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Geological modeling using Petrel Software for Mishrif Formation in Noor Oil Field, Southeastern Iraq

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Abstract

Petrel is regards one of the most important software to delineate subsurface Petrophysical properties to the reservoir. In this study, 3D Integrated geological models has been built by using Petrel software. The process includes integrated Petrophysical properties and environmental approaches.

Noor oil field within Mishrif Formation in terms of structural geology represents asymmetrical anticlinal fold with direction NW-SE. Porosity and water saturation model have been built. The reservoir was divided into several reservoirs and Non-reservoir units depends on the Petrophysical properties for each zone. In addition, intact model for the reservoir in terms of porosity and water saturation have been built. MB reservoir unit represents the most important oil bearing unit according to the high porosity and low water saturation are present in this unit. MB reservoir unit in terms of Paleoenvironment which represent the shoal including rudist biostrome. Rudist biostrome buildups comprise the major oil producing reservoirs in the carbonate strata during Cretaceous Period.

Keywords: 3D geological modeling, Mishrif Formation, Noor oil Field.

الموديل الجيولوجي ثلاثي الأبعاد باستخدام برنامج البترول لتكوين المشرف في حقل نور النفطي. جنوب شرق العراق

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الخلاصة

يعتبر برنامج البترول واحد من أهم البرامج المستخدمة لتوضيح وأظهار الخواص البتروفيزيائية تحت سطحية للمكامن النفطية. في هذه الدراسة موديل جيولوجي ثلاثي الأبعاد تم بناؤه باستخدام برنامج البترول. هذه العملية تتضمن تكامل للخواص البتروفيزيائية والتحليلات البيئية. حقل نور النفطي في تكوين المشرف بمصطلح التراكيب الجيولوجية يتكون من طية محدبة غير متناظرة باتجاه شمال غرب-جنوب شرق. موديل المسامية والتشبع المائي تم بناؤه في هذه الدراسة. المكنم تم تقسيمه الى وحدات مكنية خازنة للنفط ووحدات مكنية غير خازنة للنفط اعتمادا على الخواص البتروفيزيائية التي تظهرها الوحدات اعلاه. بالإضافة الى ما ذكر سابقا، موديل ثلاثي الأبعاد للمسامية والتشبع المائي تم بناؤه. الوحدة المكنية MB تمثل اهم وحدة مكنية خازنة للنفط تبعا للمسامية العالية والتشبع المائي القليل. الوحدة المكنية MB في مصطلح التحليلات البيئية تمثل بيئة الحديد المتضمن سحنات الرودست . الشعاب البانية للرودست تمثل المكامن الرئيسية المنتجة للنفط للتتابعات الكربوناتية خلال زمن الكريتاسي.

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Introduction

3D geological modeling has been built for Mishrif Formation using Petrel software. Petrel represents one of the most familiar and popular software in oil industry[1].The 3D model is the grid which represents integrated of the stratigraphy, reservoir properties, and the structure in three direction(X,Y,and Z) [2].Realistic geologic models are required in the oil and gas industry as input to reservoir simulator programs, which can be predict the rocks behaviors under different hydrocarbon recovery scenarios.

The aim of this paper is to reconstruct 3D geological modeling using Petrel software for eight wells in Mishrif Formation in Noor Oil Field. This model includes structural models and Petrophysical properties for each reservoirs and final model for the reservoir.

Study Area

Noor oil field is located 15 km northeastern of Amara City, Misan Governorate. The field is NW-SE trending anticline, and is about 20 km long and 6.5 km wide Figure-1.

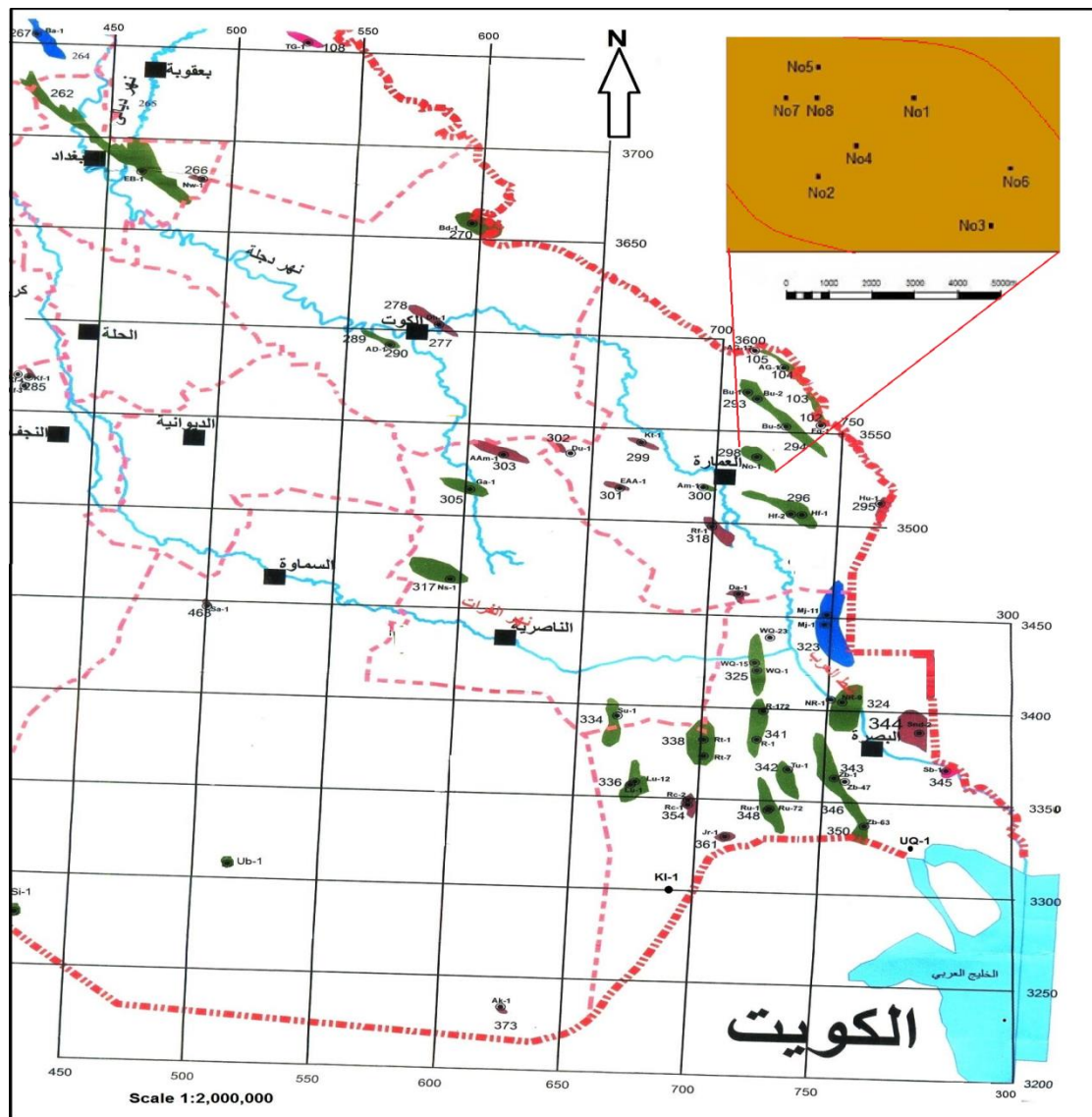


Figure 1- Location Map of the study area.

Methodology

Petrel software has been chosen for built 3D geological modeling for Mishrif Formation. There are several steps starting as data requirements for building this type of model. These data are:

1-Well head: include the position for each well of Noor oil field. These data include northern, eastern, and rotary table Kelly bushing (RTKB).

2-Well tops: include well tops for all reservoir units in Mishrif Formation within Noor oil field. In addition, the total depth for each well have been imported to petrel Software.

3-Well logs: data for eight borehole(include porosity ,water saturation, and CPI values that exported form IP(Interactive petrophysics software) have been imported to the petrel software.

Workflow steps for design 3D model

In order to build 3D model, there are several steps must be completed in terms of static Petrel model in petroleum reservoir. These are:

1-3D Grid Construction

This step represents the main steps for build 3D model. This step involves the model were divided into boxes and each box called a grid cell and will have a single rock type, one value of porosity, one value of water saturation. These are referred to as the cell's properties. This is a simplification of the true case, but allows us to generate a representation of reality that can be used in calculation [3]. (Figure-2)

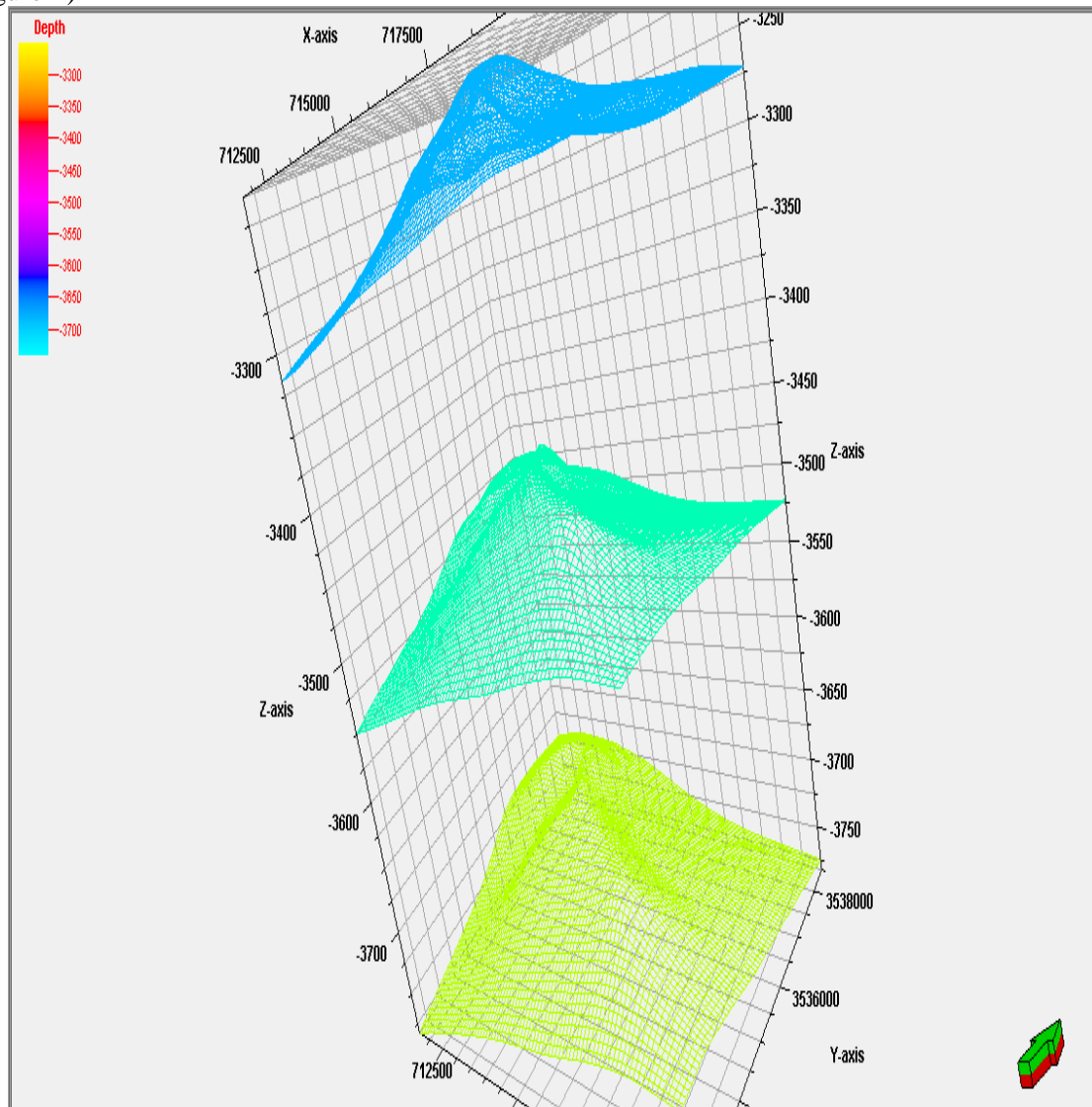


Figure 2- 3D Grid of Mishrif Formation in Noor Oil Field.

1- Structural Contour Map

A structure contour map represents one of the most important step to create three-dimensional structural interpretation. Contour maps can be drawn by computer from the surface and correlated boreholes[4].(Figure-3).

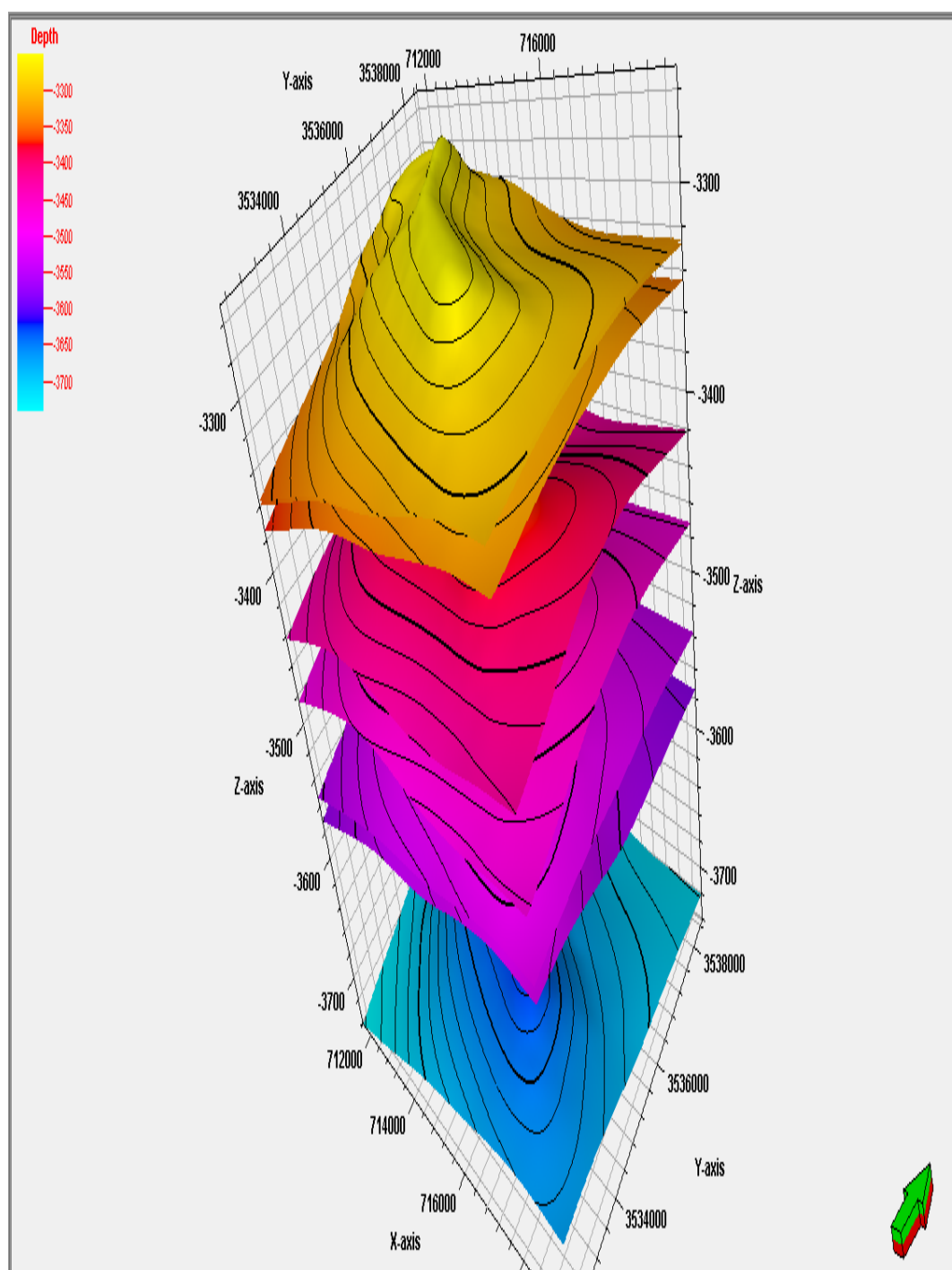


Figure 3- 3D Structural modeling of Mishrif Formation in Noor Oil Field.

3- Layering of Geological Model

A geologic model requires accurate representation of layered volumes. Three-dimensional (3-D) geologic models are increasingly the best method to constrain geology at depth [5].

Each reservoir unit has been divided into many layers depending on facies and Petrophysical properties. MA is divided into 10 layers, MB11 unit has been divided into 10 layers, while MB12 unit of 5 layers. MB21 unit is divided into 10 and the MB22 unit is divided into 5 layers, MC is divided into 20 layers, (Figure-4).

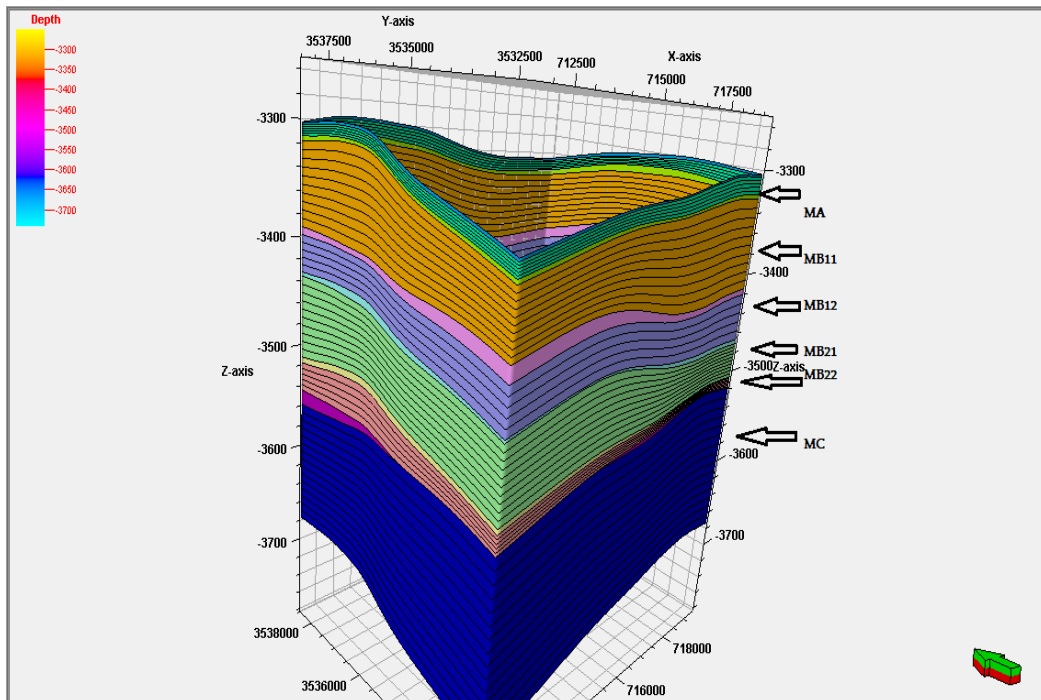


Figure 4- Layers setting for Noor Model showing the number of layers in Mishrif Formation.

4-Scale up Well Logs

This process includes an averages the values to the cell in the 3D grid that are penetrated by the well. Each grid cell has a single value for each property. As the grid cells are often much larger than the sample density for well logs, well log data must be scaled up before entering them into the grid. This process is also called blocking of well logs [5]. There are many statistical methods used to scale up such as (arithmetic average, harmonic, and geometric method). The distribution of porosity and water saturation values in the current model used the (arithmetic average) while in the facies model (most of method) was used. Figures-(5, 6, 7) shows the scale up well logs setting that using in the Noor model.

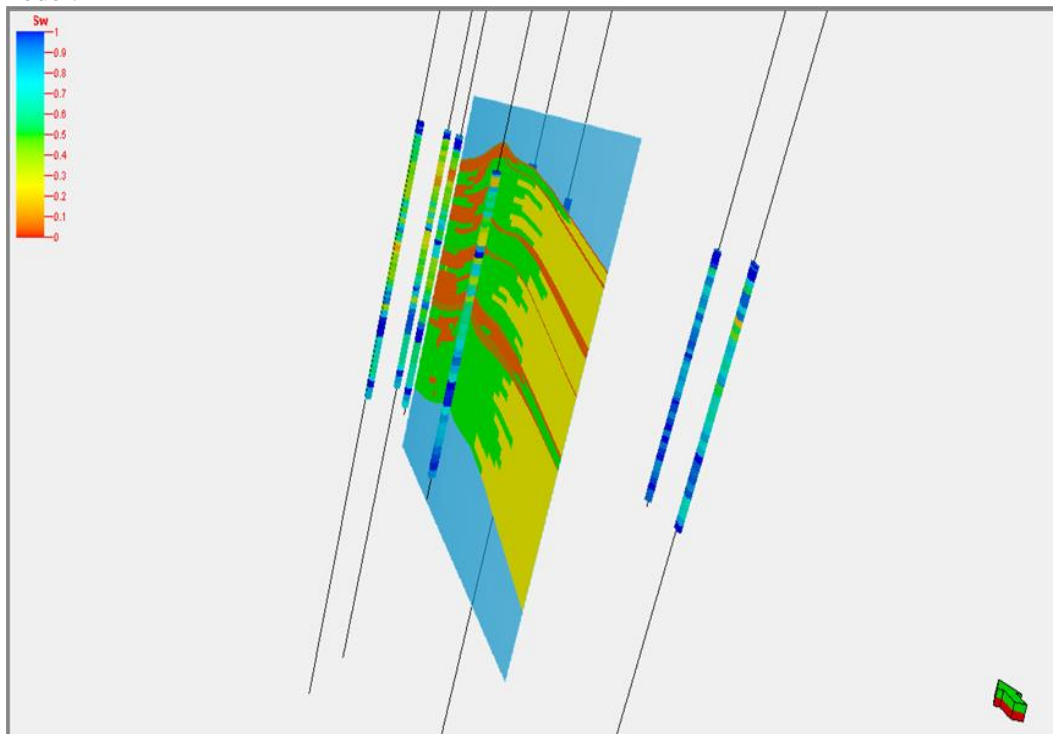


Figure 5-Scale up to water saturation.

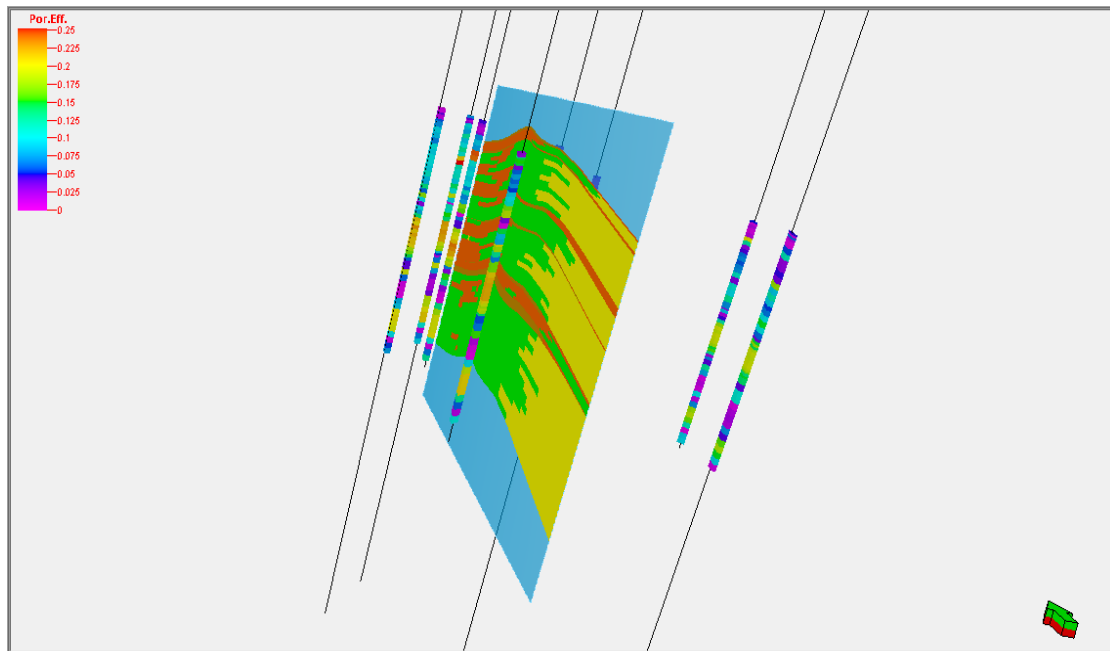


Figure 6- Scale up to the porosity.

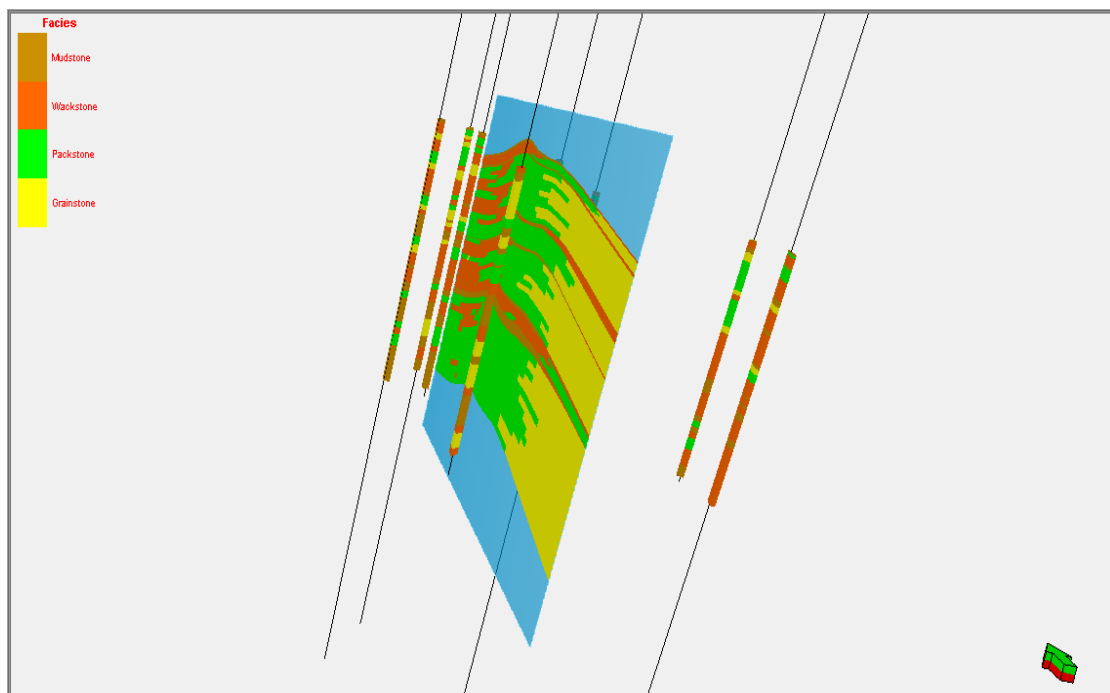


Figure7- Scale up to the facies.

5. Property Modeling

Property modeling is a process of filling the cells of the grid with discrete (facies) or continuous (Petrophysical) properties. Petrel assumes that the layer geometry given to the grid follows the geological layering in the model area. These processes are therefore dependent upon the geometry of the existing grid. When interpolating between data points, petrel will propagate property values along grid layers [6].

The aim of a geological reservoir model is to provide a complete set of continuous reservoir parameters (i.e. porosity ,permeability, and water saturation) for each cell of the grid .Many different techniques can be used to generate these parameters [7].

5.1 Facies and Environmental modeling

Facies modeling is discrete facies throughout the model grid. Facies model of Mishrif Formation in the Noor Oil field was constructed based on the results of the microfacies interpretation of sedimentary environments as obtained from logs and other geological data, (Figure-8).

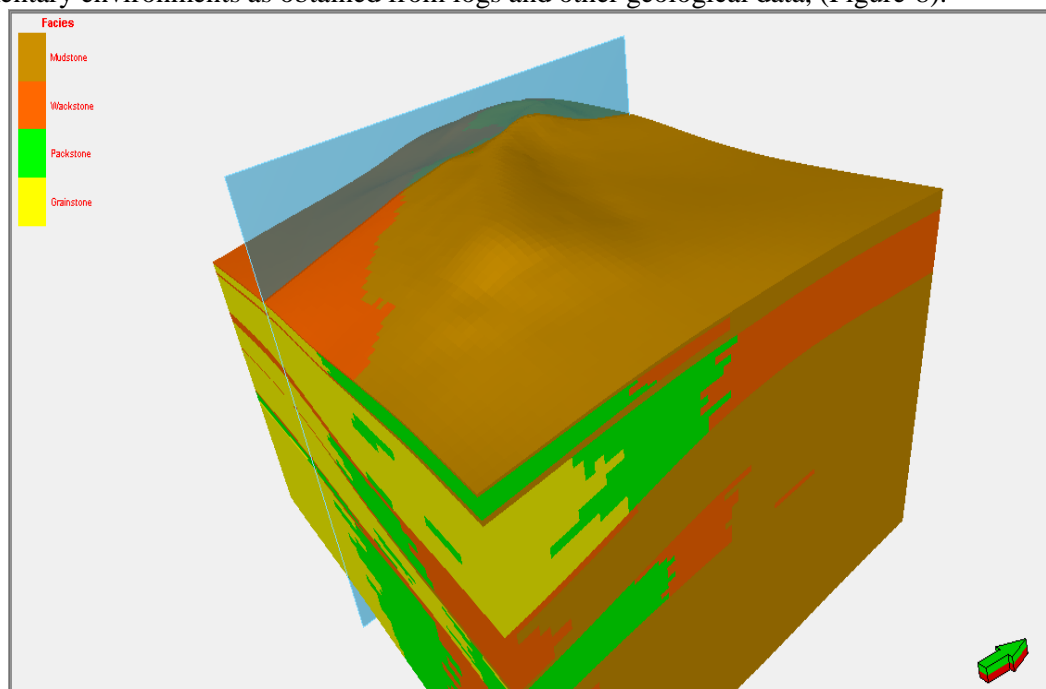


Figure 8- 3D facies model of Mishrif Formation in Noor field.

According to the microfacies model, environment of Mishrif Formation was built. The environment divides into shallow restricted, back-shoal, shoal, shallow open and deep marine environment. The Results from environmental modeling show that the Mishrif Formation in Noor Oil field has many stratigraphic traps. Fine textures (mudstone-wackstone) mainly dominate in the lower and uppermost Mishrif Formation. In contrast, the coarse texture dominant Mainly in the middle of Formation (back shoal, shoal including rudist biostrome, with some areas in shallow open marine environment, (Figure.9)

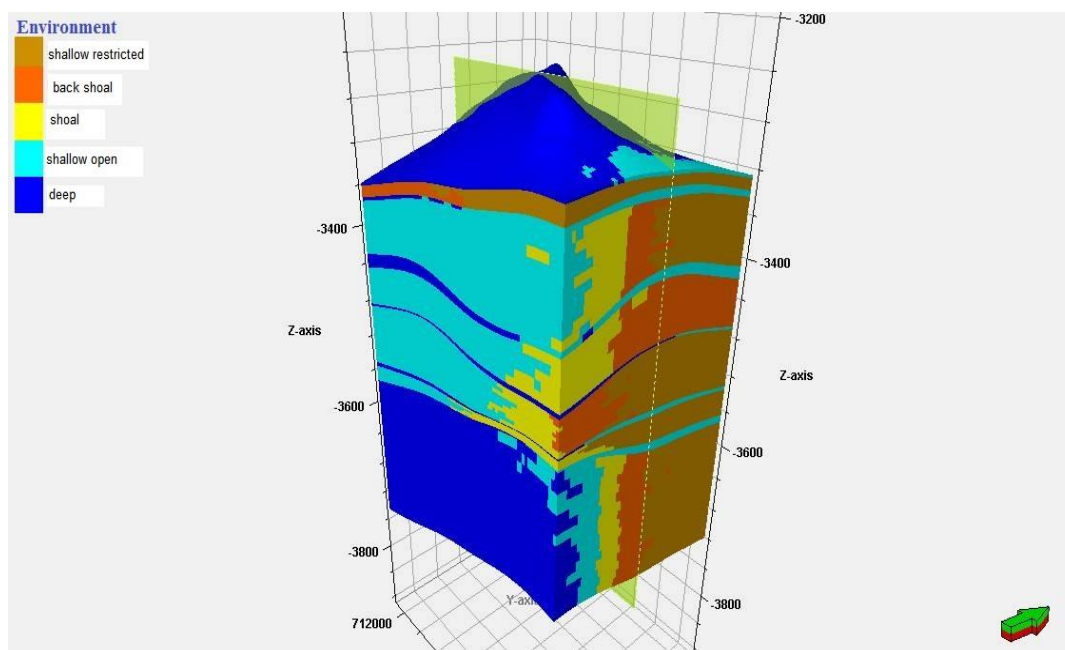


Figure 9- 3D environment model of Mishrif Formation in Noor field.

5. 2 Porosity Model

Porosity model was built depending on the results have been determined from porosity logs. In this model, porosity model was built for each unit to the Mishrif Formation in the Noor oil field. Each unit characterized by specific range of porosity values Figures-(10, 11, 12, 13, 14, 15).

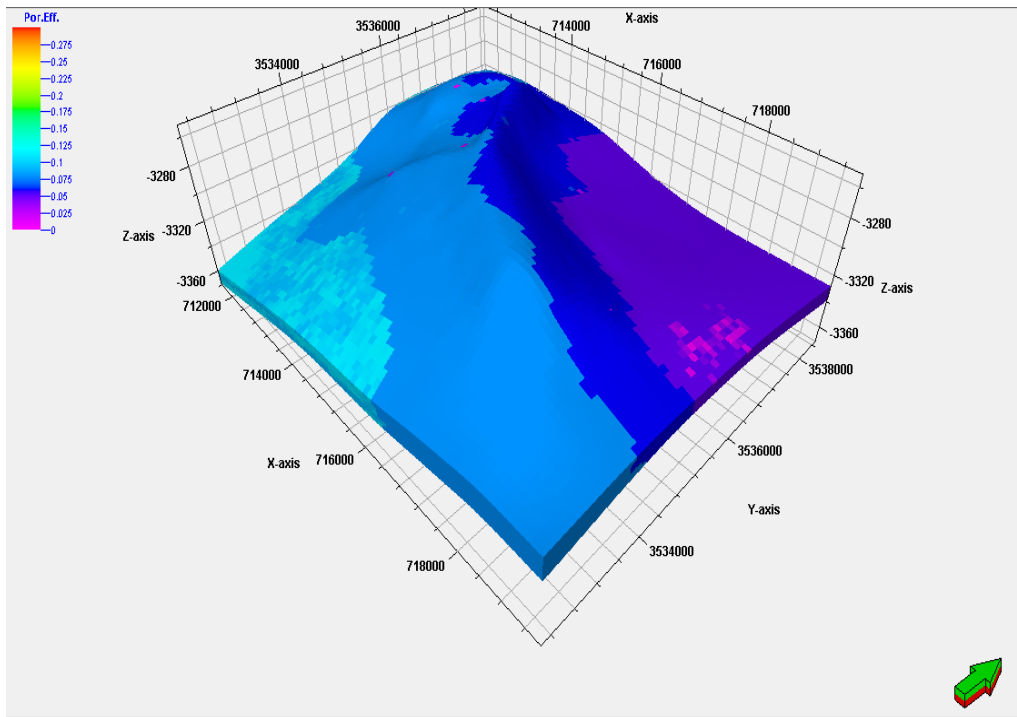


Figure10- Porosity Model of the MA unit

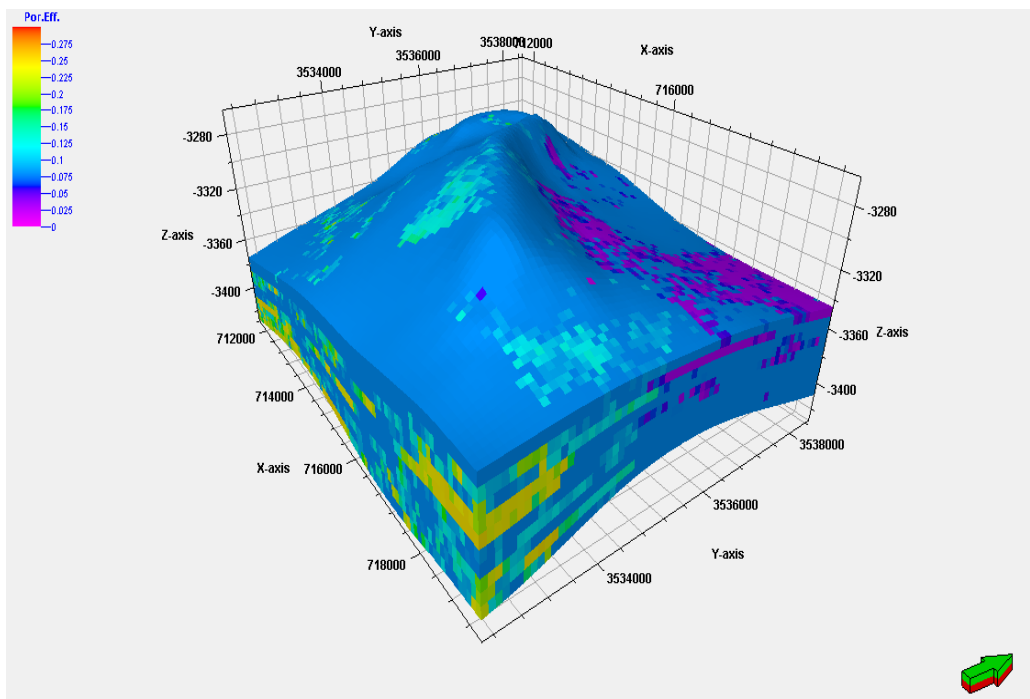


Figure 11- Porosity Model of the MB11 unit.

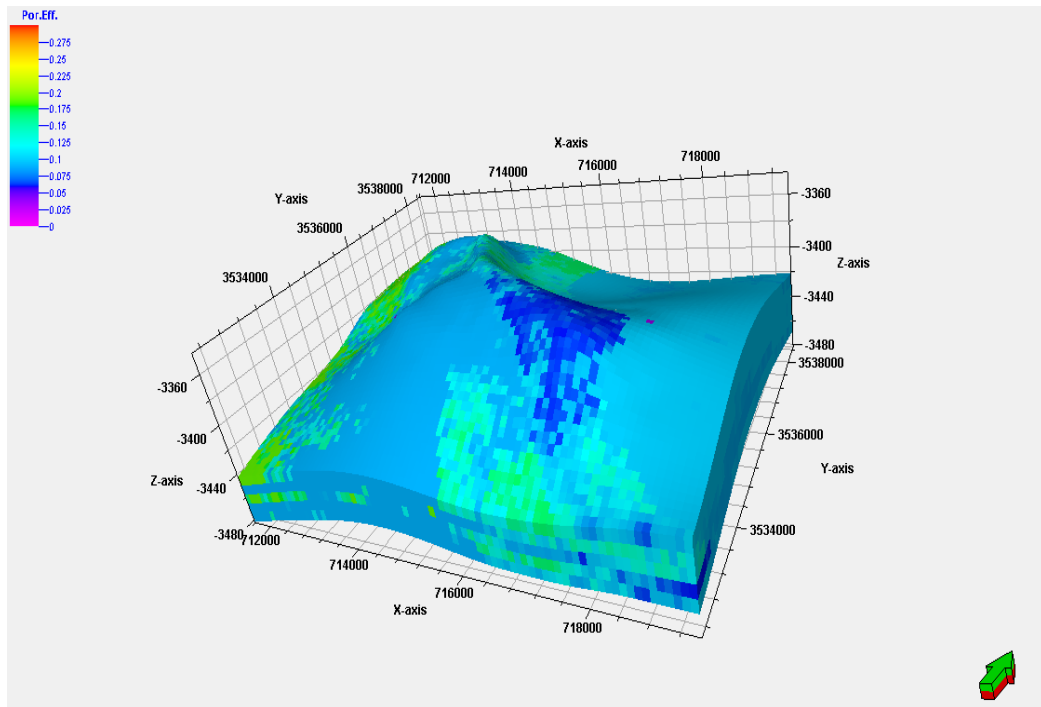


Figure 12- Porosity Model of the MB12 unit.

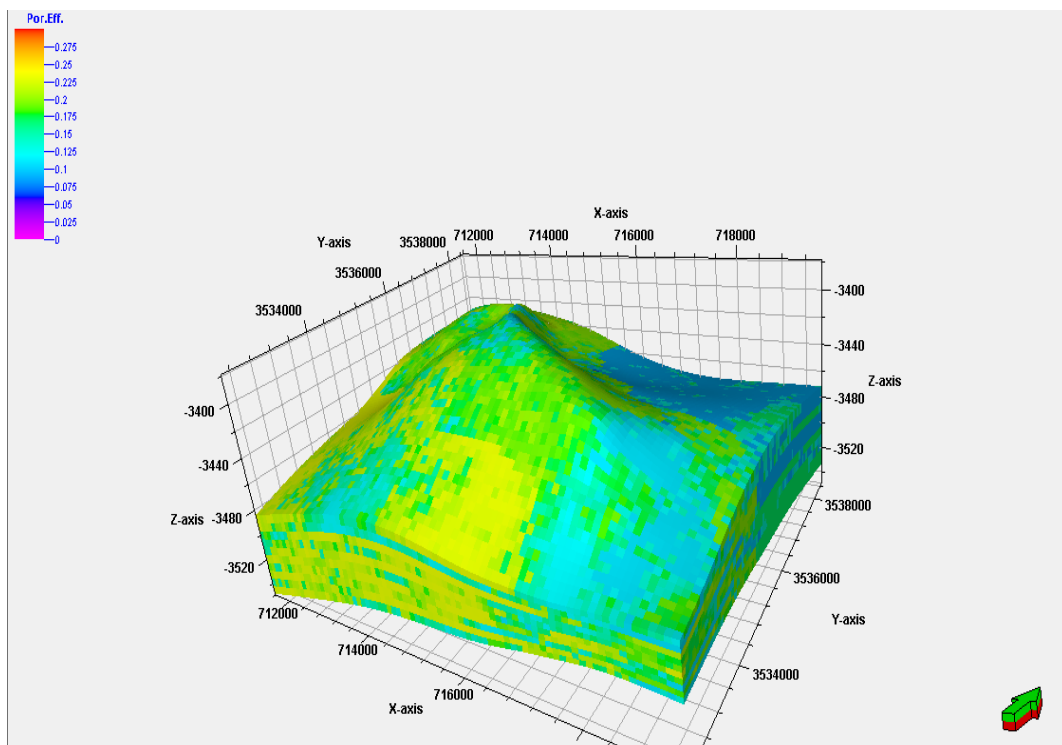


Figure 13- Porosity Model of the MB21 unit.

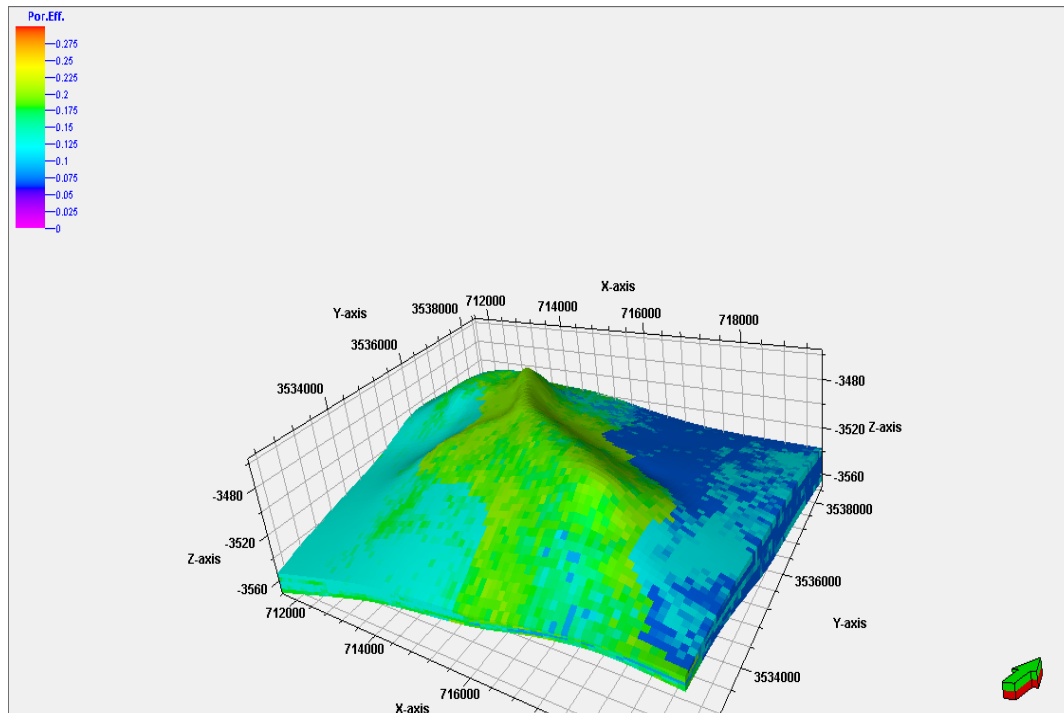


Figure 14- Porosity Model of the MB22 unit.

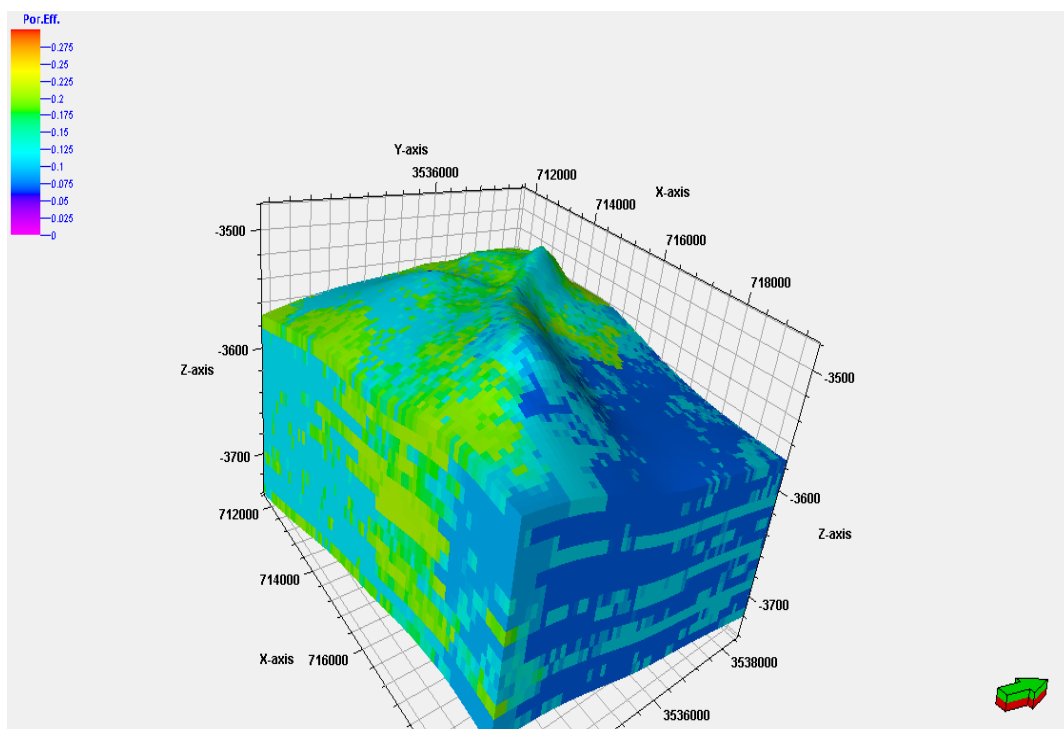


Figure 15- Porosity Model of the MC unit.

5.3 Water Saturation

Water saturation represents one of the Petrophysical properties in terms of formation evaluation. Each units is characterized by its water saturation values. Matching was noticed between porosity, environment, and water saturation models. Figures-(16,17,18,19,20, 21) respectively.

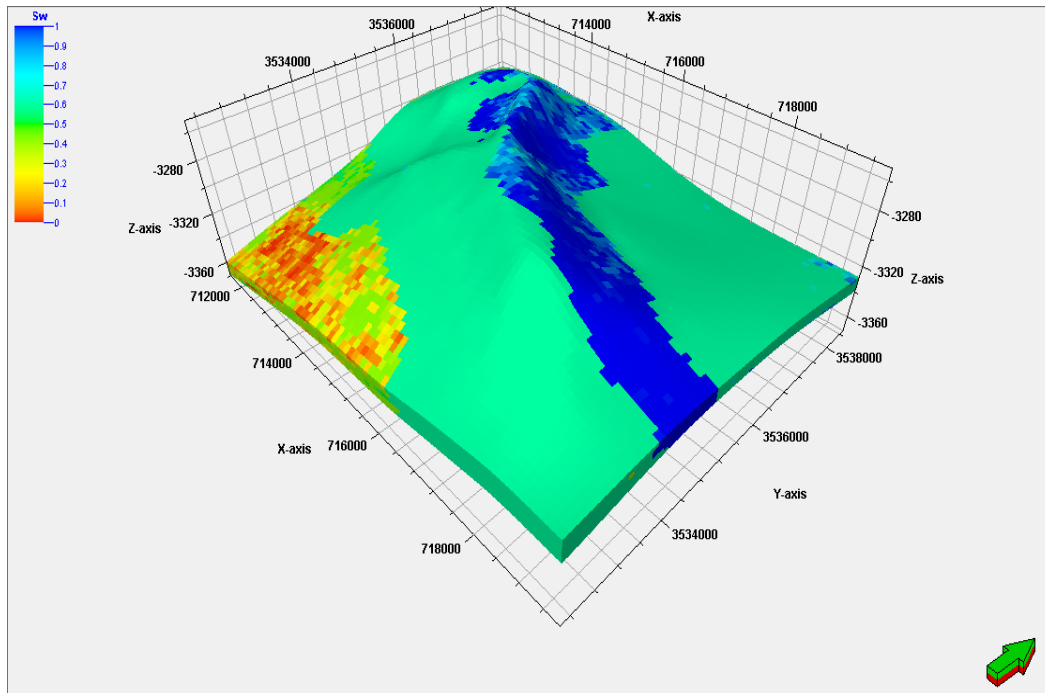


Figure 16- Water saturation model of the MA unit.

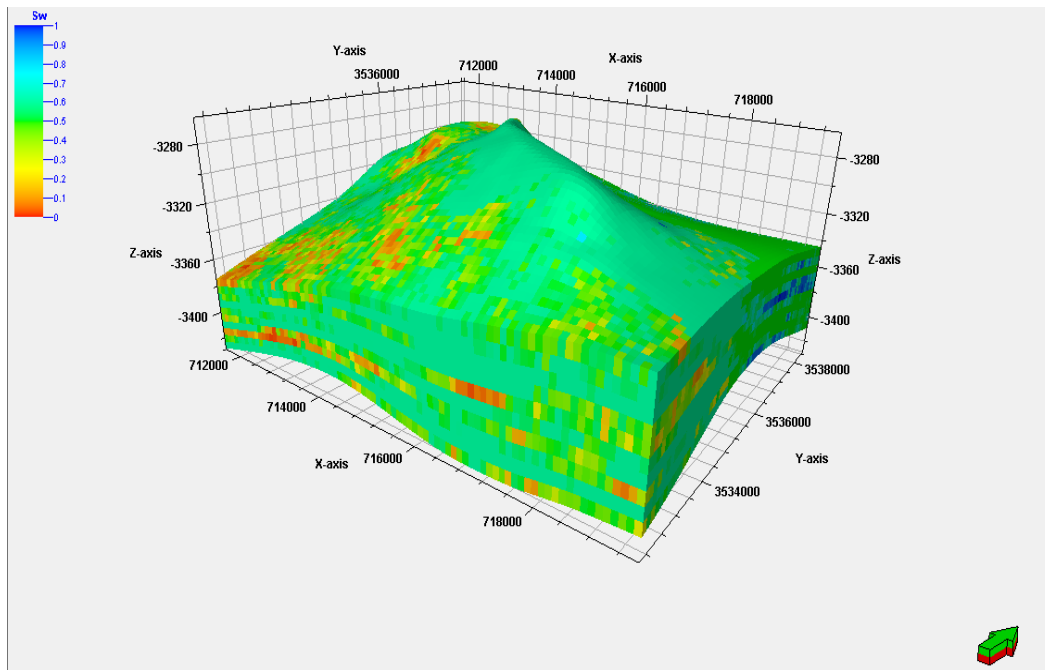


Figure 17- Water saturation model of the MB11 unit.

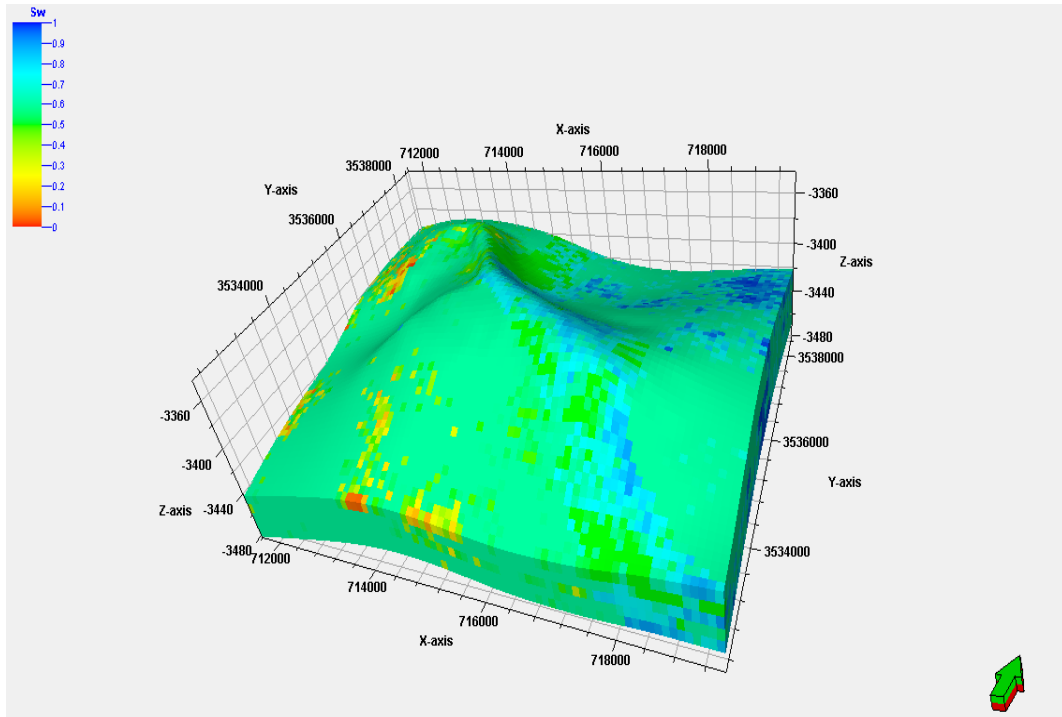


Figure 18- Water saturation model of the MB12 unit.

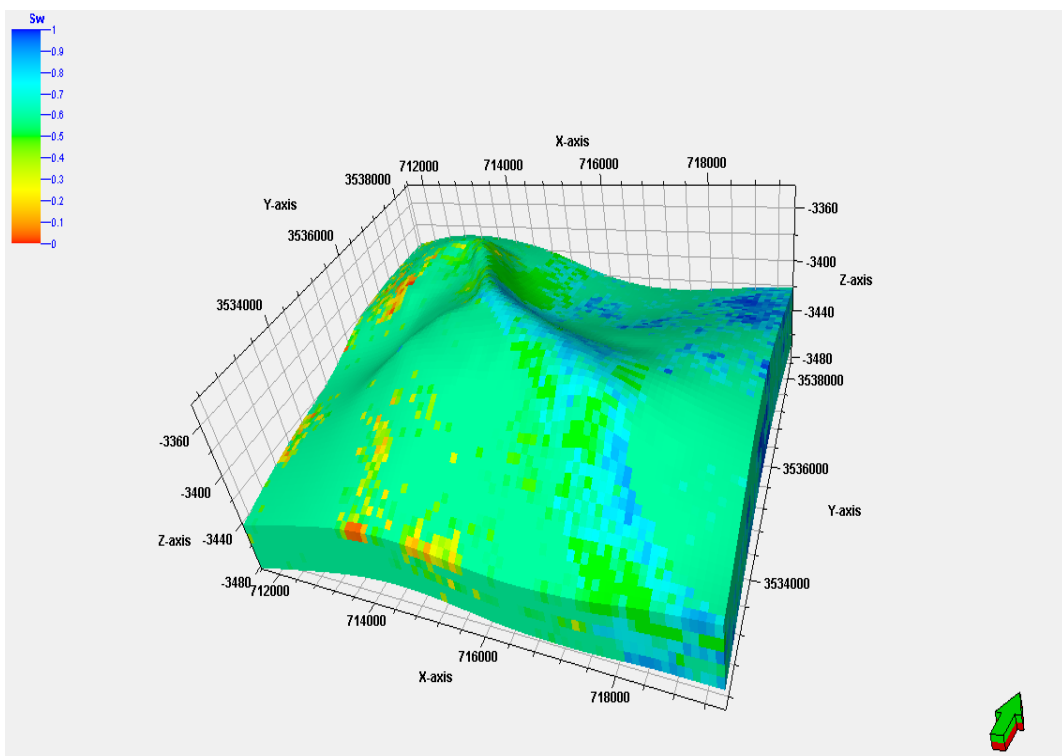


Figure 19- Water saturation model of the MB21 unit

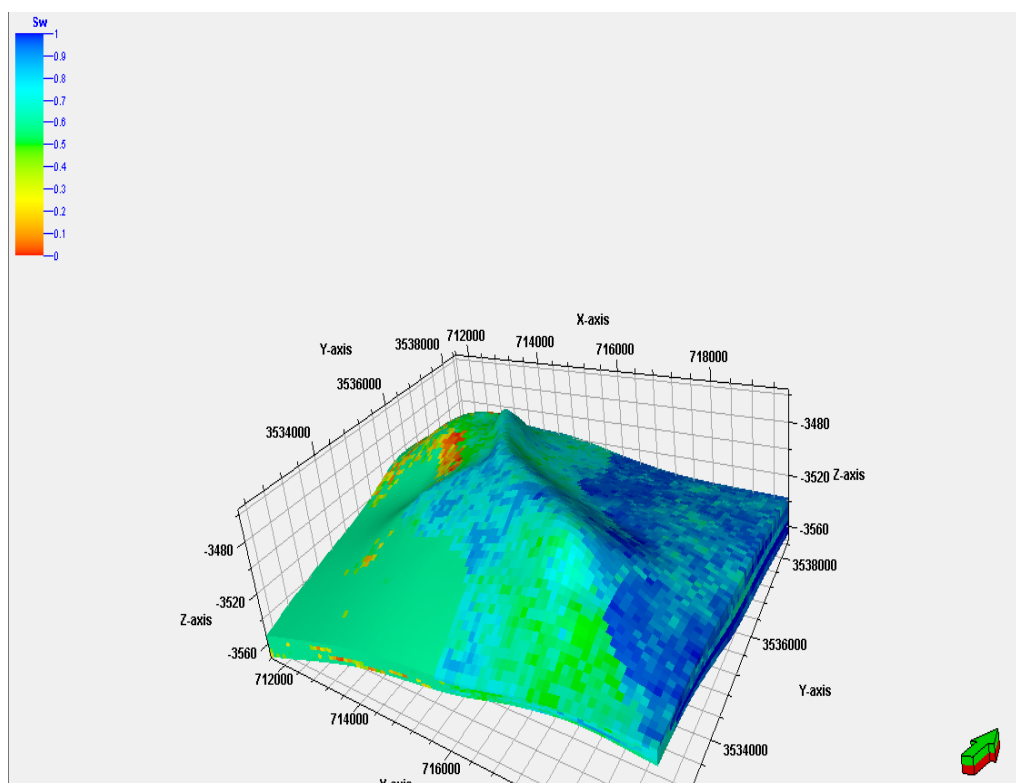


Figure 20- Water saturation model of the MB22 unit.

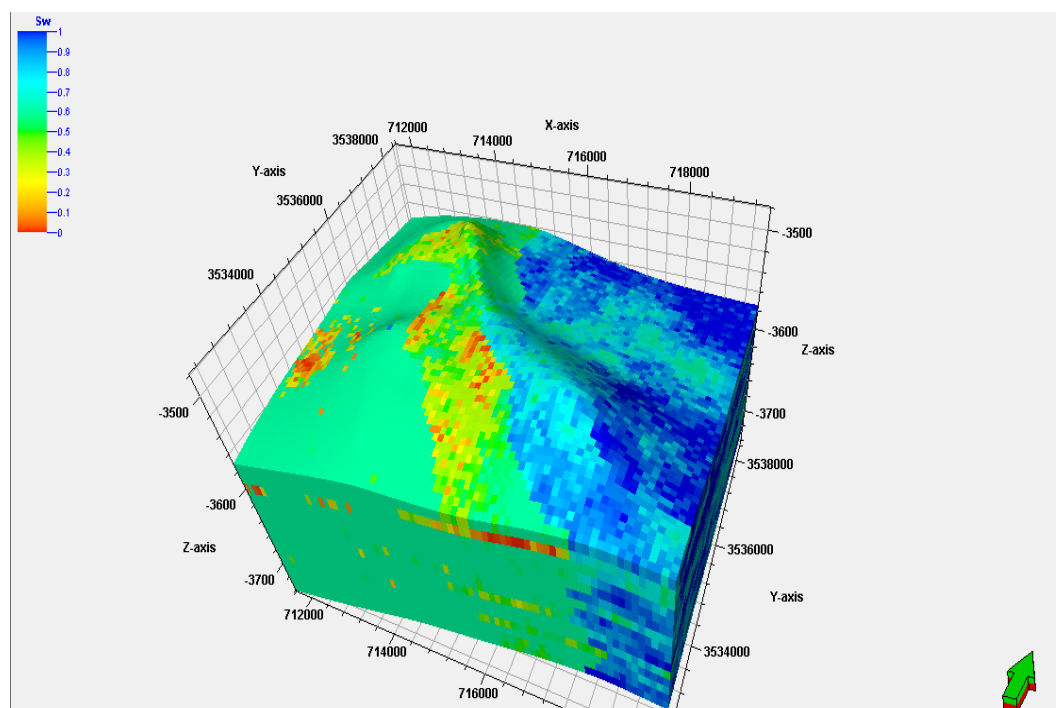


Figure 21- Water saturation model of the MC unit.

Results and Conclusions

According to the Petrophysical properties, Mishrif Formation is divided into several reservoirs units. These are MA, MB11, MB12, MB21, MB22, and MC. Each reservoir unit is characterized by specific Petrophysical properties (porosity and water saturation).

1- MA reservoir unit is located in the upper most in Mishrif Formation. According to the porosity and water saturation models, MA unit characterized by low to moderate porosity up to 9% with moderate to high water saturation.

2-MB major unit in this study is divided into minor units according to improvement of Petrophysical properties in (MB11, MB12, and MB21). In general this reservoir unit shows moderate to high porosity reaches in MB 12 to 25% with low values of water saturation. This results shows that the MB12 is the main reservoir of Mishrif Formation in Noor oil field.

3-MC unit is characterized by low porosity with high water saturation.

4- High value of porosity in MB12 is due to presence this unit within shoal (including rudists biostrome) environment. Rudists biostrome represents the main components and then major oil producing reservoirs in the Cretaceous carbonate strata in the Middle East.

5-Structural contour map shows that the Mishrif Formation in Noor oil field represents asymmetrical anticlinal fold with trending in NW-SE direction.

5-One of the most important goals from using Petrel software is to determine which directions the Petrophysical properties enhance or decrease.

6-3D environmental model have been made depending on the facies analysis. The shoal, including rudist biostrome environment represents the main environment for oil bearing facies. The improvement in porosity affected by lateral and vertical facies variation. This facies variations affected by sea level changes and their relationships with the tectonic factor. Therefore, each unit in terms of reservoir and stratigraphy has facies distribution differs from the others and then differences in porosity. In Noor Oil Field, bath improvement take a direction NW-SE passes through the dome of the structure. MA and MB11 reservoir units the improvement in porosity taking a bath in S and SE direction from the field. Figure(10 and 11). While in MB12 the improvement is located in the eastern direction and southern part of the field. (Figure 12). Finally, MB22 reservoir unit, the improvement in porosity taking a zone extended from SE-NW. (Figure-14)

7-From the porosity model, the porosity increases in the shoal including rudist biostrome environment.

Conclusions

1. According to the structural map, the Mishrif Formation in Noor oil Field shows asymmetrical anticlinal fold which contains one dome.
2. According to the described horizons of Mishrif Formation, this formation was divided into several reservoirs units MA, MB11, MB12, MB21, MB22, and MC. Each reservoir unit is characterized by specific range of porosity and water saturation.
3. MB11 and MB12 which are the highest in terms of Petrophysical properties (porosity values).
4. 3D Environmental models were built by using Petrel software. The results show the shoal including rudist biostrome environment represent the main oil bearing facies.
5. High porosity values are present in the shoal including rudist biostrome environment because the rudist represent the main rock forming organisms within Cretaceous period.

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