



## Geological Model for Khasib Formation of East Baghdad Field Southern Area

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### **Abstract:**

Geological model construction is an important phase of reservoir study as the production capacity of a reservoir depends on its structural and petrophysical characteristics. The economic benefit of the reservoir is evaluated by estimating the formation petrophysical properties and calculating the oil reserves. East Baghdad southern area field is a newly developing oil field in the middle region of Iraq, where Khasib formation is its main reservoir. The aim of this study is to estimate the petrophysical properties and determine the pay units of the formation under study and the initial oil in place. Sequential Gaussian Simulation was used here to distribute the petrophysical properties as the statistical method and volumetric method was used to calculate the oil in place. The results show that the main reservoir units of the formation are K2 and K3 units, and the estimated oil reserves equal to 2179 mmSTB (346.43 million cubic meters).

**Keywords:** Limestone, 3D Geological modeling, oil in place calculation.

**(( موديل جيولوجي لتكوين الخصب في حقل شرق بغداد المنطقة الجنوبية ))**

### **الخلاصة:**

يمثل بناء الموديل الجيولوجي مرحلة مهمة في دراسة المكامن النفطية، حيث تعتمد الطاقة الإنتاجية للمكمن على خصائصه الهيكلية والبتروفيزيائية. يتم تقييم الجدوى الاقتصادية للمكمن من خلال تقدير الخصائص البتروفيزيائية للتكوين وحساب احتياطي النفط. حقل شرق بغداد المنطقة الجنوبية هو حقل نفطي حديث التطوير يقع في المنطقة الوسطى من العراق ، ويعتبر تشكيل الخصب المكمن الرئيسي في الحقل. تهدف هذه الدراسة إلى تقدير الخواص

البتروفيزيائية وتحديد وحدات المكنم الرئيسية للتكوين المعني بالدراسة وكذلك تقدير كمية النفط به. كانت المحاكاة الغوسية المتتابعة (Sequential Gaussian Simulation) هي الطريقة الإحصائية المستخدمة لتوزيع الخواص البتروفيزيائية، وتم استخدام الطريقة الحجمية لحساب النفط الموجود في المكنم. تشير النتائج إلى أن وحدات المكنم الرئيسية للتكوين هي K2 و K3، وأن احتياطي النفط المقدرة تساوي 2179 مليون برميل بالشروط السطحية (346.43 مليون متر مكعب).

### **Introduction:**

The construction of the reservoir geological model called static model, is probably the most important step of a reservoir study due to the large number of parameters involved, and its impact on the study results [1]. Geological model is a visualize representation of geological structure and geophysical properties distribution for a specific geological area, e.g. reservoir. In formation evolution studies, the geological model is used to assess the original oil in place and detect water oil contacts areas of the reservoir under study [2].

Geological model construction includes two main stages, structural modeling and Petrophysical modeling; Structural modeling is the interpretation of seismic and geophysical data to introduce the fault pattern and build a gridded three-dimensional framework to identify the model inner geometry. Structural modeling is subdivided into three processes; fault modeling, gridding and vertical layering. Petrophysical modeling is the process of distributing petrophysical log properties overall the reservoir, using geostatistical approaches [3].

In reservoir engineering, volume of hydrocarbon in a reservoir is called volume in place (oil and/or gas). Volume of hydrocarbon that can be commercially recovered is called "Reserves". Reserves must satisfy four criteria; discovered, recoverable, commercial and remaining based on the development method. For a new reservoir (no oil production history), volumetric methods are the most used method to estimate the oil in place of the reservoir. Estimating the oil in place is the most important factor for reservoir engineers to make a right decision if the discovered area is profitable or not [4].

### **The Study Area:**

East Baghdad is a super-giant oil field that is located in Baghdad and Saladin governorates, 10 km east of Baghdad city. The contract area for east Baghdad field covers

the portion north-west of the Diyala River and is 65 kilometres long and 11 kilometres width. East Baghdad holds 8 billion barrels proven reserves. East Baghdad oil field is subdivided geographically into six areas from northwest to southeast; respectively North Extension, Al-Taji, Al-Rashdiya, Urban, South 2 and South 1 areas. East Baghdad southern area includes both south 2 and south 1 [5].

Khasib formation is the main reservoir of east Baghdad oil field, it is a carbonate reservoir described by two lithological parts, upper and lower; The upper part is consisting mainly of grey marly limestone, while the lower is characterized by the presence of dark shale Khasib formation is bounded by Tanuma formation at the top and Kifil formation at the bottom. Based on recognition of depositional cycles and lithological changes; Khasib formation is subdivided into nine zones; K1 to K9 [6].

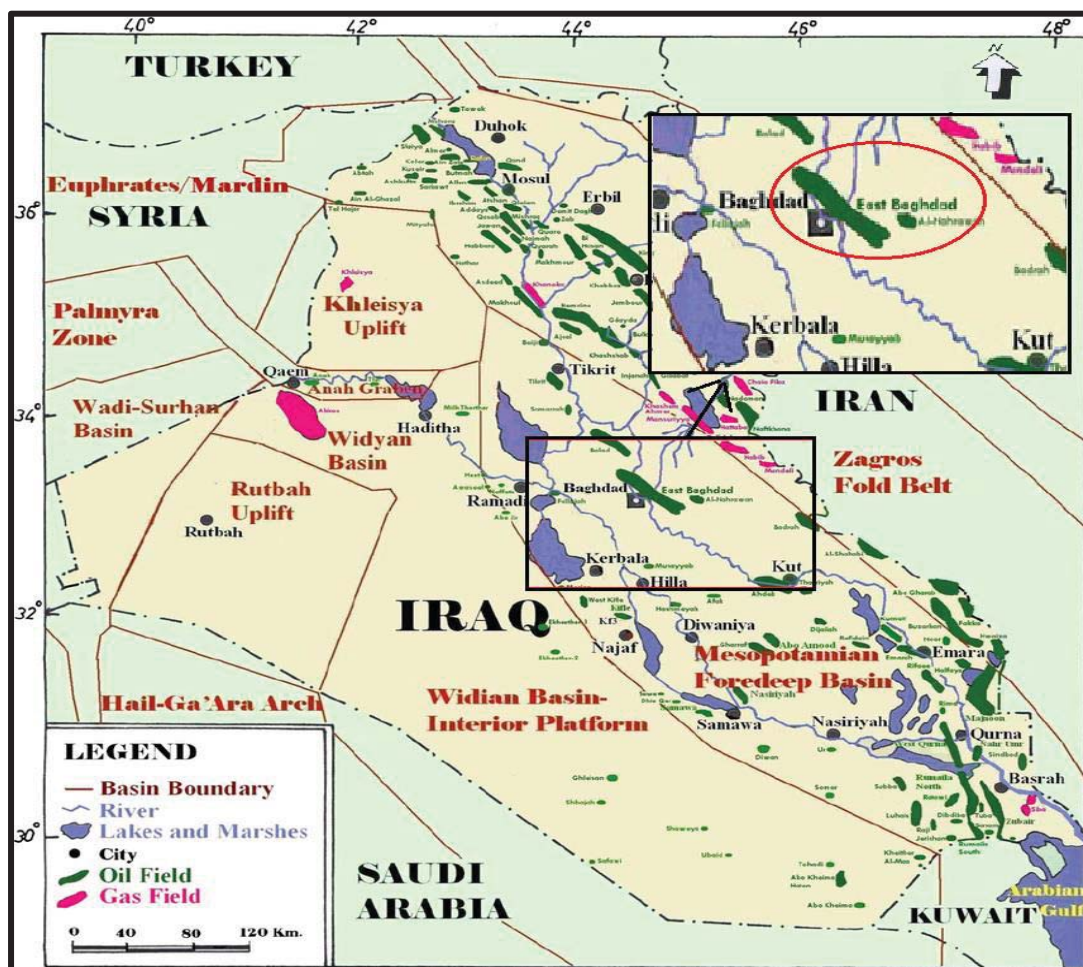


Fig. (1) Iraq oil location map [7].

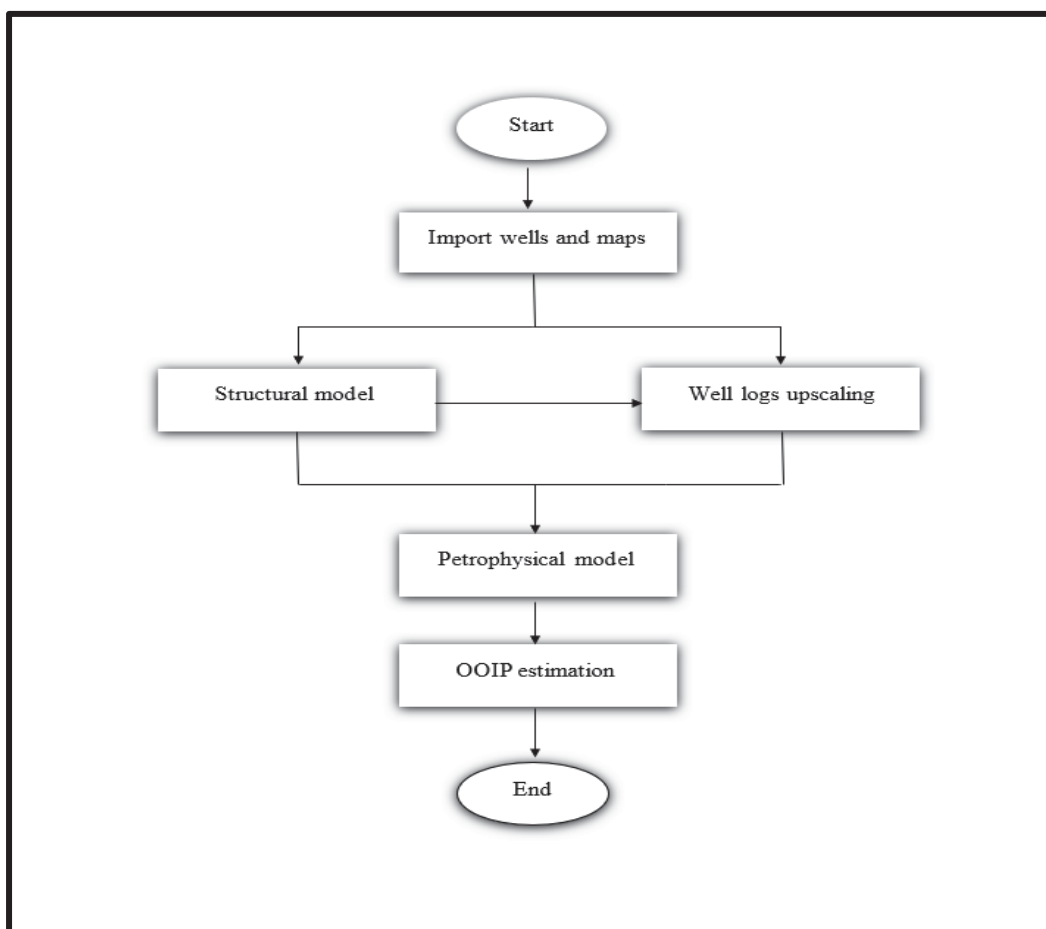
### **The objective of the Study:**

The objective of this study is to construct a 3D geological model of Khasib formation in east Baghdad southern area oil field, to identify the pay reservoir units and preferred perforation intervals of Khasib formation depending on the distribution of the petrophysical properties and estimate the quantity of oil in the reservoir, by volumetric method.

### **Methodology:**

The geological model of Khasib reservoir had been constructed by Petrel E&P software platform 2016. data from different resources were employed in this process including: FWR, FGR well tops, CPI, structural map, seismic interpreted data, etc.

Figure (2) shows flow diagram of the processes of geological model construction.

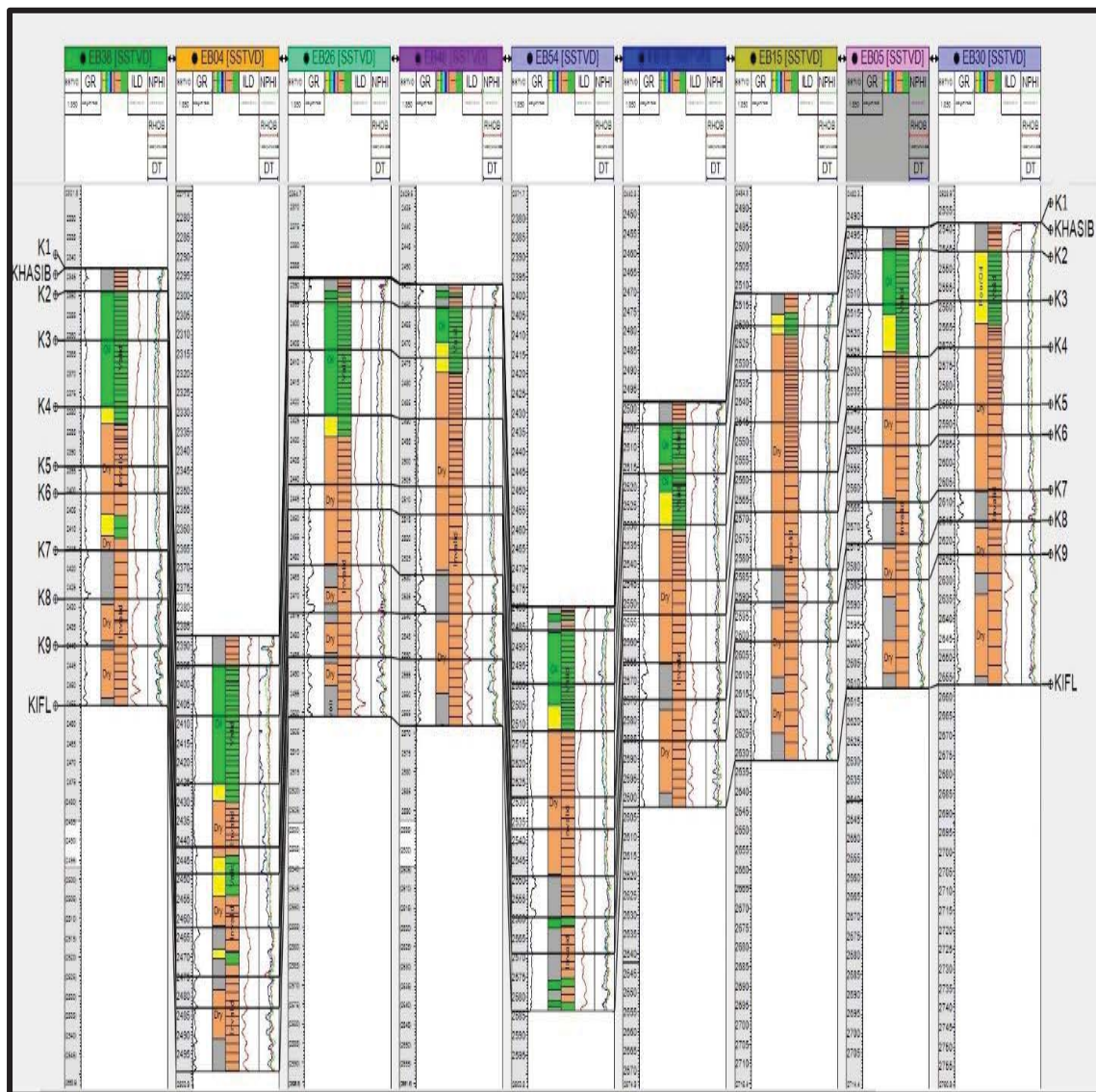


**Fig. (2) Geological model construction methodology flow diagram.**

**Results and Discussion:**

**Well correlation:**

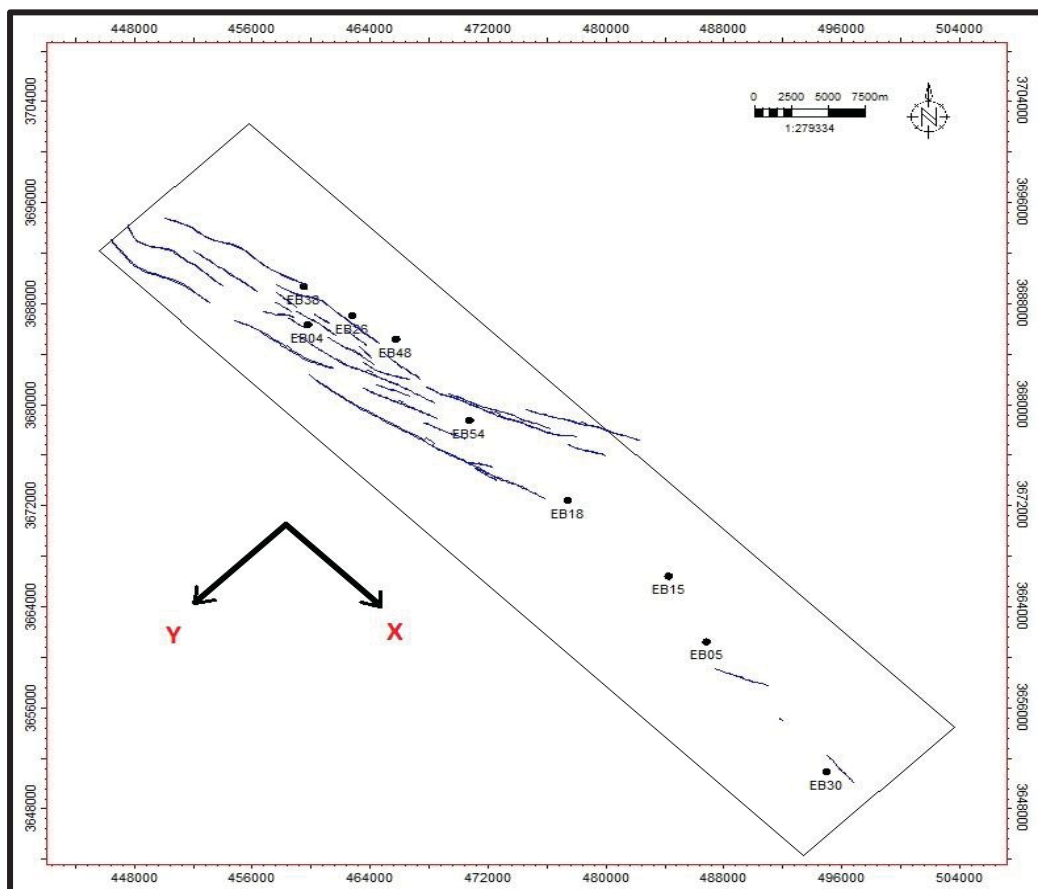
Figure (3) shows the well correlation of all the nine wells of the study, the logs parameters used for the correlation were; gamma ray, resistivity and the three porosity logs, the reason of using these logs for the correlation is that they are linked to all the major petrophysical properties, in other words their behavior on the log scale is related to the formation property behavior. Good correlation of the top of the zones was shown, and only minor adjustment was needed.



**Fig. (3) Wells correlation.**

### Structural model:

Thirty-one major and minor faults were interpreted passing through Khasib formation. Almost all the faults are parallel to each other and oriented in the direction of NW-SE (North West to South East) along the structure. Most of the faults are founded in the north part of the formation (S2 area) as shown in Figure 4. The orientation of the grid cell is parallel to the main faults' direction, where X-direction is approximately parallel to the main faults. The horizontal grid cell size is 50 by 50 meters with 1370 cell on X-axis row and 371 on Y-axis row (508270 cells in total). The horizontal grid cell size is defined according to reservoir heterogeneity and needed accuracy. The nine units/zones of the reservoir were subdivided into 60 layers. Layers thickness and numbers in each zone are designed to consider the characteristics of the zone, important zones (oil-bearing zones) represented by more layers with smaller thickness. Table (1) illustrates number and thickness of layers per each zone.



**Fig. (4) Fault network of Khasib formation in the study area.**

**Table (1) Layers numbers and thickness as designed in the model**

zone	Zone average thickness, m	Number of layers	Layer average thickness, m
K1	6.9	5	1.38
K2	13.3	10	1.33
K3	15.4	12	1.28
K4	14.8	10	1.48
K5	7.7	3	2.56
K6	13.6	5	2.72
K7	10.9	4	2.72
K8	11.1	4	2.77
K9	18.8	7	2.68

### **Petrophysical properties distribution:**

After Upscaling the CPI data, Petrophysical properties have been distributed by petrophysical modeling, by which each cell in the model structure is assigned by porosity, permeability and water saturation value. Sequential Gaussian Simulation method was applied to predict Porosity, water saturation and permeability for every non-well cell in the reservoir. Sequential Gaussian simulation is a geostatistical method used to estimate formation characteristics between two points-. SGS is commonly used with continuous data due to its simplicity and flexibility and the ability of dealing with large amount of data [8].

Properties of each zone of the formation are shown in Table (2), where porosity ranged from 0.1 in zone K1 to 0.23 in zone K4. Close values of porosity are shown in most of the zones. The permeability on the other hand ranged from 1.67 in K6 to 11.16 in K1, the reservoir units (zones) show variety values of permeability, the average permeability exceeded 10 md in K1 and K7, while it is lower than 3 md in K2, K5 and K6, this variety is shown due to formation heterogeneity and justify why the formation is divided into nine units.

The water saturation ranged from 0.76 in K2 to 0.94 in K8 and K9, the water saturation was the determination factor to detect the reservoir units. Most of the formation

units is considered water bearing zones despite the acceptable porosity and permeability - as compared with cutoff values- in most the zones, only K2 and K3 are good reservoir pay units.

A better vision of petrophysical properties distribution for k2 and k3 units (the best pay zones) is shown in Appendix. The porosity and permeability show no high variety along the units with a range of 0.13 to 0.25 of porosity and 1 md to 5 md of permeability in most of K2 and K3 areas. Water saturation in the other hand shows a distinct high-water areas and others with acceptable water saturation ranges, most of the east side of two units is saturated with water with a percentage exceeded 90%, while the west-south parts contain less water with a range of 55% to 90%. The water saturation in west-north sides ranged from 30% to 55%, which make it the best portions in the reservoir units as compared with water cut.

**Table (2) All zones average petrophysical properties based on petrophysical model results**

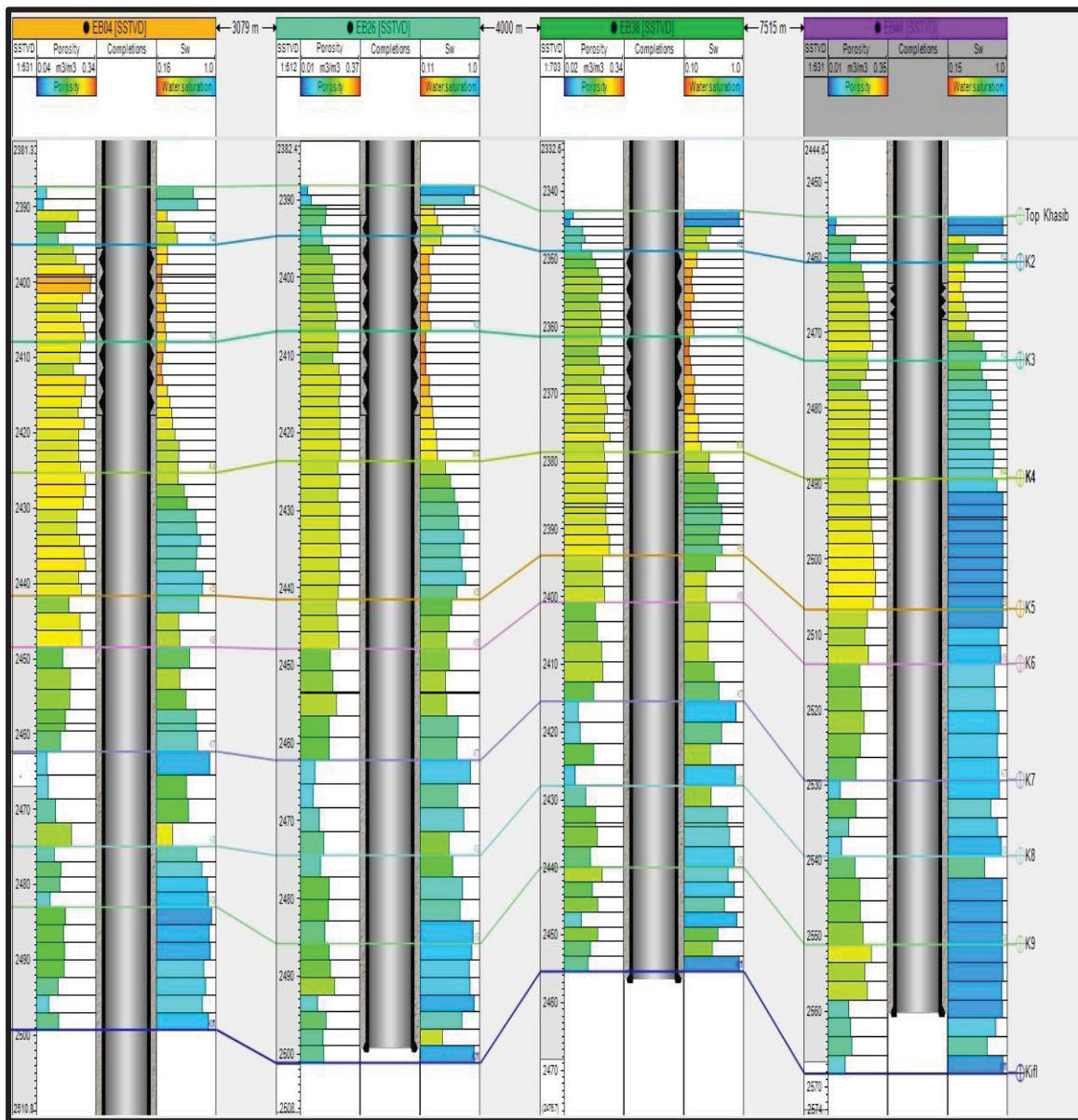
Khasib zone	Porosity	Permeability, md	Water saturation
K1	0.10	11.16	0.78
K2	0.21	2.76	0.76
K3	0.22	3.02	0.84
K4	0.23	3.28	0.92
K5	0.21	2.80	0.89
K6	0.19	1.67	0.90
K7	0.11	10.25	0.91
K8	0.17	4.46	0.94
K9	0.16	4.69	0.94

#### **Perforation intervals:**

The perforation intervals were determined for four of the wells under study. These wells have been chosen depending on their location, where only wells that drilled in pay zone area are chosen for production. The specific perforation intervals were picked up



based on the petrophysical properties; water saturation and porosity, low water zone with suitable porosity zones are favorite for perforation. Petrel 2016 has been used to present the perforation intervals along the wells as shown in Figure (5).



**Fig. (5) Suggested perforation intervals**

**Oil volume calculation:**

Original oil in place (OOIP) was calculated by volumetric method depending on the geometry of the reservoir and its petrophysical properties. Oil formation volume factor (Bo) also involves in the calculations and it was extracted from PVT data. The estimation

of pore volume ( $V_p$ ) of each grid cell is done by multiplying the net volume ( $V_{net}$ ) by the porosity ( $\varphi$ ):

$$V_p = V_{net} \times \varphi \quad (1)$$

Where, the net volume is obtained by multiplying the bulk volume ( $V_b$ ) by net to gross ratio:

$$V_{net} = V_b \times NTG \quad (2)$$

The (OOIP) is calculated by multiplying the pore volume by oil saturation divided by the oil formation volume factor ( $B_o$ ) for each grid cell [9].

$$OOIP = \frac{V_p \times (1 - S_w)}{B_o} \quad (3)$$

The total stock tank original oil in place of the reservoir is the sum of each grid cell (OOIP) in the reservoir. It was estimated to be equal to 2179 mmSTB (346.43 million cubic meter) in Khasib formation of East Baghdad southern area oil field.

### **Conclusions:**

The 3D geological model of Khasib formation in East Baghdad southern area oil field was constructed by presenting the structural model and distributing the petrophysical properties out of nine zones of the formation Khasib, the reservoir pay zones were K2 and K3 as the petrophysical properties; porosity, permeability and most importantly water saturation, were in the cutoff limits. Most of the oil quantity of the formation is in these zones. The Initial oil in place (OIIP) for Khasib formation of east Baghdad field southern area was estimated to be equal to 2179 mmSTB (346.43 million cubic meters).

The two regions of the field; south1 (S1) and south2 (S2), when compared to each other do not show much differences in many of geological and petrophysical properties. The porosity and permeability ranged in the same domain for S1 and S2. yet the main difference, after faults types and distribution, where the water saturation, as S1 area is more saturated with water than S2, which obviously means that S2 has more quantity of oil than S1.

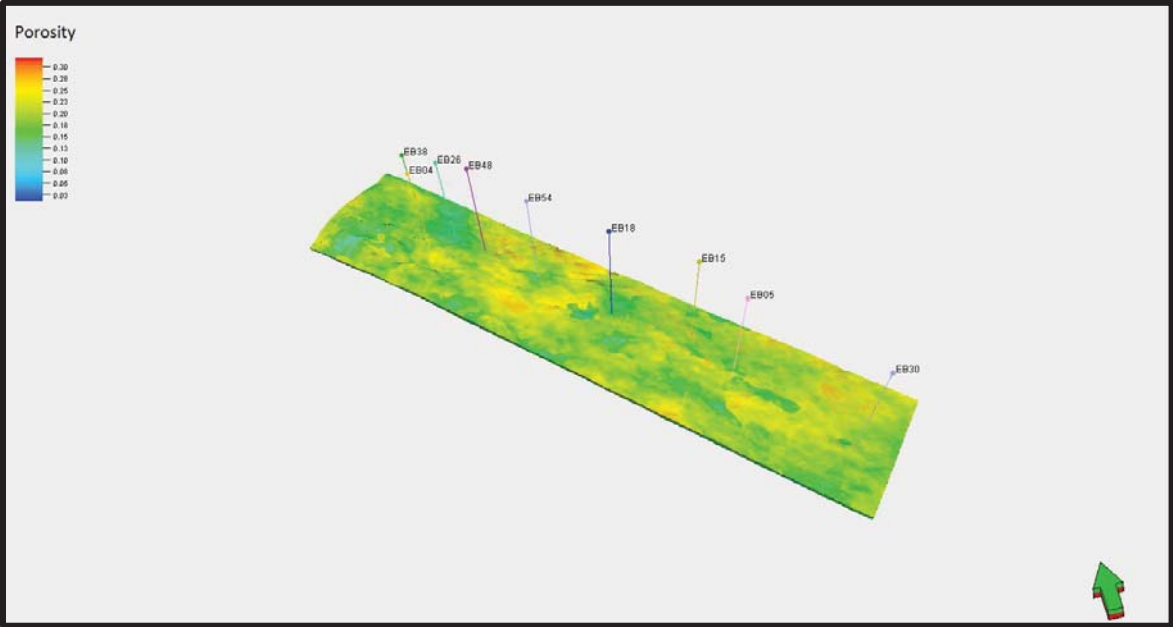
**Nomenclature:**

OOIP:	Original oil in place
FWR:	Final well report
FGR:	Final geological report
CPI:	Computer processed interpretations
SGS:	Sequential Gaussian simulation
NTG:	Net to gross ratio
SSTVD:	Subsea true vertical depth
GR:	Gamma ray log
ILD:	Dual induction log
ROHB:	Density log
DT:	Sonic log
NPHI:	Neutron log

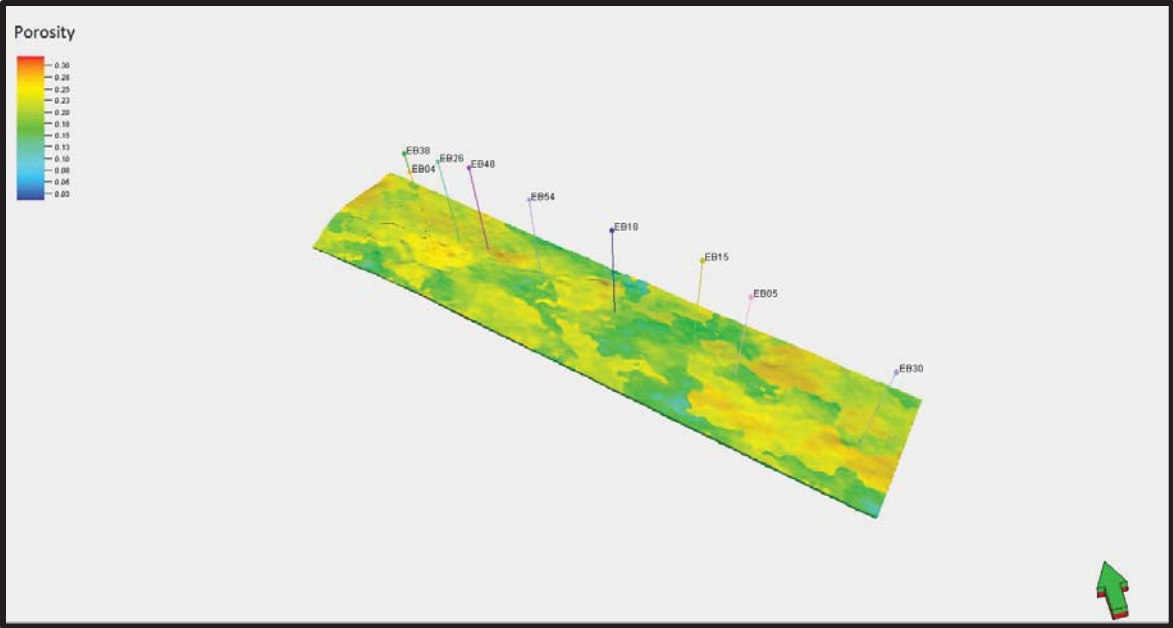
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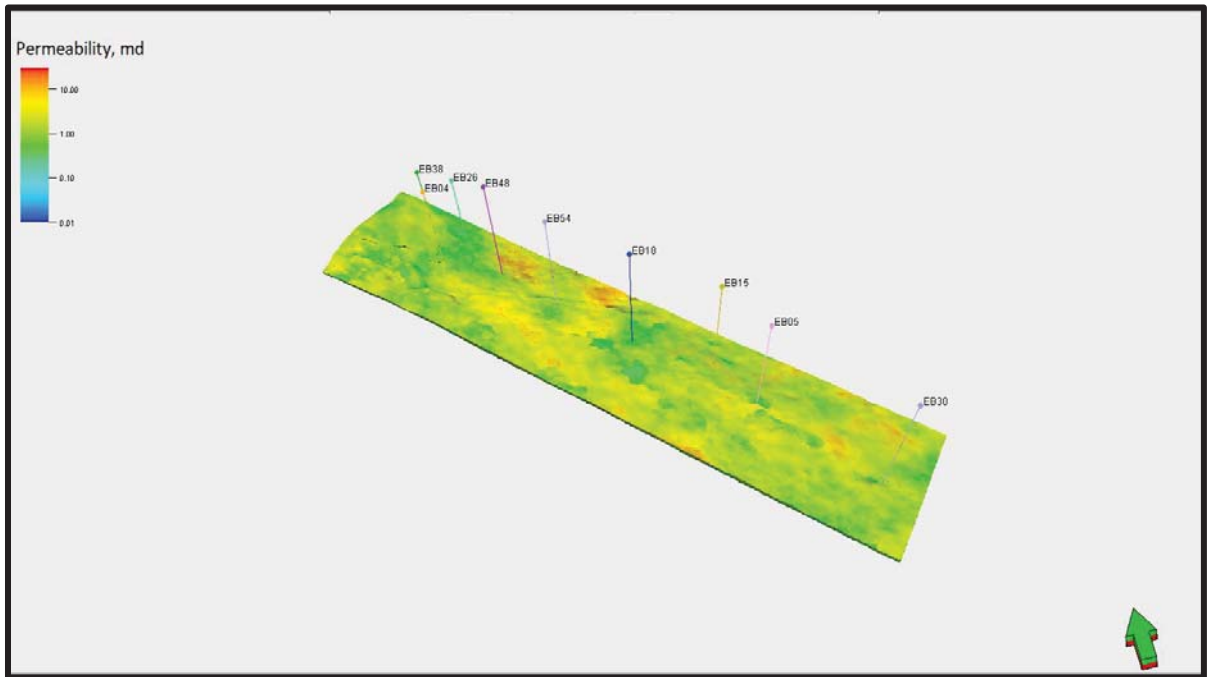
Appendices:



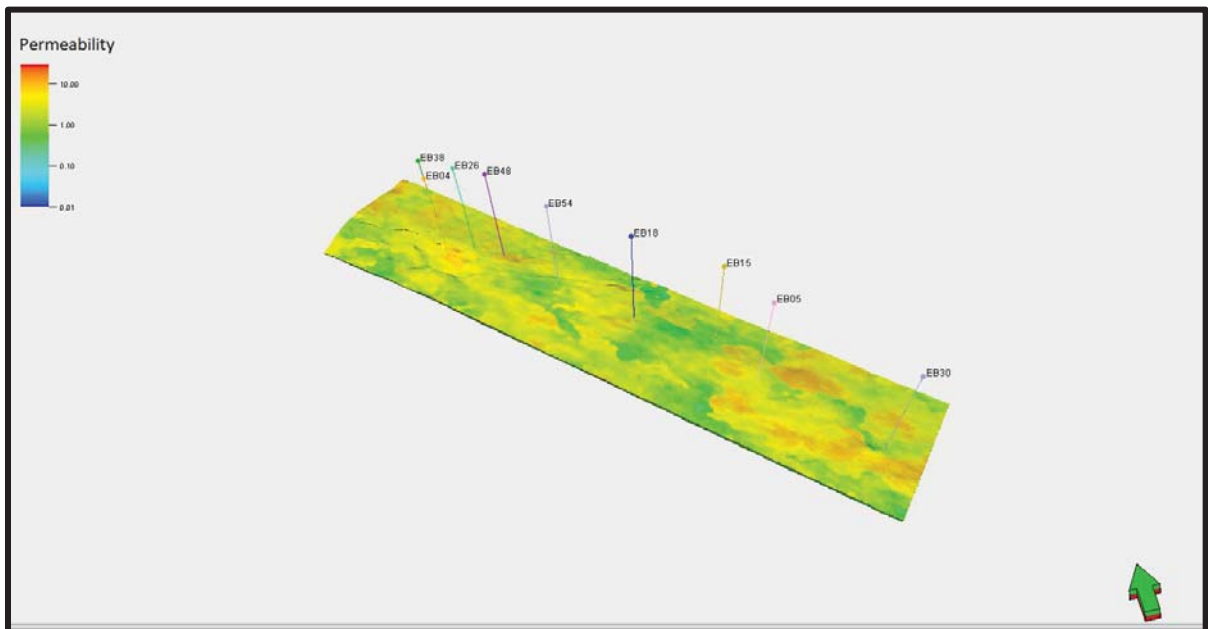
**Fig. (6) Porosity distribution of unit K2**



**Fig. (7) Porosity distribution of unit K3**



**Fig. (8) Permeability distribution of unit K2**



**Fig. (9) Permeability distribution of unit K3**

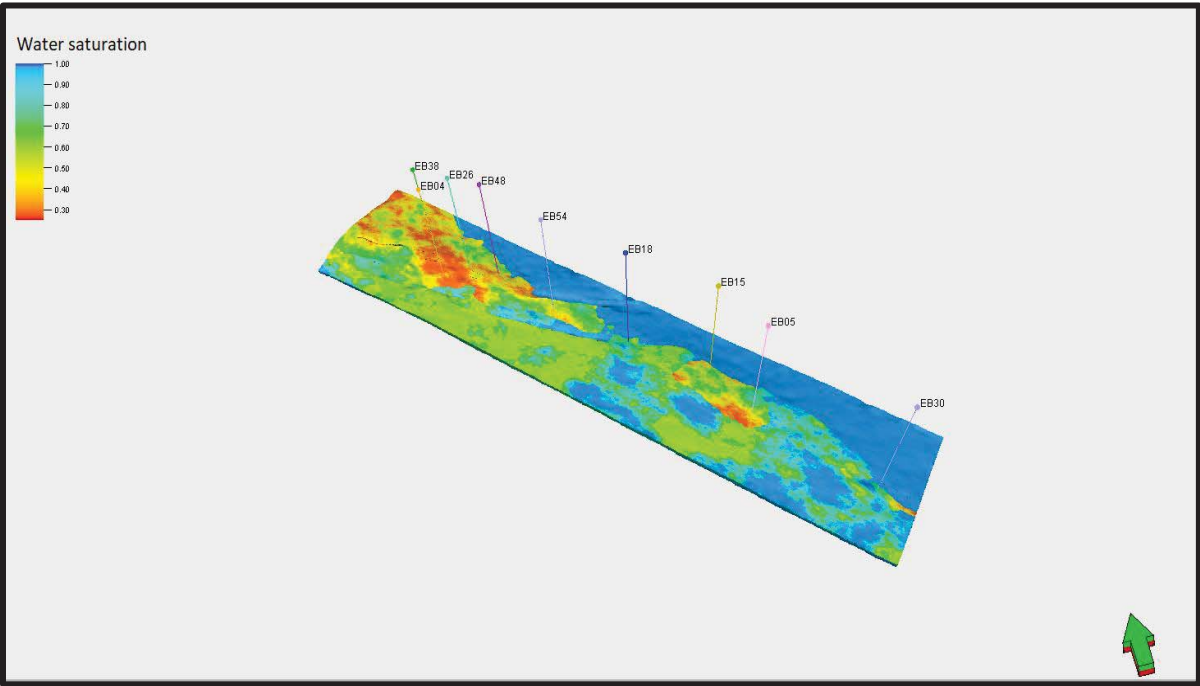


Fig. (10) Water saturation distribution of unit K2

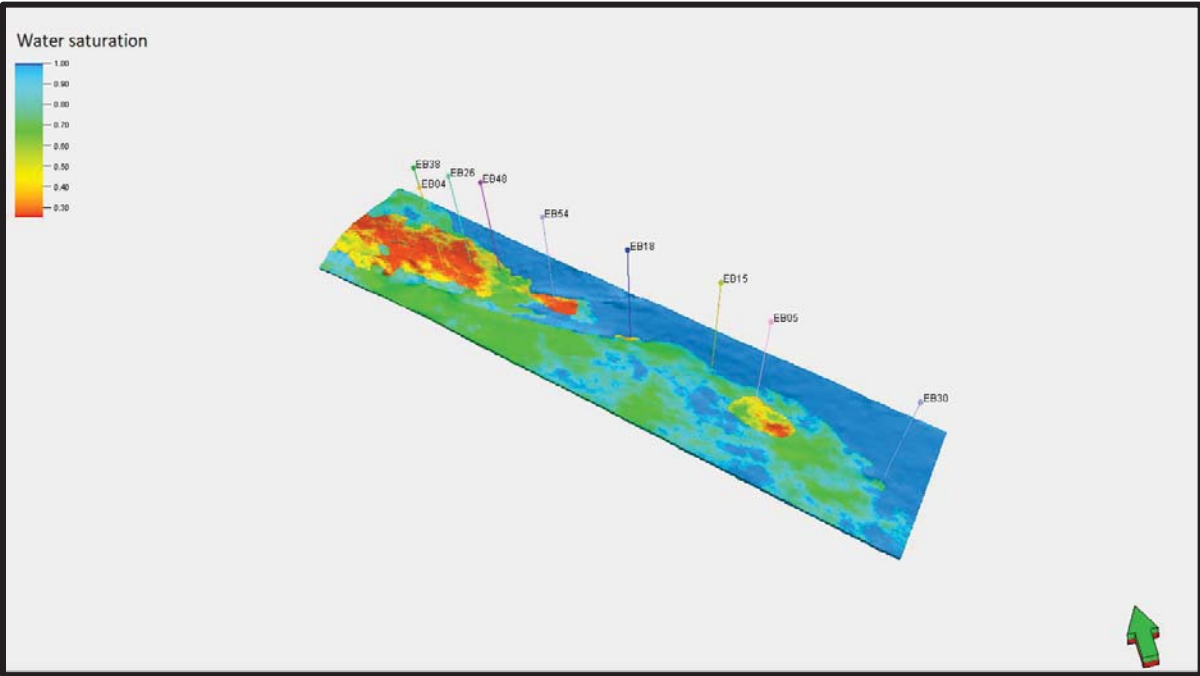


Fig. (11) Water saturation distribution of unit K3