Journal of Petroleum Research and Studies

Open Access
Vol. 14, No. 1, March, 2024, pp. 77-87

P- ISSN: 2220-5381
E- ISSN: 2710-1096

DOI: http://doi.org/10.52716/jprs.v14i1.730

Evaluation of Reservoir Quality of the Mishrif Formation in Faihaa Oil Field

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Received 27/12/2022, Revised 20/02/2023, Accepted 28/02/2023, Published 20/03/2024

Abstract

Two wells are selected in the Faihaa field (well-1 and well-2) to study the petrophysical properties and evaluate the reservoir units of the Mishrif Formation. The cross plots of density-neutron and M-N show that the Mishrif Formation consisting mainly of limestone with calcite as the main mineral with the presence of dolomite in very few percentages and points within the range of secondary porosity and gas. Petrophysical properties were determined and plotted as computer processing interpretation (CPI) such as shale volume, porosity, water saturation, and hydrocarbon saturation by using Techlog software and showing that well-2 has a good petrophysical property than well-1. The main reservoir units in both wells are MA, MB, MC, MD and ME. The MD unit considered as the best reservoir unit with good of reservoir quality compared to the rest of the units due to good porosity values and low values of shale volume and water saturation. each of the MB and MC units has a good reservoir quality in well-2 and the lowest reservoir quality in well-1, while both the MA and ME units consider the weakest units that have poor reservoir quality, especially the MA unit which has a few thicknesses with high shale volume values.

Keywords: Well log, Petrophysical properties, Mishrif Formation, Faihaa Field, Techlog.

تقييم الجودة المكمنية لتكوين المشرف في حقل الفيحاء النفطي

الخلاصة:

تم اختيار بئرين في حقل الفيحاء بئر 1 وبئر 2 لدراسة الخواص البتروفيزيائية وتقييم الوحدات المكمنية لتكوين المشرف. أظهرت المخططات المتقاطعة للكثافة النيوترونية وM-N أن تكوين المشرف يتكون بشكل رئيسي من الحجر الجيري مع الكالسيت كمعدن رئيسي مع وجود الدولومايت بنسب ونقاط قليلة جداً ضمن نطاق المسامية الثانوية والغاز. تم تحديد الخواص البتروفيزيائية ورسمها باستخدام تفسير معالجة الحاسوب (CPI) مثل حجم الصخر النفطي والمسامية والتشبع المائي والتشبع الهيدروكاربوني باستخدام برنامج Techlog، وإظهر أن بئر 2 لديه خصائص بتروفيزيائية جيدة اكثر من بئر 1. الوحدات الرئيسية المكمنية في كلا البئرين هي MA، MB، MC، MD وME. وتعتبر وحدة MD أفضل وحدة مكمنية ذات جودة مكمنية جيدة مقارنة ببقية الوحدات بسبب قيم المسامية الجيدة وانخفاض قيم حجم الصخر النفطي والتشبع المائي. تتمتع كل وحدة من وحدات MB وMC بجودة خزان جيدة في بئر 2 وأقل جودة خزان في بئر 1، بينما تعتبر كل من وحدتي MA وME أضعف الوحدات وذات جودة مكمنية ضعيفة، خاصة وحدة MA التي لديها سمك قليل مع قيم عالية من حجم الصخر النفطي.

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1. Introduction:

The Mishrif Formation (Cenomanian-Early Turonian) is one of the most important carbonate oil reserves in the Middle East. Mishrif Formation deposited within the AP8 mega sequence (late Tithonian-early Turonian) as part of the Wasia group [1]. The Mishrif Formation in Iraq is composed of organic detrital limestones with beds of algal, rudist, coral-reef, shallow open-marine and lagoonal facies. The major hydrocarbon quantities are noticed in the rudist-bearing facies that form along the shelf margins[2]. The Mushrif formation is located between the Rumaila and Al-Khasib formations, where it is bounded from the top by a surface that is unconformity with the Al-Khasib formation, and from the bottom it is bounded by the Rumaila Formation with a conformity surface [1].This study selects the Mishrif Formation in the Faihaa oil field to calculate the reservoir petrophysical parameters in order to evaluate the reservoir quality for Mishrif Formation.

Recently, researchers have been very interested in the Faihaa oil field which is considered a new field such as Maryam Al-Hassani and Salam Al-Dulaimi (2020) studied thin sections by using the polarizing microscope examination to determine microfossils and biozone [3], while Hiba et al. (2021) used the structural contour maps and well logs to analysis the geometrical of Faihaa field structure in southern Iraq [4]. Also, Aymen et al. (2022) used a geological model drilling data of the Faihaa Oil field to determine the structural geological attitudes (interlimb angle, hinge line, and axial surface) by using the geometric and genetic analyses results of Faihaa Oilfield [5].

2. Study Area

Faihaa field is an anticline fold located in the southeastern part of the Mesopotamian basin within the Zubair subzone in the north-east of Block 9 north of Basra in southern Iraq, about 20 kilometers north of Basrah city, adjacent and parallel to Iraqi and Iranian borders. Faihaa field borders with Sindbad field borders the south and Majnon field in the north, Iranian Hosseinieh field borders the east and Nahr Omar field borders the west [6] as shown in the Figure (1). Faihaa field was discovered in 2013 by Kuwait energy company and had been drilled the first well in 2014. Two wells selected in this study well-1 and well-2

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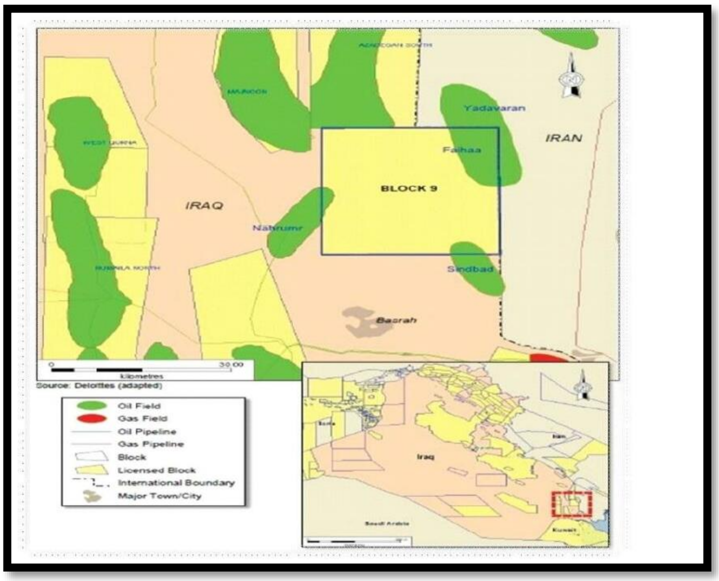

Fig. (1): Location map of study area (Fiahaa Field).

3. Materials and methods

1. Calculating petrophysics properties by using data from the available open hole logs for well-1&well-2 such as (gamma-ray, density, sonic, caliper, neutron, and resistivity logs).
2. Techlog software to show the petrophysical results and plots.
3. Excel program to calculate petrophysics properties.

4. Combination Cross plot

One technique for determining lithology, mineralogy, and rock cement based on well-log data is the use of cross-section profiles and consider very important in the depths where there are no lithology samples from the core. The density, neutron, and sonic logs are impacted by a variety of factors, including lithology, clay content, and the presence of gas. This study determines the lithology from the Density-Neutron cross plot by density and neutron porosity logs using Techlog software as shown in fig 2&3, while the mineralogy determines using the M-N cross plot as shown in fig 4&5, M and N are defined by the following formulae [7]:

$$M = \left(\frac{\Delta tf - \Delta tlog}{\rho b - \rho f}\right) * 0.01 \qquad (1)$$

$$N = \left(\frac{\phi_{NF} - \phi_{N}}{\rho b - \rho f}\right) \qquad (2)$$

Δt_f: interval transit time in fluid (189 (us/ft) for fresh water 185 (m/s) for salt mud).

Δt_{log}: interval transit time (the log reading).

ρ_b: formation bulk density (the log reading). $\O_{NF}$: neutron porosity for fluid =1.0

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ρ_f : fluid density (1 (g/cm^3) for fresh water or 1.1 (g/cm^3) for salt mud).

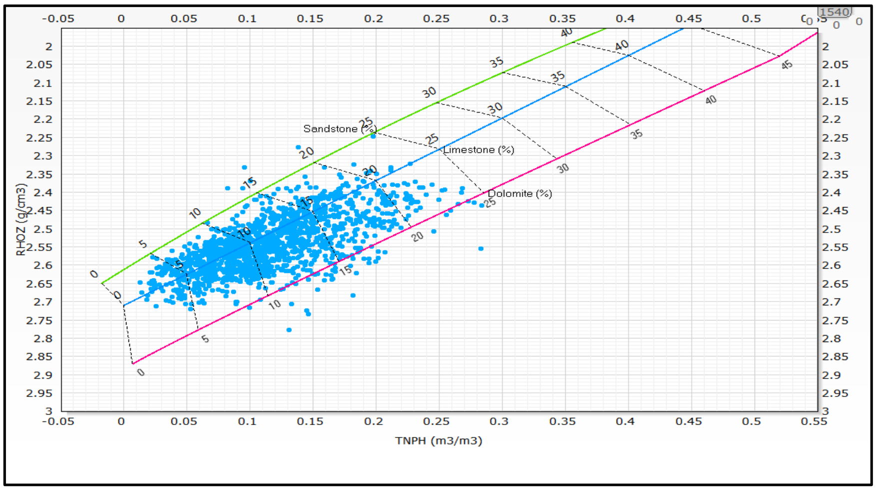

Fig. (2): Neutron–density lithology plot for well-1

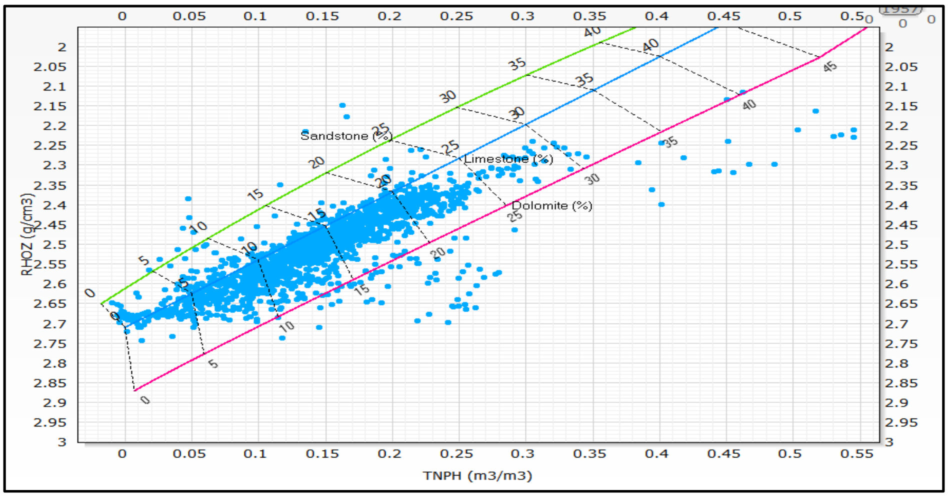

Fig. (3): Neutron–density lithology plot for well-2

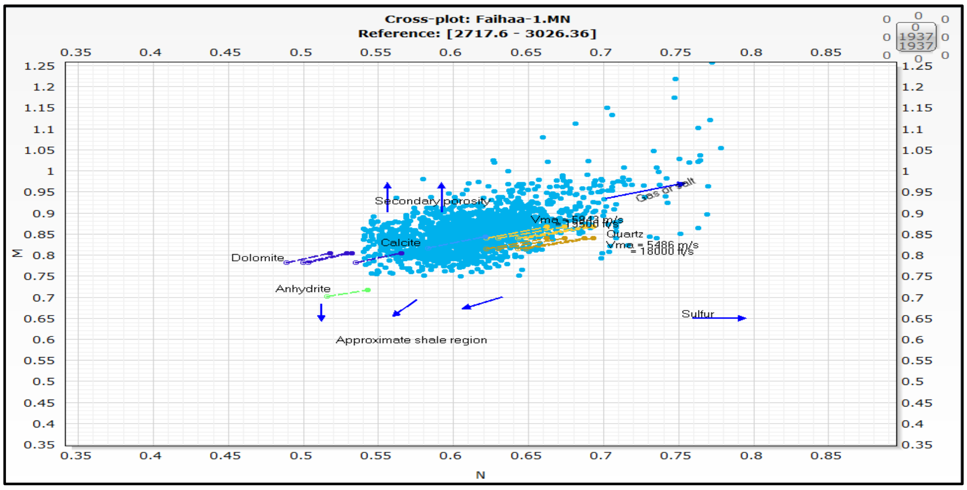

Fig. (4): M-N cross plot for well-1

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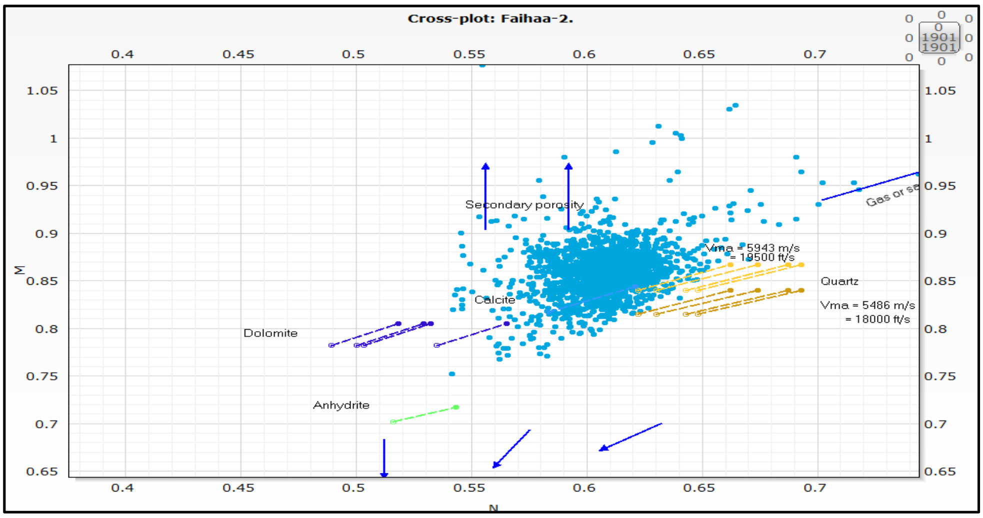

Fig. (5): M-N cross plot for well-2

5. Calculating Petrophysical Properties

Reservoir properties of Mishrif Formation (shale volume, corrected porosity, and corrected water saturation) shows in Table (1) and Figures 6&7 which were calculated by the equations below:

5.1 Shale volume (V_{sh})

Vsh calcauted from gamma ray (GR Log) by using the equation of Schlumberger (1974) [8].

$$IGR = (GR_{log} - GR_{min}) / (GR_{max} - GR_{min}) \qquad (3)$$

Where: GR_{log} is gamma ray reading of formation, GR_{min} is the minimum gamma ray reading (clean carbonate), and GR_{max} is maximum gamma ray reading (shale).

Volume of shale determined by using the formula of Dresser Atlas [9] for older rocks as follows:

$$V_{sh} = 0.33 * [2 (2*IGR) - 1] \qquad (4)$$

5.2 Porosity

The porosity of Mishrif Formation was determined through a combination of Neutron – Density porosities. Neutron porosity corrected for shale effect by using the equation of Tiab & Donaldson (2015) [10].

$$Ø_{Ncorr} = ØN - (V_{sh} * Ø_{Nsh}) \qquad (5)$$

Where: $Ø_{Ncorr}$. is the corrected Shale-corrected neutron porosity, $Ø_N$ is the Neutron porosity reading direct from neutron log, and $Ø_{Nsh}$ is Neutron porosity for shale.

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the porosity of density log calucted using Wyllie et al. (1958) equation [11] when the matrix density (ρ_{ma}) and the density of the saturating fluids (ρ_f) are known as below:

$$Ø_D = (\rho_{ma} - \rho_b) / (\rho_{ma} - \rho_f) \qquad (6)$$

Where: ρma is the density of matrix (2.71 gm/cm^3 for limestone, ρ_f = density of fluid 1.1 gm/ cm3 for saline water).

equation below for porosity density which corrected from the effect of the shale for intervals with a shale ratio of more than 10%, using equation (Dresser Atlas, 1979) [9].

$$Ø_{Dcorr} = Ø_D - (V_{sh} * Ø_{Dsh}) \qquad (7)$$

Where: $Ø_{Dcorr}$. is the corrected porosity derived from the density log for dirty rocks, and $Ø_{Dsh}$ is density porosity for shale. Porosity from Neutron-Density log will be calculated by using the following equation:

$$ØN.D = (Ø_N + Ø_D) / 2 \qquad (8)$$

Corrected Neutron – Density porosity for shale effect can be calculated by using the equation of Schlumberger (1998) [7]

$$Ø_{N.D\_corr} = ((Ø_{N\_corr}) + (Ø_{D\_corr}))/2 \qquad (9)$$

5.3 Water and hydrocarbon saturation

Water saturation for the uninvaded zone is calculated according to Archie (1942) [12]:

$$Sw = \{(a * Rw) / (Rt *)\}\ 1/n \qquad (10)$$

In depth intervals when shale volume (Vsh) more than 10 the water saturation calculated by using the Simandoux equation, 1963 [13]:

$$S_{w=} [0.4*R_t/Ø^2{}_{corr} * \sqrt{[\{(V_{sh}/R_{sh})^2 + (5 * Ø^2/R_w * R_t)\}]} - (V_{sh}/R_{sh})] \qquad (11)$$

Where: Sw is water saturation, Ø is Neutron – Density porosity, Rt is true formation resistivity, Øcorr is corrected Neutron – Density porosity, Rsh is Resistivity of shale, Rt is 0.018 was obtained from the Kuwait energy company report.

Then the hydrocarbon saturation can be calculated by using the following equation:

Sh = 1 – Sw

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Table (1): Average of petrophysical properties of well-1 and well-2

Mishrif units	well-1				well-2			
	thickness	PHIE	Vsh	Sw	thickness	PHIE	Vsh	Sw
Mishrif/MA	16.5	0.05	0.15	0.98	23	0.04	0.14	0.98
MB	77	0.05	0.1	0.68	86	0.09	0.05	0.56
MC	51	0.06	0.16	0.74	50	0.15	0.02	0.14
MD	61	0.13	0.09	0.4	64	0.15	0.03	0.2
ME	101	0.06	0.13	0.74	75	0.11	0.09	0.7

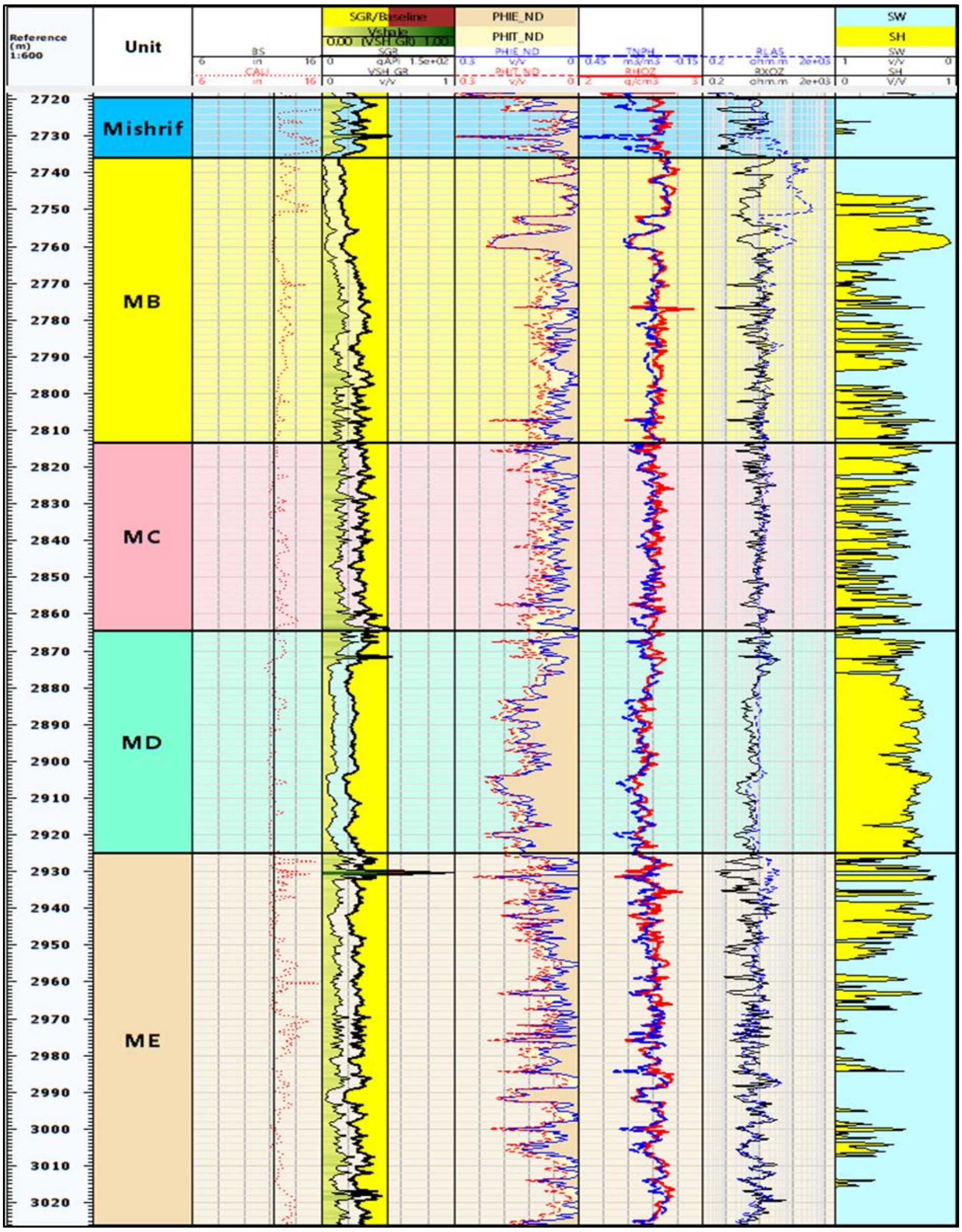

Fig. (6): Petrophysical properties (CPI) of well-1

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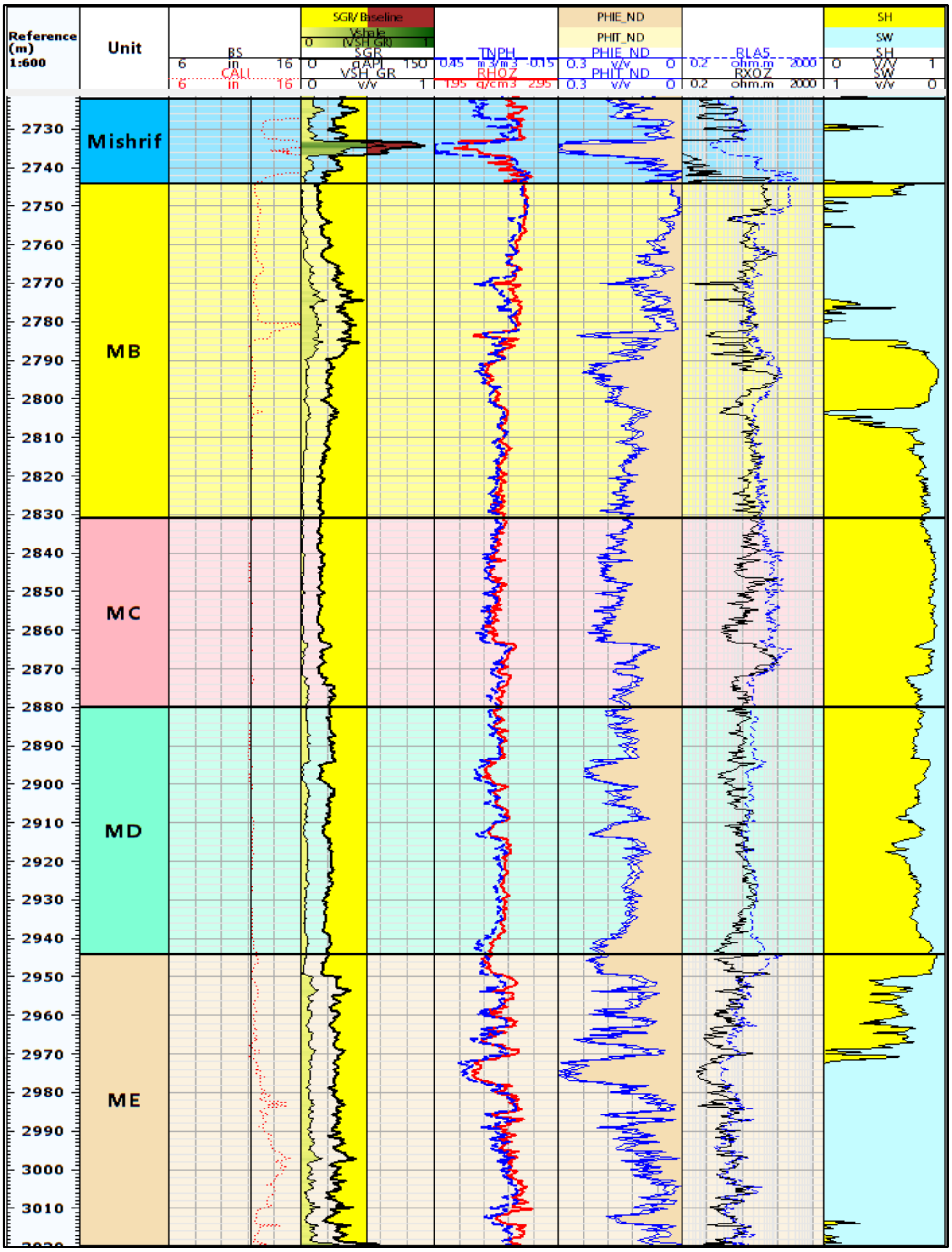

Fig. (7): Petrophysical properties (CPI) of well-2

6. Results and Discussions

Mishrif Formation was divided into five units (Mishrif or MA, MB, MC, MD, ME) respectively by Kuwait energy Company. Each one of these units were characterized by different petrophysical properties and as Table (1) and Figures (6) & (7).

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6.1 Mishrif or MA unit:

MA unit in Faihaa field compared with the rest of the fields in southern Iraq has very few thick may be back for deposited in a short and fast period or was exposed to erosion and can be considered as the cap rock for MB unit because it has a high rate from shale volume as 15% in well-1 and well-2 with the thickness about 16.5m in well-1 and 23m in well-2.

6.2 MB unit:

The thickness MB is 77 m in well-1 and 86m in well-2. The MB unit is characterized with poor effective porosity as average 5% in well-1and 9% in well-2 and high shale volume average near to 10% in well-1, and from Figures (6) & (7) can notice the middle part of the MB unit in well-1 has a good oil show while in well-2 the lower part of the MB unit has a good oil show.

6.3 MC unit:

The thickness of this unit is 51m in well-1 and 50m in well-2, MC unit in well-1is characterized by high shale volume around 0.15 and poor effective porosity with an average reach of 6%, so it has a weak oil show, while in well-2 have good reservoir equality, that has a good average of effective porosity reach to 15% with a low average of shale volume reach to 0.02 that makes the MC as a good reservoir unit in well-2 with good oil show.

6.4 MD unit:

The thickness for the MD unit is 61m in well-1and 64m in well-2. The average of petrophysical properties and SPI figures shows MD unit is the best reservoir unit in each well because it has good petrophysical properties with low values of shale volume, especially in well-2, and has a good average of effective porosity reach to 15% with an average of water saturation less than 50%.

6.5 ME unit:

The thickness of the ME unit is 101m in well-1 and 75 m in well-2, this unit has good reservoir equality in well-2 (especially at the upper part of the unit) than well-1 that have a good average of effective porosity reaches 11% while in well-1 reaches 6%, also the average of shale volume in well-1 is high reach 0.13 than well-2. The average water saturation in each well reaches 70%, so each well in this unit has a poor oil show.

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7. Conclusions

The CPI of the petrophysical properties shows that well-2 has a good of reservoir quality than well-1, and the MD unit is the best reservoir unit in both wells (well-1&well-2) as it has good petrophysical properties while the MA unit in both wells is considered as the weakest unit, which has a high ratio from shale volume. The lithology and mineralogy identification cross plot shows that Mishrif Formation is mainly consisting of limestone and calcite as the main minerals and traces of dolomite with points located in the gas and secondary porosity range, there are also a few scattered points located within the quartz in well-1 which may indicate the presence of thin layers of sandstone.

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P- ISSN: 2220-5381
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