Ministry of Higher Educationand Scientific Research

Al-Ayen University

College of petroleum Engineering

3D Integrated Geological Modeling By Using Petrel Software

Project Under Graduation

submitted to council of the college of petroleum engineering, university of AL_ayen, in partial fulfilment of the requirements for the bachelors degree in petroleum engineering

By

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قـال تعـالى:

﴿قَالُواْ سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ﴾[1]

صدق الله العظيم

Dedication

We dedicate this humble work to our dear fathers. To the source of tenderness, our dear mothers. To our brothers, sisters, and everyone who helped us and prayed for us with success and excellence. To our teachers, professors, and all members of the educational family. To everyone who stood with us and supported us, we dedicate all this work

Acknowledge

Praise be to Allah who guided us and prayer and peace be upon the Messenger of Allah Muhammad bin Abd Allah.

We thank the College of Petroleum Engineering at Al- Alayen University for providing opportunities and facilities for the completion of this project. We also thank Dr. Ali Al Tameemi for his supervision of this Project.

We submit our huge gratitude to our family, in particular to our parents.

Finally, we thank to all who helped us and not mentioned above

Abstract

Petrel software represents one of the most important software to delineate subsurface Petrophysical properties to the reservoir. In this study, building 3D geological models from the Mishrif subsurface data in Noor Oil Field is a typical task in this study. The process includes integrated Petrophysical properties and environmental approaches

The reservoir was divided into several reservoirs and Non-reservoir units depend 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 is present in this unit. MB reservoir unit in terms of Paleoenvironment which represent the shoal including rudist biostrome

Chapter 0ne

3D GEOLOGICAL MODELING

1.1 Introdction

Mishrif Formation is regarded as one of the most important reservoirs throughout of the Middle East (Al-Khersan, 1975; Reulet, 1982; Harris and Frost, 1984; Videtich et al., 1988; Alsharhan and Narin, 1988 and 1993; Burchette, 1993; Alsharhan, 1995; Aqrawi 2010 et al; Mahdi and Aqrawi; 2014).The Mishrif Formation comprises 30% of the total Iraqi oil reserves (Al-Sakini, 1992). It was deposited during the Cretaceous period in the Cenomanian-Early Turonian sedimentary cycle as a part of the Wasia Group and widespread throughout the Arabian Gulf. The carbonates of Mishrif Formation succession is widespread throughout of the Arabian Gulf, and it was deposited on the passive margin which existed in the east of the Arabian Craton throughout much of the Mesozoic. Rudist units in the Mishrif Formation were deposited in carbonate ramps and low- gradient shelves which rimmed these basinal areas within Mesopotamian basin (Aqrawi et al., 2010).

1.2 Location of Study Area

Noor oil field is located 15 km North East of Amara city, Missan governorate. The field is NW-SE trending anticline, and is about 20 km long and 6.5 km wide. Figure (1.1).

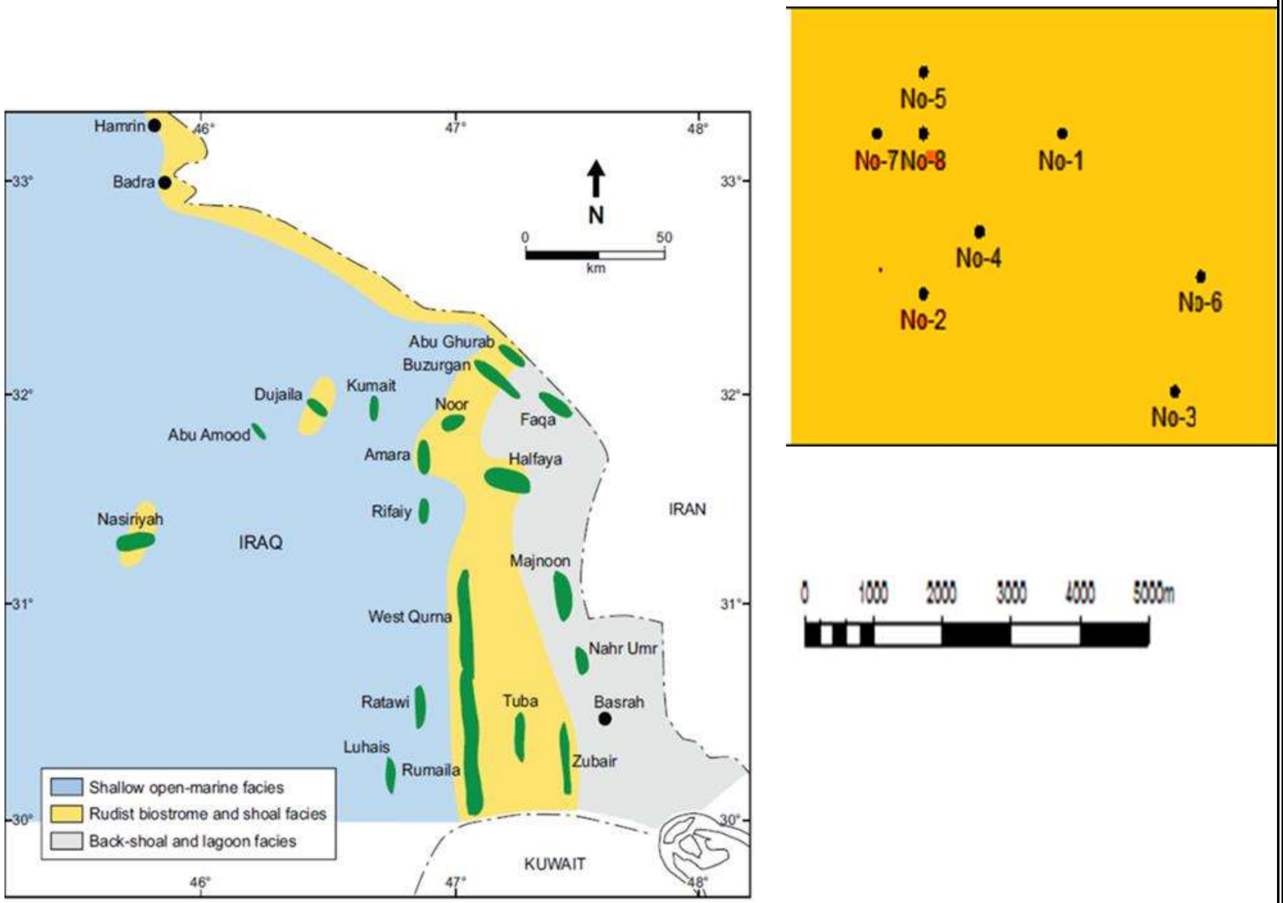


Figure (1.1) Location map of the study area

1.3 The Aim of Study

`1-Build 3D geological modeling for the Mishrif Formation by using Petrel Software.

1.4 Data and Materials

Eight boreholes in Noor Oil Field have been studied. About 263 core samples were described, in addition, more than 443 cuttings samples. Additional lithological information provided by Spontaneous Potential (SP), Gamma Ray (GR), Sonic (S), Density and Neutron logs. Finally, information from final geological and wells reports have been provided

1.5. Methodology:

Methodology is the most important part in any objective research. Its represent the foundation of the research. Choosing the fit and accurate methods gives accurate results. Especially when these methods conjunction or integrated with the each others. In this study several methods have been used for the dissertation goals. These are:

1.5.1. Core description

Cores provide an accurate representation of lithofacies and vertical stacking patterns to infer sedimentary processes and depositional systems. In addition, cores were used to calibrate well logs in order to identify representative wire line log signatures of each lithology and vertical stacking patterns.

1.5.2. Petrographic Study

Petrographic study permits centimeter to micrometer scale assessment of rock properties. The study includes observations of rock composition, sedimentary texture and structures, and fossils of cores using naked eyes and thin-section microscopy. The results were used to interpret depositional systems and sequence stratigraphic framework**.**

Thin-section microscopy is the most effective way to document mineralogic composition and texture of the cores on the basis of the optical properties of minerals. The documentation will be done through point-counting. Point-counting results will be analyzed to interpret the depositional environment. Transport pathway, distance, depositional process and reservoir qualities can also be inferred from compositional and textural maturities analyses. Seven hundred and Six thin-sections of chiefly carbonates will be studied. Four hundred points, including framework grains, pores, cement, and matrix will be counted in each thin-section.

1.5.3. Wire line Log Analysis

Wire line log analysis is a centimeter to meter scale examination of rock properties. Core-calibrated log analysis will focus on interpretation and delineation of lithofacies, electrofacies, sedimentary cycles, depositional systems, system tracts, and sequences. In addition, wire line log have been provided information for determination effective porosity, calculation of clay volume, and water saturation.

1.5.4. Software Programs

Interactive petrophysics (IP) is used in well log analysis and interpretation. In addition, Petrel Software is used to interpret and build 3-D geological modeling to the reservoir.

1.6 Stratigraphic Setting

The Cretaceous sequence in the Middle East is usually divided into three parts, due to the existence of two regional intra-Cretaceous unconformities of late Aptian (or early Albian) and early Turonian ages (Harris and Frost, 1984), figure (1.3). The mid-Cretaceous (early Albian early Turonian) sequence in the Mesopotamian Basin of Southern and Central Iraq consists of two sedimentary cycles (Buday, 1980). The older cycle, of early Albian -early Cenomanian age, includes the Nahr Umr and Mauddud Formations and their equivalents. The upper (Cenomanian - early Turonian) cycle in the Mesopotamian Basin begins with the transgressive Ahmadi Shale Formation, overlain by the chalky/marly limestones of the Rumaila Formation. These grade upwards into the regressive Mishrif Formation (middle Cenomanian-early Turonian), which in turn grades up into the Kifil Formation evaporates in a number of oilfields in the west of the basin (Fuloria, 1976) (e.g. The Kifil and Afaq areas; boreholes Kf-1 and Aq- (Aqrawi et al., 1998).

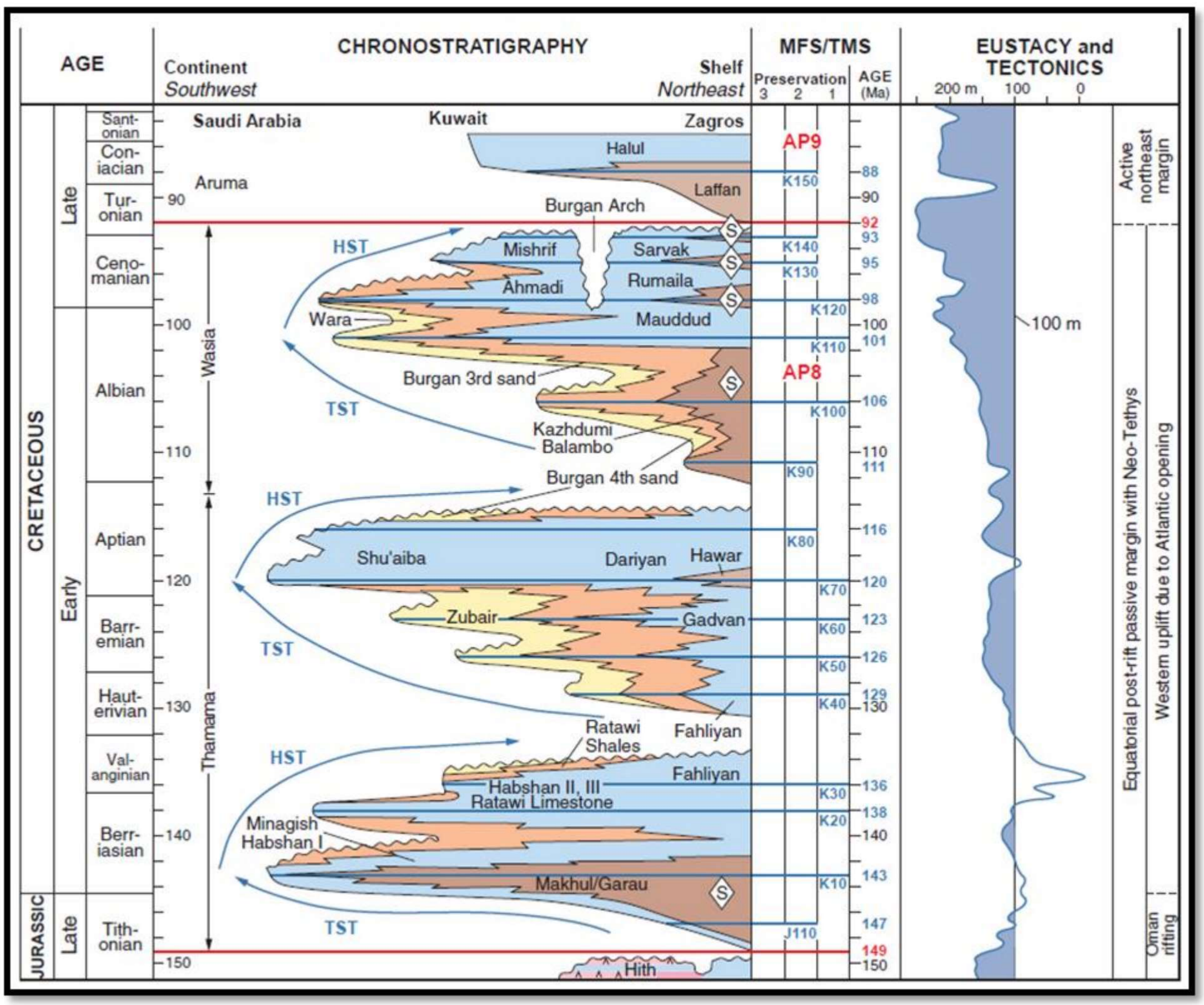


Figure (1. 3): Chronostratigraphic of the Cretaceous formations age (modified from Aqrawi,2010).

The carbonates succession in the Mesopotamian Basin can be divided into packages separated by regional-scale unconformities and maximum flooding surfaces which are related to regional-scale tectonic deformation and eustatic sea-level changes. These surfaces were used by Aqrawi et al. (2010) to group the late Albian –Early Turonian rocks of the Mesopotamian Basin into single su

persequence (their SupersequenceIV).The Mishrif Formation represents the uppermost part of this supersequence and is overlain by the Khasib Formation with a sharp contact corresponding to an Early-Middle Turonian un conformity (Aqraw et al., 1998) By contrast, at its lower boundary, the Mishrif Formation passes gradationally into underlying Rumaila Formation, and the two formations cannot easily to differentiate in many wells (Mahdi and Aqrawi, 2006). The Mishrif Formation carbonates are heterogeneous (Gaddo, 1971) and include Rudistid, bioclastic, algal and foraminiferal-rich facies deposited in setting ranging from deep marine to lagoonal. Division of the formation into two long-term regressive cycles (or sequences) was proposed by Reulet (1982) and Aqrawi et al (1998).This division was based on facies evolution and the identification of a regional-scale intra-formational disconformity surface, separating the two sequences. The Formation is dated from foraminiferal studies as middle Cenomanian-Early Turonian (Chattton and Hart, 1961; Al-Naqib, 1967; Al-Sidiki, 1978; Buday 1980). Regional stratigraphic and sedimentological studies (e.g. Buday, 1980; AlMashadani, 1986; Aqrawi et al., 1998; Sadooni, 2005; Jasim and Golf, 2006) indicate that the Mishrif Formation deposits formed a carbonate platform extending throughout the Mesopotamian Basin in southern and central Iraq.

Chapter two

2.1 Preface

In this research, 3D geological model has been built to the Mishrif Formation in the Noor Oil field using Petrel Software. The 3D Model is the grid which represents the structure, stratigraphy and reservoir properties (porosity, and water saturation) in three direction (X , YandZ) (Turner and Gable, 2008). Geologic modeling is an applied science of creating computerized representations of portions of the earth's crust, especially oil and gas fields. In the oil and gas industry, realistic geologic models are required as input to reservoir simulator programs, which predict the behavior of the rocks under various hydrocarbon recovery scenarios. Using reservoir simulation allows reservoir scientists to identify which recovery options offer the safest and most economic, efficient, and effective development plan for a particular reservoir.

(Turner and Gable, 2008). In 2 dimensions a geologic formation or unit is represented by a polygon, which can be bounded by faults, unconformities or by its lateral extent, or crop.

In the geological models a geological unit is bounded by 3-dimensional triangulated or gridded surfaces (Turner and Gable, 2008). Petrel is a Windows based software for 3D visualization, 3D mapping and 3D reservoir modeling and Simulation. Petrel has an option to use 3D glasses for obtaining a true 3D effect (Virtual Reality) (Schlumberger, 2007).

Static 3D geological models are essential to reservoir characterization and

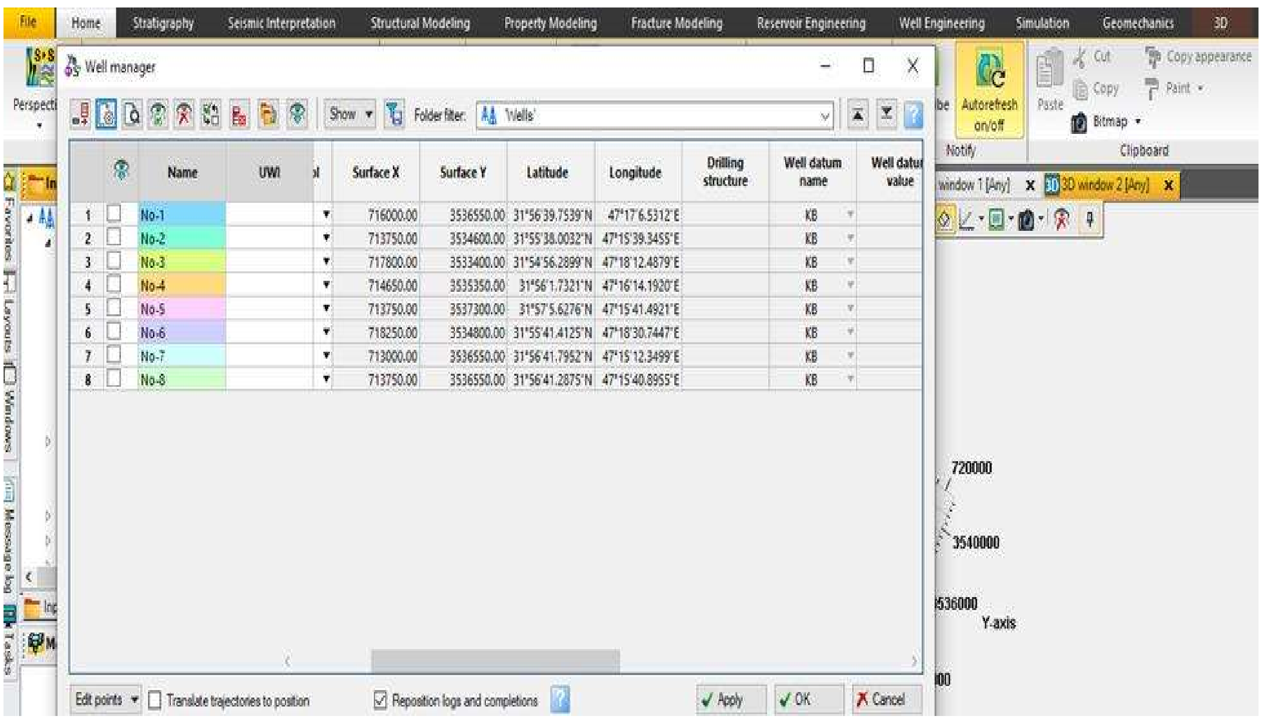
dynamic models (Moeck, 2005).

2.2 *Data Import*

To build a 3D model, there are many types of data should be supplied to the Petrel software, they are included

.2.2.1 Well heads and well tops

Well heads of 8 boreholes of Noor oil field are import to the Petrel software, they include; eastern, northern and rotary table Kelly bosh (RTKB). Well tops of the reservoir units of the Mishrif formation have been imported to Petrel also as well as the total depth for each studied well.



	Name	UWI	Surface X	Surface Y	Latitude	Longitude	Drilling structure	Well datum name	Well datum value
1	No-1		716000.00	3536550.00	31°56'39.7539"N	47°17'6.5312"E		KB	
2	No-2		713750.00	3534600.00	31°55'38.0032"N	47°15'39.3455"E		KB	
3	No-3		717800.00	3533400.00	31°54'56.2899"N	47°18'12.4879"E		KB	
4	No-4		714650.00	3535350.00	31°56'1.7321"N	47°16'14.1920"E		KB	
5	No-5		713750.00	3537300.00	31°57'5.6276"N	47°15'41.4921"E		KB	
6	No-6		718250.00	3534800.00	31°55'41.4125"N	47°18'30.7447"E		KB	
7	No-7		713000.00	3536550.00	31°56'41.7952"N	47°15'12.3499"E		KB	
8	No-8		713750.00	3536550.00	31°56'41.2875"N	47°15'40.8955"E		KB	

Figure (2.1):well heads (coordinate)of the well

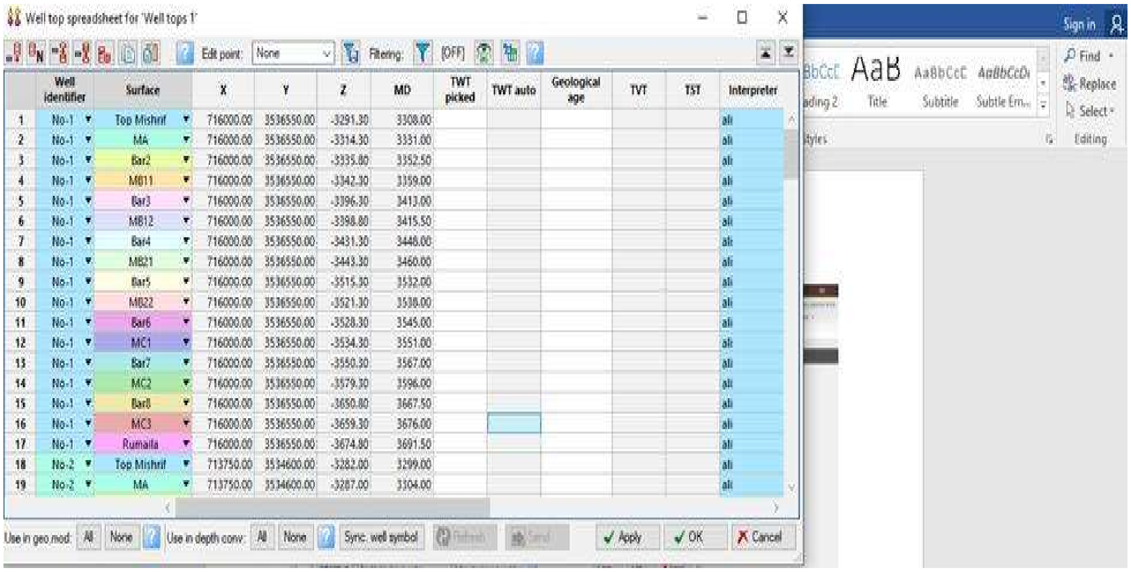
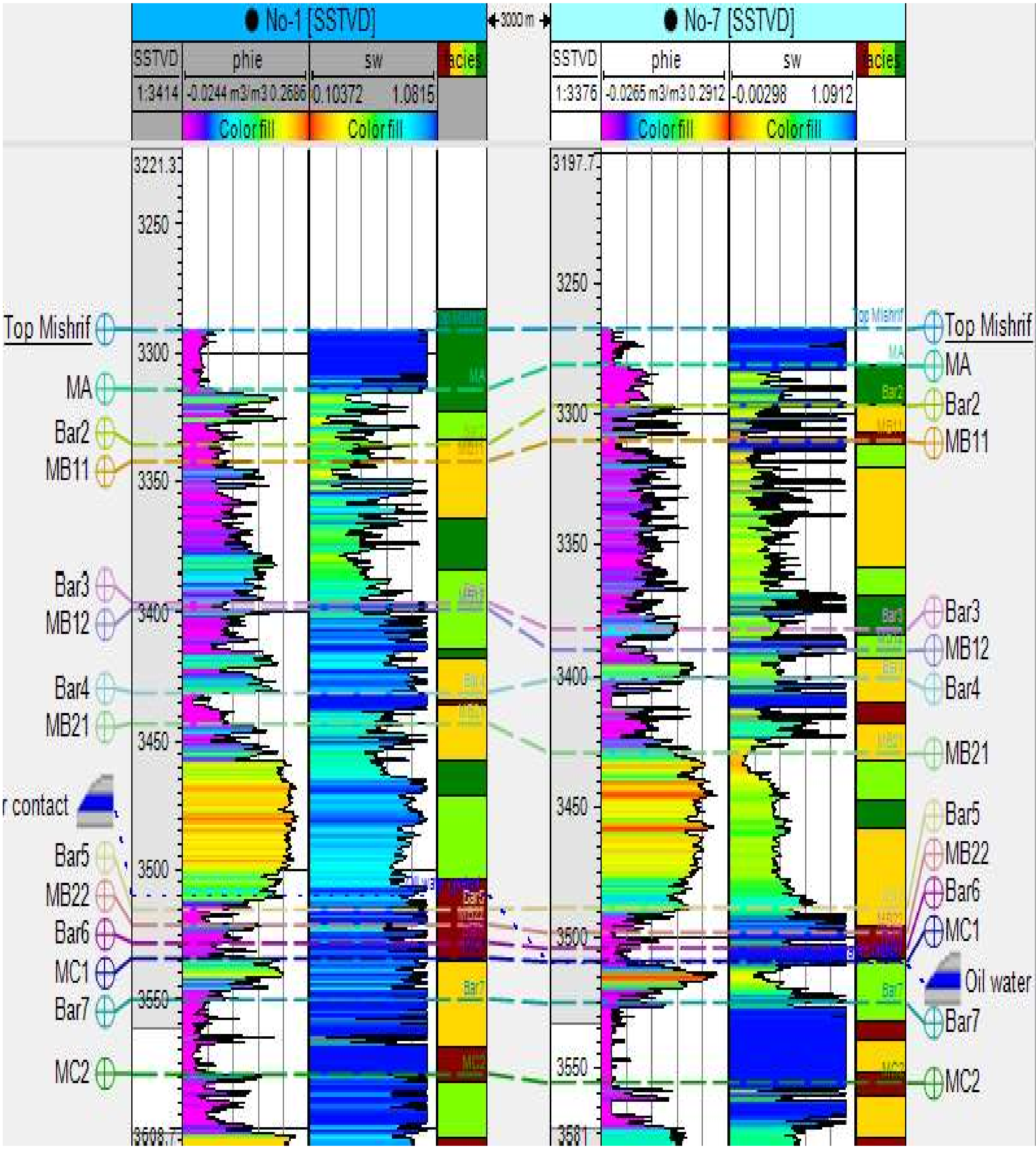


Figure (2.2):Well tops

2.2.2. Well logs

Well logs of 8 studied wells (No-1, No-3, No-4, No-5, , No-7, and No-8) are include ; gamma ray , sp. , neutron, sonic , density and resistivity as well as the CPI that exported from (IP) software .Figure (2.3)&(2.4)



Figure(2.3): correlation sections from east to west of Noor wells

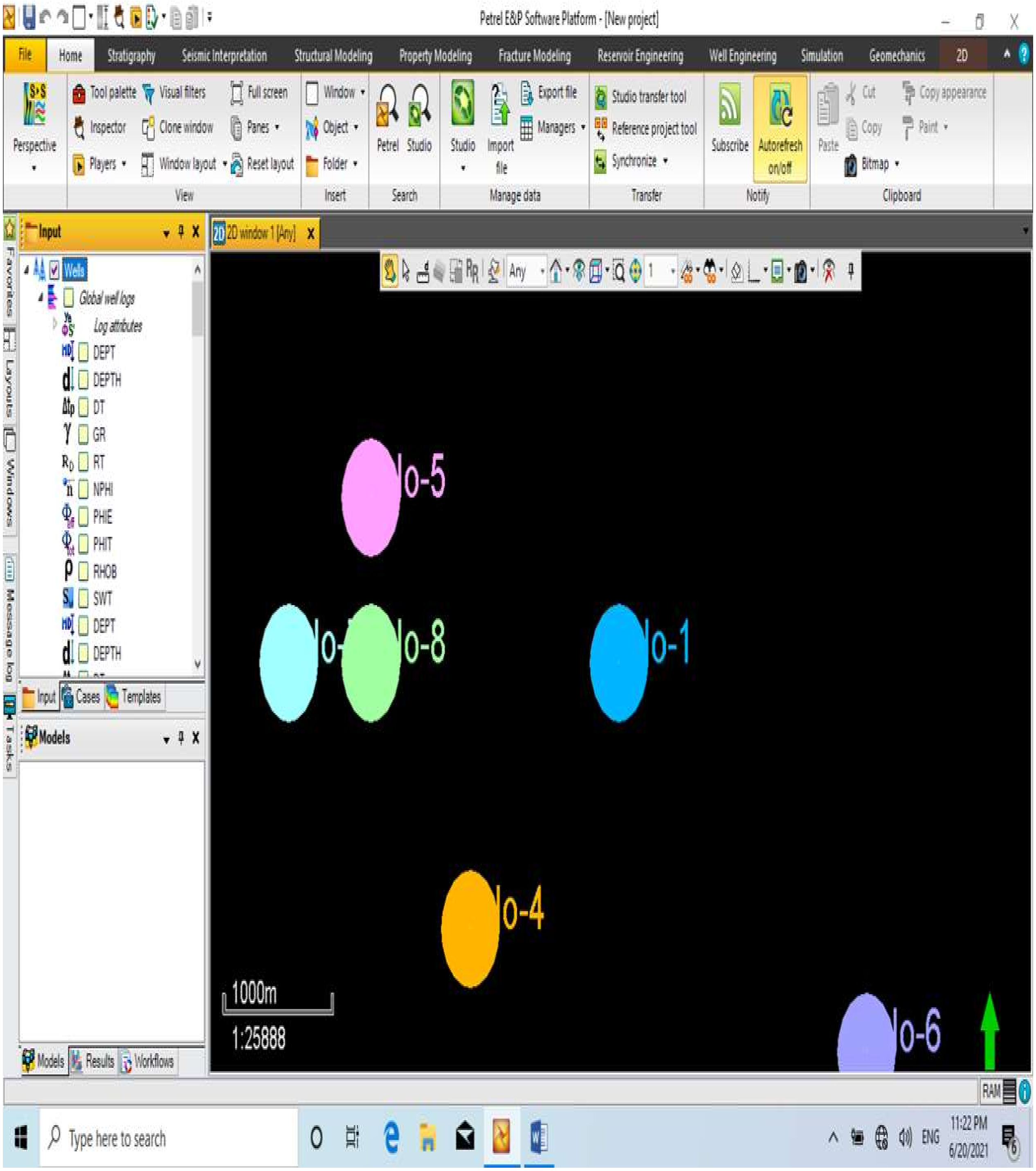


Figure (2.4) 2-D window of the studied wells.

2.3. 3D Grid Construction

A 3D grid construction is the first step to build the 3D model. In simple terms, a 3D grid divides a model up into boxes. Each box is called a grid cell and will have a single rock type, one value of porosity, one value of water saturation, etc. 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 calculations, etc. (Schlumberger, 2007). Figure (2.5).

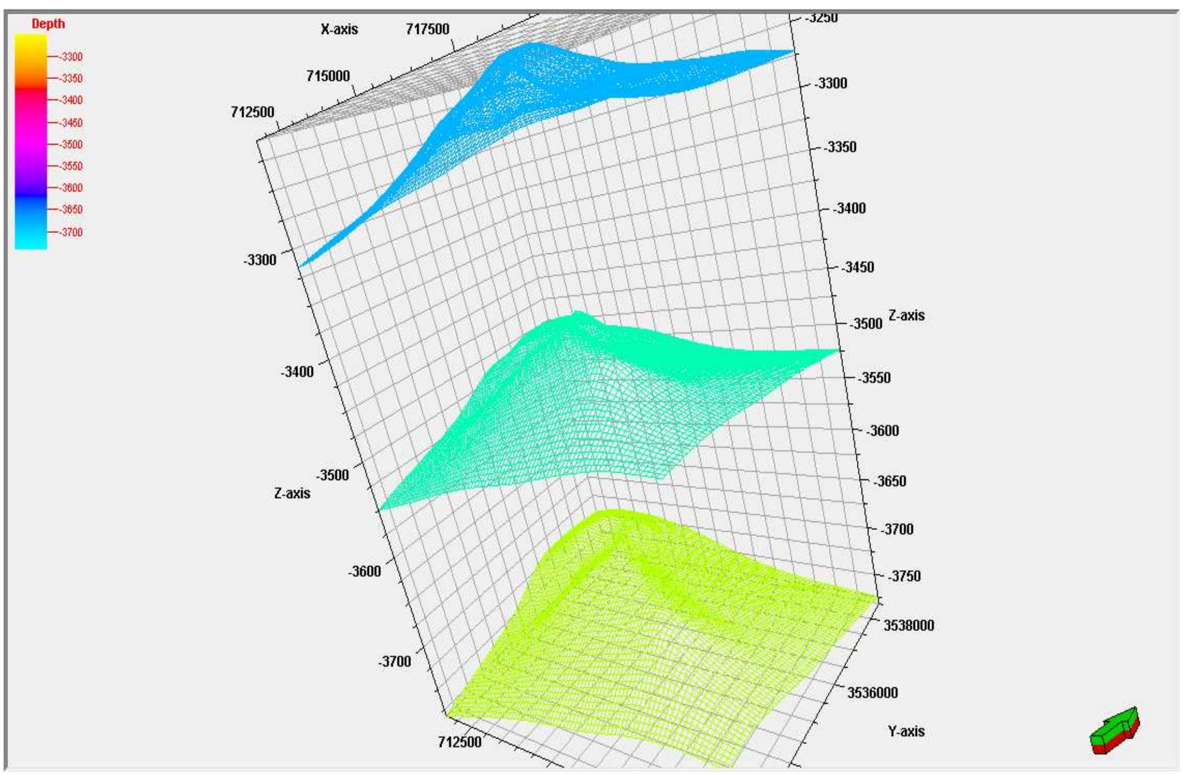


Figure (2.5): 3D Grid of Mishrif formation in Noor Field

2.4 Structural contour map

Contour map can be made by computer from the surface and correlated borehole (Pack, 2000).Structural contour maps of top in Mishrif Formation, MA, MB11, MB12, MB21, MB22 and MC have been induced using Petrel software. Figures (2.6) ,(2.7), (2.8), (2.9)and (2.10) respectively.

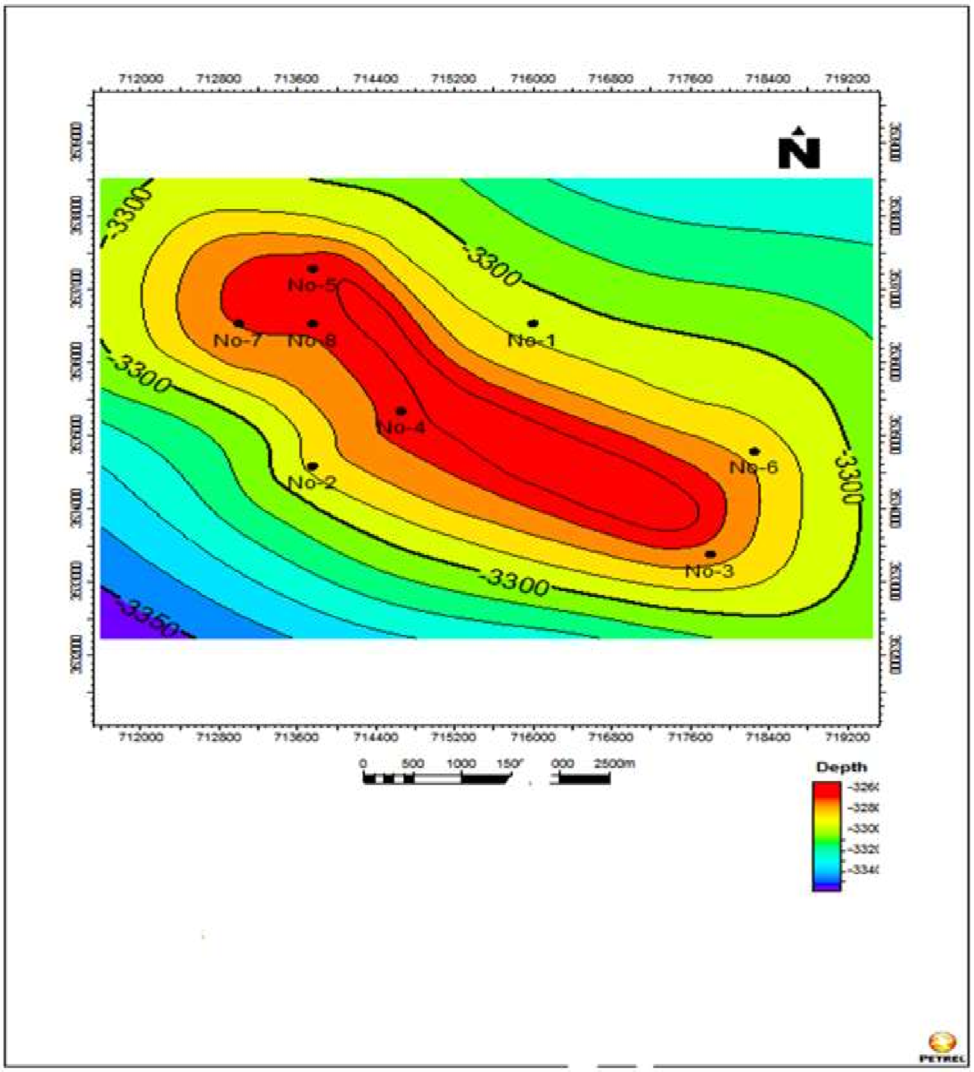


Figure (2.6) Structural countour map of Mishrif Formation in Noor oil Feild.

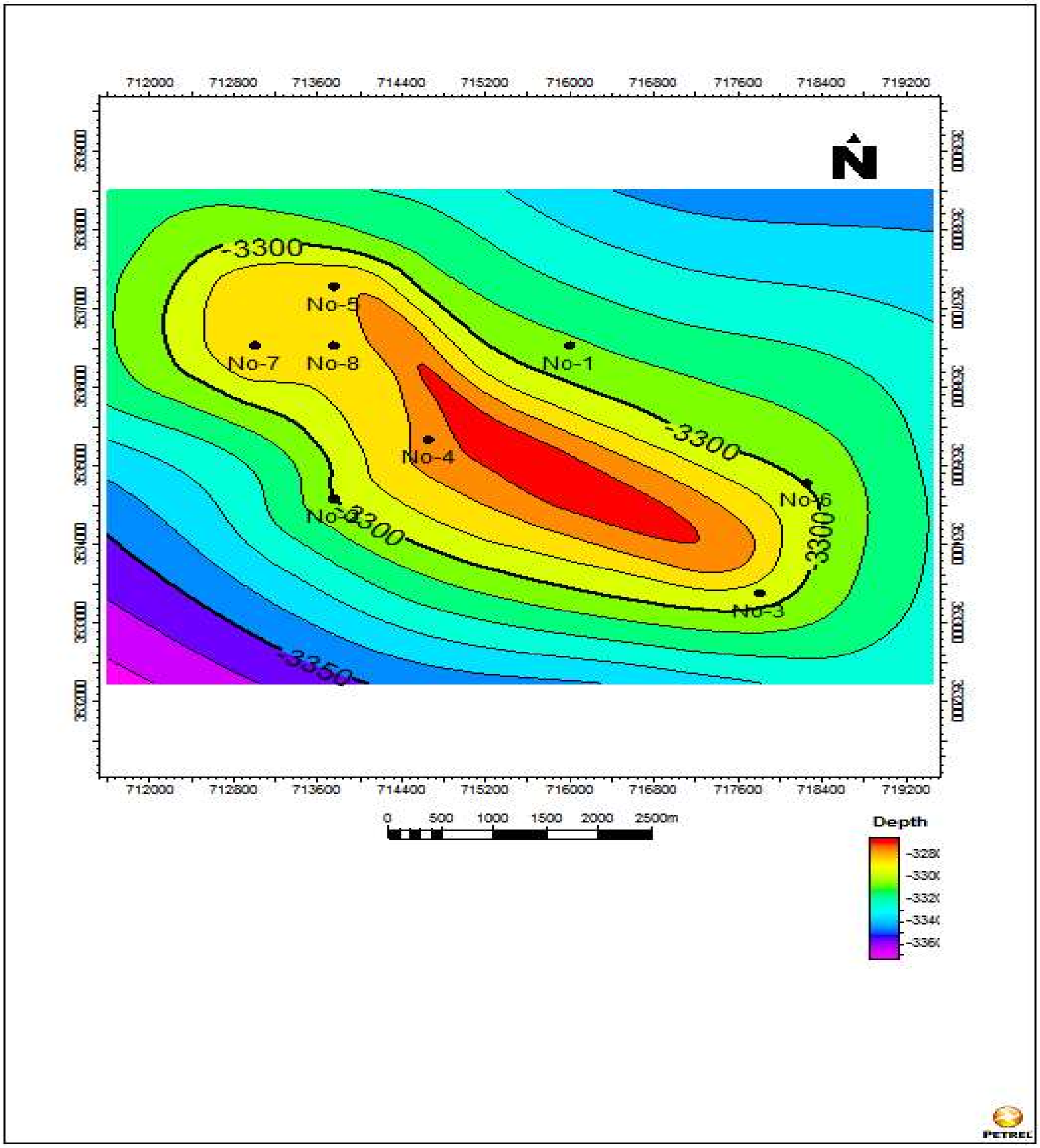


Figure (2.7): Structural depth map on top MA unit in Mishrif Formation.

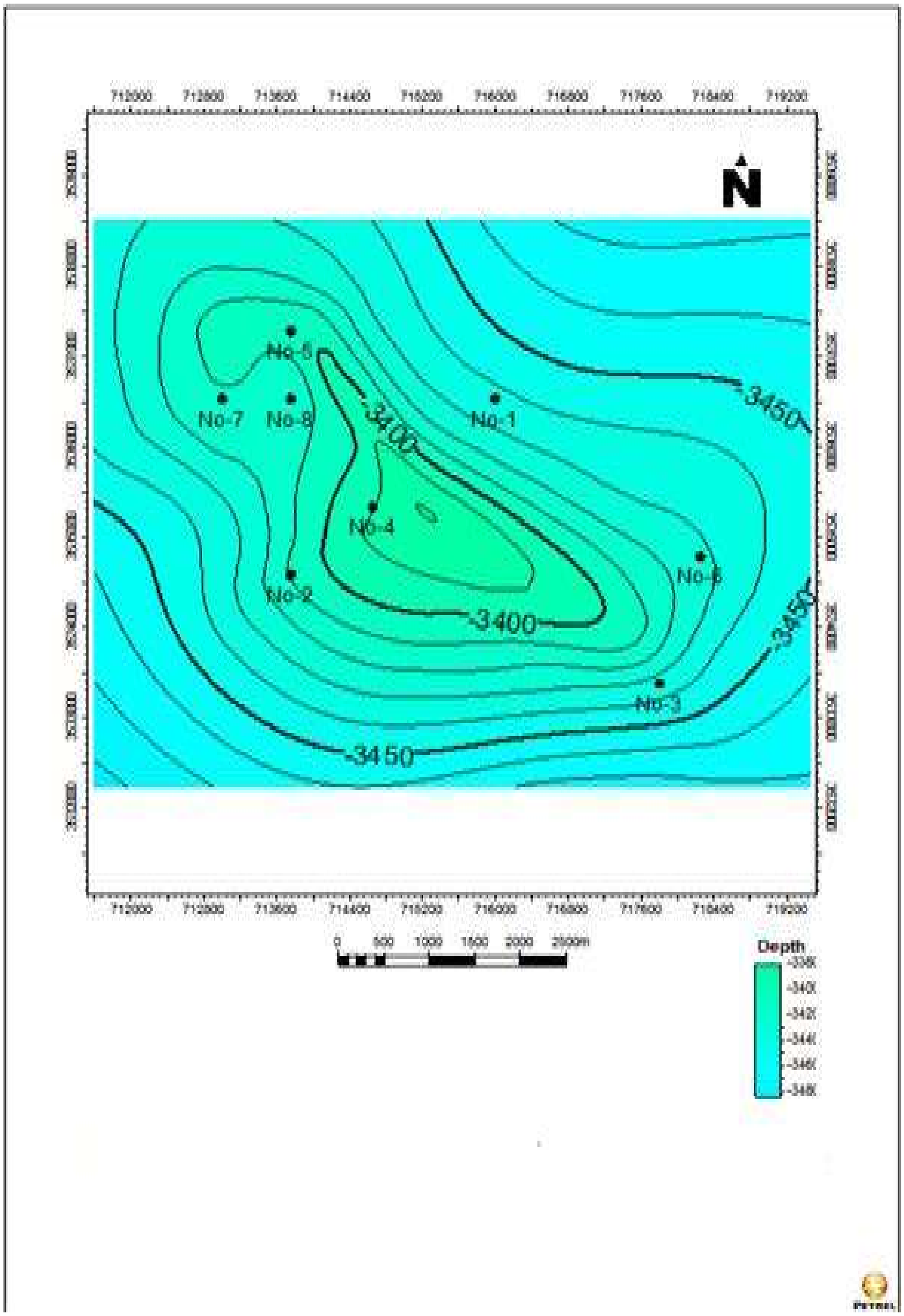


Figure (2.8): Structural depth map on top MB11unit in Mishrif Formation

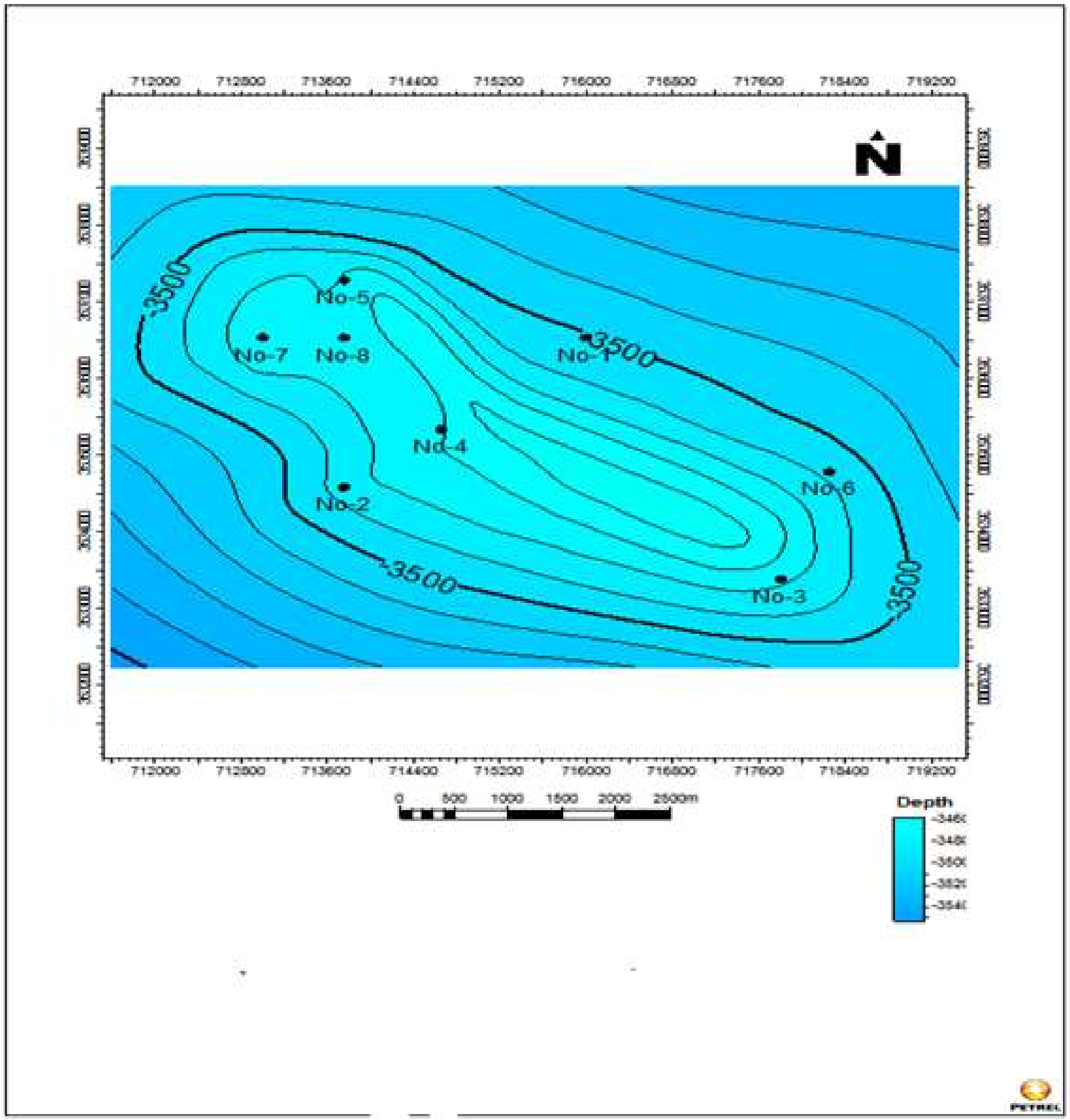


Figure (2.9): Structural depth map on top MB12 unit in Mishrif Formation.

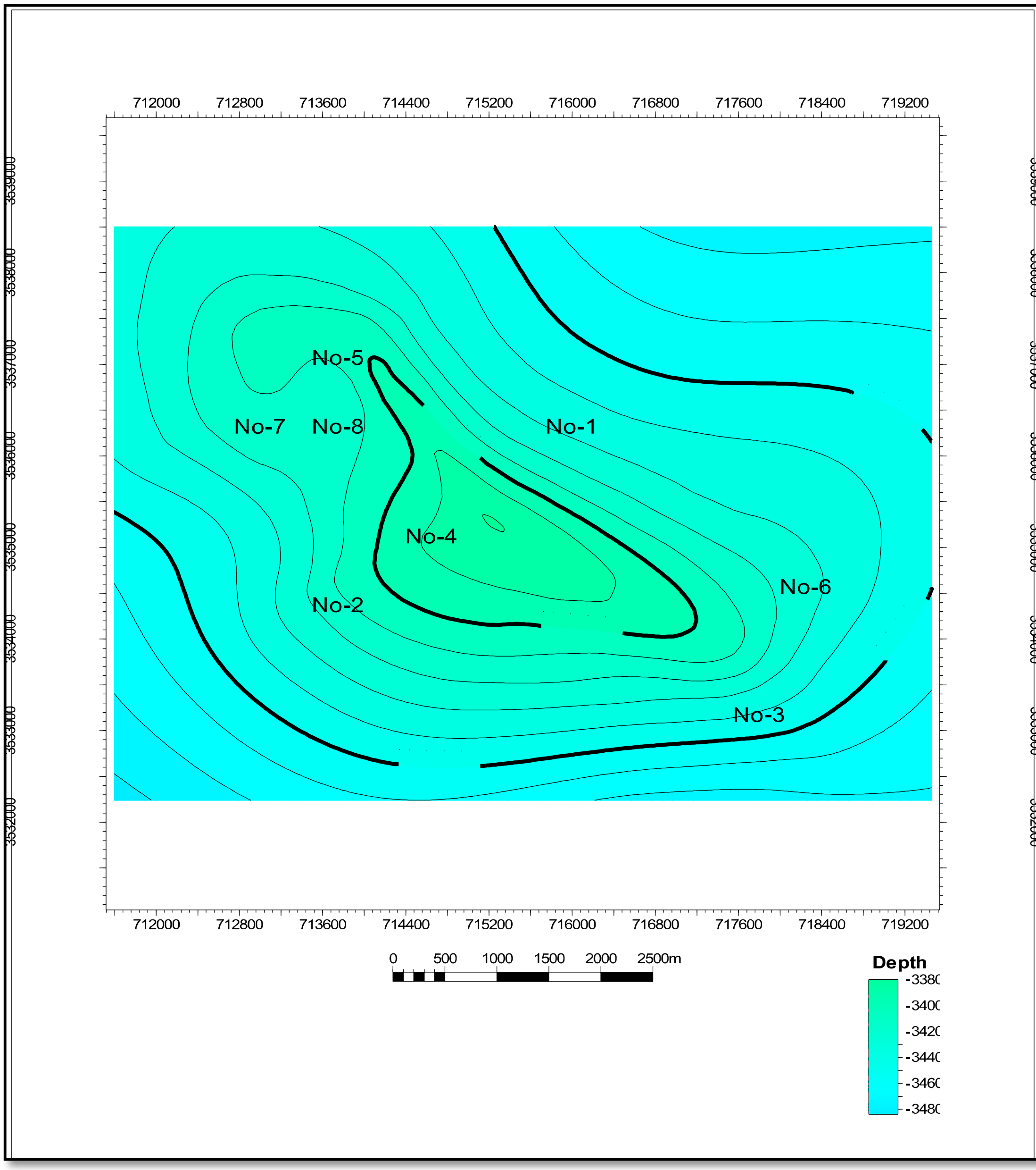


Figure (2.10): Structural depth map to the MB21unit in Mishrif Formation.

2.5 *Make Horizons Process*

Make horizons process step is used in defining the vertical layering of the 3D grid in petrel. This presented a true 3D approach in the generation of 2D surfaces which were gridded in the same process. (Schlumberger, 2009).

For the surfaces to be incorporated into the 3D grid they needed to be transformed into horizons which was done in the "Make horizons" process. With the creation of the six horizons (figure 4-7), five zones were created in between the horizons. The zones, in turn, were divided into layers at a later.

2.6 *Layering Process*

The layering will be part of the zone, and will not have a direct filter like the zones do; layering however, is defined as the internal layering reflecting the geological deposition of a specific zone (Schlumberger, 2010).

Layering is the process when a zone is subdivided into internal layers, the layering is manually carried out to accurately depict the original log. (Schlumberger, 2008).

Each reservoir unit in Yamama formation has been divided into many layers depending on log behavior and petrophysical properties, YR-A is divided into 25 layers, while YR-B unit has 40 layers (a greater number of layers in the formation), and 20 layers in YR-C which is least layers in the formation, figure (2.11).

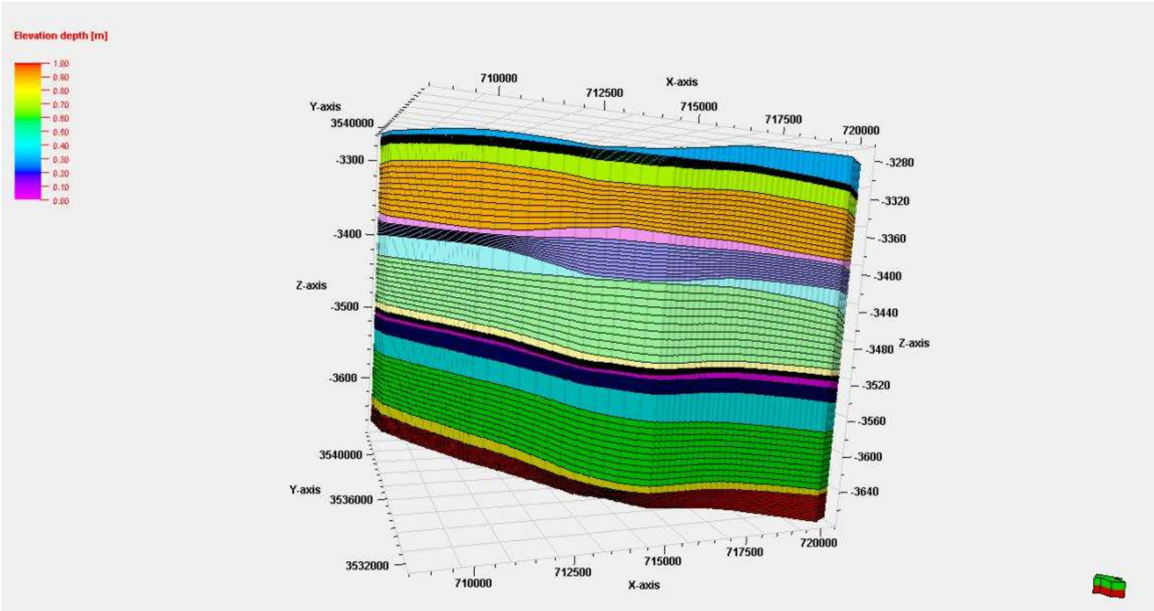


Figure (2.11): Layers setting for Noor Model showing the number of layers in Mishrif Formation.

2.7 *Scale up well log*

When modeling petrophysical properties, a 3D grid cell structure is used to represent the volume of the zone. The cell thickness will normally be larger than the sample density for well logs. As a result the well logs must be scaled up to the resolution of the 3D grid before any modeling based on well logs can be done. This process is also called blocking of well logs. (Schlumberger,2008).

When scaling up the well logs, PETREL will first find the 3D grid cells the wells penetrate. For each grid cell, all log values that fall within the cell will be averaged according to selected algorithm to produce one log value for that cell.

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 using the (arithmetic average). (Schlumberger, 2008).

After the cells being penetrated by the wells had been detected the log data falling into the cells were averaged depending on many statistical and was used for the porosity and water saturation scaling up, figures (2.8)& (2.9) show the scale-up for No-1, No-2, nd No-8 wells.

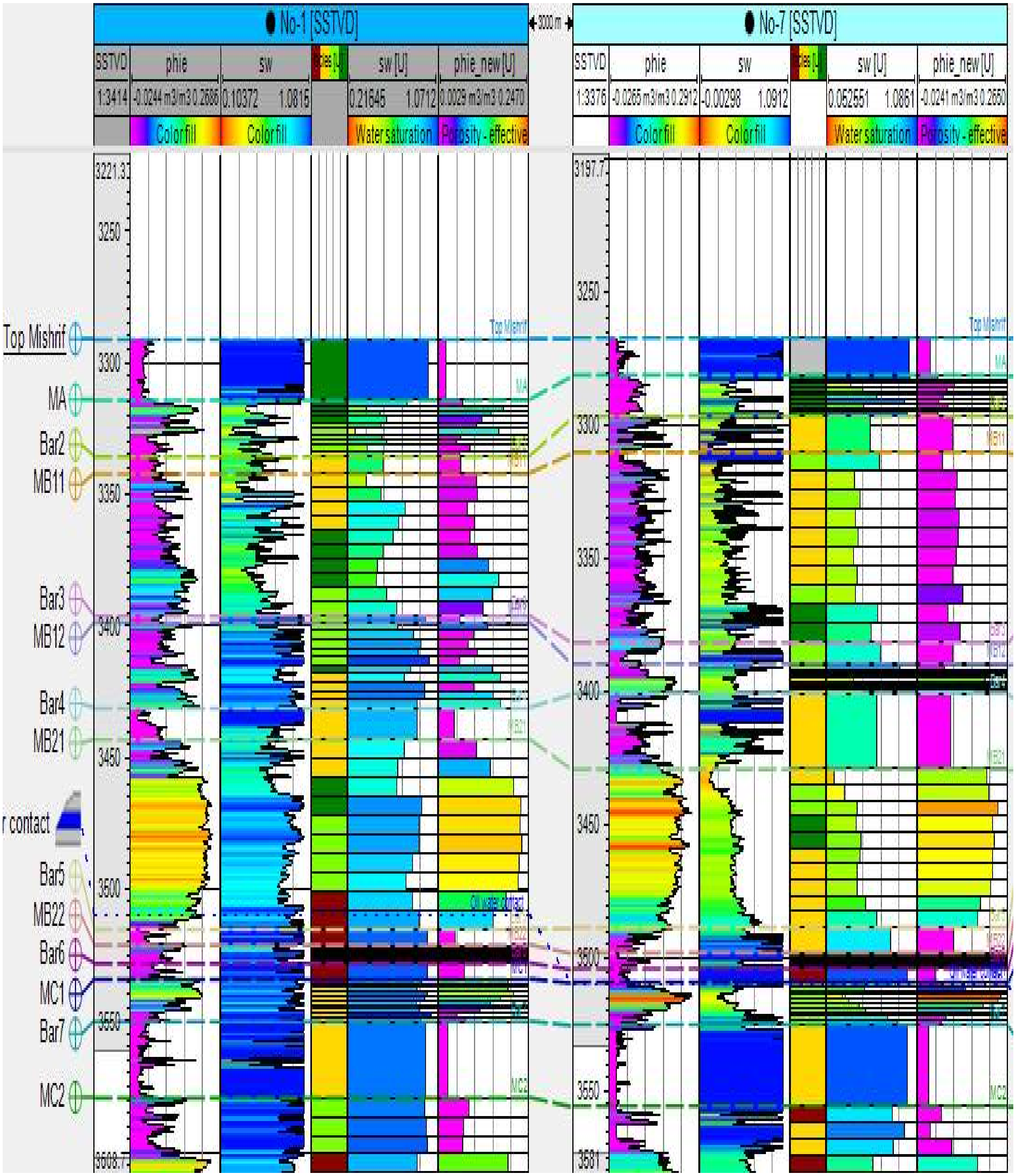


Figure (2.12) : The Scale up of porosity and water saturation for No-1 and No-7 Model.

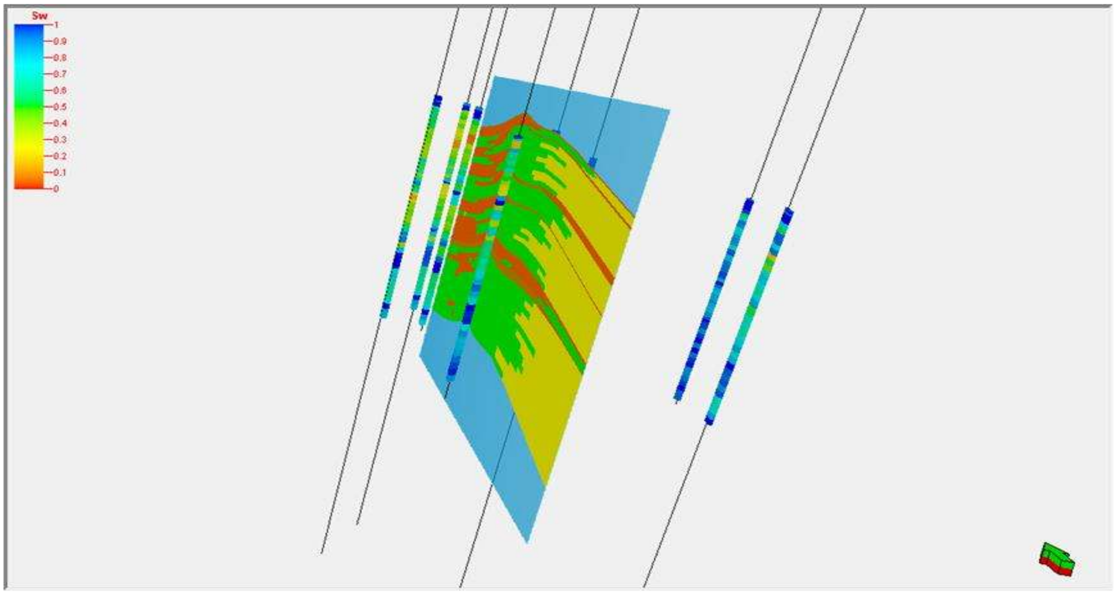


Figure (2.13): Scale up to water saturation.

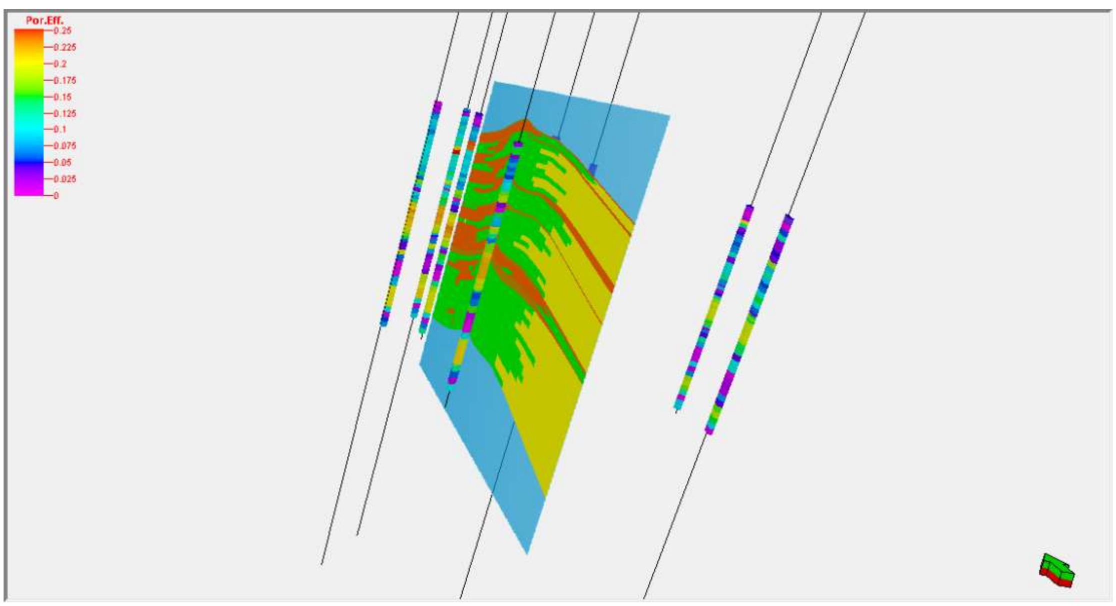


Figure (2.14): Scale up to the porosity.

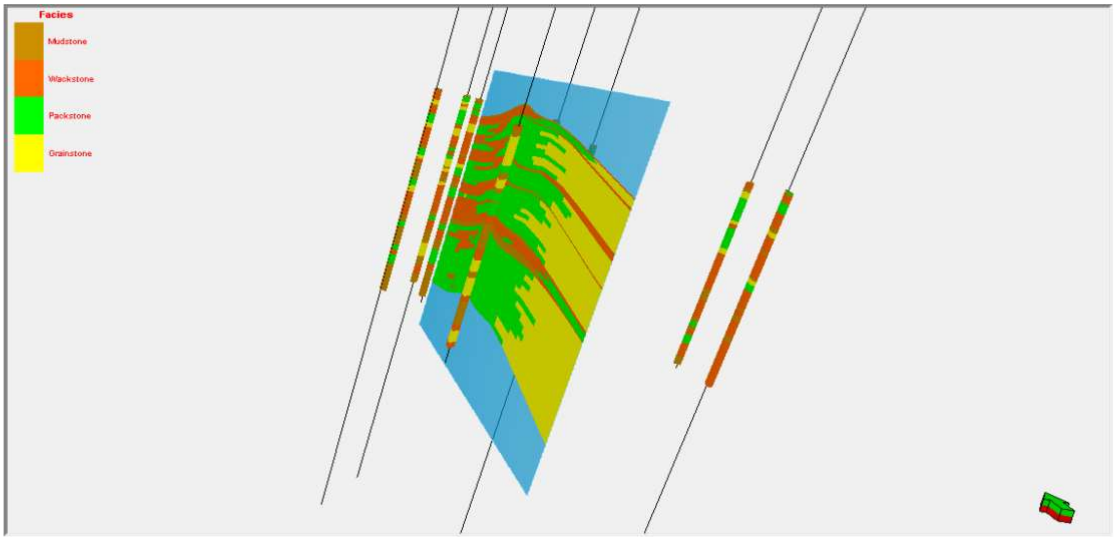


***Figure (2.15): Scale up to the facies*.**

2.8 *Property Modeling*

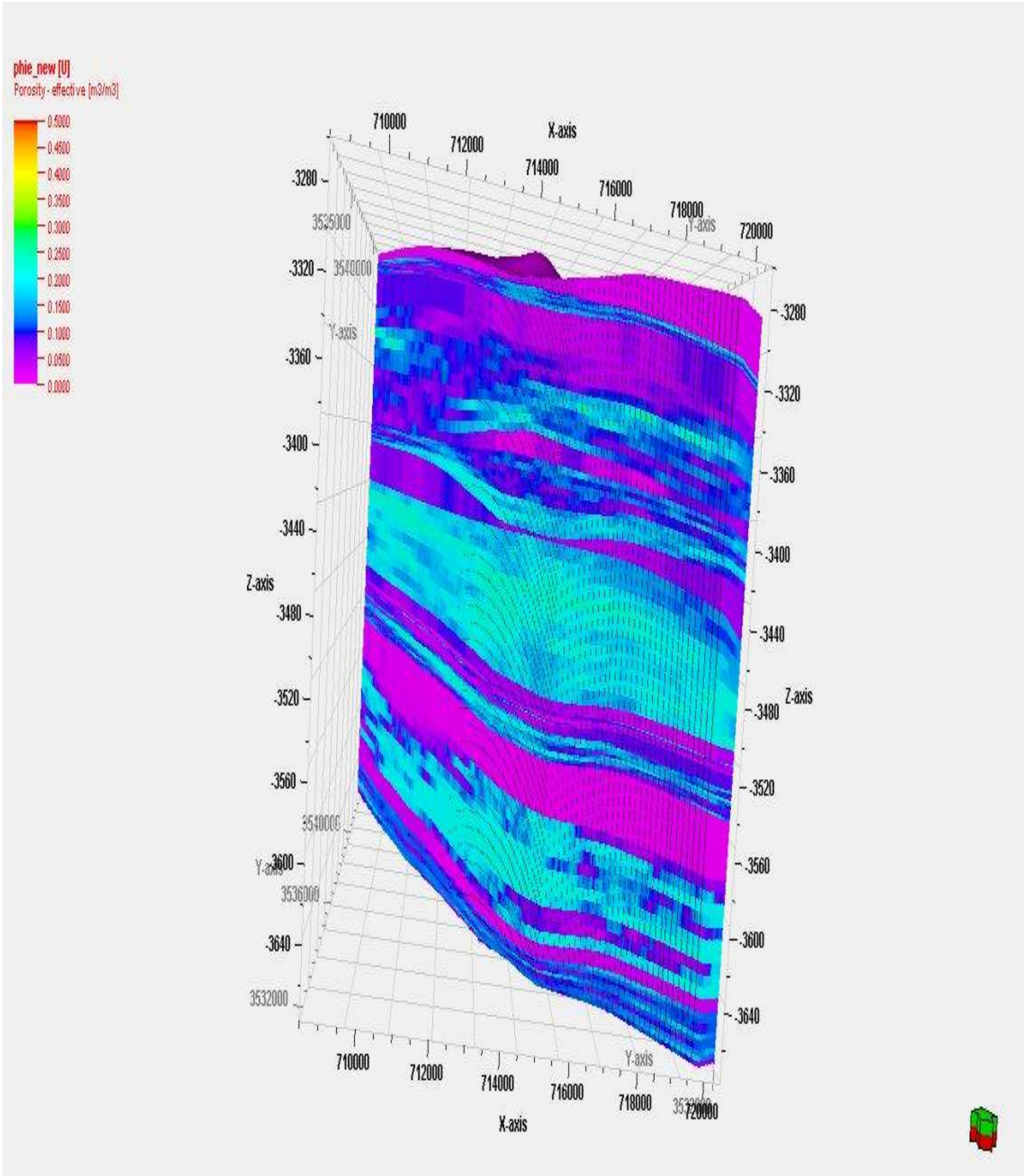
Petrophysical property modeling is the process of assigning petrophysical property values (porosity, water saturation, etc.) to each cell of the 3D grid. Petrel offers several algorithms for modeling the distribution of petrophysical properties in a reservoir model (Schlumberger, 2005).
When the well logs have been scaled up to the resolution of the cells in the 3D grid, the values for each cell along the well trajectory can be interpolated between the wells in the 3D grid. The result is a grid with Property values for each cell.
Sequential Gaussian simulation is the most widely used geostatistical method in the recent modeling projects. This method is very simple and flexible. (Schlumberger,2008).
Geological Model has been created in PETREL software with grid size of X, Y and Z directions and cell size of 100m X 100m cell. Porosity and water saturation maps have been generated based on well values.
Petrophysics model was built using geostatistical methods. The petrophysics models include:

2.8.1 *Porosity:*

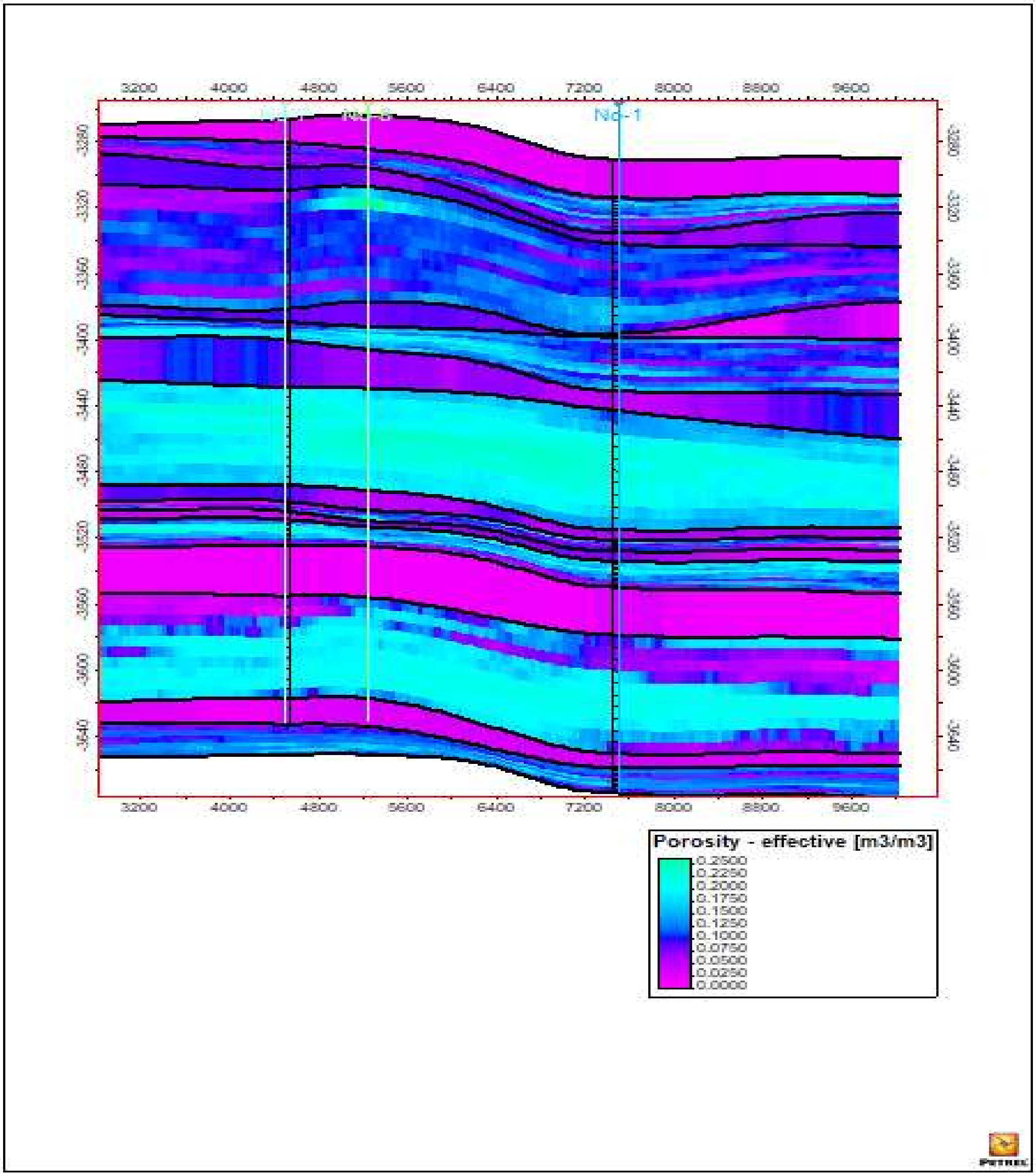
Porosity model was built depending on the results of porosity logs (density, neutron, and sonic logs) which have been interpreted in the Interactive Petrophysics software after the process of scaling up of well logs .

The essential step in the "porosity model" process is to scale up the porosity from the well grid cells to the entire model with the aim of distributing the porosity from the well log data to the grid cells in the 3D model as realistically as possible preserving the heterogeneity of the geological subsurface. Before the porosity could be modeled the original porosity distribution was transformed into a stationary and normally distributed data set. The reason for removing trends prior modeling is for the input data to be stationary. The geostatistical algorithm (Statistical sequential Gaussian simulation algorithm) represents a statistical method which fits with the amount of available data. (Bellorini et al., 2003).

Figures (2.16)& (2.17) show the distribution of the porosity in the reservoir unit in Mishrif Formation.



Figure(2.16) The porosity model of Mishrif Formation in Noor Oil .



Figure(2.17) The porosity model of Mishrif Formation in Noor Oil in intersection window.

2.8.2 Water Saturation (Sw) :

Water saturation at a point within a model is dependent upon both the elevation at that point (point on the saturation curve) and petrophysical parameters, such as pore size distribution. When interpolating between well logs to generate a saturation model, it is therefore important to take into account both petrophysical effects and capillary effects.

After the scale up of water saturation that exports from IP software, the water saturation model was built for each reservoir unit of the Mishrif Formation in the Noor oil field. The same geostatistical method was used in the porosity model (Statistical sequential gaussian simulation algorithm).

Figures (2.12& and 2.13 show the distribution of water saturation models of the reservoir units.

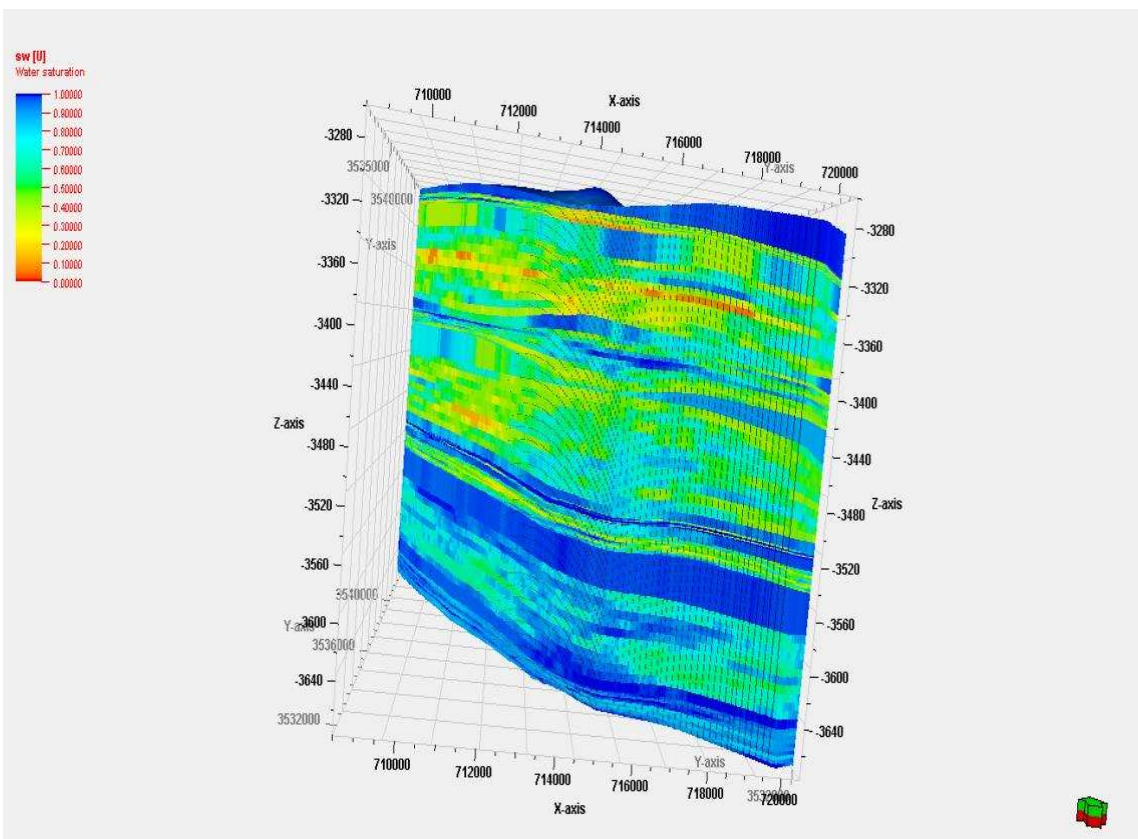


Figure (2.18) : The Water saturation model of Mishrif Formation in Noor Oil Feild.

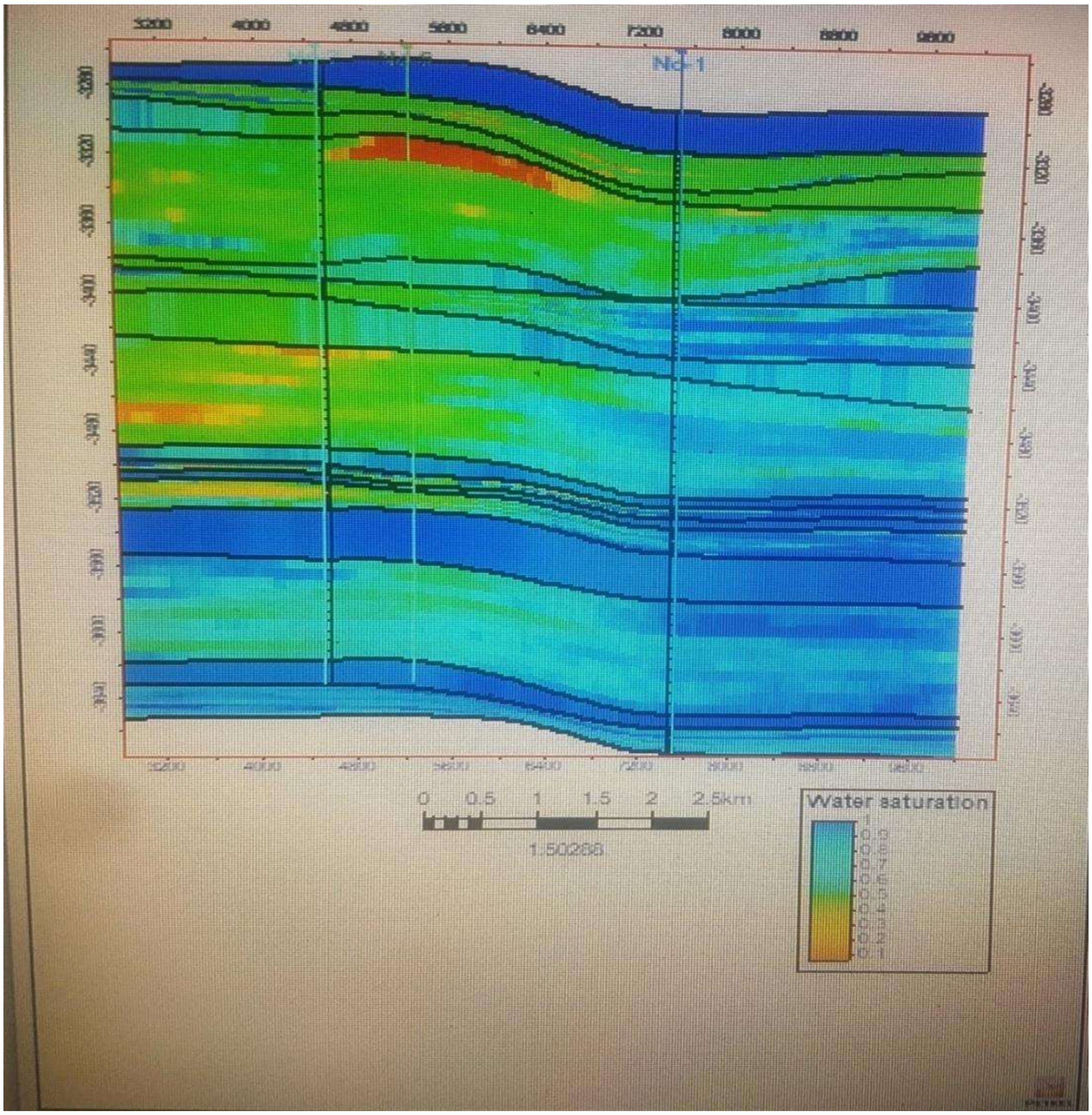


Figure (2.19) : The Water saturation model in intersection window of Mishrif Formation in Noor Oil Field.

2.8.3 Facies and Environmental modeling

Facies modeling is discrete facies throughout the model grid Facies model of Mishrif Formation in the Noor Oil field was built on the results of the microfacies interpretation of sedimentary environments as obtained from logs and other geological data. Figures (2.14,15,16,17,18, and 19).

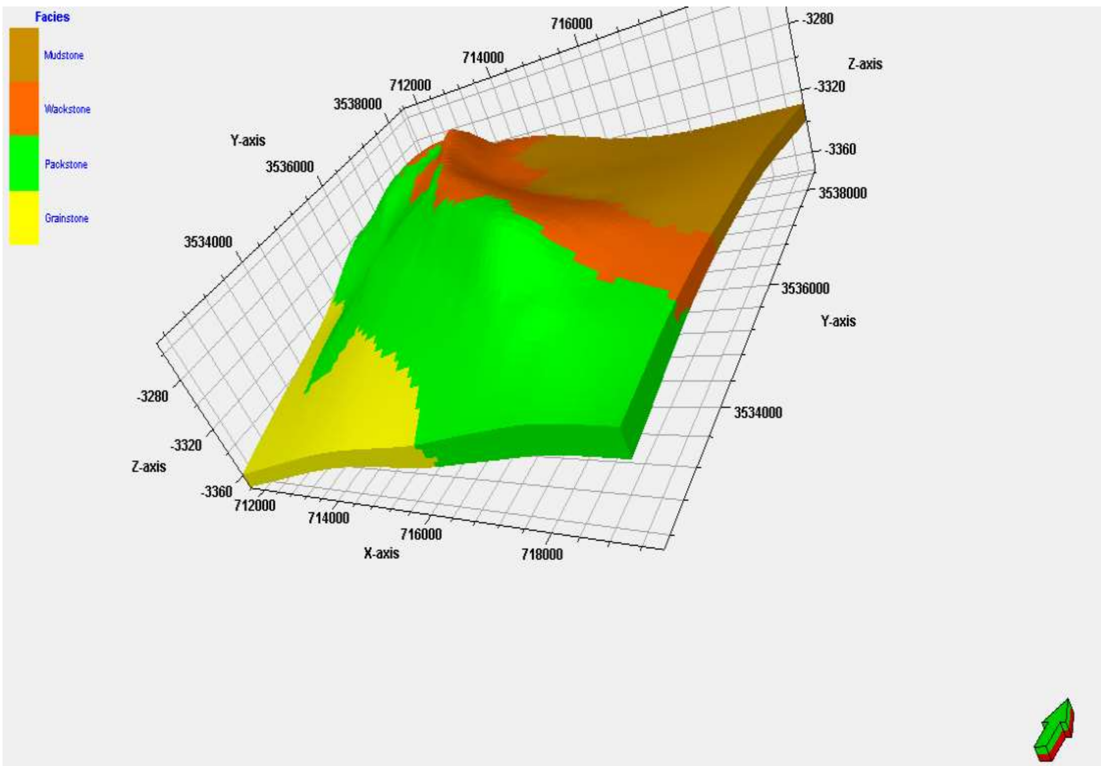


Figure (2.20): Facies model of MA unit in Mishrif Formation.

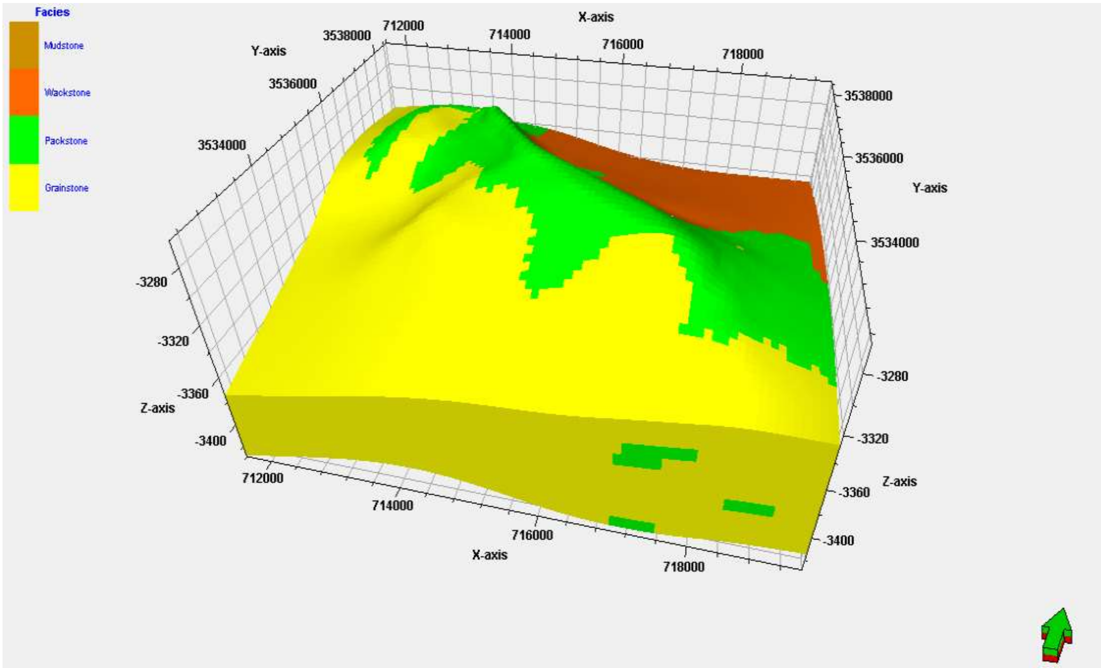


Figure (2.21): Facies model of MB11 in Mishrif Formation.

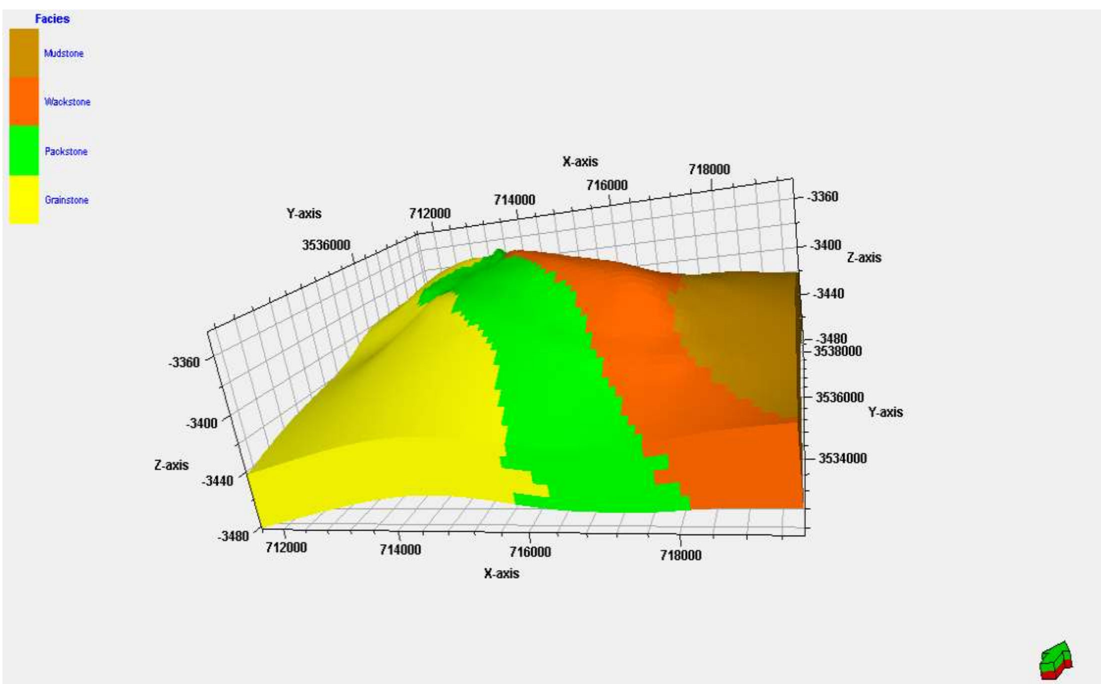
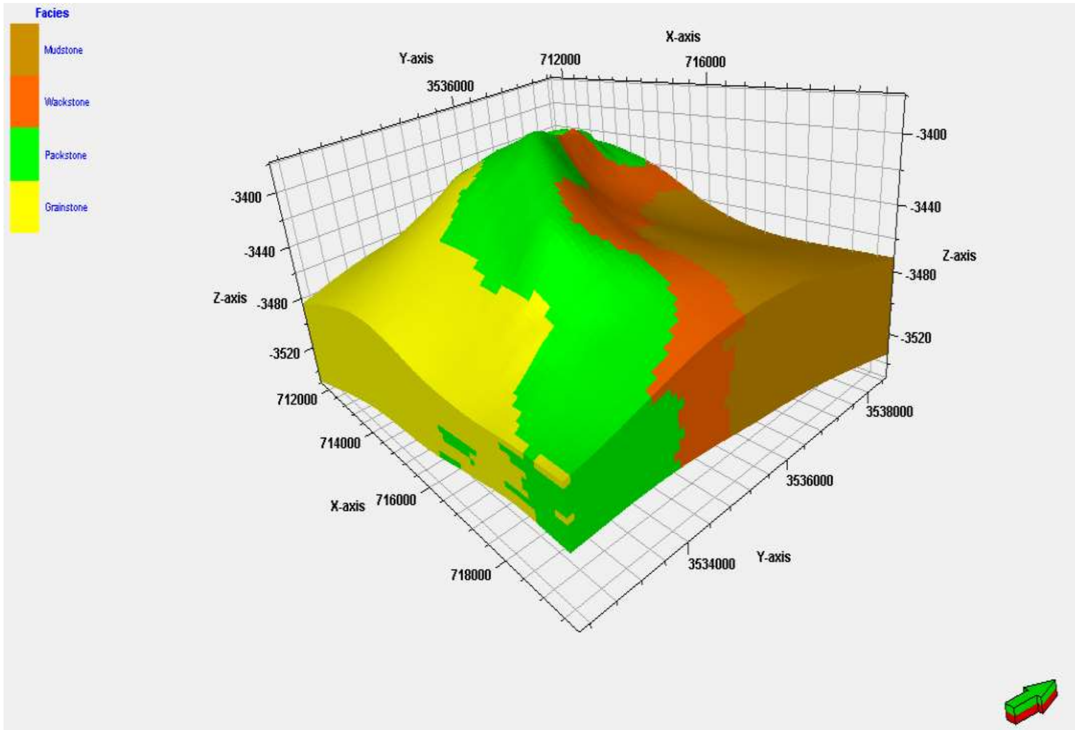


Figure (2.22): Facies model of MB12 unit in Mishrif Formation.



Figure(2.23): Facies model of MB21 unit in Mishrif Formation.

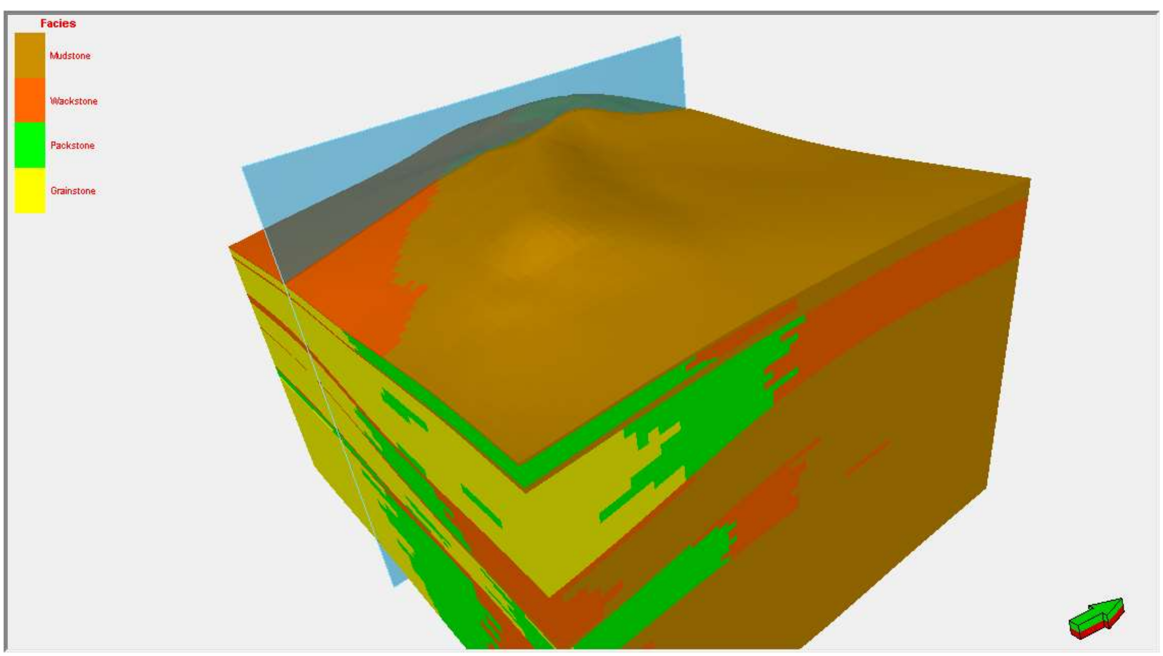


Figure (2.24): 3D facies model of Mishrif Formation in Noor field.

According to the micro facies 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) dominant mainly 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. Figures (2.20, 21, 22, and 23).

Discussion

According to the Petrophysical properties, Mishrif Formation is divided into several units. These are MA, MB11, MB12, MB21, MB22, and MC. Each 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 porosity and 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 units show moderate to high porosity with low values of water saturation.

High value of porosity is due to presence this units within shoal (including rudists biostrome) , back shoal, shallow open marine environments. Rudists biostrome represents the main components and then major oil producing reservoirs in the Cretaceous carbonate strata in this formation.

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

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

5-3D 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 enhancement in porosity affected by lateral and vertical facies variation. This facies variations affected by sea level changes and their relationships with the tectonic factors. 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, path improvement take a direction NW-SE passes through the dome of the structure. MA and MB11 reservoir units the improvement in porosity taking a path in S and SE direction from the field. While in MB12 the enhancement located in and southern part of the field.

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