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Evaluation Uncertainty in the Volume of Oil in Place in Mishrif Reservoir

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ABSTRACT

Calculating oil reserves is one of the most important applications of geological models, as it is considered an essential step to evaluate whether the reservoir is economical or not. Uncertainty methods can be used based on several reservoir factors to predict a range of reserve values, each value gives a range of production forecasts. These values are divided into probable estimates that give the highest, lowest and mean expected production, called P90, P50, and P10. Geostatistical models of the reservoirs P90, P50, and P10 must be established for dynamic models, analysis of the risk, reservoir management, and prediction. Formation volume factors, initial water saturation, and formation porosity values might be used to produce a range of values for the reserve via the volumetric method. A reserve requires to be proven when there is a probability of 90% indicating that the recovered quantities in reality are equal or above the estimates. These are typically denoted as P90 throughout the estimating process. P10 refers to the total of potential and probable reserves, and P50 refers to proven and probable reserves. In this research, these quantities were calculated using statistical functions to assess the uncertainty in the oil volume. This was done by building a geological model from the data of a group of wells using the Petrel program. Then the uncertainty techniques were used to determine the expected values of the uncertain variables and their corresponding values of oil in place originally (OOIP). The result of OOIP values presents that the OWC level is the most influential parameter on oil in place. A histogram was created with bin values ranging from 3300 to 3700 and with Bin step equal to 25 and the normal distribution for these bins was calculated to estimate P10, P50, and P90 values.

Introduction

Calculating the volume of oil in place originally (OOIP) is one of the main objectives of establishing geological models and the preceding steps that include the interpretation of well logs readings to obtain a description of the rock's petrophysical properties [1]. Where these volumes represent the basic criterion for determining whether the explored reservoir has economic feasibility or not [2], and on this basis, the development operations are completed and their expenses determined [3]. In simulation software, the OOIP is calculated by using the volumetric method that estimates the in-place oil by using core data analysis and logs interpretations to calculate the porosity, the bulk volume, and the saturations of fluids and by

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use fluid sample analysis to calculate the oil formation volume factor [4]. The oil in place (OOIP), fluids production rates, and recovery factor are the most important variables that require uncertainty management [5]. Uncertainty qualification workflow can be used to produce a group of probabilistic P90, P50, and P10, from these cases different dynamic models can be obtained [6]. Several studies have used uncertainty techniques in the petroleum industry to determine uncertain variables and their impact on the calculations of static and dynamic models [7, 8]. One of the important and influential factors in calculating the quantities of oil in formations is the volume of the shale in the rocks [9], which in turn affects the porosity and permeability.

Methodology

The source data is known to undergo comprehensive verification and classification before entering it into the Petrel program, after that A 3D reservoir model was then created. The workflow of the study included well-log upscaling, petrophysical modeling, volume calculation, and uncertainty qualification as shown in Fig. 1.

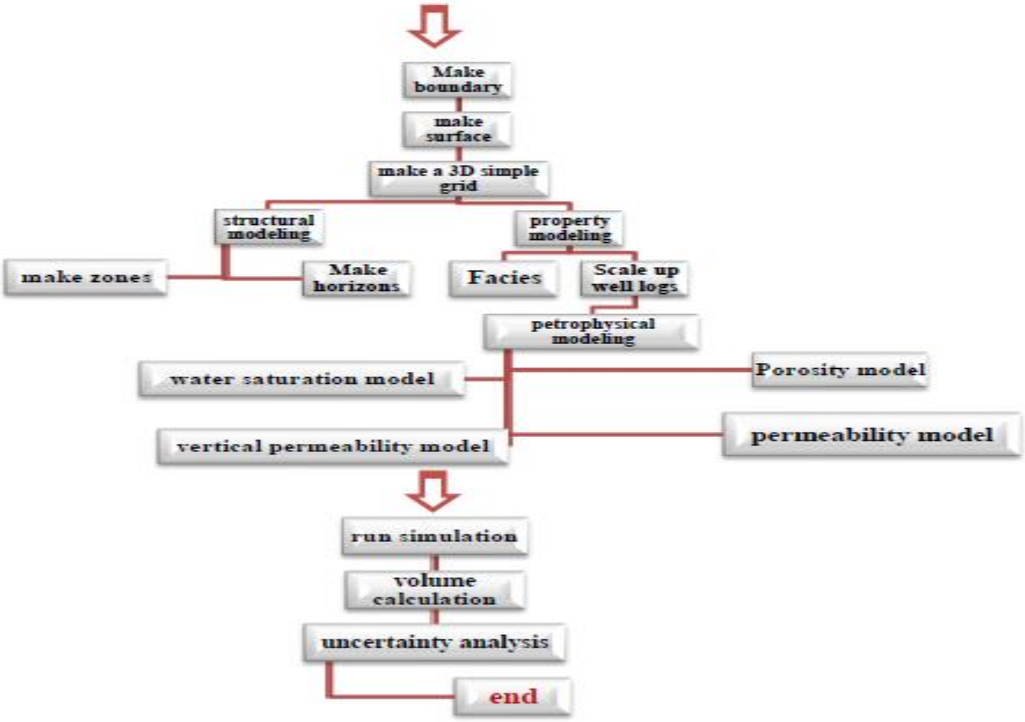


Fig. 1. Evaluating uncertainty in the volume workflow

Data Preparation

To build the static model and make an uncertainty analysis, the following data were inputted into Petrel software:

1. Digitized Contour Map.
2. Petrophysical Properties include net-to-gross ratio, porosity, and water saturation. These properties are computed by well logs and core data analysis by Techlog software.
3. Well Tops.
4. Well Position.

Model Building

The geological model is one of the basic steps in reservoir modeling. It is a three-dimensional representation of the layers of the reservoir and the rocks it contains, as well as the representation of the petrophysical properties and their distribution within the reservoir. In this research, this model was built according to the following steps:

Structural Maps

The following data set is utilized to construct the structural model of the identified reservoir:

1. Digitized contour maps (2D/3D).
2. Well tops according to the results of the detailed correlation of the oilfield wells

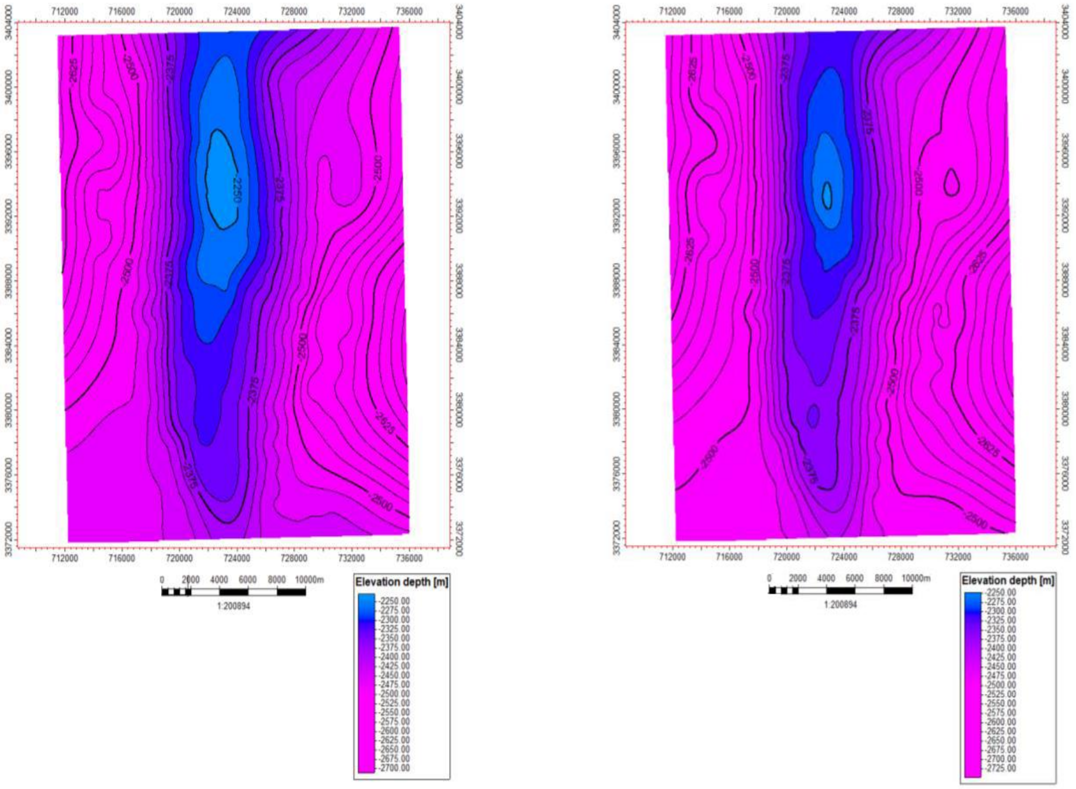


Fig. 2. Structural maps

3D Gridding

The 3D grid permits the visualization of rock properties, for instance, lithology, porosity, fluid saturation, and permeability, in a way that accurately represents the subsurface geology. It also enables the display of the deformation of the subsurface layers due to tectonic forces, folding, faulting, and other geological processes [9]. This procedure gives the ability to choose the optimal well placement and design by identifying areas of high reservoir quality and avoiding areas with low quality or high heterogeneity [10].

Table 1. Gridding model information

Axis	Min	Max	Delta
X	711530.4	736030.4	24500
Y	3371815.28	3403715	31900
Elevation	-2746.47	-2127.43	619.05
Lat	30◦27'19.40	30◦44'51.32	0◦17'31.926
Long	47◦12'11.44	47◦27'55.60	0◦15'44.160

Grid cells (nI, nJ,nK)	490 * 638 * 40
Grid nodes (nI, nJ,nK)	491 * 639 * 41
Total number of grid cells:	12504800
Total number of grid nodes:	12863709
Number of geological horizons	41
Number of geological layers	40
Average X inclination	50
Average Y inclination	50
Average z inclination (along pillar)	3.62835

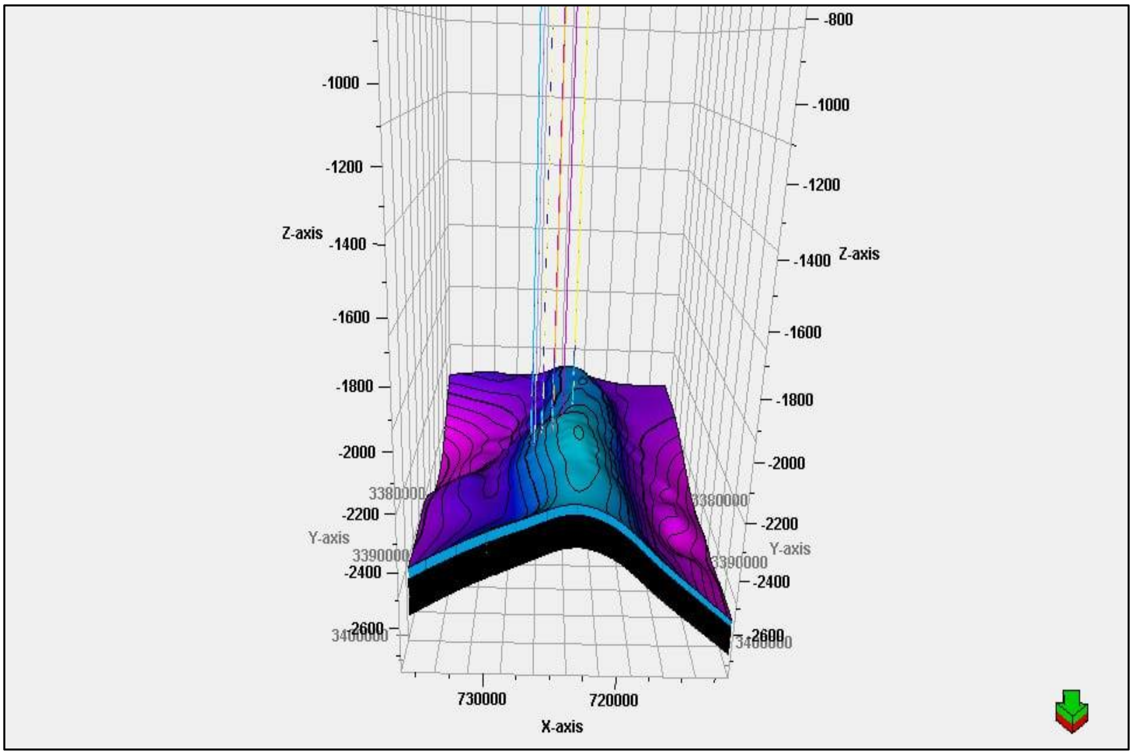


Fig. 3. 3D gridding model

Well Log Upscaling

Well log upscaling is the process of converting high-resolution well log data, typically obtained from a single well, into coarser resolution data that can be used in reservoir modeling studies. The upscaled data can be used to build a more efficient and accurate reservoir model, with reduced computational costs.

The properties that are distributed during log upscaling may include porosity, net to gross, permeability, and saturation.

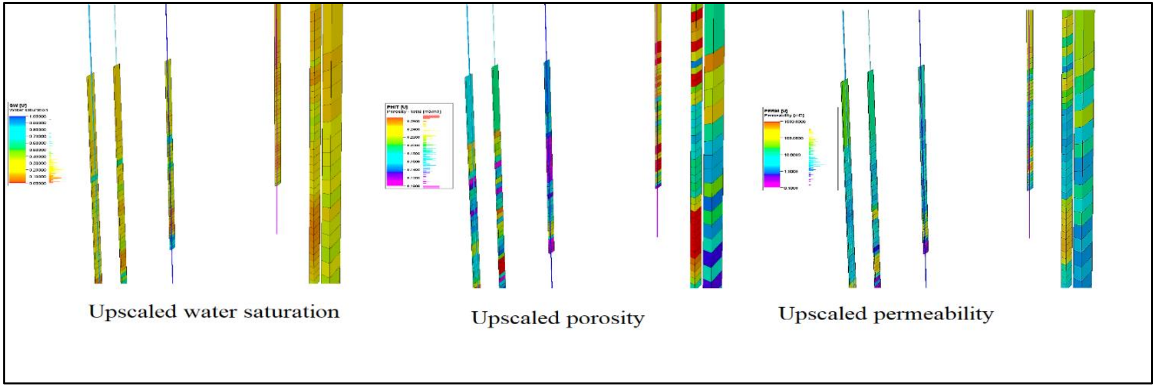


Fig. 4. Upscaling of well log petrophysical properties

Table 2. Petrophysical modeling descriptions

Petrophysical Modeling Descriptions	Seed Number
Phi	25583
Sw	30369
K	11926
NG	8414

Model of porosity

The porosity model was developed by interpreting the petrophysical well logs results with a minimum porosity value of 0.0139 and a maximum of 0.3016, when averaging these values, the minimum and maximum values are 0.0458 and 0.3016, respectively. To create the porosity model, the "Sequential Gaussian simulation" method was utilized along with data transformation by vertical and lateral probability trends.

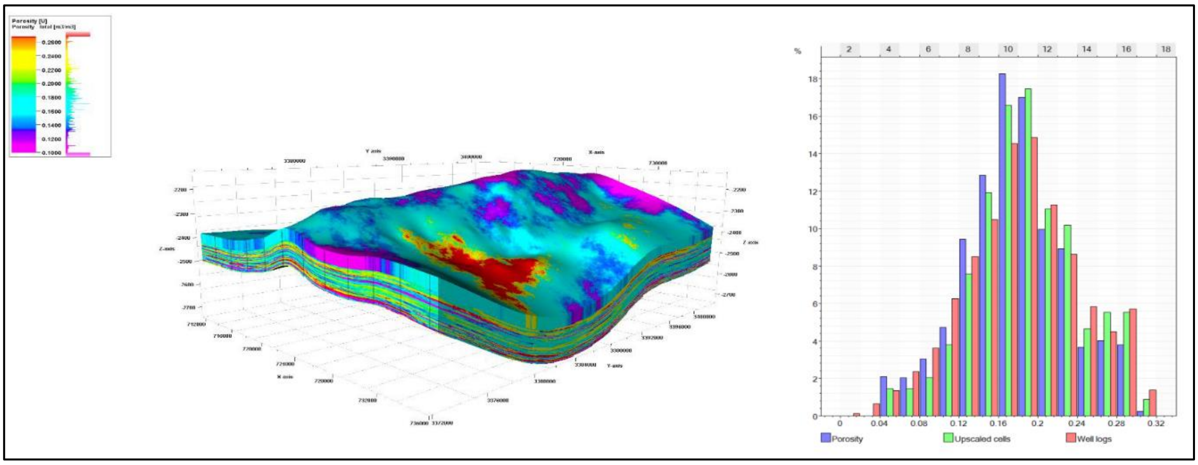


Fig. 5. Porosity modeling

Permeability Model

The well logs scale-up was executed by the harmonic average method, and the statistical method, Sequential Gaussian Simulation, was used to create a permeability model [11, 12]. The permeability model revealed that permeability values in the Mishrif formation range from the lower limit of 0.0280 mD to the highest limit of 1824.0193 mD, after averaging these numbers it will be a min and max of (0.126mD-398.7423mD) respectively with varying concentrations across the formation.

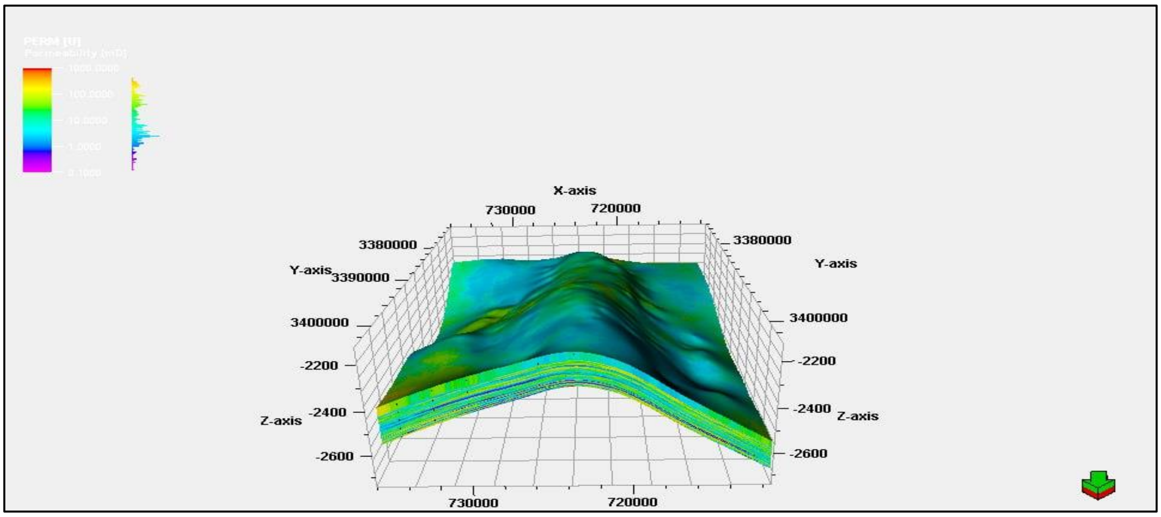


Fig. 6. Permeability modeling

Water Saturation Model

The importance of calculating water saturation is substantial to calculate hydrocarbon saturation [13]. The statistical method, Sequential Gaussian Simulation, was used to create the Mishrif formation water saturation model by Petrel software [14].

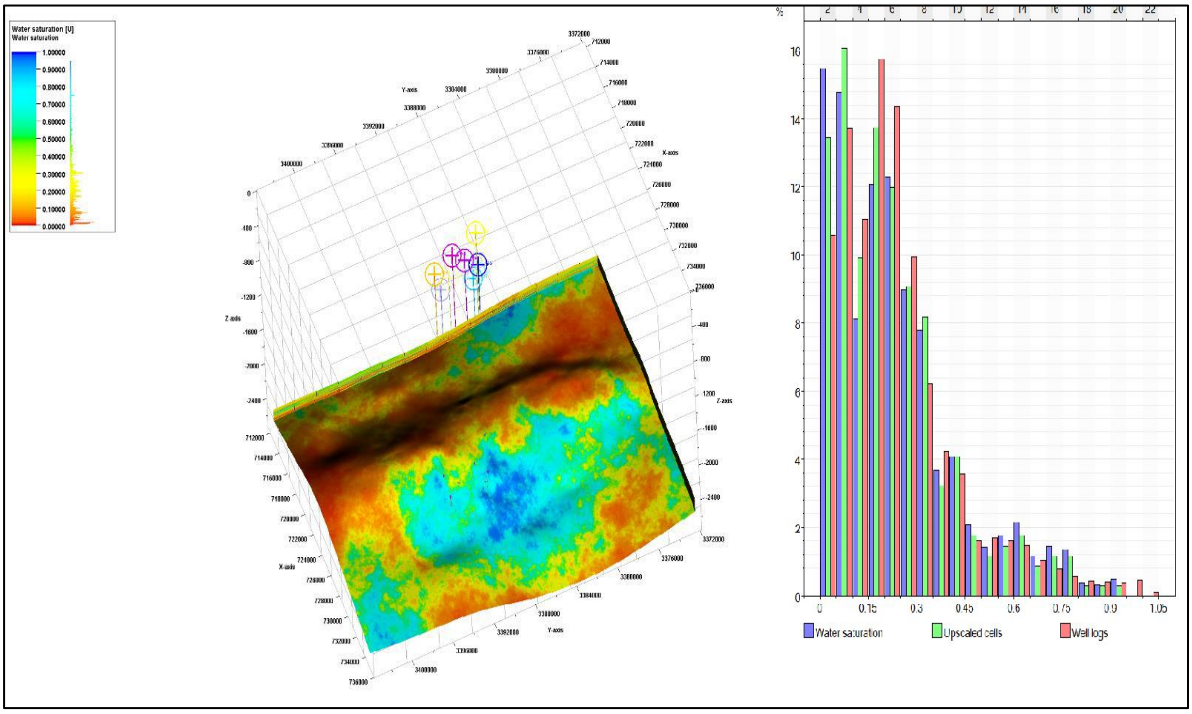


Fig. 7. Water saturation modeling

Facies Modeling

Facies modeling can help to predict reservoir properties, various amount of facies often has different petrophysical properties such as PHI, K, Sw. By modeling facies locative distribution, the prediction of the distribution of these properties can be used to evaluate the potential for hydrocarbon reservoirs.

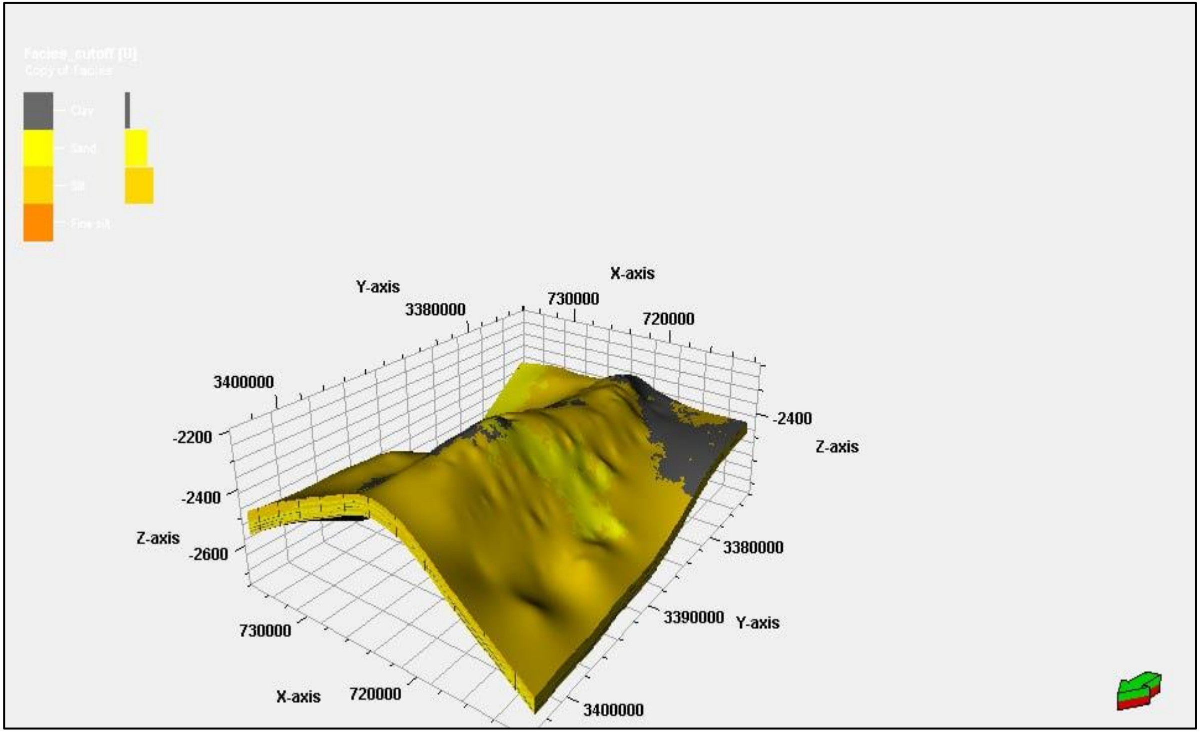


Fig. 8. Facies modeling

Volume Calculation of OOIP

The Calculation of OOIP volume in the Petrel geological model is done by the volumetric method. This calculation is important for evaluating the potential economic viability of a reservoir and for planning reservoir management strategies [15]. The total amount of OOIP is 3443 * 10^6 sm^3, where the formation volume factor (Bo) was equal to 1.34 bbl/STB.

The formula for volumetric calculation is:

$$OOIP = \frac{7758\ Ah\phi\ (1-Sw)}{Boi} \tag{1}$$

Uncertainty Analysis

P90, P50, and P10 geostatistical models of the reservoir must be created, because this is essential for reservoir management and prediction, dynamic modeling, and the analysis of the risks [16]. To obtain a range of the reserve values by the volumetric method the porosity, formation volume factor, and initial water saturation could be utilized [17].

When the probability of real obtained quantities is the same as or larger than the estimated 90%, it is considered a proven reserve. These are usually denoted in the estimation process as P90. P50 is the proved and probable reserves and the P10 refers is the sum of probable and possible reserves [18, 19].

Uncertainty analysis was used to obtain more than one value for the OOIP, by using the minimum and maximum values of the imprecise variables involved in the calculation process. In this paper, there was uncertainty about the location of the OWC, because its measurements were only available from two wells only. For this reason, several values were taken for it within the available measurement range [20]. The second uncertain variable was the amount of the oil formation volume factor due to the availability of measurement from the PVT report for only one well.

Numerical Monte Carlo (MC) simulation has been used in uncertainty quantification which is considered the most reliable method as a measure of uncertainty within the oil and gas industry in flow simulation and volumetric estimation of OOIP [12]. Outputs of MC simulations resulted from various realizations of input parameters.

Results and Discussion

One hundred values were calculated for the OOIP using optimization and uncertainty analysis found in the Petrel Software depending on the change in the uncertain values within the lower and upper bounds as shown in Table 3 below.

Table 3. The calculation of STOIIP as a function of WOC level and Bo values

CASE	STOIIP_sm3 *10^6	WOC	Bo
1	3375.4752	-2442	1.320
2	3389.278538	-2443	1.321
3	3361.678484	-2441	1.323
4	3458.251212	-2448	1.330
5	3375.4752	-2442	1.323
6	3444.481172	-2447	1.337
7	3403.082095	-2444	1.330
8	3472.008393	-2449	1.339
9	3458.251212	-2448	1.340
10	3403.082095	-2444	1.340

The resulting values ranged between 3300 * 10^6 and 3700 * 10^6 sm^3. From the resulting OOIP values, it can be seen that the OWC level is the most influential parameter on oil in place. For this reason, a histogram was created with bin values ranging from 3300 to 3700 and with a bin step equal to 25, and the normal distribution for these bins was calculated as shown below.

Finally, the values of P10, P90, and P50 were calculated using the probability function depending on the mean of the OOIP values and their slandered deviation.

It can be seen from the above figure that P10 curve covers 90 percent of the normal distribution curve for OOIP, while curve P50 covers 50% of the normal distribution curve for OOIP and P90 is only 10% of the calculated values.

Table 4. Normal distribution of STOIIP

Bin	Frequency	Normal distribution
3300	0	0.151008937
3325	0	0.884642559
3350	1	3.396508655
3375	8	8.546677976
3400	10	14.09488946
3425	14	15.23441304
3450	12	10.79169087
3475	12	5.010176029
3500	2	1.524460555
3525	0	0.304003873
3550	0	0.039732122
3575	0	0.00340333
3600	0	0.000191058
3625	0	7.02956E-06
3650	0	1.69508E-07
3675	0	2.67886E-09
3700	16	2.77467E-11
More	0	

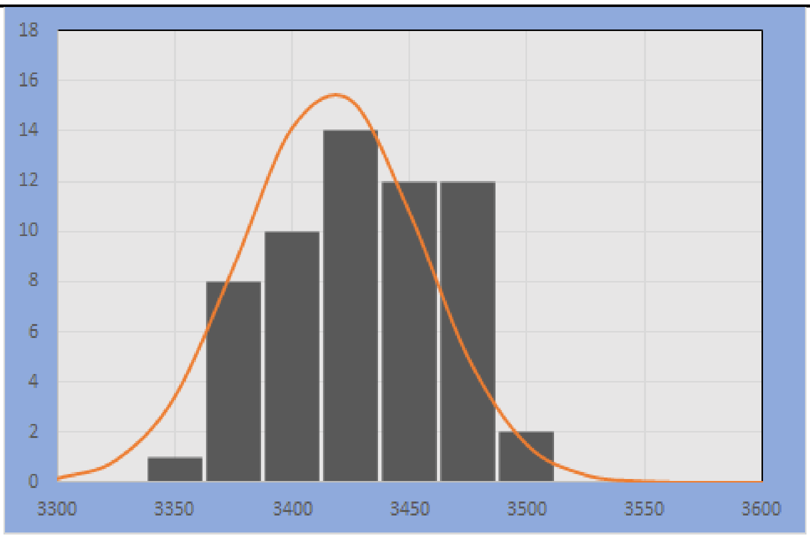
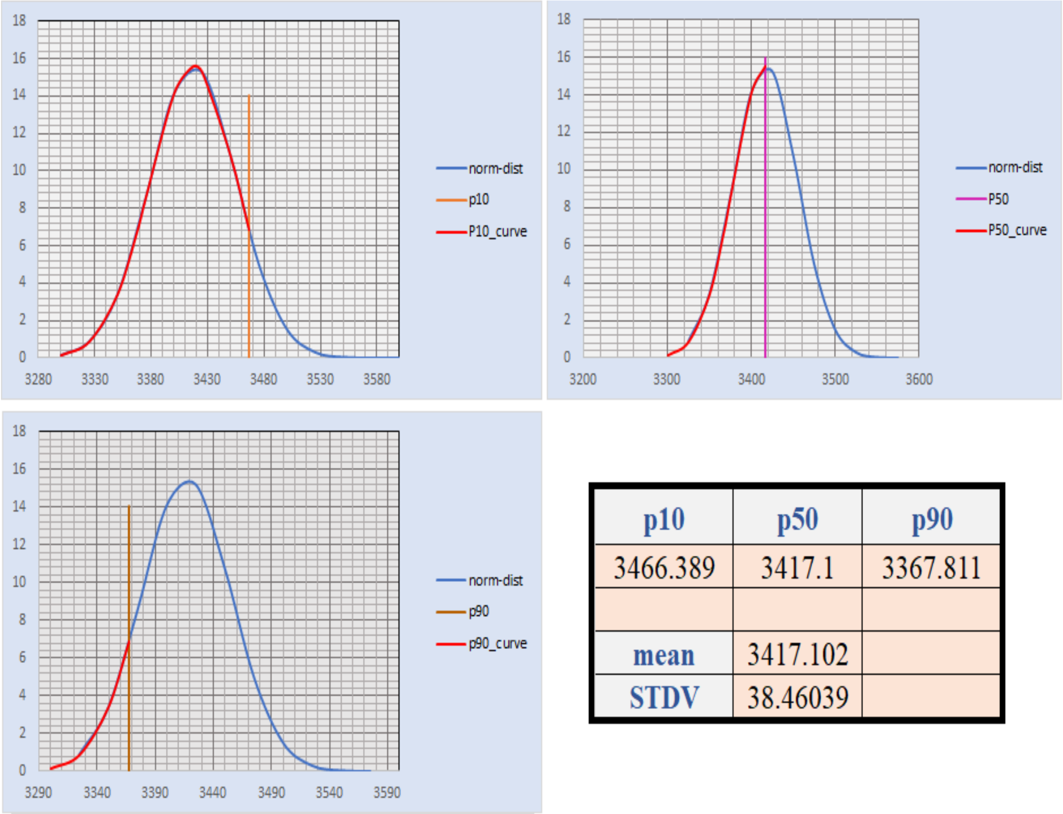


Fig. 9. Normal distribution curve with histogram for the values of OOIP



p10	p50	p90
3466.389	3417.1	3367.811
mean	3417.102	
STDV	38.46039	

Fig. 10. Normal distribution curve with P90, P50, and P10 values

By building a digital geological model, the STOIIP of the Mishrif-Rumaila formations was computed using the volumetric approach. The STOIIP for the base case of calculation was equal to 3443 * 10^6 sm^3 for the Mishrif formation in the chosen oilfield before applying the uncertainty estimation. Hence this formation has a very high oil volume and this model appears to be the first step in the design of a reservoir dynamic model, it is evident why it is important to continue developing the formation. Depending on the mean values of the OOIP and the corresponding standard deviation, the values of P10, P90, and P50 were determined using the probability function. As can be seen, curve P10 only represents 10% of the calculated values and covers 90% of the normal distribution curve for OOIP, P50 only represents 50% of the normal distribution curve for OOIP, and P90 represents 10% of the calculated data. Uncertainty processes can help speed up the calculation of the changes in oil volume as a result of the influence of uncertain variables such as OWC, for which there is insufficient data. It has been found that the OWC is the most influential parameter on oil in place.

Conclusion

By building a digital geological model, the STOIIP of the Mishrif-Rumaila formations was computed using the volumetric approach. The STOIIP for the base case of calculation was equal to 3443 * 10^6 sm^3 for the Mishrif formation in the chosen oilfield before applying the uncertainty estimation. Hence this formation has a very high oil volume and this model appears to be the first step in the design of a reservoir dynamic model, it is evident why it is important to continue developing the formation. Depending on the mean values of the OOIP and the corresponding standard deviation, the values of P10, P90, and P50 were determined using the probability function. As can be seen, curve P10 only represents 10% of the calculated values and covers 90% of the normal distribution curve for OOIP, P50 only represents 50% of the normal distribution curve for OOIP, and P90 represents 10% of the calculated data. Uncertainty processes can help speed up the calculation of the changes in oil volume as a result of the influence of uncertain variables such as OWC, for which there is insufficient data. It has been found that the OWC is the most influential parameter on oil in place.

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References

[1] Abdel-Fattah MI, Metwalli FI, El Sayed IM. Static reservoir modeling of the Bahariya reservoirs for the oilfields development in South Umbarka area, Western Desert, Egypt. Journal of African Earth Sciences. 2018 Feb 1;138:1-3. doi.org/10.1016/j.jafrearsci.2017.11.002

[2] Abdulrazzaq FN, Hasan OF. A review of automatic history matching. Materials Today: Proceedings. 2023 Jan 1;80:3817-22. doi.org/10.1016/j.matpr.2021.07.395

[3] Acosta LM, Jiménez J, Guedez A, Ledezma EA, Bello JA, Millán AJ, Guzman M, Marin E, Gómez FJ, Herrera I, Córdoba P. Integrated Modeling of the El Furrial Field Asset Applying Risk and Uncertainty Analysis for the Decision Making (SPE94093). In67th EAGE Conference & Exhibition 2005 Jun 13 (pp. cp-1). European Association of Geoscientists & Engineers. doi.org/10.3997/2214-4609-pdb.1.P151

[4] Agnia A, Algdamsi H, Amtereg A, Alkouh A, Alusta G. Monte Carlo Simulation for Uncertainty Quantification of Probabilistic Original Hydrocarbon in Place Estimation a Convergence Study How Many Samples With a Particular Sampler are Needed. InAbu Dhabi International Petroleum Exhibition and Conference 2021 Dec 9 (p. D042S282R001). SPE. doi.org/10.2118/207241-MS

[5] Ahmed RA, Hamd-Allah SM. Geological Model for Mauddud Reservoir Khabaz Oil Field, Kirkuk, Northern Iraq. The Iraqi Geological Journal. 2021 Apr 27:29-42. doi.org/10.46717/igj.54.1D.3Ms-2021-04-23

[6] Alpak FO, Vink JC, Gao G, Mo W. Techniques for effective simulation, optimization, and uncertainty quantification of the in-situ upgrading process. InSPE Reservoir Simulation Conference? 2013 Feb 18 (pp. SPE-163665). SPE. doi.org/10.2118/163665-MS

[7] Bachu S. Sequestration of CO2 in geological media: criteria and approach for site selection in response to climate change. Energy conversion and management. 2000 Jun 1;41(9):953-70. doi.org/10.1016/S0196-8904(99)00149-1

[8] Derakhshan SH, Deutsch CV. Direct simulation of P10, P50 and P90 reservoir models. InPETSOC Canadian International Petroleum Conference 2008 Jun 17 (pp. PETSOC-2008). PETSOC. doi.org/10.2118/2008-188

[9] Khamees LA, Alrazzaq AA, Humadi JI. Different methods for determination of shale volume for Yamama formation in an oil field in southern Iraq. Materials Today: Proceedings. 2022 Jan 1;57:586-94. doi.org/10.1016/j.matpr.2022.01.455

[10] El Bahri S, Al-Shaarawy O, Chouaibi M, Ghorayeb K, Amanov B, Stojic S. Phased-Development Strategy to Mitigate Subsurface Uncertainties and Risks in Developing a New Gas Field: A Case Study in the ADCO Fields, UAE. InAbu Dhabi International Petroleum Exhibition and Conference 2014 Nov 10 (p. D021S026R004). SPE. doi.org/10.2118/172029-MS

[11] Dommisse R, Sivila L, Male F, Hamlin HS. The value of building a multiscale, regional geomodel for reserves assessment of the Midland Basin. InSPE/AAPG/SEG Unconventional Resources Technology Conference 2018 Jul 23 (p. D013S019R009). URTEC. doi.org/10.15530/URTEC-2018-2902841

[12] Tali AH, Abdulridha SK, Khamees LA, Humadi JI, Farman GM, Naser SJ. Permeability estimation of Yamama formation in a Southern Iraqi oil field, case study. InAIP Conference Proceedings 2023 Sep 1 (Vol. 2806, No. 1). AIP Publishing. doi.org/10.1063/5.0163281

[13] Kurah BK, Shariatipour MS, Itiowe K. Reservoir characterization and volumetric estimation of reservoir fluids using simulation and analytical methods: a case study of the coastal swamp depobelt, Niger Delta Basin, Nigeria. Journal of Petroleum Exploration and Production Technology. 2021 Jun;11(6):2347-65. doi.org/10.1007/s13202-021-01206-1

[14] Magomadov I, Balhasan S, Khalifa S, Awad M, Yaqoob S. Challenges in Original Oil-In-Place Estimation: Selection of the Best Method for a Field with Non-Uniform Geological Parameters. InSPE Annual Caspian Technical Conference 2022 Nov 15 (p. D021S011R002). SPE. doi.org/10.2118/212112-MS

[15] Meddaugh WS, Champenoy N, Osterloh WT, Tang H. Reservoir forecast optimism–Impact of geostatistics, reservoir modeling, heterogeneity, and uncertainty. InSPE Annual Technical Conference and Exhibition? 2011 Oct 30 (pp. SPE-145721). SPE. doi.org/10.2118/145721-MS

[16] Pal N, Mandal A. Compositional simulation model and history-matching analysis of surfactant-polymer-nanoparticle (SPN) nanoemulsion assisted enhanced oil recovery. Journal of the Taiwan Institute of Chemical Engineers. 2021 May 1;122:1-3. doi.org/10.1016/j.jtice.2021.04.022

[17] Park H, Scheidt C, Fenwick D, Boucher A, Caers J. History matching and uncertainty quantification of facies models with multiple geological interpretations. Computational Geosciences. 2013 Aug;17:609-21. doi.org/10.1007/s10596-013-9343-5

[18] Robinson JG, Elliott D. National Instrument 51-101 (NI 51-101) Reserves Reconciliation-Part 2, A Review of Technical Revisions In Annual Information Form Filings For End 2003. Journal of Canadian Petroleum Technology. 2005 Feb 1;44(02). doi.org/10.2118/05-02-HT

[19] Shah Z, Kumar MD. In the midst of the large dam controversy: Objectives, criteria for assessing large water storages in the developing world. Water Resources Management. 2008 Dec;22:1799-824. doi.org/10.1007/s11269-008-9254-8

[20] Yang C, Nghiem L, Erdle J, Moinfar A, Fedutenko E, Li H, Mirzabozorg A, Card C. An efficient and practical workflow for probabilistic forecasting of brown fields constrained by historical data. InSPE Annual Technical Conference and Exhibition? 2015 Sep 28 (p. D011S008R008). SPE. doi.org/10.2118/175122-MS

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