Petrophysical Characteristics and Reservoir Modeling of Mishirf Formation at Noor Oil Field, South of Iraq

Fahad M. Al-Najm [*] ;Muwafaq F. Al-Shahwan [*] ; Fawzi M. Al-Beyati[**]

[*] Department of Geology, College of Science, Basra University,[**]Department of Survey, College of Technical, Kirkuk

Abstract:

Petrophysical properties of the Mishrif reservoir at Noor oil field have been done. Based on the interpretation of the open hole data from wells (No-1, 2, 3, 4, and 5) .Which have been calculated total porosity, effective and secondary porosity, water and hydrocarbon saturation (moveable and residual hydrocarbon) in invaded and uninvaded zones. Depends on the calculated of petrophysical properties, Mishrif Formation can be divided into eight reservoir units (RU-1 to 8), separated by eight caped rock units (barrier) (Bar-1 to Bar8). Three-dimensional reservoir model of oil saturation was constructed using the Petrel Software, (2009). Distribution of these petrophysical properties for each reservoir unit within the studied field has been done. The results showed that the best reservoir units are the second, fourth and first reservoir unit. It's worth mentioned here that the heterogeneity of the thicknesses of these units and its individual direction. In addition, observed that the oil saturation increases towards the north of the field at the well (No-5) and the center of the field at the well (No-4).

Introduction

Mishrif Formation represents one of the important Cretaceous formations. As distinguished by its lithological and geographic spread makes it a good storage of hydrocarbons. It is the second oil storage after the Zubair Formation in southern Iraq (Al-Naqib, 1967). As well as the importance it represents a unique lithological architectural derivative of multi-environments within a shallow shelf.

Stratigraphic succession of Mishrif Formation at study wells shows that this formation deposits between the ages of (Late Cenomanian- Early Turonian). Rabanit (1952) was first describing of this formation at type section in a well (Zb-3) in southern Iraq. Where the deposition of this formation gradually within environmental from the outer shelf to shallow

open shelf environments at the lower part of the formation, whereas, organic reefal complex deposited at the middle part, the upper part deposits under restricted lagoon environment condition (Razoian, 1995).

The study area represented by five oil wells within the field (No-1, 2, 3, 4, and 5) note that the well (No-4) is not fully penetrated of drilling to study formation. The field is located in the province of Amara. Structural map on top of Mishrif Formation indicated that the dimensions of the field are about 20 km long and 7.5 km wide. The axis of structure extend to northwest – southeast direction, and it turned out that dip slope of the north-east flank approximately (2°), either southwest flank has reached the degree of inclination of about (1.5 °) (Figure 1).

Mishrif Formation lays gradually contact with Rumaila Formation from the bottom and the unconformable contact with Khasib Formation at the top. The main goal of the study to determine petrophysical properties of Mishrif reservoir units in Noor oil field and detailed review of the most important petrophysical properties to clarify their changes vertically and laterally within the wells by using programs (Techlog and Petrel).
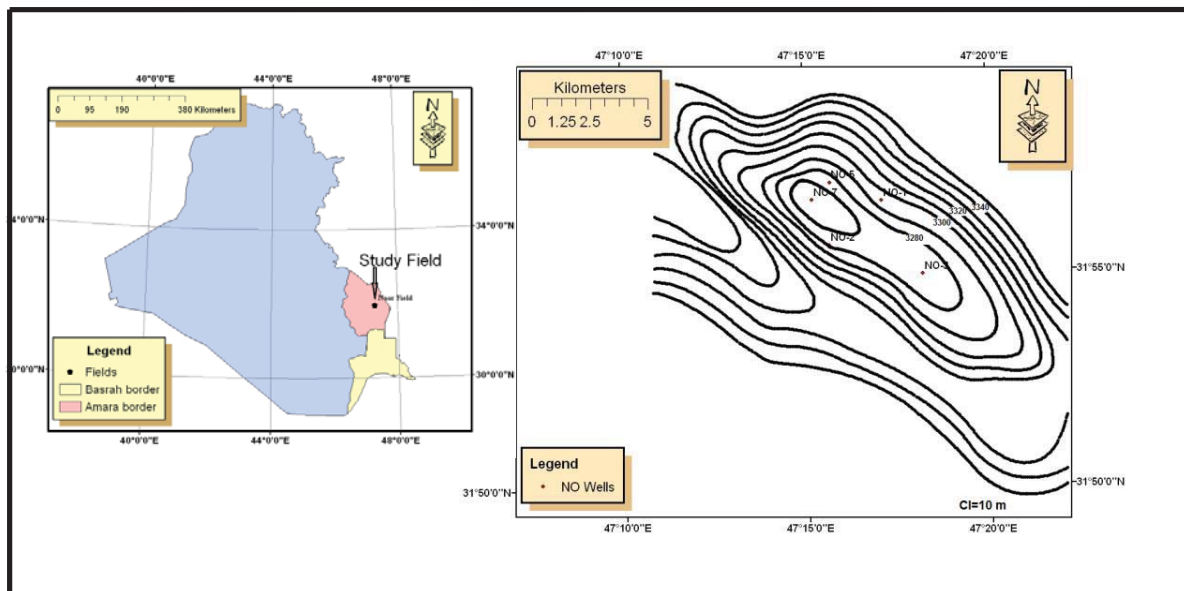

Fig.(1) Structural contour map on top of Mishrif Formation at Noor Oil Field.

Research methods

1 - Petrophysical characteristics have been calculated through the use of open hole logs, such as (Gamma Ray (GR), Neutron (NPHI), Density (RHOB), Sonic, Shallow and Deep Resistivity Logs (Rxo and Rt).

2 - Mishrif rocks was divided into reservoir units and other unreservoir units dependent on the results of petrophysical properties account for (Computer Processes Interpretation (CPI)) using the program (Techlog).

3 - Reservoir characteristics for reservoir units within the wells of the field were done by use the Petrel Software (2009).

Petrophysical parameters

1- Calculated of shale volume

Gamma ray log is the best tool using to identify and calculate the volume of shale. Because of its so sensitive to the response of radioactive material. This tool concentrates on the appearance of shale and argillaceous carbonate rocks. Calculated of shale volume in the following equation:

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \qquad \dots\dots\dots\dots (1)$$

Where:

I_{GR}: Coefficient of gamma rays index.

GR_{Log}: read the gamma rays of the formation.

GR_{min}: minimum gamma rays read opposite clean layers.

GR_{max}: maximum gamma rays read opposite shale layers.

It is then calculating the volume of shale (Vsh) using the following equation:

$$V_{sh} = 0.33[2^{2*I_{GR}} - 1] \quad \text{................} \quad (2)$$

Depends on the percentage of the shale volume extracted from previous equation (2) for studied wells were identified free shale zones (clean zone), which is by the volume of shale less than (Vsh <% 10) and zones containing volume shale large from (Vsh ≥% 10) as shally zone (no clean zone).

2- Calculation of porosity:

Porosity can be divided into two classes depends on the time of their formation. The first class represents initial porosity (primary porosity) and the second represents a porous secondary (secondary porosity). There are several methods of calculation of porosity; it is possible to calculate the primary porosity of the sonic log, as in equation Wyllie *et al*. (1958) which are used in the depths of the shale-free (clean Zone):

$$\emptyset_S = \frac{\Delta t_{log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}} \quad \text{.....................} \quad (3)$$

Where:

$\emptyset_S$: porosity calculated from sonic log.

Δt_{log}: Full-wave interval of the formation and registration of the log is measured directly (μsec/ ft).

Δt_{ma}: wave interval transit thought matrix (47.5 μsec/ ft to limestone rocks).

Δt_f: wave interval transit thought the pore fluid (185 μsec/ ft to saline water).

But in the depths that exceed Shale volume by about (10%), a zones bearing shale (Shally zone) are used equation (Dresser Atlas, 1979) to remove the effect of shale and correct, as in the following equation:

$$\emptyset_S = \left[\frac{\Delta t_{log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}\right] - \left[\frac{\Delta t_{sh} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}\right] * V_{sh} \text{.....................} \quad (4)$$

Where:

Δt_{sh} : Full-wave interval of the adjacent shale.

To correct the effect of hydrocarbons are used equation Hilchie, (1978):

$$\emptyset = \emptyset_S * Bhc \dots\dots\dots\dots (5)$$

Where:

Ø: Porosity calculated from the sonic log of the corrected effect of hydrocarbons.

Bhc: coefficient of hydrocarbon effect the impact of (0.7) for gas and oil (0.9).

It is possible to calculate the porosity of the Density log through the use of density as in equation Wyllie *et al.* (1958):

$$\emptyset_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \quad \dots\dots\dots\dots\dots (6)$$

Where:

$\emptyset_D$: Porosity calculated from the density log.

ρ_{ma}: the matrix density (2.71 g / cm^3 for limestone).

ρ_b: the density of the total composition.

ρ_f: density of the fluid (1.1 g / cm^3 for the saline water).

As for the interval containing shale can be used Dresser Atlas, (1979) equation to remove the effect of shale:

$$\emptyset_D = \left[\frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}\right] - \left[\frac{\rho_{ma} - \rho_{sh}}{\rho_{ma} - \rho_f}\right] * V_{sh} \quad \dots\dots\dots\dots . (7)$$

Where ρsh represent total density of the adjacent shale.

While the Neutron log measures the porosity directly to the depths of the shale-free zones, but for the depths of the record containing shale can be used Tiab and Donaldson (1996) equation:

$$\emptyset_{Nc} = \emptyset_N - (\emptyset N_{sh} * V_{sh}) \dots\dots\dots\dots (8)$$

Where:

$\emptyset_N$: porosity derived from neutron log.

$\emptyset_{Nc}$: porosity derived from neutron log corrected the impact of shale.

$\emptyset_{Nsh}$: neutron porosity of the adjacent shale.

3- Calculate the total porosity (effective) and secondary porosity

Total porosity or the so-called influential porosity (effective porosity) is calculated through the use of Schlumberger, (1997) equation:

$$\emptyset_{N.D} = \frac{\emptyset_N + \emptyset_D}{2} \ldots\ldots\ldots\ldots\ldots (9)$$

Where:

$\emptyset_{N.D}$: effective porosity calculated from neutron and density logs.

While we can use the Bowen, (2003) equation to get the corrected porosity affecting the impact of the gas, as used in this equation depths where $(D_\emptyset > \emptyset_N)$.

$$\emptyset_{N.D} = \sqrt{\frac{(\emptyset_N)^2 + (\emptyset_D)^2}{2}} \ \ldots\ldots\ldots\ldots\ldots. (10)$$

The secondary porosity can be calculated from Schlumberger, (1997) equation:

$$SPI = \emptyset_{N.D} - \emptyset_s \ldots\ldots\ldots\ldots\ldots (11)$$

Where, SPI: Coefficient of secondary porosity index.

4- Calculate the formation temperature

The formation temperature (T_f) is an important factor in the analysis of borehole logs, because the drilling mud resistivity (Rm) and mud filtrate (Rmf) and formation water (Rw) changes with temperature, and we can determine the formation temperature from the equations (12 and13):

$$T_f = (GG * d) + T_s \ \ldots\ldots\ldots\ldots. (12)$$

$$G.G. = \frac{BHT - T_S}{TD} \ ... ... \ (13)$$

Where:

d: calculate the depth temperature (m).

G.G.: Geothermal Gradient ($\Delta T/m$).

BHT: the temperature of the bottom of the well (C °).

TD: total depth (m).

5- Calculation of Formation Factor (F)

The formation factor is an important factor in the well log calculations , since this factor is associated with an inverse relationship between water resistivity (Rw), and a positive correlation with the resistivity formation saturated (100%) with water (Ro) as shown by Archie, (1944) equation:

$$F = \frac{R_o}{R_w} \ .... \ (14)$$

The experiments showed that the formation factor (F) can be associated with porosity through equation Archie, (1944) equation:

$$F = \frac{a}{\emptyset^m} \ .... \ (15)$$

The cementation factor (m) depends on the shape and distributed of the pores (pores geometry). Noted that the longer the road and held in front of the electric currents through the rock increased the value of (m), on the other hand, increase (m) increases the value of (F) too. While (a) represents a tortuosity factor is based on the along the path that takes liquid or current to pass through the rock and it is usually given value (1) (Khyuikh, 1990).

6- Calculation of formation water resistivity

The water resistivity of Mishrif Formation (Rw) have been identified based on values that are installed at the heads of logs (log header) , as well as the case for mud filtrate resistivity (Rmf), were then corrected (Rmf) for each depth by use the equation (16):

$$R_{mf} @T_f = R_{mf} @ T_s \left(\frac{T_s+21.5}{T_f+21.5}\right) \ldots\ldots\ldots\ldots (16)$$

Where:

$R_w @ T_s$: Formation water resistivity at the surface temperature (Ω. m).

$R_w @ T_f$: Formation water resistivity at formation temperature (Ω. m).

7- Water and Hydrocarbon saturation

Water saturation (Sw) is the ratio between the size of voids filled with water to a total volume of rock voids and measured as a percentage; either hydrocarbon saturation is what remains of the size of the voids in the rock, and, as in the following equation.

$$S_w + S_h = 1 \ldots\ldots\ldots\ldots\ldots\ldots. (17)$$

Both are calculated from water saturation in the uninvaded zone (Sw), and water saturation in the invaded zone (Sxo), so as to know the movement of hydrocarbons (MOV) and residual of hydrocarbon (ROS) by Archie, (1944) equations (18 and 19):

$$S_w = [(F * R_w)/R_t]^{1/n} \ldots\ldots\ldots\ldots.. (18)$$

$$S_{xo} = [(F * R_{mf})/R_{xo}]^{1/n} \ldots\ldots\ldots\ldots\ldots (19)$$

It also we can be calculated hydrocarbon saturation by the following equation:

$$S_h = 1 - S_w \ldots\ldots\ldots\ldots (20)$$

8- Calculate the total volume and movement of hydrocarbons

Can calculate the total volume of water in invaded zone (BVxo) and uninvaded zone (BVw) through the following equations:

$$BV_W = S_W * \emptyset_{N.D} \ldots\ldots\ldots.. (21)$$

$$BV_{XO} = S_{XO} * \emptyset_{N.D} \ldots\ldots\ldots\ldots (22)$$

Whereas the value of the total calculated of water volume in the uninvaded zone at different depths constant, this indicates that these zones homogeneous and saturated by irreducible

water. In this case, we can calculate the volume of total hydrocarbons, which includes the volume of recoverable oil movement (Moveable Oil Saturation (MOS)) and the volume of oil non-movement (Residual Oil Saturation (ROS)) by use the equations (23 and 24):

$$BV_O = S_h * \emptyset_{N.D} \dots\dots\dots\dots (23)$$

While moveable oil saturation (MOS) was calculated by the following equation:

$$MOS = S_{XO} - S_W \dots\dots\dots\dots (24)$$

It also can calculate the coefficient of the movement of hydrocarbons, which represents the ratio between the water saturation in the uninvaded zone to water saturation in invaded zone by the following equation:

$$\frac{S_w}{S_{XO}} = \left[\frac{\left(R_{XO}/R_t \right)}{\left(R_{mf}/R_w \right)} \right]^{1/2} \dots\dots\dots\dots\dots\dots\dots (25)$$

If the value (Sw / Sxo) equal to or greater than one, then that means the hydrocarbons did not move during the invasion, no matter what the zone contains hydrocarbons or not. When the value of (Sw / Sxo) less than (1), it indicates that the hydrocarbons in the invasion zone has moved from the scope of the near wellbore by drilling fluids (Al-Saddoni, 1990).

Finally, the residual oil saturation can be calculated by the following equation:

$$ROS = 1 - S_{XO} \dots\dots\dots\dots (26)$$

9- Interpretation of well log curves (CPI)

The completion of the analysis of petrophysical properties of the reservoir using open well logs as previously mentioned, the wells of the study area to Mishrif Formation facilitates the process of dividing the formation to the number of units of reservoir and non-reservoir units depending on such characteristics show in the figures (2 to 6).

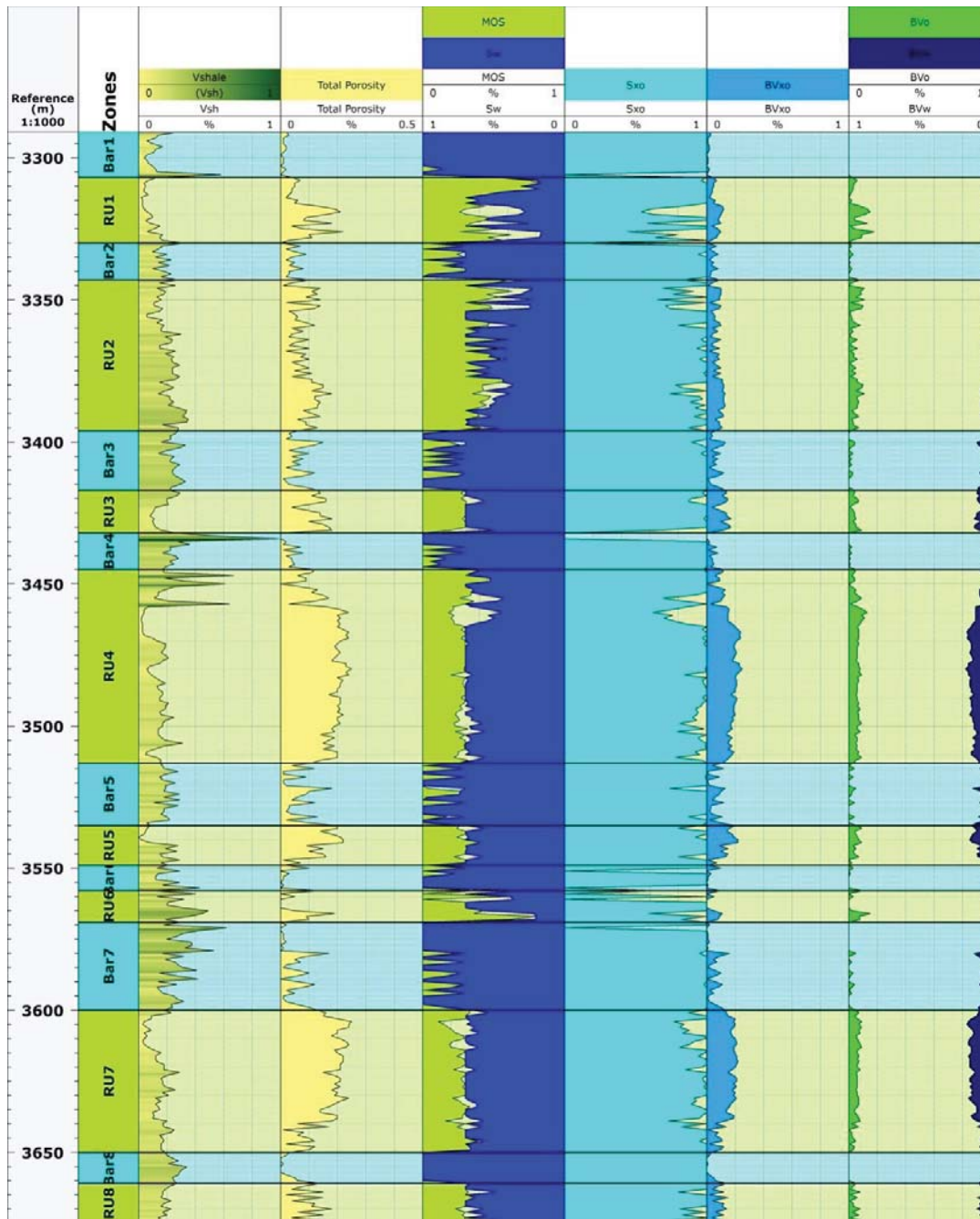As the area between (Sw) curve and (MOS) curve represents the residual hydrocarbon saturation value (ROS).

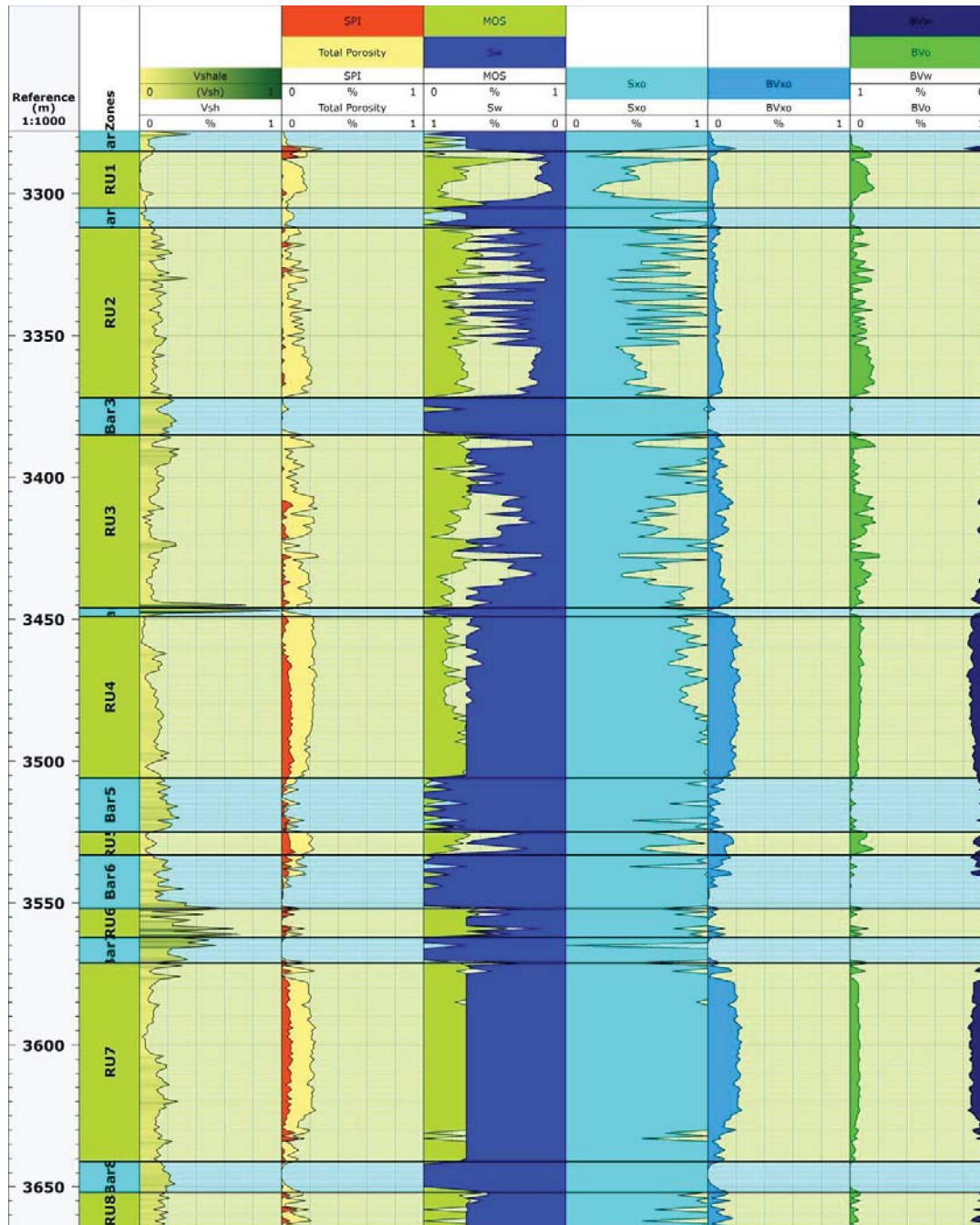**Fig. (2) well logs interpretation (CPI) of Mishrif Formation at well No-1.**

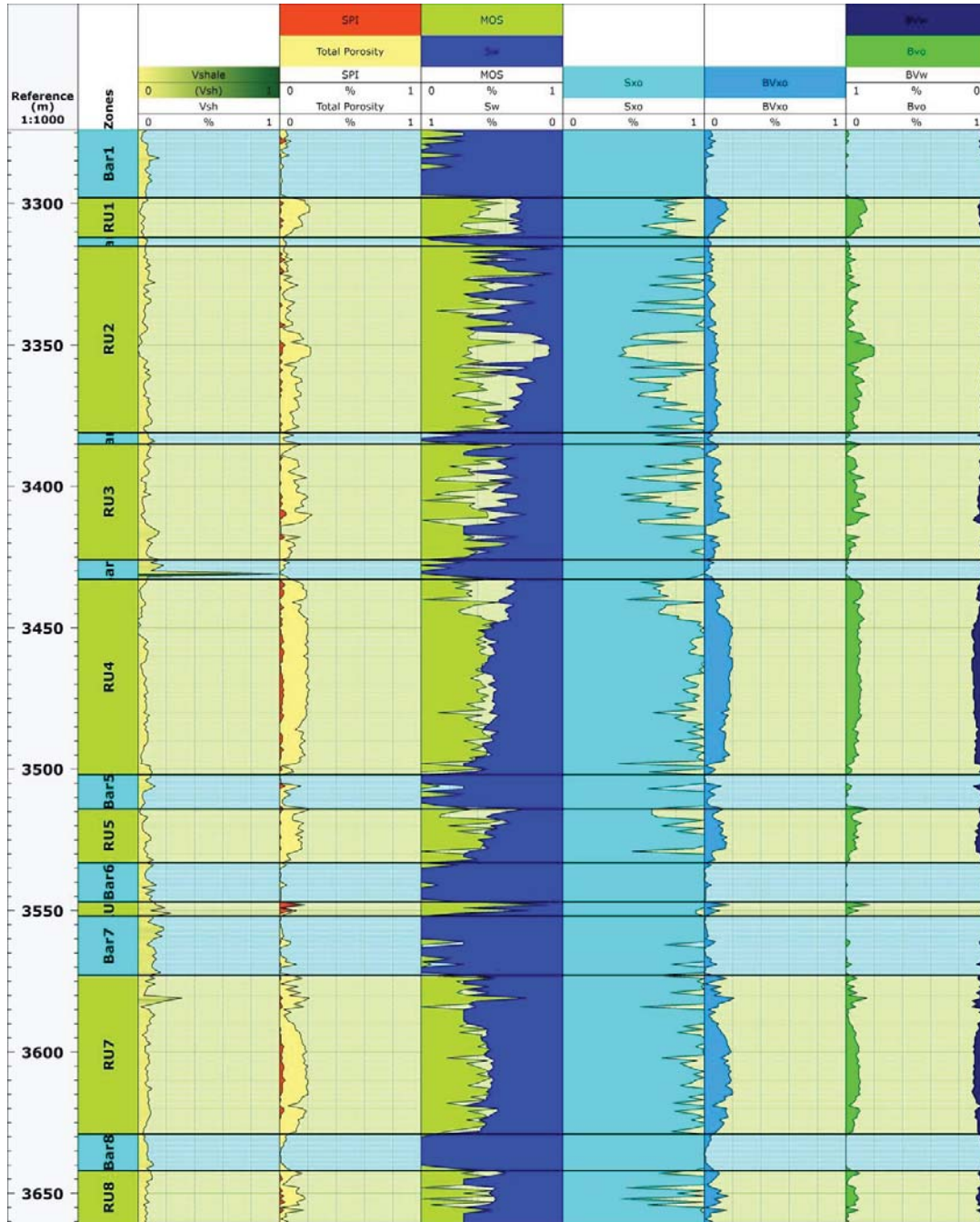**Fig .(3) well logs interpretation (CPI) of Mishrif Formation at well No-2.**

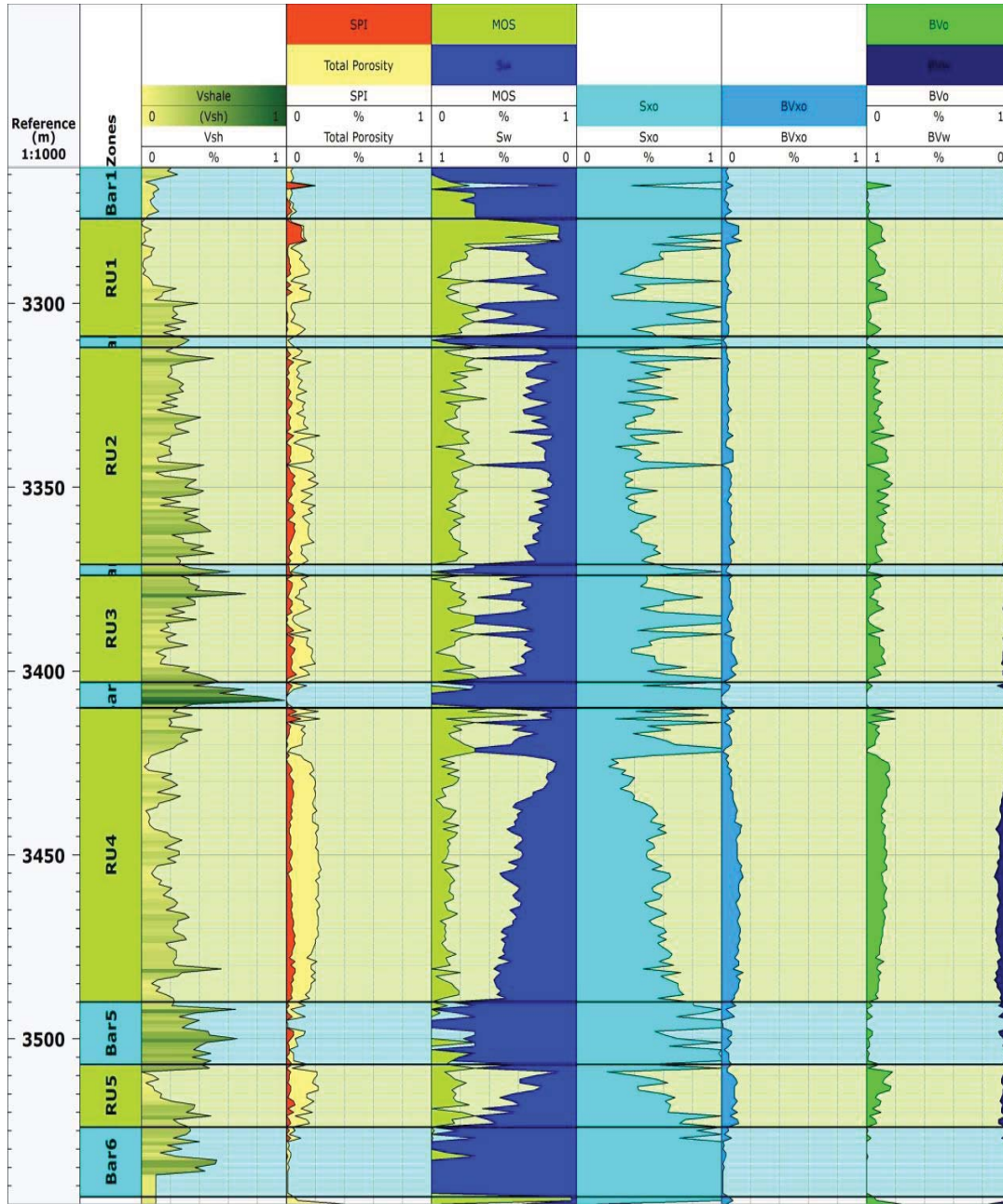**Fig.(4) well logs interpretation (CPI) of Mishrif Formation at well No-3**

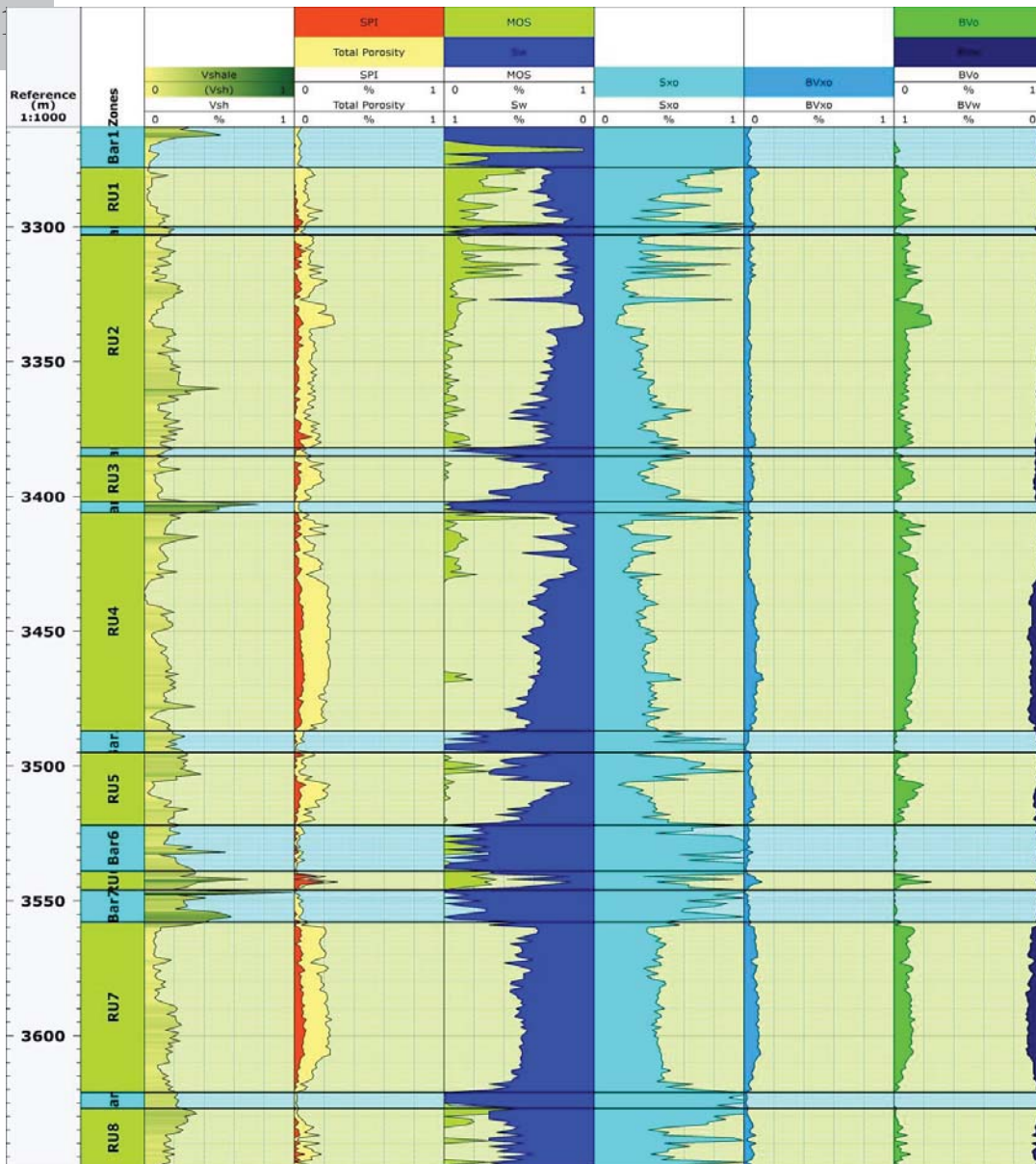Fig .(5) well logs interpretation (CPI) of Mishrif Formation at well No-4.

Fig.(6) well logs interpretation (CPI) of Mishrif Formation at well No-5.

10- The study of reservoir

Require a reservoir study to identify and distinguish the petrophysical properties and their relationship lithological facies. This relationship very important in determined the locations of hydrocarbon fluid storage, movement and production (Luciae *et. al*., 2007). Reservoir model basis on petrophysical characteristics such as porosity can be diagnosis and division of the reservoir units. The rate of reservoir oil production indicated on the type of porous system, dimensions of the reservoir units, reservoir pressure and the thickness of these reservoir units' producers. Mishrif Formation classify into eight reservoir units (RU1-RU8) separated by eight

Barrier Units (Bar1-Bar8) depends on the results of petrophysical properties obtained from the interpretation of open well logs.

A- Preparation of Reservoir Modeling

Use Petrel Software (2009) for preparation of three-dimensional (I, J, K) reservoir model. As the (J) is parallel to the longitudinal axis of the field, while the axis (I) is perpendicular to the longitudinal axis of the field (J), whereas, (K) represents the vertical axis for the current study values such as thickness, porosity, hydrocarbon saturation , etc.. It was prepared maps of porosity and oil saturation per reservoir unit by the following procedures.

B - Distribution tomography (UP Scale)

Using various mathematic methods in the distribution of reservoir properties .The purpose was to obtain a single value for each property suitable petrophysical properties in a single cell (one cell) per reservoir unit note that the dimensions of the cell is (500 * 500) meter.

C- Distribution of petrophysical properties

Mathematical method (Sequential Gaussian Simulation algorithm) was used for find the values of the petrophysical properties in the distances between the wells under study. Petrel Software (2009) was used for constructed three dimensional reservoir model through of calculates the saturation of oil. Porosity data and water saturation are the basic inputs in this model that the distribution of the saturation of oil within the reservoir units in Noor field, as shown in the figures (7 to 12).
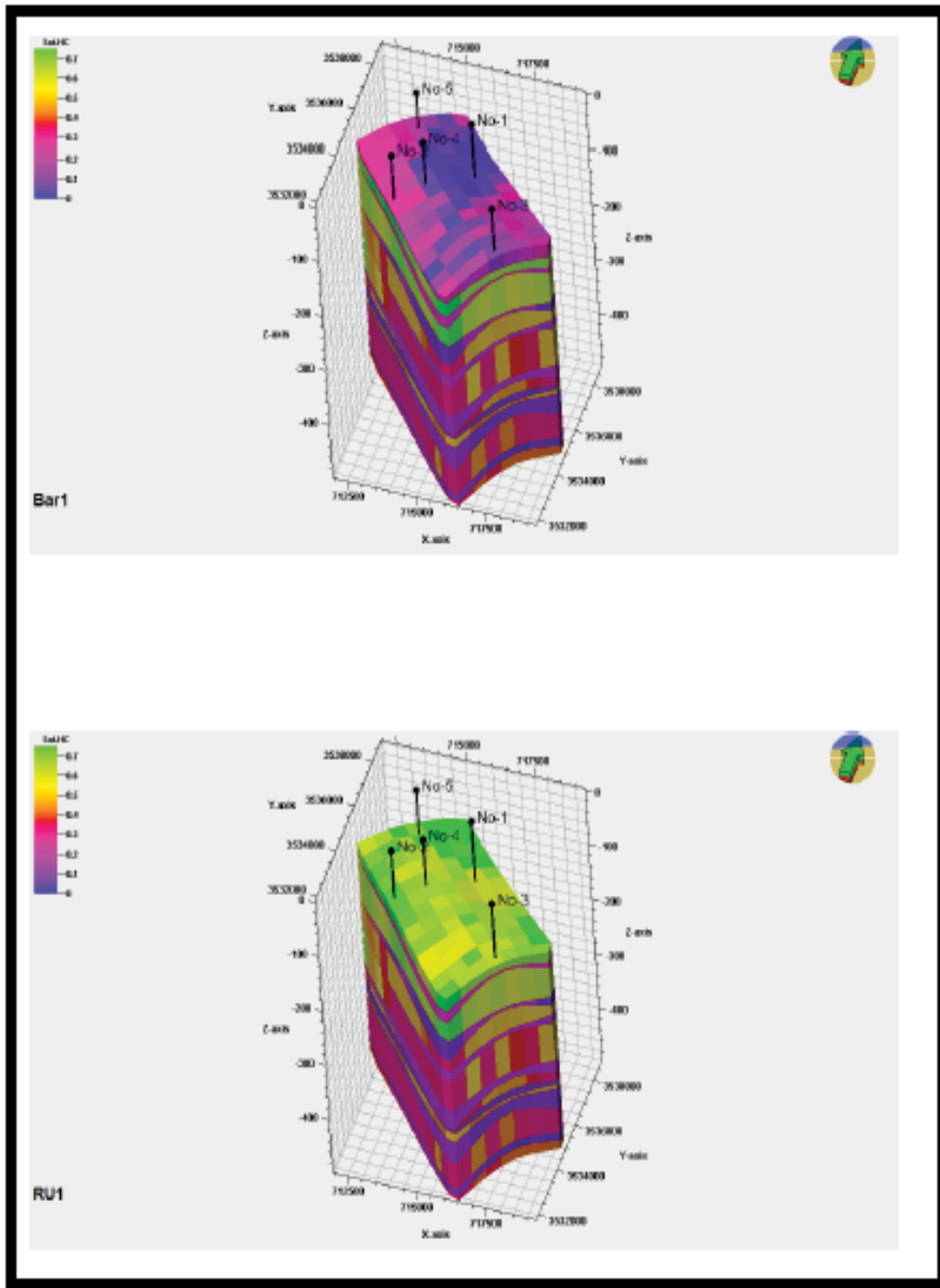
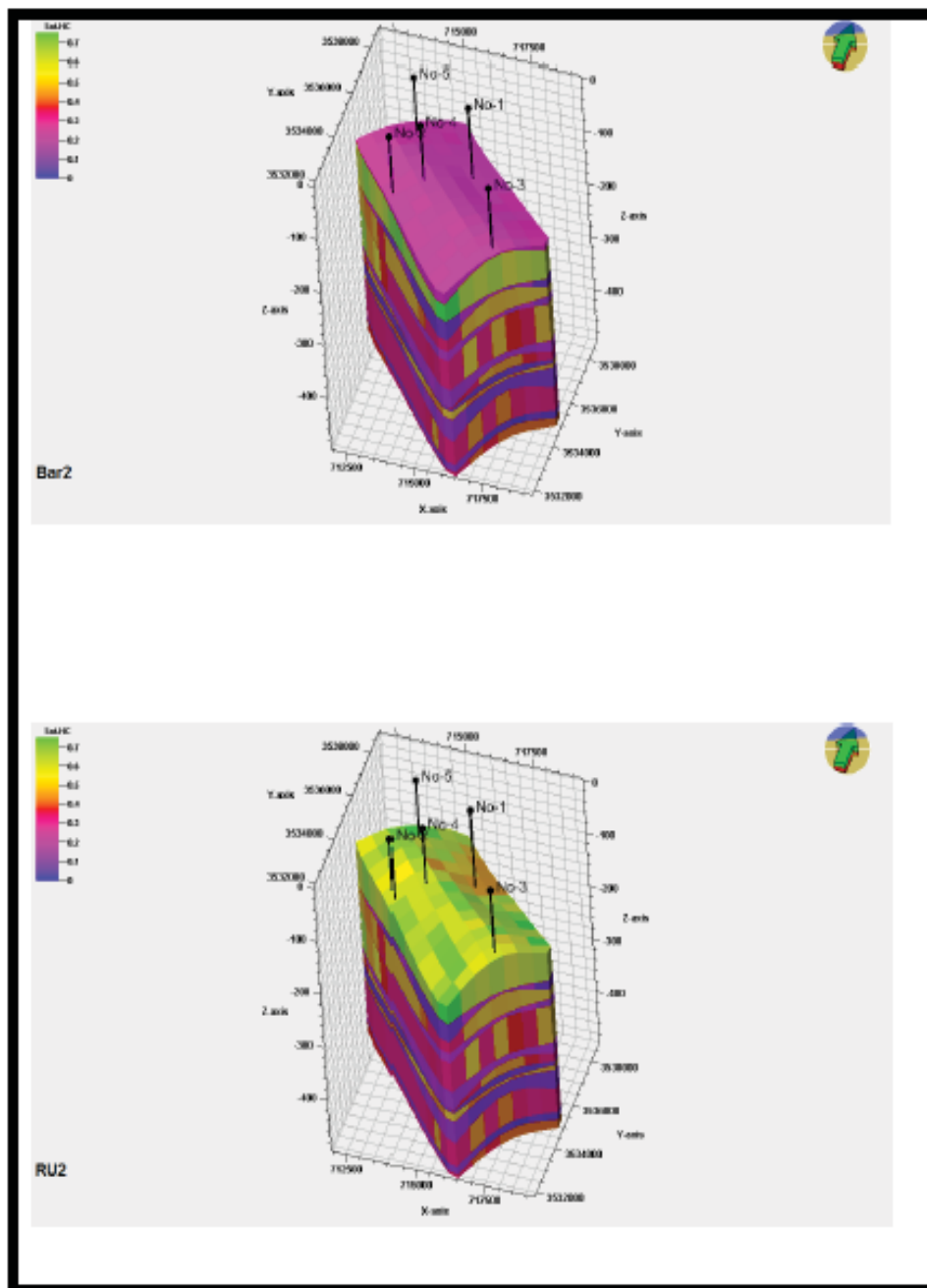**Fig .(7) shows the distribution of oil saturation into Mishrif units (Bar1 and RU1) at Noor oil field.**

Fig .(8) shows the distribution of oil saturation into Mishirf units (Bar2 and RU2) at Noor oil field.
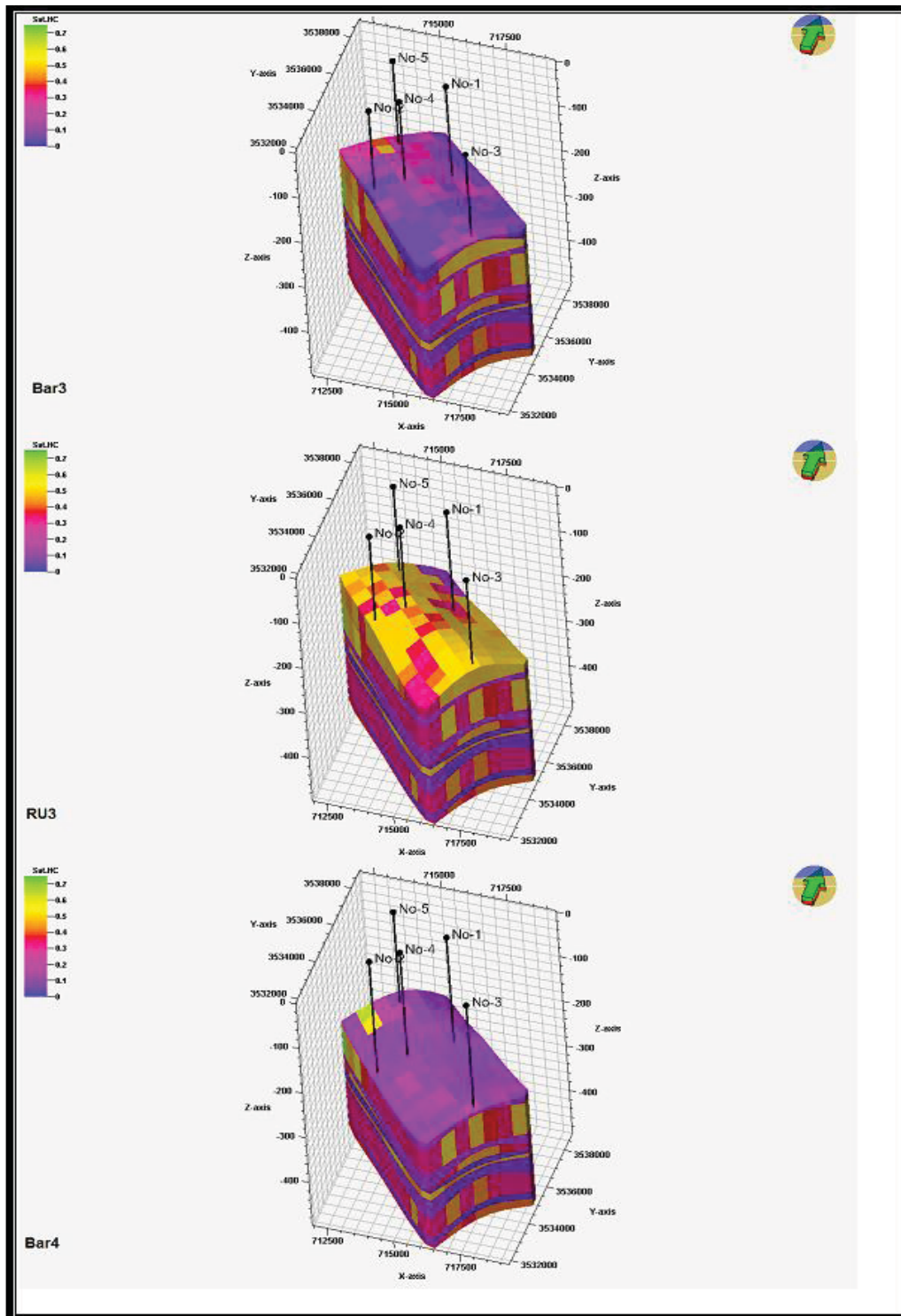
Fig .(9) shows the distribution of oil saturation into Mishrif units (Bar3, RU3, and Bar4) at Noor oil field.
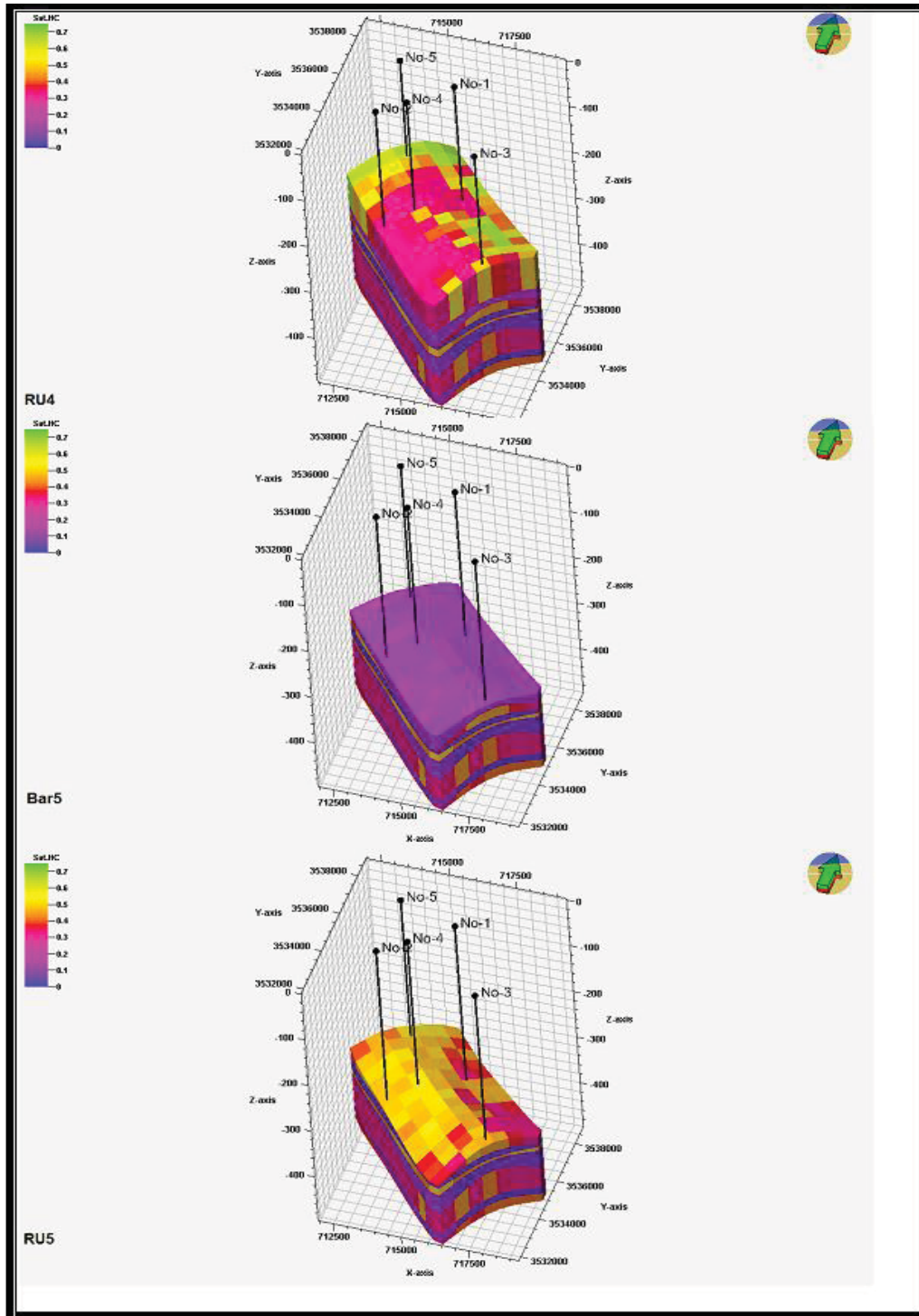
Fig. (10) shows the distribution of oil saturation into Mishrif units (RU4, Bar5, and RU5) at Noor oil field.
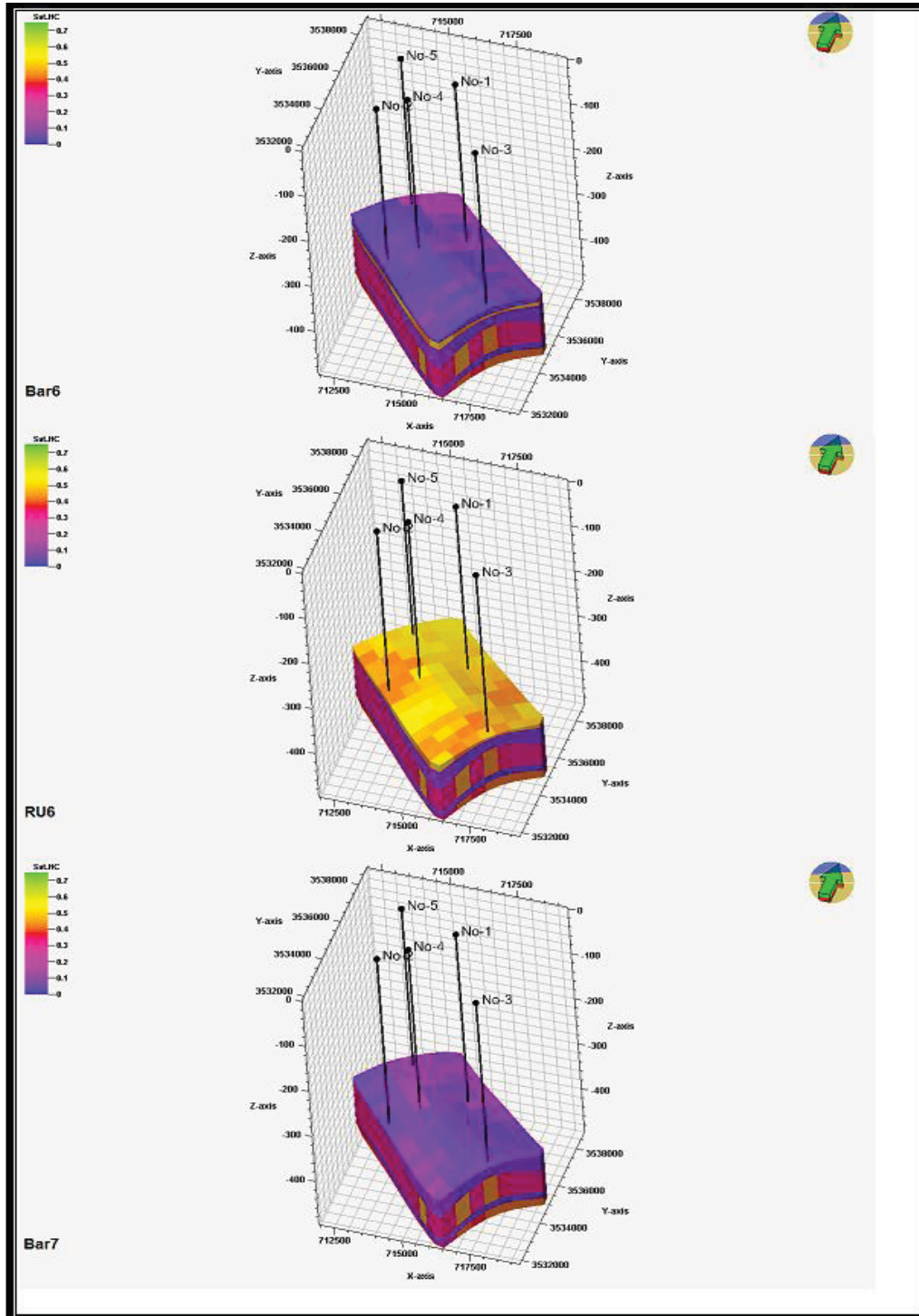
Fig .(11) shows the distribution of oil saturation into Mishrif units (Bar6, RU6, and Bar7) at Noor oil field.
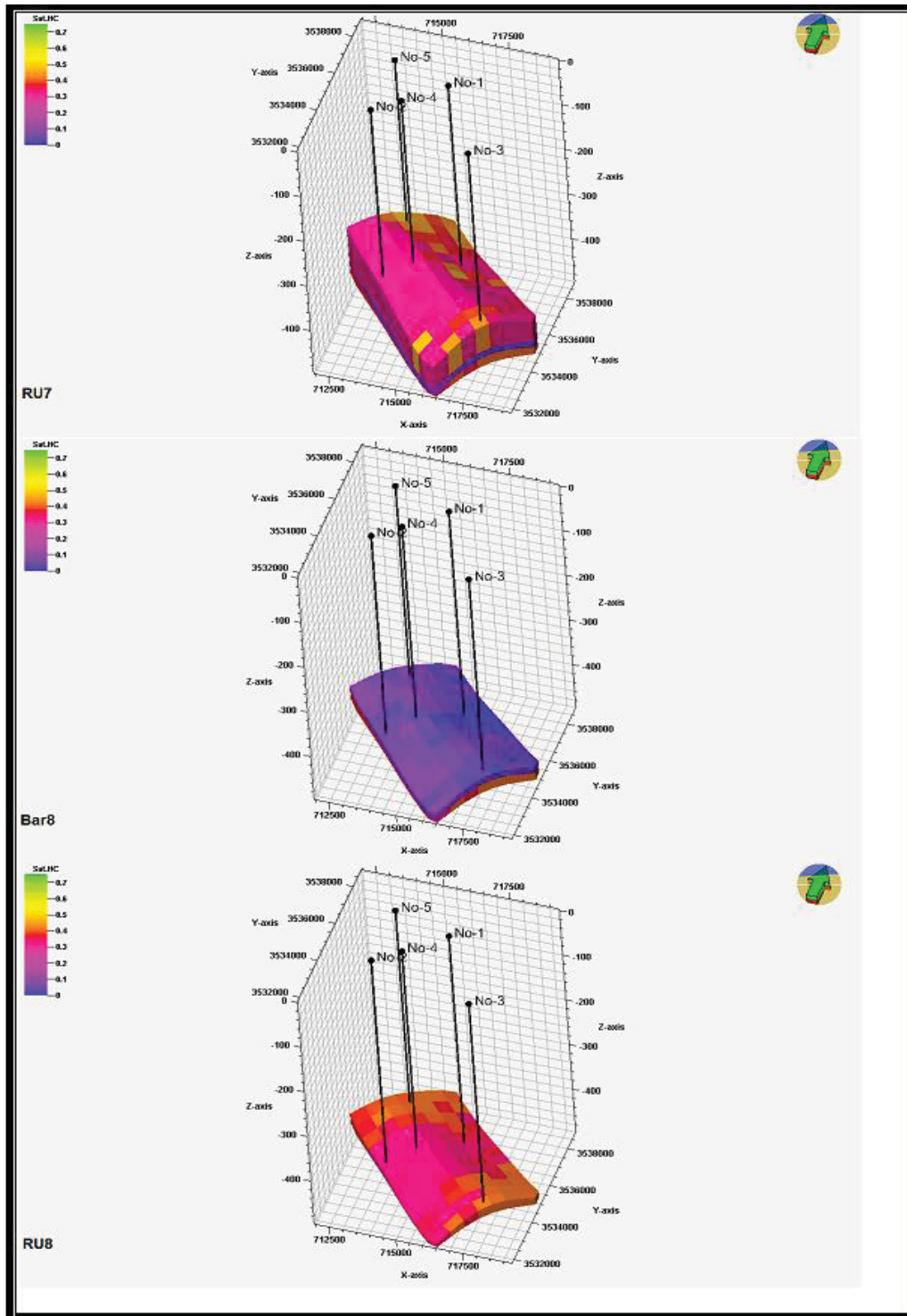
Fig .(12) shows the distribution of oil saturation into Mishrif units (RU7, Bar8, and RU8) at Noor oil field.

Results and Discussions

Interpretation of the results of the reservoir model

1-First Barrier Unit (Bar1): This unit thickness ranges between (7) meters at the well (No-2) locates at the west flank of the field. Reached thickness about (24 meters) at the well (No-3) south of the field, and on average (15 meters) for all wells of the field. This unit is characterized by poor porosity ranging between (0 - 0.1), which varies from one location to another. Is also characterized by an oil saturation of between (0 -0.3), with increases saturation towards west and north of the field at wells (No-2, and 5), respectively.

2 - First Reservoir Unit (RU1): This unit thickness ranges between 14 meters at the well (No-3) which locate at south of the field, and thickness (32) meters at the well (No-1) locates on the east flank of the field, and the average (22 meters) for all wells of the field. This unit is characterized by excellent porosity ranging between (0.15-0.25) in most parts of the field, such as porosity increases towards the wells located in the north of the field, especially at the well (No-5). Its oil saturation ranges between (0.6-0.8), which increases towards the north of the field at the well (No-5). This unit have high oil saturation, so that, it represents the important reservoir unit within Mishrif Formation at studied field.

3- Second Barrier Unit (Bar2): This unit thickness range between (3) meters at the wells (No- 3, 4, and 5) and thickness (13) meters at the well (No-1) which locates at the east flank of the field and on average (6) meters of all wells of the field. This unit is characterized by poor porosity ranging between (0 - 0.1). It has oil saturation about (0.3) in most of the wells of the field.

4- Second Reservoir Unit (RU2): This unit thickness ranges between (53) meters at the well (No-1) which locates at the east flank of the field and reached thickness about (79 meters) at the well (No-5) which locates at north of the field, whereas , reached average (63 meters) for all wells of the field. This unit is characterized by good porosity ranging between (0.15-0.2). Noted that the increase of porosity around north of the field. This unit has highly oil saturation range (0.65-0.8), it's increased toward the wells located in the central and north of the field as in the wells (No-2, 4, and 5).

5- Third Barrier Unit (Bar 3): This unit thickness ranges between (3) meters at the wells (No- 4, and 5) caught the central and northern field. Thickness reached (21 meters) at the well (No-1) which locates at east of the field, and its average (9 meters) to all anther wells of the field. This unit is characterized by poor porosity does not exceed (0.1) in most parts of the field. Also is characterized by an oil saturation of between (0.1-0.3), as saturation increases toward the wells located in the north of the field as well (No-5).

6- Third Reservoir Unit (RU-3): This unit thickness ranges between (15) meters at the well (No-1) which locates at east of the field. Thickness reached (61) meters at the well (No-2) which locates at the west of the field, whereas, reached thickness about (33 meters) for all wells of the field. This unit is characterized by porous medium (0.15-0.2), which increases to the north of the field at the well (No-5), while its oil saturation ranges between (0.4-0.6), with increasing saturation at the northern and southern sides of the field as in the wells (No-3, and 5).

7- Fourth Barrier Unit (Bar-4): This unit thickness ranges between (3) meters at the well (No-2) which locates at west of the field and its thickness (13) meters at the well (No-1) which locates at east of the field. Average thickness of this unit reached about (7 meters) in all wells of the field. This unit is characterized by poor to moderate porosity ranging between (0.0 - 0.15), with increasing porosity in the middle part of the field when the well (No-4). Also is characterized by an oil saturation of between (0.1-0.3), as varies saturation of one location to another within the wells of the field.

8- Fourth Reservoir Unit (RU-4): This unit thickness ranges between (57) meters at the well (No-2) in the west of the field, and thickness (81) meters at the well (No-5) in the north of the field. Average thickness reached about (71) meters for all wells of the field. This unit is characterized by good to very good porosity ranging from (0.2-0.3), is also characterized by an oil saturation of between (0.4-0.7), with increasing porosity and saturation oil toward the wells located in the north of the field as well (No-5).

9- Fifth Barrier Unit (Bar-5): This unit thickness ranges between (8) meters at the well (No-5) in the north of the field. Thickness reached about (22) meters at the well (No-1) which locates at the east of the field. Average thickness reached about (16) meters for all wells of the field. This unit is characterized by non-existent porosity ranging from a few to (0 - 0.1). Also is characterized by an oil saturation ranges between (0.1-0.2), which varies from one location to another within the wells of the field.

10- Fifth Reservoir Unit (RU-5): This unit thickness ranges between (8) meters at the well (No-2) in the west of the field, and thickness (27) meters at the well (No-5) in the north of the

field. Average thickness reached (17) meters for all wells of the field. This unit is characterized by good porosity ranging between (0.2-0.25), with increasing porosity toward the wells located in the west of the field as well (No-2) and the east in the field as well (No-1). Also is characterized by an oil saturation ranges between (0.4-0.6), where increasing oil saturations at western and central field around the wells (No-2, and 4), as well as, increasing the oil saturation in the north of field as in the well (No-5).

11-Sixth Barrier Unit (Bar-6): This unit thickness ranges between (9) meters at the well (No-1) in the east of the field. Its thickness reached (19) meters at the wells (No-2, and 4) which locates at central and west of the field, respectively. Average thickness reached about (16) meters for all wells. This unit is characterized by poor porosity reached a few do not exceed (0.1). Note that the porosity varies from one location to another within the wells of the field. Also is characterized by an oil saturation ranges between (0 - 0.3), with increases oil saturation toward north of the field at the well (No-5).

12-Sixth Reservoir Unit (RU-6): Ranges thickness of this unit between (5) meters at the well (No-3) which locates at south of the field. Reached thickness (11) meters at the well (No-1) which locates at the east of the field. Average thickness (8) meters of all wells in the field. Also, it has characterized porosity ranging (0.15 - 0.25). Note, the porosity increases towards the north of field at the well (No-5), while the oil saturation ranges between (0.55 - 0.65), with increasing oil saturation toward the wells which locates in the north of the field as well (No-5). As well as, noted that increasing oil saturation toward wells in the east and center of the field as in the wells (No-1, and 4), respectively.

13-Seventh Barrier Unit (Bar-7): Ranges thickness of this unit between (9) meters at the well (No-2) which locates at west of the field. Note, that the increase of the thickness at the well (No-1) which locates at east of the field, its thickness reached about (31) meters. Whereas, average thickness reached (18) meters for all wells field. Also, this unit characterized by porosity zero to a few so do not exceed (0.1) in most of the wells of the field. Is also characterized by an oil saturation of between (0 - 0.2), as oil saturation increases toward the wells located in the north of the field as well (No-5).

14-Seventh Reservoir Unit (RU-7): This unit thickness ranges between (50) meters at the well (No-1) to the east of the field, and thickness (70) meters at the well (No-2) in the west of the field. Average thickness reached (60) meters for all wells of the field. This unit is characterized by a rate of porosity (0.2-0.25) in most of the wells of the field. Is also characterized by an oil saturation ranges (0.4 -0.65), with increasing oil saturation toward the wells located in the north of the field as well (No-5).

15-Eighth Barrier Unit (Bar-8): Ranges thickness of this unit between (6) meters at the well (No-5) in the north of the field, and thickness (13) meters at the well (No-3) at south of the field. Average thickness (10) meters for all wells field. This unit is characterized poor porosity almost non-existent in all wells. Also is characterized by an oil saturation ranges (0 - 0.05) all wells in the field, and thus constituting a good barrier unit.

16-Eighth Reservoir Unit (RU-8): This unit thickness ranges between (13) meters at the well (No-2) in the west of the field, whereas it   thickness reached (22) meters at the well (No-5) in north of the field. Average thickness reached (17) meters for all wells of the field. This unit is characterized by moderately porosity ranges (0.1-0.15) vary from one location to another. Is also characterized by an oil saturation ranges between (0.4-0.5), as oil saturation increases when the wells located south and north of the field as in the wells (No-3, and 5), respectively.

.   Clear from the foregoing that the best wells in the oil saturations within the Noor field is the well (No-5) which locates at north of the field and the well (No-4) in the center of the field. While the best units in terms of oil saturation of reservoir unit is the second, fourth and first, respectively, taking into account the thickness variation of these units between wells of the field.

No.13 Journal of Petroleum Research & Studies (JPR&S)

References:

1. Al-Naqib, K.M., 1967.Geology of the Arabian Peninsula, Southwestern Iraq, U.S. Geol. Survey Prof. paper, 560-G, P. 54 .

2. Al-Saddoni, F. N., 1990. Principle of oil well logging for Geologist (in Arabic). College of Science, university of Baghdad., 338p.

3. Archie, G. E., 1944.The electrical resistivity log as an aid in determining some reservoir characteristics. Petroleum Technology, Vol. 5, Pp. 54- 62.

4. Bowen, D.G., 2002. Formation evaluation and Petrophysics, Jakarta, Indonesia, 194 P.

5. Dresser Atlas, 1979. Long Interpretation Charts: Houston, Dresser Industries, Inc., 107 P.

6. Hilchie, D. W., 1978. Applied open hole log interpretation. Golden, Colorado, 161 P.

7. Khyuikh, M. H., 1991. Well logs Interpretation (in Arabic), College of Science, Baghdad University, Al-Musal press. 218p.

8. Lucia, F. J., 2007. Carbonate Reservoir Characterization. An Integrated Approach, Second Edition. Springer- Verlag Berlin, Heidelberg, 336 P.

9. Rabanit, P. M. V., 1952. Rock units of Basrah area, BPC, unpublished report.

10. Razoian, A. M., 1995. Stratigraphic succession of Cretaceous period in southern Iraq and surrounded area (in Arabic), internal Report (unpublished), south oil company, 151p.

11. Schlumberger, 1997. Log interpretation charts, Houston, Schlumberger Wireline testing, and 193 P.

12. Tiab, D. and Donaldson, E. C., 1996. Petrophysical Theory and practice of Measuring Reservoir Rock and Fluid Transport properties; Houston, Texas, 706 P.

13. Wyllie, M. R. J. Gregory, A. R., and Gardner, H. F., 1958. An experimental investigation of the factors affecting elastic wave velocities in porous media. Geophysical, Vol. 23, PP: 459-493.