجيوكيمياء العضوية، المصدر غير التقليدي، حوض سرت، مجموعة الراكب.

1. Introduction

Attributes with new resources that drive to more explore about unconventional reservoirs. Since in recent years many companies have started searching and exploring the new fields for unconventional hydrocarbons, especially in the north America which its production of shale gas about 8 billion cubic feet per day in 2009 (Dadi et al, 2019).

In Libya most of sedimentary basins are considered candidates to be economic value for the discovery of unconventional reservoirs. The upper Cretaceous rocks in the Sirte basin are among the most important of these resources. Figure (1) shows the study area in east Sirte basin and structural pattern of the three arms of the Sirte basin.

This research study the geochemical characteristics of the Rakb group in the Maragh depression east of the Sirte basin, also define the possibility of this formations as a source of unconventional reservoir.

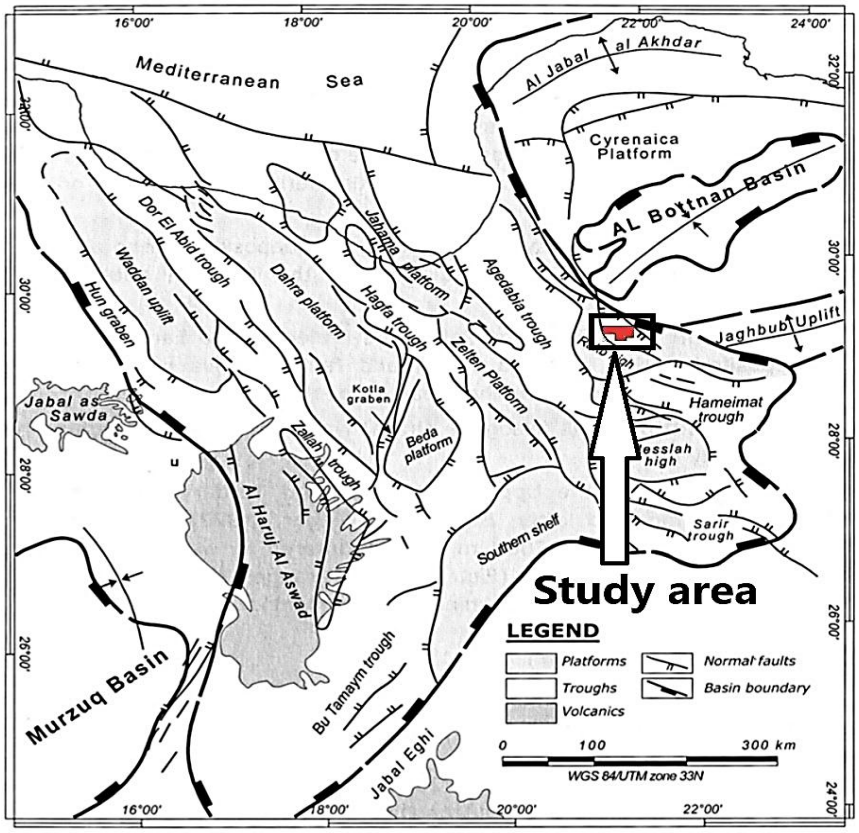

Figure 1. show structure of Sirte basin and study area (modified after Pawellek, 2007).

2. Methodology

This study uses subsurface data from two wells (A2 and B2) drilled in Maragh trough in NC84 include Rock Eval pyrolysis. This analysis used to evaluate upper Cretaceous source rocks in this area as unconventional source, which determine quality, quantity, thermal maturity of Rakb rocks, and potential to be unconventional source.

3. Geological Setting

Sirte basin is located in the center of Libya covers an area about 600000 Km2, formed by complex structure platforms and troughs Figure (1). Maragh trough in east basin covers an area of 2,500 km2 floored by Palaeozoic sequences Amal formation followed by Triassic sediments which consider as source rock in this trough, then continental Nubian formation take place in lower Cretaceous, in upper Cretaceous the trough was a distinctive by transgression and marine condition Rakb rocks. during Tertiary Time Shallow water carbonate Sabil formation, and the trough cover by upper Miocene and Quaternary sediments. The Maragh Trough was tectonically inactive at the end of the Cretaceous (Hallett and Lowes, 2016).

Petroleum system of the Maragh trough has two source rocks Triassic shale and upper Cretaceous Rakb group, where the Palaeozoic and Triassic Amal and Maragh formations are considered as reservoirs in the Maragh trough, these reservoirs are sealed by shale of upper Triassic (Hallett, 2002).

4. Results and Discussion

The results are in Table (1) show the Rock Eval results of cutting samples from Rakb formation from two wells.

Table 1. show the Rock Eval results.

WELL ID	FORMATION	DEPTH (feet)	S1 mg/g	S2 mg/g	PI S1/S1+S2	TOC wt. %	TMAX Deg. C	HI S2/TOC*100	Ro % Measured	OSI S1/TOC*100
A2-NC84	Rakb	9400	2.1	3.8	0.3	2.6	434	145	0.54	81
A2-NC84	Rakb	9700	0.18	0.6	0.23	0.4	432	153	0.35	45
A2-NC84	Rakb	10200	3.7	7	0.37	1.43	437	490	0.9	258
A2-NC84	Rakb	10600	5.4	2.3	0.71	1.12	439	205	-	482
B2-NC84	Rakb	10100	0.8	5	0.14	1.7	433	294	0.68	47
B2-NC84	Rakb	10400	0.3	1.2	0.2	0.6	432	210	-	50
B2-NC84	Rakb	10500	0.9	9.5	0.09	1.9	459	484	0.82	47
B2-NC84	Rakb	10750	0.86	4.2	0.17	1.3	441	326	1.19	66
B2-NC84	Rakb	10900	0.1	0.43	0.19	0.5	432	86	-	20

4.1. Organic Matter Richness

Total organic matter of samples ranges between 0.4% to 2.6% this suggests a variance of preservation and potential of organic matter. In 1986 Peters described organic matter richness as 0.5% poor, 0.5 to 1% fair, 1 to 2% good and more than 2% is very good. The samples of well A2 Toc between 0.4 to 2.6 which indicates poor to very good source potential, while samples of well B2 range from 0.5% to 1.9% shows fair to good source rock characteristics.

4.2. Quality and Type of Organic Matter

Organic Matter classified to four types of kerogen type I oil prone, Type II oil prone, type III gas prone and type IV is dead carbon (Peters and Cassa, 1994). rock eval analysis shows hydrogen index Hi between 86 to 490 mg/g TOC That indicates vary in categories between Type II and type III kerogen, Figure (2) illustrates plot for HI vs. T_{max} and type kerogen which indicates to Type II and type III mixed marine and terrestrial organic matter. Also Figure (3) agree with plot of HI vs. T_{max}, suggests Type II and type III and have potential to both oil and gas generation.

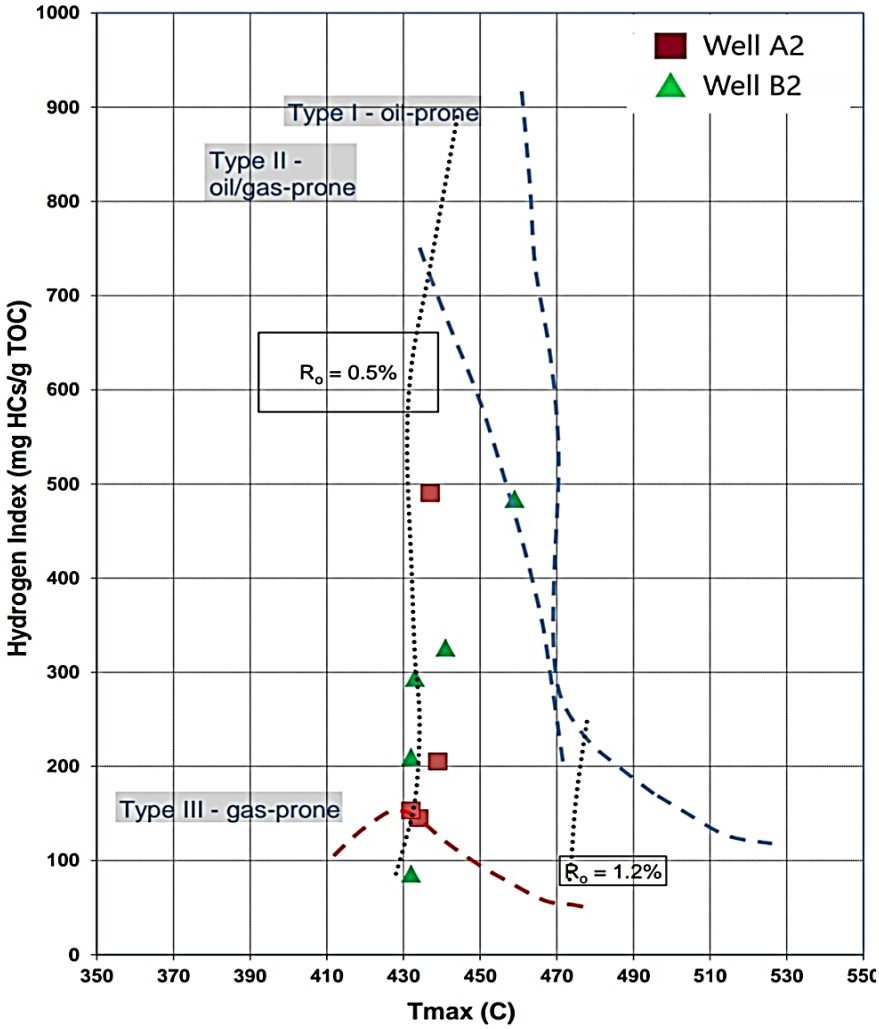

Figure 2. illustrates plot of HI vs. T_{max} for kerogen types of Rakb formations.

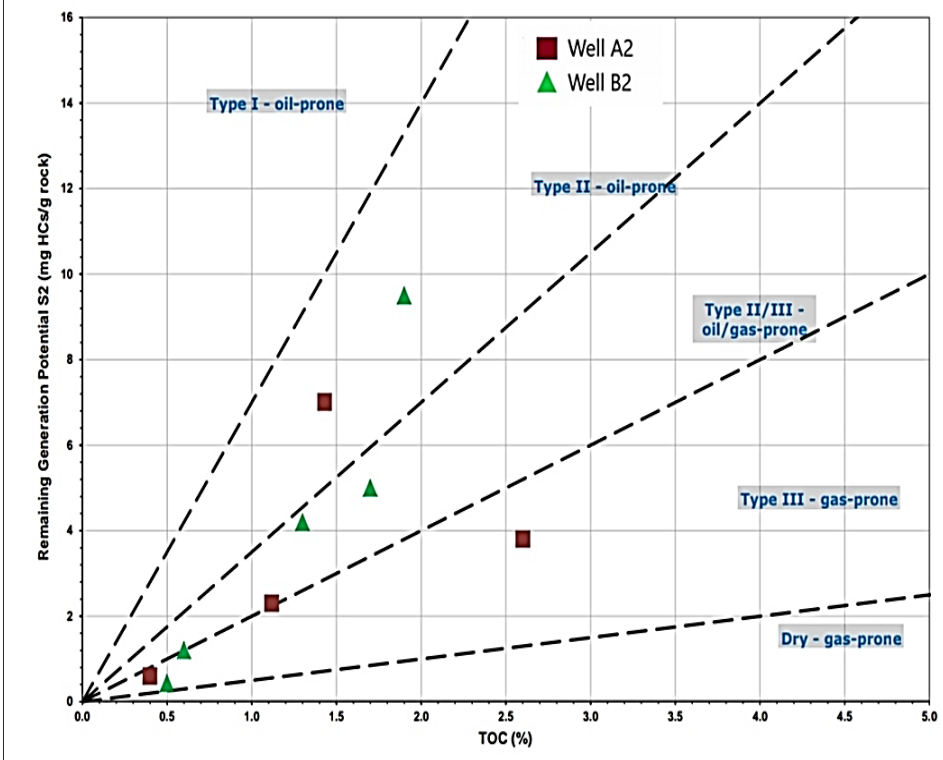

Figure 3. plot of S2 and TOC showing kerogen type and potential generation of Rakb group.

4.3. Thermal Maturity

Thermal maturity of Organic matter can be assessed by T_{max}, R_o or plot as PI vs. T_{max}. Figure (4) displays plot of PI vs. T_{max} which indicates to most samples are in mature zone, also value of vitrinite reflectance (R_o) are range between 0.54 to 1.16% suggests samples are in oil window.

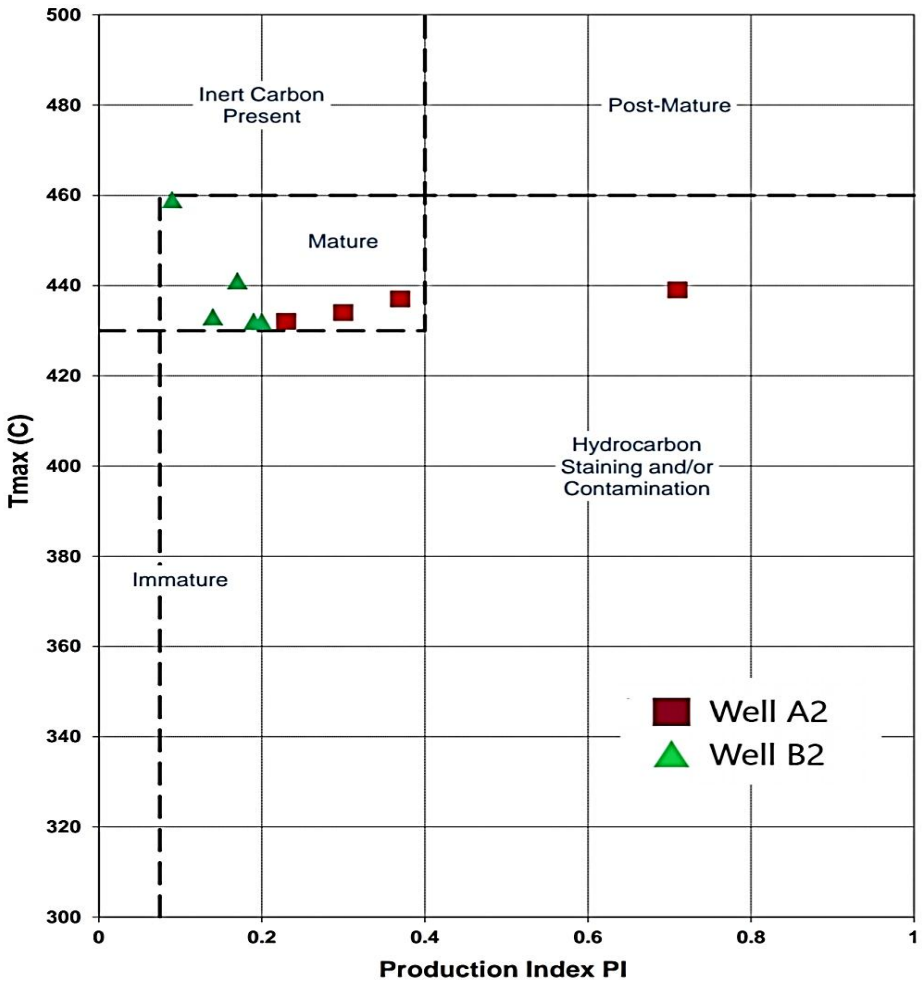

Figure 4. plot of PI vs. T_{max} shows thermal maturity of study samples.

4.4. Unconventional Reservoir Potential

The pyrolysis data shows S1 range from 0.1 to 5.4 mg/g Toc and S2 between 0.43 to 9.5 mg/g Toc indicates poor to good potential. The plot of S1+S2 versus TOC Figure (5) suggests Rakb rocks range from fair to good potential and most samples have good generation potential.

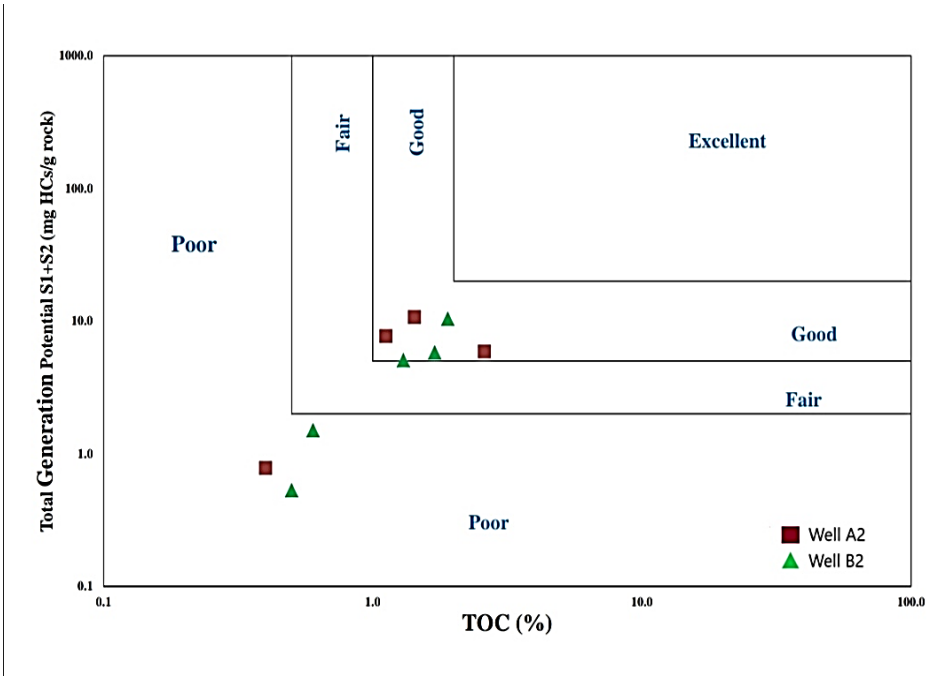

Figure 5. plot of S1+S2 versus TOC showing generation potential.

Oil saturation index OSI (S1*100/TOC) geochemical parameter used to define potential intervals in unconventional reservoirs, when oil saturation index OSI reaches about 100 mg HC/g TOC that indicates good potential reservoir, while values less than 100 mg HC/g TOC suggests less possibility and high risk (Jarvie, 2012).

Oil saturation of Rakb formation ranges between 20 to 482 mg HC/g TOC that shows vary in potential of samples study. The samples from well A2 have OSI values reaches to 258 and 482 mg HC/g TOC of depths 10200ft and 10600ft respectively, which indicates good potential source, while at depth 9400ft OSI about 80 mg HC/g TOC which suggests less potential. In well B2 OSI doesn't exceed 66 mg HC/g TOC of all samples, that indicates less potential with high risk Figure (6).

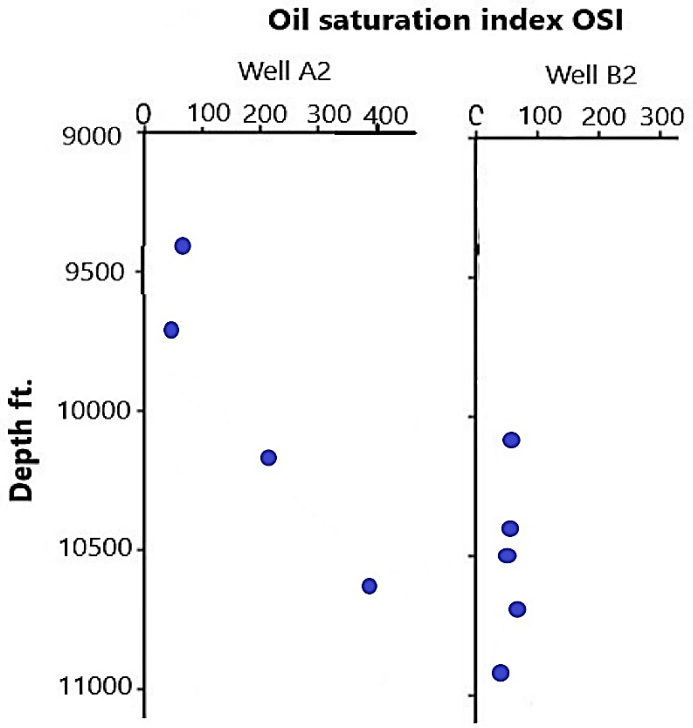

Figure 6. illustrates Oil saturation in wells A2 and B2.

5. Conclusion

Based on Rock Eval pyrolysis of samples Rakb group from two wells A2 and B2 in east Sirte basin total organic carbon range between 0.4 to 2.6% indicating fair to very good quantity of organic matter. Also Rakb group appears to be Type II and type III kerogen mixed marine and terrestrial organic matter with thermal maturity (Ro) are range between 0.54 to 1.16% suggests the samples are in oil window. Oil saturation of Rakb formations varieties between 20 to 482 mg HC/g TOC, which indicating this rocks have potential to produce shale oil.

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