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Calculation of Gaseous Storage and Building A 3d Geological Model for Jeribe Formation in Mansuriya Gas Field in Diyala Governorate

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Received: 20 August 2023 **Accepted: 31 October 2023**

DOI: https://dx.doi.org/10.24237/ASJ.02.04.823B

Abstract

Al-Mansuriya Gas Field is considered one of the important gas fields in Iraq because of its good economic gas reserves. The major gas reserves of the Mansuriya field are situated in the Jeribe formation. The period of formation deposition dates to the lower middle Miocene. The present study aims to build the three-dimensional geological model for Jeribe Formation in Mansuriya Gas Field using (Petrel) software. Drawing on well logging exported from Techlog software in LAS format. Four wells have been chosen in the Mansuriya gas field (MN_1, MN_2, MN_3, and MN_4) to construct structural and petrophysical (effective porosity, water saturation and lithology). After creating zones for Jeribe Formation, which was divided into 7 zones J1, J2, J3, J4, J5, J6 and J7, based on the final results of computer processing interpretation CPI was imported from techlog software. The three-dimensional grid of the Jeribe Formation model that was built consists of (10494848) cell and each cell have dimensions I =272 * J = 371 * K =104. Petrophysical models (effective porosity, water saturation and lithology) had been constructed for each zone of the Jeribe Formation which showing the J2, J3, J4 and J5 are important reservoir units in terms of their good properties (high effective porosity, low water saturation). Two types of lithology appear (dolomite and limestone) in different proportions to each unit. The results showed that units J1 and J6 are non-reservoir units that do not contain gas because they consist of layers of anhydrite with very low porosity. The mn-4 well showed different results from the other wells, and none of its units can't be considered a reservoir due to the large water saturation volume.

Keywords: Jeribe Formation, 3D geological model, Mansuriya Gas Field, Petrel software.

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حساب الخزين الغازي و بناء النموذج الجيولوجي ثلاثي الابعاد لتكوين الجريبي في حقل المنصورية في محافظة ديالى

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الخلاصة

يعتبر حقل غاز المنصورية من حقول الغاز المهمة في العراق بسبب الاحتياطيات الاقتصادية الجيدة من الغاز ، احتياطيات الغاز الرئيسية في حقل المنصورية الواقع في تكوين الجريبي ، وتعود فترة ترسيب التكوين إلى أسفل المايوسين الاوسط.
تهدف الدراسة الحالية إلى بناء نموذج جيولوجي ثلاثي الأبعاد لتكوين الجريبي بحقل غاز المنصورية باستخدام برنامج Petrel. يعد بناء نموذج جيولوجي ثلاثي الأبعاد من البيانات الميدانية وتحت السطحية المهمة في الدراسات الجيولوجية التي تشمل تقييم الموارد الطبيعية وتقييم المخاطر. بالاعتماد على سجلات جس الآبار المصدرة من برنامج Techlog بتنسيق LAS. تم اختيار أربعة آبار في حقل غاز المنصورية (MN_1 ,MN-2, MN-3, MN-4) لإنشاء الموديل التركيبية وبتروفيزيائية (المسامية الفعالة ، تشبع الميائي والصخارية). أظهر النموذج الهيكلي أن حقل غاز المنصورية يتكون من طية واحدة طويلة غير متماثل باتجاه NW-SE يبلغ طوله حوالي 30 كم وعرضه من 7 إلى 8 كيلومترات و الانغلاق التركيبي بحوالي 70 كم في قمة تشكيل الجريبي.
بعد إنشاء الموديل لتكوين جيريبي ، والتي تم تقسيمها إلى 7 مناطق J1 و J2 و J3 و J4 و J5 و J6 و J7 ، اعتمادًا على نتائج التفسير النهائية لمعالجة الكمبيوتر CPI باستخدام برنامج (Techlog).
تتكون الشبكة ثلاثية الأبعاد لنموذج تكوين الجريبي الذي تم بناؤه من (10494848) خلية وكل خلية لها أبعاد I = 272 * J = 371 * K = 104. تم إنشاء الموديل البتروفيزيائية (المسامية الفعالة ، والتشبع بالماء والصخارية) لكل منطقة من مناطق تكوين جيريبي تظهر أن J2 و J3 و J4 و J5 هي وحدة خزان مهمة من حيث الخواصة البتروفيزيائية (المسامية الفعالة العالية ، انخفاض تشبع الماء) ويظهر نوعان من الصخارية (الدولومايت والحجر الجيري) بنسب مختلفة لكل وحدة. أظهرت النتائج أن الوحدتين J1 و J6 هما وحدتان غير مكمنيتين ولا تحتويان على غاز لأنهما تتكون من طبقات من الأنهيدريت ذات مسامية منخفضة للغاية. اضهرت النتائج ان البئر MN-4 مختلف عن باقي الابار ولا يمكن غازي اعتباره مكمن بسبب محتوى التشبع المائي الكبير في البئر.

الكلمات المفتاحية : تكوين الجريبي, نموذج جيولوجي ثلاثي البعاد, حقل المنصورية, برنامج بيترل.

Introduction

This study uses Petrel software to create a three-dimensional geological model of Jeribe Formation in the Mansuriya Gas field. The period of formation deposition dates back to the lower middle Miocene. This Three-dimensional (X, Y, and Z) Structure, lithology, and reservoir characteristics (porosity and water saturation) are all included in this model. Geological modeling is an applied science that involves building digital images of various parts of the Earth's subsurface, particularly gas or oil fields. Realistic geologic models are needed in the gas and oil sector for use in reservoir simulator programs, which forecast how rocks will behave in different hydrocarbon recovery situations. Reservoir engineers can determine which recovery options give the safest and most economical, efficient, and effective development plan for a specific reservoir by using reservoir simulation. [1]

In geological studies involving the assessment of hazards and the evaluation of natural resources, it is common practice to set up a three-dimensional geological model using subsurface data [2]

Study of area

Al-Mansuriya Gas Field is located in Diyala Governorate, northeast of Baqubah, about 50 km away from it, and about 102 km away from Capital Baghdad towards the northeast and southwest of the Hamrin Lake, as shown in Figure (1). The field area's overall landscape features gentle hills and is partially submerged in water. The field occurs in Block 45. The field covers an area of about 150 km^2 and was discovered in October 1979. The Mansuriya structure is an asymmetric anticlinal extending in a northwest-southeast direction, about 5-6 km wide and 25 km long [3].

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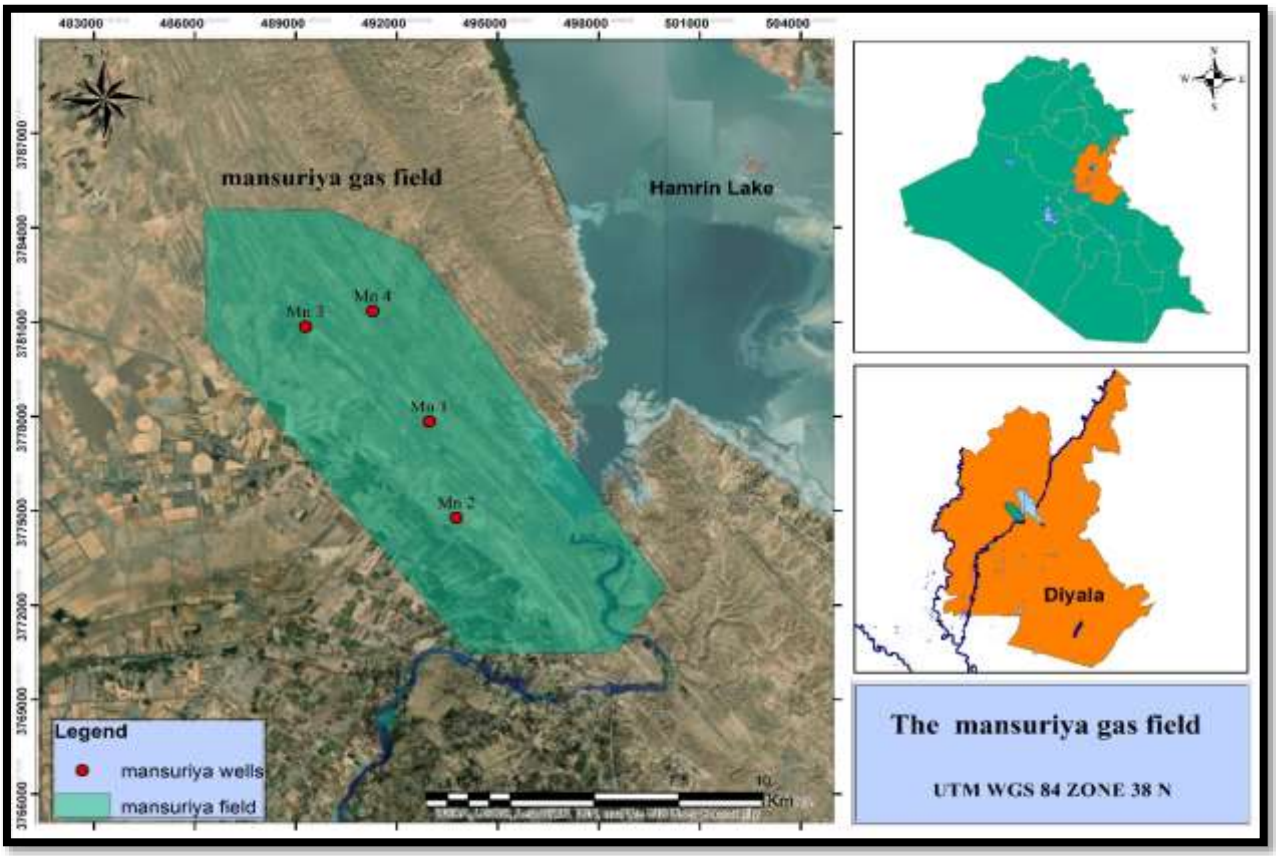

Figure 1: Location map of the study wells

Materials and methods

Georeferencing

Before beginning a geological modeling project, georeferencing is the first stage in which all information is gathered and put into a common coordinate system. Selecting the right value for the coordinate system is a crucial stage in defining the project's parameters. WGS 1984 UTM, Zone 38 North have been introduced as the coordinate system for this study in accordance with the study area.

Data Import

Petrel allows the import of almost any form of data, including lines and points, 2D trends,2D grids (depth, isochors and time grids, well tops, and more data). There are different types of well data, including.

Well heads

Well-heads of 4 boreholes of Mansuriya field are imported to the Petrel software. They are imported to Petrel software along with position (eastern, northern), "Rotary Table Kelly Bushing" (RTKB), and the overall depth for each studied well.

Well tops

The tops of the wells that constitute the markers for each reservoir unit in the Jeribe Formation as well as their total depths have also been imported**.**

Well logs

The four wells of the mansuriya gas field that have been imported to the Petrel program include Well logs (SP, gamma ray, resistivity logs, neutron, density, and sonic), as well as CPI (lithology, water saturation and porosity).

Results and Discussions

Well Correlation

Well correlation concepts may help to clarify the distribution of petrophysical characteristics, thickness and extents of various lithological zone in formation [4]. Correlations have been used in this study as a reasonably simple way to offer information and allow simple visualization of the changes in thickness within Jeribe units and the change in petrophysical characteristics.

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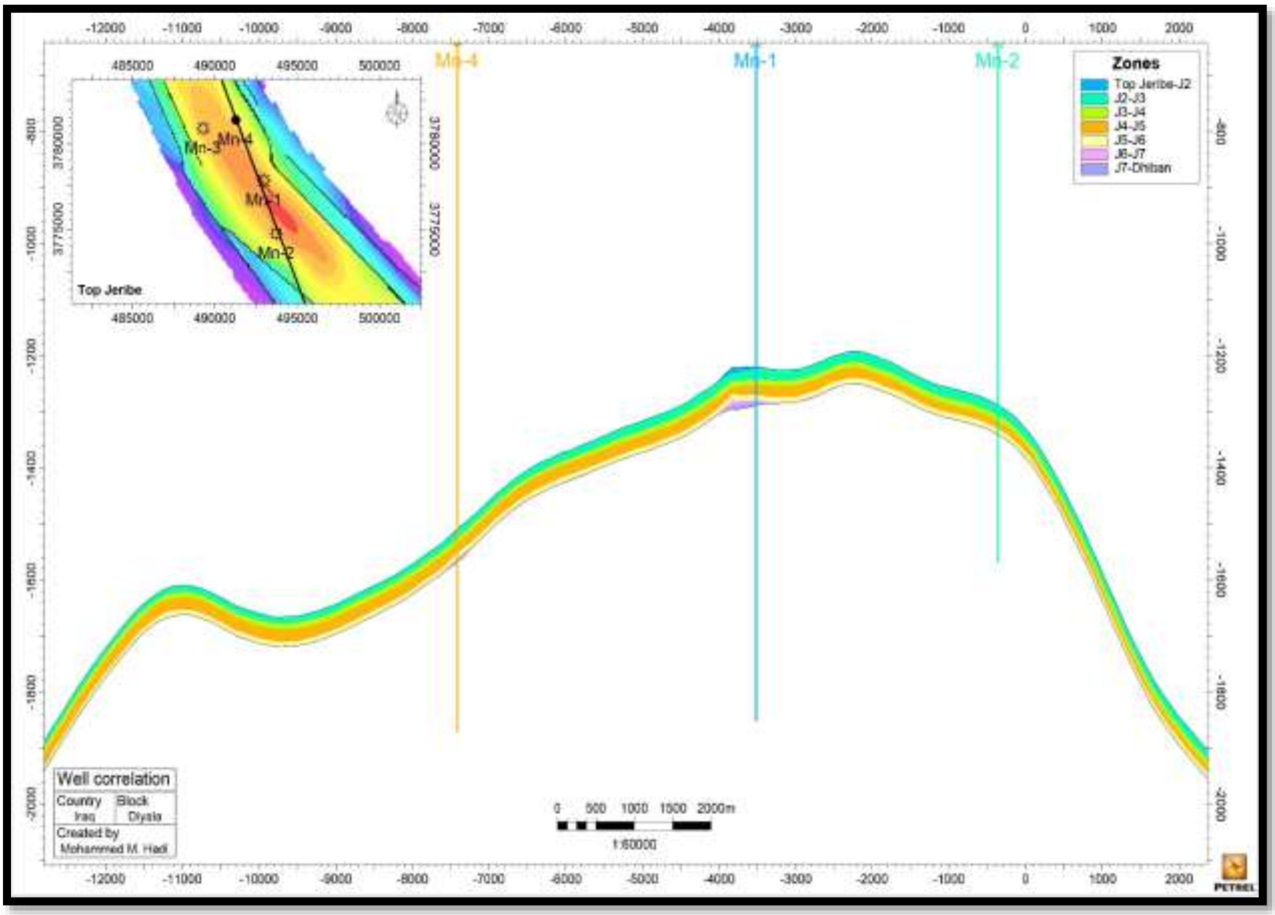

Figure 2: shows these correlation sections of mansuriya wells. The first one represents a horizontal section that includes three wells (Mn-1, Mn-2, and Mn-4).

Structural Modeling

Structural modeling represents setting up a structural contour map for each unit in Jeribe Formation. It is split into three separate processes: vertical layering, pillar gridding, and fault modeling. To create one single data model, all three processes are carried out sequentially. [5] Computers can create contour map using data from correlated boreholes and the surface. [6] Figures (3) show 3D structural contour maps for Jeribe Formation. The structural contour map show the current image of AL-Mansuriya structure composed of a symmetrical anticline fold with an axis trending NW – SE, a length of structure of about 25 Km and a width of about

6 Km, with a structural closure of about 70 m. This map reflect the steps of the growth of the dome structure of the Jeribe Gas Field.

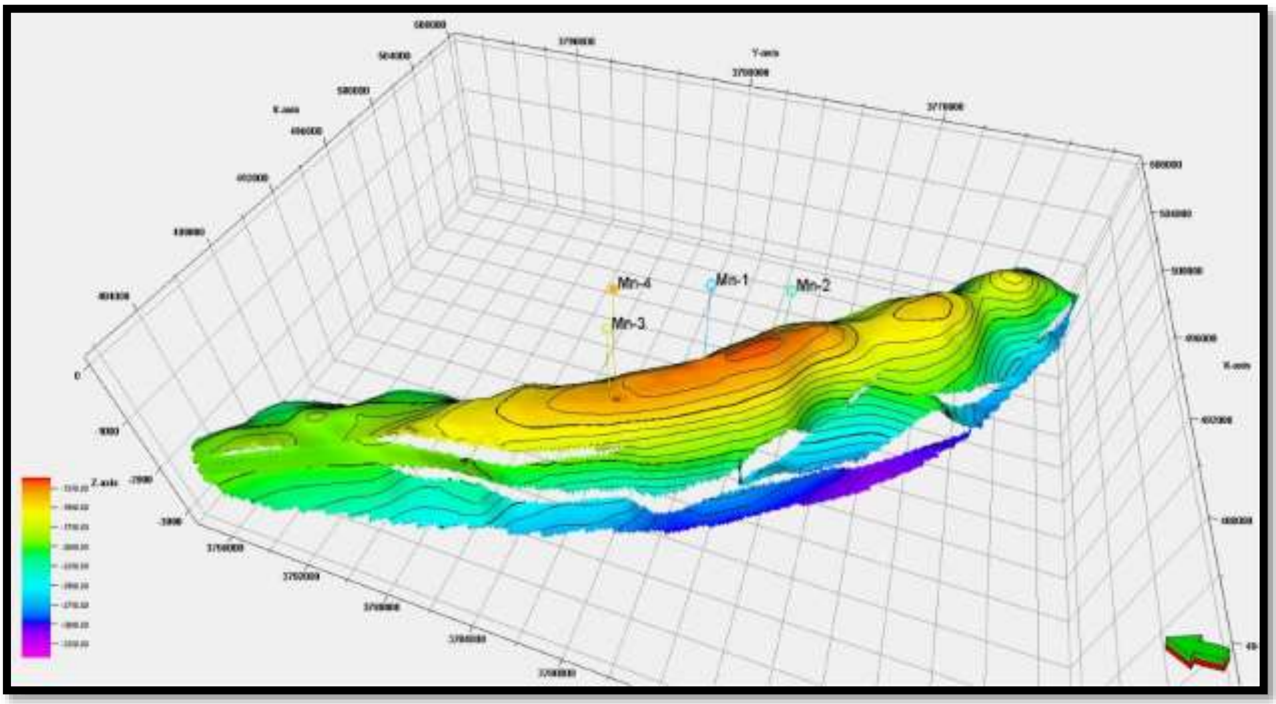

Figure 3: 3D Structure Model of Jeribe Formation in the Mansuriya Gas Field.

Fault Modeling

The 2D surface model went through the fault model process for obtaining 3D grip model. Fault polygons from 2D seismic interpretation are converted to fault planes. And the model with seven faults (treated as vertical faults) was constructed after some plane editing and fault connection making (Figure 4).

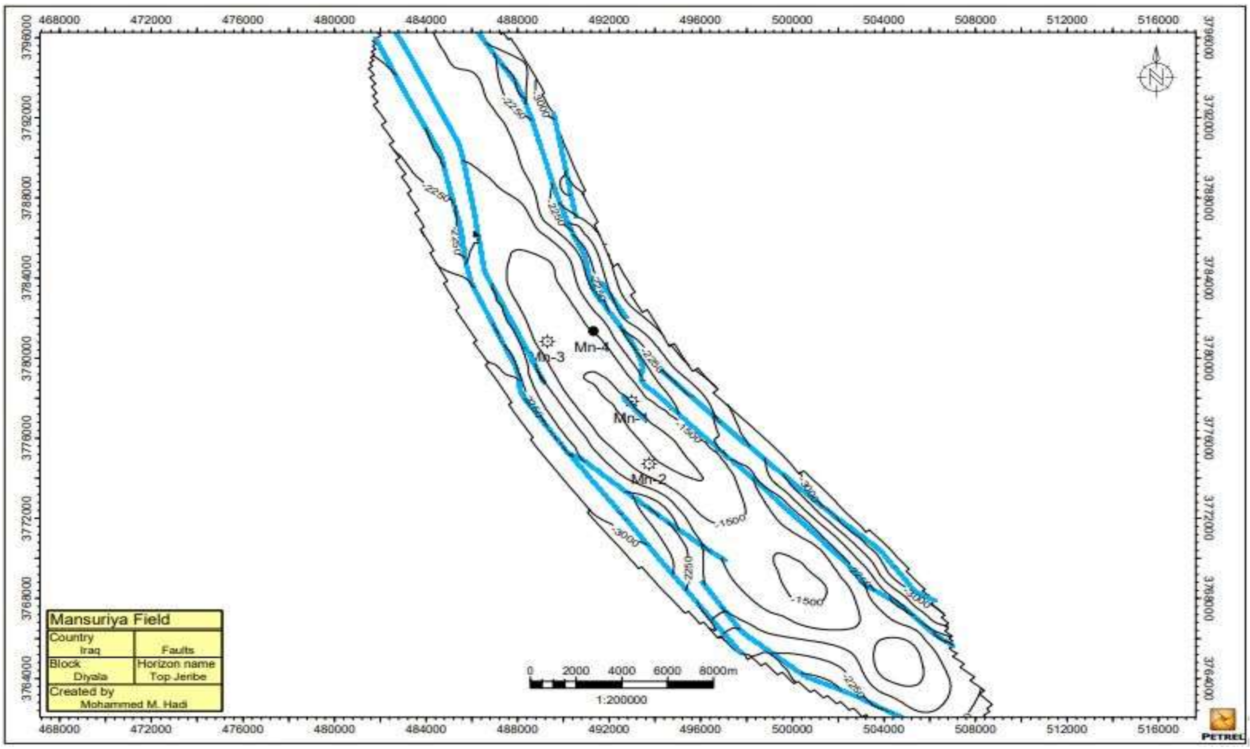

Figure 4: Fault model of Jeribe Formation in the Mansuriya gas field.

3D Grid Construction

A three-dimensional grid divides a model into boxes, each of which is referred to as a grid cell. Each grid cell will has a single rock type, a single value for porosity and for water saturation, etc [7]. The first stage in setting up the 3D model is to create a 3D grid. These are referred to as the cell's properties. This is a simplification of the true situation but allows us to produce a representation of reality that can be used in calculations, etc.[8]. The description of grid cells :

Grid cells(nI *nJ *nk) = 272 *371*104

Total number of grid cells =10494848

Pillar Gridding

The Grid generation is the first step in the modeling process. Top, Mid, and Base skeleton grids are known as pillar gridding [4].

By using the Pillar Gridding, the three-dimensional grid model of the Jeribe Formation in the Mansuriya gas field has been constructed. The top, middle, and base skeletons on the pillar gridding's output are the main skeletons. (figure- 5).

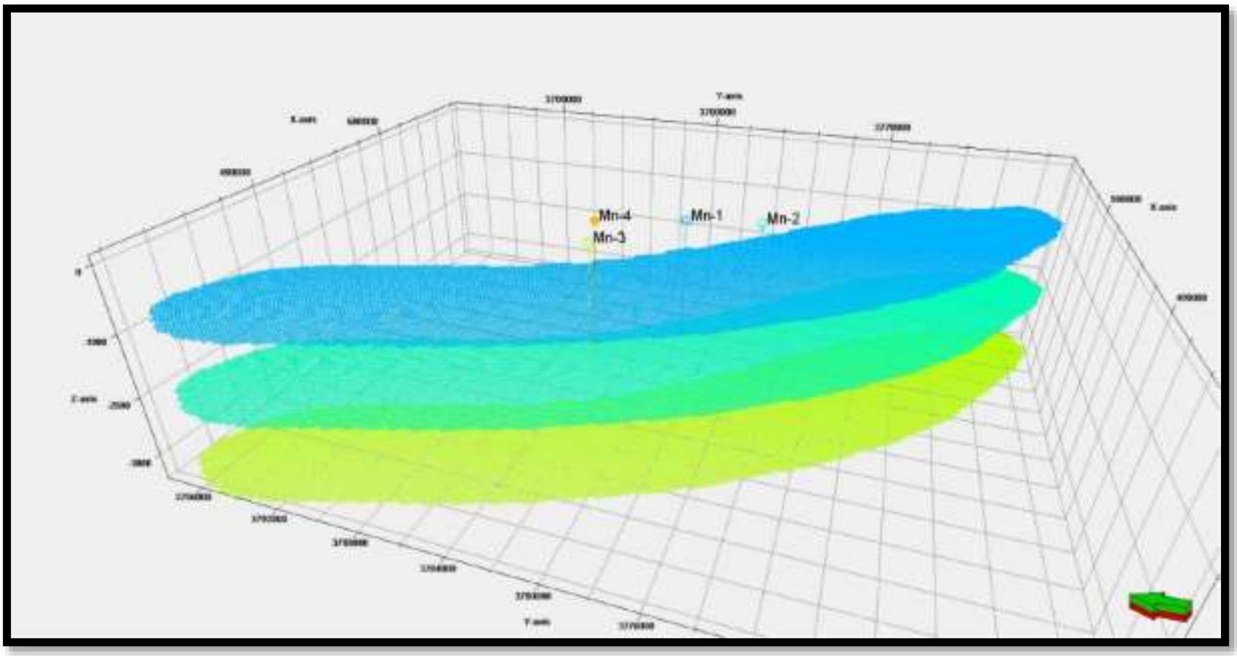

Figure 5: The skeletons of the Jeribe Formation in the Mansuriya gas field.

Horizons

Inserting the structural boundaries into the pillar grid is the following stage in structural modeling. this is an important step in the process of creating the vertical layering of the 3D grid by using relative distance to already existing horizons, the contraction of horizons creates separate geological horizons from X, Y, and Z input data. [7]

Layering of the geological model

The structure is finally divided vertically by layering (figure-6). Layering is defined as the internal layering representing the geological deposition of a particular zone; it will be a component of the zone but will not act as a direct filter like the zones do. [5]

By including thickness information in the shape of isochore maps, constant thickness, and percentages zones can be added to the model. The top constructions can also be connected to the well picks using well tops. [9] Layers subdivide the grid between the zone- related horizons [7]. Table (1) represents the layering of The Jeribe zones.

Table 1: Layering of The Jeribe units.

Zone name	Color	Layering method	Layering type	
Top Jeribe-J2		Proportional	Number of layers	3
J2-J3		Proportional	Number of layers	12
J3-J4		Proportional	Number of layers	8
J4-J5		Proportional	Number of layers	12
J5-J6		Proportional	Number of layers	8
J6-J7		Proportional	Number of layers	3
J7-Dhiban		Proportional	Number of layers	5

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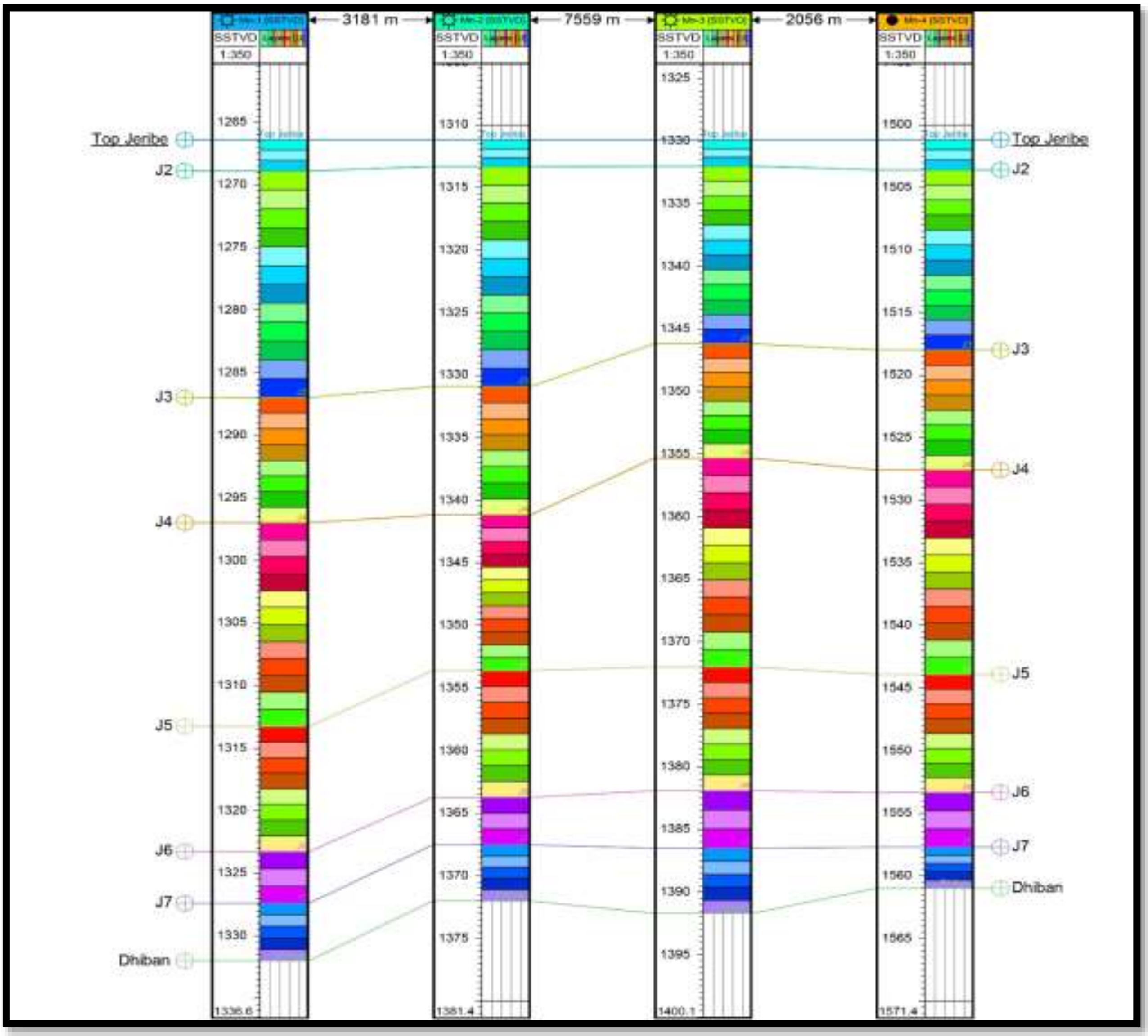

Figure 6: The Layering of the Jeribe Formation in the Mansuriya gas field.

Scale up Well logs

The scale up technique averages the values to the 3D grid units' cells that the wells penetrate. The scaling up of PHIE and SW logs for all wells in the Mansuriya Gas Field's Jeribe Formation is shown in Figure (7) in the correlation window. Every cell unit receives one value from the upscaled log. In order to represent properties, these cellular units are later employed as a starting point [5].

Scaling up statistics can be done using several kinds of methods, including geometric, arithmetic and harmonic methods. The current model's porosity and water saturation values were scaled up using the (arithmetic) method, whereas the lithology was scaled up using (most of) the available methods.

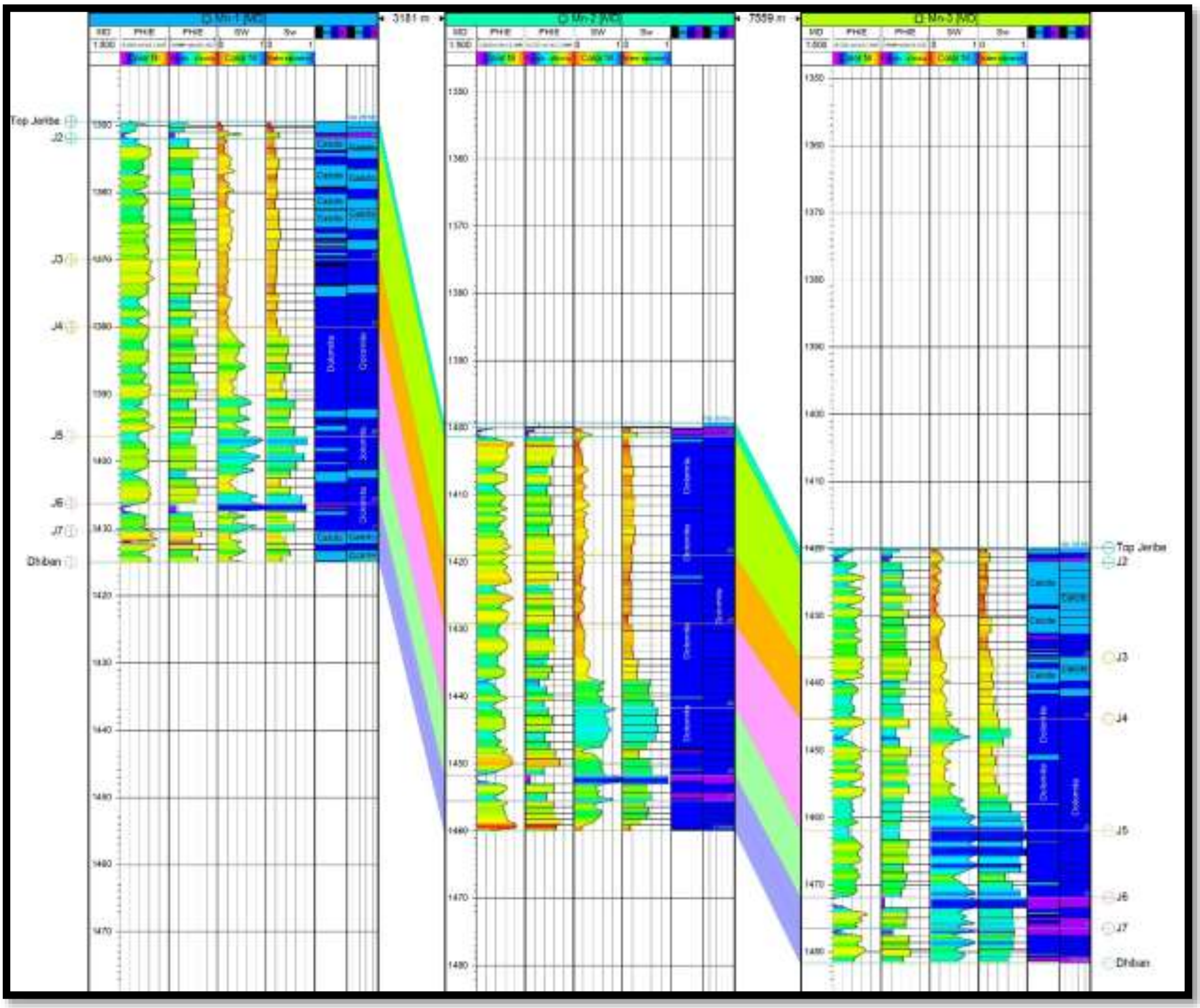

Figure 7: Scale up of PHIE and SW logs for (Mn-1, Mn-2 and Mn-3) wells.

Property Modeling

Porosity, water saturation, and other petrophysical property values are assigned to each cell of the 3D grid through a procedure known as petrophysical property modeling.

The objective of property modeling is to distribute properties between available wells in such a way that In order to realistically preserve reservoir variability and Filling grid cells with discrete (lithology) or continuous (Petrophysics: Phi, Sw) attributes is property modelling, and it is used to match good data. [5]

The data from well logs provide the foundation for three-dimensional property modeling. For example, SW transforms based on a 3D model of porosity are examples of calculations for solving complex mathematical equations applying one or more 3D property models [8].

The objective of a geological reservoir model is to supply each grid cell with a complete set of continuous reservoir characteristics such porosity, lithology and water saturation. These parameters can be generated using a variety of techniques [10].

Lithology Model

Facies modeling is the process of distributing discrete facies across the model grid.

For simulating the distribution of discrete attributes in a reservoir, Petrel provides stochastic and deterministic (estimation or interpolation) approaches.

When dense data is available, deterministic approaches are often used. When compared to stochastic approaches, they are faster to run [5]. They generate hypothetical results depending on the given data and can be used to generate numerous equally likely realizations.

There are numerous methods used to build lithology model, the lithology model have been built by using (SIS) sequential indicator simulation the methods.

Use a 3D Facies (lithology)model to incorporate lithological information when modeling reservoir parameters such as porosity Figure (8).

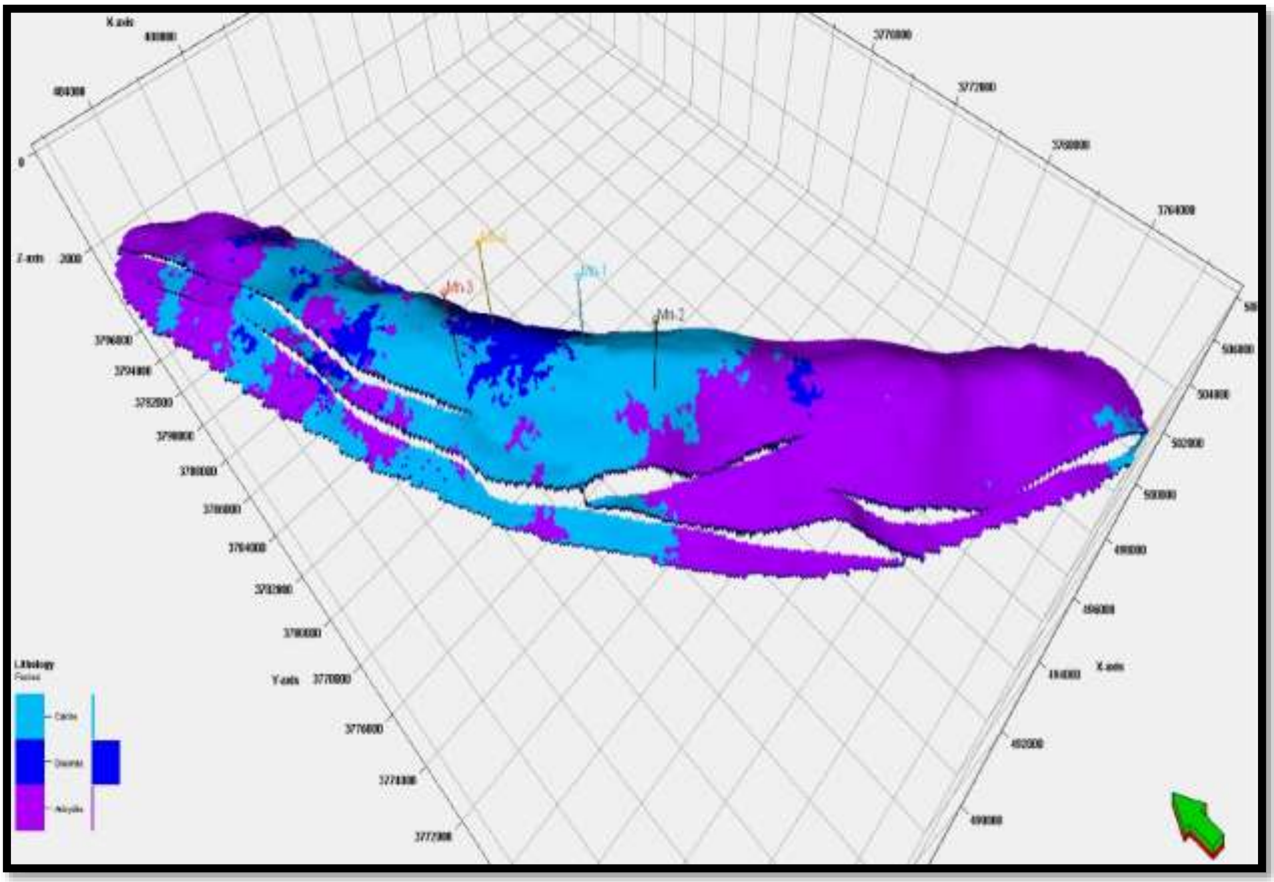

Figure 8: lithology 3D Model of the Jeribe Formation in the Mansuriya Gas Field.

Petrophysical Model

The aim of petrophysical property modeling is to generate a collection of continuous reservoir parameters for each 3D grid cell, such as porosity and water saturation [7].

The Petrel software offers a number of algorithms for making reservoir model according to the distribution of the petrophysical parameters. Inputs include variograms, facies realization, well data, trend data, a secondary variable, and there are a number of user settings accessible [4].

Porosity Model

The porosity model was developed based on the findings of porosity logs (density, neutron, and sonic) that have been appropriately corrected and interpreted using the Petrel software. The initial porosity distribution was transformed into a stationary, normally distributed data set before the porosity could be modeled. The input data must be stationary for trends to be eliminated before modeling. The geostatistical algorithm, known as the Statistical Sequential

Gaussian Simulation algorithm, is a statistical method that is compatible with the available data [10] Figure (9)

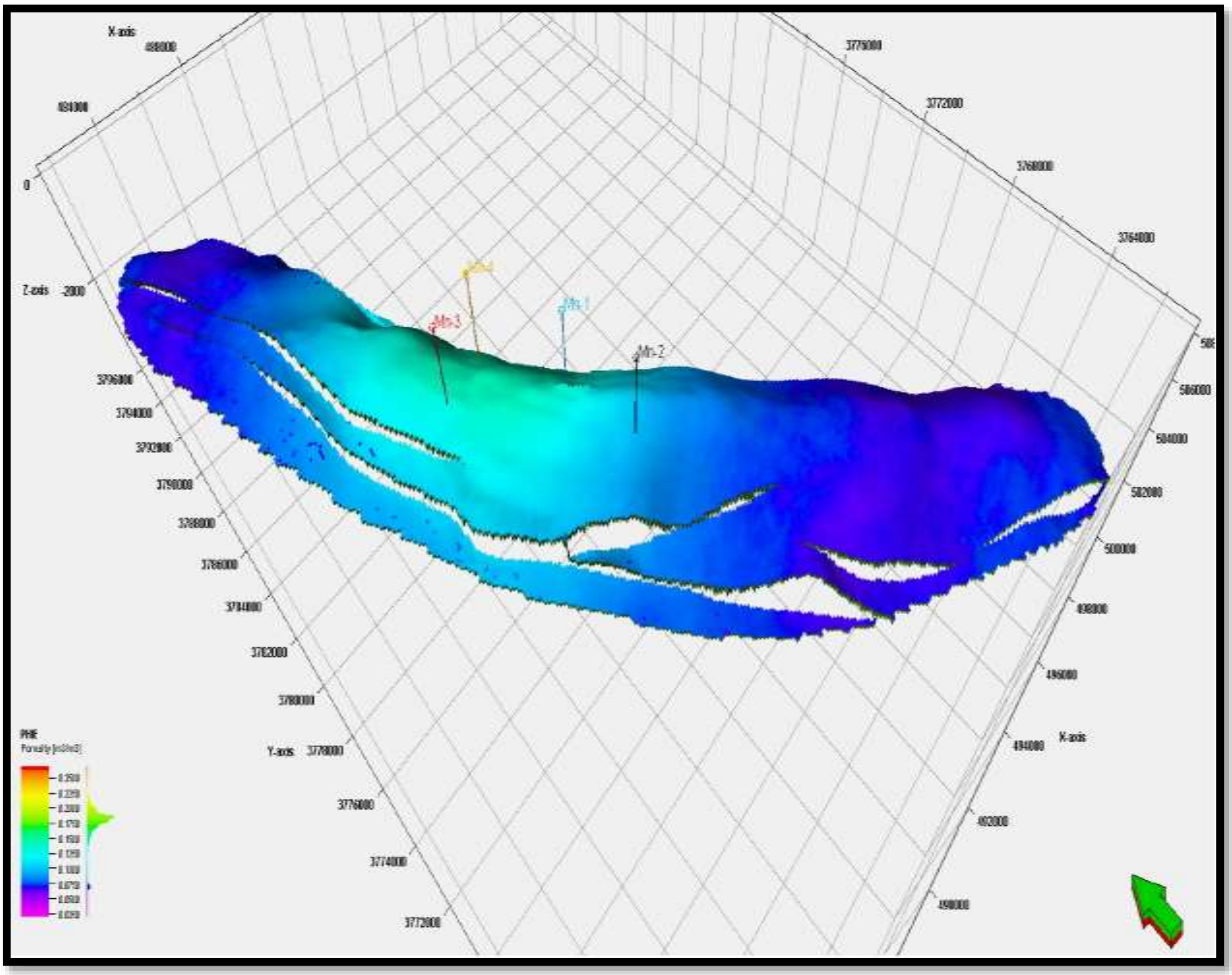

Figure 9: porosity 3D Model of the Jeribe Formation in the Mansuriya gas field.

Water Saturation Model

The scale-up of water saturation that Petrel software exported for each zone of the Formation was used to create the water saturation model. According to the available data, the water saturation was calculated using the (SGS) method (Statistical Gaussian Simulation Algorithm). The facies distributions are used as an indication to distribute and build the water saturation model of the Jeribe Formation, the Figures (10) to (11) shows the cross-section and water saturation model of Jeribe Formation in a NW-SE direction.

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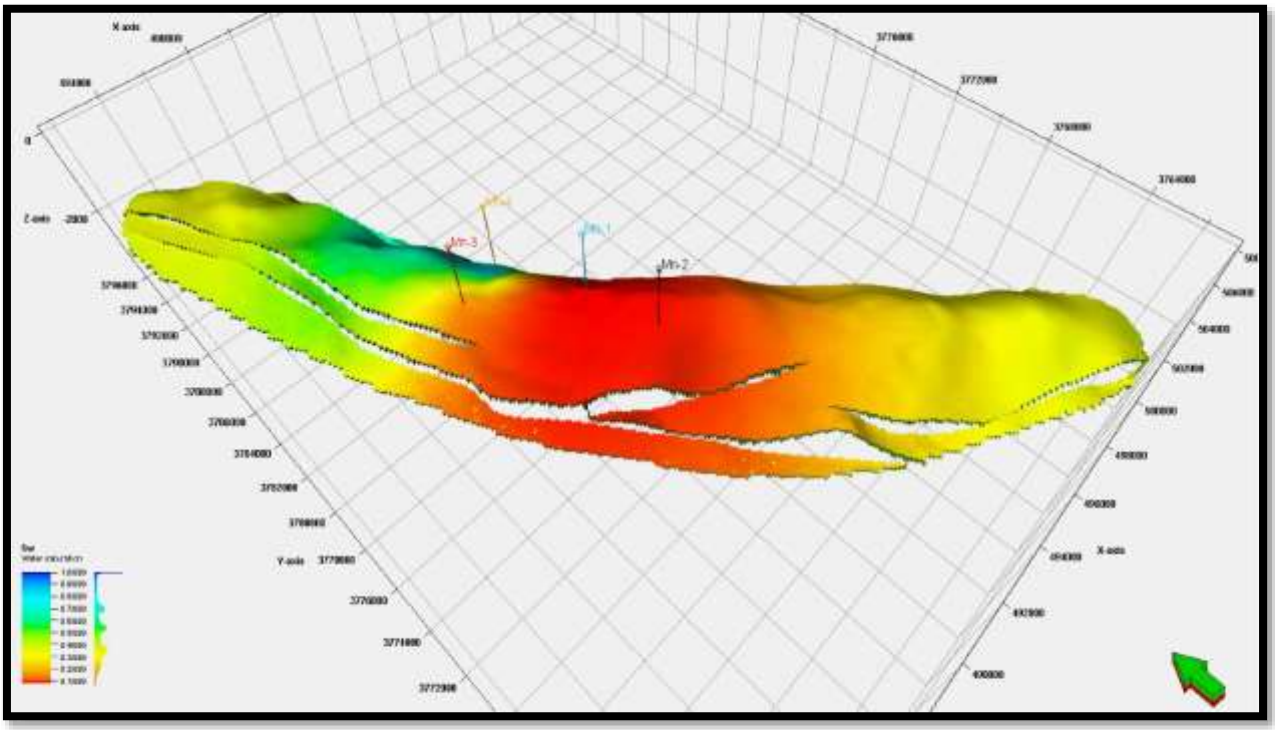

Figure 10: Water saturation model of the Jeribe Formation in the Mansuriya Gas Field.

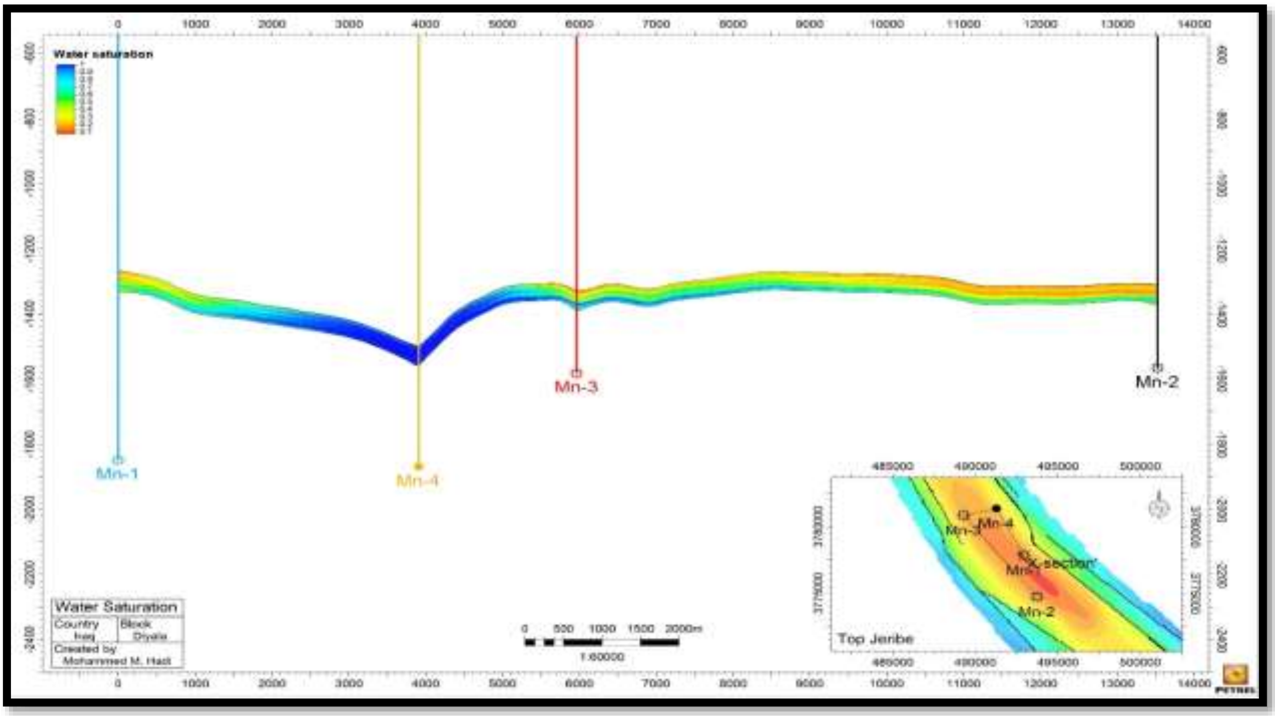

Figure 11: Cross section in direction NW-SE shows the Water Saturation of the Jeribe Formation in the Mansuriya Gas Field.

Cutoff boundaries

The cutoff limits are used to find out the permeability of the reservoir and the production of hydrocarbons from it. The permeability is not always present along the sequence of the reservoir and not in all wells, therefore the cutoff boundaries are determined by Extensive data from the probes. In addition to the categorical boundaries are important for knowing the hydrocarbon range. It is also important to know the (net pay) of the reservoir. In some reservoirs, a single cut-off term is sufficient. As for complex reservoirs, more than one categorical boundary must be identified [11].

In order to obtain the net pay thickness, the basic step is to know the cutoff limits for each of Porosity and water saturation. Table (2) shows the net pay thickness of the Jeribe wells within the stratified units taken from the geological model. And using the cut-off limits for each of the porosity (12%) and water saturation (60 %) and apply it in the equation below:

NTG= 0.1 ; If Sw > 60% and PHIE < 12%

NTG: Net pay thickness to total gross thickness

Sw: represents the water saturation model

PHIE: Model of effective porosity

The net pay thickness was calculated for each stratified unit in the study wells, and thus the effective fractions were extracted. It can be considered as a representative of the net gas column in it, Figure(12). That is, the productive unit (Pay) has a less water saturation value than 60% and its effective porosity is greater than 12%.

Table 2: Net to gross values with summary calculations for well MN-1.

Units	THICKNES	Cross	Net	N/G	AV. Phi	AV .Sw
J1	2.5	……	……	…….	7	52
J2	18.1	11.2	11.2	1	17	25
J3	10	2.5	2.5	1	19	19
J4	16.25	7.3	7.3	1	18	59
J5	10	5.75	5.75	1	18	57
J6	4.15	……	……	…….	11	74
J7	4.6	4.6	4.6	1	20	49
ALL ZONE	65.5	31.35	31.35	1	15.7	47

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Gas-water contact boundaries

Determine the gas-water contact level in the wells of the study area based on the results of probe interpretation (CPI), in addition to the cross-border. Through this, the lowest level of presence of gas (T.D.G) was determined for the wells of the region of study and choosing the lowest level of gas presence in the Jeribe Formation based on the cut-off (60% Sw and 12% PHIE). Figure (13) Cross section in direction NW-SE shows the boundaries of the gas patch on the Jeribe Formation.

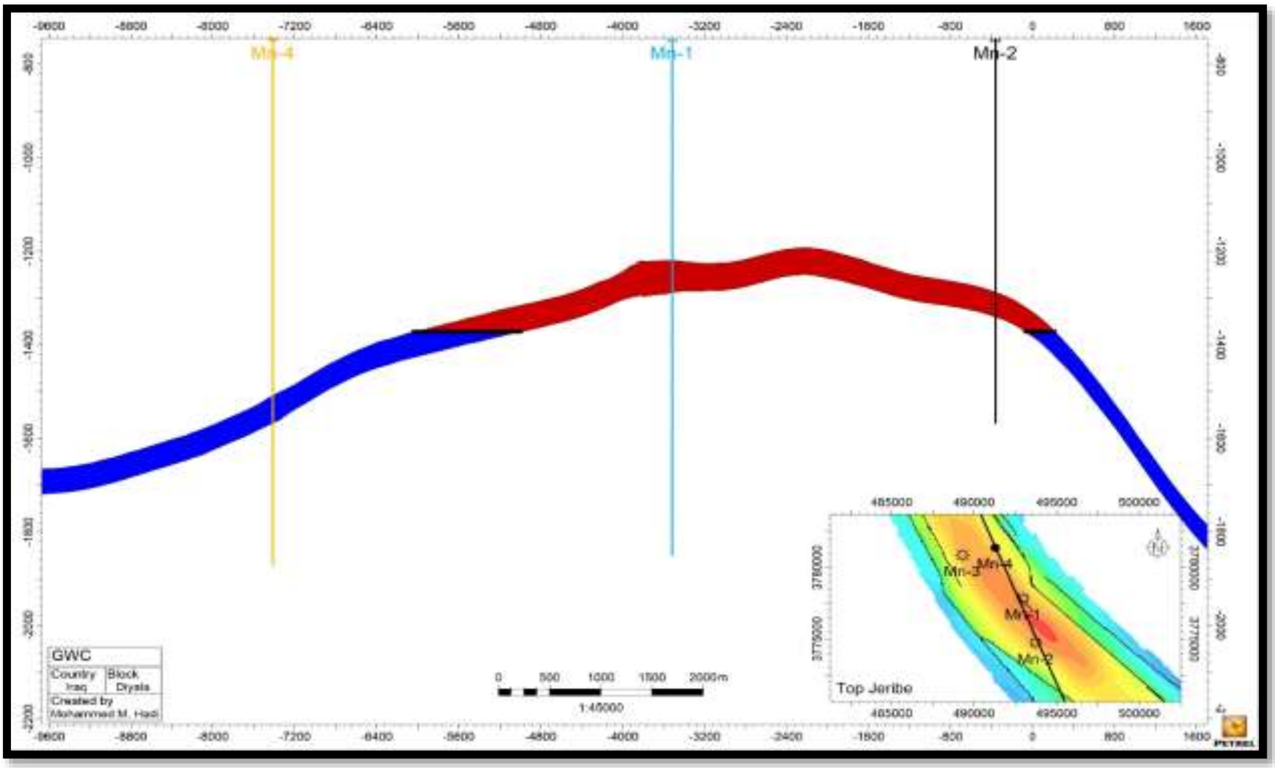

Figure 13: Cross section in direction NW-SE shows the boundaries of the gas patch of the Jeribe Formation in the Mansuriya gas field.

Calculating the Volume gas storage

After knowing the volume of the reservoir and calculating the ratio of the net pay thickness to the Gross pay thickness (Gross/Net). Calculating the weighted average for each of the effective porosity (Ø) and water saturation (Sw) and determining the lowest point of presence hydrocarbons.

There is nothing left to know about the gas formation volume factor (Bg), whose value was taken from Oil Exploration Company (1990) was 261 STB/RB. In the light of these values, the gas reserves were calculated using the volumetric method by applying the equation below:

B.V = Total Rock Volume Net.V = B.V * Net/Gross

Pore Volume = B.V * Net/Gross * Ø

HCPV gas = B.V * Net/Gross * Ø * Sg

GIIP = HCPV gas/Bg

Gas volume at reservoir condition = $\mathbf{10^6 *97\ rm^3}$

Gas volume at surface condition = $\mathbf{10^9 * 25\ rm^3}$

Conclusions

1. Structural model has been made using petrel software for Jeribe reservoir.The structural model showed that the Mansuriya Gas Field is composed of one Elongated asymmetrical anticline toward NW-SE About 30 km long and 7-8 km wide Structural closure of about 70 km at the top of the Jeribe Formation.
2. The Fault model showing that the content of the Mansouriya Gas Field has saven faults of different lengths. Its effect reaches the Jeribe Formation, which extends from the northwest to the southeast direction along the field.
3. The construction of horizons was undertaken for the Jeribe Formation, which has been categorized into seven distinct zones, namely Top Jeribe, J2, J3, J4, J5, J6, and J7. Based on petrophysical parameters, layers are built for each zone. As a barrier, top jeribe and J6 units were divided into three layers. While the unit J2 and J4 was divided into twelve layers because it represents reservoir zones and the unit J3 and J5 was divided into eight and the J6 was divided five layers.
4. 3.The lithology model shows that the Jeribe Formation consists of three types of lithology, which are the anhydrites that are present in the J1 and J6 units in a large percentage, as they represent the cover rocks of the reservoir. while the rest of the units are mostly composed of dolomite in a large percentage and calcite in a lesser percentage.

5. Petrophysical model (water saturation and porosity) for Jeribe reservoir in Mansuriya Gas field was built from porosity and water saturation values using (SGS) Sequential Gaussian Simulation algorithm as a statistical method after scaling up of porosity and water saturation. The model indicates that the J2, J3, J4, and J5 zone, which is the main gas-bearing unit in the Jeribe reservoir, will have low water saturation and high porosity. while J7 is characterized by moderate petrophysical properties And this unit can be considered as a reservoir in wells Mn-1 and Mn-2 and it is not a reservoir in wells mn-3 and mn-4 because the water saturation is above the cut-off limit of the formation in these wells. J1 and J6 units are not reservoir unit in Jeribe Formation because it low porosity and consist of anhydrite lithology.
6. The Mn-4 well showed different results from the other wells, and none of its units can be considered a reservoir due to the large water saturation volume and its lack of hydrocarbons, according to CPI results, because the mn-4 well is located on a different contour line than the other wells, as shown. In the structural picture of the field, which we can consider outside the gas patch.

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