

3D Geological Modeling Using Petrel Software

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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.

Keywords- Petrophysical; geological model; Petrel Software.

I. INTRODUCTION

a 3D geological model of a simple petroleum reservoir will be built. All steps will be shown with screen shots of the necessary figures. The software to be used is Petrel, which is a product of Schlumberger, the ultimate objective of this Geological study was to construct 3D models of Mishrif Formation in the Noor field for the consequent reservoir simulation study. 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 engineers to identify which recovery options offer the safest and most economic, efficient, and effective development plan for a particular reservoir. [1]. The Petrel platform provides the tools and the freedom to explore and think creatively in all dimensions, allowing complex geology to be understood and characterized — quickly. [2].

II. GENERAL WORK FLOW OF 3D GEOLOGICAL MODELING

Identifying and recovering hydrocarbons requires accurate, high-resolution geological modeling of the reservoir structure, stratigraphy, and rock properties. The Petrel software platform provides a full spectrum of geological workflows to solve the most complex geological and modeling challenges. 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). [3].

III. DATA AND MATERIALES

Four borehole have been studied (No-1, No-3, No-4 and No-5).PHIE and SW have been collected from these wells .In addition full sets of logs(gamma ray, sp., neutron, sonic, density and resistivity).

IV. DATA IMPORT

In this study, to build a 3D model there are many types of data that should be supplied to the Petrel software. They are include:

A. WELL HEADS

Well heads of 4 boreholes of Noor field are import to the Petrel software (No-1, No-3, No-4 and No-5), they include; position (eastern, northern) and "Rotary Table Kelly Bosh" (RTKB) and as well as the total depth for each studied well Fig. (1).

ID	Name	LWI	Folder	Well symbol	Surface X	Surface Y	Latitude	Longitude	Drilling structure	Well datum name	Well datum value	TD (IVSS)	TD (MD)
1	No-1	Well		OH	71650.00	333650.00	31°58'39.939"N	47°16'53.912"E	KB	KB	16.7	3674.0	3691.0
2	No-3	Well		OH	71780.00	333180.00	31°56'50.999"N	47°15'48.917"E	KB	KB	16.5	3642.0	3659.0
3	No-4	Well		OH	71460.00	333550.00	31°58'17.521"N	47°16'14.933"E	KB	KB	17.2	3596.0	3642.0
4	No-5	Well		OH	71590.00	333700.00	31°57'50.797"N	47°15'41.480"E	KB	KB	16.3	3523.0	3648.0
5	No-6	Well		OH	71650.00	333400.00	31°58'44.257"N	47°15'37.748"E	KB	KB	16.5	3594.0	3583.0
6	No-7	Well		OH	71300.00	333650.00	31°56'41.905"N	47°15'33.887"E	KB	KB	15.5	4132.0	4142.0
7	No-8	Well		OH	71390.00	333850.00	31°58'41.287"N	47°15'10.895"E	KB	KB	19.2	3652.0	3672.0

Fig. (1); Well Heads.

B. WELL TOPS

Data include the Markers representing significant points (well picks) along the well path, normally a change in stratigraphy, the reservoir units of the Mishrif Formation have been imported to Petrel as well as the total depth for each studied well Fig. (2).

No-1	Top Mishrif	3308
No-1	MA	3331
No-1	Bar2	3352.5
No-1	MB11	3359
No-1	Bar3	3413
No-1	MB12	3415.5
No-1	Bar4	3448
No-1	MB21	3460
No-1	Bar5	3532
No-1	MB22	3538
No-1	Bar6	3545
No-1	MC1	3551
No-1	Bar7	3567
No-1	MC2	3596
No-1	Bar8	3667.5
No-1	MC3	3676
No-1	Rumaila	3691.5
No-3	Top Mishrif	3292.5
No-3	MA	3317
No-3	Bar2	3329.5
No-3	MB11	3345
No-3	Bar3	3398.5
No-3	MB12	3409.5
No-3	Bar4	3431.5
No-3	MB21	3452
No-3	Bar5	3517

Fig. (2); Well Tops.

C. WELL LOGS

Well logs of studied wells (No-1, No-3, No-4, and No-5) are include; (gamma ray, sp., neutron, sonic, density and resistivity) as well as the CPI with (porosity and water saturation) that have been calculated from IP software Fig. (3,4).

DEPTH	DT	GR	RT	NPHI	PHIE	PHIT	RHOB
3308	72.0396	29.0639	7.7273	0.3028	0.0722	0.077307	2.3313
3308.1	69.5999	29.1035	8.7806	0.2903	0.0635	0.068616	2.311
3308.2	65.8927	28.049	9.9775	0.2778	0.052	0.056469	2.2954
3308.3	62.4964	26.5755	11.3376	0.2653	0.0422	0.045788	2.2854
3308.4	60.2311	25.0152	12.883	0.2505	0.0364	0.039156	2.2793
3308.5	59.1504	23.3548	14.6392	0.2342	0.035	0.036769	2.2794
3308.6	58.2997	22.2603	16.3733	0.2179	0.0335	0.03468	2.2911
3308.7	57.4447	21.0429	17.6315	0.2015	0.0321	0.032654	2.3181
3308.8	56.8268	19.7271	17.6772	0.1852	0.0313	0.031306	2.3451
3308.9	56.6926	19.204	16.6863	0.1689	0.0308	0.03083	2.3653
3309	56.9051	19.1274	16.5096	0.1526	0.0316	0.031584	2.381
3309.1	57.2054	19.2749	16.3348	0.1479	0.0326	0.032649	2.4053
3309.2	57.5801	19.4302	16.1618	0.1501	0.034	0.033978	2.413
3309.3	58.4753	18.6957	15.0395	0.1574	0.0372	0.037153	2.39
3309.4	60.0122	18.3973	14.4465	0.1647	0.0426	0.042604	2.3534
3309.5	61.9061	18.2392	13.9738	0.1771	0.0493	0.049321	2.3485
3309.6	63.2099	18.0364	13.6573	0.1993	0.0539	0.053945	2.3503
3309.7	63.3639	17.6816	13.348	0.2215	0.0545	0.054491	2.3495
3309.8	62.412	17.3463	12.5816	0.2437	0.0511	0.051115	2.2978
3309.9	60.8591	17.5388	11.5314	0.2659	0.0456	0.045607	2.2736
3310	59.5115	17.8775	10.7435	0.2677	0.0408	0.040828	2.2882
3310.1	58.5666	18.0048	10.7872	0.2618	0.0375	0.037477	2.3144
3310.2	58.0737	17.7383	11.6022	0.2456	0.0357	0.035728	2.3326
3310.3	57.5264	17.3906	13.3153	0.2293	0.0338	0.033787	2.3335
3310.4	56.7649	17.0109	15.2814	0.213	0.0311	0.031086	2.3336
3310.5	55.9837	16.2647	17.8627	0.1967	0.0283	0.028316	2.3404

Fig. (3) : Well logs.

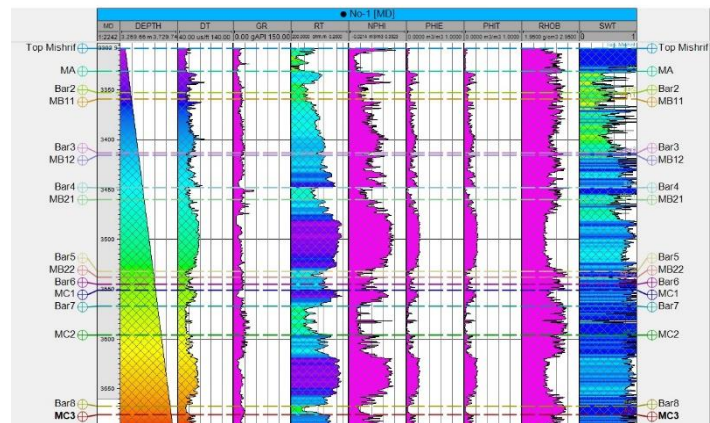


Fig. (4); Well logs No-3.

D. WELL CORRELATION

Well correlation Process used to visualize, correlate or edit wells, log curves, well tops, stratigraphic information, together in order to perform a better geological interpretation. Well correlation has been applied as a relatively easy method to give an idea and allow simple visualization of the changes in the thickness within Mishrif units and the change of the petrophysical properties (Porosity and water saturation). [4]Fig.(5,6).

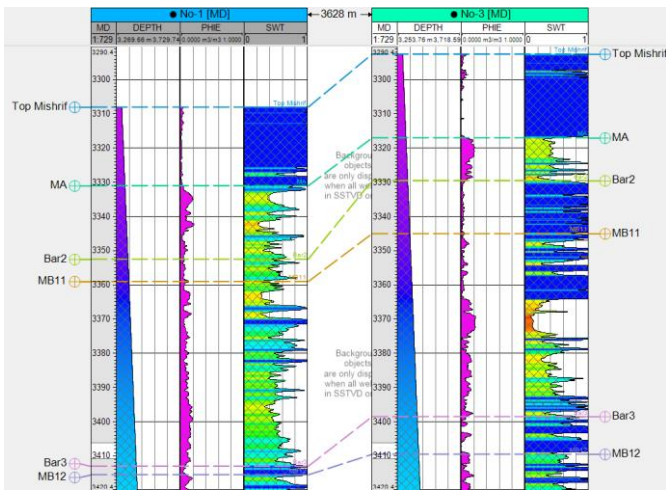


Fig.(5) ; Well Correlation (No-1,No-3).

E. STRUCTURAL CONTOUR MAP

Contour maps can be made by computer from the surface and correlated borehole. [5]. Contour maps for exploration may depict geologic structure as well as thickness of formations. [6]. Structure contour map of top Mishrif Formation have been digitized by Didger program, the result convert to Text file to loaded it in petrel program then to step (make edit surface), Fig.(7)

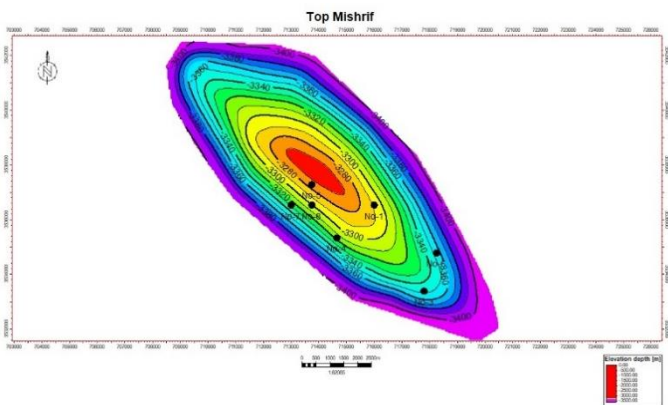


Fig. (7) : Structural contour map on top of the (Mishrif) in Noor Oil field.

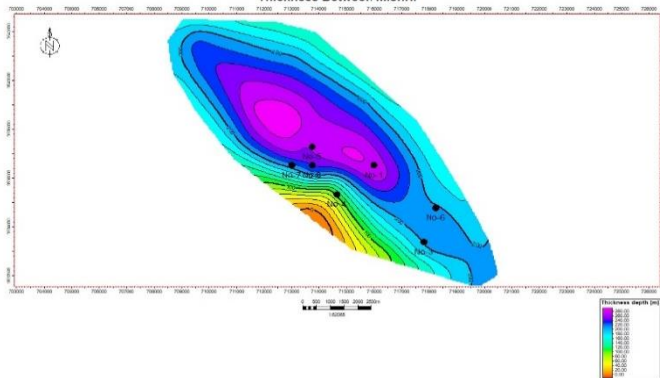


Fig. (8) : Structural contour map on top of the (thickness Mishrif) in Noor Oil field.

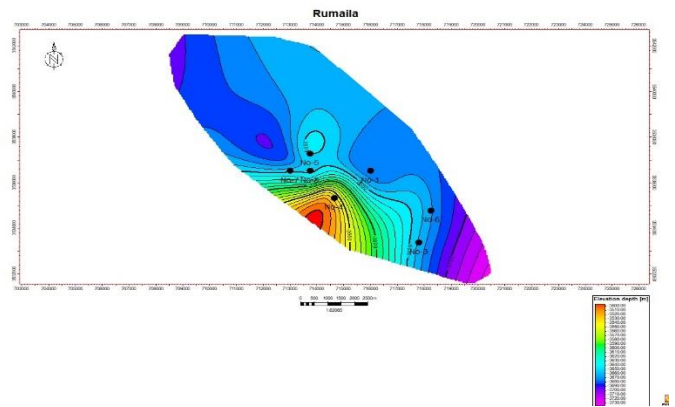


Fig. (9) : Structural contour map on top of the (Rumaila) in Noor Oil field.

V. 3D GRID CONSTRUCTION

3D Grid - a network of horizontal and vertical lines used to describe a three-dimensional geological model. [6]. The lateral limits on the grid (modeling area) were determined and designed for geological modeling and in consideration of the expected hydrocarbon accumulation areas. The horizontal cell size was set at 100 x100 m and the grid rotation angles were determined to reflect the major orientation of the anticline of the structures. 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. [7].

A. SKELETON

The skeleton is made up of the three grids created during Pillar Gridding. These three so-called skeleton grids are associated with Top-, Mid- and Base-Shape Points, but not related to the layering of the 3D grid. [8]. By using the Pillar Gridding, the 3D grid model of Mishrif Formation in Noor field has been constructed. The result from the Pillar Gridding is the main skeletons in top, mid and lower skeletons as seen in the Fig. (10).

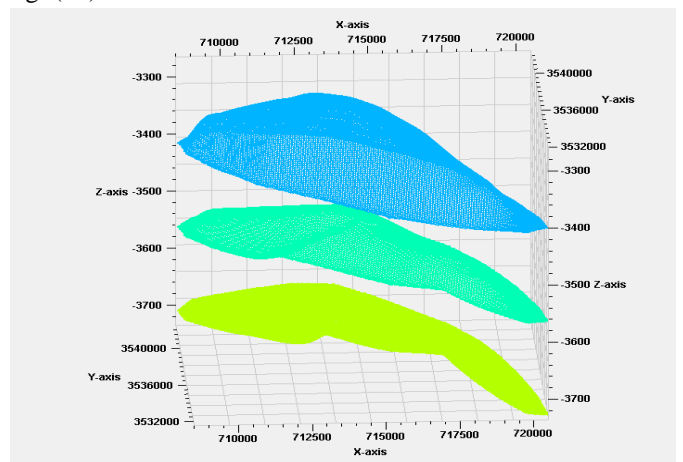


Fig. (10): The Skeletons of Mishrif Formation in Noor Oil field.

B. 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. [9]. 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 fifteen horizons (Fig.11).

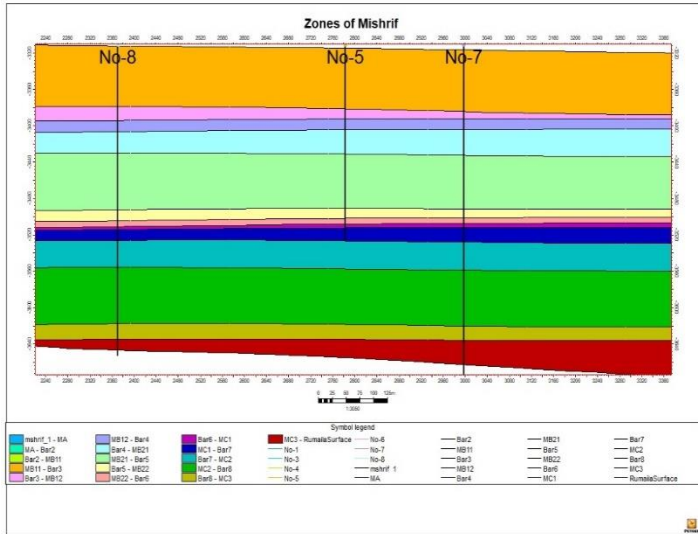


Fig. (11): Zones of Mishrif Formation in Noor Oil field.

C. 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 [10]. Layering is the process when a zone is subdivided into internal layers, the layering is manually carried out to accurately depict the original log. [11]. Each reservoir unit in Mishrif Formation has been divided into many layers depending on log behavior and petrophysical properties.

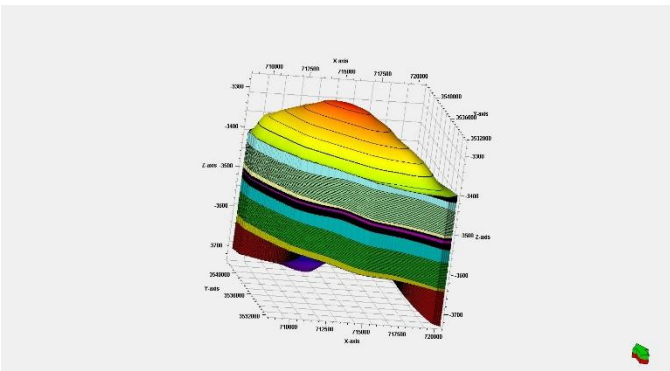


Fig. (12); Layers setting of Noor Model.

D. SCALE-UP WELL LOGS

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. [12]. 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). [13]. 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, Fig. (13) shows the scale-up for No-1 well.

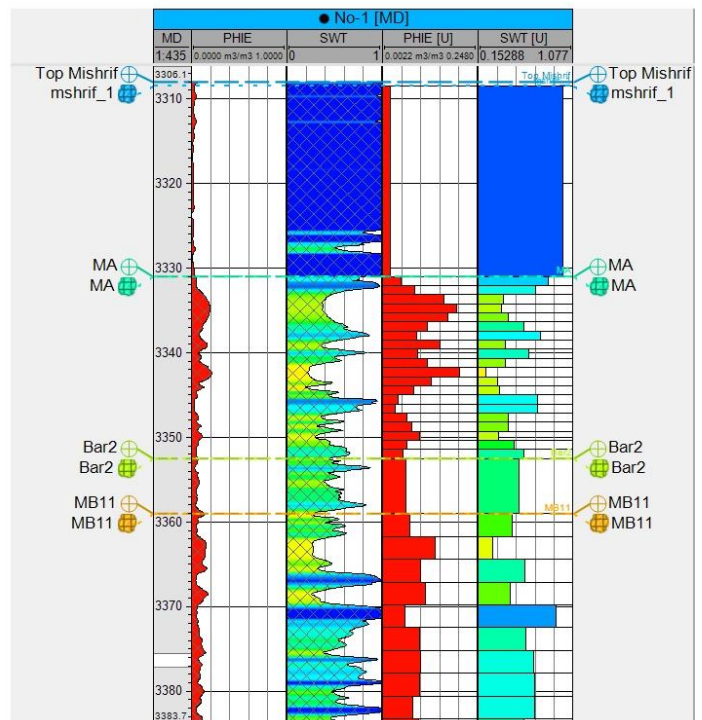


Fig. (13) ; The Scale up of porosity and water saturation for No-1 Model.

E. 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 [14]. 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. [15]. 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 .

1. POROSITY

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 Fig.(14,15,16).

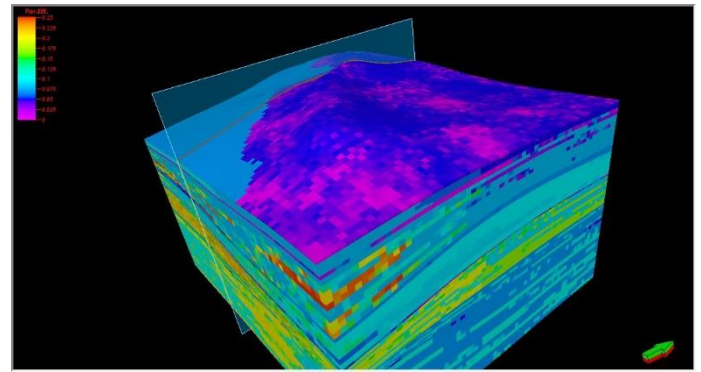


Fig.(16); The porosity model of Noor field.

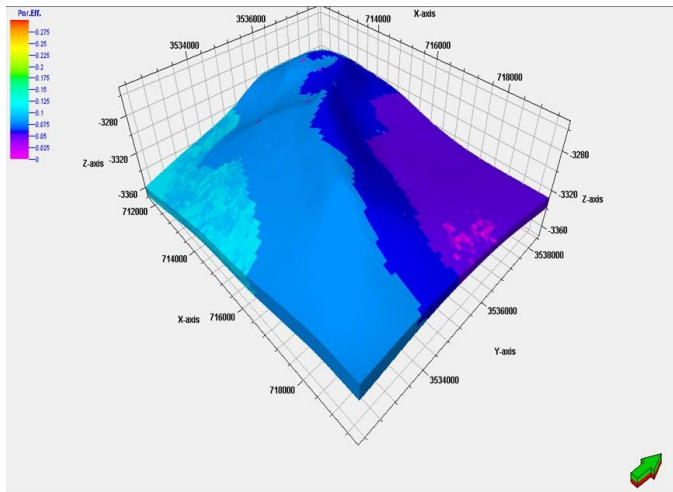


Fig. (14); The porosity model of MA in Noor field.

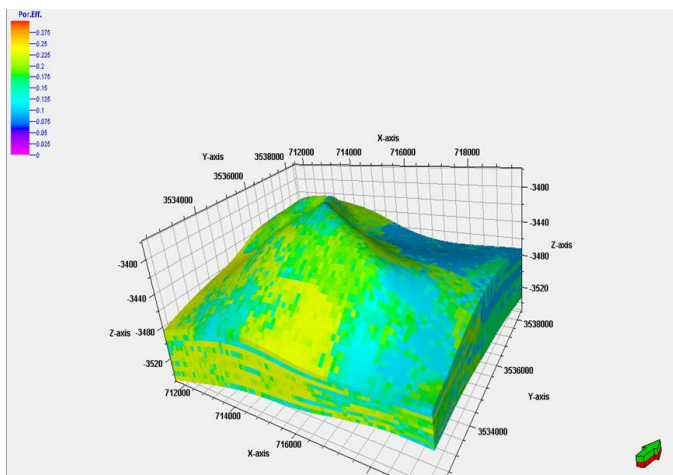


Fig.(15); The porosity model of MB12 in Noor field.

2. WATER SATURATION (SW)

Water saturation represents one of the Petrophysical properties in terms of formation evaluation. Water saturation estimation already done in chapter 4 .Each units is characterized by water saturation values. There is a matching between porosity, environment, and water saturation models. Fig.(17,18)

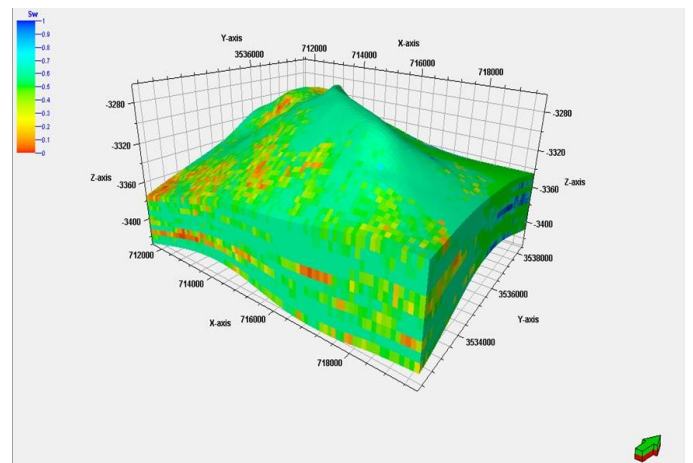


Fig.(17);The Water saturation model of MB12 in Noor field.

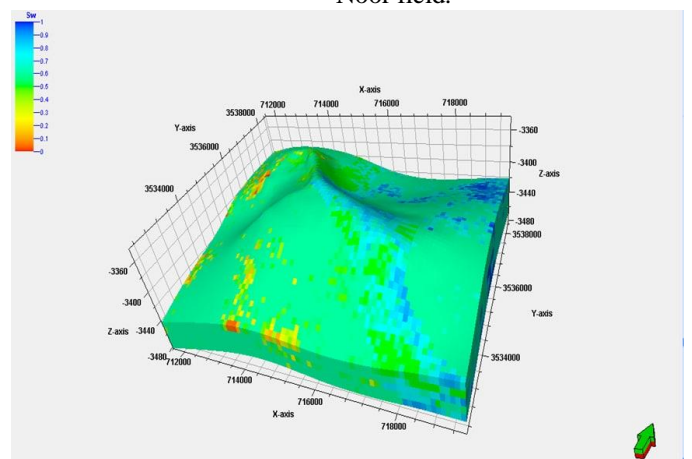


Fig.(18). The Water saturation model of MA1 in Noor field.

VI. 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.

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