Available online at http://ijcpe.uobaghdad.edu.iq and www.iasj.net
Iraqi Journal of Chemical and Petroleum Engineering
Vol. 24 No.2 (June 2023) 41 – 51
EISSN: 2618-0707, PISSN: 1997-4884

Evaluation of the Mishrif Formation Using an Advanced Method of Interpretation

Aymen M. Al-Heeti [a, *], Omar F. Al-Fatlawi [b, c], and Md Mofazzal Hossain [c]

a Basra Oil Company, Iraqi Ministry of Oil, Iraq
b Petroleum Engineering Department, College of Engineering, University of Baghdad, Iraq
c WASM: Minerals, Energy and Chemical Engineering, Curtin University, WA, Australia

Abstract

The Mishrif Formation is one of the most important geological formations in Iraq consisting of limestone, marl, and shale layers since it is one of the main oil producing reservoirs in the country, which contain a significant portion of Iraq's oil reserves. The formation has been extensively explored and developed by the Iraqi government and international oil companies, with many oil fields being developed within it. The accurate evaluation of the Mishrif formation is key to the successful exploitation of this field. However, its geological complexity poses significant challenges for oil production, requiring advanced techniques to accurately evaluate its petrophysical properties.

This study used advanced well-logging analysis techniques, including mineralogical inversion with the Quanti-Elan model employed in Schlumberger's Techlog software to evaluate this formation. The lithology, clay volume, porosity, permeability, and hydrocarbon saturation data were obtained from the open hole logging of three wells in a southern Iraqi oil field. The environmental correction was applied for open-hole logging tools, and the primary mineral of the formation was determined using porosity log cross-plotting. Pickett plot technique was utilized to determine water resistivity and Archie's parameters, and the reconstruction log was generated based on volumetric and response parameters for each component. Based on thorough analysis, the clay volume of the Mishrif formation is estimated to be about 10%, which is a common value for this rock type. The porosity was computed based on the total fluid volume, ranging from 11% to 14%, and water saturation was determined using Archie's equation. The final results of the volume of each component for rock and fluid are presented using computer programming interpretation. The results of this study provide valuable insights into the petrophysical properties of the Mishrif formation and are expected to inform for better interpretation and evaluation of petrophysical properties of similar formations, which is essential for optimum field development planning as well as minimising the uncertainties.

Keywords: Formation evaluation, Water saturation, Porosity, Permeability, Quanti-Elan Solver and Well logging analysis.

Received on 29/08/2022, Received in Revised Form on 27/09/2022, Accepted on 02/10/2022, Published on 30/06/2023

https://doi.org/10.31699/IJCPE.2023.2.5

1- Introduction

The geological characteristics and significance of the Mishrif Formation in Iraq have been extensively studied in the literature [1–4]. The Mishrif Formation is composed primarily of limestone and is considered one of the main oil-producing reservoirs in Iraq [3, 4]. Petrophysical properties such as lithology, porosity, permeability, and hydrocarbon saturation are critical to understanding the potential of the Mishrif Formation as an oil reservoir [5, 6]. The formation is known for its excellent reservoir properties, such as high porosity and permeability, which make it a prime target for hydrocarbon exploration and production. However, despite its potential as a valuable oil reservoir, the geological complexity of the Mishrif Formation presents significant challenges, especially associated acquisition and interpretation of well data for the accurate evaluation and characterization of the petrophysical properties, particularly for Mishrif formations due to its complex mineralogical and varying lithological characteristics.

Moreover, the accurate characterization of the petrophysical properties of the Mishrif Formation is very critical for optimum field development, reduction of uncertainties, and overall optimization of the production of hydrocarbons from this reservoir. The main objective of this study is to investigate the petrophysical properties of the Mishrif Formation in a southern oil field in Iraq, using advanced well-logging techniques. Specifically, the study aims to determine the lithology, clay volume, porosity, permeability, and hydrocarbon saturation of the formation. To achieve this, the Quanti-Elan model using mineralogical inversion will be applied to evaluate the petrophysical properties of the Mishrif Formation. The outcomes of this study will provide valuable insights into the potential of the Mishrif Formation as an oil reservoir necessary to reduce the level of uncertainties, and aid in informed decision-making in regard to better development planning and optimizing the production strategies.

The evaluation of these properties is typically accomplished using well-logging tools, which provide a

*Corresponding Author: Name: Aymen M. Al-Heeti, Email: aymen.abdullah2008m@coeng.uobaghdad.edu.iq

continuous record of the geological properties of the formation, such as lithology, porosity, and permeability. In this study, we use an advanced technique of well logging analysis, a mineralogical inversion application using the Quanti-Elan model that was produced by Schlumberger company in Techlog software, to evaluate the petrophysical properties of the Mishrif Formation. This technique allows for a more accurate and detailed interpretation of the open-hole logging data, enabling us to estimate the lithology, clay volume, porosity, permeability, and hydrocarbon saturation of the formation.

The enormous importance of formation evaluation (FE) is to determine the potential of a producing hydrocarbon zone [7, 8]. Formation evaluation (or well logging analysis) is a part of more than one discipline such as reservoir engineering, geology, and geophysics [9, 10]. Recently, computer programs have supported the interpretation and formation evaluation processing. It helps to make an easy calculation. Many petrophysical criteria, such as porosity, lithology identification, hydrocarbon saturation, and permeability, are required for formation evaluation [11].

This article deals with carbonate rock, which is described as a free clay mineral, with variation in texture and the presence of secondary porosity such as fractures or vugs [12]. The Mishrif formation of the X-field in the south of Iraq, the Basra government will evaluate. The study area of this field is 35 kilometers long and 20 kilometers wide, with a surface area of 700 square kilometers [13]. It is considered to be one of the most important fields in this area. The Mishrif, Yamama, Nahr-umer, and Mauddud Formations are among the reservoirs in the X-field. Exploration and evaluation wells were drilled in the 1970s by Iraqi National Oil Company (INOC), followed by development wells by Basra Oil Company (BOC) to reach a total of 53 wells by 2020. According to the geologic time scale (GTS), the Mishrif formation is classified as Cenomanian-Early Turonian Age, Cretaceous period, and Mesozoic era [14], It is composed of brown, detrital, porous, and extremely shelly limestone with rudist detritus at the bottom and grey-white, thick algal limestone with gastropods and shell parts on top. The Mishrif Formation in this field is surrounded by the Khasib Formation at the top and the Rumaila Formation at the bottom [15].

Many previous studies have concentrated on this significant field, Thamer et al. (2009) show that Gas Chromatography Mass Spectroscopy (GC-MS) was used to investigate the hydrocarbon system of the Ratawi's Mishrif Formation as well as other fields in southern Iraq [13]. Manal and Musaab provided two types of studies for this field: a structural (geometric) study of the Ratawi Structure, which included the reinterpretation of seismic data and demonstrated the absence of any fault in the Ratawi Structure; and a kinetic analysis, which pointed to a salt structure being discovered under the Ratawi Structure [16]. The study by Maher (2019) looked at the reservoir interpretation and 3D geological model of the Mauddud Formation in the Ratawi field for five wells, as well as diagenesis processes and their impact on petrophysical parameters [17]. In general, there are three types of formation evaluation or interpretation systems, as shown in Fig. 1.

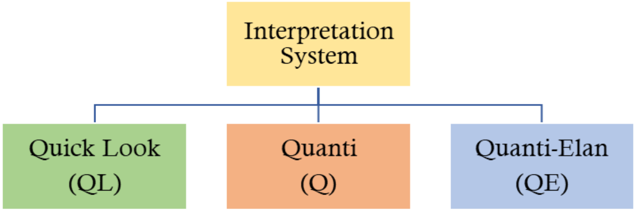

Fig. 1. Classification of Interpretation Systems

The Quick Look method provides a simple petrophysical interpretation, Shale volume and porosity are calculated using a Quick Look that is built using a Neutron-Density cross plot. The Quanti method is considered a traditional interpretation that includes all steps of analysis to define the lithology, porosity, water resistivity, cementation, saturation exponent, and water saturation. This article will discuss the evaluation of the Mishrif formation with advanced analysis using the Quanti-Elan approach, where all the petrophysical properties will be calculated using the mineral volume that was fed into the system. Open hole logging tools such as calliper (Cal), spontaneous potential (SP), Gamma Ray (GR), Porosity and resistivity logs have been used to make this analysis. potential (SP), Gamma Ray (GR), Porosity and resistivity logs have been used to make this analysis.

2- Theory of Quanti-Elan Model

This model is a mineralogical inversion application that allows quantitative formation analysis of cased and open-hole logs, level by level. Optimization of simultaneous equations describing one or more interpretation models is used to do the assessment. Elan was created for Schlumberger on Vax, then on GeoFram, and currently on Techlog. In this system, equations and unknowns must always be equal in number, at least in the system as determined: If the number of independent equations equals the number of unknowns and if the number of independent equations exceeds the number of unknowns, the system can be overdetermined. After preliminary data modification is completed, Elan can be performed at any time. A model of Elan interpretation has four steps [18].

1. Formation components are needed for volumetric results.
2. Response equations are solved using input data and uncertainty.
3. The program control parameters or its response.
4. The limits to which volumetric findings must adhere are known as constraints.

The connection between the first three variables is frequently shown as a triangle diagram in Fig. 2.

The (t) refers to the tool vector, which includes both artificial curves and all logging instrument data. The volume vector (v) represents the volumes of the formation's component parts and the (R) refers to the response parameter in 100% of the formation's components. There are three types of problems [18].

- The inverse problem, v is calculated using t and R.
- Forward problem, R and v are used to find t also known as log reconstruction.
- What response parameter values should I use in the calibration problem utilizing t and v to compute R.

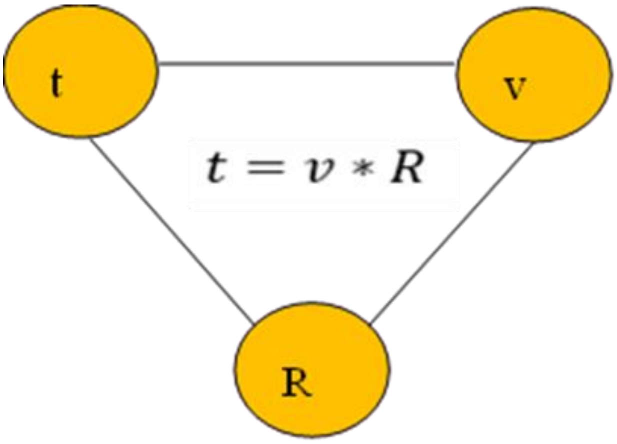

Fig. 2. The General System of Equations in Quanti-Elan Model [18]

The volumes of each component will be determined using the logging tool data and parameter responses in the first step, as shown in Fig. 3. Part (A), while the forward problem will be utilized to solve the log reconstruction (synthetic) utilizing both volume and response vectors. Then, it is compared to the real logging tools to fix the error percentage between them, as shown in Fig. 3. Part (B). This is the basic process of Elan-Solver.

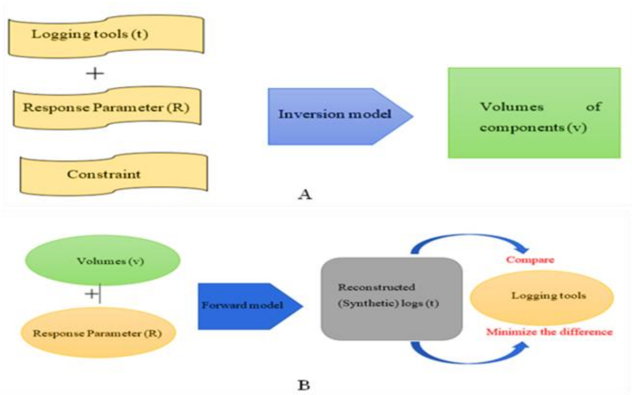

Fig. 3. Quanti-Elan Solver System for both (A) Inversion Model and (B) Forward Model

2.1. Response type of equation

In this case, there are two types of equation systems: linear response equations and nonlinear response equations. Gamma-ray logs and bulk density logs are examples of logging tools that, in the first kind, can only respond to the formation. The non-linear response of logging tools can be influenced by formation, fluid content, and any other factor. The second type of response includes resistivity (conductivity), dielectric, sonic log, and neutron porosity tools (except for NPHI, which has a linear response). In Quanti-Elan, linear equations have the following general form:

$$L1 = (C11 \times V1) + (C12 \times V2) + (\ldots..) + (C1n \times Vn) \qquad (1)$$

Where, Cn is the response endpoint for the L1 component at 100%, and Vn is the volumetric constituent The general idea is the same, even though some linear equations include additional components and nonlinear equations are more complicated. The total measurement seen is defined by:

- The amount of each formational element.
- How that formation component affects the tool's response.

2.2. Assumption types

The Elan calculation should take into account the fundamental constraints or assumptions[18], as illustrated below:

1-The volumes of the fluids and minerals combined in the model equal unity.
2-Component volume regulations are based on earlier support data (default value in between 0-1).
3-Sum of unflushed fluid = sum of flushed fluid = total porosity.
4-Maximum porosity limit based on prior support data.
5-Other constraints based on the local knowledge and interpreting expertise.

2.3. Uncertainties and Weight Concept

Uncertainties are a hard issue to understand without prior knowledge, which generates the incoherence function and standard deviation as the following equations:

$$incoherence = 0.5\left\{\left[\frac{(Rhob_{rec}-Rhob)\times Rhob_{unc.WM}}{Rhob_{unc.}\times largest\ weight}\right]^2 + \cdots\right\} \qquad (2)$$

$$Standard\ Deviation = \sqrt{\frac{2\times incoherence}{No.\ Tools}} \times largest\ weight \qquad (3)$$

Where: Rhob: input density curve, Rhobrec: Reconstructed density using output formation components, Rhobunc.: the density curve's uncertainty, Rhobunc WM: Density uncertainty weight multiplier, largest weight: the greatest weight of all weights observed.

A multiplier weight relies on log analyst expertise; a multiplier value of 1.0 indicates that the tool will have the same influence on the answer as the Volume Summation tool. The software normalizes the biggest weight to 1.0 to invert the uncertainty and provide a weighting factor. Each weight is multiplied by the user-zonal parameter (xxx_WM) to obtain the solver's weight. As seen in the following equations:

$$\text{Weight} = \frac{1/xxx_{unc.}}{\text{largest weight}} \times xxx_{WM} \quad (4)$$

Weight multipliers allow for the consistent change of balanced uncertainty without the need for any computations. They are especially useful when the input uncertainties are provided through uncertainty curves. Lastly, you can make a variable have less of an effect on the answer by giving it a low weight and a big uncertainty [18].

The absolute default setting used for the input logging tools in this model is shown in Table 1.

Table 1. Default Uncertainties and Weight Multipliers for the Elan Solve Input Logs [18]

Logging tool	Balanced uncertainty	Multiplier Weight
Bulk density	0.027	1
Sonic	2.25	0.75
Neutron (NPHI) porosity	0.015	1
Gamma-ray	6	0.3
Unflushed resistivity	Initialization step	1
Flashed resistivity	Initialization step	1

3- Methodology

Tech-log software for Schlumberger company, version 2015.3. has been used to calculate all the interpretation output. All the available data from logging tools have been digitized using Neuralog software, Version: 2015.04, to convert images to las file form. Three wells have been selected with different locations in the area's field. RT-B in the north of the field; RT-C in the northwest of the field; and RT-D near the field's centre. Only RT-B and RT-C have core data that can be used to compare the result with it. The tops and bottoms of these wells, with hole size and formation thickness, are shown in Table 2. Mud resistivities have a slight effect on porosity instruments, but it can have a significant impact on resistivity tools [19]. Generally

Rmc>Rm >Rmf

This is because the mud cake is largely clay particles and contains very little water. Mud resistivity is a function of temperature and ion concentration. Because the temperature rises with depth due to the geothermal gradient, the mud resistivity at the bottom of the hole is lower than at the surface. Table 3 illustrates the weight and resistivity of mud for the well's study.

Table 2. Information about Well's Study

Wells	Bit Size, IN	Tops, m	Bottoms, m	Thickness, m
RT-B	12.25	2204	2316	112
RT-C	12.25	2211	2344	133
RT-D	8.5	2098.5	2231.5	133

Environment correction for GR, Bulk density, and Resistivity tools has been done, where the GR-log has corrected for mud weight, hole size, and tool's position. The formation density compacted (FDC) tool for lithology density has been adjusted for the borehole size effect. The resistivity tool has been corrected for the borehole effect for holes larger than 9 inches to cut the signals that are generated by mud in holes. Then the invasion effect has been applied to compute the true resistivity in invaded and uninvaded zones and estimate the depth of investigation. All these corrections have been applied first.

Table 3. Mud's Information of Well's Study

Well	Mud Type	Mud Weight gm/cc	Rm @ MTEMP. Ohm.m @F̊	Rmc @ MTEMP. Ohm.m @F̊	Rmf @ MTEMP. Ohm.m @F̊
RT-B	FCL-CL	1.3	0.339 @ 98	0.857 @ 98	0.195 @ 98
RT-C	FCL-CL	1.3	0.86 @ 82	1.72 @ 73	0.59 @ 73
RT-D	FCL-CL	1.22	0.255 @ 102	0.46 @ 102	0.19 @ 102

3.1. Lithology Identification

The petrophysical logs include the majority of the subsurface data accessible to an exploration geologist, the bulk density vs. Neutron cross plot. This is significant and widely used to offer a sufficient lithological resolution for quartz, calcite, and dolomite. There is no secondary porosity impact since both logs measure total porosity; shale and gypsum move east and northeast, whereas light hydrocarbons and gas trend northwest. The clay influence is plainly seen by displacing certain points to the east, while the bad-hole effect scatters some points [20]. The multi-cross plot for three wells has been done as shown in Fig. 4 to understand the main component of lithology in this formation. limestone is the main component with some dolomite and shale, finally, a quartz dispersed in the formation may be noted.

3.2. Water Resistivity (Rw) and Archie's Parameters (a, m & n)

In certain reservoirs, the value of Rw can vary greatly from well to well due to factors such as salinity, temperature, freshwater incursion, and varying depositional conditions. Also, Archie's parameter has a great effect on water saturation determination. One of the most straightforward and efficient cross-plot techniques used to determine Rw and Archi's parameters is the Pickett plot. Rw has been calculated using this method based on deep resistivity (Rt) and core porosity for two wells, as shown in Fig. 5. The result of this approach illustrates that the m= 1.78 and Rw=0.01958 ohm.m with assuming a=1, n=2.

3.3. Quanti-Elan model's Application

As mentioned above, the first step is converting the logging tools and response parameters to the component's volume for the item that was selected in the inversion model. According to available data and lithology identification results, the mineral and fluids components of Mishrif formation selected in this model as the following: Illite, Quartz, Calcite, Dolomite, Invaded, Uninvaded water, Invaded oil and Uninvaded oil.

So, volume constraints for each component were applied according to local knowledge and the lithology identification result. Whereas the percentage of quartz, as an example, never exceeds 5% in the clean zone, the dolomite percentage is less than 11% in most of the wells studied. The higher percentage of lithology components in Mishrif is calcite.

Then, after the volume of each component was calculated as will be shown in the final result (CPI) track 9, it was used to determine the reconstruction logging tools using the response parameter of each logging tool in 100% component. The response parameter is illustrated in Table 4 for each component.

The reconstruction log for wells illustrated in Fig. 6 to Fig. 8, Track 1 shows the difference and matching ratio between the gamma-ray log (GR) and the reconstruction gamma ray (Gr-REC-QE), bulk density, neutron porosity, sonic log, invaded zone resistivity, and uninvaded zone resistivity, which were shown respectively in the next track to show the difference between both logs. The final track sees the percentage error of the Quanti-Elan. In this output, the error percentage is absolutely minimal in RT-B, which indicates a good match between real and reconstruction logging tools, except in GR-log, where the clear mismatch between both logs is noted due to the high uncertainty. In RT-C and RT-D, the mismatch was noted during the intervals (2256-2266 m) and (2125-2130 m, 2150-2158 m) respectively, because of the washout effect after comparing the bit size with the calliper log.

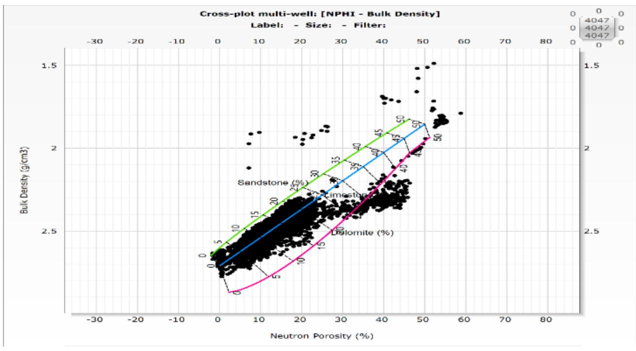

Fig. 4. Multi-Cross Plot between Bulk Density vs. Neutron Porosity to Identify Lithology

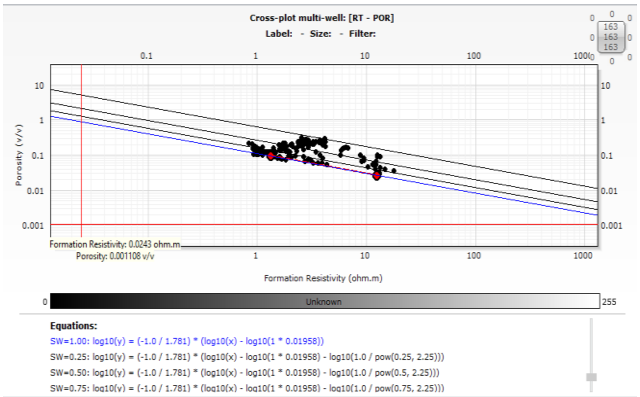

Fig. 5. Pickett Plot for Determination Water Resistivity and Archie's Parameters

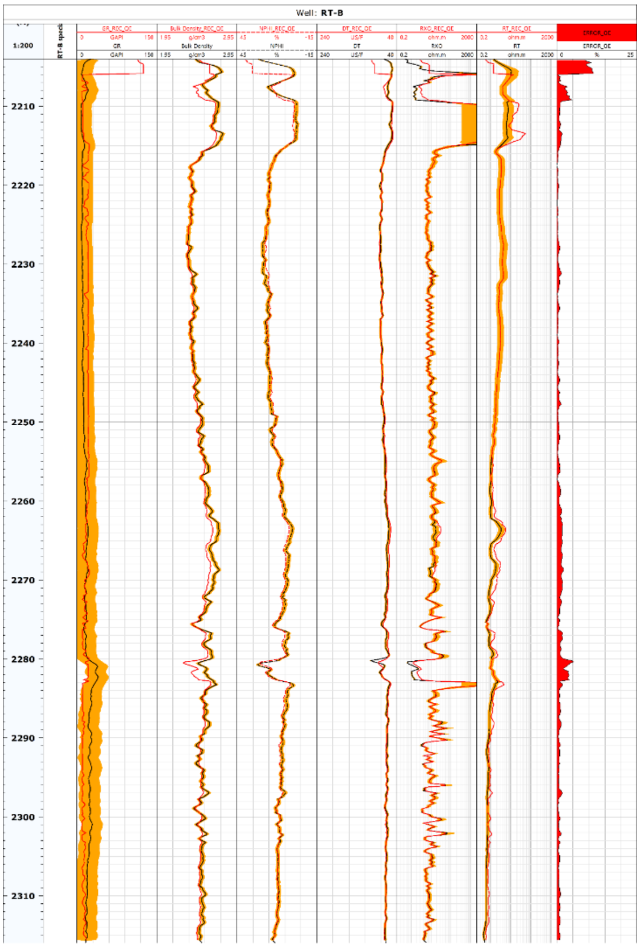

Fig. 6. The Comparison between Real and Reconstruction Logs using Elan-Solver for RT-B

Table 4. The Default Values of Response Tools in 100% of each Component

Logging tools	Illite	Quartz	Calcite	Dolomite	oil	Water (Flushed -unflushed)
Bulk density, gm/cc	2.79	2.65	2.71	2.87	0.7	0.99-1.15
Neutron Porosity, frac.	0.3	-0.0684	0	0.05568	0.95	1
Sonic, us/ft	90	55.5	47.5	43.5	210	189
Conductivity, mho/m	0	0	0	0	0	6.08-51.09
Gamma Ray, API	150	30	11	8	0	0

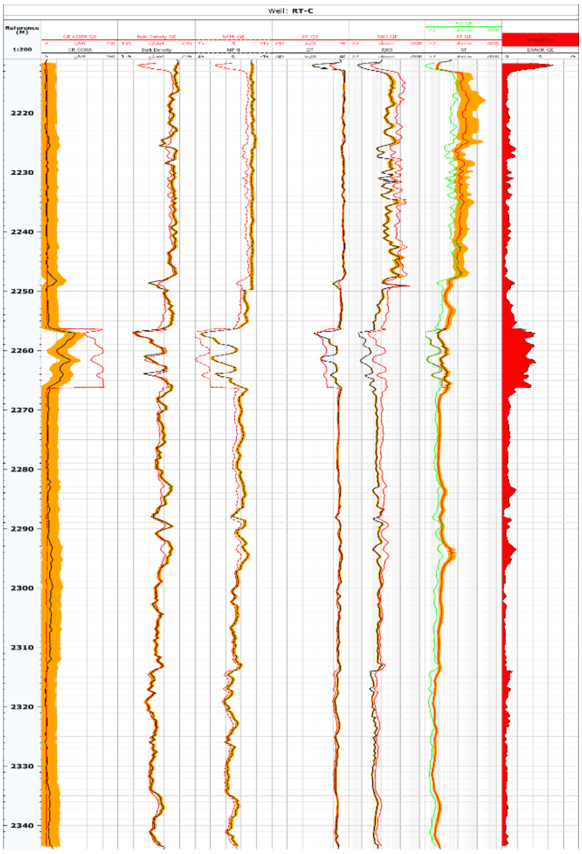

Fig. 7. The Comparison between Real and Reconstruction Logs using Elan-Solver for RT-C

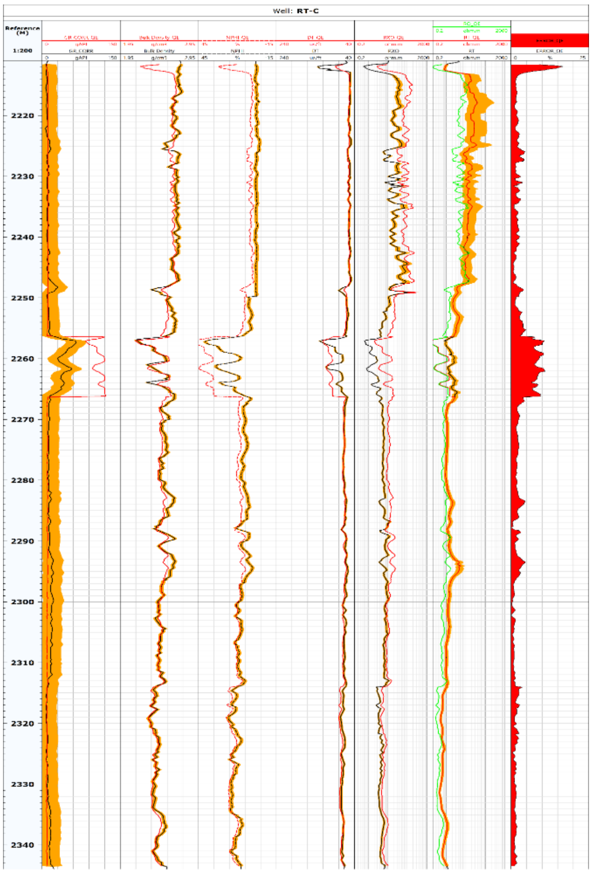

Fig. 8. The Comparison between Real and Reconstruction Logs using Elan-Solver for RT-D

3.4. Calculation of Petrophysical Properties

After the volumes of each component and the reconstruction log have been calculated, the petrophysical properties are generated. The porosity was analyzed according to the volume of the fluid components that were generated in the converting step, while the water saturation was calculated using Archie's equation, and water resistivity, and Archie's parameters were selected using the Pickett plot as mentioned in section 3.2. The permeability prediction in Quanti-Elan was generated using Herron, 1987. Permeability was generated using the following steps [21]:

1-Determine the mineral weight percentage of dry rock.

2-Then, the general form of permeability is written as a function to total porosity (PHIT) and weight percentage of mineral as shown by the following equation:

$$Permeability = 4.4 + Wghtperm + 3.0\,Log(PHIT) - 2.0\,Log\,(1 - PHIT) \quad (5)$$

4- Result and Discussion

4.1. Shale volume estimation

Keep in mind that the Quant-Elan model deals with clay minerals, and the primary clay mineral in southern Iraq, according to local knowledge, is Illite. According to the description of geological reports, the clay volume in the Mishrif formation is very small. So, the best-fit technique in this study was dependent on estimating clay volume from GR-log. This method approximately gives less than 14 % shale from the total bulk volume in RT-D, while the clay volume was estimated to be less than 8% in both RT-B and RT-C. So, for more specific analysis, the main zone of clay has shown clear in RT-C during the interval (2257-2265 m) with about 49%, and in RT-D during both intervals (2126-2132 m) and (2150-2158 m) equal to 45% and 40% respectively.

4.2. Porosity

As mentioned above during the assumption section of this model, the sum of unflushed fluid = the sum of flushed fluid = total porosity. This is the basic concept of porosity calculation. The porosity compared to core data in both RT-B and RT-C as shown in Fig. 9, the result shows a good match with core data especially in RT-B, while in RT-C there is a mismatch in the interval (2250-2265 m), because of the limited core data available in this section and the washout effect. Finally, the arithmetic mean porosity of the Mishrif formation in this field ranges from 11 to 14 per cent. These values are familiar with carbonate rock.

4.3. Permeability

Permeability is the most significant variable influencing the reservoir's dynamic condition. The texture of carbonate rocks is more complicated than that of other sedimentary rocks. Permeability is mainly dependent on porosity, although it is also affected by other factors such as grain size, pore size, sorting, throat size, cementation factor, capillary pressure, and others. In this article, the permeability is computed utilizing Herron's equation. When the results of RT-B and RT-C were compared to core data (Ka-corr), it was observed that the core permeability has a good match with the measured permeability (Kint-Geo-QEPP) in RT-B and that the core result is greater than the measured result for RT-C, as shown in Fig. 10. In general, the Permeability of Mishrif is less than 1 md., with an average value of 0.2-0.3 md.

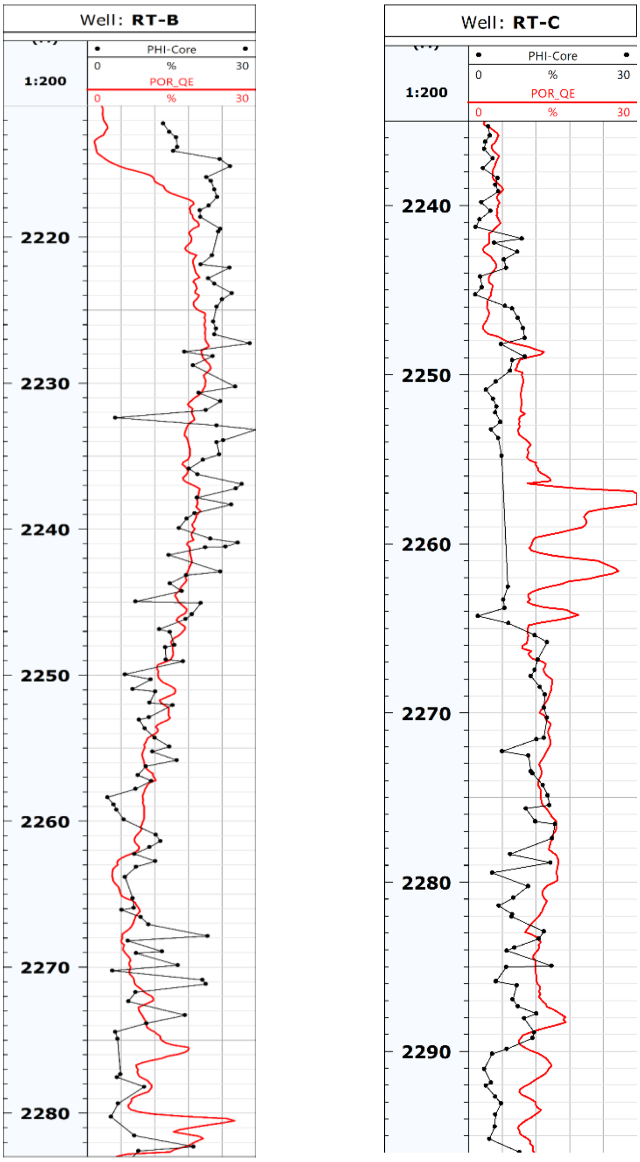

Fig. 9. The Comparison between Measured Porosity and Core Porosity for both RT-B and RT-C

4.4. Water saturation

There are a lot of techniques to determine water saturation [22], in this study water saturation was determined using Archie's equation. Therefore, formation resistivity, water resistivity, and Archie's parameters have been determined using the Pickett plot. The true formation resistivity has been generated from deep resistivity logging tools after correction for both borehole and mud invasion effects. Finally, the porosity that was computed according to the Quanti-Elan model is used in Archie’s equation to estimate water saturation.

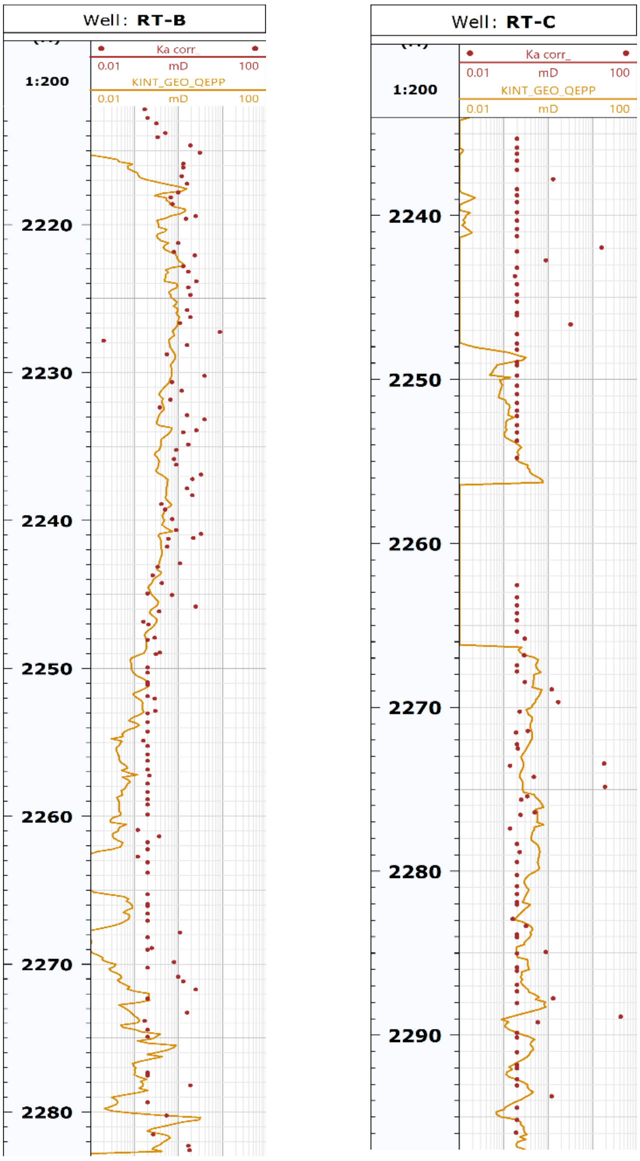

Fig. 10. The Comparison between Measured Permeability and Core Permeability for both RT-B and RT-C

In RT-B, the most potential hydrocarbon saturation during the interval (2216-2255 m) with an average value of 55 per cent, Ro less than Rt and Rt close to Rxo, indicating a good hydrocarbon zone with good permeability because the resistivity of filtrate invasion of fresh water and residual hydrocarbons in the invasion zone has a clear impact. While the water-bearing zone was quite obvious under the depth of 2255 m, where the formation resistivity is low and matches the water-bearing resistivity (Ro).

As noted in RT-C, there is poor oil saturation in this well, with an average of 30%. In RT-D, the main part of this well during the interval (2130-2140m), where the average oil saturation is 80-90 per cent, there is a good separation between formation resistivity (Rt) and water-bearing resistivity (Ro), which provides a good signal for hydrocarbon zone, the lowest portion of this formation (below 2190 m) also shows signs of hydrocarbon saturation.

The final results of Quanti-Elan are shown in Fig. 11 to Fig. 13. As a CPI shows, the calliper log and bit size with the effect of washout and mud cake was illustrated in track 1, the volume of clay with reconstruction gamma ray log (GR-REC-QE) was illustrated in track 2, track 3 shows the porosity reconstruction log (DT-REC-QE, NPHI-REC-QE, and bulk density-REC-QE), and track 4 shows the invaded reconstruction resistivity, uninvaded reconstruction resistivity, and resistivity of the water-bearing zone (RXO-REC-QE, RT-REC-QE, and Ro). Tracks 5, 6, and 7 illustrate the petrophysical parameters. So, the total and effective porosities were conducted. Then, the effective water saturation (SWE) was computed using effective porosity by the application of Archie's equation. The next track contains three types of permeability results: intrinsic (Kint), air (AIRK), and relative permeability (Kgas, Koil, and Kwtr). The best fit of these permeabilities was intrinsic as compared to core permeability. The final track depicts the percentage volume of fluids and minerals in the Mishrif formation, including movable water and movable hydrocarbon fluids. The movable hydrocarbon saturation is estimated by subtracting water saturation in the unflushed zone (SW) from water saturation in the flashed zone (Sxo).

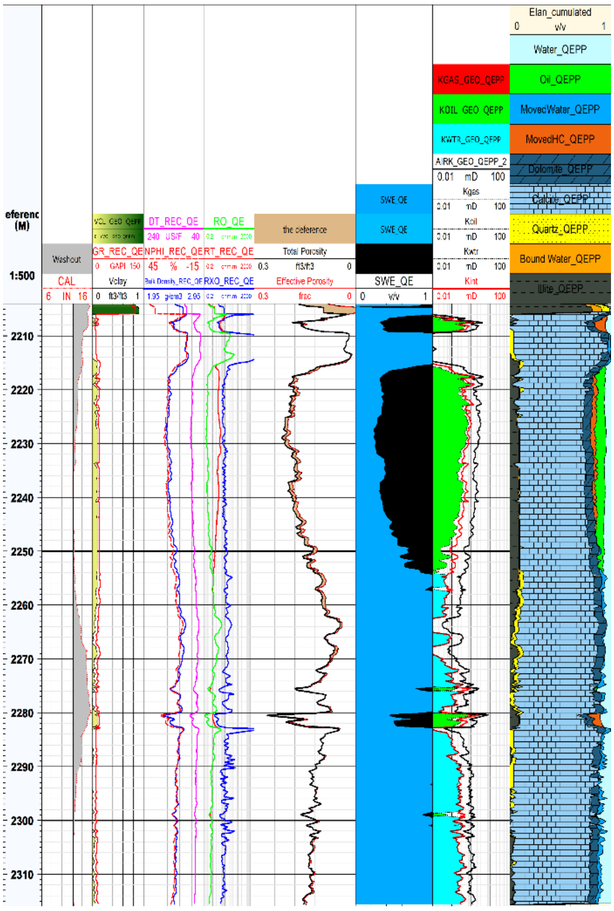

Fig. 11. The Final CPI Result of RT-B

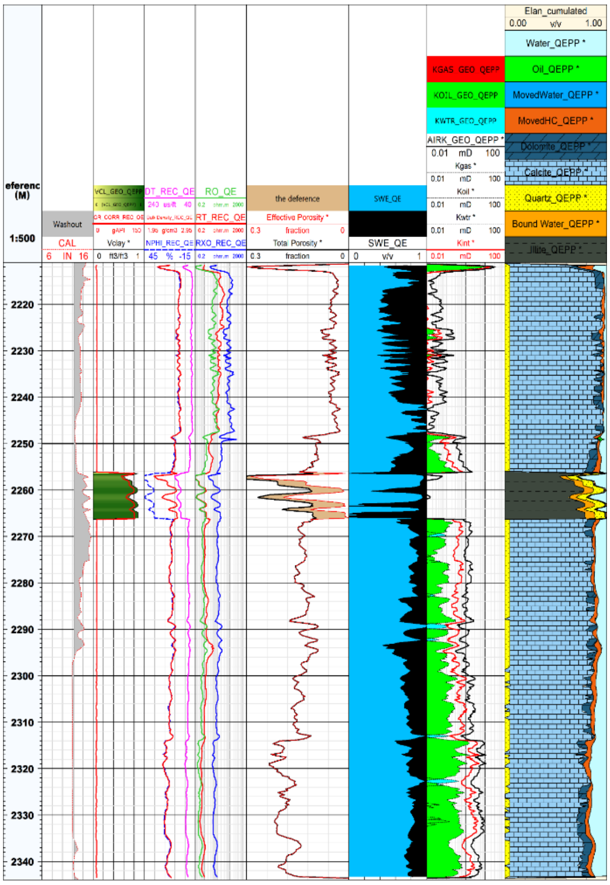

Fig. 12. The Final CPI Result of RT-C

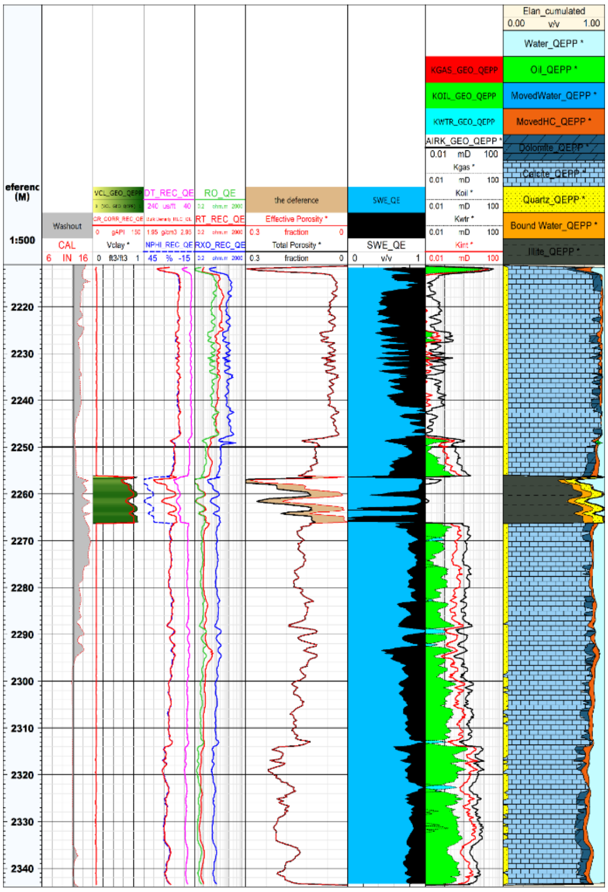

Fig. 13. The Final CPI Result of RT-D

5- Conclusion

Quantitative formation analysis using a mineralogical inversion application (Quanti-Elan) has been used in this article to estimate the petrophysical properties of Mishrif formation in one of the south of Iraq oil field using open hole logging data for three wells and compared it with available core data. The following points will summarize this study:

1- Mishrif formation is a carbonate rock with heterogeneous petrophysical properties in vertical and horizontal directions; lithology identification using cross plots between bulk density and neutron porosity logs revealed that limestone (Calcite) is the main component of this formation.

2- The clay volume in this formation is small. Illite is considered the main clay mineral in the southern Iraqi oil fields. So, the percentage of clay in this formation is about 10% as an average value.

3- The basic concept of porosity calculation in this article is derived from the total volume of fluid components in the formation. In this field, the arithmetic means porosity of the Mishrif formation ranges from 11 to 14 per cent, which is typical of carbonate rock.

4-In this article, the permeability was computed utilizing Herron's equation. The Permeability of Mishrif is less than 1 md, with an average value of 0.2-0.3 md.

5-Water saturation was determined using Archie's equation. In RT-B, the most potential hydrocarbon saturation occurs during the interval (2216-2255 m) with an average value of 55 per cent, while the poorest hydrocarbon saturation is noted in RT-C. In RT-D, the main part of this formation during the interval (2130-2140m), the average oil saturation is 80-90 percent.

Nomenclature

BOC: Basra Oil Company.
Ro: Water Bearing Resistivity
CPI: Computer Programming Interpretation
RT-: Prefix of well's name
FE: Formation Evaluation
Rt: True formation Resistivity
FCL-CL: Ferrochrome lignosulphonate-Chrome lignite
SWE: Effective Water Saturation
GTS: Geological Time Scale
INOC: Iraqi National Oil Company
MTEP: Measuring Temperature
QEPP: Quanti-Elan Post Processing
REC-QE: Reconstruction Quanti-Elan
Rmc: Mud Cake Resistivity
Rmf: Filtrate Mud Resistivity
Rm: Mud Resistivity

References

[1] H. Liu *et al.*, "Pore types, origins and control on reservoir heterogeneity of carbonate rocks in Middle Cretaceous Mishrif Formation of the West Qurna oilfield, Iraq," *J Pet Sci Eng*, vol. 171, pp. 1338–1349, 2018. https://doi.org/10.1016/j.petrol.2018.08.034

[2] L. Zhang *et al.*, "Identification, distribution characteristics, and effects on production of interlayers in carbonate reservoirs: A case study from the Cretaceous Mishrif Formation in Halfaya Oilfield, Iraq," *J Pet Sci Eng*, vol. 202, p. 108571, 2021. https://doi.org/10.1016/j.petrol.2021.108571

[3] Y. Zhong *et al.*, "Characteristics of depositional environment and evolution of Upper Cretaceous Mishrif Formation, Halfaya Oil field, Iraq based on sedimentary microfacies analysis," *Journal of African Earth Sciences*, vol. 140, pp. 151–168, 2018. https://doi.org/10.1016/j.jafrearsci.2018.01.007

[4] X. Fang and H. Feng, "Study on discriminant method of rock type for porous carbonate reservoirs based on Bayesian theory," *Sci Rep*, vol. 11, no. 1, p. 18622, 2021. https://doi.org/10.1038/s41598-021-99325-6

[5] F. N. Sadooni, "The nature and origin of Upper Cretaceous basin-margin rudist buildups of the Mesopotamian Basin, southern Iraq, with consideration of possible hydrocarbon stratigraphic entrapment," *Cretac Res*, vol. 26, no. 2, pp. 213–224, 2005. https://doi.org/10.1016/j.cretres.2004.11.016

[6] O. Salman, O. Al-Fatlawi, and S. Al-Jawad, "Reservoir Characterization and Rock Typing of Carbonate Reservoir in the Southeast of Iraq," *The Iraqi Geological Journal*, pp. 221–237, 2023. https://doi.org/10.46717/igj.56.1A.17ms-2023-1-29

[7] H. H. Mahmood and O. F. Al-Fatlawi, "Construction of Comprehensive Geological Model for an Iraqi Oil Reservoir," *The Iraqi Geological Journal*, pp. 22–35, 2021. https://doi.org/10.46717/igj.54.2F.3ms-2021-12-20

[8] O. Al-Fatlawi, A. R. Vimal Roy, M. M. Hossain, and A. H. Kabir, "Optimization of infill drilling in Whicher range field in Australia," in *SPE Kingdom of Saudi Arabia Annual Technical Symposium and Exhibition*, OnePetro, 2017. https://doi.org/10.2118/188085-MS

[9] G. B. Asquith, D. Krygowski, and C. R. Gibson, *Basic well log analysis*, vol. 16. American Association of Petroleum Geologists Tulsa, 2004.

[10] F. S. Kadhim and H. Al-Sudani, "Petrophysical Properties of Khasib Formation in East Baghdad Oil Field Southern Area," *Iraqi Journal of Chemical and Petroleum Engineering*, vol. 21, no. 4, pp. 41–48, 2020. https://doi.org/10.31699/IJCPE.2020.4.5

[11] S. Staff, "Log Interpretation Principles/Applications." SMP-7017, Schlumberger Wireline and Testing, Sugar Land, Texas, 1989.

[12] M. Watfa, "Carbonate Interpretation." Schlumberger, 1987.

[13] T. K. Al-Ameri, A. J. Al-Khafaji, and J. Zumberge, "Petroleum system analysis of the Mishrif reservoir in the Ratawi, Zubair, North and South Rumaila oil fields, southern Iraq," *GeoArabia*, vol. 14, no. 4, pp. 91–108, 2009. https://doi.org/10.2113/geoarabia140491

[14] C. géologique international. C. de stratigraphie, R. C. van Bellen, H. v Dunnington, R. Wetzel, and D. M. Morton, *Lexique Stratigraphique International: Asie. Iraq. Tertiary. Mesozoic and Palaeozoic*. Centre National de la Recherche Scientifique, 1959.

[15] S. Z. Jassim and J. C. Goff, "Geology of Iraq," *Dolin,Prague and Moravian Museum, Brno, Czech Republic*, vol. 5, 2006.

[16] H. Q. Hameed and A. H. Saleh, "Petrophysical Evaluation of Mauddud Formation in Selected Wells from Ratawi Oil Field, Southern Iraq," *Iraqi Journal of Science*, pp. 2956–2969, 2021. https://doi.org/10.24996/ijs.2021.62.9.12

[17] Al-Mohsen.M, "Facies architecture, clay minerals and its effect on petrophysical properties of Mishrif formation in west Qurna oil field Southern Iraq," Baghdad University, 2019.

[18] C. Schlumberger, *Techlog Fundamentals-Workflow and Solution Training.* 2013.

[19] W. Lyons, *Working guide to reservoir engineering*. Gulf professional publishing, 2009.

[20] M. Al-Hilali, "Using Modified Coriband Technique to Evaluate Carbonate Reservoirs in East Baghdad Oil Field.," Baghdad University, 2006.

[21] M. M. Herron, "Estimating the intrinsic permeability of clastic sediments from geochemical data," in *SPWLA 28th Annual Logging Symposium*, OnePetro, 1987.

[22] A. M. Al-Heeti and O. F. Al-Fatlawi, "Review of Historical Studies for Water Saturation Determination Techniques," *The Iraqi Geological Journal*, pp. 42–62, 2022. https://doi.org/10.46717/igj.55.2A.4Ms-2022-07-20

التقيم الطبقي لتكوين مشرف بأستخدام طرق التفسير المتقدمة

أيمن محمد الهيتي [١، *]، عمر فالح الفتلاوي [٢، ٣]، و مفضل حسين [٣]

١ شركة نفط البصرة، وزارة النفط، العراق
٢ قسم هندسة النفط، كلية الهندسة، جامعة بغداد، العراق
٣ مدرسة غرب استراليا للمناجم: المعادن والطاقة وهندسة الكيمياء، جامعة كيرتن، غرب استراليا، استراليا

الخلاصة

يعد تكوين مشرف واحد من أهم المكامن المنتجة للنفط، ومن المهم جدا دراسة الخواص البتروفيزيائة لهذا التكوين، بواسطة استخدام البيانات المستحصله من مجسات الابار تم تطبيق التقيم الطبقي بواسطة الطرق المتقدمه الحديثة والمعتمدة على حجم المعادن وحجم السوائل الموجوده في التكوين بواسطة برنامج Techlog وباستخدام موديل Quanti–Elan العائد الى شركة شلمبرجر النفطية. تم توفير البيانات الحقلية والمتضمنة مجسات الابار لثلاث ابار في احد حقول جنوب العراق لغرض حساب حجم السجيل ونوع اللثولوجي بالاضافة الى المسامسية والنفاذية والتشبع الهايدركاربوني. ان هذا الموديل معتمد على ثلاث عناصر رئيسية وهي Tool Vector والتي تشمل بيانات جس الابار و Volume Vector والذي يمثل حجم العناصر المختاره في النظام سواء للصخرة ام للسوائل التي تتضمنها مثلا" عنصر الكالسايت- عناصر السجيل- عنصر الماء وعنصر النفط. واخيرا Response parameters Vector والتي تتضمن قيم المجسات المدخله للنظام لكل عنصر نقي ١٠٠% مثلا قيمة Bulk density, Neutron porosity, GR and Resistivity لهذه العناصر النقية.

في البداية تم اجراء التصحيح البيئي للمجسات المستخدمه ثم بعد ذلك تم تحديد اهم المعادن الموجودة في طبقة مشرف باستخدام الرسم بين مجس الكثافة والمسامية, مقاومة ماء التكوين وثوابت معادلة ارجي قيمت باستخدام تقنية Pickett Plot. بواسطة استخدام حجم العناصر وقيم استجابة المجسات تم حساب Reconstruction logs والتي تعتبر الاساس في حساب الخواص البتروفيزيائية في هذه الدراسة. تم حساب حجم السجيل باستخدام مجس GR والذي قيمته اقل من ١٠% وهذه القيمة طبيعية في الصخور الكاربونية، المسامية في هذا البحث تم حسابها اعتمدا على تقنية حجم السوائل والتي تتراوح بين ١١-١٤ % اما التشبع المائي تم حسابه باستخدام معادلة ارجي ووضحت جميع هذا النتائج مع حجم العناصر المحسوبه ضمن نتائج ال CPI.

الكلمات الدالة: التقيم الطبقي، التشبع المائي، المسامية، النفاذية، موديل ايلان، تفسير مجسات الابار.