



Geochemistry study of chia gara formation in selected wells from Ajil oilfield

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Abstract

This study has been carried out to Chia Gara Formation of (Late Jurassic-Early Cretaceous) age which composed of marly limestone at two subsurface wells in (Aj8) and (Aj12) North Iraq. The rock of the formation contain different percentage of (TOC) between medium to very good. According to qualitative posit the kerogene type are mixed of (II/ III) and type (III) and amount of type (II) . Evaluation found that organic material are of singular structure type (AOM) forming the main type of kerogene (A & C) where the A- type mostly forming the liquid hydrocarbons and B-type mostly formed gas hydrocarbon.

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Introduction:

The importance of organic geochemical study comes from its interest in organic matter, which is the basic building block in the sources rocks and the generator of hydrocarbons, as its different behavior towards burial factors, temperature and time affects the speed of hydrocarbon generators, i.e. early maturation, and also affects its quality as well as the quantity generated from it, which has a direct effect on the efficiency of expulsion and migration of source rocks (1). Ajil field is located northeast of Tikrit city (.30 km) within the northern and northeastern margin of the Arabian plate, Figure (1). Ajil field is an

asymmetrical anticline where its southwestern wing is more inclined than the northeastern wing and the axis of the structure is directed towards the northwest-southeast (2). Tectonically, it is located within the unstable shelf area within the Foot hill zone according to the division of (3). The study aims to:

1- Quantitative and qualitative evaluation of the rocks of the geological formation for the purpose of confirming that they are source rocks for hydrocarbons.

2- Identify the organic carbon content and thermal decomposition of the rocks

Table (1) Coordinates of the wells under study.

Field	Name of the well	Coordinates
Ajil	Ajil 8	43.91.00 E 34.45.00 N
Ajil	Ajil 12	43.54.00 E 34.82.00 N

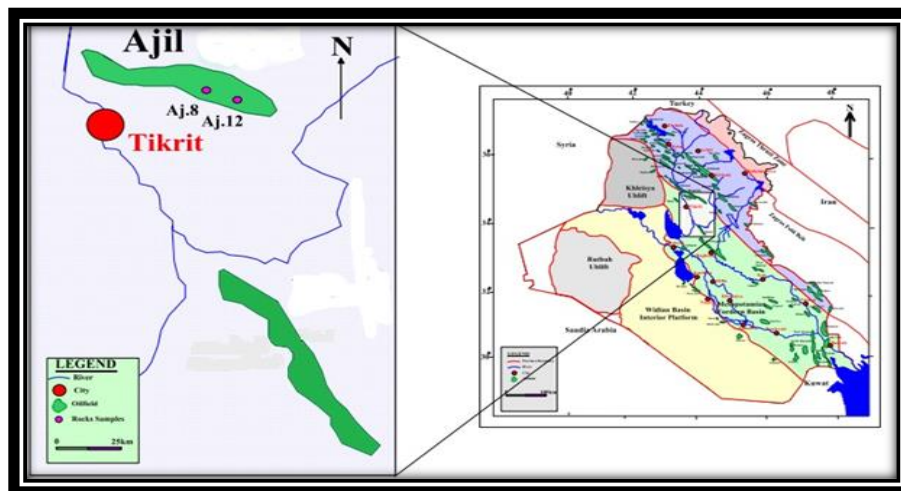


Figure1: The location of the wells under study.

Study methodology:

1- The samples were washed with distilled water to remove traces of drilling mud and dried at room temperature, then packaged and evaluated.

2- The (Leco Analyzer) device was used to measure the percentage of organic carbon (%TOC) for all study samples, Stratochem Company, New Maadi, Cairo, Egypt, and samples with a percentage of organic carbon less than (0.5) were excluded.

3- The (pyrolysis) device was used to obtain values of (S1) which is the amount of hydrocarbons released, (S2) which is the amount of hydrocarbons generated thermally, (HI) the hydrogen function that is calculated from the data provided by the (pyrolysis) device and according to the

equation $HI = S2 / TOC * 100$,... (4) PI is the hydrocarbon production index that is calculated from the data provided by the (Pyrolysis) device and according to the equation $PI = S1 / (S1 + S2)$,... (4) The following is a detailed explanation of these steps:

1- Organic geochemical analyses: Two wells were selected to study the Giacra Formation from an organic geochemical perspective. For this purpose, 25 samples were taken, where 10 samples of cores were taken in well (Aj8) and 15 samples of rock fragments (cutting) in well (Aj12). The organic carbon content and pyrolysis of the rock were calculated. Table (2) shows the results of the analysis:

Table (2) Organic geochemical analysis.

Sample No.	Sample Name	Depth)m(	TOC)%(	S1)g/mg(	S1/ TOC	S2)g/mg(	S3)g/mg(	Tmax(°C)	PI	OI (CO2/g)	HI (HC/mg)
1	AJ.8	3166	22.42	4.14	0.18	60.99	0.8	442	0.064	4	272
2	AJ.8	3167	21.95	3.43	0.15	54.12	1.46	443	0.06	7	246.6
3	AJ.8	3168	21.8	3.39	0.15	51.23	1.54	442	0.062	7	235
4	AJ.8	3169	21.76	2.99	0.13	46.24	1.49	439	0.061	7	212.5
5	AJ.8	3170	13.5	3.65	0.27	43.00	1.7	439	0.078	21.5	318.5
6	AJ.8	3171	6.50	3.00	0.4	20.10	1.3	442	0.129	20	309.2
7	AJ.8	3172	7	2.27	0.32	31.95	1.29	443	0.066	18	456.4
8	AJ.8	3173	19.00	5.22	0.27	45.78	1.00	442	0.102	5.2	240.9
9	AJ.8	3174	17.00	2.33	0.137	26.67	1.10	440	0.080	6.4	156.8
10	AJ.8	3175	23.09	4.43	0.191	73.03	1.68	443	0.057	7	316.3
11	AJ.12	3222	0.5	0.4	0.8	1.35	1.9	430	0.229	380	270
12	AJ.12	3230	10.50	5.00	0.47	47.33	1.7	446	0.095	16.1	450.7
13	AJ.12	3244	0.5	0.21	0.42	1.08	1.42	429	0.163	284	216
14	AJ.12	3256	3.80	1.75	0.46	0.50	1.55	441	0.777	40.7	13.15
15	AJ.12	3268	1.44	0.55	0.38	2.00	1.14	441	0.215	79.1	138.8
16	AJ.12	3280	0.75	0.33	0.44	1.97	1.62	428	0.143	216	262.7
17	AJ.12	3290	1.22	1.58	1.29	3.11	1.33	440	0.336	109	254.9
18	AJ.12	3310	1.01	0.47	0.46	3.24	1.99	431	0.127	197	320.8
19	AJ.12	3330	1.71	1.55	0.90	5.79	1.62	431	0.211	95	338.6
20	AJ.12	3340	1.15	0.71	0.61	1.22	1.87	445	0.367	162	106.08
21	AJ.12	3364	1.61	1.69	1.04	5.7	1.18	430	0.229	73	354
22	AJ.12	3378	1.22	0.9	0.73	4.33	1.62	431	0.172	133	354.9
23	AJ.12	3390	1.41	1.27	0.62	5.34	2.75	429	0.192	195	378.7
24	AJ.12	3405	1.82	1.14	0.62	6.47	2.19	436	0.15	120	355.5
25	AJ.12	3425	0.99	0.21	0.21	1.38	4.42	439	0.132	446	139.4

2-Determination of Total Organic Carbon (TOC):

This analysis is one of the important analyses in organic geochemistry that determines the number of samples that will be subjected to subsequent analyses, as samples with a TOC ratio of less than (0.5%) are excluded from subsequent analyses. The calibration method of (El-Wakeel 1957) (5) was used in (Al-Ubaidi, 2020) (6) to determine the TOC ratio in the current study instead of the calibration method using the (LECO) device.

3-Pyrolysis of rock: The ability of rock samples to produce petroleum by pyrolysis is estimated. The emitted hydrocarbons are monitored by a flame ion detector (FID) producing two distinct elevations, the first S1 is the heat-

free hydrocarbon, and the second S2 is the hydrocarbon resulting from the cracking of kerogen. The temperature reached by the second elevation S2 is called Tmax, which gives an impression of the degree of maturity of kerogen. Tmax can be used to calculate the reflectance of ferritin. In addition, carbon dioxide gas emitted during decomposition can be monitored by infrared rays and is called the S3 meeting according to the information if the kerogen oxidation occurs. Other diagnostic ratios that can be calculated from the elevations S1- S2= S3 represent the production content (PI), hydrogen content (HI), and oxygen content (OI) (Mahdi, 2015) (7).

Previous studies:

The formation was first described by (Elwakeel, 1957)(5) in its ideal section, as the thickness of the formation in the Giakara fold south of Amadiya city is about (232) meters, which consists of two units, the lower consisting of a succession of thin layers of limestone and shale rocks with a high content of ammonite fossils, and the upper consisting of an intercalation of yellow clay rocks and limestone rocks with the recording. The study of (Rushdi, 1990)(8) showed that the formation rocks in surface sections of northeastern Iraq contain different organic materials, as for the migration of the generated hydrocarbons, it occurred during the Miocene age, as it was towards the northwest as a horizontal migration alongside the vertical migration in the region. As for the study of (Al-Bayati, 1998) (9), it focused on the evaluation of organic and environmental geochemistry of the Giakara formation rocks in selected wells from central Iraq. (Al-Amri et al., 2013) (10) studied the organic geochemistry and micro-palenological units of the Jurassic

and Cretaceous periods of the Ajil oil field formations in northern Iraq. The results showed that the source rocks of the (Sarkalu, Nauklikan and Jiakkara) formations have a very high potential for generating hydrocarbons.

Source rock evaluation:

McCarthy (2011) (11) defined it as any rock rich in organic materials of various sizes and has the ability to generate hydrocarbons after being fully exposed to heat and pressure. The generated hydrocarbons are determined by the amount of organic material and the extent of their thermal maturity. Source rocks are also defined as rocks that combine with sedimentary organic materials and produce hydrocarbons under pressure and heat and during a certain time and migrate towards oil accumulation areas (11). the carbonate content value of 1.0 is the minimum for effective source rocks because effective source rocks with an organic content value of less than 1.0% will be unable to generate oil to begin the initial migration as shown in Table (2).

Table (3) shows the description of kerogen types

Kerogen	HI mg Hc/gToc	S3/S2	Atomic C/H	Main expelled at peak maturity
I	> 600	> 15	> 15	Oil
II	300-600	10-15	10-15	Oil
III/II	200-300	5-10	5-10	Mixed oil and gas
Iv	50-200	1-5	1-5	Gas
	< 50	< 1	< 1	Non

Thermal maturity:

The degree of change in organic materials as a result of heating is called thermal maturation (12). Organic materials have three stages of maturation: immature, mature and post mature as shown in table.(3)

Pyrolysis:

The pyrolysis process involves evaluating the oil potential of rock samples according to the programmed temperature pattern, and the temperature program was defined in order to distinguish (ionization detector flame) and free hydrocarbons begin to volatilize when reaching a temperature of (300 C') to give the first peak (S1) while the hydrocarbons that can be released through thermal cracking

of organic materials (OM) with thermal heating to a temperature of 300-650 C' give the second peak (S2) In addition, (CO) and (CO₂) released during the pyrolysis process are monitored by the infrared cell to give us the third peak (S3) and (CO and CO₂) can be calculated through the conductivity detector as it gives us information about the oxidation state of organic materials. This process of oxidizing rock samples is completed according to the programmed temperature system allowing the calculation of the total organic carbon in addition to the mineral carbon of rock samples (12). Table (4).

Hydrogen Index:

Hydrogen Index: The hydrogen index is defined as the percentage of hydrogen in the sample to the amount of (TOC) and can be calculated according to the following equation: $S3/TOC \times 100$. The hydrogen index is used with other parameters to determine the quality and maturity of kerogen .

Oxygen Index:

The oxygen index (OI) represents the percentage of oxygen in the sample to the amount of (TOC) and can be calculated according to the following equation: $S3/TOC \times 100$. It is used with other parameters to determine the quality and maturity level of kerogen

T-Max.:

Maximum temperature (T-Max.) is the most important pyrolysis data that has great importance in determining the maturity of organic materials and their quality when

Production index. Which is derived from the sum of the ratio of free hydrocarbons present in the rock, S1, to the total free hydrocarbons liberated as a result of thermal

Determination of the amount of organic matter (%TOC):

The percentage of total organic carbon in the rocks of the Giakara Formation was estimated from wells Aj8 and Aj12, where the highest value of TOC% in well Aj8 was (23) at a depth of (3175m) and its lowest value in the same well was (6.5) at a depth of (3171m), while its highest value in well (Ajil 12) was (10.50) at a depth of (3230m) and its lowest value in the same well was (0.5) at a depth of (3244m). Table (2) shows the results of the analyses of the rocks of the formation under study, which showed an appropriate content of total organic carbon with depth. Figures (2, 3) show that most of the samples showed the presence of excellent to very good organic matter with the presence of some samples with a moderate level-, which helped in conducting organic geochemical analyses to identify the quality of kerogen, organic maturity and production index (PI). The samples of organic matter with a content higher than (4%), the presence of some samples of formation rocks showed a high value of (%TOC) and thus falls outside the classification adopted in the current study, but it indicates the high ability to generate liquid and gaseous hydrocarbons according to the highest values within the approved classification.

Determining the quality of kerogen from the relationship between (%TOC) and the hydrogen index (HI):

combined with other treatments. (Hunt, 1996) (13) suggested determining the maturity of organic materials and the quality of organic matter based on the relationship between the maximum temperature Tmax and the hydrogen index in terms of vitrinite reflectance and the determinant (435c) degree Celsius for the degree of thermal maturity and mature samples that have high Tmax values are likely to fall within the oil generation network..

Genetic potential (Gp):

Conventional potential. It is called (petroleum potential) and has a concentration of (pp) and is derived from the sum of free hydrocarbons (S1) and hydrocarbons that are released as a result of thermal cracking (S2). It is used to infer the potential efficiency of generating hydrocarbons from organic materials that have been exposed to a sufficient period of temperature in the source rocks (Tissot & Welte, 1984) (14) and is measured in units (mg hydrocarbons/g of sample rock).

Production Index (PI):

cracking, S2, and is measured in mg hydrocarbons/g of sample rock (4).

The quality of kerogen was determined through the relationship between (TOC) and (HI) in the wells, and the hydrogen index (HI) is calculated according to the following equation: $\{HI = (S2/TOC) \times 100\}$ ----(4). The highest value of the hydrogen index in the wells under study was (Aj8=450.6, Aj12=456.4) for depths (3312, 3230m) respectively, as in Table (1) and (2), where most of the formation rock samples in well (Aj8) have a mixture of kerogen of the second and third types (II/III) with the presence of one sample represented by the third light, while in well (Aj12) it was found that most of the formation rock samples are represented by the third light of kerogen (III) with a mixture of kerogen (II/III) and kerogen (II), and perhaps the reason for this is that they were contaminated with hydrocarbons from the lower layers that may have generated liquid and gaseous hydrocarbons, which is the same reason For the model in well (Aj8). In addition to the presence of some models of formation rocks that showed high values of (HI and %TOC), which indicates a high ability to generate liquid and gaseous hydrocarbons according to the highest values within the approved classification. It is clear from the above that the formation rocks only above are oil-generating with models that are inclined to generate gaseous hydrocarbons.

Table (2) shows the description of kerogen types.

Kerogen Type	HI mg Hc/gToc	S3/S2	Atomic C/H	Main expelled at peak maturity
I	> 600	> 15	> 15	Oil
II	300-600	10-15	10-15	Oil
III/II	200-300	5-10	5-10	Mixed oil and gas
Iv	50-200	1-5	1-5	Gas
	< 50	< 1	< 1	Non

Table (3) shows the stages of thermal maturation according to (Cassa 1994; Bacon et al., 2000).

Stage of thermal maturity of oil		Tmax for type 1	Tmax for type 2	Tmax for type 3	Tmax for type 4
Immature		<440	<435	<445	<0.10
Mature	Early	440	435	445	0.10–0.25
	Peak	445	440	450	0.25 – 0.40
	Late	450	460	470	>0.40
Postmature		>450	>460	>470	

Determining the type of kerogen dependent on total organic carbon values and liberal hydrocarbons majority at thermal temperatures (S2):

The importance of the amount of hydrocarbons released at the maximum temperatures (S2) and its lack of impact by the pollution resulting from the migrating hydrocarbons made it an important element in determining the quality of kerogen in the source rocks in relation to the total organic carbon content (%TOC), as the highest value of (S2) in the wells under study reached (Aj8=73.03, Aj12=47.33) and for depths (3175, 3230 m) respectively, while its lowest value in the wells under study reached (Aj8=20.10, Aj12=1.22) and for depths (3171, 3340 m) respectively. The results of the analysis of the rock samples of the Giakara Formation in well Aj8 showed that its content of kerogen ranged from type II to a mixture of types II and III (II/III)

Figure (4), while in well (Aj12), the formation rocks contained kerogen of type III (III) and type IV in addition to a mixture of types II and III (II/III) and III (III) Figure (5). The formation rock samples showed, as in the indicated figures, the presence of a small amount of type II kerogen and water to generate liquid and gaseous hydrocarbons, in addition to the presence of some formation rock samples that showed a high value of (TOC%, S2), which generally indicates a high ability to generate liquid and gaseous hydrocarbons according to the highest values within the approved classification

. Table (4) shows the calculations for thermal cracking coefficients and their abbreviations according (Johannes et al, 2006)

Abbreviation	Unit	Formula	Name
Gp	RX g/ Hc Mg	S1+S2	Genetic potential
PI	----	)S1+S2/(S1	Production Index
PC	Wt%	$0.1 \{0.83(S1+S2) + 0.273S3 + 0.429 (S3 \text{ CO} + 0.5S3\text{CO})\}$	Pyrolysable organic carbon
TOC	Wt%	PC+Rc	Total organic carbon
HI	TOC g / Hc Mg	TOC/100S2	Hydrogen Index
BI	Wt%	TOC/100S1	Bitumen Index
OI	Toc g /co2 Mg	TOC/ 100S3	Oxgen Index
RC CO	Wt%	0.0428 S4C0	Residual carbon organic (CO)
RC CO2	Wt%	0.0273S4CO2	Residual carbon organic (CO2)
RC	Wt%	RC CO+RCCO2 TOC-PC	Residual carbon organic

Table (6) shows description of kerogen types (Peter and Cassa, 1994).

Kerogen Type	HI gToc/mg Hc	S2/S3	Atomic H/C	Main expelled at peak maturity
I	> 600	> 15	> 15	Oil
II	300-600	10-15	10-15	Oil
II/III	200-300	5-10	5-10	Mixed oil and gas
Iv	50-200	1-5	1-5	Gas
	< 50	< 1	< 1	Non

Table (7) shows kerogen types according to its content (OI,HI) (Tissot & Welte, 1984 (14); Peter & Cassa, 1994(15).

Kerogen Type	HI Values	OI values
Type1	>600 mg Hc/g Toc	<50 mg co2/ g Toc
Type2	300-600 mg Hc /g Toc	<50 mg co2 / g Toc
Mixture1,2	200-300 mg Hc / g Toc	-----
Type4	50-200 mg Hc / g Toc	50-100 mg co2/ g Toc
Type5	<50 mg Hc / g Toc	-----

Determination of kerogen type using the

Hydrogen and oxygen functions are used to determine the type of kerogen from the rock samples of the Giacara Formation in the wells under study. The highest value of OI reached (Aj8=21.5, Aj12=446) for depths of (3425, 3230) meters, respectively, while the lowest value in the wells under study reached (Aj8=7, Aj12=9) for depths of (3503, 3170) meters, respectively. The results showed, as in Table (10), that the type of kerogen is of the second type (II) and the second and third mixed types (II/III) in the rock samples of the formation in (Aj12). The mixed type also predominated with the presence of the second type (II) samples in well (Aj8) Figures (6, 7). The models show that they are of the water type for generating liquid and gaseous hydrocarbons and are consistent with the above figures for the relationships between the total organic carbon content and other elements resulting from analysis using the pyrolysis tool.

Hydrocarbon Production Index (PI):

The analysis and production of liquid and gaseous hydrocarbons requires knowledge of the value of the hydrocarbon production index (PI), and to know this value, the values of free hydrocarbons (S1) and the value of hydrocarbons released at the maximum temperature (S2) must be extracted according to the following equation :

$$PI= S1/ (S1+S2) \text{ -----}(4)$$

Many studies (16) have set specific values to infer the generation of liquid and gaseous hydrocarbons at a value of (0.1). In light of the results obtained from the analysis of this ratio, in addition to the type of rock surrounding the organic matter, as the clay content works to absorb the (Tmax). Determining the kerogen type using hydrogen index and values of the maximum temperature:

The type of kerogen was shown by representing the urban data in Table 1 to be a mixed type of the second/third type (II/III) in addition to the second type (II) of kerogen as in Figures (10, 11), with the exception of some samples in well (Aj12) that showed a type of kerogen close to the ineffective type and may have been due to either leaching

hydrogen index HI and the Oxygen index:

the rock models of the Giacara Formation from the study wells, as in Table (1) and Figures (8,9), it is clear that the formation rocks have entered the stage of hydrocarbon generation in well (Aj8) through the relationship between the organic production index (PI) and the maximum temperature (Tmax). As for the rock models of the formation, Giacara in well (Aj12) showed results that differed from those in well (Aj8) as the vast majority of the samples generated hydrocarbons while some samples, especially at depths (3364 meters) and (3390 meters) showed contamination with hydrocarbons migrating through other layers and this can be easily identified by comparing the value of the production index (PI) which recorded values of (0.22, 0.19) versus the maximum temperature value (T-max) which reached (430, 429) at the two depths indicated respectively as these temperatures were lower than the maturity temperature which is (435) degrees Celsius (14). As for the samples taken from depths (3170-3166) and (3274-3230) meters, it was shown that they were inactive carbon according to their values of the organic production index (PI) and the maximum temperature. (Tmax), while the models taken from depths (3166-3169 meters) represent values below the threshold of hydrocarbon generation, although the maximum temperature (Tmax) has shown that it has entered the maturity stage. This is attributed to either the low organic content (TOC) or the low hydrogen index (HI). The type of kerogen also has an effect on

hydrocarbons generated on its surface, which leads to raising the maximum temperature such that its content was exhausted with the generation of hydrocarbons, or some samples in well (Aj12) showed a type of thermal immaturity such that their maximum temperature values were less than (435) degrees Celsius.

Table (8) shows the Gp scale compared to the rock type (Tissot and Welte,1984)(14)

Source potential	Genetic potential
Poor	g/mg poor<2
Moderate	g/mg moderate2-6
Good	g/mg >6

Determining the kerogen type using hydrogen

The type of kerogen was shown by representing the urban data in Table 1 to be a mixed type of the second/third type (II/III) in addition to the second type (II) of kerogen as in Figures (10, 11), with the exception of some samples in well (Aj12) that showed a type of kerogen close to the ineffective type and may have been due to either leaching such that its content was exhausted with the generation of hydrocarbons, or some samples in well (Aj12) showed a type of thermal immaturity such that their maximum temperature values were less than (435) degrees Celsius.

The percentage of total organic carbon (%TOC) in the formation rocks represents source rocks of the oil shale type, because the current (%TOC) values were characterized by values higher than (5%). Therefore, the formation rocks in well (Aj8) are considered rocks rich in organic matter and there are types of marine and continental palynols, pollen grains and kerogen, so they express the mixed type, which indicates that the type of oil shale is of the marine type affected by continental sediments that mixed with it either through marine progress or through upwelling currents.

S1 is considered one of the important elements indicating the formation and migration of hydrocarbons if the values of S1/TOC are taken into consideration. It is produced from the values obtained that there is generation of hydrocarbons with migration and expulsion of hydrocarbons from the recording in the lower part of the formation rocks at a depth of (3256-3364) which were characterized by being of the type (oil shale) noting that the highest value reached (5.22) and the lowest value reached (0.2).

S2 reached the highest value (60.99) and the lowest value (0.5) and is considered one of the bound hydrocarbons that are released in the form of hydrocarbons with increasing temperatures, which affects the increase in the maturity of organic matter. It is worth noting that the high ratio of (S2) values with high values of (Tmax) for the same analyzed models indicates a delay in the organic maturity of shale rocks (oil shale) due to the fact that kerogen is of the mixed type with the dominance of the third type sometimes and the presence of clay minerals within the shale rocks, which work to absorb heat and collect it because clay minerals are not good thermal conductors, which leads to slow maturation with the retention of the formed hydrocarbons

index and values of the maximum temperature:

due to their absorption on the surfaces of clay minerals present within the shale rocks, which affects the values of (PI).

HI where the highest value was (450.7) and the lowest value was (13.15) it was shown that the type of kerogen through the representation of the urban data in Table (2) is a mixed type of the second/third type (II/III) in addition to the second type (II) of kerogen with the exception of some samples in well (Aj12) which showed a type of kerogen close to the inactive type and may be due to maturity so that its content was exhausted with the generation of hydrocarbons.

OI where the highest value was (284) and the lowest value was (4) where the results showed as in Table (2) that the type of kerogen is of the second type (II) and the mixed type of the second and third types (II/III) in the formation rock samples in (Aj12) and the mixed type was dominant with the presence of the second type (II) samples in well (Aj8). In general, the results show that it is inclined to generate liquid and gaseous hydrocarbons and is consistent with what was presented for the relationships between the total organic carbon content and other elements resulting from analysis using the pyrolysis tool.

PI The highest value was 0.367 and the lowest value was 0.06. It is clear that the formation rocks have entered the hydrocarbon generation stage in (Aj8) through the relationship between the organic production index (PI) and the maximum temperature (Tmax), versus the maximum temperature (T-max), which reached (430, 429) at the two depths indicated respectively, as these temperatures were lower than the maturity temperature, which is (435) degrees Celsius+ (1994, Peter and Cassa) (15) . As for the samples taken from depths (3170-3166) and (3174-3230) meters, they showed that they are inactive carbon according to their values of the organic production index (PI) and the maximum temperature (Tmax), while the samples taken from depths (3170-3166) meters represent values below reaching the threshold of hydrocarbon generation, although the maximum temperature values (Tmax) may It was shown that it entered the maturity stage, and this is attributed to either the low organic content (TOC) or the low hydrogen index (HI). The type of kerogen also has an effect on this percentage, in addition to the type of rock surrounding the

Table (9) shows the immature organic matter and its corresponding (PI) Tissot and Welte,(14)
 (1987: in Pitman *et al.*, 1987)

Organic matter type	Production index (PI)
Type I	<0.1
Type II	<0.1
Type III	0.1-0.2

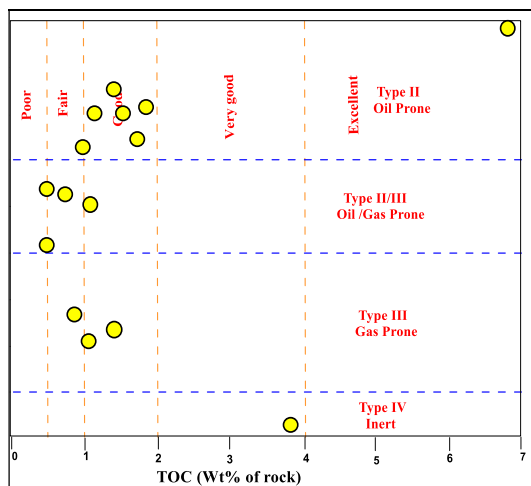


Fig.(3)Kerogentype in the rocks of Giakara Formation from the Aj12 well from the relationship between the percentage of total organic carbon(TOC%)and the hydrogen function HI (Dembicki, 2009).

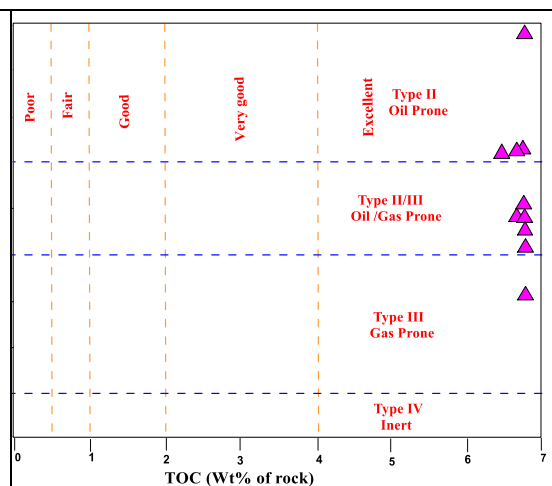


Fig.(2)Kerogentype in the rocks of Giakara Formation from the Aj8 well from the relationship between the percentage of total organic carbon(TOC%)and the hydrogen function HI (Dembicki, 2009).

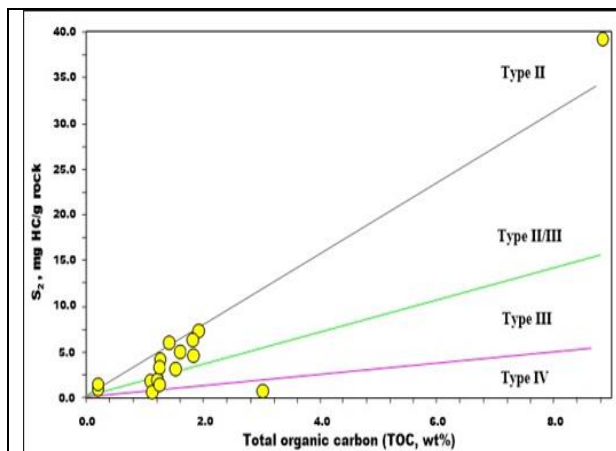


Fig. (5) Total organic carbon (TOC%) and hydrocarbons released at the maximum temperature S2 of Giakara formation rocks in well Aj12 (Dahl et al., 2004).

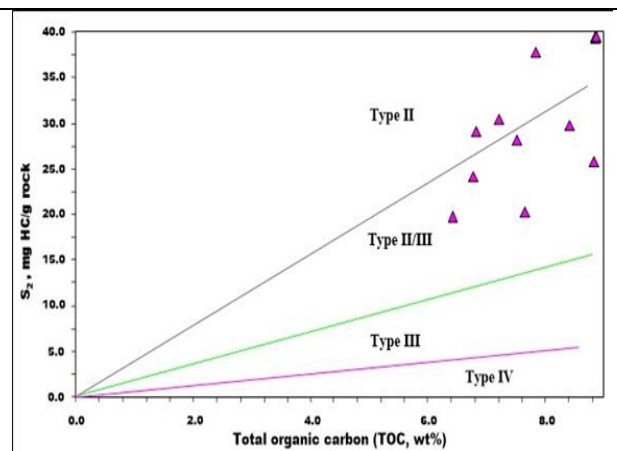


Fig. (4) Total organic carbon (TOC%) and hydrocarbons released at the maximum temperature S2 of Giakara formation rocks in well Aj8 (Dahl et al., 2004).

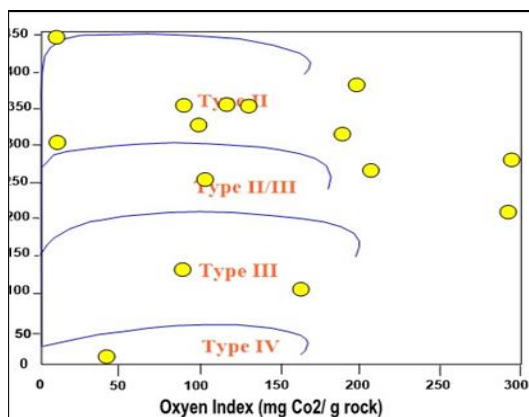


Fig. (7) Kerogen type of the giacara formation in well (Aj12) (Espitalie et al, 1977).

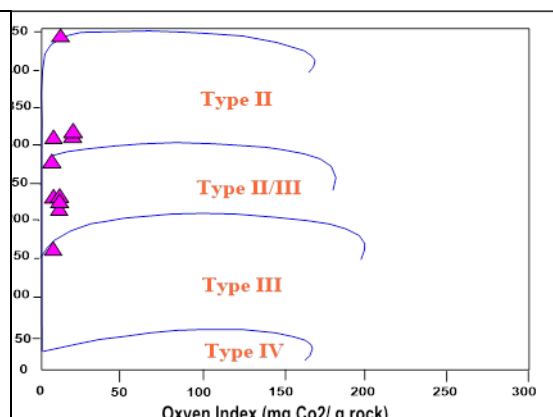


Fig. (6) Kerogen type of the giacara formation in well (Aj8) (Espitalie et al, 1977).

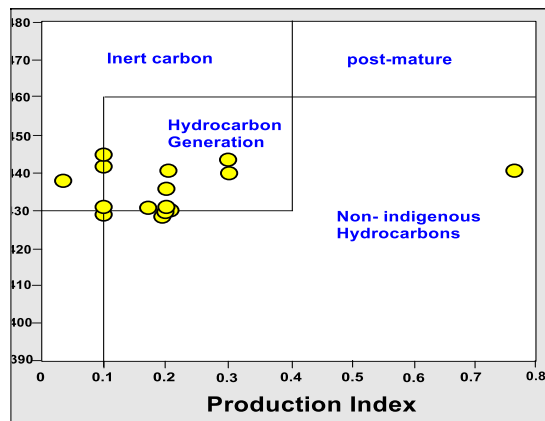


Fig.(9) Hydrocarbon-generating samples from the rocks of the Giacara formation in well Aj12 (Langford and Blanc Velleron, 1990).

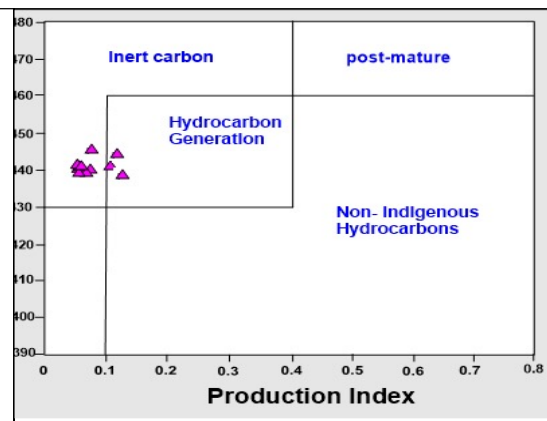


Fig.(8) Hydrocarbon-generating samples from the rocks of the Giacara formation in well Aj8 (Langford and Blanc Velleron, 1990).

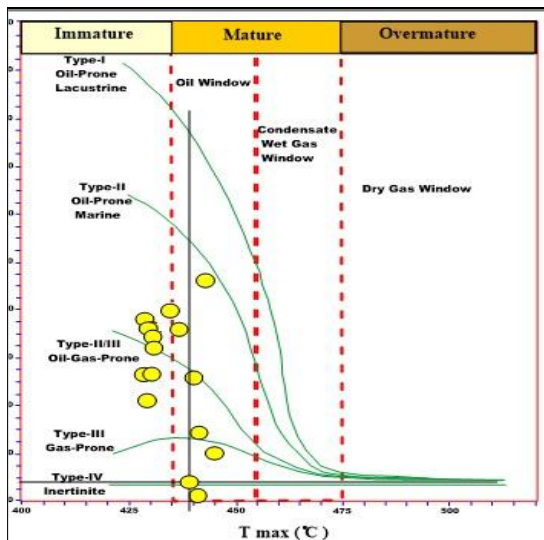


Fig.(11) Relationship between hydrogen function (HI) and maximum temperature (Tmax) for giacara formation in well (Aj12) according to (Espitalie et al., 1985).

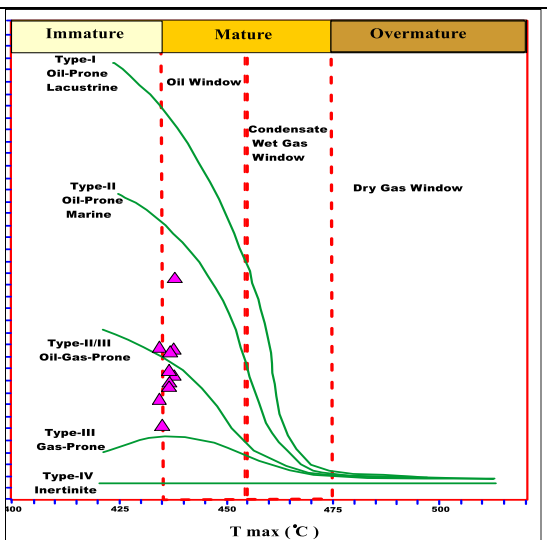


Fig.(10) Relationship between hydrogen function (HI) and maximum temperature (Tmax) for giacara formation in well (Aj8) according to (Espitalie et al., 1985).

Table (10) Total organic carbon percentage and maturation temperature.

TOC(%)	TOC/0.64	Tmax
22.42	35.03	442
21.95	34.23	443
21.8	34.06	442
21.76	33.85	439
13.5	21.09	439
6.50	10.15	442
7	10.93	443
19.00	29.68	442
17.00	26.56	440
23.09	36.07	443
0.5	0.78	430
10.50	16.40	446
0.5	0.78	429
3.80	5.93	441
1.44	2.25	441
0.75	1.17	428
1.22	1.90	440
1.01	1.57	431
1.71	2.67	431
1.15	1.79	445
1.61	2.51	430
1.22	1.90	431
1.41	2.20	429
1.82	2.84	436
0.99	1.54	439

Conclusion

1- The content of the formation rocks of organic matter (%TOC) ranged from very good to moderate with percentages exceeding their limits when compared with the percentages shown in the tables related to the classification of rocks according to the value of (%TOC) and therefore it was named in the current study as the excellent value.

2- The type of liquid kerogen within the rocks of the Giakara Formation was represented by the dominance of the mixed type of kerogen (II/III) with the presence of some kerogen of the third type (III) and a percentage of the second type (II) where it was shown that the two types (A, C) predominated.

3- Most of the results examined were mature in terms of the maximum temperature values (Tmax) for the generation of hydrocarbons.

4- The hydrogen index (HI) values measured from the formation rocks were shown to be very good values in well Aj-8, while in well Aj-12, their values were almost similar. This may be due to the percentage of organic content (TOC), which was generally excellent, in addition to the type of organic matter within the formation rock samples in well Aj-8

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الخلاصة

أجريت هذه الدراسة على تكوين شيا غارا من العصر الجوراسي المتأخر - الطباشيري المبكر والذي يتكون من الحجر الجيري المارلي في بئر تحت سطح الأرض في (Aj8) و (Aj12) شمال العراق. تحتوي صخور التكوين على نسب متفاوتة من (TOC) بين متوسطة إلى جيدة جدًا. ووفقًا للوضع النوعي فإن نوع الكيروجين عبارة عن خليط من (II / III) والنوع (III) وكمية النوع (II). وجد التقييم أن المواد العضوية من النوع المفرد (AOM) تشكل النوع الرئيسي من الكيروجين (A & C) حيث يشكل النوع A في الغالب الهيدروكربونات السائلة والنوع B في الغالب الهيدروكربون الغازي.