The petroleum system of the Nahr Umar field

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Abstract— **The Nahr Ibn Omar field is located in the Basrah Governorate in the southeastern part of Iraq, about 30 km north to northwest of the city of Basrah. The reservoir oils under study were classified into two groups depending on the geochemical characteristics. The first group includes the Mishref and The lower Faris reservoirs, while the second group includes the Nahr umar, Al Yamamah and Al Zubair reservoirs.**

● We note the low maturity in the reservoirs of the first group, and also, the data of the study, which included the sulfur content Pr/Ph, CPI, showed that the oils of the first group originated from limestone rocks. The study also showed that the oils of the second group contain a lower percentage of asphalt than the first group, and this is evidence that the oils of the second group are sourced from muddy carbonate rocks, deeper than the carbonate rocks generating the oils of the first group.

● The results also indicated that the sections of asphalt and resins do not exceed 26% in the oils of the second group. While it reached 39.64% in the first group, and this is evidence that the second group has greater mobility and migration than the first group.

Keywords**; The petroleum system, Nahr Umar field,**

I. INTRODUCTION

The Structure of the Naher umer was surveyed seismically during the years 1946-1947, where it was confirmed that there was a structural closure. In 1948, the exploration well was drilled (Nahr Ibn Omar 1). ● 2/through basin analysis programs and making geochemical models based on the geological history of the sedimentary basin and the arrangement of layers and the processes affecting the stratigraphic situation such as erosion, sedimentation, compression, and dissolution

Geochemical techniques and laboratory analyzes of samples of oil and rocks of all kinds and the development of a comparative relationship between the results of the analyzes to know each element of the petroleum system and thus these analyzes give us an idea of the generation, migration and accumulation of oil in sedimentary basins.

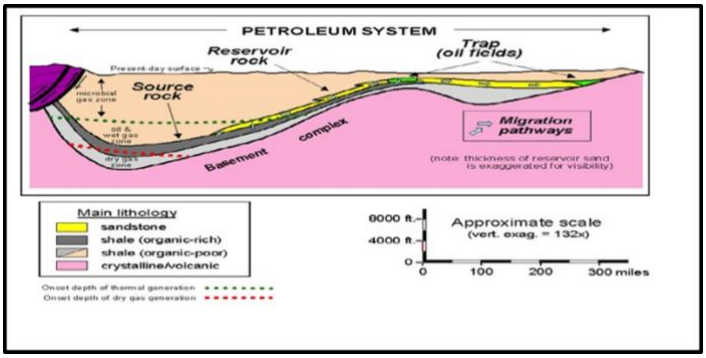


Figure (1) shows the basic data of the integrated petroleum system [8]

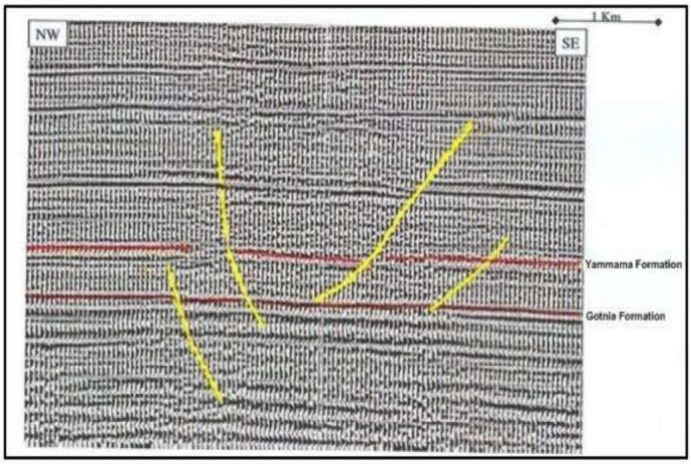
The Petroleum system is the geological system that includes the source rocks that generate hydrocarbons and everything related to hydrocarbon fluids, and the Petroleum system contains a set of basic data that works to collect hydrocarbons in Reservoirs [8] as in Figure (2)

II. AIMS OF STUDY

1- A statement of the petroleum system and the relationship of the hydrocarbon-generating source layers to the oil assemblies in the reservoirs, determining the migration of oil within the study area, as well as showing a basin model that shows the relationship between the elements of the petroleum system in the field and its impact on the sedimentary basin.

2- Explanation of the effect of geochemical factors on the oils, especially the heavy oils, in the Lower Fars reservoir in the field.

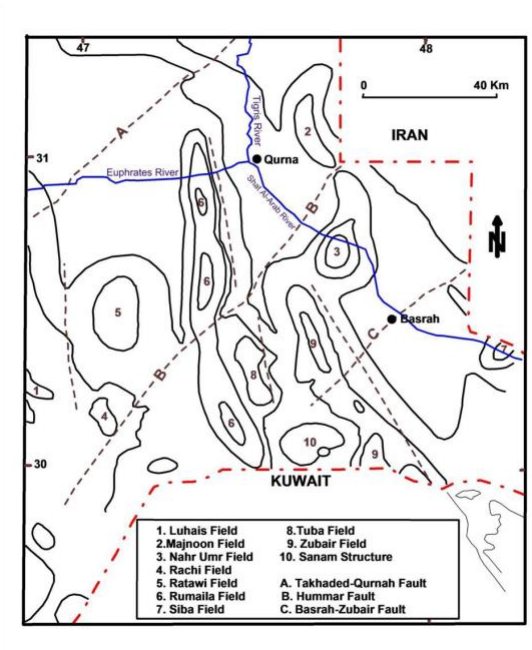
3- Calculation of the potential energy of the oil-generating organic matter in the field and its relationship to the type of



Fig(2) Seismic section(5-BRI) shows graben Nahr Umr field , (Total fina Elf Co.2001

III. STUDY AREA

The Nahr Umar oil field is located in the Basra Governorate in the southeastern part of Iraq, about 30 km north-northwest of the city of Basrah, and the Shatt al-Arab passes through it and divides it into two parts.It is located between the Zubair field in the south and Majnoon field in the north, separated from them by a shallow saddle. The structural relationship between Nahr Umar field and the two mentioned fields is characterized as having a variable axis.The field is about 32 km long and 17 km wide. As in Figure (3),(4)



fig(3): the location of Nahur Umr field with respect surrounding major structure at the depth (4000m),Basra city with some of basement faults in Mesopotamian zone . Modified from Al-Mutury and Alasadi(2007)zone.

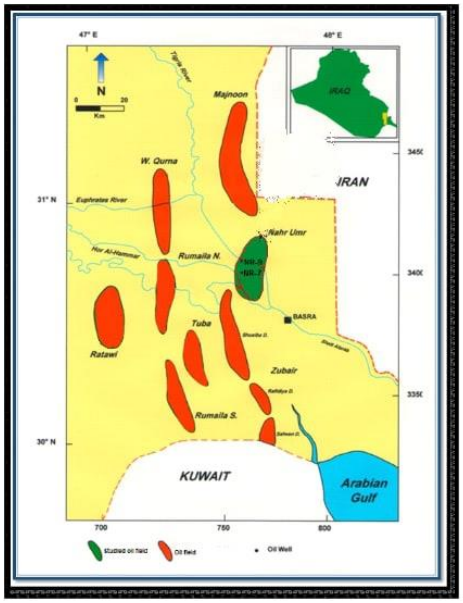


Figure (4)A location map of Nahr Umar field

IV. OIL SHOW

28 wells were drilled in Nahr umar field, and the deepest wells were (NR-1, NR-3, NR-7, NR-10, NR-12) and drilling in these wells reached the Sulaiy Fm formation (Final Geological Reports), where oil was found in several formations, which are from bottom to top:

►Zubair formation and Yammama formation (Early cretaceous).

►Mishrif formation and Nahr Umr formation (Middle cretaceous

►Sa, adi formation and Khasib formation (Late cretaceous)-

►Fatha formation and Ghar formation (Early – Middle Miocene).

The best of these reservoirs are Yamamah , Zubair and Mushrif. As in Figure (5)

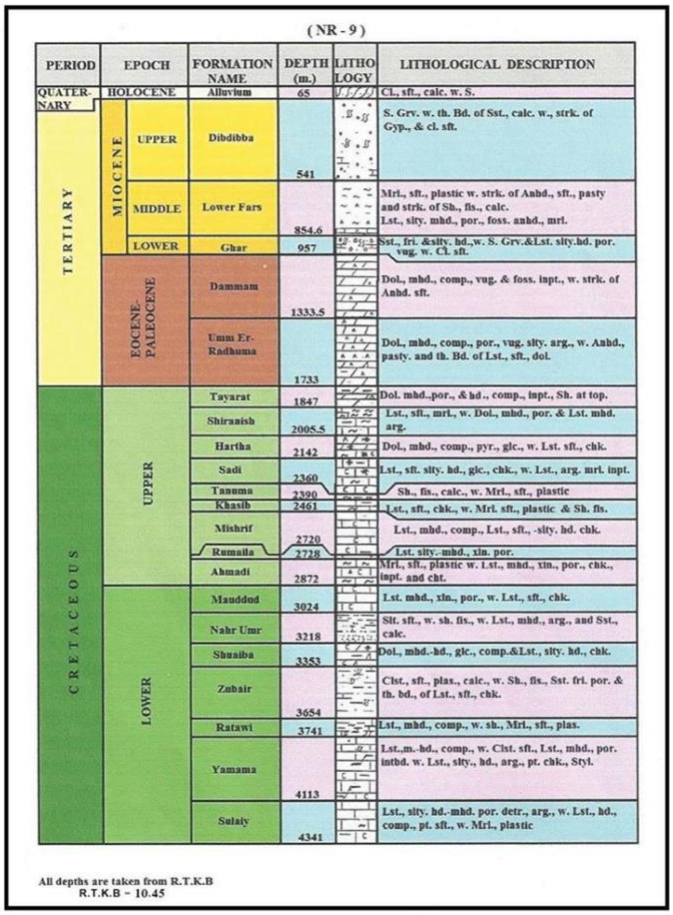


Figure (5) the stratigraphic column for NR-1 well.

V. METHODOLOGY

A-Collection and selection of samples:

41 Rock samples were collected by representing (19) reservoir samples and (22) samples of source rocks from Yamama and Sulaiy Formations. In addition to collecting (39) oil samples from wells (NR-7, NR-9, NR-18, NR-23) representing (4) crude oil samples and (35) oil samples extracted from lower Fars, Zubair and Nahr Umr and Yamamah reservoirs. Table (1)

Table (1) shows the number and type of samples used in the study

Formation name	Rocks	Crude Oil	Extracted Oil
Lower Fars	7	1	7
Zubair	12	2	12
Yammama	18	1	16
Sulaiy	4	-	-

Table (2) shows the types of analyzes of the samples used in the study.

Formation name	SR	GC	Pyrolysis-GC
Lower Fars	-	7	1
Nahr Umr	-	1	2
Zubair	12	4	1
Yammama	18	2	-
Sulaiy	4	-	-

B-Chemical analyzes

All samples analyzes were carried out in the laboratories of the Geological Studies Department / Geochemistry Division, as shown in Table (3)

VI. SOURCE ROCKS EVALUATION

(19)core rock samples were modeled and distributed over two wells (NR-9) and (NR-7) and analyzed by (SR-TPH analysis), as well as previous studies issued by oil explorations and some doctoral theses that were concerned with the study of the Nahr Umar field were used to calculate The amount of organic matter % TOC. The results can be seen in Table (3) and Figure (6). The focus was on the deep formations in the Nahr Umar field because of the possibility of the abundance of organic matter in them, namely Zubair formation, the shale member, Yamama and Suliay formations. The results were as follows:

Zubair Formation: Eleven core samples have been modeled. These samples represent dark black shale rocks containing an amount of organic matter TOC% (0.63 - 1.5) of class II & III. Figure (6) Total Organic Carbon

TOC (Total Organic Carbon)

TOC, is the amount of organic carbon present in a source rock expressed as a weight percent. It is a proxy for the total amount of organic matter present in the sediment (Ronov, 1958) and used as an indicator of source richness with respect to how much hydrocarbon the sediment may generate. TOC is determined by taking a portion of the source rock, grinding it to a fine powder, and weighing the sample to be analyzed.

Source richness interpretations of TOC usually use a semi quantitative scale (Peters, 1986; Jarvie, 1991), While this scale is broadly used, most petroleum geochemists believe a sediment will need at least 2.0% original TOC to be an effective source rock, assuming a large proportion of the organic matter is reactive. Such as shown in table (4)

Table -3: shows the results obtained from the TOC technique

Formation	Dpth (m)	TOC	S1	S2	PP	Tmax (oC)
zbFm	3032	0.63	0.29	0.34	0.63	432.5
zbFm	3035		0.39	0.54	0.93	427.6
zbFm	3041		0.27	0.17	0.98	432
zbFm	3046		1.2	1.5	2.7	423.4
zbFm	3051	0.97	1.77	1.58	3.35	432
zbFm	3054	0.97	0.22	0.61	0.83	436.2
zbFm	3058	0.97	0.27	0.67	0.94	436.7
zbFm	3069		0.89	0.49	1.38	414.1
zbFm	3076	1.56	1.16	1.93	3.09	427
zbFm	3081	1.56	0.33	1.8	2.13	434.7
zbFm	3093		1.93	0.84	2.77	452.6
YaFm	3343	0.43	2.8	2.63	5.43	416.4
YaFm	3344	0.43	1.05	0.49	1.54	420
YaFm	3353		0.6	0.61	1.21	426.8
YaFm	3370	0.66	1.43	1.41	2.89	424
YaFm	3375	0.66	0.49	0.5	0.99	376.7
YaFm	3400	0.25	0.08	0.43	0.51	434
YaFm	3408		1.08	1.25	2.33	498.8
YaFm	3518		0.28	1.22	1.5	430.5
YaFm	3570		1.15	1.93	3.08	564.9
YaFm	3572	1.07	0.11	1.19	1.3	516512.1
YaFm	3575	1.07	0.3	0.52	0.82	430.4
YaFm	3641		0.37	0.66	1.03	424.4
YaFm	3775		2.27	1.72	3.99	428.3
YaFm	3783		2.39	2.85	5.24	431.9
YaFm	3785		4.07	4.14	8.21	430
YaFm	3815	0.37	0.42	0.37	0.79	434.5
YaFm	3823	0.37	1.38	1.58	2.96	425.5
YaFm	3838		1.37	1.04	2.41	390.6
YaFm	3906		1.56	1.23	2.79	428
YaFm	3909	0.2	0.28	0.16	2.96	335.2
YaFm	3910	0.2	1.13	1.73	2.41	339.4
YaFm	3923		1.5	1.34	2.79	440.3
YaFm	3947		1.79	2.36	0.44	434.3
YaFm	3950		2.19	3.43	2.86	299.5
YaFm	4034	0.18	0.48	0.55	2.84	435.4
YaFm	4042		1.36	1.24	4.15	432.3
YaFm	4049		23	2.54	5.62	431.6
SuFm	4055	2.93	79	12.15	91.15	444
SuFm	4058	3.98	70	11.7	81.7	442
SuFm	4180	4.95	81.6	10.5	92.1	446

Caio (%RO)	HI	N.O.C.	PI
0.62		46.03175	0.460317
0.54			0.419355
0.62			0.27551
0.46			0.444444
0.62	136	182.4742	0.528358
0.69	62.8	22.68041	0.26506
0.7	69	27.83505	0.287234
0.53			0.644928
0.66	124	74.35897	0.375405
0.99	115.3	21.15385	0.15493
0.34			0.696751
0.4	646.5	651.1628	0.515654
0.52	114	244.186	0.681818
0.47			
-0.38	214	216.6667	0.495868
0.65	60.6	74.24242	0.49481
1.82			0.156863
0.589			0.463519
3.0082			0.186667
2.128	111	10.8037	0.084615
2.0578	168.2	28.03738	0.365854
0.59			0.359223
0.4792			0.568922
0.5494			0.465107
0.6142			0.495737
0.58	100	113.5135	0.531646
0.661	427	372.973	0.466216
0.499			0.568465
-0.1292			0.55914
0.544	80	140	0.6636364
-1.1264	865	565	0.395105
-1.0508			0.528169
0.7654			0.431325
0.6574			0.38968
-1.769	50	266.6667	0.466019
0.6772			0.523077
0.6214			0.475223
0.6317			0.457207
0.83	415	2696.2246	0.866703
0.8	278	1758.794	0.856793
0.868	274	1648.485	0.885993

Table (4) semi quantitative scale (Peters, 1986

Richness	**TOC**
Poor	0.0-0.5
Fair	0.5-1.0
Good	1.0-2.0
Very good	>2.0

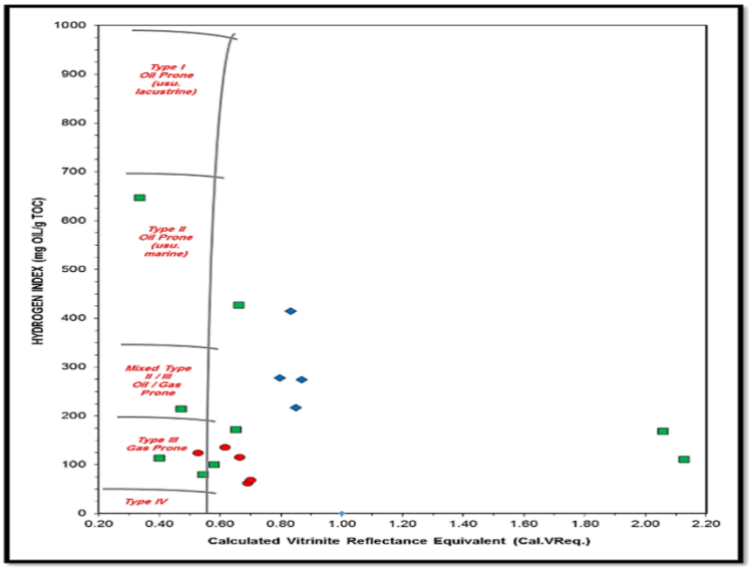


Figure (6) shows the relationship of the hydrogen coefficient with the temperature change in the formations under study

VII. CRUDE OIL CLASSIFICATION

The proportion of saturated hydrocarbon compounds higher than (30%) in all reservoir oils under study, except for the Mishrif and Lower Fars reservoirs, is less than (20%) Table (5) Figures (7, 8). Into two groups:

Table (5) show the alkans value in the study area

normal alkan	NR-23 Z5 FM	NR-7 Z5 FM	NR-7 NR fm	NR-9 Yam Fm	NR-18 LF Fm	Z5-155 Mish Fm
c7	-	94332	16433	-	-	-
c8	-	71640	15752	-	-	-
c9	51118	62838.8	10697	5815.1	-	-
c10	41612	49994.2	9041	4721.7	-	-
c11	40857	46804.6	7040.8	4241.1	-	-
c12	39057	37977.3	6464.9	3942.6	-	-
c13	35759	31686.2	5016.66	3436.4	-	-
c14	32735	22704.3	4221.31	2973.2	-	33
c15	31236	21493.6	3422.99	2744.19	675	29
c16	30680	20178.3	2523.35	2245.35	765	35
c17	28238	18053.4	1624.12	2163.75	876	40
pr	5043.9	1247.3	169.34	375.6	538.2	34
c18	27126	15293.4	1076.36	2012.43	1787.9	33
ph	8982.2	2429.6	325.58	542.3	724.9	60
C19	25909	13038.2	871.26	1801.35	1694.1	110
c20	24632	11567.9	683	1683.77	1861.4	100
c21	23721	9521.44	609.68	1216.45	2811.1	99
c22	19935	8873.04	574.77	1088.5	2776	100
c23	18667	7831.4	474.86	961.08	2877.8	134
c24	17908	7003.1	308.05	580.14	2784.1	200
c25	15131	6781.48	245.61	536.82	2656.6	224
c26	11819	6374.62	133.01	483.73	2401.3	234
c27	10969	4778.91	-	457.52	2203.8	234
c28	9541	3565.31	-	427.87	1949.5	267
c29	7519.2	3132.74	-	406.09	2345	288
c30	7310.8	2862.22	-	394.41	3389	289
c31	5656.8	2253.55	-	311.17	4345	300
c32	3937.3	1733.67	-	279.77	5437	33
c33	2821.1	1446.5	-	262.94	-	29
c34	1783	1342.17	-	219.99	-	-
c35	1050.7	956.19	-	196.74	-	-
c36	472.21	702.33	-	160.86	-	-
c37	159.12	271.55	-	124.34	-	-
c38	-	177.55	-	99.81	-	-
c39	-	-	-	60.44	-	-
c40	-	-	-	55.67	-	-
c41	-	-	-	15.1	-	-
pr/ph	0.5615	0.513376688	0.520117943	0.692605569	0.742447234	0.566666667
pr/c17	0.1786	0.069089479	0.104265695	0.173587522	0.614383562	0.85
ph/c18	0.3311	0.158865916	0.302482441	0.269475212	0.405447732	1.81818182
CPI	1.224	1.15840733	1.846552891	1.093461515	0.904535459	1.153470186

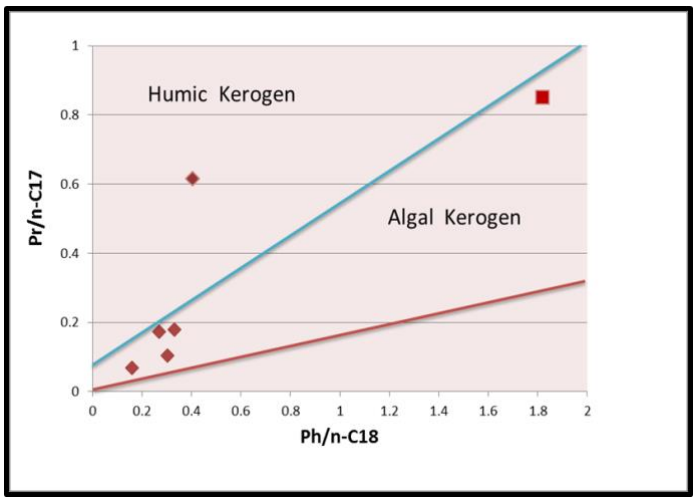


figure (7) shows the type of kerogen

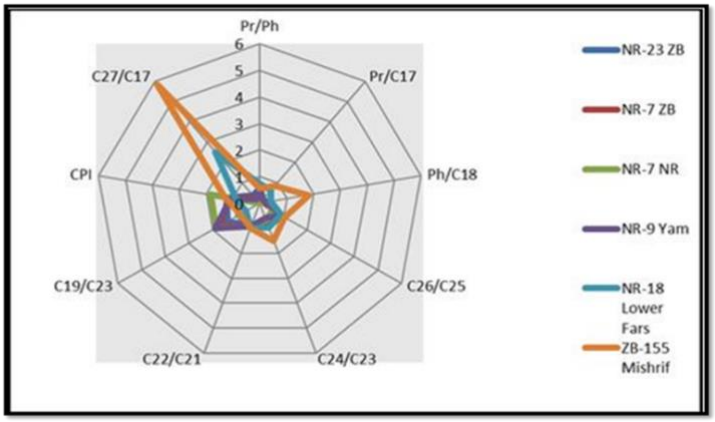


Figure (8) shows the hydrocarbon aggregates of the formations under study

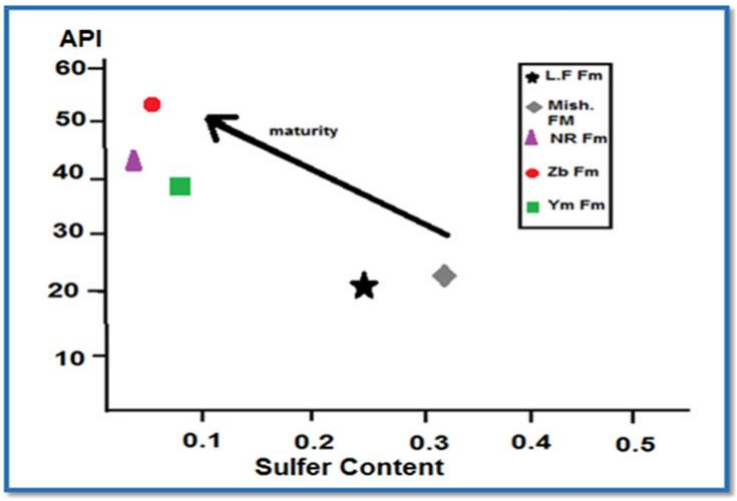


Figure (9) shows the relationship between sulfur content and API

Group 1

The Lower Fars Reservoir: It represents limestone rocks intertwined with clay rocks with a depth of up to (450 m) and the chronological age of formation is the Middle Miocene.
The Mishrif reservoir: It represents the upper Cretaceou limestone rocks with a depth of about (2000m) with shallow marine facies

Source of organic matter

1. n-alkane distribution

By observing the n-alkane distribution, (Fig. 11), it is clear that the chromatograph curves belonging to the first group, which represent the oils of lower Fars and Mishrif , contain high proportions of components with high molecular weight (HMW) and decrease In the ingredients with low molecular weights (LMW), the reason is that these oils are classified among the heavy oils, but it can be noted the prevalence and abundance of n-alkane compounds C17 and C16 in these oils, which indicates that the organic matter formed from them is marine algae and bacteria. [13]

2. Carbon Preference Index:

The value of the carbon differential coefficient for the first group representing the lower Fars and Mishrif formations, which ranges between (1.15-0.9), and depending on these values ,oil samples considered as medium –mature . [13]

The paired carbon numbers can be adopted in determining the specifications of the sedimentary environment of the source rocks that generated these oils, as well as the origin of the organic matter.

3. API:

The API values for the first group range between (20-28) Table (6) and it is classified as oil (medium-heavy) according to (1988, Clayton) and it is not possible to adopt API values in knowing the conditions of the oil system because of the impact of these oils on geochemical factors after being held in reservoirs. Under study (after the migration process).

4. sulfur content

The sulfur content of the first group ranges between (2.3 - 3.4), as these oils have a high sulfur content [13]. The main source of sulfur is sea water and the presence of a type of bacteria called (SRB) that reduces (Sulfide) in environments reducing organic matter in the absence of iron ion (Fe).

In general, and based on the above sulfur values, these samples represent a carbonate marine environment, according to [12].

Table (6) shows the chemical specifications of crude oil analyzed by HPLC technology

Formation Name	Yamama	Zubair	Nahr-Umr	Mishrif	Mishrif In Zubair field
Weight Oil	7.34	5.56	5.45	-	6.50
weight Sat.	2.20	3.48	3.17	-	1.54
Weight Aro.	3.11.	1.36	1.55	-	2.95
Weight Res.	1.20	0.29	0.96	-	1.45
Weight Asphalt.	0.61	0.06	0.46	-	1.03
%Sat.	30.0	62.66	35.28	-	23.69
%Aro.	42.11	24.44	33.97	-	31.53
%Res.	16.34	5.22	17.66	-	22.30
% asphalt.	8.34	1.15	6.65	5.5	15.84
Recovery %	97.38	93.47	93.56	-	95.55
Sulfur Content%	1.0	0.35	0.2	3.4	3.2
API Gravity	41	52	44	27	28

The increase in sulfur concentrations in crude oil and extracted oil indicates that the source rocks are marine with a low concentration of iron ion content. Sulfur concentrations are associated with oils of high partial weights (resins, asphalts, aromatic sections) [2]

Figure (9) represents the relationship of API with sulfur ratios, as it shows that the values of sulfur content decrease with increasing API, and we notice an increase in ripening towards the reservoirs of the second group

Lithofacies

Clay-containing rocks and black shale rocks are good source rocks that generate hydrocarbons. Oil-generating carbonate rocks have the following characteristics:

- High sulfur content [6]
- Pr/Ph <1. [9]
-CPI < 1 [13]
- High concentration of asphalt [3]

All these specifications are available in the first group, and this indicates that the oils of this group come from carbonate source rocks, Figure (10).

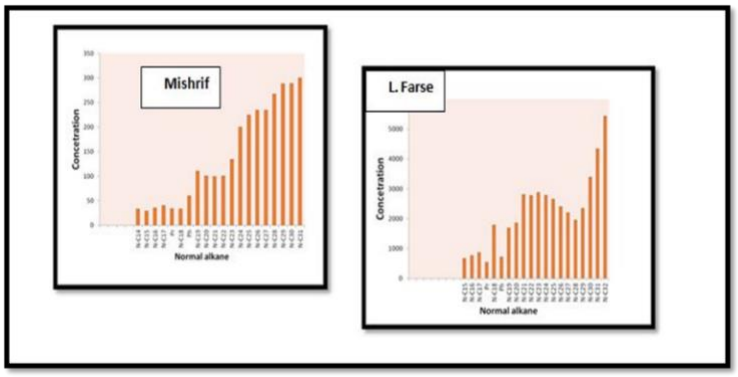


Figure (10): Show a relationship that shows the type of source rocks

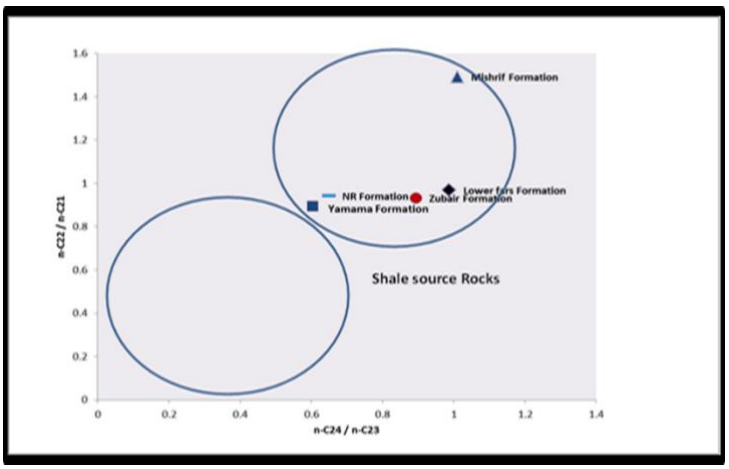


Figure (11): Show a relationship that shows the type of source rocks

Group 2

1. The Nahr Umar reservoir: It is composed of calcareous shale rocks in the upper part and sandy rocks with shale and silt in the lower part, with a thickness of up to (200 m) at the age of the middle Cretaceous.
2. Zubair reservoir: It consists of thick shale rocks and soft sandy rocks interspersed with calcareous rocks of small thickness. The thickness of the formation is about (310-280 m) at the age of the Lower Cretaceous.
3. Yamamah reservoir: It is a limestone rock with a thickness of 307-378 m at an early Cretaceous age.

Source of organic Matter

This group is characterized by its inclusion of light compounds paraffins and naphthenes (saturated) and from the observation of Figures (9, 10) it is clear that the chromatographs curves show the distribution of components with low molecular weights (LMW) in high proportions and decreasing towards Components with high molecular weights (HMW). The Pr/Ph ratios in this group ranged between (0.51-0.69), the Pr/C17 ratios of the oils of this group ranged between (0.104-0.178), and the Ph/C18 ratios ranged between (0.302-0.158). Table (6) and these values indicate that the oils of the second group are more mature than the oils of the first group. This leads us to the fact that the source of the organic matter results from different sedimentary environments according to the [7].

Depositional environment

The oils of the second group contain sulfur percentages less than (1%) and API values ranging between

(46-52) and based on these values, the oils of the

second group are more mature than the first group.

Lithofacies

We note that the ratio of Pr\Ph in the oils of the second group is less than (1) and even alkanes \ odd

alkanes are common in the samples, Table (6).Since the oils of the second group contain less

asphalt than the first group, and this indicates that

the oils of the second group come from carbonate rocks.

Thermal maturity

The distribution of the normal alkanes for the oils of this group, as shown in Figure (12), shows that there is an increase in the

Low molecular weight (LMW) , medium molecular weight (MMW) carbon numbers and a significant decrease in the normal alkanes of high molecular weights (HMW), and this is clear evidence that these oils are characterized by high maturity compared with the first group.

This result was confirmed by the API relationship with Sulfur as shown in Figure (9).

Migration

The sections of Asphelten and Resins do not exceed (26%) in the oils of the second group. As for the first group, it amounted to (39.64%), and this indicates that the second group has greater mobility and migration than the first group.

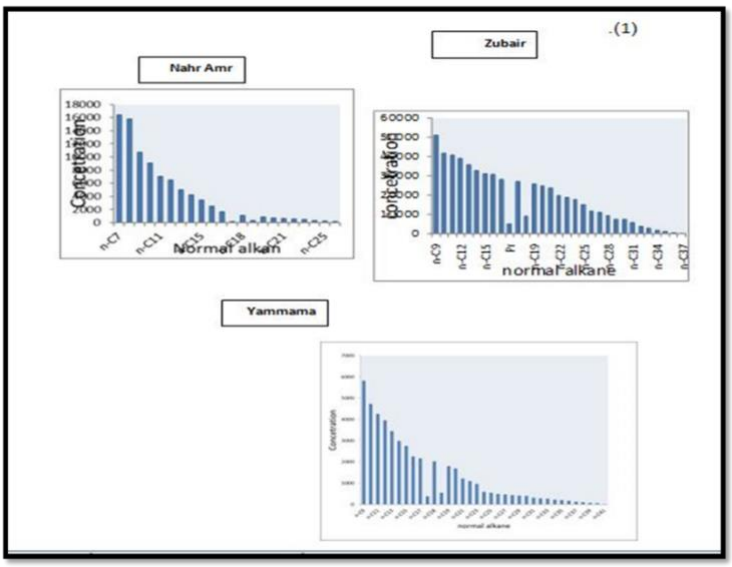


Figure (12) shows the distribution of the usual alkanes in Nahr Umr , Zubair and Yamama Formations

Conclusions

1. The study showed that the abundance of organic matter TOC% in the formations of Zubair, Yamama and Sulaiy in varying proportions, but the formation of Suliay recorded the highest percentage, reaching 4.9%, so these rocks are very rich in organic matter and excellent source rocks
2. The results of the study indicated that Zubair formation has a maximum temperature (Tmax) whose value ranges between (452-414ċ), and this indicates the beginning of the thermal maturation of the black shale rocks of the formation, and that the HI value of these rocks ranged between (69-136) and these values indicate the generation of gas-type hydrocarbons.
3. The results of SR technical analyzes showed that Yamama Formation rocks have maximum temperature values (Tmax) ranging between (564-416) and we note that these values fluctuate with depth, meaning that they do not take constant changes with depth and that the reason for this fluctuation may be due to the intensity of modulation

processes in The lower part of Yamama formation, where these processes caused a delay in the thermal maturation of the organic matter at a stage, which appears to be rocks between the beginning of maturity until after maturity.

4. The Suliay Formation rocks are excellent source rocks of type II & III. It has a high ability to generate hydrocarbons. As for the maturation of organic matter, depending on the maximum temperature Tmax, which ranges (442-446) and the degree of reflection of vetrernite Ro%, ranging (0.8-0.86), they are mature rocks and have the ability to generate oil only.

5. The oils of the reservoirs under study were classified into two groups, depending on the geochemical characteristics.

6. The study showed that the chromatograph curves of the first group, which represents the oils of Lower Fars and Mishrif reservoirs, contain high percentages of components with high molecular weights) and a decrease in components with low molecular weights (and the prevalence and abundance of n-alkane compounds C17, C16 in these oils, which is indicated by However, the organic matter made up of it is marine algae and bacteria.

7. The study indicated that the sulfur content of the first group ranges between (2.2 - 2.3), where these oils have a high sulfur content and the relationship of API with sulfur ratios, as it shows that the values of sulfur content decrease with an increase in API and we notice the lack of maturity in the deposits of the first group.

8. The data of the study, which included the sulfur content CPI , Pr/Ph, indicated that the oils of the first group came from limestone rocks.

9. The results of the study showed that the Pr\Ph ratios in this second group, which includes the reservoirs of Nahr Umar, Zubair and Yamama, ranged between (0.51-0.69), while the Pr\C17 ratios ranged between (0.104-0.178), and the Ph\C18 ratios ranged between (0.302-0.158).) which indicates that the oils of the second group are more mature than the oils of the first group. This leads us to the fact that the source of the organic matter is from different sedimentary environments.

10. The oils of the second group contain less asphalt than the first group, and this indicates that the oils of the second group come from muddy carbonate rocks that are deeper than the carbonate rocks that generate the oils of the first group.

11. The sections of Aspheltens and Risens do not exceed (26%) in the oils of the second group. As for the first group, it amounted to (39.64%), and this indicates that the second group has greater mobility and migration than the first group.

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