

EVALUATING UNCERTAINTY IN THE VOLUME OF OIL IN PLACE IN MISHRIF RESERVOIR

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 for the purpose of predicting a range of reserve value, each value gives range of production forecast. These values are divided into probable estimate that give the highest, lowest, and mean expected production, called P90, P50, and P10. Geostatistical models of the reservoir 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 prove and probable reserves. In this research, these quantities were calculated using statistical functions in order 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 present that the OWC level is the most influencer parameter on oil in place. A histogram was created with Bins value ranged from 3300 to 3700 and with Bin step equal to 25 and the normal distribution for these Bins were calculated to estimate P10, P50, and P90 values.

Keywords: Oil volume, mishrif reservoir, geostatistical models, Petrel program, OOIP.

1. 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 rocks 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 estimated the in place oil by use core data analysis and logs interpretations for the purpose of calculating the porosity, the bulk volume, and the saturations of fluids and by 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 required 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 in 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.

2. 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, uncertainty qualification as shown in figure (1).

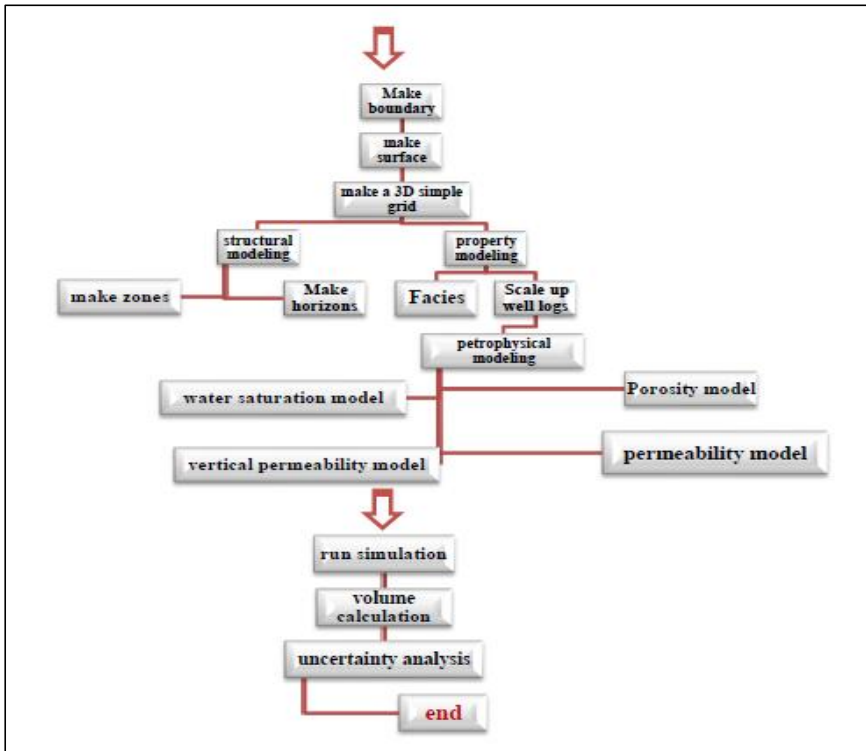


Figure 1: Evaluating uncertainty in the volume workflow

2.1. Data Preparation

In order to build the static model and make uncertainty analysis, the following data were inputted in Petrel software:

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

2.2. 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

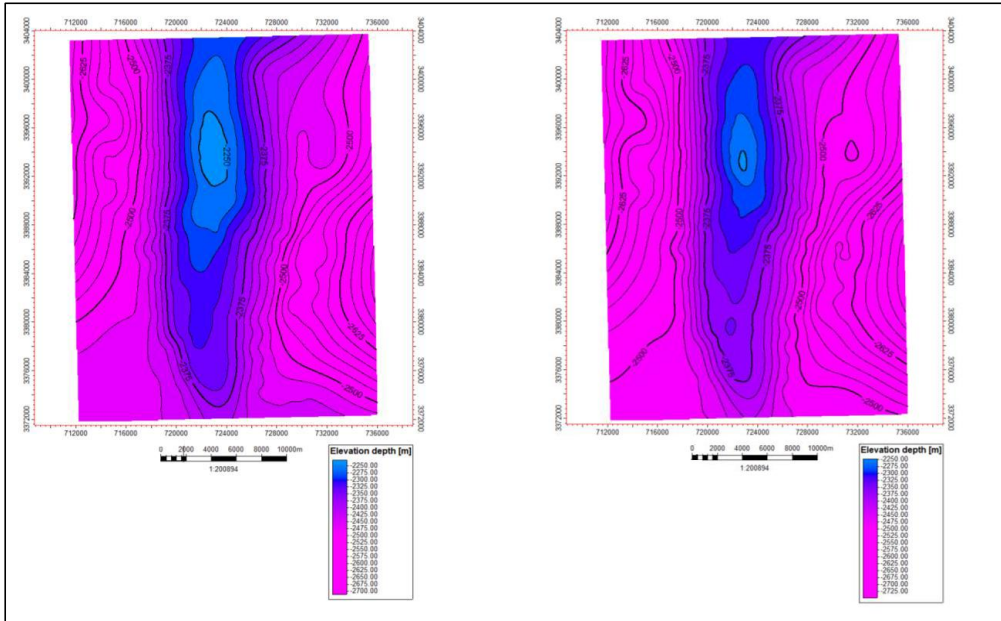


Figure 2: Structural Maps

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 informations

Grid cells(nI, nJ,nK)		490 x 638 x40	
Grid nodes(nI, nJ,nK)		491 x 639 x41	
Total number of grid cell:		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	
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

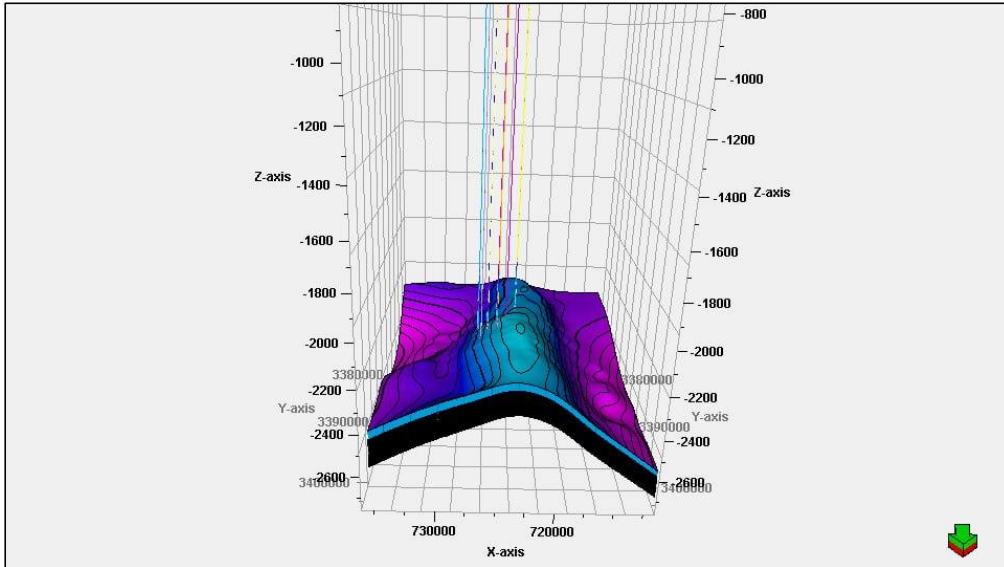


Figure 3:3D gridding model

Well Log Upscaling

Well log upscaling is the process of converting high-resolution well log data, typically obtained from a single well, into a 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:

- 1-Porosity
- 2-Net to gross
- 3-Permeability
- 4-Saturation

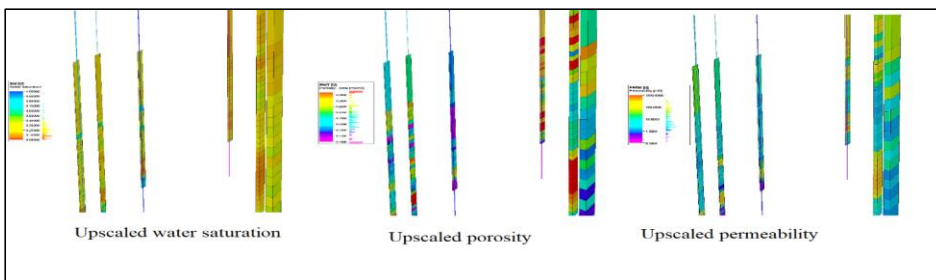


Figure 4: Up scaling of well log petrophysical properties

Table2: 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 minimum porosity value of **0.0139** and maximum of **0.3016**, when averaging to these values is done minimum and maximum values are **(0.0458 , 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.

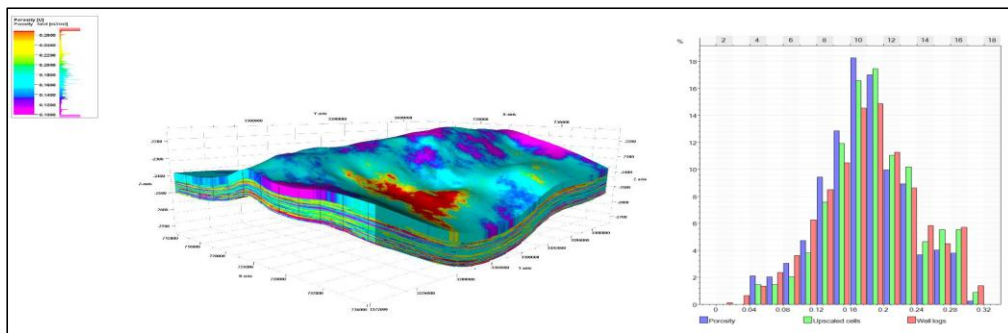


Figure 5: Porosity modeling

Permeability Model

The well logs scale up was executed by harmonic average method, and the statistical method, Sequential Gaussian Simulation, was used to create permeability model [11] [12]. The permeability model revealed that permeability values in the Mishrif formation range from the lower limit **0.0280 mD** to the highest limit **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.

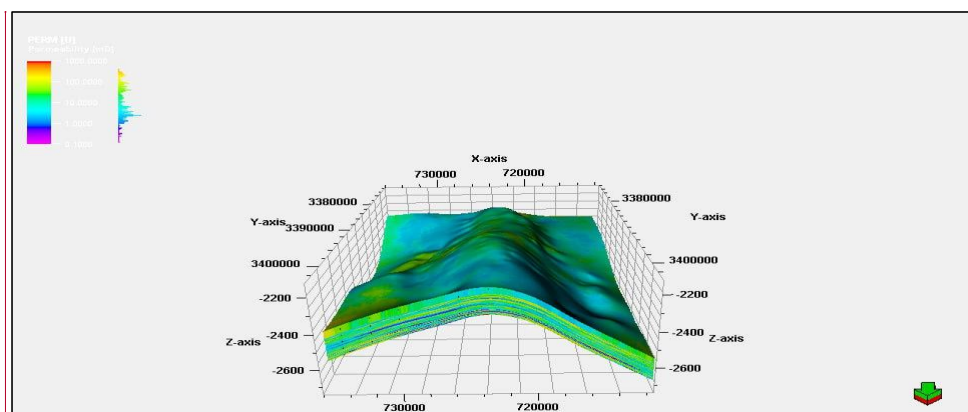


Figure 6: Permeability modeling

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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 Mishrif formation water saturation model by Petrel Software [14].

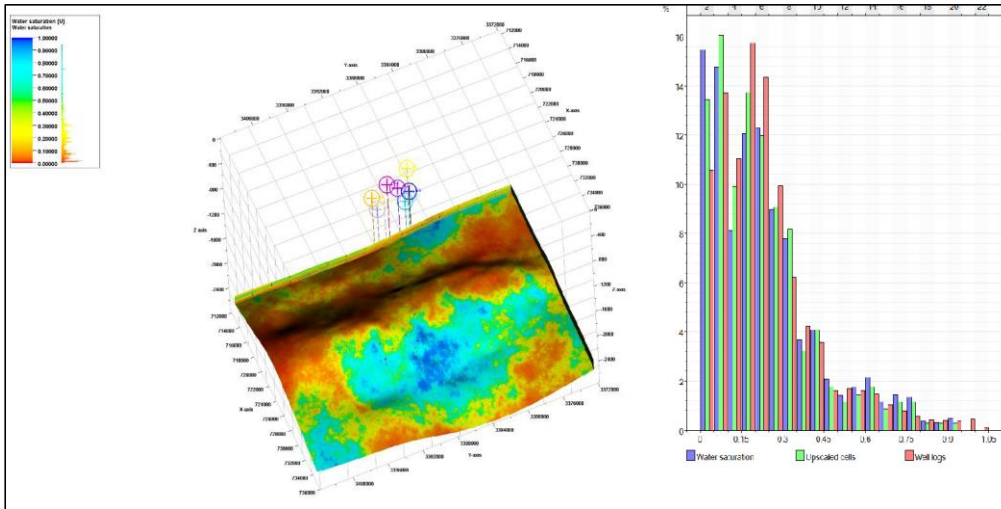


Figure 7: Water saturation modelling

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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.

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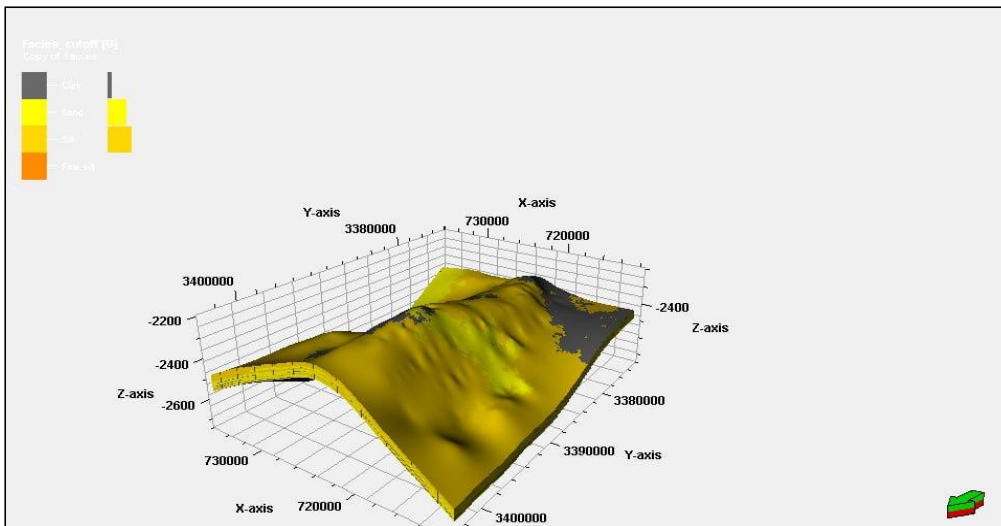


Figure 8: Facies modeling

Volume Calculation of OOIP

The Calculation of OOIP volume in 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 $(3443 \times 10^6 \text{ sm}^3)$ where the formation volume factor (B_o) was equal to 1.34 bbl/STB.

The formula for volumetric calculation is:

$$OOIP = \frac{7758 Ah\phi (1 - S_w)}{B_{oi}}$$

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 utilize[17].

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

Uncertainty analysis was used for the purpose of obtaining 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 measurements range[20]. The second uncertain variable was the amount of the oil formation volume factor due to the availability of measurement form PVT report for only one well.

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

3. 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 table1 below.

Table 3: The calculation of STOIPP as function of WOC level and Bo values

CASE	STOIPP_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 $3300 \times 10^6 \text{ sm}^3$ and $3700 \times 10^6 \text{ sm}^3$. It can be seen from the resulting OOIP values that the **OWC level** is the most influencer parameter on oil in place. For this reason, a histogram was created with Bins value ranged from 3300 to 3700 and with Bin step equal to 25 and the normal distribution for these Bins were calculated as shown below

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Table 4: normal distribution of STOIP

<i>Bin</i>	<i>Frequency</i>	<i>normal distribution</i>
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
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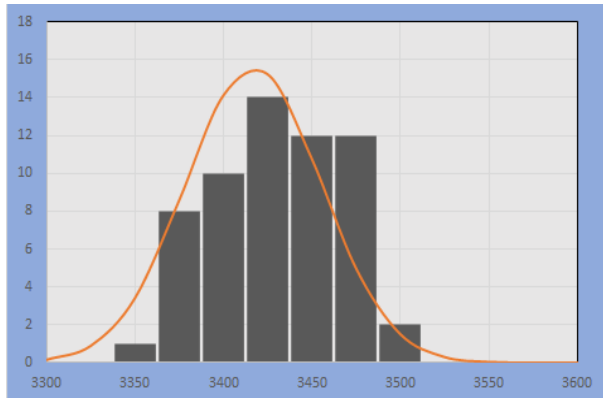


Figure 9: Normal distribution curve with histogram for the values of OOIP

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

$$NORM.INV(Probability; mean; standered_{dev})$$

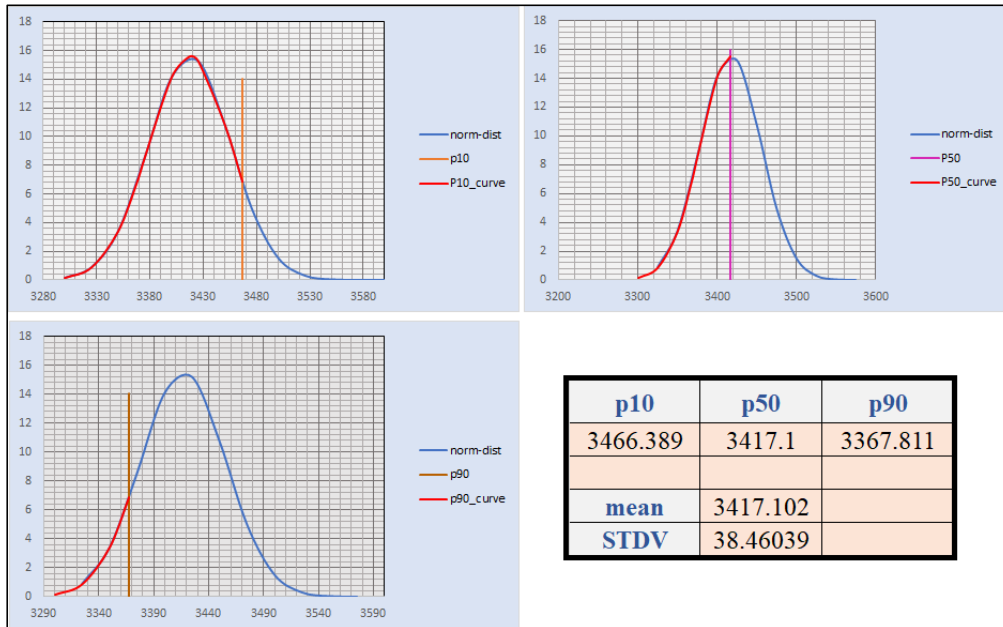


Figure 10: Normal distribution curve with P90, P50 and P10 values

It can be seen from the above figure, curve P10 covers 90 percent of the normal distribution curve for OOIP while P50 curve cover fifty percent of the normal distribution curve for OOIP and P90 is only ten presents of the calculated values.

4. Conclusions

By building 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 $3443 \times 10^6 \text{ m}^3$ 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 could 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 are insufficient data. It has been found that the OWC is the most influencer parameter on oil in place.

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Acknowledgment

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References

