

Reservoir Evaluation of Nahr Umr Formation at Abu-Amood Oil Field, Southern Iraq

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Abstract

This study presents the first comprehensive evaluation of the Nahr Umr Formation in Abu-Amood Oil Field, southern Iraq, addressing a critical research gap. Using well log data, the formation is divided into five lithological units. Key steps include depth correction of logs, shale volume calculation, and porosity-permeability estimation via neutron-density and sonic methods. Water saturation is computed using Archie (clean zones) and Indonesia (shaly zones) equations. The results have identified Unit 3 (clean sandstone) as the primary reservoir with high average porosity, permeability, and oil presence above the oil-water contact (OWC) at 3120 m. Units 1 and 5 exhibit low porosity and high-water saturation, while Unit 2 has suffered from data gaps due to borehole instability. The study highlights Nahr Umr's potential as a hydrocarbon reservoir and underscores challenges in shaly zones. These findings provide foundational insights for future exploration and development, emphasizing the need for improved core recovery and advanced modeling to reduce uncertainties in heterogeneous formations.

Keywords:

Abu-Amood, Formation Evaluation, Nahr Umr.

DOI: [10.33899/injes.v26i4.56157](https://doi.org/10.33899/injes.v26i4.56157), ©Authors, 2026, College of Science, University of Mosul.This is an open-access article under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The process of preparing a comprehensive study for a potential reservoir model usually starts with well log interpretation; then the results of interpretation will help in building an accurate model for the purpose of the study.

Abu-Amood oil field is located in Dhi Qar province, approximately 16 km north of the Qall'at Sukkar area and 26 km north of Refa'i, with an adjacency of only 17 km southwest of the Dejaila field as shown in Figure (1) (Khorshid and Khaleel, 2017a). The field is around 22 Km long and 6 Km wide with an azimuth of N65°W. The field primarily consists of several formations with high production potential.

Nahr Umr Formation at the Abu-Amood oil field is primarily characterized by sandstone rocks. According to the available geological reports, the formation top is at a depth of 3025 m below sea

level, with an average thickness of 139 m. No faults are recognized in the formation, indicating a stable geological structure (Khorshid and Khaleel, 2017b).

Several studies have investigated the Abu Amood oil field, exploring different formations. The Mishrif, Zubair, and Yamama formations took center stage, with researchers analyzing them for petrophysical interpretation and geological modeling (Al-Baldawi, 2021; Hussain et al., 2021; Mahdi and Farman, 2023b, 2023a; Nasser et al., 2021). Beyond specific formation, other studies covered the entire field. They addressed various aspects, such as designing seismic surveys (Khorshid and Khaleel, 2017a), assessing the thermal maturity of source rocks (Abdullah et al., 2018), and designing an optimum completion method (Hameed and Al-Jawad, 2020). It is worth highlighting that, while the Nahr Umr Formation has received attention, the scrutiny has been

primarily centered on a structural and stratigraphic study only (Khorshid and Khaleel, 2017b).

Up to the present moment, no research attempts have been undertaken to study the Nahr Umr Formation at the Abu Amood oil field. Consequently, the primary objective of this study is to present the first reservoir evaluation for the Nahr Umr Formation. As a result, a knowledge gap in the existing research landscape has been filled. This study stands as an essential step toward enhancing our understanding of the reservoir within the Abu Amood oil field, particularly about the Nahr Umr Formation.

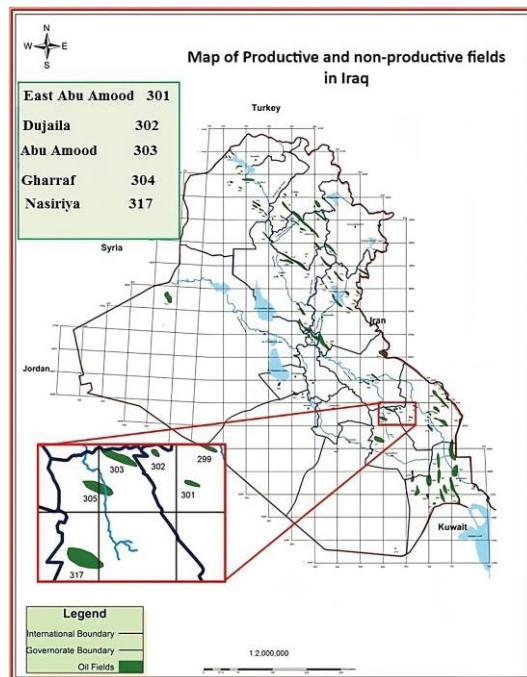


Fig. 1: Abu-Amood oil field location (Odeh, 2021).

2. Methodology

A. Log Depth Shifting

Different logging tools have different setting arrangements inside the borehole. Some are set up centrally in the borehole (e.g., resistivity logs), and others are pushed against the borehole wall (e.g., density log), and this results in off-depth errors in some tools due to drag, which makes the cable stretch, which in turn makes the readings inconsistent (Bassiouni, 1994).

The gamma-ray logging tool in the resistivity set is used as a reference to correlate the readings of other logging tools. The built-in Techlog shifting algorithm is used to make the shifting for all logs.

B. Shale Volume

The calculation of shale volume is important as it contributes to the calculations of effective porosity, which in turn is used in building the dynamic model of the reservoir.

Before computing the shale volume, a correction for the Gamma Ray log (GR) was conducted for mud weight. The mud weight, as well as the minimum and maximum gamma ray reading for each well, is shown in Table (1).

Table 1: Mud weight, minimum and maximum gamma ray reading for each well.

Wells	AAM-1	AAM-2	AAM-3	AAM-4	AAM-5
Mud weight (g/cm ³)	1.26	1.3	1.3	1.28	1.31
MIN GR corrected, GAPI	14.5	14.3	15.5	14.6	12.7
MAX GR corrected, GAPI	155.2	202.4	233	199	245

After correcting the gamma-ray readings, the volume of shale is computed using the Clavier equation (2) (Bassiouni, 1994). The result is illustrated in Figure (2).

$$GR_{Index} = \frac{GR - GR_{min}}{GR_{max} - GR_{min}} \quad (1)$$

$$V_{SH} = 1.7 - \sqrt{3.38 - (GR_{Index} + 0.7)^2} \quad (2)$$

Where: GR_Index: Gamma-ray index; GR: Gamma-ray reading from log; GR_min: Gamma-ray reading in a clean rock; GR_max: Gamma-ray reading in shale rock; V_SH: Volume of shale

C. Zonation

Zonation is a crucial step in well log interpretation for dividing the formation into similar rock lithologies and characteristics and using the equations fit for that lithology, as each equation has different parameters depending on the rock type under study.

As there are no previous works that investigate the Nahr Umr Formation in the Abu-Amood oil field, there is no prior zonation for it. The zonation of the formation is based on cutting reports of wells AAM-1 and AAM-3 found in the Final Geological Report (FGR), as well as GR, caliper, and deep resistivity log deflections as depicted in Figure (2). A summary of cutting reports of both wells is shown in Tables (2 and 3), respectively.

Table 2: Summary of cutting report for well AAM-1.

Depth interval, m	Details
3025 - 3027	Shale, slightly hard
3027 - 3046	Limestone, compact, moderately hard
3046 - 3050	Sandstone
3050 - 3068	Shale with beds of limestone, compact
3068 - 3100	Sandstone, medium Coarse
3100 - 3140	Sandstone, medium Coarse
3140 - 3143	Siltstone, slightly hard
3143 - 3162.6	Sandstone, slightly hard

Table 3: Summary of cutting report for well AAM-3.

Depth interval, m	Details
3046 - 3065	Limestone, compact, moderately hard
3065 - 3081	Sandstone, slightly hard, fine-grained
3081 - 3100	Sandstone, fine - medium grain
3100 - 3127	Sandstone, slightly hard, medium - coarse grain
3127 - 3163	Sandstone, fine - medium grain
3163 - 3188	Mix siltstone and sandstone, fine - medium grain

Nahr Umr Formation is divided into five units: unit-1 (mix of limestone and shale with a high proportion of limestone), unit-2 (mainly shale and its features with high caving approaching 23 inches in AAM-1), unit-3 (clean sandstone), unit-4 (shale), and unit-5 (clean sandstone).

D. Porosity

Porosity is a dimensionless quantity that describes the capacity of the rock to store fluids. Two types of porosity are calculated using different logging tools (i.e., density, sonic, and neutron logs); the first is the total porosity, which, as the name suggests, is the total porosity of the rock; the second type is the effective porosity, which is the total porosity minus the clay-bound water that is usually stored in the shale rocks (Bassiouni, 1994). Effective porosity is generally calculated using equation (3):

$$\phi_{effective} = \phi_{total} - V_{shale} \phi_{shale} \quad (3)$$

According to the well log headers, the mud used in drilling well AAM-1 was FCL-CL mud, while lime mud was used in the rest; Thus, all the equations used to calculate the porosities took into consideration the fluid properties of fresh water-based mud for AAM-1 and brine water for the other wells.

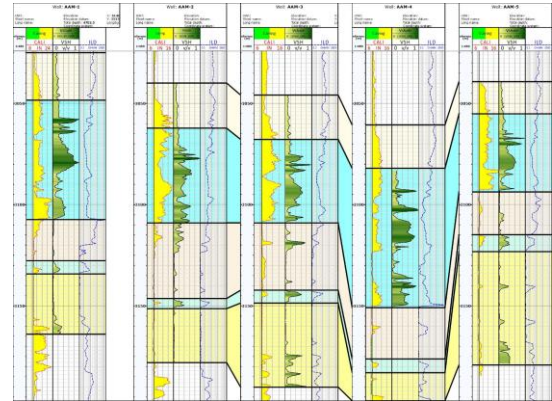


Fig. 2: Caliper, shale volume, deep resistivity and zonation of wells.

For each unit, different logging tools and equations are used depending on the unit's characteristics and rock type. All units' porosities are calculated using the neutron-density method (equation (4)), except unit-2, which is calculated using the sonic log only due to the excessive caving in unit-2 as indicated by the caliper log.

$$\phi_{ND} = \sqrt{\frac{\phi_D^2 + \phi_N^2}{2}} \quad (4)$$

Where: ϕ_{ND} : Neutron-Density porosity; ϕ_D : Porosity from density log; ϕ_N : Porosity from neutron log

After calculating the porosity of the formation, a calibration of the calculated porosity with the core porosity is needed, but due to the low recovery of some cores, there is an uncertainty in the depth-value data provided from the cores; a summary of core data is shown in Table).

Table 4: Summary of core data.

Property	Porosity, %	Permeability, mD
Mean	24.6	1596
S. D.	3.7	1216
Minimum	13.8	1.1
Maximum	34.7	6299
Count	62	63

A program written in Python is used to shift the core data to get a better match with the porosity log. The program takes the core data, log data, and the top and bottom interval of the core as input and calculates the optimum upward shift value that gives the lowest root mean square error (RMSE). The core details and the optimum shift value are shown in Table).

Table 5: Core description.

Well	Core	Recovery, %	Top interval, m	Bottom interval, m	Shift value, m
AAM-1	Core:4	53	3099	3115	6.15
AAM-2	Core:2	64	3113	3122	0.19

	Core:3	94	3105	3113	0
AAM-3	Core:4	64	3117	3126	0.1
	Core:5	79	3126	3135	0
	Core:6	66	3135	3145	0.19
AAM-5	Core:2	13.3	3096	3111	0.44
	Core:3	63.5	3111	3126	0.26

After shifting the cores, a cross plot is made between the porosity log and the shifted core porosity to get an equation that modifies the porosity log to make a better correlation with core data. Fig. 3 shows the cross plot as well as the equation used to modify the porosity.

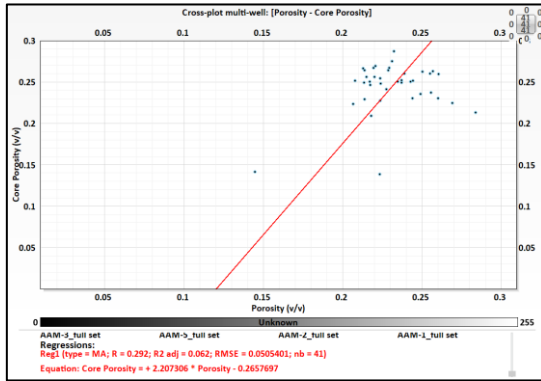


Fig. 3: Cross plot between computed porosity and core porosity.

E. Water Saturation

Water saturation is one of the most important results that can be calculated from well logs, as it reflects fluid content in a pore, whether hydrocarbon or water. Additionally, it's one of the parameters used when estimating the original oil in place (OOIP) (Bassiouni, 1994).

Unlike porosity, there is no direct log tool that can be used to calculate water saturation in a rock. Consequently, a range of empirical correlations is used with different parameters taken from other logs such as the deep resistivity log and the calculated porosity log, and used to estimate the water saturation of the rock (Bassiouni, 1994). The Archie equation (5) and Indonesia equation (6) are used to calculate the water saturation of the formation.

$$S_{wArchi} = \left(\frac{a R_w}{\phi^m R_t} \right)^{\frac{1}{n}} \quad (5)$$

$$S_{wIndonesia} = \left(\frac{\sqrt{\frac{1}{R_t}}}{\left(\frac{V_{sh}(1-0.5 V_{sh})}{\sqrt{R_{sh}}} \right) + \sqrt{\frac{\phi_e^m}{a R_w}}} \right)^{\frac{2}{n}} \quad (6)$$

Where: S_w : Water saturation; a : Tortuosity factor; m : Cementation exponent; n : Saturation exponent; R_w : Formation's water resistivity; R_t :

Formation's resistivity; V_{sh} : Shale volume; R_{sh} : Shale resistivity; ϕ : Porosity, ϕ_e : Effective porosity.

Formation water resistivity (R_w) is an important parameter used to estimate water saturation. There are many methods to determine R_w if there is no water analysis is conducted.

For this case, a water analysis is conducted for a sample taken from well AAM-2. The reported R_w (0.0591 ohm.m) is at 22°C; so, equation (7) is used to convert the reported R_w to reservoir temperature, which is 94.4°C (Bassiouni, 1994).

$$R_{res} = R_{lab} \frac{T_{lab} + 6.77}{T_{res} + 6.77} \quad (7)$$

Where: R_{res} : Water resistivity at reservoir temperature; R_{lab} : Water resistivity at reference temperature; T_{lab} : reference temperature, °F; T_{res} : Reservoir temperature, °F

The computed formation's water resistivity is 0.022 ohm.m at reservoir temperature 94.4 °C.

The rest of the required parameters (i.e., a , m and n) are determined using the Pickett plot. After the water zone is determined from FGR, the selected points are used in Pickett plot. Fig. 4 illustrates Pickett plot, and Table shows Archie parameters for Nahr Umr Formation.

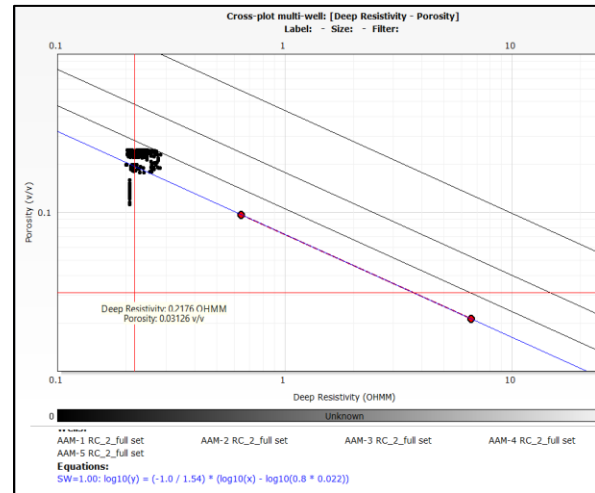


Fig. 4: Pickett plot for water zone data points.

Table 6: Archie parameters for Nahr Umr Formation in Abu-Amood oil field.

Parameter	Value
R_w ohm.m	0.022
m	1.54
a	0.8
n	2

The Archie equation is used to calculate the water saturation for units (1, 3, and 5). In contrast, the Indonesia equation is used for units (2 and 4). This is due to the presence of shale, as the Archie

equation is used for clean formations. For unit-1, default Archie parameters ($a = 1$, $m = 2$, $n = 2$) are used since the obtained parameters were for sandstone formation and not for limestone.

F. Permeability

Permeability is a rock property that describes how easily a fluid can flow through a rock. There are many methods in the literature to calculate the permeability of the rock, ranging from empirical correlation to machine learning techniques (Lazim et al., 2018; Matinkia et al., 2023). Due to the low number of core data, using the advanced methods in the literature is impractical. A cross plot between porosity and the logarithm of permeability, as shown in Fig. , was created to formulate an equation to predict the permeability.

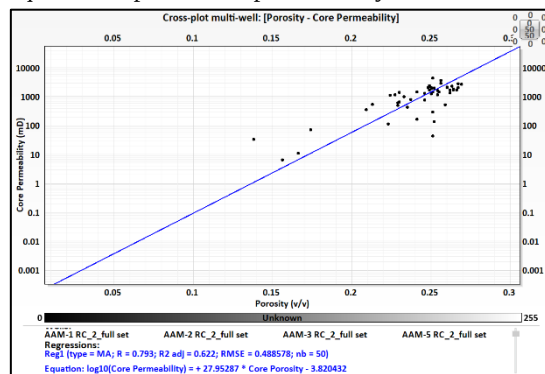


Fig. 5: Cross plot between porosity permeability for Nahr Umr Formation.

G. Oil-Water Contact

Oil-water contact (OWC) is an important parameter to determine since it is involved with the calculation of original oil in place. Two depths are found for OWC in the final geological reports of wells AAM-1 and AAM-5, which are 3120 m and 3126.75 m, respectively. The depth used in this work is 3120 m, as it's aligned with the interpretation of the logs.

3. Results and Discussion

The interpretation results are shown in Figs. 6 to 10, and each figure is divided into four sections. The first section represents the lithology, where the first track shows the lithology with depth, the second track is the caliper log, the third is the spontaneous potential (SP) log, and the last track shows the volume of shale. The second section shows the Neutron, density, and sonic logs, while the third section shows the deep and shallow resistivity logs, and the last section shows the

results, where the first track is the porosity, the second track is the permeability, and the last track is water saturation, while the red line shows the OWC depth (i.e., 3120 m).

Unit-1 likely appears as a transition zone between the Nahr Umr Formation and the carbonate Maaddud Formation above it, which is characterized by low porosity approaching zero, low permeability, and high-water saturation, and it can be assumed that this unit acts as a caprock for the Nahr Umr Formation.

Unit-2 is the most ambiguous unit in the formation because of the lack of information about it due to the excessive caving that happened in the unit. As a result of the caving, most logging tools record the information of the mud instead of the formation. It is characterized by high caliper and high gamma-ray readings.

The most promising unit in the formation is Unit 3; it is a clean sandstone rock. It's characterized by high porosity and high permeability, and the uppermost part of the unit has oil, as indicated by the water saturation track, as well as an in-gauge caliper reading.

The next unit is unit-4, which is a thin shaly sandstone rock that appears in all the wells. It's characterized by medium porosity and permeability and low water saturation. The low water saturation is an error caused by the high resistivity of the shale, and this is confirmed by the fact that the OWC is at 3120 M and the shallowest depth of unit-4 in all wells is 3127 m, with well AAM-5 as an exception. This confirms that the low water saturation is due to shale resistivity and not the presence of oil.

The last unit in the Nahr Umr Formation is unit-5. It's characterized by medium-high porosity and permeability and is water-filled, as indicated by the water saturation track.

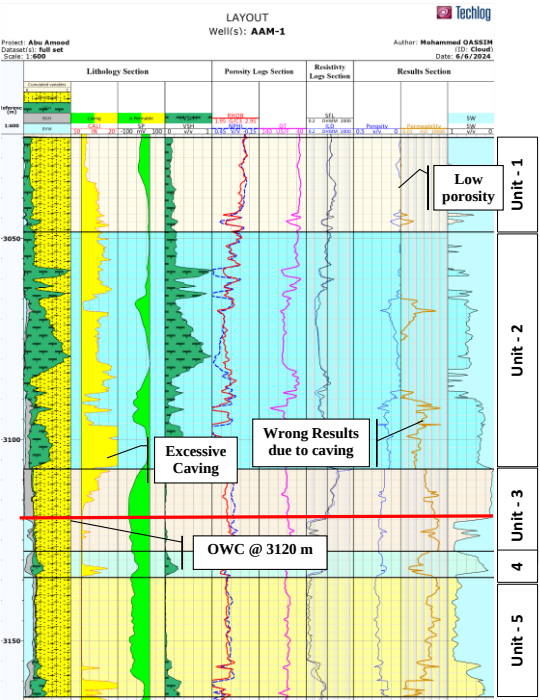


Fig. 6: AAM-1 conventional logs and interpretation results.

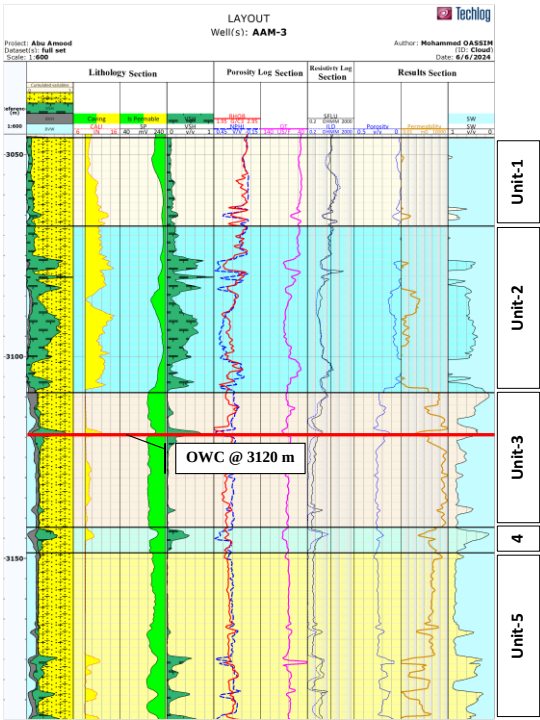


Fig. 8: AAM-3 conventional logs and interpretation results.

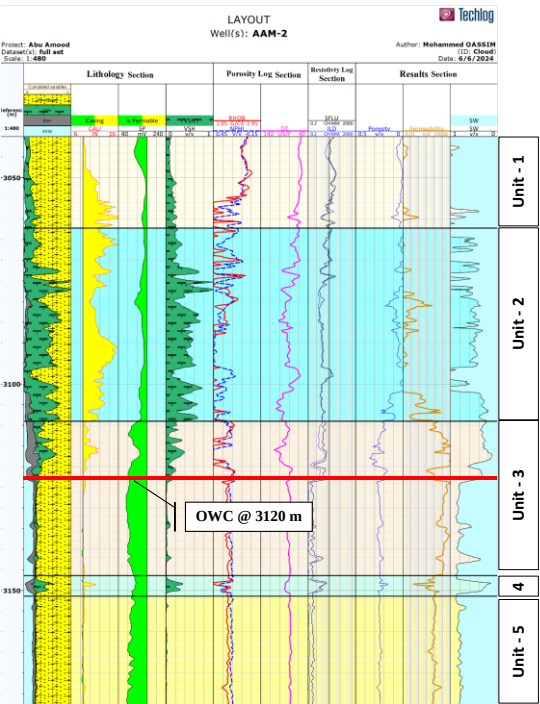


Fig. 7: AAM-2 conventional logs and interpretation results.

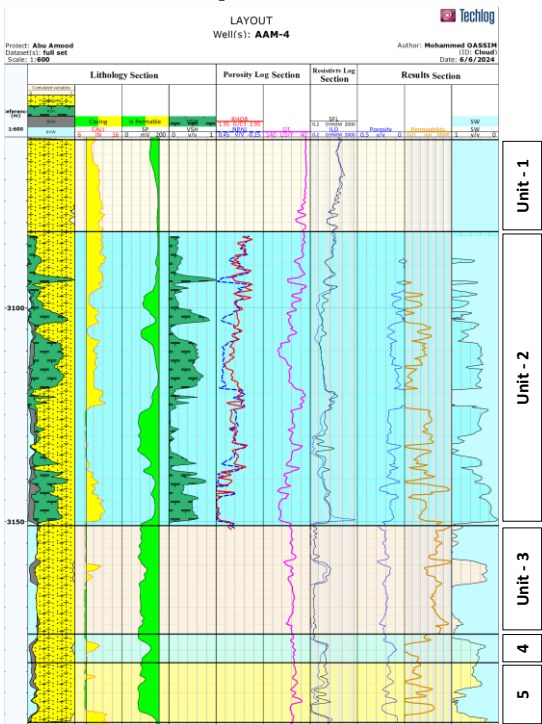


Fig. 9: AAM-4 conventional logs and interpretation results.

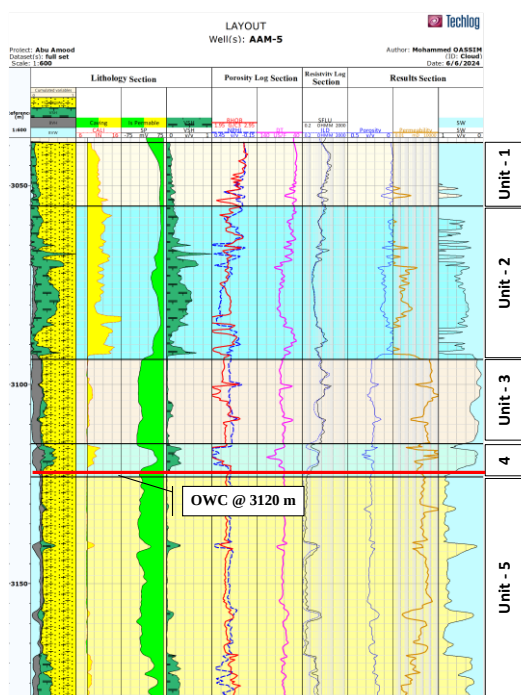


Fig. 10: AAM-5 conventional logs and interpretation results.

4. Conclusion

The Nahr Umr Formation in Abu-Amood Oil Field comprises five distinct units. Unit 3 (clean sandstone) emerged as the primary hydrocarbon-bearing zone due to its high porosity and permeability. The oil-water contact is established at 3120 m, aligning with log interpretations. Challenges include unreliable data in Unit-2 due to borehole caving and uncertainties in permeability estimation from limited core samples. This study successfully fills a knowledge gap by providing the first detailed evaluation of the Nahr Umr Formation, highlighting its potential as a viable reservoir. Future work should focus on core recovery improvements and advanced modeling to reduce uncertainties, particularly in shaly and unstable zones. These findings have paved the way for optimized resource extraction strategies in the Abu-Amood oil field.

5. Conflict of Interest

The authors declare that they have no conflict of interest.

6. Funding Statement

This research received no external funding.

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تقييم مكن تكوين نهر عمر في حقل أبو عامود النفطي، جنوبي العراق

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الملخص

تقدم هذه الدراسة أول تقييم شامل لتكوين نهر عمر في حقل أبو عمود النفطي جنوبي العراق لسد فجوة بحثية حرجية. باستخدام بيانات السجلات البئرية، قُيِّم التكوين إلى خمس وحدات صخرية. شملت المنهجية تصحيح أعماق السجلات، وحساب حجم الطين، وتقدير المسامية والنفاذية باستخدام طرق نيوترون-كثافة وقياس سرعة الموجات. جرى تحديد تشبع الماء بمعادلة أرشي (للمناطق النظيفة) وإندونيسيا (للمناطق الطينية). أظهرت النتائج أن الوحدة الثالثة (حجر رملي نقي) هي المستودع الرئيس بمسامية عالية ونفاذية مرتفعة، ووجود نطف فوق تماس الماء-النفط عند عمق 3120 متراً. بينما أظهرت الوحدة الأولى والخامسة مسامية منخفضة وتشبعاً مائياً عالياً، وعانت الوحدة الثانية من نقص البيانات بسبب انهيار جدار البئر. تُبرز الدراسة إمكانات نهر عمر كمستودع هيدروكربوني وتحديات المناطق الطينية. توفر النتائج أساساً لاستكشافه مستقبلاً، مع التأكيد على تحسين استعادة العيانات والنمذجة المتقدمة لتقليل الشكوك في التكوينات غير المتجانسة.

الكلمات المفتاحية:

أبو عامود، تقييم تكوين، نهر عمر.

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