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3D geological modeling for Yamama reservoir in Al-Nasiriyah oil field Southern Iraq

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***Abstract*---**The geological modeling of an oil-bearing reservoir, which specifies the lithology and analyzes the petrophysical parameters of complex reservoir, its being created using Petrel software to construct reservoir models that describe and estimate porosity and water saturation distributions. 3D modeling of carbonate reservoirs has proven to be a highly effective technique for evaluate the economic benefit of the reservoir by estimating the formation petrophysical properties and calculating the oil reserves. The study aims constructed on evaluated Yamama formation in Four drilling wells (Nasiriyah-1, Nasiriyah-3, Nasiriyah-4, and Nasiriyah-5) entering the Yamama Formation of the Al-Nasiriyah field. In Al-Nasiriyah Oil field, and within the Lower Cretaceous Stratigraphic Column in the south of Iraq, the Yamama Formation is one of the most important reservoirs that deposited into shallow marine habitats throughout the (Valanginian- Early Hauterivian) period, that made up of reservoir and impermeable barrier units in the Al-Nasiriyah field, Yamama Reservoir units are divided into three reservoir units (YA, YB, and YC), with the YB reservoir unit subdivided into (YB1, YB2, and YB3) subunits. The main reservoir units are separated by four sharp impermeable barriers represented by (B1, B2, B3, and B4). Generally, the 3D Geological modeling concluded that the YB reservoir unit represents the best petrophysical properties reservoir unit represented by (highest porosity, lowest water saturation) with an average thickness of about (81.5-124.5 m) in most studied wells, while the YC reservoir is moderately Good after YB unit more than YA represents the lowest petrophysical Unit, where unit YB and YC represented Oil bearing zones that product of Oil percentage strong oil with gas in some intervals.

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***Keywords*---**Yamama formation, Al-Nasiriyah oil field, petrophysical characterization, 3D modeling of Yamama formation.

Introduction

The geological model of an area is used for modeling the distribution of the different geological, geophysical or petrologic properties of a subsurface body.To achieve the best results, this model contains all the available geological features of the area, as accurately as possible, in this case, the grid resolution is usually high, and the cell of the grid adapt to the presented geometry (Bartucz, 2009).Yamama Formation in the Al-Nasiriyah Oil field is one of the most important limestone reservoirs, which represented as non - homogenous carbonate rock that was deposited in the Lower Cretaceous from the major retrograde sedimentary cycle (Barriasian – Aptian) in Southern Iraq within the main retrogressive depositional cycle (Valanginian – Early Hauterivian), As well as, formations (Zubair, Shuiaba, Ratawi, Yamama, Sarmord, Garagu and Balambo) depict the depositional cycle as shallow basins (Budy, 1980).

The examinations of the petrophysical properties of Yamama development to appraise how much petroleum and the distinctions inefficiency among them.The 3D geological model for each unit especially the three hydrocarbon units comprising the Yamama Formation in 4 wells which are Ns-1, Ns-3, Ns-4, and Ns-5, distributed on the crest and flanks of the Al-Nasiriyah oil field structure were carried out in the present study that represented as Structural and petrophysical property Models (porosity and saturation) of Yamama formation. The fundamental objective was to assemble a 3D geological model for the Yamama reservoir in Al-Nasiriyah Oil Field includes a structural model as well as the petrophysical organization features (Porosity (Phi), Water Saturation (Sw)). The Stages will be displayed with images of the essential figures, and the software to be used is (petrel) programming.

Materials and Methods

Study Area

Al-Nasiriyah oil field located at the east of the Euphrates River, around 34 kilometers northwest of the city of Nasiriyah in Thi-Qar Governorate, At Mishrif surface reflection, it is approximately 38 km long and 13 km wide (According to INOC. in 1978).Al-Nasiriyah field was investigated by the Iraq National oil company (INOC) in 1975, by seismic review of the National oil company, where the survey has demonstrated the presence of convexity of NW-SE trend (OEC,1995).The field is situated on an unstable platform (zone of the Mesopotamian Basin) (Buday,1980).The Nasiriya structure was formed during the Miocene as a result of lateral movement connected to the Alpian orogeny, which resulted in the growth of the structure and an increase in capacity. that main oil aggregation zones in the field are Mishrif and Yamama formations. The long axis of the Al-Nasiriyah oil field Anticline structure shows the NW-SE trend. The size of the structure is around about 22 km in length and 10 km in width at top of each reservoir unit, run in parallel to and close to the Euphrates Boundary Fault,

especially between Samawa and Nasiriyah. They've been connected to the development of horsts and grabens along the fault zone. The basement of this subzone is typically 7-6 km deep, making it the shallowest unit of the Mesopotamian Zone (Jassim and Goff,2006). Where the Dip of the Southeast structural flank is about 1.4ºat the top of the formation and the Dip of the Northwest flank is about 0.99º, the structure shows that the dip is lesser at the North and South flanks. The study envelops of 4 wells represented by Nasiriyah-1, Nasiriyah-3, Nasiriyah -4, and Nasiriyah -5 that penetrated Yamama formation in this field. Fig1.

Tectonic and Structural Setting

As the extensional activities at the north of Arabian Plate framed the Early Cretaceous fracturing, the structural developments shaped toward the start of the Earlier Cretaceous, as well as the Valanginian basin, which was gained as a result of these processes in the Berriasiain era (Koop and Stonely, 1982).confirmed that events surrounding the Arabian plate's boundaries, such as the fracturing of Gondwanaland and subsequent collision with Asia, had an impact on the plate's structural history. At the end of the Jurassic and beginning of cretaceous, India separated from the southeast margin resulting in an uplift in western Arabia and clastic influxes covered the platform, according to (Schlager and Philip, 1990). the Early Cretaceous onlapped the Arabian Shield of central and western Saudi Arabia and from the Arabian Sea and Gulf of Oman in the south and east, northwest to Syria and, northeast to Iran, (AL-Sharaa, 2004). The structural role had a significant impact in determining the last configurations of the Yamama reservoir, which reaches out over various structural areas represented by:

- The Arabian Platform's stable shelf forms the western edge of the basinal (Salman subzone).
- The Mesopotamian foredeep is represented by the eastern edge of the basinal, which is located inside the unstable shelf.

The northern slant of Arabian stage, which passes near the Khider Alma-1 well and stretches out Kuwait borders, serves as a hinge between these two structural divisions. (Sadooni, 1993) .Al-Nasiriyah Oil Field situates on an unstable shelf near the Arab stage (Buday, 1984), precisely in the Euphrates subzone (Mesopotamian zone) (Al-Naqib,1967). Fig2. The Mesopotamian basin is a result of millions of years of accumulated organic material and various rocks, which have become part of its source rock, which generates hydrocarbon from the source, and the cap rocks, which act as a cap for these oil reserves (Aqrawi et al., 2010).it's essentially a flat terrain with a gentle slope from Northwest to Southeast towards the Arabian Gulf, which was historically referred to as the area between the Tigris and Euphrates Rivers, It is primarily covered by various types of Quaternary deposits, where Late Neogene sediments are exposed, with the exception of a few cases, no significant tectonic features visible on the surface.

In addition, the geomorphological features associated with recent fluvial accumulation, such as natural levees, river terraces, alluvial fans, flood plains, etc. are very common (Fouad, 2010) .The Euphrates subzone is located west of the

Mesopotamian zone, it is a monocline with short anticlines (less than 10 km) and structural noses that plunge to the Northeast. Longer NW-SE-oriented anticlines (20-30 km long) run in parallel to and close to the Euphrates Boundary Fault, especially between Samawa and Nasiriyah. They've been connected to the development of horsts and grabens along the fault zone. The basement of this subzone is typically 7-6 km deep, making it the shallowest unit of the Mesopotamian Zone (Jassim & Goff,2006).

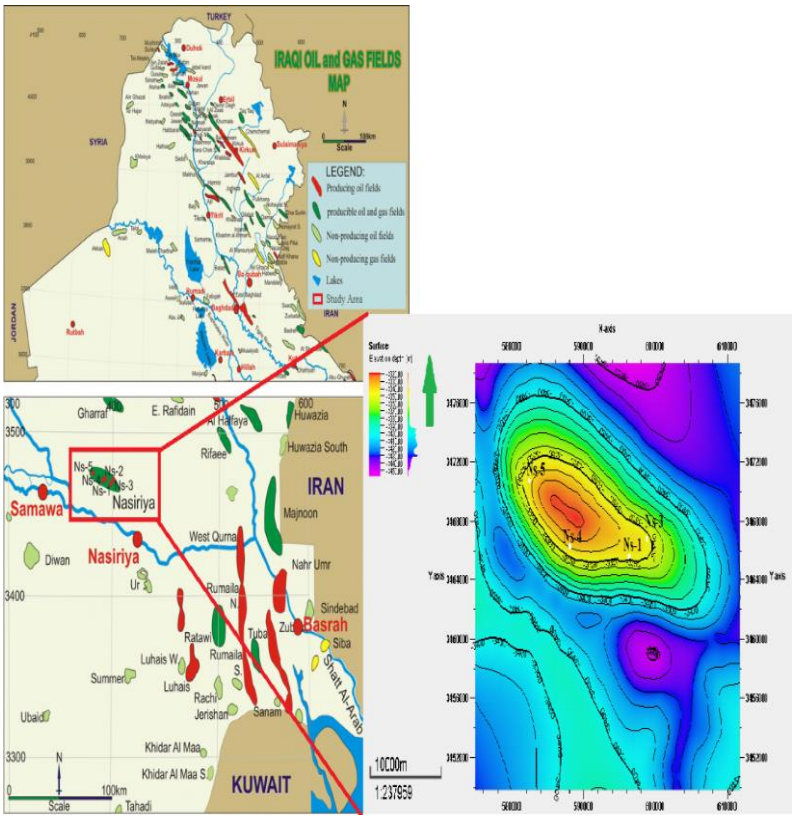

Fig 1. location map of the studied area and the Contour map of (Al-Nasiriyah oil field) (Al-Khafaji, 2015)

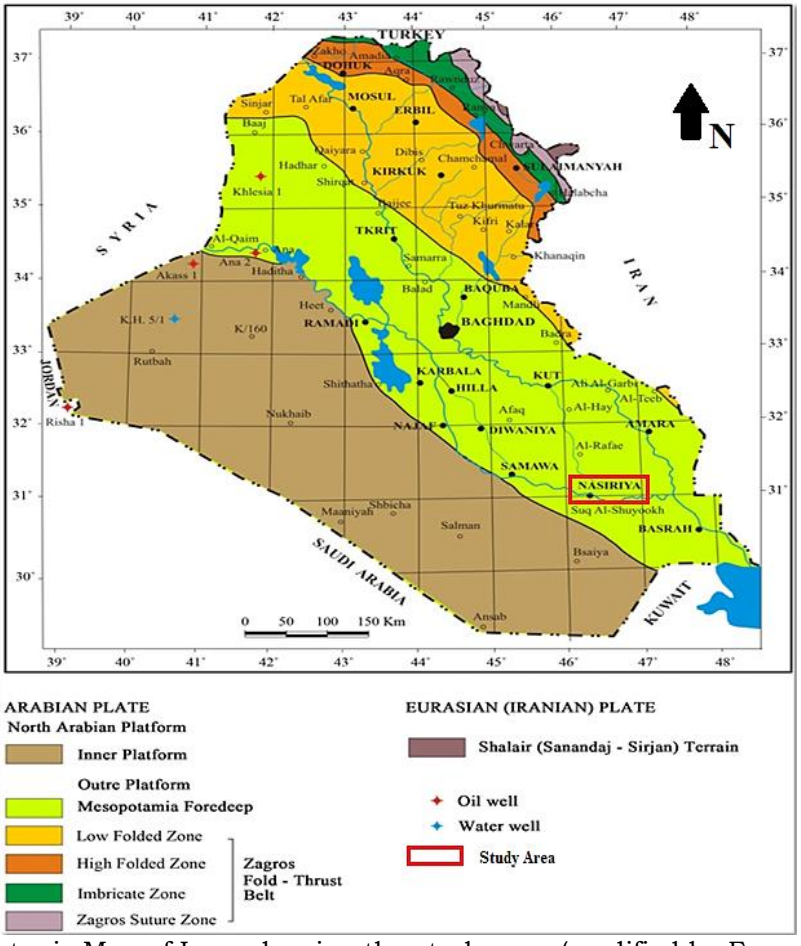

Fig 2. Tectonic Map of Iraq, showing the study area (modified by Fouad, 2012)

Research Methods

To construct a 3D Geological model, some have been applied steps as a data foundation:

- Using the (Didger) program, digitized the primary shape Map for the top of Yamama reservoir in Al-Nasiriyah field that applied as 2D seismic data from Iraqi Oil exploration company and stacked them into Petrel-Programming.
- Determining the petrophysics parameters of Yamama reservoir units that evaluated from Techlog Software.
- Creating a 3D geographical presentation includes the creation of (a structure model and a petrophysical property modelling) with Petrel programming (2017 v.).

Reservoir Modelling

The Modeling procedure represent as distribution of the different geological and petrologic properties of the subsurface body. as 3Dimensionals geo-model of a

simple petroleum reservoir will be built to reflected the relationships between reservoir litho-facies and petrophysical properties that are reflected by logs.The goal of reservoir studies is to develop and evaluate reservoir models that characterize and explain the spreading of porosity and water saturation (Flugel, 2010).To achieve the best results, this model contains all the available geological features of the area, as accurately as possible, in this case, the grid resolution is usually high, and the cell of the grid adapts to the presented geometry (Bartucz, 2009).

Modeling Workflow

The Petrel programming stage represents solving a full range of complex geological processes that demonstrate difficulties. Petrel is Windows-based programming for 3D perception, 3D planning, 3D supplies displaying, and Simulation. This study aims to introduce the ongoing practice of building a static Yamama reservoir model. The work process will continue with six significant structures:

- Data Import.
- Structure map.
- Vertical Layering (prepared by three processes generating three hierarchies: "Horizon" and "Layering".
- scale-Up in the Vertical Direction-Well Logs Scaling-Up.
- Petrophysical Modeling.
- Well Correlation. (Schlumberger, 2008).

Formation Units

Yamama reservoir was partitioned in to a few areas and units in the Al-Nasiriyah field, which clearly define the stratigraphic stretch and a sequence of petrophysical properties in the response of well log information, comprising three repository Units (YA, YB, and YC), where the YB Unit was subdivided into (YB1, YB2, and YB3) Subdivision units. These Reservoir Units separated by impermeable sharp units represent as barriers (Barrier-1, Barrier-2, Barrier-3, and Barrier-4). Table 1. shows Top and Bottom of each layer with their thicknesses in the concentrated-on wells.

Table 1
Top and Bottom of Yamama reservoir Units in The Studied wells (Nasiriyah-1, Nasiriyah -3, Nasiriyah -4, and Nasiriyah -5) in Al-Nasiriyah Oil field

Well No.	YA Reservoir Unit	YB Reservoir Unit	YC Reservoir Unit
Ns-1	3178-3224	3242-3328	3363-3400
Unit Thick	46m	121m	37m
Ns-3	3177-3222	3241-3327	3361-3421
Unit Thick	45m	81.5m	60m
Ns-4	3166-3214	3228-3316	3352.5-3388
Unit Thick	48m	124.5m	35.5m
Ns-5	3168-3213	3230.5-3318	3358.5-3388
Unit Thick	45m	81.5m	29.5m

The Stratigraphic boundary suggested from well logs and compared with similar available studies. top and bottom boundaries of the Yamama reservoir southern Iraq, which could be defined using the different responses of different logs . Generally, the upper boundary characteristic by the Ratawi formation above that consider the cap rocks for the Yamama formation when reading of Gamma-ray, Sonic, Neutron, and Density logs were low. The lower geologic boundary of the Yamama reservoir with Sulaiy formation contains mainly Argillaceous mudstone characteristic by distinctive SP and Gamma-ray deflection. Fig3

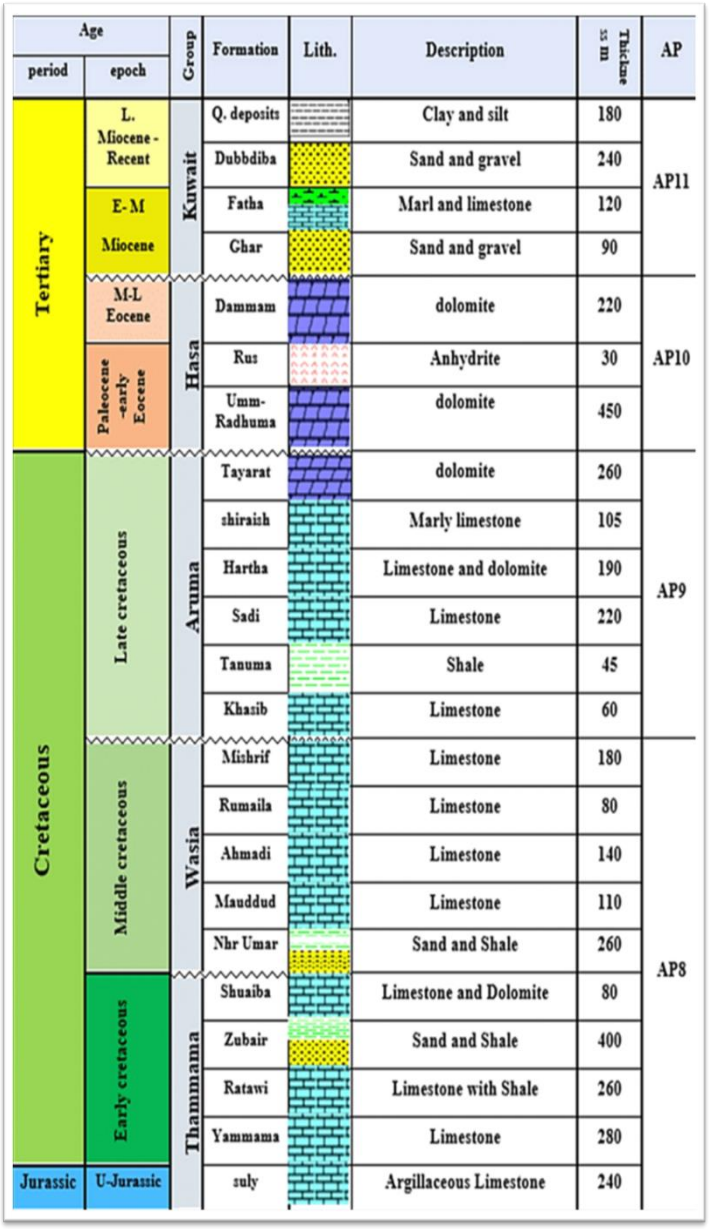

Fig 3. The Stratigraphic column of the Mesopotamian Zone southern Iraq. (Mahdi TA, Aqrawi AM., 2010)

Property Modeling

Petro physically modeling represents the reflection of distributing the continuous log properties to the whole reservoir and is represented by:

(PHI) Porosity Model

The porosity model was constructed relying upon the effects of porosity logs (Density (RHOB), Neutron (NPHI), and sonic (DT)) that modified and decoded in the intuitive petrophysics Techlog programming (Schlumberger, 2010). Figures 5, 6, 7, 8 and 9 show the distribution of the porosity in each reservoir unit in Yamama Formation Units (YA, YB1, YB2, YB3 and YC) respectively in Al-Nasiriyah Oil Field.

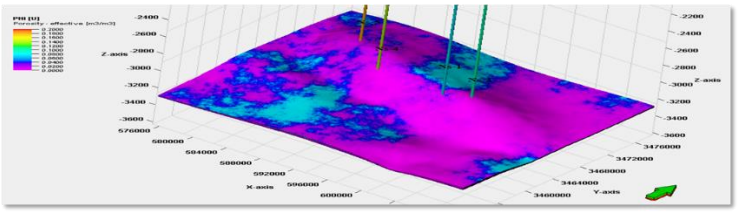

Fig 5. The porosity model of YA reservoir Unit in Al-Nasiriyah oil field

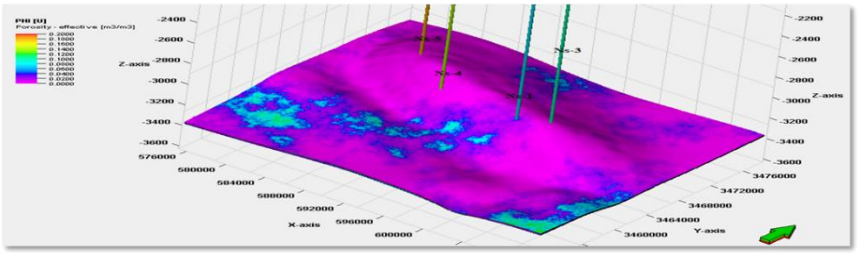

Fig 6. The porosity model of YB1 reservoir Unit in Al-Nasiriyah oil field

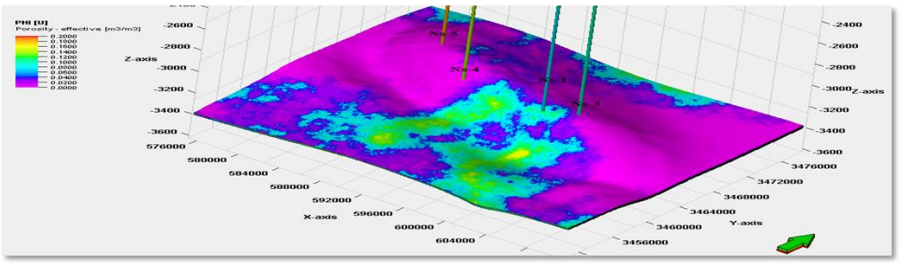

Fig 7. The porosity model of YB2 reservoir Unit in Al-Nasiriyah oil field

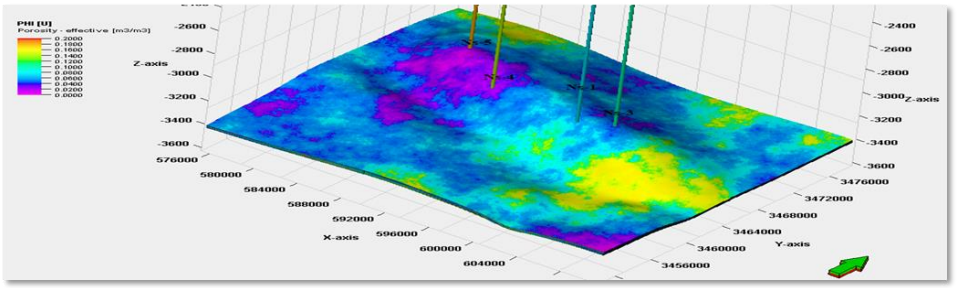

Fig 8. The porosity model of YB3 reservoir Unit in Al-Nasiriyah oil field

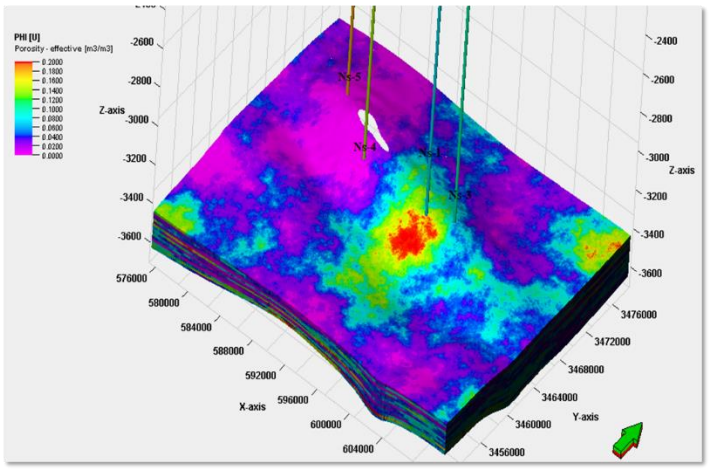

Fig 9. The porosity model of YC reservoir Unit in Al-Nasiriyah oil field

Yamama succession is divided into three main zones (YA, YB, and YC) Units, as a result, the interpretation of the log's porosity and porosity Modeling of Yamama reservoir unit divisions, the intersection of porosity distribution of Yamama formation in the Al-Nasiriyah oil field represents a completion identification method. Fig.10 shows Good effective porosity in the YB Reservoir unit in the studied wells which represent the best reservoir unit in formation, and the porosity distribution in the YC reservoir unit shows an improvement percentage from low-medium effective porosity in most of the Studied wells .while showing an improvement of the YA unit has been noted in the Ns-1 well represents a low-medium effective porosity, and generally YB reservoir unit represents the lowest porosity value.

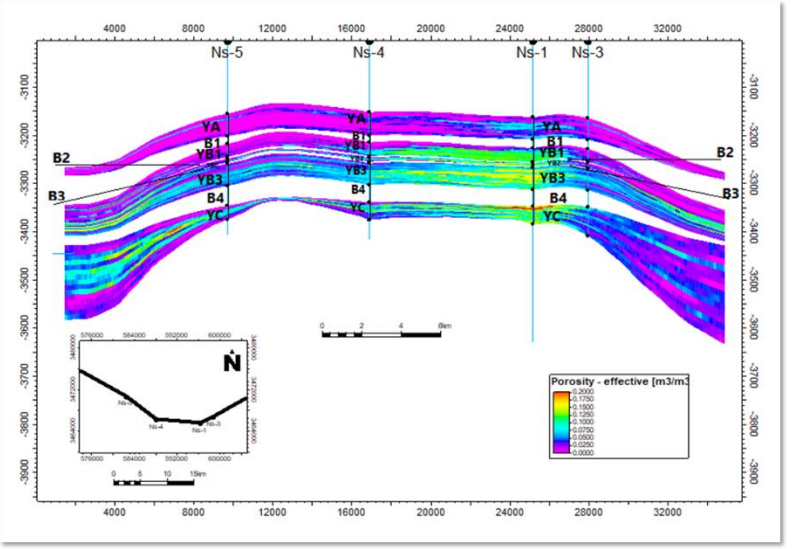

Fig 10. Porosity Distribution Intersection of Yamama formation in Al-Nasiriyah oil field

(SW) Water Saturation Model

After scaling up water immersion from Techlog programming for each supply unit of reservoir, the model of water saturation was developed .The SW-Model was worked for all reservoir units of the Yamama reservoir in the Al-Nasiriyah field, in the Figs. 11, 12,13,14,15, that shows the SW models of the reservoir units (YA, YB1, YB2, YB3 and YC) respectively. When interpolating between well logs to generate a saturation model, it is therefore important to take into account both petrophysical effects and capillary effects.

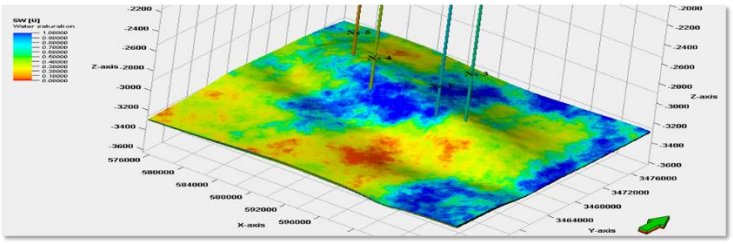

Fig 11. The SW model of YA Reservoir Unit in Al-Nasiriyah oil field

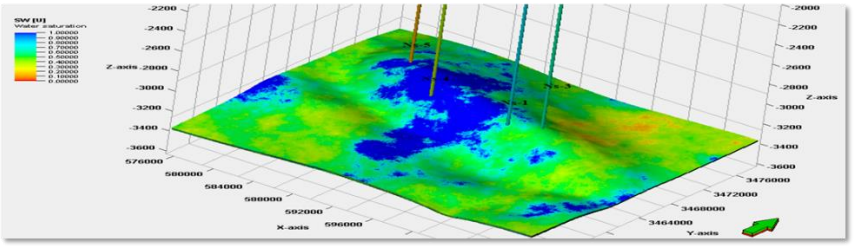

Fig 12. The SW model of YB1 Reservoir Unit in Al-Nasiriyah oil field

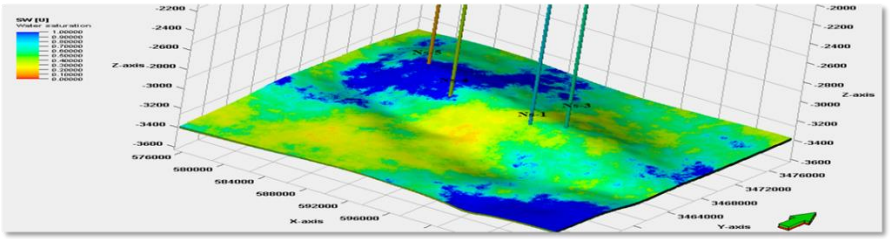

Fig 13. The SW model of YB2 Reservoir Unit in Al-Nasiriyah oil field

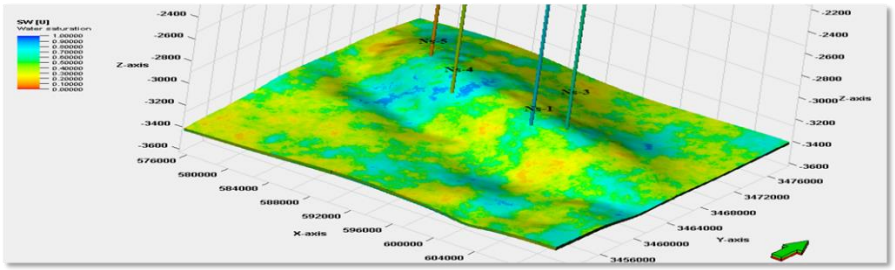

Fig 14. The SW model of YB3 Reservoir Unit in Al-Nasiriyah oil field

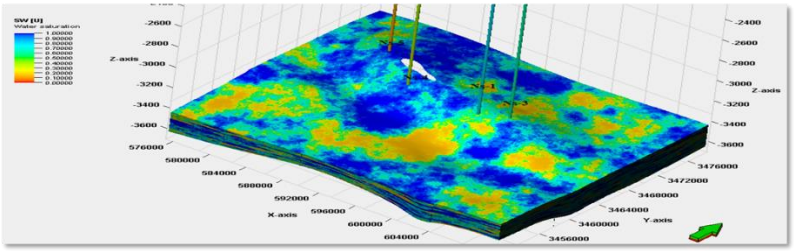

Fig 15. The SW model of YC Reservoir Unit in Al-Nasiriyah oil field

From these figures, and the general intersection of Water saturation Model of Yamama formation reservoir units in the Al-Nasiriyah oil field, shows that YA reservoir unit represent with (low-medium) percentage of water saturation, especially in Ns-4 and Ns-5 at middle and Northwestern part of field. While YC reservoir Unit reflect the high percentage of water saturation value among the Ns-3 and Ns-1 into trend South and Southeast, where, YB reservoir unit represent the low from YC reservoir unit, and reflect a high percentage of water saturation in YB1 unit in Ns-5 and Ns-4 into trending Northern and Northwest and decreasing toward the southern and southeastern part of field. Fig.16 .Generally, can detect the YB reservoir Unit as the best petrophysical properties, where the low water saturation and medium-high porosity rang. Unit YB1 has a percentage of water saturation of about (5-10%) in Nasiriyah-5 and Nasiriyah-4 wells.

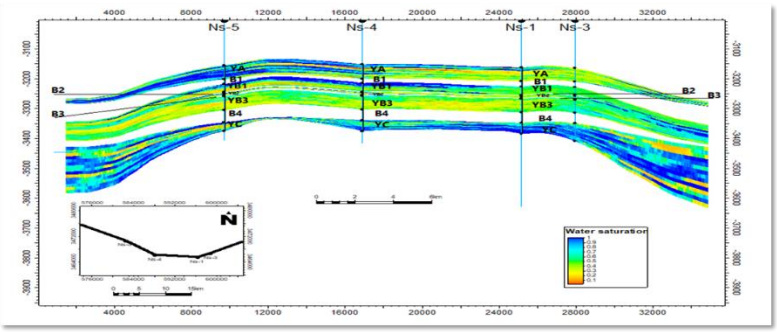

Fig 16. the SW intersection of Yamama formation in Al-Nasiriyah Oil filed

Results and Discussion

The 3D Geological Model of Yamama formation represented as Structural and Reservoir property (porosity and saturation) in three dimensions X, Y and Z in Al-Nasiriyah Oil field, Yamama formation in this field consist of Three Reservoir Units separated by low porosity Units YB1, YB2, YB3 and YB4, the following point can be showing the results of modeling and taking in consideration the values of porosity and water saturation determination to detect the best reservoir unit of Yamama formation that had a large capacity among the Formation:

- YA Reservoir Unit has average Thickness about (45-48 m) and porosity range between (3-7%) While the water saturation about (10-38 %) as showing in the Table 2.
- YB Reservoir Unit has average Thickness about (81.5-124.5 m) with porosity range between (5-15%) while the Water saturation about (25-59%).
- YC Reservoir Unit has average Thickness about (29.5-60 m) and average porosity between (6-18%) with water saturation about (24%).

Table 2
The Top, Bottom, thicknesses, average PHI and SW of Yamama formation in Al-Nasiriyah field

Well No.	R.T.K.B.	YA	YB	YC
Ns-1	15.70m	3178-3224	3242-3328	3363-3400
Unit Thick		46m	121m	37m
Ns-3	12.75m	3177-3222	3241-3327	3361-3421
Unit Thick		45m	81.5m	60m
Ns-4	13.56m	3166-3214	3228-3316	3352.5-3388
Unit Thick		48m	124.5m	35.5m
Ns-5	13.36m	3168-3213	3230.5-3318	3358.5-3388
Unit Thick		45m	81.5m	29.5m
PHI (%)		3-7%	5-15%	6-18 %
SW (%)		10-38%	25-59%	24%

Conclusion

- From the Water saturation model and porosity Modeling, showing that the YB is the best Reservoir Unit, which has a high Porosity with low water saturation, it represents the precibal oil-bearing unit in the formation, while YC has good petrophysical properties more than YA represents the lowest petrophysical unit.
- Generally, from the petrophysical Model and their intersections, the Authors concluded that Yamama formation at Al-Nasiriyah Oil Field has distinctive petrophysical properties that increase downward and Decrease toward the flanks of the structure.

Recommendation

The results of the research Qualify that to increasing the productive capacity, Iraqi Oil exploration company can drill wells between Ns-1 and Ns-4 and also between Ns-4 and Ns-5 according to the petrophysical properties in this part of Yamama formation in Al-Nasiriyah oil field.

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