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Building Geological Model for Tertiary Reservoir of Exploration Ismail Oil Field, North Iraq

Sameera M. Hamdulla[a], Aboosh H. Hassan[b] and Yahya Jarjees Tawfiq[c]

[a]University of Baghdad/College of engineering/ Petroleum department
[b] North Oil Company/Kirkuk
[c] University of Kirkuk/College of engineering/ Petroleum department

Abstract

Geologic modeling is the art of constructing a structural and stratigraphic model of a reservoir from analyses and interpretations of seismic data, log data, core data, etc. [1].

A static reservoir model typically involves four main stages, these stages are Structural modeling, Stratigraphic modeling, Lithological modeling and Petrophysical modeling [2].

Ismail field is exploration structure, located in the north Iraq, about 55 km north-west of Kirkuk city, to the north-west of the Bai Hassan field, the distance between the Bai Hassan field and Ismael field is about one kilometer [3].

Tertiary period reservoir sequences (Main Limestone), which comprise many economically important units particularly reservoir pay zone, in Ismail field are belong to middle Miocene age and Oligocene age, which includes six formations, Jeribe, Bajwan, Baba, Baba/palani and Palani formation.

The information of Ismail field such as final well report, drill stem test, completion test and well logs data also previous studies and results of core data, indicated that hydrocarbons are accumulated in the Baba formation.

The main purpose of this study is to make use of all the available sets of data acquired from Ismail field to build a static geological model for Baba formation in Ismail field to get full description for this reservoir.

Keywords: Geologic modeling, Ismail field

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1- Introduction

The most important phase of a reservoir study is probably the definition of a static model of the reservoir rock, given both the large number of activities involved, and its impact on the end results. As we know, the production capacity of a reservoir depends on its geometrical/structural and petrophysical characteristics.

The availability of a representative static model is therefore an essential condition for the subsequent dynamic modeling phase. A static reservoir study typically involves four main stages, carried out by experts in the various disciplines, these stages are Structural modeling, Stratigraphic modeling, Lithological modeling and Petrophysical modeling [2].

2- Model Design

Petrel 2009 software was chosen to build geological model for exploration Ismail field. Petrel is a software application package for subsurface interpretation and modeling, allowing building and updating reliable subsurface models.

It is a latest reservoirs modeling software recently deployed by schlumberger information solutions Inc. For the purpose of this study, a data base was created within petrel, clearly delineating the different information and data needed to complete the study. The geological, and petrophysical data were imported to petrel within the main data base. This made it possible to generate and visualize the imported data in 2D as well as 3D. The work flow design used for the study and wide range of functional tools in the petrel software include: 3D visualization, well correlation, 3D mapping, and 3D grid design for geology simulation, well log up scaling, petrophysical modeling, data analysis, and volume calculation.

3- Data Preparation

Data preparation is the basis for geologic model. This geologic model building chiefly applies software of petrel. On the basis of software demand and research area characteristic, the data prepare for this 3D-geological model are well heads, well tops, well logs (Raw data and CPI), and core analysis.

Corresponding Authors: Sameera M. Hamdulla, Email: NA, Aboosh H. Hassan, Email: NA, Yahya Jarjees Tawfiq, Email: yahyapetroleum@yahoo.com

4- Import Data

Import data describes the data import procedure, various data formats supported and organize the imported wells in sub folders. Well data are imported in three steps:

4.1. Well Head

A well head include the top position of the well path, the measured depth along the path, the well name and optionally a well symbol.

4.2. Well Tops

Well tops are used to marker representing significant points along the well path when there is a change in stratigraphy between reservoir units of well IS-1.

4.3. Well Logs Data

Well logs included; gamma ray, neutron, sonic, density and resistivity as well as the CPI (porosity, and water saturation). Well logs imported log values along the well path and attached to the path.

5- Structural Modeling

Structural modeling was used for building geological model. It was subdivided into three processes as follows: fault modeling, pillar gridding, and vertical layering.

All the three operations were performed one after the other to form one single data model [4].

Structural maps were built depending on the depth structural map for top of Jerebi formation. Fig. 1 show structural contour maps for top of Baba formation in exploration Ismail field.

6- Stratigraphic Modeling

In this study, the stratigraphy description will be focused on the Tertiary period reservoir sequences (Main Limestone), which comprise many economically important units particularly Reservoir Pay Zone (Oligocene and Miocene) ages. It is worth mentioning that the division of formations in Ismail field is similar to the division in the Bai Hassan field completely. Tertiary period formation in this field consists of a series of Sedimentology that had been deposited in the period between the end of upper Cretaceous (end of shiranish formation) and early middle Miocene. The main divisions were adopted as contained in the study of stratification and porosity units study of the tertiary rock in Bai Hassan field, issued by the north oil Company, Department of fields/Department of Geology, 1980 [5].

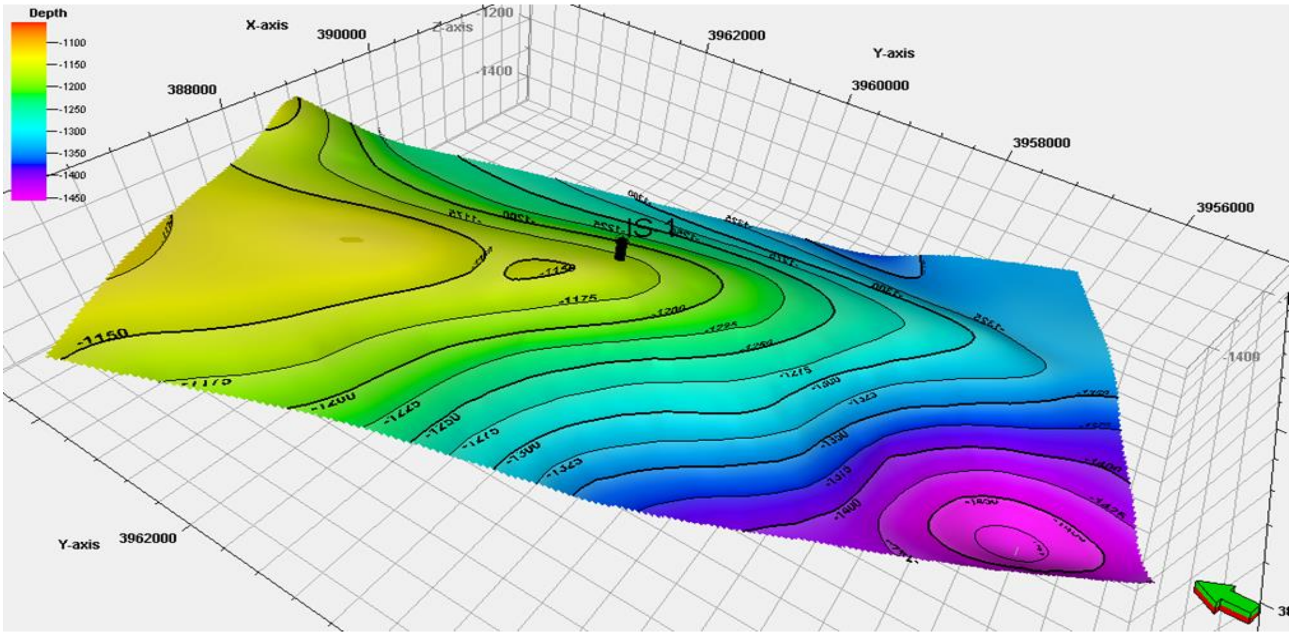

Fig. 1. 3D Structural Depth Map for Top of Baba formation

In this study, we focus on the main limestone reservoir which represented by Baba formation. Baba formation includes the most coral reefs in the upper parts while includes the reef facies in the lower parts. Most rocks of this formation consist of dolomite.

The upper part of this formation contains greatly coral reefs while presence of these coral reefs in the lower part of the formation is rarely [5]. Based on this, Baba formation can be divided into two sections:

a. The upper part, which consists mostly of coral reefs.
b. Bottom part, which contains mainly limestone.

The stratigraphy of Baba formation in Ismail field was prepared by using Petrel (2009) software, as shown in Fig. 2, by depending on the *Graphical Well Log* stratigraphy and lithology description for well IS-1. Fig. 2 shows the stratigraphy of Baba formation in well IS-1.

7- 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 [4]. Many statistical methods were used to scale up such as (arithmetic average, harmonic, and geometric method). The porosity and water saturation have been scaled up using above averaging methods.

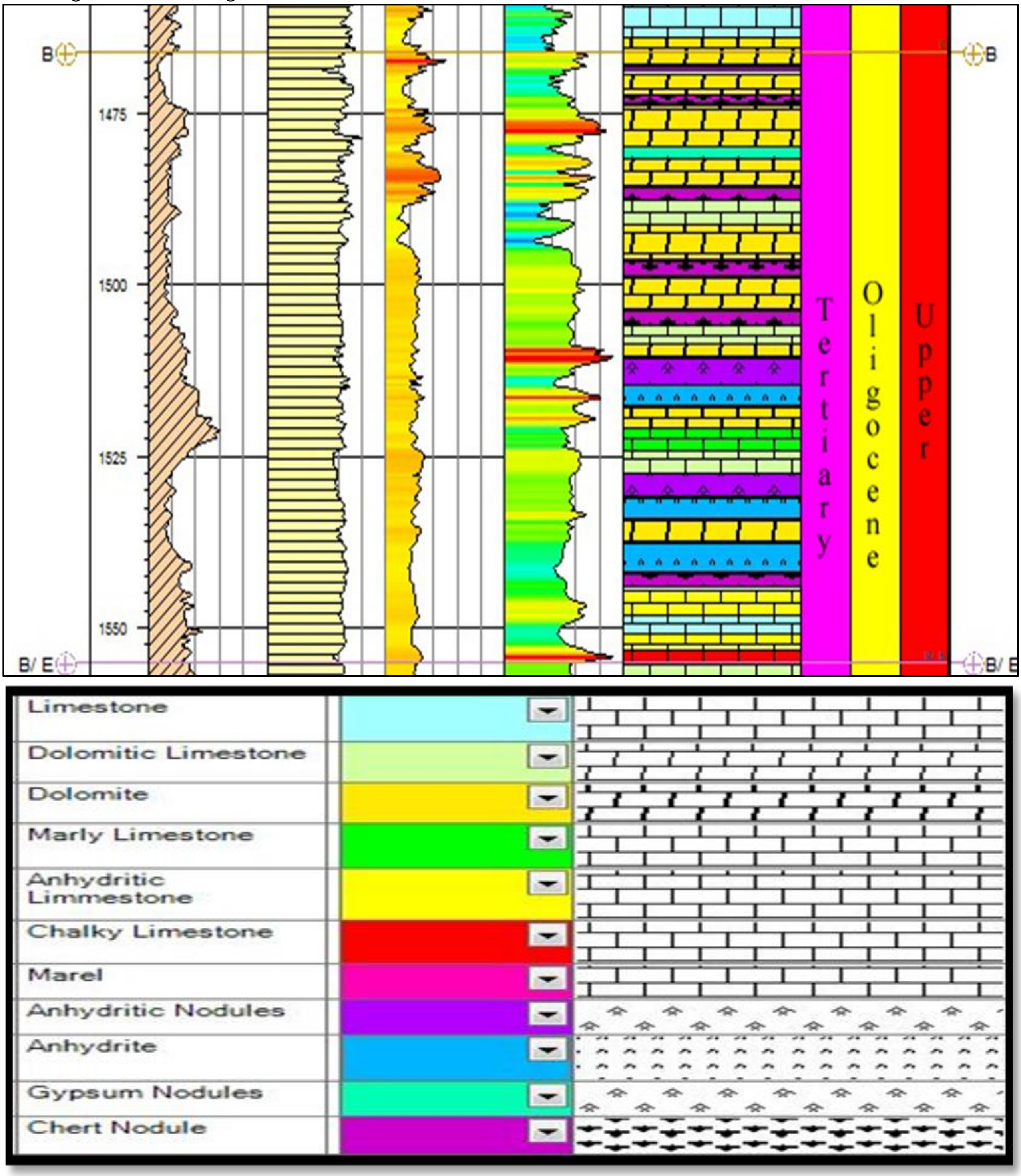

Fig. 2. Stratigraphic Model of Baba formation

8- Facies Modeling

Facies modeling is a means of distributing discrete facies throughout the model grid. Definition of certain number of lithological types (basic facies) for the reservoir in question, which are characterized on the basis of lithology proper, sedimentology and petrophysics [2].

Facies model was built depending on the Graphical Well Log stratigraphy and lithology description for well IS-1. Statistical Sequential Gaussian Simulation Algorithm was used as a statistical method to build facies model.

Data analysis was first performed to calculate normal score transforms and experimental variogram ranges. Variogram ranges were set to1000 m in the major direction, 1000 m in the minor direction, and variable values in the vertical direction, using an exponential variogram model with a variable nugget and a major direction azimuth of -45°. We observed from Fig. 3 which represents the facies distribution through Baba formation that: this formation represents a four-reef facies and highly dolomitized limestone, porous, vugy crystalline with streaks of anhydrite beds and marel.

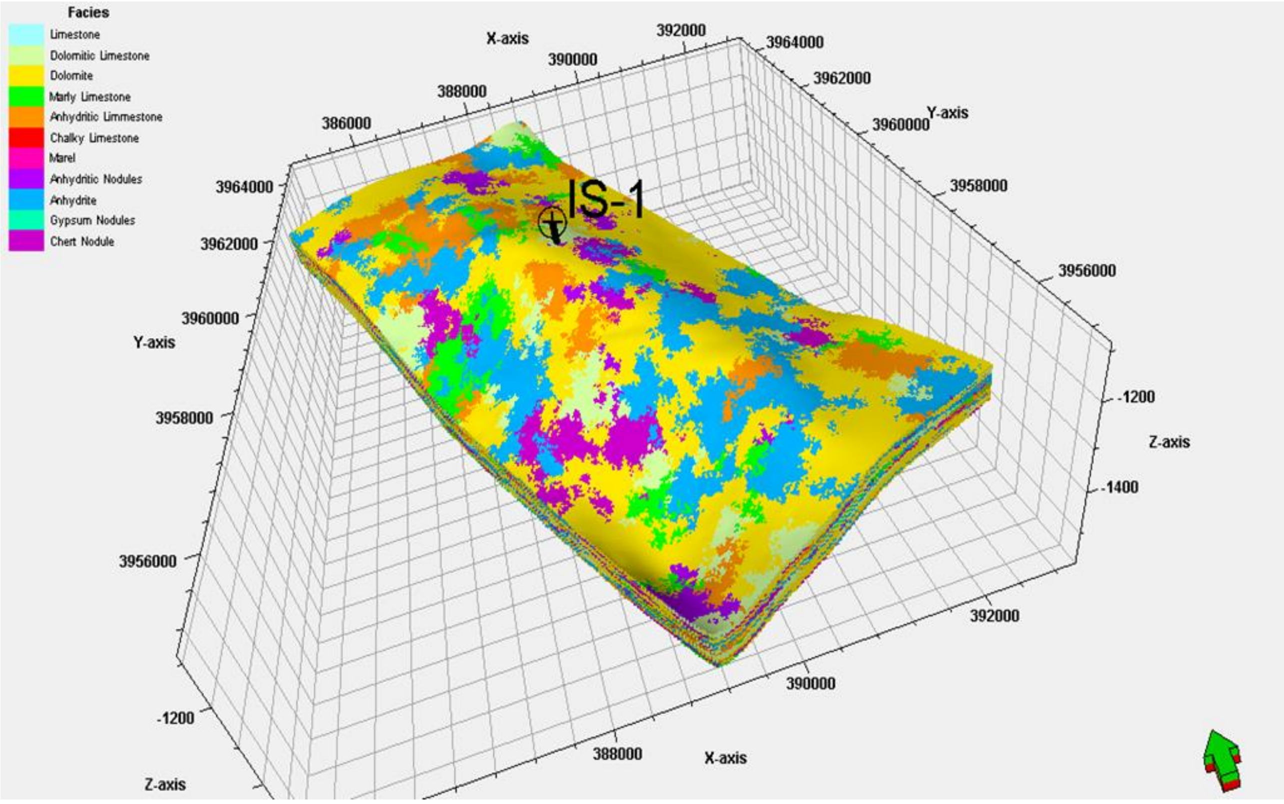

Fig. 3. Facies Distribution of Baba Formation

9- Petrophysical Modeling

Petrophysical property modeling is the process of assigning petrophysical property values (porosity and water saturation) to each cell of the 3D grid. Petrophysics model was built using geostatistical methods. The geostatistical algorithm (Statistical sequential Gaussian simulation algorithm) represents a statistical method, which fits with the amount of available data. The Petrophysics models include:

9.1. Porosity Model

Porosity model was built depending on the results of porosity logs which have been corrected and interpreted by IP software. Statistical Sequential Gaussian Simulation Algorithm was used as a statistical method to build porosity model. Data analysis was first performed to calculate normal score transforms and experimental variogram ranges.

Variogram ranges were set to 5000m in the major direction, 5000m in the minor direction, and variable values in the vertical direction, using an exponential variogram model with a variable nugget and a major direction azimuth of -45°.

Fig. 4 represents the porosity distribution through Baba formation in well IS-1.

From the previous figure it is clear that Baba formation is homogeneous and has a very good value of porosity.

The porosity in general in this unit is good and ranged between (0.17-0.19), due to the effect of the high dolomitization.

Porosity increasing toward north western direction of the field which has good porosities in that sector which is greater than 19%.

9.2. Water Saturation Model

Water saturation model was built depending on the results of logs. The same geostatistical method was used in the porosity model (Statisticaln Sequential Gaussian Simulation Algorithm), according to available data that deduced from interpreted logs. Data analysis was first performed to calculate normal score transforms and experimental variogram ranges.

Variogram ranges were set to 5000m in the major direction, 5000m in the minor direction, and variable values in the vertical direction, using an exponential variogram model with a variable nugget and a major direction azimuth of -45°. From Fig. 5 which is represent the water saturation distribution through Baba formation, it is clear that this formation has very low values of water saturation which are ranged from less than 5% to the less than 65%. The hydrocarbons are concentrated in the south, south eastern, north western, east and west parts in the Ismail field through this formation. This formation may be considered as reservoir due to its economical hydrocarbons amounts.

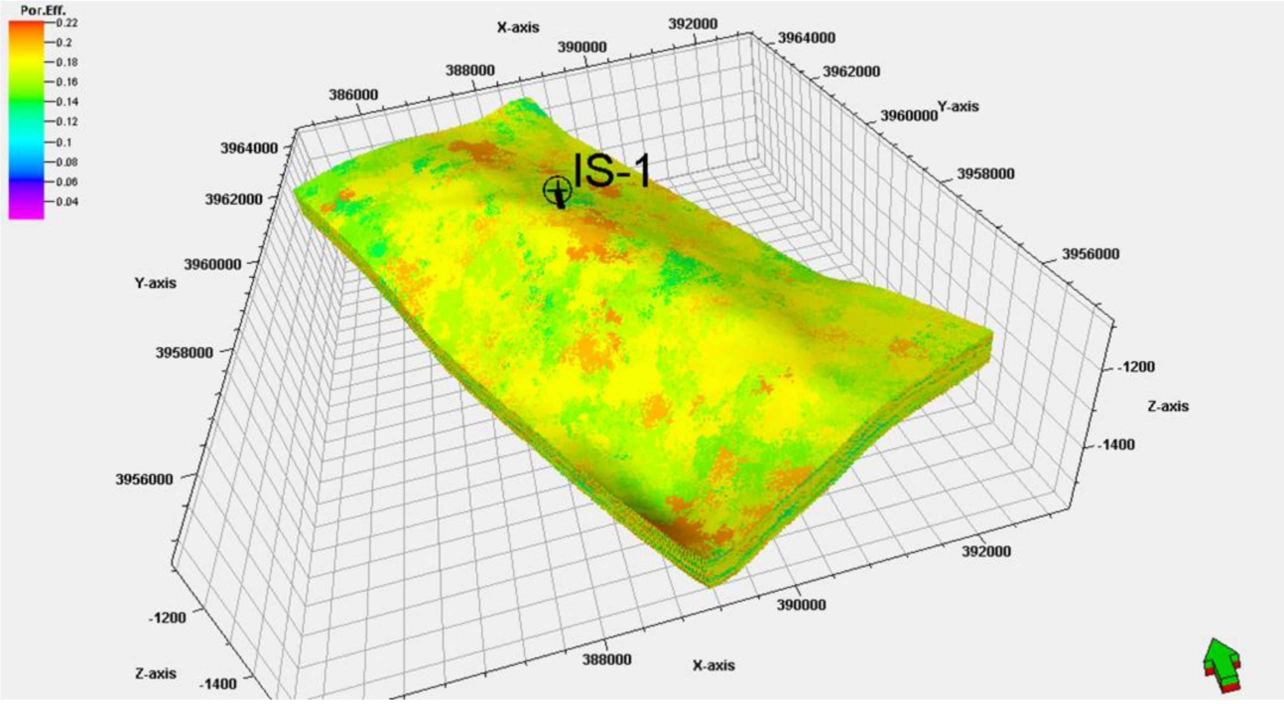

Fig. 4. Porosity Distribution in Baba Formation

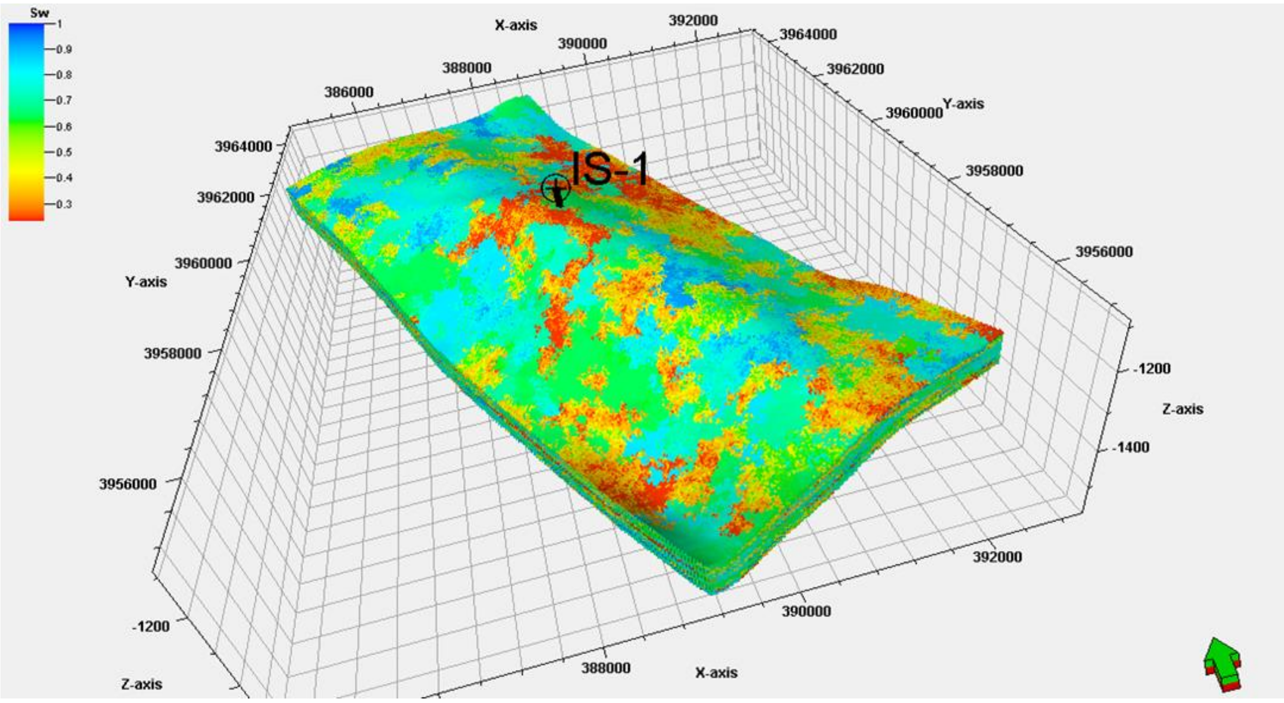

Fig. 5. Water Saturation Distribution in Baba Formation

10- Oil Water Contact Model

Oil/water contact is the depth where water saturation first reaches close to100%. This sometimes called the free water level (FWL). Perforations below this point will produce 100% water. Oil water contact can usually be picked on the resistivity log where resistivity reaches its lowest values in a clean, porous reservoir. Sometimes it is difficult to recognize porous high water statured zone from logs data due to present of shale or in high heterogeneity carbonate rock where porosity was too low, then in this case oil water contact is located where water saturation become 100%.

The contact of oil/water in the well Ismail-1 is determined from resistivity log. It was fixed on depth 1496 m RTKB (1200 m MSL) within Baba formation, by depending on comparison between the resistivity log and DST (drill stem test) results for interval (1510-1541) which indicate productive water existence with salinity 70000 ppm and density 1.04 gm/cc.

11- Conclusions

In this study, the following conclusions may be drawn; and a number of recommendations are suggested which could enhance our understanding and evaluation of the reservoir characteristics of Baba formation in Ismail oil field under study.

1- The Tertiary Main Limestone reservoir in well IS-1 is Baba formation (Unit B), Upper Oligocene as interval section from (1466 m. RTKB) to the OWC level.
2- Calculations of the porosity from porosity logs indicated that the primary porosity is the main controller porosity in the porous media, where the secondary values are very scarce and ranged between (0.2-3.4) percent.
3- The clay volume calculations from GR log, pointed out the clay in well IS-1 is distributed in varied ratio, where the minimum clay volume (3.3–10.3%) was recorded in the Bajwan and Baba formations. The clay volume was concentrated in the other formations (Jeribi, Baba/Palani, Palani) and it was relatively high (41.7 – 44.5) %.
4- The oil water contact level in the Ismail field within Tertiary period was found to be located in 1496 m RTKB (1200 m. MSL).
5- The cut off results indicated that the best reservoir characteristics are associated with unit (B), while other units and formations have poor reservoir characteristics, especially with water saturation cut off value.
6- The porosity and water saturation model showed that the good petrophysical properties direction to the west and north-west direction of the field.
7- Oil initially in place (OIIP) is calculated for Main Limestone reservoir in Ismail field and it is found equal ($15.687*10^6$) STB, where the last study about Ismail field estimated OOIP equal to $14.21*10^6$ STB.

12- Recommendations

1- Making three-dimensional seismic survey to illustrate and clarify the structural geometry of the Ismail field and determine the levels of fluid contact and field extensions, especially the field extension toward north east and reconsider the location of exploratory and evaluating wells by depending on the results of the mentioned seismic interpretations.
2- Using modern techniques such as (*Instantaneous Frequency Analysis*) and (*Seismic Inversion Analysis*) in determining the dimensions of Ismail field. The use of traditional methods in determining the dimensions of stratigraphic traps do not give accurate results in calculation of oil reserves accurately.
3- Drill more wells in Ismail structure with using advanced and modern logging tools such as EPT log, NMR log, etc. to get more accurate results and new data.
4- Develop an integrated reservoir study for this field using the geological modeling data to establish reservoir management strategies and provide a basis for more developing plans.
5- Give more focus on (unit B) by making more production test and taking more core data as it has good reservoir production properties.
6- Make a study to build accurate geological model for cretaceous age formations in Ismail field, after drilling some wells.

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بناء موديل جيولوجي للمكمن الثلاثي في حقل اسماعيل الاستكشافي، شمال العراق

الخلاصة

الموديل الجيولوجي هو بناء موديل تركيبي وطباقي للمكمن من خلال تحليل وتفسير المعلومات الزلزالية ومعلومات جس الابار ومعلومات تحاليل اللباب.. الخ. الموديل الجيولوجي الاستاتيكي نموذجيا يتضمن اربعة مراحل، وهذه المراحل هي الموديل التركيبي والموديل الطباقي والموديل السحني والموديل البتروفيزيائي. حقل اسماعيل عبارة عن تركيب استكشافي، يقع في شمال العراق، حوالي 55 كلم من شمال الغربي من مدينة كركوك، والى الشمال الغربي من حقل باي حسن، والمسافة بين حقل اسماعيل وحقل باي حسن حوالي واحد كلم. طباقية عصر المكمن الثلاثي (مكمن الكلس الرئيسي)، والتي تشمل تكوينات مهمة اقتصاديا خصوصا مناطق العطاء المكمني, في حقل اسماعيل تعود الى عصر الاوليجوسين وعصر الميوسين الاوسط وتتضمن ستة تكوينات هي جريبي , باجوان الصلد , باجوان المسامي , بابا , بابا/بالاني , بالاني. المعلومات حول حقل اسماعيل مثل التقارير النهائية للبئر والفحوصات الاكمالية ومعلومات جس الابار وكذلك الدراسات السابقة ومعلومات تحاليل اللباب، كلها تشير الى ان الهيدروكاربونات تجمعت في تكوين (بابا). الهدف الرئيسي من هذه الدراسة هي استخدام كل المعلومات المتوفرة والمستحصلة من حقل اسماعيل لبناء موديل جيولوجي لتكوين (بابا) في حقل اسماعيل لحصول على الوصف الكامل لهذه المكمن.