Iraqi Journal of Chemical and Petroleum Engineering
Vol.17 No.3 (September 2016) 1- 10
ISSN: 1997-4884

University of Baghdad
College of Engineering

Geological Model of Khasib Reservoir- Central Area/East Baghdad Field

Mohammed Saleh Al-Jawad[*] and Khalid Ahmed Kareem[**]
[*]Petroleum Technology Engineering Department, College of Engineering, University of Technology
[**]Petroleum Engineering Department, College of Engineering, University of Baghdad

Abstract

The Geological modeling has been constructed by using Petrel E&P software to incorporate data, for improved Three-dimensional models of porosity model, water saturation, permeability estimated from core data, well log interpretation, and fault analysis modeling.

Three-dimensional geological models attributed with physical properties constructed from primary geological data. The reservoir contains a huge hydrocarbon accumulation, a unique geological model characterization with faults, high heterogeneity, and a very complex field in nature.

The results of this study show that the Three-dimensional geological model of Khasib reservoir, to build the reservoir model starting with evaluation of reservoir to interpretation of well log by using IP software for 14 wells, defining and divided the layers based on the GR Log and Resistivity log to nine layers and then maintained the fault model for a divided central area to four regions. Compared porosity log with porosity core to estimate correction porosity and enter this value to predict the permeability value for each layer by using FZI, and RQI method. The model Containing faults, horizons, zones, and layers depending on this data to make gridding by using pillar gridding.

This paper presents a geological modeling and an uncertainty analysis for stock-tank original oil in place. The distribution of the faults is also discussed.

Key words: Porosity, Permeability, Water Saturation.

Introduction

A great portion of the world’s oil reserves is contained in carbonate reservoirs, which play an important role in oil exploration and makes a large contribution toward oil production worldwide. However, characterization of carbonate reservoir is very complex as compared to conventional reservoirs.

East Baghdad field [1] was discovered by the Iraq National Oil Company (INOC) in 1974 with extension of Al-Ssaouira Area (South East) to AL-Nibayia (North West), in 1975 was drilled first well, East Baghdad -1 (EB-1) approximately 20 km in the East of Baghdad city, which reached to the Adaiya formation at depth 4842 m of the Early Jurassic. Since then, up to Eighty wells were drilled reach 38 wells to Zuiber Formation and 41 wells to Kifel Formation include 19 wells are directional, have been drilled from 1980 to 1989 as exploration and development wells in the Al-Rashdiya area, about two third of which are located in AL-Rashdiya and Urban Areas. The geological model is often performed making by using of the static data, i.e. Seismic interpretation, logs interpretation and core analysis data, dynamic data is used to consistency of the model and its ability to reproduce the observed reservoir performance.

A Petrophysical model was created from the core analysis and logs interpretation in one dimension. The geological model needed to distribute the information data in 3D.

Fault Model

The proposed fault pattern includes the main faulting parallel to the NW-SE axis of the structure, and secondary system associated to the main one including NNW-SSE and E-W trending faults [2].

The full-field geological model was split into four regional models, each bounded by sealing faults, as shown in Figure 1 and the secondary faults are not sealed. The central area is divided into four separate equilibrium region, which have unique fluid contacts identified by the equilibrium region number EQLNUM. The Khasib Fault model analysis depends on [3].

Petrophysical Modeling

The object of the petrophysical variable need to estimation a reservoir, include (porosity (Ø), hydrocarbon saturation, thickness (h), and permeability (k)), an addition to the parameter include (formation temperature, reservoir pressure, and lithology of formation) applied in the evaluation wells, completion wells, and production wells [4].

This section discussion of the methodology developed for petrophysical model and its application to Khasib formation. The systematic approach presented in the following sections evaluates the combination of (porosity, permeability and irreducible water saturation) at each depth.

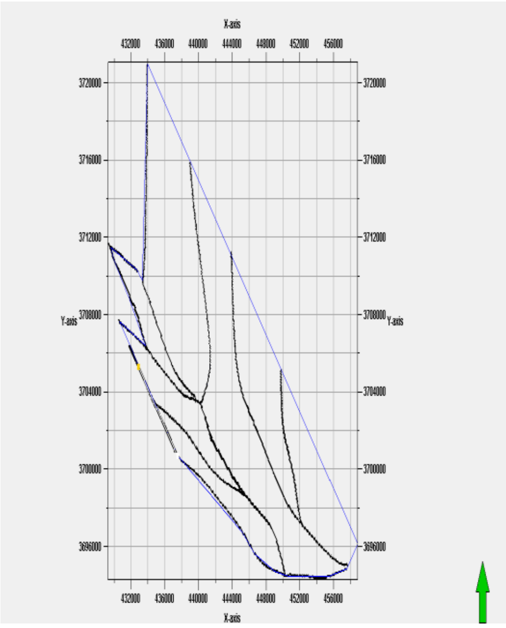

Fig. 1: 2D- Boundary and Fault Model

Porosity Model

3D distribution of porosity was exported to the simulation from geological model.

Porosity data for Khasib reservoir was obtained from (502) core samples analysis for seven wells are (EB-11, EB-14, EB-19, EB-25, EB-29, EB-35, and EB-74) and the well logs interpretation of most of them are available for thirteen wells. The well EB-35 is located on the northeastern flank of the anticline, and the other wells are located on the axis. The effective porosity data from core analysis and log interpretation was matched at the same interval, example wells EB-11, as shown in Figure 3. The Effective Porosity log ($Ø_e$) from IP Program was scaled up by using arithmetic averaging and ‘as point’ options in Petrel, as shown in Figure 2 for K2.

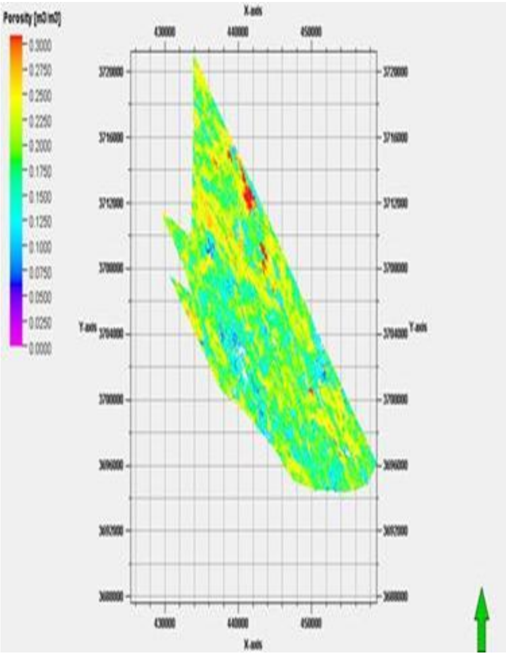

Fig. 2: 2D-Porosity model for K2 unit

Permeability Model

The 3D permeability in 3D x-direction (k_x), y-direction (k_y) and z-direction (k_z) were exported to the simulation from static model. Permeability in y-direction (ky) was set equal to the x-direction (kx).

The Hydraulic Flow Unit (HU) can be used excessively as soon as a method in the rock typing and permeability calculation. Hydraulic Flow Unit (HU) is relataed to flow zone indicator (FZI) and rock quality index (RQI). This method is effective in predicting permeability in the uncored section.

In this study, the HU for hydrocarbon can calculate from the core analysis data .This method can be explained by [5], calculated the Flow Zone Indicator (FZI) and Reservoir Quality Index (RQI). The predicted permeability by the modified method was used in the geological model. Equations 1, 2, 3 and 4 were used to calculate RQI, PHIZ (Øz) and FZI.

$$\mathrm{RQI} = 0.0314\sqrt{\frac{\mathrm{K\ core}}{\emptyset\ \mathrm{core}}} \quad \ldots(1)$$

$$\emptyset z = \frac{\emptyset \mathrm{core}}{1-\emptyset \mathrm{core}} \quad \ldots(2)$$

$$FZI = \frac{RQI}{\emptyset z} = \frac{0.0314\sqrt{\frac{\mathrm{k\ core}}{\emptyset\ \mathrm{core}}}}{\left(\frac{\emptyset \mathrm{core}}{1-\emptyset \mathrm{core}}\right)} \quad \ldots(3)$$

$$k\ pridicte = 1014\ FZI^2\ \frac{\emptyset e^3}{(1-\emptyset e)^2} \ldots(4)$$

All available cores from 7 wells (EB-11, EB-14, EB-19, EB-25, EB-29, EB-35, and EB-74) were used to be a database for HU classification. Depending on the HU definitions obtained from the log-log plot for the RQI Vs. (ØZ), as shown in Figure 4, this figure shows the HU approach which is applied to East Baghdad Oil Fields / Central Area where three distinct HU are evident with different number of HU and defined by different FZI.The unit slope lines were drag related to the FZI that will be intercepted with the $\emptyset_Z$ =1. The core Samples that have a plot of the log permeability vs. porosity (Ø), as shown in Figure 5.

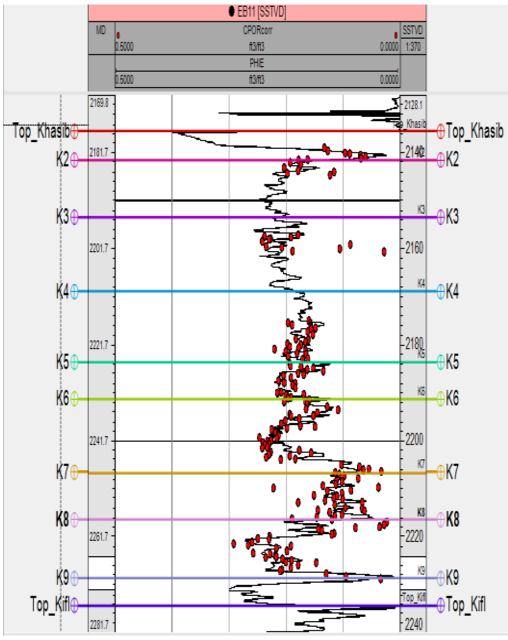

Fig. 3: Log Porosity vs. Core Porosity for well EB-11

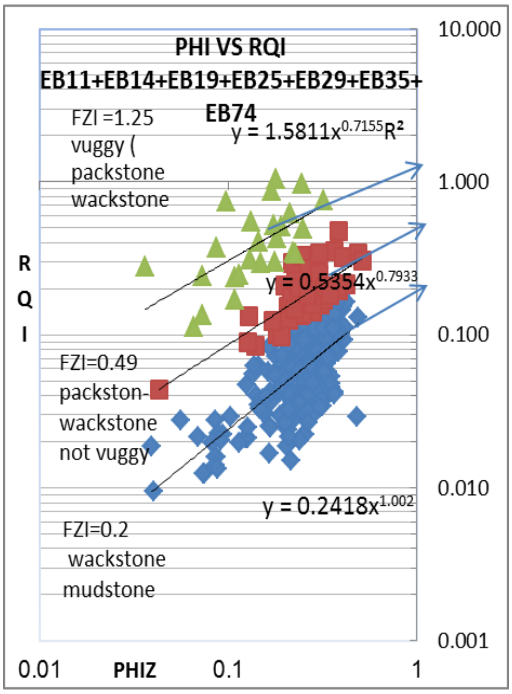

Fig. 4: RQI Vs. PHIZ ($\emptyset_Z$) plot for different HU'S

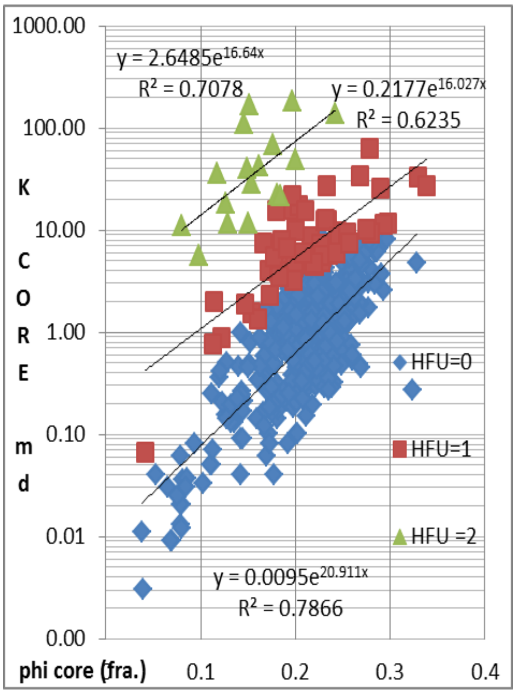

Fig. 5: Porosity vs. Permeability Relationships for different HU'S

The relation between porosity and permeability for each rock type was illustrated using the power law model, correction coefficient was obtained for all rock types, and then permeability can be estimated accurately from the equation of curve for each rock type, permeability distribution as shown in Figure 6.

According to the Core description in **7** wells Khasib Formation has been subdivided into three facies are Vuggy (Packstone – Wackstone), not Vuggy (Packstone –Wackstone), and Wackstone – Mudstone [6].

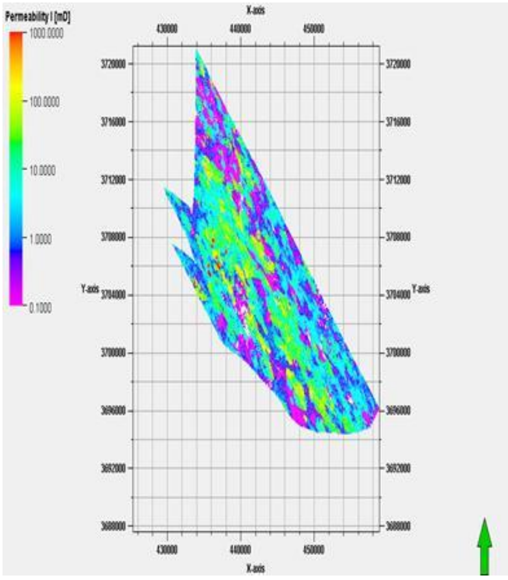

Fig. 6: 2D-permeability model for K2 unit

Formation Evaluation

The interpretation of well logs was done by using Interactive Petrophysics Program (IP) (an interactive program to carry out interpretations and log corrections for borehole environment and invasion effects). The interpretation of wells logs sets were used as input data to evaluate the carbonate rocks (Khasib Formation) for the wells under study.

Water Saturation and Hydrocarbon Determination

The target of using logging wells is to estimate oil or gas that found in the reservoir units, for example resistivity logs that used to estimate the true resistivity of the reservoir with using the bottom hole parameter, fluid mud, lithology of formation, and the invasion of the formation [7].

For clean formation the Archie saturation equation can be written:

$$Sw = \left[\frac{a\,Rw}{\emptyset^m\,Rt}\right]^{\frac{1}{n}} \qquad \ldots(5)$$

Taking m=n=2, a=1, and Rw=0.033 ohm.m at 150 °F which is admissible approximation, emphasizes the relation between the porosity (Ø) and the formation Resistivity (Rt). These parameters have effective on calculation of water saturation and effect on the fluid contact and reserves calculation [8].

Equation 5 can be used to determine the water saturation in the main zone. Instead Rt put Rxo with the micro resistivity log to give the value of the Sxo in flash zone, with mud filtrate Rmf, express in equation form:

$$Sxo = \left[\frac{a\,Rmf}{\emptyset^m\,Rxo}\right]^{\frac{1}{n}} \qquad \ldots(6)$$

The residual oil saturation (Sor) and movable hydrocarbon (Shr) are calculated from the following equations [9]

$$Sor = [\emptyset eff\,(1 - Sxo)] \qquad \ldots(7)$$

$$Shr = [\emptyset eff\,(Sxo - Sw)] \qquad \ldots(8)$$

Formation Analysis by Well Log Interpretation

1. Porosity Analysis

The effective porosity Formation with better selective for Neutron-Density logs, to determine the Formation properties. Porosity was calculated by Neutron-Density logs, applying variable density with grain density =2.71gm/cc and Maximum grain density =2.95 gm/cc for the wells [7]. Porosity analysis, which is divided into effective porosity (φe), water filled porosity in the invaded zone (φe.Sxo), and water filled porosity in the uninvited zone (φe.Sw). The area between (φe.Sxo) and (φe.Sw) represents the Movable hydrocarbon, but the area between (φe) and (φe.Sw) represents the Residual oil saturation, as shown in Figure 5.

2. Shale Volume Analysis

The percentage of shale or the volume of clay (Vcl) was mainly determined using the gamma ray data with the linear method as follows:

$$Vsh = \frac{(GR\,log - GRclean)}{(GRsh - GRclean)} \qquad \ldots(9)$$

Volumetric Calculation

The stock tank Oil intial in Place (STOIIP) is calculated by using a volumetric method applying formation volume factor (Bo) obtained from PVT test results. Once the petrophysical properties are simulated, the volumetric will have been computed**.** The calculated STOIIP equals to 9,540 MMSTB without cut-off (Φe, Sw, Vsh) and 6,617.8 MMSTB with cut-off according to the equation:

$$STOIIP = \frac{7758\,Ah\,\emptyset\,(1 - Sw)}{Boi} \qquad \ldots(10)$$

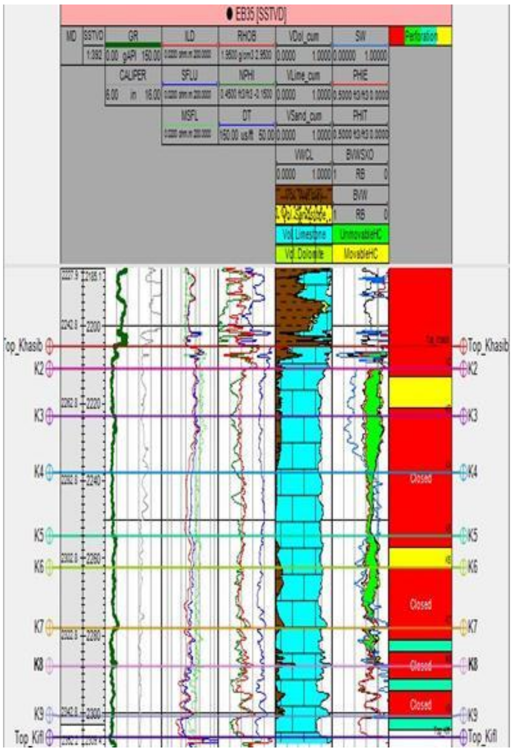

Fig. 7: Fluid and Formation Analyses for well EB-35 (Region/1)

Conclusions

- Uncertainty in calculating STOIIP compared with previous studies.
- The oil water contact can divide into four fluids depend on four regions at well EB-35, EB-43, EB-47, EB-33 in each region.

Nomenclatures

Symbols	Description	Unit
Φe	Effective porosity	fraction
S_{wi}	irreducible water saturation	fraction
ρ_{ma}	Matrix density	gm/cc
ρ_b	Formation bulk density	gm/cc
ρ_f	Fluid density	gm/cc
a, n,m	Archie's parameters	dimensionless
Sw	Water Saturation	fraction
Bo	Oil Formation Volume Factor	rbbl/stb
Boi	Intial Oil Formation volume factor	rbbl/stb
Sor	residual oil saturation	fraction
Shr	Movable Hydrocarbon	fraction
h	thickness	m
A	Aera	m^2

Abbreviations

IP	Interactive Petrophysics Software
Sp	Self potential log
Rw	Resistivity of water Formation
Rmf	Resistivity of mud
Rt	Resistivity of uninvited zone
Rxo	Resistivity of invaded zone
Tf	Formation Temperature
GR	Gamma ray log
RHOB	Density log
NPHI	Neutron log
ρb	Bulk density recorder by log
ILD	Deep Induction Log
SFLU	Spherically focused log
MSFL	Microspherically focused log
DT	Digital Sonic
K	SP Coefficient
STOIIP	Stock Tank Oil Initial In Place
PVT	Pressure Volume Temperature
HU	Hydraulic Flow Unit
RQI	Rock Quality Index
FZI	Flow Zone Indicator

References

1. Japex study, 2006, "The Technical Evaluation Report for the G&G study of the East Baghdad Field, central Iraq".
2. Total Study, December 1981 "Geological Study of East Baghdad Field - Area 3 ".
3. Japex study, September 2008, "Final technical report of East Baghdad Field full-scale development study"
4. Schlumberger; 1989: "Log Interpretation Principles/ Application".
5. Amaefule, J.O., Altunbay, M., Tiab, J., Kersey, D.G., Keelan, D.K., 1993, Enhanced Reservoir Description: Using Core and Log Data to Identify Hydraulic (Flow) Units and Predict Permeability in Uncored Intervals / Wells: SPE Annual Technical Conference and Exhibition, SPE 26436.

6. Japex study, September 2008, "Final technical report of East Baghdad Field full-scale development study".
7. Schlumberger Educational Services, Houston, TX. John H. Doveton – Kansas Geological Survy 1999 "Basic of oil and gas analysis".
8. Total Study, December 1981, East Baghdad Field, Area 3 "Geological Study".
9. Asquith, G.B., and Gibson, C.,1982, "Basic well log analysis for Geologists", 2nd ed., AAPG, Tulsa, Oklahoma, 216.

Appendixes

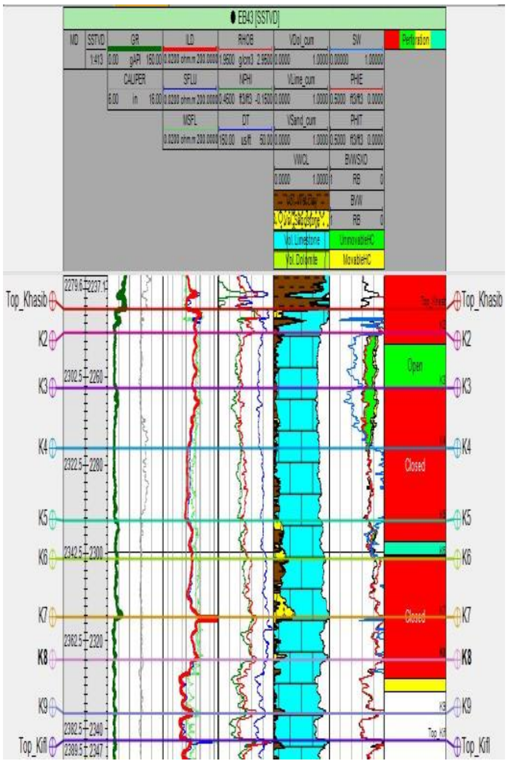

Fig. 8: Fluid and Formation Analyses for well EB-43 (Region/2)

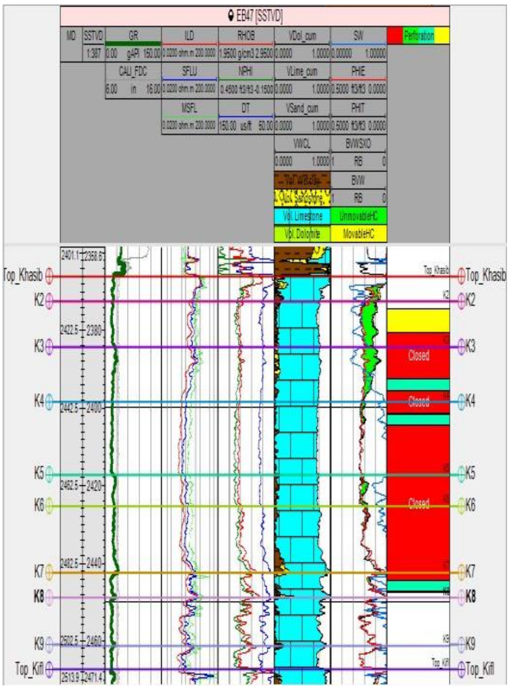

Fig. 9: Fluid and Formation Analyses for well EB-47 (Region/3)

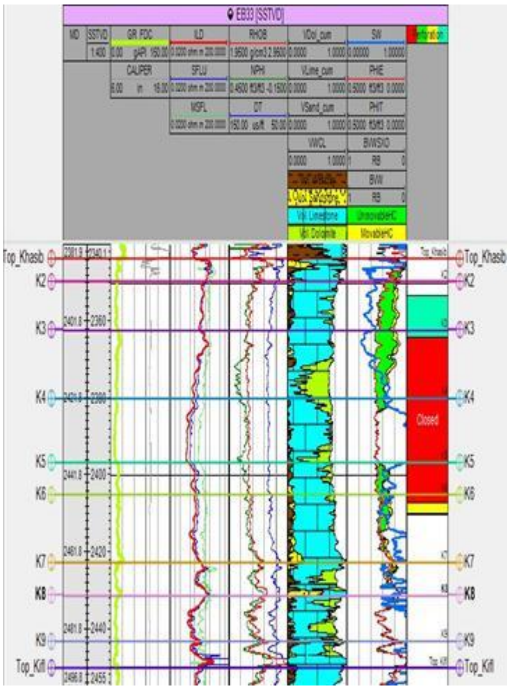

Fig. 10: Fluid and Formation Analyses for well EB-33 (Region/4)

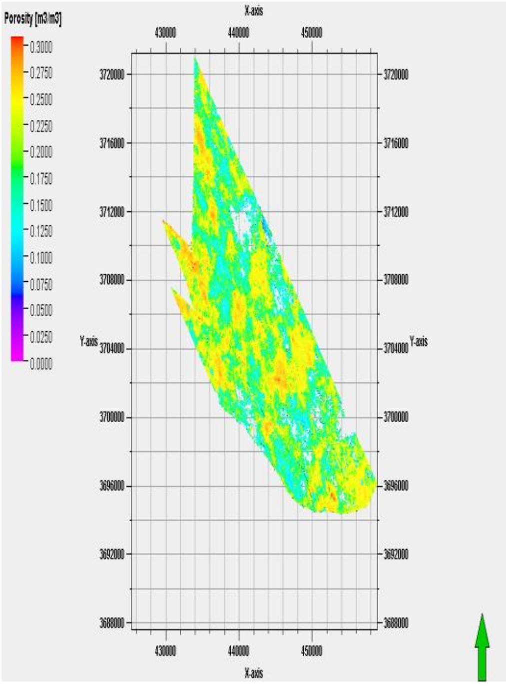

Fig. 11: 2D-Porosity model for K3 unit

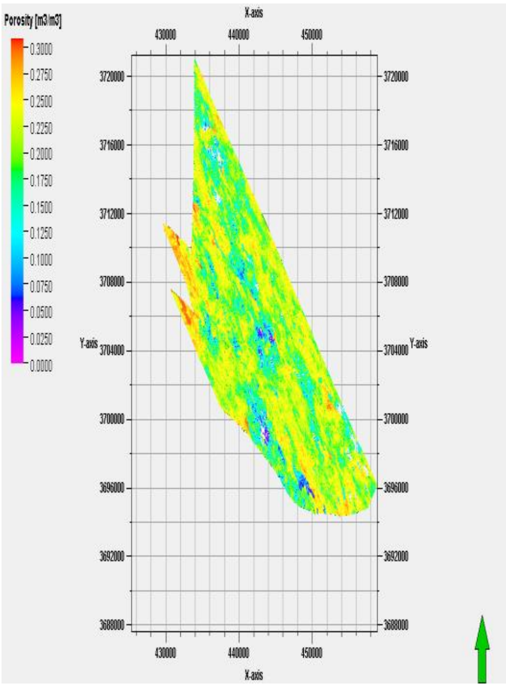

Fig. 12: 2D-Porosity model for K4 unit

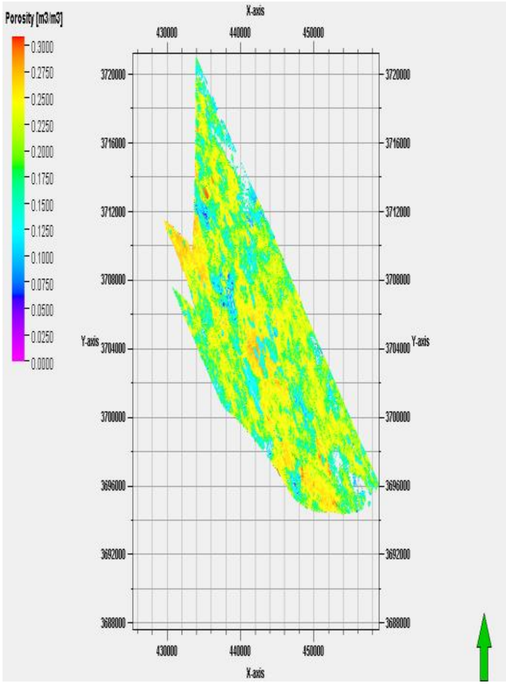

Fig. 13: 2D-Porosity model for K5 unit

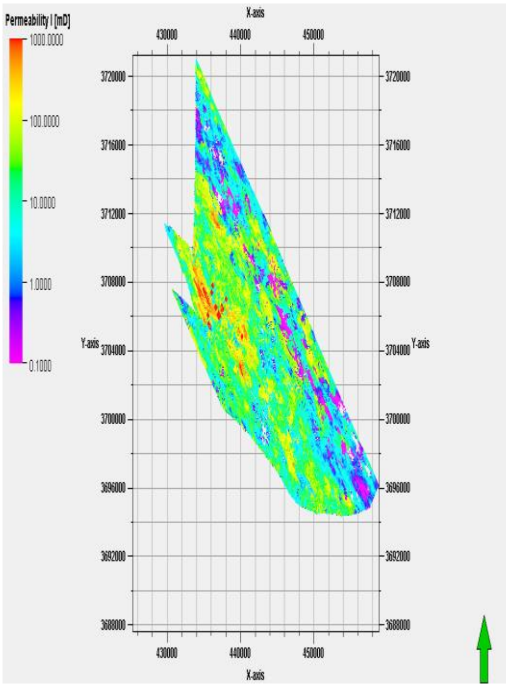

Fig. 14: 2D-permeability model for K3 unit

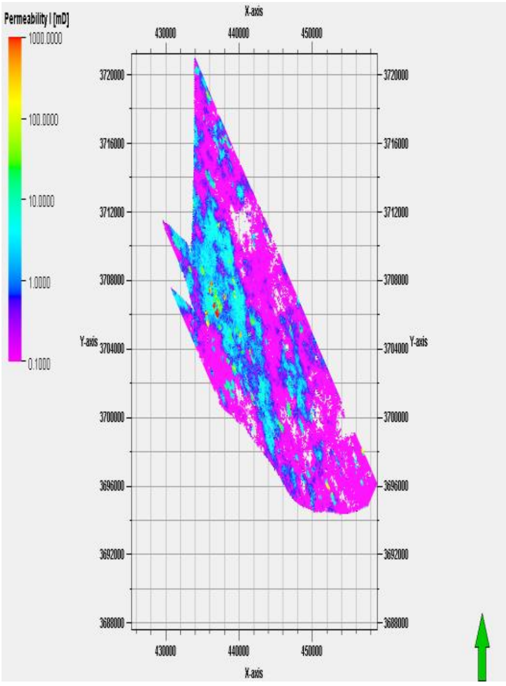

Fig. 15: 2D-permeability model for K4 unit

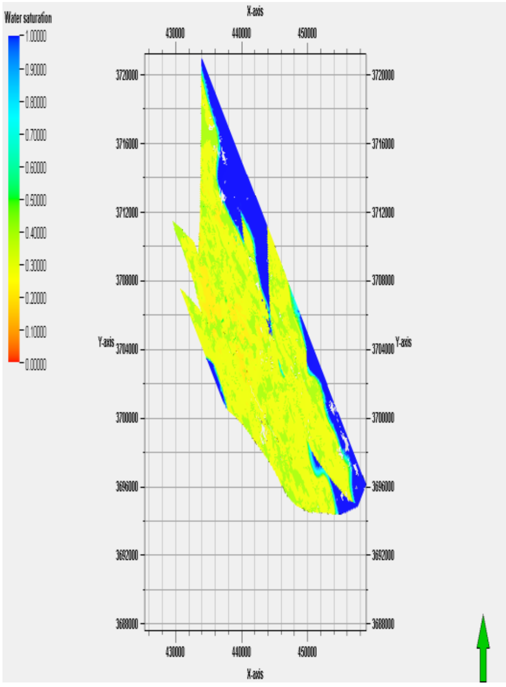

Fig. 17: 2D-Water Saturation Model for K2 unit

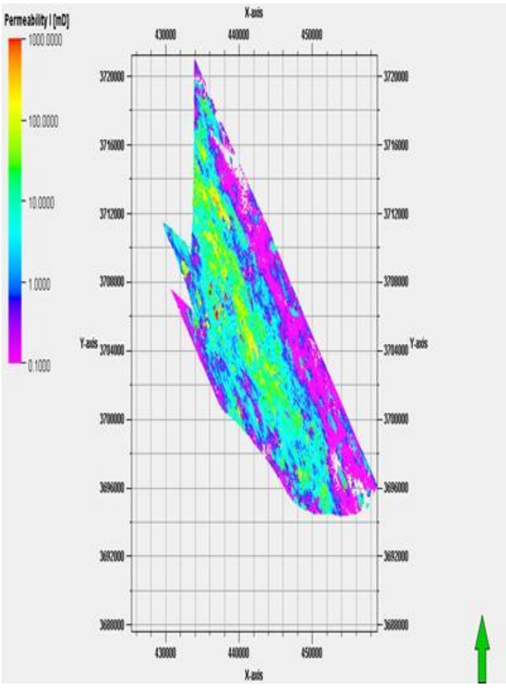

Fig. 16: 2D-permeability model for K5 unit

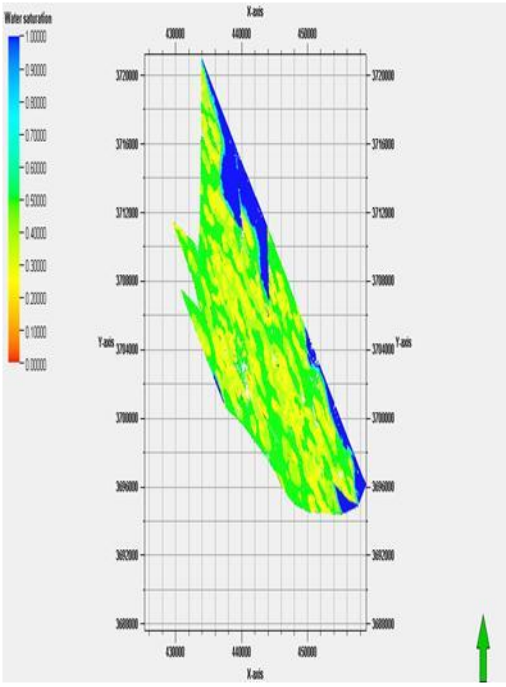

Fig. 18: 2D-Water Saturation Model for K3 unit

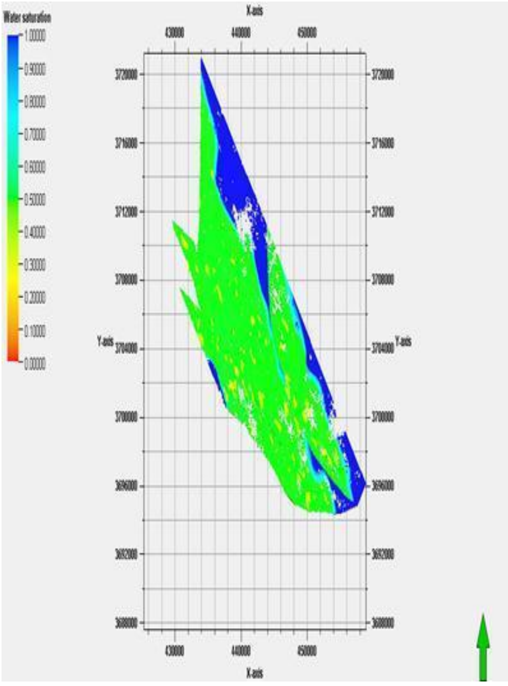

Fig. 19: 2D-Water Saturation Model for K4 unit

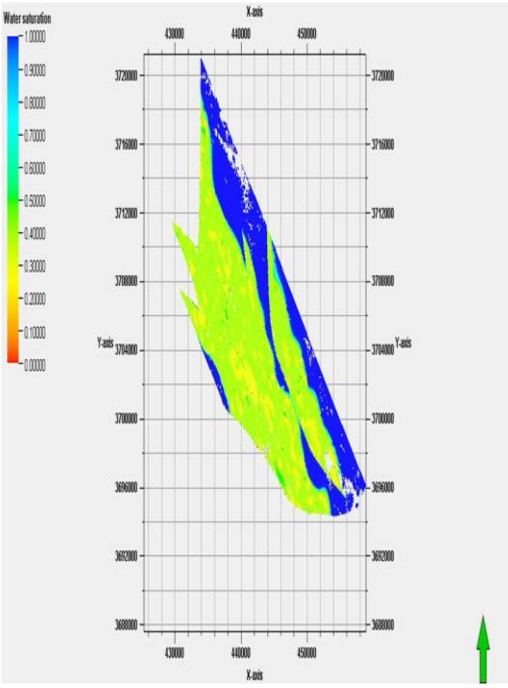

Fig. 20: 2D-Water Saturation Model for K5 unit