Modeling of Petrophysical Properties and Reserve Estimation of Mishrif Formation-Garraf Oil Field

Ahmed T. Abeed 1, Samaher A. Lazim 2, Ramzy. S. Hamied
1, 2, 3 Department of Petroleum Technology, University of Technology, Baghdad-Iraq
Corresponding author, ahmedtalal284@gmail.com

Abstract. In this study a build-up a 3D geologic model both depend on the information of field and subsurface is a usual task in geologic studies including resource evaluation and hazard assessment. During this study a 3D geologic model for Mishrif Formation in Garraf oil field has been set-up by using petrel 2015 software system. Mishrif Formation represents the foremost important reservoir in Garraf oil field. Four vertical oil wells and one directional well were chosen in Garraf Oil Field so as to set-up structural and petrophysical models delineated by a 3D static geologic model in 3 dimensions. The structural closure is shifted from GA-3 well to GA-A1P well. Mishrif Formation was divided into 10 zones. Sequential Gaussian Simulation algorithm was used to build-up Petrophysical model (NTG, permeability, water saturation and porosity) for Mishrif Formation keeping with information analyses and also the results from modeling the units (M1.2, L1 and L1.2) are thought-about as prime quality reservoir units because of the high PHIE and low water saturation. Units (L2, L2.2, L2.3 and L2.4) are thought-about as poor reservoirs because of low PHIE and high water saturation, and non-reservoir units include (Top Mishrif, M1 and M2) thus, they represent cap units. Cross sections of petrophysical model were conducted to Illustrate the vertical and horizontal distribution of porosity, permeability, Net to gross and water saturation between wells within the field. This study calculated the reserves of the Mishrif formation of Garraf oilfield by petrel, that alter the issue that the reserves parameters are difficult to properly acquire when estimate complex reservoir's reserves in terms of ancient volume technique.

1. Introduction
Models of reservoir can be formed comparatively quickly with geo-statistical tools, like petrel 2015 software package, one of preferred modeling code in petroleum industry, but often, a limited variety should be chosen for input to flow simulation due to procedure time needs.[1] 3D model is the method of developing a mathematical illustration of any 3–D surface of object via specialized software system. The product is termed a 3D model.[2] The ranking engine has been written as petrel plug-in. This enables petrel users to rank reservoir models in petrel and choose limited representative ones for flow simulation.[3] The objective of this study to build up a 3D geologic model for Mishrif Formation in Garraf oil field using petrel 2015 software system. This model includes structure, Stratigraphic and reservoir properties (porosity and water saturation) in 3 dimensions (X, Y and Z). Geological modeling is an engineering science of making processed representations of parts of the Earth's crust, particularly hydrocarbon reservoirs. Within the petroleum industry, Geological models are needed as input to reservoir simulator software, that predict the performance of the rocks beneath various hydrocarbon recovery situations using reservoir simulation permits reservoir engineers to detect that recovery choices provide the safest and most economic, efficient, and effective development plan for a specific reservoir.[4]
Reserve volume is that the comprehensive analysis of oil field exploration and development, as a consequence, the rationality of reserves calculation positively have an effect on the choice of oil field prospecting and exploitation. The reserves calculation method based on the high exactness of tridimensional reservoir geologic model, will be used to influence the issues that reserve parameters are troublesome to correctly acquire when estimating complicated reservoir's reserves in terms of traditional volume method [5].

2. Area of Case Study

The Garraf oil field is located in Thi Qar province regarding eighty-five km to the north of Nassriya city south of Iraq. The Garraf oil field could be a north west south east trending anticline with an area of twenty-four km length and five km width [3]. Three wells were drilled in Garraf oil field throughout. Six vertical wells (GA-1, GA-2, GA-4, GA-A1P, GA-3 and GA-5) and one directional well (GA-B8P) were studied in Garraf Oil Field (Figures 1 and 2) [6].

The Mishrif and Yamama Formation were containing the most oil accumulation within the field area. The second accumulation zones are found within the Ratawi and Zubair Formation [7].

![Figure 1 Map of appearance location of the area study (ARCMAP, 2015).](image-url)
3. Workflow

Petrel software system 2015 has been used to set-up a 3D model. Petrel is a PC-based mostly progress application for underground interpretation and modeling [8]. On this basis of program system required and analysis area characteristics. The input data are imported from files- on file for every data object. These data include:

1. **Well head**: includes the coordinates of every well in 3-dimensions, and also the measured depth along the path.
2. **Well tops**: markers represent well picks on the well path, commonly a change in stratigraphy.
3. **Well logs**: the information of logs include effective porosity, permeability and water saturation values on the well path.
4. **Depth maps**: structural contour maps obtained from seismic acquisition.

![Figure 2 Contour map of top Mishrif in Garraf oil field.](image)
5. **WOC**: Water oil contact is a used in several reservoir studies to explain the elevation higher than that fluids apart from water can be found within the pores of a rock.

4. **Design of Model**
   The main steps of set-up a geological model of a crude oil reservoir using petrel 2015 software system are:
   
   - Data import.
   - Quality check (Q.C).
   - Well correlation.
   - Structural modeling, that includes:
     a. Pillar gridding,
     b. Build horizons,
     c. Layering.
   - Property modeling, that includes:
     a. Scale up,
     b. Data analysis
     c. Petrophysical modeling.
   - Volumetric calculation
   - Uncertainty analysis

5. **Quality Check**
   In any modeling study, the input file need to be pre-processed to create it appropriate for fitting the model. Similarly, the results could need post-process before mapping and coverage. The process includes: editing, removing or adding data, furthermore as logical, mathematical and object connected operations. Therefore, it's necessary to see the statistics whenever any process operations are performed, and it's necessary to continuously compare those statistics before and when the operation to visualize if the results appear logical or not.

6. **Well Correlation**
   Well correlation principles might shed light on the distribution of petrophysical properties, extents and thickness of various lithological units in reservoirs (Figure 3). Well correlations perform by using petrel 2015 software. Well correlation in petrel 2015 permits the chance to observe multiple wells in a well section, produce marker picks and bring up new wells to check with already correlate wells [9]. Figure (4) illustrates correlation section of Mishrif Formation in Garraf oil field. Mishrif Formation in Garraf oil field has been divided into 3 main components, upper, middle & lower. The upper & middle components are divided by marl units. The upper part from top of Mishrif to M1 unit. However, there's oil shows inside this part it's not thought of inside reservoir zone, as a result of it's not producible. Middle & lower components are reservoir units. They extend from M1 to top of Rumaila Formation. The Mishrif Formation (middle & lower) components contain many reservoir units (M1.2, L1, L1.2, L2, L2.2, L2.3 and L2.4) that are sealed by 2 cap layers (M1 and M2).
7. Structural Modeling

Structural modeling represents setting up the structural map for every unit in Mishrif Formation (Figure 5). It's divided into 3 operations as follows: fault modeling, pillar gridding, and layering. All the 3 operations are performed one when the opposite to create one single information model. Simple grid method is used here rather than pillar gridding. The studied formation in Garraf Oil Filed has no fault thus fault modeling method is neglected. Contour maps can be created by computer from the surface data and related to boreholes.

8. 3D-Grid Construction

In easy terms, a 3D grid divides a model into boxes, every box is named a grid cell and will have a single rock kind, one value of shale volume, one value of permeability, etc. A three-dimension grid building is the first step to set up the three-dimension model in easy terms. These are remarked because the cell's properties. This can be a simplification of actuality case, however permits us to come up with an illustration of reality that may be used in calculations, etc.

9. Pillar Gridding

Pillar gridding is the method of creating the grid, that denotes the bottom of all modeling. The skeleton is a grid involving of top, middle and lower skeleton grids (Figure 6).

10. Make Horizons

Make horizons method step was utilized in describing the vertical layering of the three-dimension grid in petrel 2015 software. This presented a real three-dimension methodology within the creating of Two-dimension surfaces that were gridded within the same method, taking the relationships between the surfaces under consideration. The next step in structural modeling is to insert the structural horizons into the pillar grid. It's a step for building the vertical layering of the three-dimension grid in petrel 2015.
Figure 4 Correlation section of Mishrif Formation in Garraf oil field.
The used grid increment in Mishrif Formation here is (50m*50m) with Conformable horizon rule that horizons are truncated by erosional, base and discontinuous.

The contraction of horizons generates independent geologic horizons from X, Y, and Z input file and it's used to generate extra horizons using relative distance to existing horizons (Schlumberger, 2009). Figure (7) shows horizons of Mishrif Formation in Garraf oil field in a 3D window.

11. Layering

The 3D grid might have as several main layers as number of horizons inserted into the set of pillars. This is shown as horizons within the models window of the petrel adventurer. The create zones and create subzones processes were the 2 last steps used in process the vertical resolution of the 3D grid. The create subzones allowed the definition of the final vertical resolution of the grid by setting the cell thickness or the quantity of desired cell layers. The future step was to start out the interpretation of the well logs to stipulate contacts between totally different facies identification of unconformities. The top and bottom of this specific unit were known inside the cell sections and well tops inserted to be displayed inside the well section in 3D. Layering is the final vertical subdivision of the framework (Fig. 8). The layering is a part of the zone, and cannot have an instantaneous filter just like the zones do; layering but, is outlined because the internal layering reflective the geologic deposition of a selected zone.

Zones is added to the model by introducing thickness information within the form of isochore maps, constant thickness, and percentages. Table (1) represents the layering of Mishrif units.
| Zones   | Avg. Thickness (m) | No. of Layer |
|---------|--------------------|--------------|
| Mishrif | 60.5               | 20           |
| M1      | 15.42              | 5            |
| M1.2    | 35.49              | 12           |
| M2      | 22.31              | 5            |
| L1      | 18.177             | 15           |
| L1.2    | 49.26              | 20           |
| L2      | 62.36              | 15           |
| L2.2    | 8.9                | 10           |
| L2.3    | 33.9               | 10           |
| L2.4    | 30.9               | 10           |

**Table 1** Layering of Mishrif units

**Figure 6** The skeletons of Mishrif Formation in Garraf oil field.

**Figure 7** The 3D representation shows main horizons of Mishrif Formation in Garraf oil field.
12. Scale up Well Logs

The Scale up process averages the values to the cells within the three-dimension grid that are penetrated by the wells. Every cell has one value per up scaled log. These cells are used as a place to begin for property modeling. There are several statistical ways used to scale up like (arithmetic, harmonic, and geometric methods). The shale volume, porosity, permeability and water saturation values within the current model are scaled up using the arithmetic and geometric technique whereas in the facies are scaled up by using most of the ways. Figure (9) represents scale up of PHIE and SW logs for well GA-3 in correlation window.

13. Quality Control

After upscaling well logs, it’s sensible to visualize if the necessary units are captured well or not. This step is related to the layering process during which thickness of layers ought to be set with regard to the intense flow units. If the layers are too thick, too much data could also be lost and as a result, thickness of layers must be adjusted. A comparison between well log information before and when scale up process may be visualized by using histograms. It incontestable that the upscale properties in MB1&MB21 are close to the original log information. Figure (10) represent the quality control histograms of unit MB1 for PHIE, Sw, K and rock kind, respectively.

14. Data analysis

Analysis of petrel data permits interactive analysis of distributions and trends and their relationships across all information varieties. Histogram, function, and stereonet windows—as well because the petrel information Analysis process are provided for analyzing upscaled well information and grid properties. The analysis of variogram includes selections for initial search-cone factor suggestions and fitting the variogram to the regression line, with the power to additionally build nested variograms. Careful analysis is kept for every property for direct use within the modeling processes. Sensitivity plots enable users to match the impact of every unsure variable in a risk-analysis context. Variogram for each unit and property presented in petrophysical modeling.

\[\text{Figure 8} \ \text{A-Quality histogram for NTG \ B- Quality histogram for SW \ C- Quality histogram for PHIE}\]
Figure 9 The Layering of Mishrif Formation in Garraf oil field

Figure 10 Scale up of PHIE and SW logs for well GA-3.
It is used to outline the behavior of variation during a property wherever it's considered as a key parameter in a lot of geostatistical algorithms. Simply, a variogram may be a plot of variability between semivariance (y-axis) versus separation distance (lag) during a specific direction \(^{[15]}\).

Two valuable steps area unit performed in analyzing variogram:
1. Determining the directions of the variogram, major, minor and vertical direction wherever every of them are perpendicular to the opposite.
2. Calculative the experimental variogram and so making the variogram model based on the experimental one for each direction \(^{[15]}\).

The 2D variogram map in figure (11), defines the direction of sample points, has 300 azimuthal angle in major direction. The minor search direction is 210 in azimuth (perpendicular on the major one). Figures (12 and 13) show the major and minor directions, respectively.

The necessary parameters that characterize the search core of major and minor direction are the azimuth, lag, range of lag (usually capable the no. of wells) and lag distance (approaches to the distance between wells).

The following parameters also are taken into consideration \(^{[15]}\):
1. Search Radius: that is that the most separation distance utilized in the search for sample pairs (no. of lags * lag distance).
2. Bandwidth: it's 0.5 the width of the search cone used as a cut-off to prevent the search area from turning into too wide at large separation distance.
3. Tolerance Angle: it's the width angle measured from the search cone main axis.

The following table (2) summarizes the most parameters for major and minor direction. The parameters in vertical direction are varied in every unit because of the distinction in thicknesses.

### Table 2 Search Cone Parameters

| Direction | Azimuth | Dip | Lags |
|-----------|---------|-----|------|
| Major     | 300     | 0   | 8    |
| Minor     | 210     | 0   | 8    |

| Direction | Lag Dist. | Radius | Band Width |
|-----------|-----------|--------|------------|
| Major     | 2612.4    | 20899  | 3424       |
| Minor     | 2511.2    | 19689  | 5600       |

**Figure 11** 2D Variogram Map for the direction of Mishrif Formation

**Figure 12** Major Direction Based on 2D Variogram Map

**Figure 13** Minor Direction Based on 2D Variogram Map
Variogram analysis is a very important part of geostatistical modeling. Indeed, variogram shows the mean sq. distinction between the 2 values as a function of their increment \[16\]. The value of variogram is calculated by

\[ y(h) = \frac{\sum_{i=1}^{n_i}(x_i - x_{i+h})}{2n_h} \ldots \ldots \ldots \ldots \ldots \ldots (1) \]

in the above equation, \( y(h) \) is named semivariogram and \( 2y(h) \) is named variogram, and \( n_h \) is the variety of pairs of points with the distance \( h \) from each other participating within the variogram. \( x_i \) is a grade in point \( i \) and \( x_{i+h} \) is grade in a point with distance \( h \) from the purpose \( i \). By hard variogram for various \( h \) values, the \( y(h) \) diagram in terms of \( h \) are often drawn, and the \( h \) value is called lag.

For many modeling, the variogram model begins from a nonzero value and will increase up to vary called effective vary (a), eventually reach to the constant value called sill. the effective vary is that the range in that the data spatial structure has relevancy, and outside the vary, the info impact is independent from one another \[17\] (Table 3).

| Zones       | Name  | sill   | Major Exponen | Minor Exponen | Variogr Method | Property |
|-------------|-------|--------|---------------|---------------|----------------|----------|
| Mishrif     | 0     | 0.9704 | 5628          | 5001          | Exponential    | Porosity |
| M           | 0     | 1.273  | 7342          | 6274          | Exponential    | Porosity |
| M1.2        | 0     | 1.085  | 9401          | 8899          | Exponential    | Porosity |
| M2          | 0     | 0.879  | 7887          | 6331          | Exponential    | Porosity |
| L1          | 0     | 0.99   | 3855          | 2907          | Exponential    | Porosity |
| L1.2        | 0     | 0.934  | 4619          | 3756          | Exponential    | Porosity |
| L2          | 0     | 0.894  | 4976          | 6293          | Exponential    | Porosity |
| L2.2        | 0     | 0.96   | 8750          | 7008          | Exponential    | Porosity |
| L2.3        | 0     | 0.997  | 7560          | 4472          | Exponential    | Porosity |
| L2.4        | 0     | 0.995  | 9056          | 7640          | Exponential    | Porosity |
| Mishrif     | 0     | 0.923  | 4256          | 3214          | Exponential    | SW       |
| M           | 0     | 0.958  | 9754          | 9558          | Exponential    | SW       |
| M1.2        | 0     | 0.996  | 6648          | 6038          | Exponential    | SW       |
| M2          | 0     | 0.975  | 9800          | 8324          | Exponential    | SW       |
| L1          | 0     | 0.992  | 4463          | 2801          | Exponential    | SW       |
| L1.2        | 0     | 0.907  | 8090          | 7866          | Exponential    | SW       |
| L2          | 0     | 0.914  | 6622          | 6413          | Exponential    | SW       |
| L2.2        | 0     | 0.949  | 8910          | 8258          | Exponential    | SW       |
| L2.3        | 0     | 0.997  | 3836          | 3158          | Exponential    | SW       |
| L2.4        | 0     | 0.991  | 3385          | 3244          | Exponential    | SW       |

15. Property Modeling

Petrophysical property modeling is the method of distribution petrophysical property values (porosity, water saturation, NTG, K, etc.) to every cell of the 3D grid. The objective of property modeling is to distribute properties between the accessible wells therefore it realistically preserves the reservoir heterogeneity and matches the well data; so, property
modeling is the method of filling the cells of the grid with distinct (Rock type) or continuous (Petrophysics) properties. The 3D property modeling relies on well logs information. This includes a calculation for resolution advanced mathematical equations involving one or many 3D property models; i.e. SW transforms based on porosity 3D model.

The aim of a geologic reservoir model is to produce a whole set of continuous reservoir parameters (i.e. porosity, and water saturation) for every cell of the grid. Many various techniques are used to generate these parameters. Petrel offers many algorithms for modeling the distribution of petrophysical properties in a reservoir model. Petrophysics model was designed using geo-statistical methods. The Petrophysics models include:

1. **Porosity Modeling**
   
   Porosity model was built based on the results of porosity logs (density, neutron and acoustic) that are corrected and interpreted within the interactive petrophysical 3.5 software system. Sequent Gaussian Simulation formula was used as a statistical procedure, which inserts with the quantity of the accessible information. Figures (13) to (22) show the porosity models of Mishrif reservoir unit of every unit is characterized by porosity distribution.

2. **Water Saturation Modeling**
   
   Water saturation model was built after the scale up of water saturation that exported from IP software system for every reservoir unit of the Mishrif Formation. A similar geostatistical methodology was used in the porosity models (Statistical Gaussian Simulation Algorithm) in line with the accessible information. Figures (23) to (32) show the water saturation models of Mishrif reservoir unit of every unit is characterized by water saturation distribution.

3. **NTG Model**
   
   A net pay is a main parameter in analysis of reservoir, because it describing the penetrated geologic sections that have enough reservoir quality and interstitial hydrocarbon volume to perform as important producing intervals. The net pay participates to the calculation of the original oil in place. The net pay demonstrates facilitates reservoir simulation, as a result of non-reservoir rock doesn’t get to be characterized for inclusion.

   Geoscientists have usually been annoyed by the absolute assignment of petrophysical log cutoffs to outline reservoir intervals capable of hosting producible hydrocarbon. Process of the net pay is essential to estimating reserves, this method deserves an exacting level of scrutiny.

   The net Pay is quantified through the use of petrophysical cut-offs that are applied to well logs. Cut-offs is range values of formation parameters that eliminate non-producing intervals. There's no usually accepted technique of characteristic cut-offs. historically, a porosity of zero.1md is mostly thought of minimum for production, the cutoff values of porosity is used to describe net reservoir, and the cutoff values of water saturation is used to describe the net Pay. The figures (33) to (42) show the final net pay model for Mishrif formation within the Garraf field.

16. **Water Oil Contact**

   Water oil contact is used in several reservoir studies to explain the height higher than that fluids apart from water can be found within the pores of a rock. In most things within the hydrocarbon industry the term is qualified as being an WOC. In a traditional hand-excavated water well, the extent at that the water stabilizes represents the
groundwater level, or the elevation within the rock wherever air starts to occupy the rock pores. Water oil contact analysis is extremely necessary stage in characterization of reservoir and calculation of hydrocarbon reserve, as a result of it’s required for boundary delineation between oil and water zone \cite{21}. For the Mishrif formation oil water contacts at the reservoir units.

17. OIIP Calculation

Estimation of Volume process can accurately estimate the varied volumes (bulk, pore and fluid) during a 3D grid figure (12). Throughout the process of modeling of the reservoir, many three-dimension grids could produce with completely different treatments of the faults and horizons. inside those grids, there is also many versions of a property model and contacts and there are also many representations of the fluids at intervals the model.

Table (4) shows the results of the volume of Initial oil in place (OIIP) in Mishrif formation of Garraf field. As noted from Table (4), the OIIP that obtained by using petrel 2015 software system is 1061 *106 M3 that is simply too near to that calculated mistreatment average properties that equal 1085 *106 M3.

18. Results and Discussion

The correlation of the wells in Garraf field shows that Mishrif zones extent everywhere the field except m2, L1 and L1.2 zones. m2 zone that represents cap rock of L1 and L1.2 extends over the field from GA-4 well within the southeast to the well GA-3 further as L1.2 reservoir zone. Whereas L1 reservoir zone extends from GA-4 well within the southeast to well GA-B8P within the middle of the field. Rom porosity and water saturation models for every unit of Mishrif Formation, the subsequent points can be shown:

- **Top Mishrif Unit**: The thickness of this unit is homogeneous. There are oil shows among this unit it's not thought of among reservoir zone, because it's not producible. It shows low PHIE Figure-16, low NTG Figure-36 and water saturation Figure-26 average values that reach 11% ,0.8 and 93% respectively.

- **M1.2 Reservoir Unit**: The unit thickens towards GA-5 and GA-4 wells. Generally, this unit shows good PHIE Figure-18, good NTG figure 38 and water saturation Figure-28 average values that may reach 80%, 1 and 43%, severally. However, the reservoir quality decreases within the area between GA-5 and GA-3 as indicated by the higher water saturation and lower PHIE values.

- **L1 Reservoir Unit**: The L1 reservoir unit pinches out towards GA-3 well. The direction of thinning is related to decreasing PHIE values and increasing water saturation. the average PHIE Figure-20 is 12%, NTG figure 40 is 0.9and water saturation Figure-30 is 39%.

- **L1.2 Reservoir Unit**: The L1.2 units is characterized by high reservoir properties. This unit thins towards GA-3 and GA-4 wells. In most wells, very little changes in PHIE Figure-21, NTG figure 41 and water saturation Figure-31 are determined. The average of PHIE is 26%, NTG is 1 and water saturation reaches 16%. Therefore, it represents the most effective reservoir unit in Garraf oil field.

- **L2 Reservoir Unit**: The L2 unit has low reservoir quality. The L2 unit thickens towards GA-5 that has lowest reservoir properties. The average of PHIE Figure-22 is 14%, NTG figure 42 is 1 and water saturation Figure-32 reaches 58%.

- **The L2.2 units**: The L2.2 unit has low reservoir quality with 15 % PHIE Figure-23 ,1 NTG figure 43 and 73% water saturation Figure-33. Lowest reservoir properties occur in GA-3 and GA-B8P.

- **L2.3 Reservoir Unit**: The L2.3 reservoir unit is the lower reservoir quality as indicated by
the values of PHIE and water saturation in GA-3 and GA-B8P wells. Other wells have higher reservoir quality. In general, the L2.3 unit has poor reservoir quality with 15% PHIE Figure-24, 1 NTG figure 44 and 88% water saturation Figure-34.

**L2.4 Reservoir Unit:** This unit is comparable to L2.3 reservoir unit. The GA-4 and GA-A1P wells have the lowest PHIE values. Other wells have higher values. However, L2.4 units is taken into account as a poor reservoir because of low average PHIE Figure-25 (13%) 0.95 NTH figure 45 and high water saturation Figure-35 (100%).

Figures (46 to 48) show the porosity, NTG and water saturation models for Mishrif Formation in Garraf oil field that are designed from NTG, porosity and water saturation values using sequential gaussian Simulation rule as a statistical method after scale up of NTG, porosity and water saturation. Finally, the cross sections in NW-SE and NW-SE directions for NTG, porosity and water saturation models were set so as to Illustrate the vertical and horizontal distribution of NTG, porosity and water saturation in every well beneath study. Figures 49, 50 and 51 show that the most effective location characterized by good reservoir properties is between well GA-4 and GA-3 particularly within the units m1.2 and L1.2 and they decrease step by step toward well GA-5 that become bad reservoir properties.
Table 4 Volumetric calculation for Mishrif formation in Garraf field

| Zones   | Bulk volume $[\times 10^6 \text{ m}^3]$ | Net volume $[\times 10^6 \text{ m}^3]$ | Pore volume $[\times 10^6 \text{ rm}^3]$ | HCPV oil $[\times 10^6 \text{ rm}^3]$ | STOIIP (in oil) $[\times 10^6 \text{ sm}^3]$ | Type of fluid |
|---------|----------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|-------------------------------------------|---------------|
| Mishrif | 16703                                  | 6816                                   | 868                                    | 519                                    | 371                                       | Oil           |
| M1      | 549                                    | 260                                    | 33                                     | 6                                      | 4                                         | Oil           |
| M1.2    | 4347                                   | 1944                                   | 411                                    | 222                                    | 158                                       | Oil           |
| M2      | 363                                    | 64                                     | 9                                      | 3                                      | 2                                         | Oil           |
| L1      | 1136                                   | 889                                    | 135                                    | 82                                     | 59                                        | Oil           |
| L1.2    | 2151                                   | 2151                                   | 581                                    | 494                                    | 353                                       | Oil           |
| L2      | 1233                                   | 1233                                   | 229                                    | 137                                    | 98                                        | Oil           |
| L2.2    | 333                                    | 329                                    | 63                                     | 23                                     | 17                                        | Oil           |
| L2.3    | 0                                      | 0                                      | 0                                      | 0                                      | 0                                         | Water         |
| L2.4    | 0                                      | 0                                      | 0                                      | 0                                      | 0                                         | Water         |
| TOTAL   | 26816                                  | 13687                                  | 2329                                   | 1485                                   | 1061                                      |               |

Figure 14 Map of original oil in place for Mishrif formation in Garraf field.
Figure 15 Porosity model of top Mishrif Formation unit in Garraf oil field.

Figure 16 Porosity model of top M1 Formation unit in Garraf oil field.

Figure 17 Porosity model of top M1.2 Formation unit in Garraf oil field.

Figure 18 Porosity model of top M2 Formation unit in Garraf oil field.

Figure 19 Porosity model of top L1 Formation unit in Garraf oil field.

Figure 20 Porosity model of top L1.2 Formation unit in Garraf oil field.

Figure 21 Porosity model of top L2 Formation unit in Garraf oil field.

Figure 22 Porosity model of top L2.2 Formation unit in Garraf oil field.
Figure 23 Porosity model of top L2.3 Formation unit in Garraf oil field

Figure 24 Porosity model of top L2.4 Formation unit in Garraf oil field

Figure 25 Water saturation model of top Mishrif Formation unit in Garraf oil field

Figure 26 Water saturation model of top M1 Formation unit in Garraf oil field

Figure 27 Water saturation model of top M1.2 Formation unit in Garraf oil field

Figure 28 Water saturation model of top M2 Formation unit in Garraf oil field

Figure 29 Water saturation model of top L1 Formation unit in Garraf oil field

Figure 30 Water saturation model of top L1.2 Formation unit in Garraf oil field
Figure 31: Water saturation model of top L2 Formation unit in Garraf oil field

Figure 32: Water saturation model of top L2.2 Formation unit in Garraf oil field

Figure 33: Water saturation model of top L2.3 Formation unit in Garraf oil field

Figure 34: Water saturation model of top L2.4 Formation unit in Garraf oil field

Figure 35: NTG model of top Mishrif Formation unit in Garraf oil field

Figure 36: NTG model of top M1 Formation unit in Garraf oil field

Figure 37: NTG model of top M1,2 Formation unit in Garraf oil field

Figure 38: NTG model of top M2 Formation unit in Garraf oil field
Figure 39 NTG model of top L1 Formation unit in Garraf oil field

Figure 40 NTG model of top L1.2 Formation unit in Garraf oil field

Figure 41 NTG model of top L2 Formation unit in Garraf oil field

Figure 42 NTG model of top L2.2 Formation unit in Garraf oil field

Figure 43 NTG model of top L2.3 Formation unit in Garraf oil field

Figure 44 NTG model of top L2.4 Formation unit in Garraf oil field
Figure 45 Final porosity model for Mishrif Formation in Garraf oil field.

Figure 46 Final water saturation model for Mishrif Formation in Garraf oil field.

Figure 47 Final NTG model for Mishrif Formation in Garraf oil field.
Figure 48 Cross section in direction NW-SE distribution of SW for Mishrif Formation in Garraf oil field.

Figure 49 Cross section in direction NW-SE distribution of PHI for Mishrif Formation in Garraf oil field.
19. Conclusions

1. The structural model of Garraf Field created by using petrel software system showed that Garraf oil field represents a domal structure as indicated by the structural maps at prime of reservoir units. The structural closure is shifted from GA-3 well to GA-A1P well.

2. Horizons for Mishrif Formation are divided into three essential elements, further as 10 zones. Layers were designed for every zone based on petrophysical properties.

3. Mishrif zones extent complete the field except m2, L1 and L1.2 zones. m2 zone that represent cap rock of L1 and L1.2 extends over the field from GA-4 well within the southeast to well GA-3 further as L1.2 reservoir zone. Whereas the L1 reservoir zone extends from GA-4 well within the southeast to well GA-B8P within the middle of the field.

4. Model of petrophysical properties (volume shale, porosity permeability and water saturation) for Mishrif Formation in Garraf oil field was designed by using sequential Gaussian Simulation algorithmic rule as a statistical method after scale up of well logs. The model includes prime Mishrif, M1, M1.2, M2, L1, L1.2, L2, L2.2, L2.3 and L2.4. every unit is characterized by totally different reservoir properties. The unit’s money supply.2, L1 and L1.2 are thought-about as high quality reservoir units because of the high PHIE and low water saturation values. Units L2, L2.2, L2.3 and L2.4 are considered as poor reservoirs due to low PHIE and high water saturation, and non-reservoir units include prime Mishrif, m1 and m2 so, they represent cap units.

5. Depend on cross sections for porosity and water saturation models that built in NW-SE and WNW-ESE directions show that the most effective location characterized by good reservoir properties is between well GA-4 and GA-3 and these properties decrease step by step toward well GA-5.

6. The original oil in place (OIIP) within the Mishrif formation of Garraf field is (1061) million cubic meters.
References
1. Tarek Ahmed, 2005. "Working Guide to reservoir rock properties and fluid flow". Gulf professional published, USA.
2. Konica Minolta, 2012 “3D Scanning Advancements in Medical Science”.
3. Li Shaohua, 2009 “Remaining Resource Reservoir Group”, Yangtze University, Jingzhou, China.
4. Turner A. K. and Gable C. W., 2008. “A review of Geological Modeling. Colorado School of Mines “, USA, Los Alamos National Laboratory, Los.
5. Schlumberger, 2013.Petrel Geology and Modeling, Petrel Introduction Course, 559pp.
6. Mustafa Baghdad, 2015. “Reservoir Characterization and 3D Petrophysical Modeling of Mishrif Formation in Garraf Oil Field”, pp.2.
7. Modified after Al-Naqib Sargelu,1967. “Reservoir Characterization and Stratigraphic Relationships of Mishrif Formation in Gharraf Oil Field”, “PP.32.
8. Ashour, H., 2016” Reservoir Characterization and 3D petrophysical Modeling for Tertiary Reservoir in Khabaz oil field “M.Sc. thesis, Petroleum engineering, University of Baghdad.
9. Schlumberger Petrel online help,2008, “Petrel 2008 version “.
10. Schlumberger, 2009. “Petrel online help, Petrel Introduction Course Schlumberger “, pp. 560.
11. Schlumberger, 2010(a). “Petrel introduction course. Schlumberger “, 13- 493p.
12. Schlumberger, 2007. “Petrel Structural modeling course Schlumberger “, 105-123p.
13. Ataei, M., 2013. “Log Facies Evaluation and Property Modeling of a Turbidite Reservoir “, the Gulf of Mexico. A thesis submitted to Norwegian University of Science and Technology, Department of Geology and Mineral Resources-Norway, pp. 103.
14. Hector H. Perez, Akhil Datta –Gupta, “The Role of Electrofacies, Lithofacies, and Hydraulic Flow Units in Permeability Predictions from Well Logs: A Comparative Analysis Using Classification Trees”, Texas A&M U. and S. Mishra, SPE, 2003
15. Schlumberger “Petrel technical Manual”, 2013.
16. N. Cressie and D. M. Hawkins, “Robust estimation of the variogram,” Journal of the International Association for Mathematical Geology, vol. 12, no. 2, pp. 115–125, 1980.
17. R. Corstanje, S. Grunwald, and R. M. Lark, “Inferences from fluctuations in the local variogram about the assumption of stationarity in the variance,” Geoderma, vol. 143, no. 1-2, pp.123–132, 2008.
18. Schlumberger, 2010 (b). “Reservoir Engineering course “. Schlumberger, 137- 177 p
19. Peter Phillips, Janice Liwanag, 2006 Improving Net-to-Gross Reservoir Estimation”, Dew Journal, India.
20. Paul F. Worthington, 2009 “Net pay: what is it? What does it do? How do we quantify it? How do we use it?”, Gaffney, Cline & associates, SPE.
21. Jarot Setyowiyoto, Ariffin Samsuri, 2006 “Oil Water Contact and Hydrocarbon Saturation estimation based on Well logging data”, University GadjahMada Indonesia and University Technology Malaysia, Regional Postgraduate conference on Engineering and Science, Johore.