

The Evaluation of Petro-physical and Geological Properties of the Southern Asmari Reservoir / Fauqi oil field Southeastern Iraq

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Abstract:

The wire line logs of five wells from Fauqi field are studied to delineate petro-physical properties, and also the shale volume and porosities are calculated and corrected from the effect of shale in this work. It is found that the formation of water resistivity is equal to 0.0145 Ω . m, which is calculated from the SP method (through the relationship between SSP and R_w).

It is observed that the type of crude oil of the Asmari reservoir in Fauqia oil field is heavy. The Four units of oil reservoir within the Asmari Formation penetrated by the wells are delineated: A-B1-B2-C. The case study shows that the units (B1, B2) belongs to the formation of the upper Kirkuk, which is one of the main reservoir units producing oil in Asmari.

Key words: Petro-physical properties, Asmari reservoir, Fauqi, Southeastern Iraq.

تقييم الخواص الجيولوجية والبتروفيزيائية لمكمن الاسمري الجنوبي / حقل فكه جنوب شرق العراق

الخلاصة:

تم اختيار 5 أبار نفطية تعود لحقل فكه لتحديد الخواص البتروفيزيائية لمكمن الاسمري. تم حساب الحجم السجلي وكذلك حساب المسامية من مجس النيوترون، الكثافة والصوتي وكذلك تم تصحيحه من تأثير السجيل. المسامية المحسوبة هي المسامية الكلية والثانوية. تم حساب مقاومة مياه التكوين من خلال منحني الجهد الذاتي (العلاقة بين منحني الجهد الذاتي السكوني ومقاومة مياه التكوين) ووجد بانها تساوي 0.0145 اوم. متر. حسبت قيمة التشبع المائي بمعادلة Fertl & Hammack وكذلك حسب حجم النفط المتبقي والمتحرك وتبين بان حجم النفط المتبقي دائما اكبر من المتحرك وهذا يشير إلى إن النفط في المكمن هو من نوع النفط الثقيل وهذا ما عكسته قيم مجس المقاومة (الحقيقية والضحلة). تم تحديد أربع وحدات مكمنية تابعة لمكمن الأسمري التي توغلت بواسطة الآبار، وتمت متابعة استمراريتها عبر الآبار المدروسة وهي الوحدة (A-B1-B2-C). وقد بينت الدراسة بان الوحدة المكمنية (B and B1) التابعة لتكوين كركوك الأعلى هي من أحسن الوحدات المكمنية إنتاجا للنفط في مكمن الاسمري.

Introduction

The Tertiary sequence formed a large area from the surface and subsurface section that was considered very important because it contains the hydrocarbon accumulation. Asmari reservoir is a main part of Tertiary deposits (Oligocene- Lower Miocene) of southeast Iraq. In this period, tectonic complexes can effect on the sea level (transgressive and regressive). These perform to change large and rapid in facies. Reflect in contrast in petro-physics properties of this reservoir. The main focus of this work is to evaluate the petro-physical properties such as porosity and water saturation, the oil reservoir units and the performance of oil reservoir.

Location of study area

Fauqi oil field or Jabal Fauqi is located in Missan Province about 50 km from North-East of Amara city, southeast Iraq as shown in Figure 1, which is separated between two lines: Easting 737- 743 and Nothing (3554 – 3565). The geographical coordinates of this oil field are 32°02'N to 47°37' E. The north part of Fauqi Field shared with Iran, and the field extended part with Iranian land (see Figure 2).

Tectonic and structural setting

According to Buday and Jassim tectonic divisions, Fauqi oil field lies in foothill zone precisely in Hemrin – Makhul subzone [13]. While, it lies in suspended basins, foothill zone of the Quasiplat form Forland belt of the Arabian plate [22, 23, and 24] (Figure 3). The Seismic survey on the oil field showed that the geologic structure extends length 23 km and width 6 km [14]. Physically, the Fauqi field represents the anticline fold non cylindrical, which contains a number of culminations with north and south part of field is separated by depression [2], with NW- SE fold axis. The whole form of field slantwise to En-echelon fold is formed by tension force [19].



Fig. (1) Location map of study area

Stratigraphic Setting:

Asmari reservoir lies between two Formations: overlain Jaddala Formation (Eocene) and underlain Anhydrite layer (fifth member of Fatha Formation) (middle Miocene). Asmari was assumed to be Oligocene- lower Miocene based on its Stratigraphic position between underlying Eocene Jaddala Formation and the overlying Miocene Fatha (Final reports of the study wells) as presented in Figure (4)

There are nine formations of the Oligocene cycle, which belong to three sequence early (Palani, Sheikh Alas, Shurau) middle (Tarjil, Baba, Bajwan, Ibrahim) and late Oligocene age (Azkand and Anah) [13]. These Formations putted in one group called Kirkuk group. It was found in subsurface section in Kirkuk Province in north east of Iraq. These sequences have different environment from basin to reef and back reef facies. The Bellen's division modified from three cycle to two cycles: lower cycle including (Palani, Sheikh Alas, Shurau and Tarjil), whereas; an upper cycle including (Bajawan, Ibrahim and Anah , Azkand and Baba) formations.

Al Rawi and Al Din divided Asmari reservoir from above to bottom into some Formations as Jerebi/Euphrates, upper Kirkuk, Buzurgan member and lower and middle Kirkuk [4]. The thickness of reservoir in the study wells ranging between 385-438.5m. The boundaries of Asmari reservoir Formation have been determined based on the variation in the behavior of the different logs as follows: -

- 1. Gamma ray log:** gamma radiation log is gradually increased at the upper limits of the reservoir. The readings of gamma radiation log in the study wells are between 60-95 API. The highest reading recorded at Well FQ-7 reached API 95. While, the readings at the lower boundary of the reservoir were about 32 API at the rock formation, and 77 API at the well FQ-15, respectively..
- 2. Porosity logs:** it is represented by neutron, density and sonic log. It can be seen that there is a decrease in neutron log readings at the upper contact boundary of the Asmari reservoir, and the density log after recording readings up to 2.9 (anhydrite density) in the formation above the reservoir, the log readings reduced to 2.7 or higher in some wells, and this value represents the density of limestone or dolomitic limestone. For the sonic log, there was no significant change at the upper limit. Figure (5) illustrates the formations boundaries of Asmari reservoir depended on the radioactive loges (Gamma ray, neutron and density).

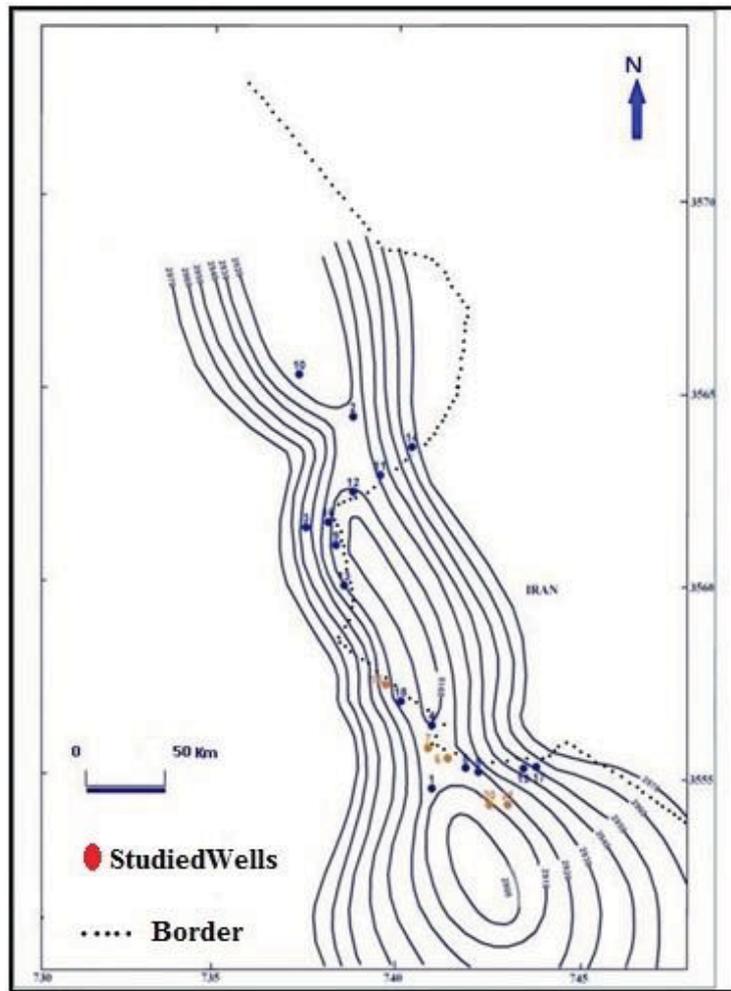


Fig. (2): The Structural map of the Fauqi oil field is taken to the top of the Jeribi / Euphrates Formations [18]

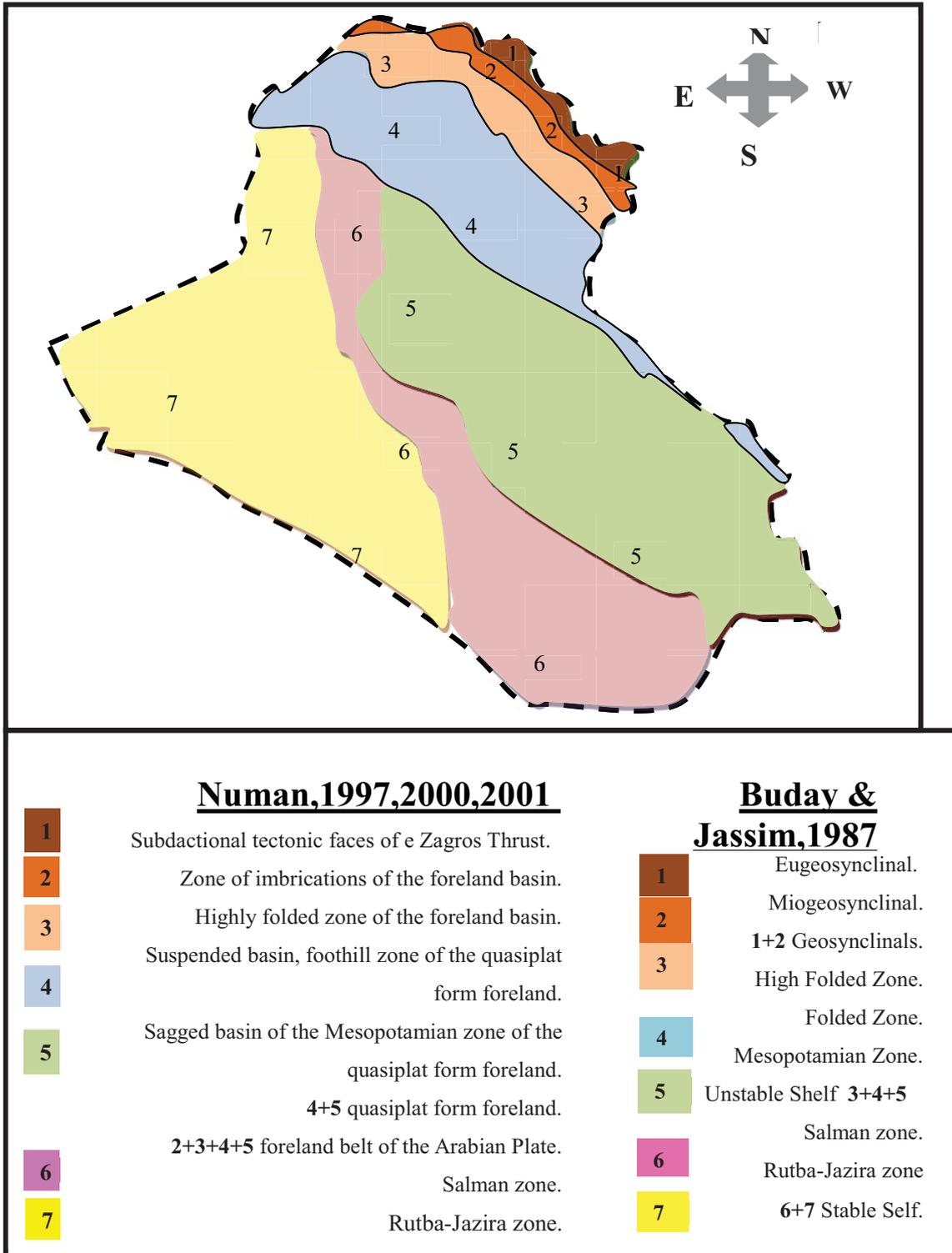


Fig. (3) A map showing Iraq's tectonic divisions [13) and Numan Divisions [22, 23, 24]

1- Jeribe / Euphratias:

It represents the upper part of the Asmari reservoir, which is lied conformably underlain Fatha Formation (middle Miocene) as the cover rocks of the reservoir. The Euphrates and Jeribe are the most important reservoirs in Iraq. They contain oil and gas in more than 30 geological formations, but they show less importance than north (Jambur field) and the south in both Fauqi and Abu Gharb having 18 API, with high sulfur content [20].

In this study, this formation insert under naming Jeribe /Euphratias due to the difficulty of these formations. Al- Daini pointed out that it was not possible to differentiate between the Euphrates and the Jeribe for in the subsurface sections [3].

The thickness of the Jeribe / Euphrates Formations in Fauqi field differs from the neighboring fields (Abu Gharb and Bazrgan), where the thickness is greater in Abu Gharb Field than in Bazrgan [17]. In this work, the thickness ranging from 24-31m. It is noted that the small thickness of the Jeribe /Euphratias formation because it is located far away from the sedimentation center during the sea regression [7].

2- Upper Kirkuk:

It is divided into five units: -

- Unite **B1**: - the upper part of it consists of pure sandstone, whilst, the bottom consists of alternate sandstone with shale with interfere limestone layer. The sandstone part has reservoir characteristic at some wells.
- Unit **B1-B2**: - consists of limestone with thin layer of shale.
- Unit **B2**:- consists of pure sandstone.
- Unite **B2-C**: - consists of limestone with layer of shale.

The Units B1 and B2 are considered very important units reservoir in field.

3-Buzrgan Member:

It is basically consisted of sandstone alternate layer from shale, Bazrgan change horizontally and gradually into limestone particularly in north and south of

field coexist shale with limestone, which is resulted a significant reduction in the permeability of the well of Fauqi field especially in the furthest north [18]. The sedimentation of this member reflects the existence of a source of classic material due to the tectonic activity in the source region, which provides a source of silicate and clay silica, indicating an increase in tectonic activity during the sedimentation of this member [5].

4- Middle and lower Kirkuk

Middle and lower Kirkuk consist of limestone, sandstone, shale, sandy shale and shaly sand. This formation considers not important from reservoir in spite of rise porosity but this formation appear high water saturation and low hydrocarbon saturation. Figure (6) shows the stat graphic correlation of Asmari formation for the study wells.

		EPOCH	FORMATION NAME	DEPTH (M.)	LITHO-LOGY	LITHOLOGICAL DESCRIPTION	
TERTIARY	PLIOCENE		Bakhtiari			Cl., gyp., w., some beds of Sand Grv., trace of CgL	
				2164		Sh., mod. hd., calc., pt. anhd. w. few bds of Sst., trace of anhd., and Lst., dol., S.	
	MIOCENE	Middle	Fatha	2973.5		Few beds of Anhd., xin., hd alt. of Anhd., & Sh. dol. sit, w. few Beds of Anhd. xin	
						alt. of Anhd., xin., Sh., sit., dol.	
		Early	Jeriba/ Euphrates	3004		Dol., w., nodules of Anhd.,	
			Upper Kirkuk	3199		alt. of Dol., Sst., calc. inpt., & Sh.	
	OLIGOCENE		Mid & L. Kirk	3361		alt. of Sh., hd sit. w Dol.	
	EOCENE		Jaddala	3522		Lst., chk., and Mrl., sft., w. cht.	
	PALEOCENE		Aaliu	3558		Mrl., w. incut. of Lst	
	CRETACEOUS	UPPER		Shranish	3590		Mrl. and Lst., org
			Hartha	3655		Lst., org. inpt.	
			Sadi	3773		Lst., and Mrl., gic	
			Tanuma	3793		Sh., and Mrl. S.	
			Khasib	3861		Lst., w., Mrl.	
			Mishrif	4222.5		Lst., comp. medusa, org., stylisapt, vug. Lst., Wackstone- Packstone	
			Rumaila	4285.5		Lst. Medusa-Wackstone, org., vug.	
			Ahmadi	4327		alt. of Mrl. and Lst., fct., w. cht.	
			Lower	Mauddud	4517		Bioclastic Lst at top, re xin., stylisapt. por., vug. Lst.
				Nahr Umr	4683		Lst., Medusa, Medusa-Wackstone, Sh., and Sst., at the Base of ...

Fig. (4) Stratigraphic Column of the FQ-1 well [28]

Data Collection and Methodology:

The data used for Asmari reservoir in the present study is obtained from Basrah oil company (BOC). Twenty-four oil wells have been drilling so far as. All of the wells do not have sufficient number of logs required for the petro-physics evaluation except 5 wells FQ6, FQ7, FQ15, FQ20, and FQ21. The petro-physics data of all these wells are available. Therefore, they have been chosen in this study. Wire line logs obtained from these wells are resistivity, density, neutron porosity, sonic porosity, and gamma Ray log, as well as spontaneous potential.

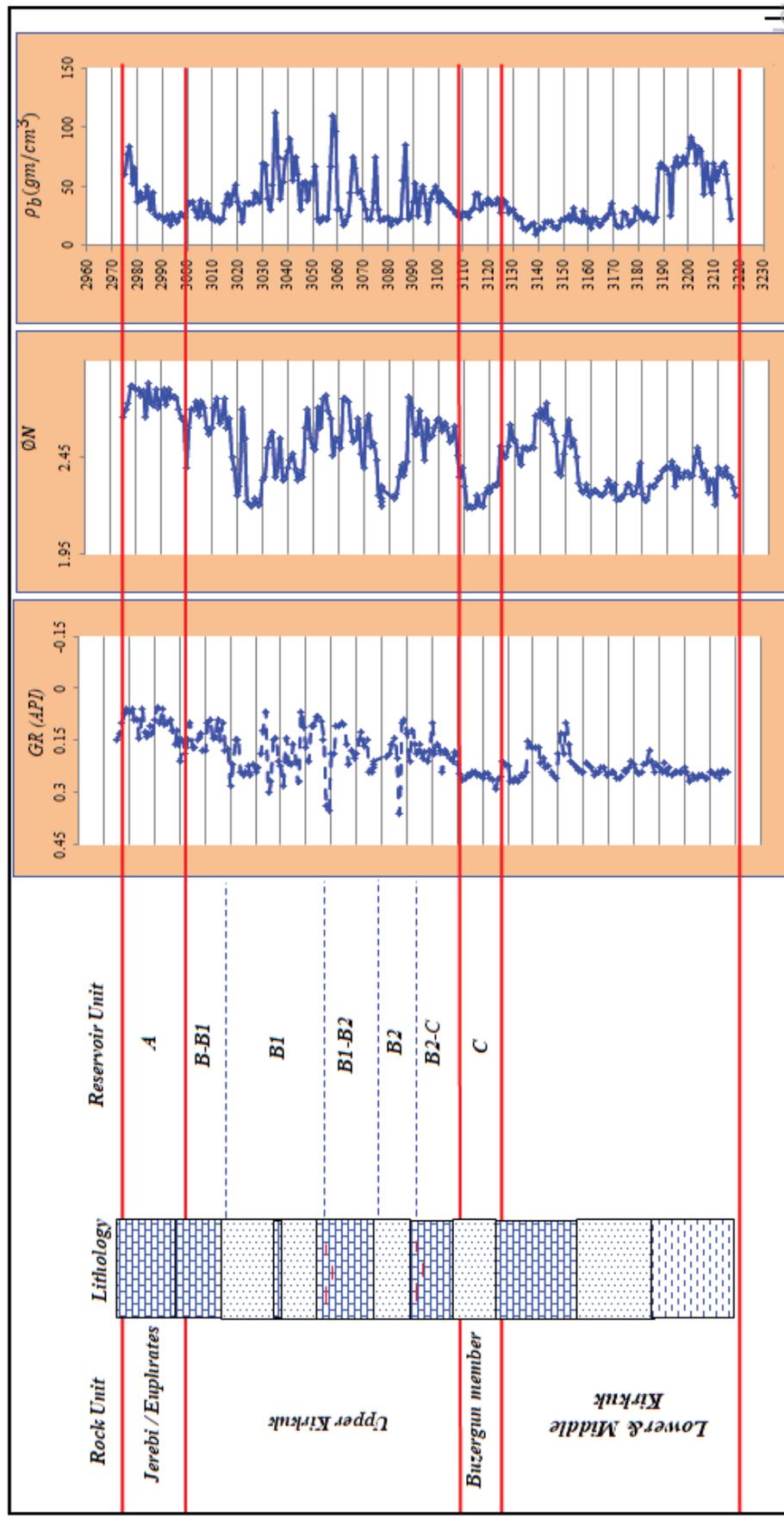


Fig. (5) lithologic of Asmari reservoir including gamma ray, neutron and density

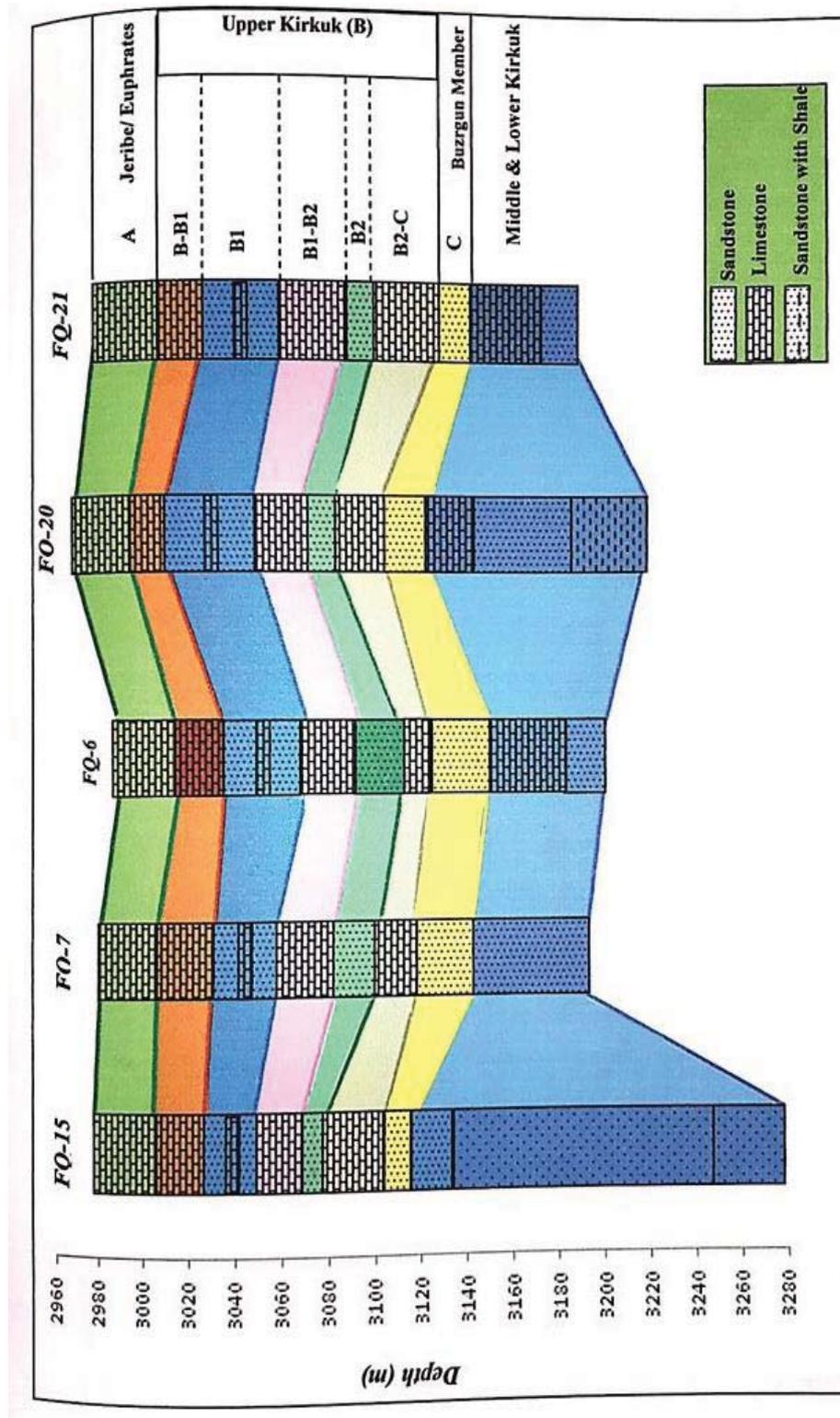


Fig. (6) Stratigraphic correlation of Asmari Formation for the study Wells.

The Petro-physical Parameter Calculation

The reservoir estimation generally needs three properties. The first one is the ability of the rock to contain liquids, while, the second one is the relative amount of fluids and the ability of liquids to pass through the rock to the well hole [15]. These properties are intended porosity, water saturation and permeability that are addressed as follows:-

Porosity (ϕ): It is an important petro-physical property in the reservoir rocks, which the oil or gas reserves is stored within the reservoirs. Porosity is the ratio between the size of the space in the rock and the total volume [11].

Water saturation (S_w): it is representing the ratio between the volumes of water-filled voids to the total volume of rock spores as an important factor in reservoir assessment [26] can determine hydrocarbon saturation. The volume of non-water-filled spaces (the hydrocarbon saturation) can be determined by using the data of water saturation [21].

The presence of shale in a reservoir gives false values of water and porosity are derived from logs. These pseudo-values are not limited to sandstone but they are also found in limestone and dolomite. Hilchi (1987) suggested that in order for the shale to significantly affect the water saturation value derived from the log, the quantity of the shale should be higher than 10% to 50%, depending on the Fertl & Hammack equation [9].

Methodology:

- The data of well logs in the Asmari reservoir are taken for 5 wells are FQ6, FQ7, FQ15, FQ20 and FQ21 according the specific methodology used in this work as shown below:
 - 1- Study the petro-physics properties for these wells depending on resistivity, porosity, gamma ray log and spontaneous potential.

2- Division the reservoir units and determine its reservoir performance. The basic analysis procedure used involves the following steps; each of which is describe in the following section.

- Manual cutting was used for the wells log, the cutting process included the calculation of R_t , GR , SP , Δt , ϕ_N , ρ_b , which were taken from the well logs, also the wells of the study and for each meter and then used Excel software for the purpose of calculating mathematical equations.
- Zoning and Point Selection: Zoning is of vital importance in the interpretation of well logs. The logs were split into potential reservoir zones and non-reservoir zones. Hydrocarbon bearing intervals were identified and differentiated based largely on the readings from the shallow and deep reading resistivity tools.
- Computing the Shale Volume from the Gamma Ray. This was derived from the gamma ray log first by determining the gamma ray index:

$$I GR = (GR_{log} - GR_{min}) / (GR_{max} - GR_{min})$$

Where: - $I GR$ = gamma ray index.

GR_{log} = gamma ray reading of the formation.

GR_{min} = minimum gamma ray reading (sand baseline);

GR_{max} = maximum gamma ray reading (shale baseline).

For the purpose of this research work, Larionov's volume of shale formula for tertiary rocks was used:

$$V_{sh} = 0.083 (2^{3.7 * IGR} - 1)$$

V_{sh} : volume of shale and $I GR$: gamma ray index.

- **Computing Total Porosity and Shale-Corrected (Effective) Porosity.** Total and effective porosity were estimated from the density, neutron and sonic logs using Archie's equation.

- Computing the neutron porosity corrected from shale :-

$$\Phi_{N\text{ corr}} = \Phi_N - [V_{sh} * \Phi_{Nsh}]$$

$\Phi_{N\text{ corr}}$ = neutron porosity corrected from shale.

Φ_N = Porosity derived from the neutron log.

Φ_{Nsh} = neutron porosity for adjacent shale.

- Computing the density porosity corrected from shale ($\phi_{D\text{corr}}$). The density porosity of the Asmari reservoir was calculated using the Wiley equation [17]:

$$\Phi_{D\text{corr}} = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} - V_{sh} \left[\frac{\rho_{ma} - \rho_{sh}}{\rho_{ma} - \rho_f} \right]$$

$\Phi_{D\text{corr}}$ = Porosity derived from the density log corrected from the effect of the shale (gm / cm³).

ρ_{ma} = Density of matrix (2.65 sand-2.71 limestone).

ρ_b = Formation density (gm / cm³).

ρ_f = Density of fluid (1.1 fresh water-1salt water).

ρ_{sh} = Density of adjacent shale.

- Computing the sonic porosity corrected from shale: - In the case of shale, the time of moving the wave (Δt_{log}) within these reservoirs is longer than the time of the transfer of the wave within the pure reservoirs that have the same amount of porosity[1].

Therefore, porosity with the presence of shale will become: -

$$\Phi_{\text{scorr}} = \frac{\Delta t_{\text{log}} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}} - \frac{\Delta t_{sh} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}$$

Φ_{scorr} = Porosity calculated from sonic log corrected from effect of the shale.

Δt_{log} = Transition Time interval through Formation($\mu\text{sec}/\text{ft}$).

Δt_{ma} = Transition Time interval through matrix (55.5 sand- 47.5 limestone) ($\mu\text{sec}/\text{ft}$).

Δt_f = Transition Time interval through fluid (189 fresh mud-185 salt mud) ($\mu\text{sec}/\text{ft}$).

Δt_{sh} = Transition Time interval for adjacent shale($\mu\text{sec}/\text{ft}$).

Calculate total porosity from equation: -

$$\Phi_{N.D} = \frac{(\Phi_n)^2 + (\Phi_d)^2}{2}$$

Calculate secondary porosity from equation:-

$$SPI = \Phi_{N.D} - \Phi_s$$

SPI = Secondary porosity index.

$\Phi_{N.D}$ = Total porosity.

Φ_s = Sonic porosity.

• **Computing the water resistivity R_w** ; this value is calculated by several ways, but in many cases the best value is easily obtained from the spontaneous potential curve. This value is recorded in clean formation (No-shale) and requires that the formation be clean, saturated, permeable and water-bearing [27]. The calculation of the R_w method in the SP method depends on the relationship between SSP and R_w :-

$$SSP = -K \log \frac{R_{mf}}{R_w}$$

For the purpose of calculation of the R_w from SP log method, SP must specify the following:

- ❖ Base Shale line.
- ❖ SSP, which represents the maximum deviation of the SP curve in a clean, thick and water bearing layer.
- ❖ Determine a temperature in the SSP area.

The formation temperature is determined by the following equation: -

$$T_f = G.G \times d + T_s$$

D:- Depth to calculate its temperature(m).

G.G = Geothermal gradient.

$$G = \frac{BHT - T_s}{Dt}$$

BHT= Bottom hole temperature(c°).

Dt:- Total depth(m).

After finding these parameters, the mathematical method is used to calculate the R_w . that developed by Bateman & Konen (1997) [17]. The R_w value of well **FQ-15** was calculated in this way and found to be equal to **0.0145 Ω. m**.

• **Computing the Water Saturation.** The presence of shale in a reservoir gives false values of water and porosity are derived from logs. These False values are not restricted to sandstone but are also found in limestone and dolomite. Hilchi (1987) suggested that in order for the shale to significantly affect the water saturation value derived from the log, the quantity of shale should be higher than 10% to 50%. Therefore, the Fertl & Hammack [9] equation was used in to calculate the water saturation of the presence of shale and as follows:

$$S_w = \sqrt{\frac{F * R_w}{R_t} - \frac{V_{sh} * R_w}{(0.4 * \Phi * R_{sh})}}$$

F= Formation factor. Calculate from this equation: -

$$F = a / \phi^m$$

R_{sh} = Deep resistivity adjacent shale.

Water saturation is an important factor in reservoir assessment. Using water saturation data, we can determine hydrocarbon saturation (S_h) which representing the volume of non-filled spaces) [21]. The hydrocarbon saturation (S_h) is determined by the following equation: -

$$S_h = 1 - S_w$$

- **Computing moveable oil saturation (S_{mo}) and residual oil saturation (S_{ro}):-** they can be calculated from the following equation [27] :-

$$S_{mo} = S_{xo} - S_h$$

$$S_{ro} = 1 - S_{xo}$$

Reservoir properties determine and reservoir divided into four reservoirs units: -

1. **Unit A:** It represents the upper part of reservoir which is consisted of two Formations (Jeribe / Euphrates Formations). The main lithology of these Formations is limestone and dolomitic limestone and is characterized by rising the radioactive ratio especially upper part of this unit. It characterized by low porosity, but some parts can consider it within reservoir boundaries. Table (1) shows the value of petro-physical parameter of study Wells for unit A.

Table (1) the reservoir properties results of Unit A1

<i>Well No.</i>	<i>Average</i>					
	<i>V_{sh} %</i>	<i>Ø_{N.D} %</i>	<i>SPI %</i>	<i>S_w %</i>	<i>S_{mo} %</i>	<i>S_{ro} %</i>
FQ-6	19.85	9.73	5.41	36.77	40.97	22.24
FQ-7	16.41	6.02	2.07	57.12	18.67	28.96
FQ-15	18.98	9.21	4.15	53.87	3.87	33.32
FQ-20	14.86	10.61	5.73	42.43	29.81	27.75
FQ-21	17.12	8.06	1.33	54.79	20.40	24.79

1. **UnitB1:** - It represents first unit of Upper Kirkuk Formation, which has good reservoir properties in studied wells. Table (2) displays the value of petro-physical parameter of study Wells for unit B1.

Table (2) the reservoir properties results of Unit B1

<i>Well No.</i>	<i>Average</i>					
	<i>V_{sh}%</i>	<i>Ø_{N.D}%</i>	<i>SPI%</i>	<i>S_w%</i>	<i>S_{mo}%</i>	<i>S_{ro}%</i>
FQ-6	5.27	27.72	9.58	20.39	30.23	49.36
FQ-7	2.66	23.36	19.66	16.15	6.24	77.60
FQ-15	2.87	22.73	9.52	20.12	16.52	63.35
FQ-20	5.78	27.12	2.78	19.19	29.3	51.50
FQ-21	5.86	26	11.39	21.88	24.66	53.44

2. **Unit B2**:- it is represented second units of Upper Kirkuk Formation, having better reservoir properties. Table (3) show the value of petro-Physical parameters of study Wells for unit B2.

Table (3) the reservoir properties results unit B2

<i>Well No.</i>	<i>Average</i>					
	<i>V_{sh}%</i>	<i>Ø_{N.D}%</i>	<i>SPI%</i>	<i>S_w%</i>	<i>S_{mo}%</i>	<i>S_{ro}%</i>
FQ-6	2.08	33.20	11.78	12.13	33.40	54.46
FQ-7	2.34	34.89	13.05	10.74	8.13	81.12
FQ-15	1.41	27.81	2.46	15.42	17.14	67.43
FQ-20	1.47	25.89	1.37	11.73	21.97	66.29
FQ-21	2.07	25.61	4.84	20.69	24.24	55.05

3. **Unit C**:- it represents of Buzurgan member. Table (4) shows the value of petro-physical parameter of study Wells for unit C.

Table (4) the reservoir properties results unit C

<i>Well No</i>	<i>Average</i>					
	<i>V_{sh}%</i>	<i>Ø_{N.D}%</i>	<i>SPI%</i>	<i>S_w%</i>	<i>S_{mo}%</i>	<i>S_{ro}%</i>
FQ-6	5.47	31.8	8.12	23.39	33.41	43.18
FQ-7	3.41	38.54	8.41	9.73	5.19	85.07
FQ-15	12	25.03	6.64	69.38	16	14.61
FQ-20	4.42	29.34	0.55	33.4	35.08	31.51
FQ-21	5.16	26.97	8	67.74	30.45	1.8

Conclusion and Results:

- 1- The result showed that the Asmari reservoir had a wide and rapid facial variation. It consisted of a sequence of sand, carbonate and clay rocks reflecting a distinct tectonic activity during the period of Oligocene-Miocene, which are shown by the results of the logs interpretation where it was found that the high proportion of shale (V_{sh}) in the reservoir units.
- 2- The result showed that the units (B1, B2) belonging to the formation of the upper Kirkuk is one of the main reservoir units producing oil in the reservoir of Asmari as compared to the unit (C).
- 3- The results of porosity logs analysis (sonic, neutron and density logs) showed that the predominant porosity are primary porosity and the secondary porosity formed very low proportion and nonexistent.
- 4- The study showed that the residual oil in the reservoir units is larger than portable. This indicates that the oil of the Asmari reservoir in Fauqia field is heavy type, this also show from the behavior of the resistivity well log (R_t and R_{xo} behavior).

References:

1. Avdisian, A. M. 1988. *Well log analysis for the evaluation of oil and gas reservoirs*. University of Mosul. administration of Dar Al Kutub for printing and publishing.685p
2. Abdul Rahman, S. M. 1978. Preliminary Geological Evaluation of Jabel Fauqa Structure, unpublished Report, I.N.O.C/S.O.C., 14P.
3. Al-Daini, N. K. 1979. *A study of the topographic and geochemical characteristics of selected sections of the Euphrates and Jeribe formation*, unpublished M.sc thesis, collage of Science, Baghdad University, Iraq 125 p
4. Al-Hashemi, A. K. 2002. *Numerical Modeling in the Asmari reservoir - Abu Gharb field*, unpublished M.sc thesis, Collage of Science, Basra University, 89 p.
5. Al-Rubaie, N. M. 1992. *A Subsurface Sedimentary Study of the Oligocene Maysan in Southern Iraq*, unpublished Ph.D. thesis, Collage of Science, Baghdad University, 108 p.
6. Al-Shammari, S. O. 1992. Preliminary geological study relative to the jeribi / Euphrates unit of the Asmari formation between the fields of Abu Gharb Bagargan and Fauqi field, unpublished report. South Oil Company. P.14.
7. Baker Hughes, 1999. *Petroleum Geology, Training and Development*, PP.8-32.
8. Baker Hughes, 2002. *Introduction of Wireline Log Analysis*, Inc. 312 P.
9. Basseoni, Z. 1994. *Theory, Measurement, and Interpretation of Well Logs*. Vol. 4. Richardson. USA. Society of Petroleum Engineers .372P.
10. Bellen, V. 1959. *Lexique Stratigraphique International*, Asie, Fasc. 10a, 322P.
11. Bowen, D.G. 2003. *Formation Evaluation and Petrophysics*, Jakarta, Indonesia. 194P.
12. Buday, T. 1980. *The Regional Geology of Iraq*, VI, Stratigraphy and paleogeography, Kassab, I., Jassim, S., (edt) SOM, Bagdad, 445P.
13. Buday, T. and Jassim, S.Z. 1987. *The Regional Geology of Iraq: Tectonism, Magnetism, and Metamorphism*, S.E Geol. Surv. And Min. Invest. (Geosurv.), Baghdad, Iraq, 352P.
14. Butros, A. S. 2002. Cracking reservoir rocks (Jeribe Formation) in selected wells of Fauqi field, Exploration Oil Company, 26 p.

15. Dresser Atlass, 1975. Log Interpretation Fundamentals, Houston, Texas, Dresser Industries, Inc., PP.13-10.
16. ELF, 1975. Final well Report of Fauqi No. 1, 26P.
17. George, A. and Charles, G.1982. *Basic well log analysis for geologist*. Tulsa, Oklahoma USA. The American Association of Petroleum Geologist.
18. Ghannawi, M. A. 1980. Report on the Formation of Bazurgan in Fauqi field, unpublished report, Iraqi National Oil Company, 5p.
19. Henry, J. and Perrin, G. 1980. Synthesis of the results from Structural and Fracturation Analyses Abu Guirab and Fauqui Fields. Unpublished report, 21P.
20. Jassim, S.Z. and Goff J.C. 2006. *Geology of Iraq*, Dolin, Prague, Czech Republic, 241P.
21. Khuwika, M. H. 1991. *Explanations of the well logging*, Ministry of Higher Education and Scientific Research, University of Baghdad, Mosul Press, 432 p.
22. Numan, N.M. 1997. A plate tectonic scenario for the phanerozoic succession in Iraq, *Jour. Geol. Soc. Iraq*, Vol. 30, No.2, PP. 85-110.
23. Numan· N.M. 2000. Major Cretaceous Tectonic Events in Iraq. *Raf. Jour. Sci.* Vol. 11, No.3, PP. 32-52.
24. Numan, N.M. 2001. Discussion on; dextral transportation in Late Cretaceous continental collision, Sanandaj-Sirjan-Zone, Western Iran, *Jour. Struc. Geol.*, Vol.23, PP. 2033-2034.
25. Petrophysical reports of wells under study FQ-6, FQ-7, FQ-15, FQ-20, FQ-21, SOC, laboratory section.
26. Schlumberger, 1972. The Essentials of Log Interpretation Practice, Services Techniques Schlumberger, France, 58 P.
27. Schlumberger, 1989. Log Interpretation Principles/Application, Schlumberger Wireline and Testing, 13-19 PP.
28. South Oil Company, Final Reports of Wells, FQ-1, FQ-6, FQ-7, FQ-15, FQ-20, FQ-21, Oil Fields division, Department of Geology.
29. Well logging for study wells FQ-6, FQ-7, FQ-15, FQ-20, FQ-21, south oil company, oil field division.