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Evaluation the Primary Drive Mechanisms and PVT Analysis by using Material Balance Software (MBAL Software) for Intisar "D" Reef Reservoir

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ABSTRACT

Identifying the driving mechanism and PVT analysis is important for optimizing reservoir development plans through primary, secondary, or tertiary recovery methods. Also, determining the size of an aquifer (based on its response to pressure support) provides a means of calibrating known physics against production data, which once calibrated can be used for prediction. In this paper, the types of natural drivers of the reservoir were estimated and compared using a program called MBAL after matching production history data with model results. The purpose of this paper is to evaluate the basic driving mechanisms and PVT analysis using MBAL software for Intisar D field. The final project results can be seen matching the real data of the reservoir with the program results using MBAL software. The simulation results show that the reservoir pressure history curve matches the stimulation curve, and this gives a good indication of the input data fed into the model. The driving mechanism for all these tanks comes from three natural forces, namely fluid expansion, compression, and water flow. It started with the expansion of the fluid from 0 to 0.60, with the compressibility from 0.60 to 0.89, and with the flow of water from 0.89 to 1 is the flow of water.

تقييم آليات الدفع الطبيعي وتحليل PVT باستخدام برنامج MBAL Software لخزان الشعاب المرجانية لحقل الانتصار"D".

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الكلمات المفتاحية:
آليات الدفع الطبيعي
تحليل PVT
برنامج MBAL
حقل انتصار د.

الملخص

إن تحديد آلية الدفع الطبيعي وتحليل PVT أمر مهم لتحسين خطط تطوير الخزان من خلال طرق الاسترداد الأولية أو الثانوية أو الثلاثية. كما أن تحديد حجم طبقة المياه الجوفية (بناءً على استجابتها لدعم الضغط) يوفر وسيلة لمعايرة الفيزياء المعروفة مقابل بيانات الإنتاج، والتي يمكن استخدامها للتنبؤ بمجرد معايرتها. في هذه الورقة، تم تقدير أنواع المحركات الطبيعية للخزان ومقارنتها باستخدام برنامج يسمى MBAL بعد مطابقة بيانات تاريخ الإنتاج مع نتائج النموذج. الغرض من هذه الورقة هو تقييم آلية الدفع الطبيعي الأساسية وتحليل PVT باستخدام برنامج MBAL لحقل D Intisar. يمكن رؤية نتائج الورقة وهي تطابق البيانات الحقيقية للخزان مع نتائج البرنامج باستخدام برنامج MBAL. تُظهر نتائج المحاكاة أن منحنى تاريخ ضغط الخزان يطابق منحنى التحفيز، وهذا يعطي مؤشرًا جيدًا لبيانات الإدخال المُدخلة في النموذج. تأتي آلية القيادة لجميع هذه الخزانات من ثلاث قوى طبيعية، وهي تمدد السوائل والانضغاطية وتدفق المياه. بدأ الأمر بتمدد السائل من 0 إلى 0.60، مع قابلية الانضغاطية من 0.60 إلى 0.89، ومع تدفق الماء من 0.89 إلى 1.

1. Introduction

The initial phase of hydrocarbon production involves utilizing natural reservoir energy—such as gas drive, water drive, or gravity drainage—

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to push hydrocarbons from the reservoir into the wellbore and up to the surface. At the beginning, the pressure in the reservoir is significantly greater than the pressure at the bottom of the wellbore. This considerable pressure difference propels hydrocarbons towards the well and to the surface. However, as production continues, the reservoir pressure decreases, leading to a reduction in the differential pressure as well. To enhance hydrocarbon production by lowering the bottomhole pressure or increasing the differential pressure, an artificial lift system must be employed, such as a rod pump, an electrical submersible pump, or a gas-lift installation. Production through artificial lift is categorized as primary recovery. The primary recovery phase is limited either when reservoir pressure decreases to a point where production rates become unviable or when the levels of gas or water in the produced stream become excessively high. During this phase, only a small fraction of the initial hydrocarbons in place is extracted, usually about 10% in oil reservoirs. Primary recovery is also referred to as primary production.

Problem Statement: Uncertainties in material balance calculations, including the initial hydrocarbon estimate, are typically influenced by the precision of input data and the mechanisms of operation.

Objectives: The objectives of this paper are:

1. To understand the primary drive mechanisms of the reservoir
2. To evaluate the PVT analysis.

Methodology: This paper evaluates the primary drive mechanisms and PVT analysis using Material Balance Software (MBAL) for Libyan oil reservoirs, as well as the predictive material balance method following the history matching of both models.

1. Intisar "D" Field Information:

Intisar D Reef Tank is a biogenic carbonate reef of Paleocene origin located within Concession 103, where seismic operations began in 1967; Located in the eastern-central part of Great Socialist Libya (see Figure 1). Intisar ‘A’, ‘C’ and ‘D’ belong to the same concession 103; Intisar ‘A’ was first discovered in April 1967 with first well A1 at a well depth of 9,417 ft; the third exploratory well drilled in concession 103 discovered Intisar ‘C’ in September 1967 and fourth well discovered Intisar ‘D’.

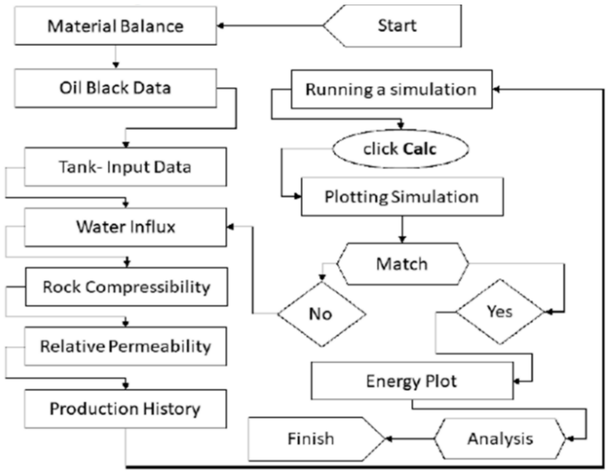


Figure 1: Flow Chart Explains the Steps of methodology of MBAL used in this Study, After Madi Naser et al 2021

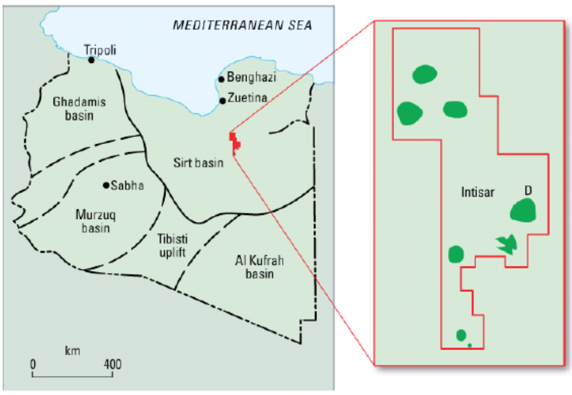


Figure 2: Location Map of Intisar “D” reef reservoir (After Vilela et al 2007)

Intisar D Reef Tank is a biogenic carbonate reef from the Paleocene era, situated within Concession 103, where seismic operations commenced in 1967. It is located in the eastern-central region of Great Socialist Libya (refer to Figure 1). Intisar ‘A’, ‘C’, and ‘D’ are part of the same Concession 103. Intisar ‘A’ was initially discovered in April 1967 through well A1, which reached a depth of 9,417 feet. The third exploratory well drilled in Concession 103 revealed Intisar ‘C’ in September 1967, while the fourth well uncovered Intisar ‘D’.

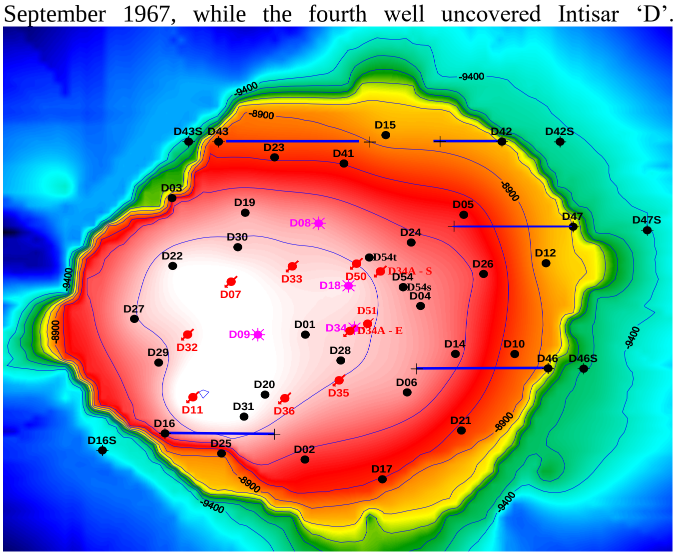


Figure 3: Structural Map of Intisar “D” reef reservoir (After Vilela et al 2007)

2. Pvt Analysis

An oil reservoir, or an oil and gas reservoir, is a subsurface accumulation of hydrocarbons located in porous or fractured rock formations.

Tool Options - Material Balance: After choosing Material Balance from the Tool menu, you can open the Options menu to set up the system configuration. This section outlines the 'Tool Options' in the System Options dialogue box, as illustrated in Figure 4.

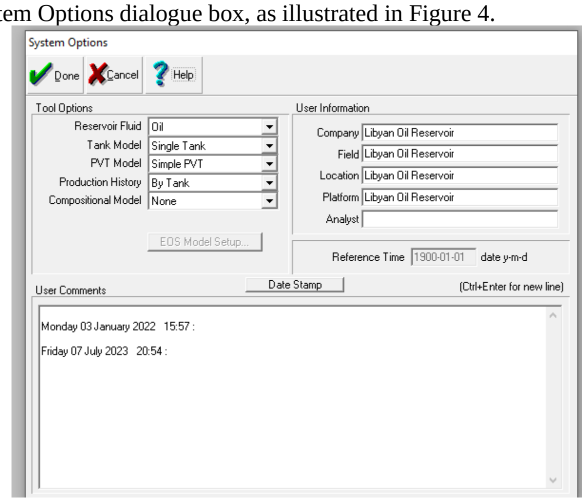


Figure 4: System Options dialogue box

PVT Oil - Single Stage Separator: If oil has been selected as the fluid type in the options menu, the subsequent PVT dialogue box appears as illustrated in Figure 5.

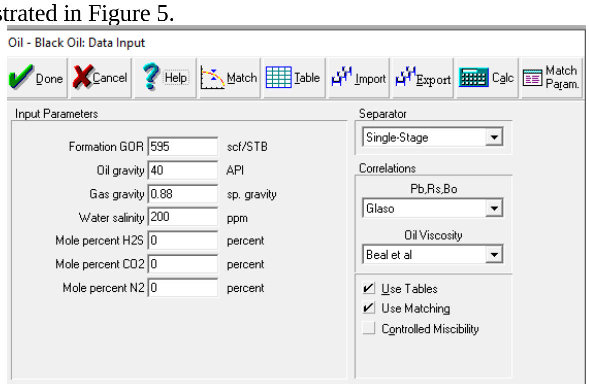


Figure 5: PVT Oil - Single Stage Separator

PVT Oil Match Input Screen: The matching facility is utilized to modify the empirical fluid property correlations in order to align with the measured PVT laboratory data, as illustrated in Figure 6.

PVT Fluid Properties Calculation Input Screen: The PVT calculator can be utilized to generate PVT properties for use in various third-party applications, such as numerical simulators, as illustrated in Figure 7.

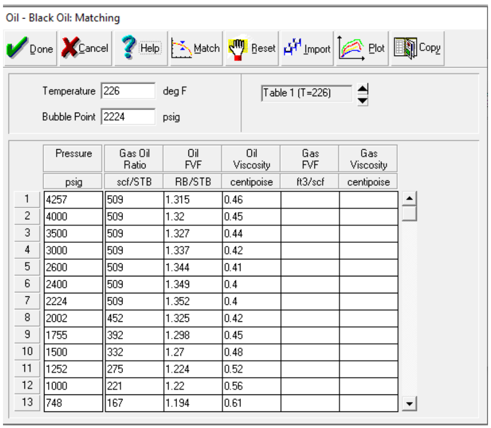


Figure 6: PVT Oil Match Input Screen

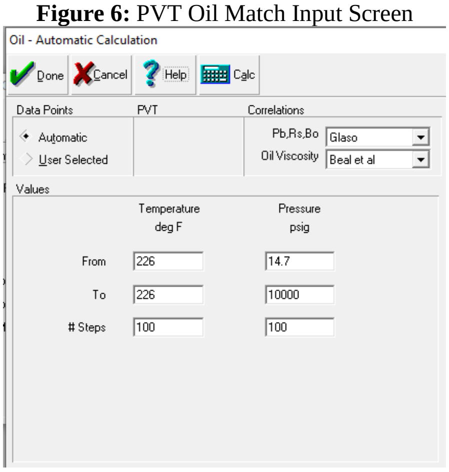


Figure 7: PVT Fluid Properties Calculation Input Screen

PVT Calculation Results: Presents the outcomes of the earlier PVT calculations as depicted in Figure 8.

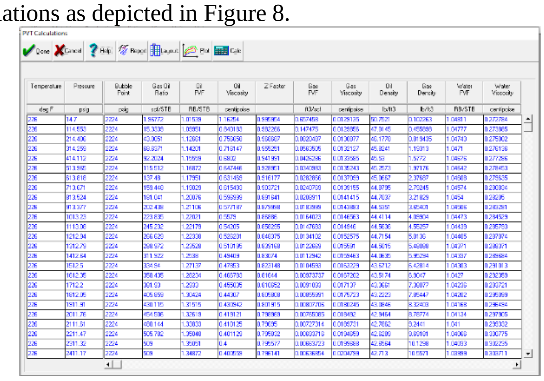


Figure 8: PVT Calculation Results

3. Analysis of Driving Mechanisms

Tank Parameters: This input data sheet screen is utilized to specify the various tank parameters that are employed in the calculations, as illustrated in Figure 9.

Water Influx: When an aquifer is present, as indicated in figure 10, this screen is used to specify its type and characteristics.

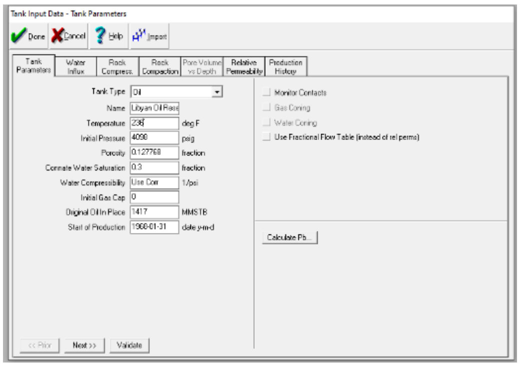


Figure 9: Tank Parameters

Rock Compressibility: As seen in picture 11, this screen is used to determine the attributes of the rock.

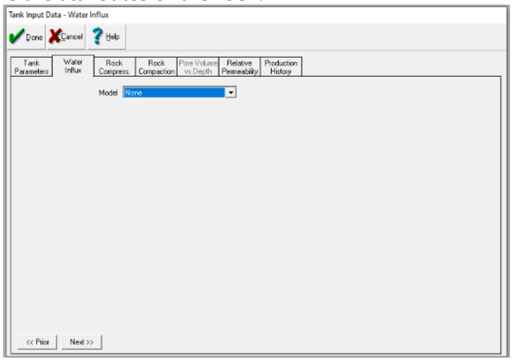


Figure 10: Water Influx

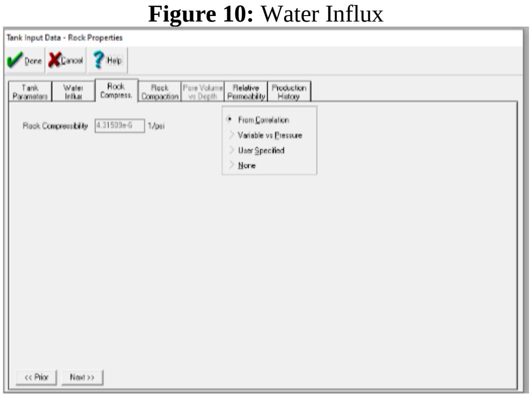


Figure 11: Rock Compressibility

Relative Permeability: As seen in picture 12, this screen describes the various phase relative permeabilities and residual saturations.

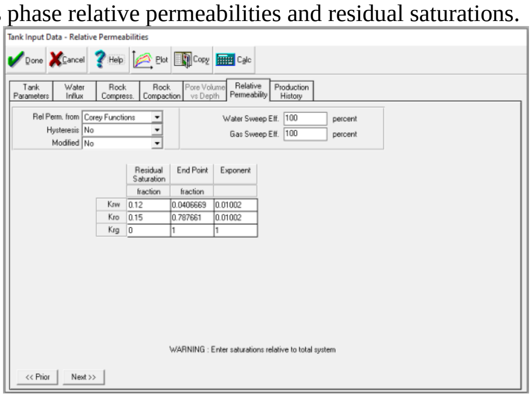
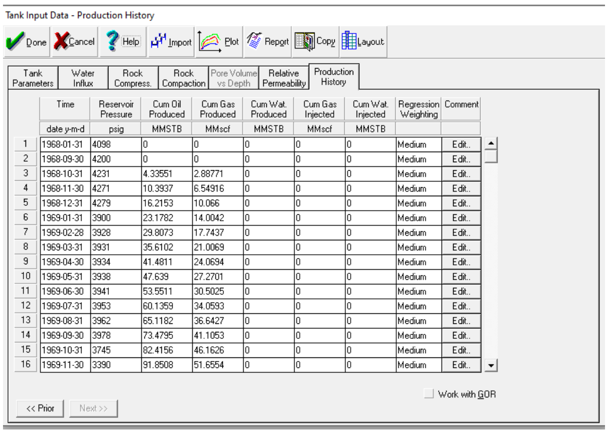


Figure 12: Relative Permeability

Tank Production History: To view the tank production history, select Input Tank Data and then click on the Production History tab. If the option dialog is configured to enter Production History by Well, it can also be derived from the well production history and allocation data available in the Well Data section, as illustrated in Figure 13.



	Time	Reservoir Pressure	Cum Oil Produced	Cum Gas Produced	Cum Wat. Produced	Cum Gas Injected	Cum Wat. Injected	Regression Weighting	Comment
	date y-m-d	psig	MMSTB	MMscf	MMSTB	MMscf	MMSTB		
1	1968-01-31	4098	0	0	0	0	0	Medium	Edit...
2	1968-09-30	4200	0	0	0	0	0	Medium	Edit...
3	1968-10-31	4231	4.33551	2.88771	0	0	0	Medium	Edit...
4	1968-11-30	4271	10.3937	6.54916	0	0	0	Medium	Edit...
5	1968-12-31	4279	16.2153	10.066	0	0	0	Medium	Edit...
6	1969-01-31	3900	23.1782	14.0042	0	0	0	Medium	Edit...
7	1969-02-28	3928	29.8073	17.7437	0	0	0	Medium	Edit...
8	1969-03-31	3931	35.6102	21.0069	0	0	0	Medium	Edit...
9	1969-04-30	3934	41.4811	24.0694	0	0	0	Medium	Edit...
10	1969-05-31	3938	47.639	27.2701	0	0	0	Medium	Edit...
11	1969-06-30	3941	53.5511	30.5025	0	0	0	Medium	Edit...
12	1969-07-31	3953	60.1359	34.0593	0	0	0	Medium	Edit...
13	1969-08-31	3962	65.1182	36.6427	0	0	0	Medium	Edit...
14	1969-09-30	3978	73.4795	41.1053	0	0	0	Medium	Edit...
15	1969-10-31	3745	82.4156	46.1626	0	0	0	Medium	Edit...
16	1969-11-30	3390	91.8508	51.6554	0	0	0	Medium	Edit...

Figure 13: Tank Production History

Running a simulation: The software does not perform the simulation automatically like it does with graphical and analytical approaches because it is relatively slow. Click Calculation as seen in figures 14 to 16, to begin the simulation.

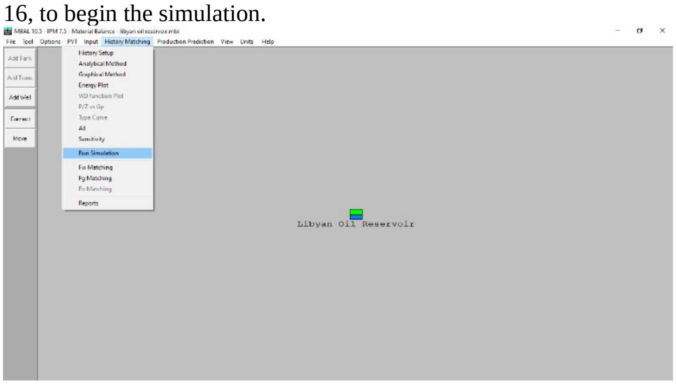


Figure 14: Running a simulation (Step 1)

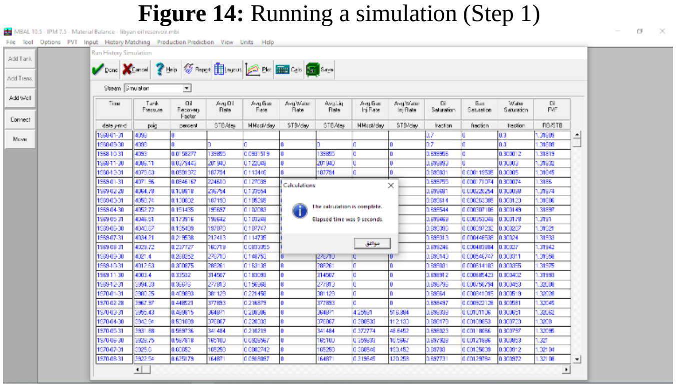


Figure 15: Running a simulation (Step 2)

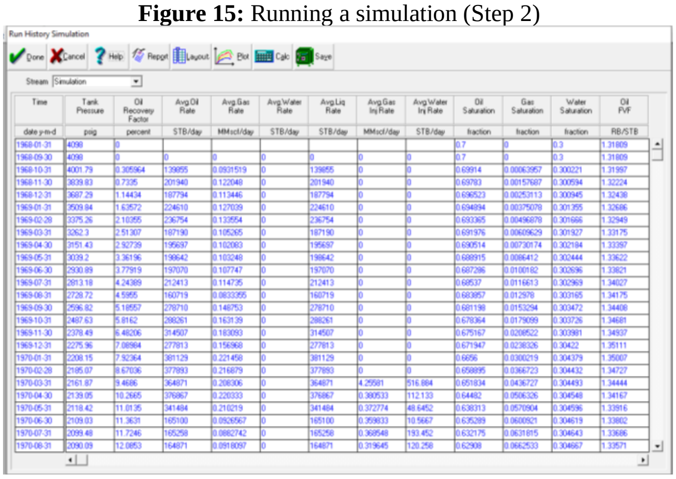


Figure 16: Running a simulation (Step 3)

4. Results and Discussion

PVT RESULTS:

Gas Oil Ratio Results: As illustrated in figure 17, it is typical for some natural gas to emerge from solution when oil is heated to the surface pressure and temperature.

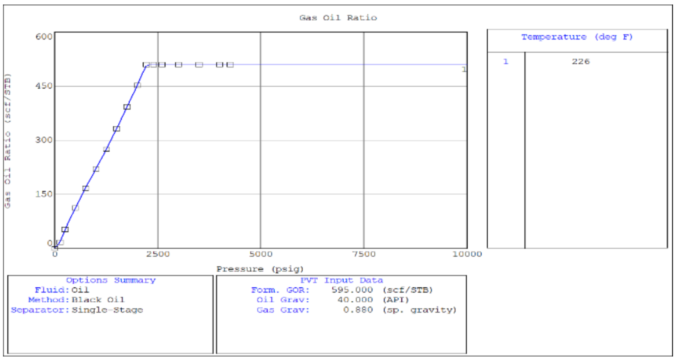


Figure 17: Gas Oil Ratio Results

Oil Formation Volume Factor Results: As seen in figure 18, the oil formation volume factor is correlated with the volume of oil in the reservoir at high pressure and temperature as well as the volume of oil in stock tanks.

Oil Viscosity Results: The oil phase is saturated with all of the soluble gas at pressures greater than the bubble point pressure. Consequently, the oil phase reacts to the decrease in pressure by becoming comparatively less viscous. However, as figure 19 illustrates, more gas is released from the liquid phase as the pressure falls below the bubble point pressure, increasing the viscosity of the oil.

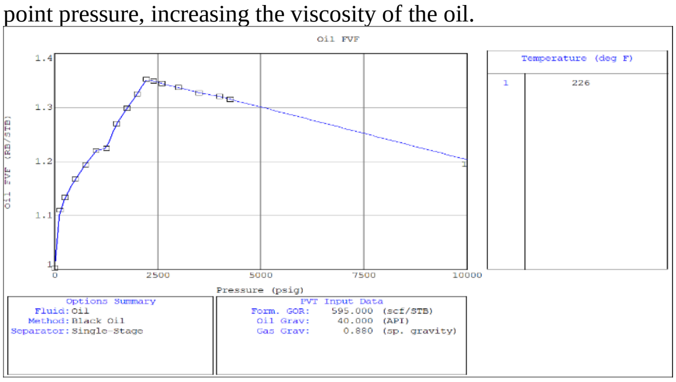


Figure 18: Oil Formation Volume Factor Results

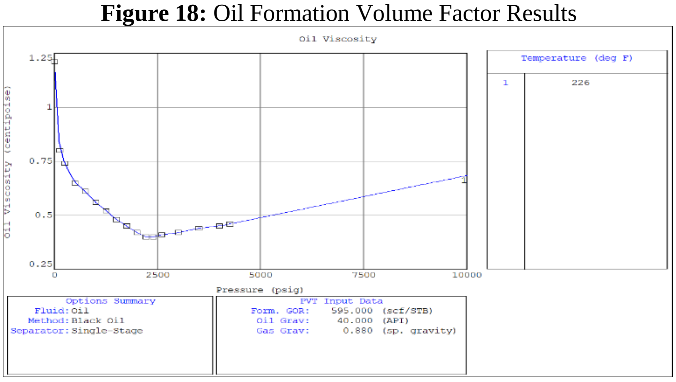


Figure 19: Oil Viscosity Results

Z Factor Results: The ratio of the volume a gas actually occupies at a particular pressure and temperature to the volume it would fill if it behaved perfectly, as depicted in figure 20, is known as the gas deflection facto

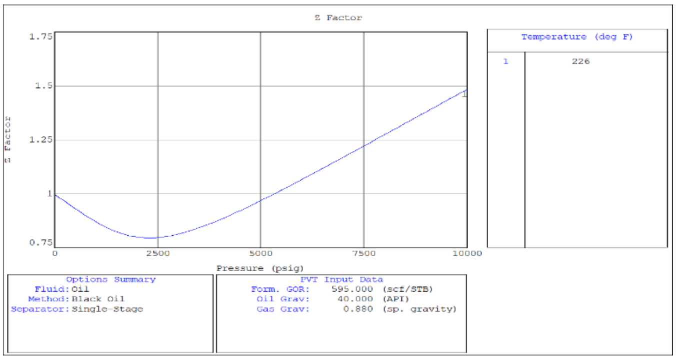


Figure 20: Z Factor Results

Gas Formation Volume Factor Results: As seen in figure 21, the gas formation volume factor can be understood as the ratio of one mole of gas under reservoir circumstances to one mole of gas at standard conditions.

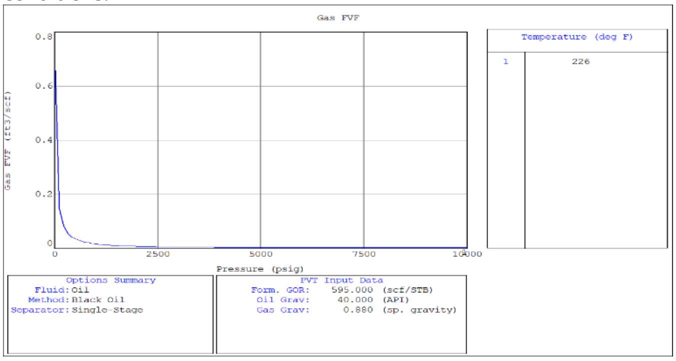


Figure 21: Gas Formation Volume Factor Results

Gas Viscosity Results: Figure 22 illustrates how pressure affects a liquid's coefficient of viscosity. As pressure rises, the coefficient of viscosity likewise rises.

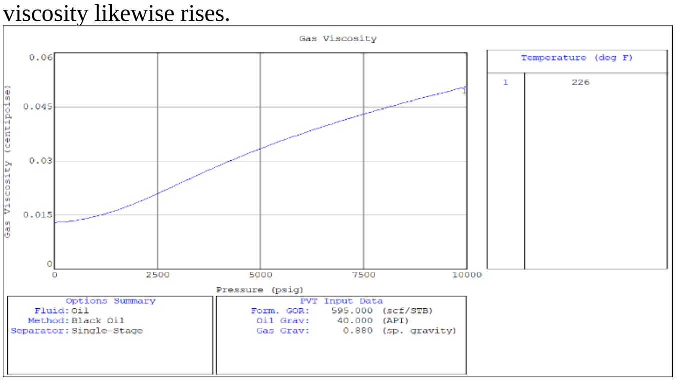


Figure 22: Gas Viscosity Results

Oil Density Results: As illustrated in figure 23, the conversion between mass and volume depends on the liquid's density and how it changes with temperature and pressure.

Gas Density Results: As seen in figure 24, gas density is a function of the gas's temperature and pressure.

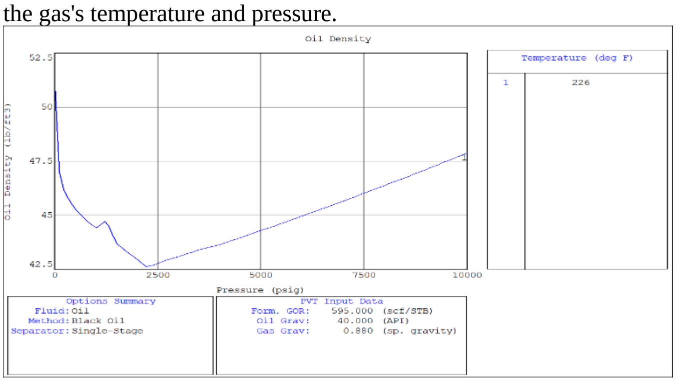


Figure 23: Oil Density Results

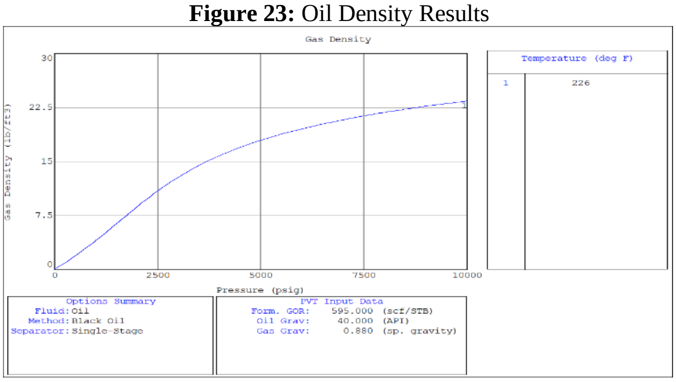


Figure 24: Gas Density Results

Water Formation Volume Factor Results: As seen in figure 25, the water formation volume factor shows how the volume of brine changes as it is moved from tank settings to surface circumstances.

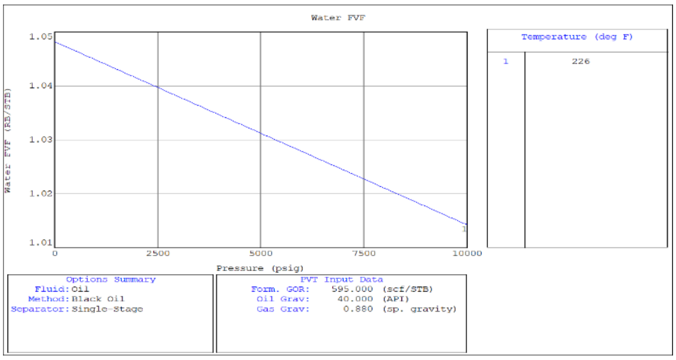


Figure 25: Water Formation Volume Factor Results

Water Viscosity Results: Figure 26 illustrates how temperature affects the dynamic and kinematic viscosities of water. The water viscosity to temperature chart that follows reflects this relationship.

Water Density Results: Density and pressure have a direct relationship. In other words, as figure 27 illustrates, pressure is directly proportional to density.

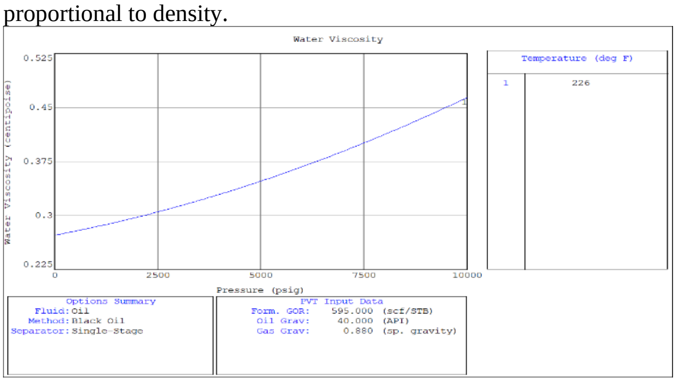


Figure 26: Water Viscosity Results

Water Compressibility Results: As seen in figure 27, compressibility, also known as isothermal compressibility, is the degree to which a liquid or solid's relative volume changes in response to pressure.

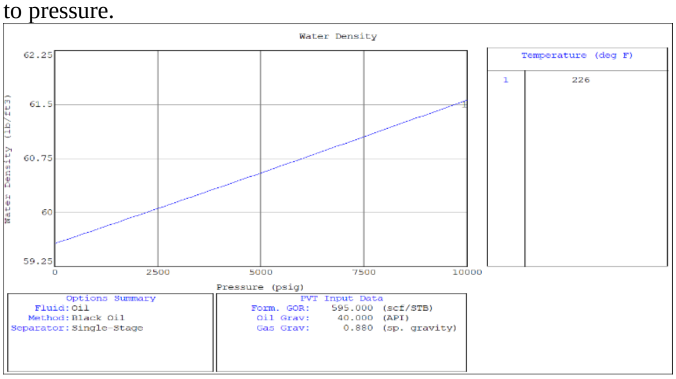


Figure 27: Water Density Results

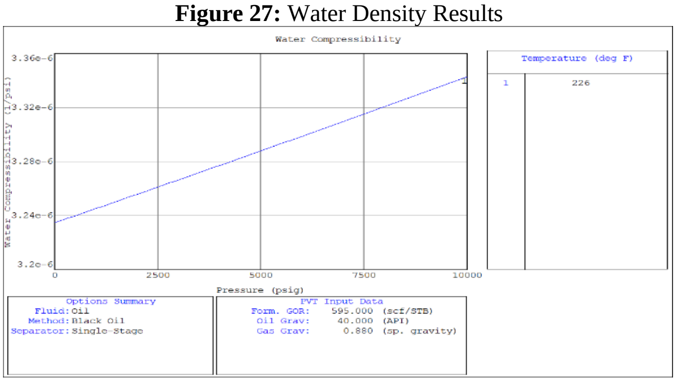


Figure 28: Water Compressibility Results

PRIMARY DRIVE MECHANISMS RESULTS:

Pressure Tank Results: The following graphic displays the simulation versus time for aquiver Diffusivity as well as the history of reservoir pressure. Given that the stimulation curve and the historical reservoir pressure curve match, the input data given into the model is well-alluded to. The reservoir pressure matches when the reservoir aquiver volume is changed to Diffusivity 503 RB/psi/day, as indicated in Figure 29, based on past production data from the simulator and actual reservoir performance.

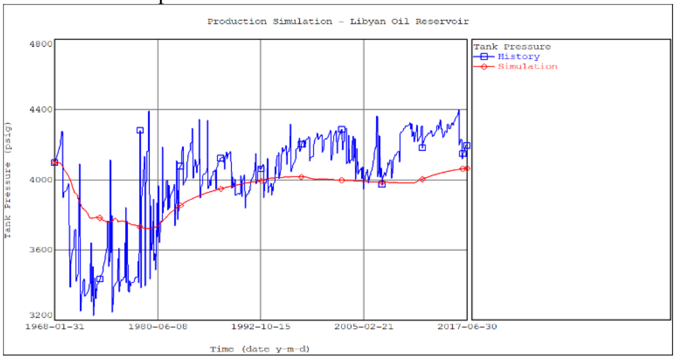


Figure 29: Pressure Tank Matching Results

Cumulative Oil Production Results: The cumulative oil production from 1968 to 2017 is shown against time in the following figure. The graph shows us that oil output rises cumulatively over time. Up until it stabilizes at about 1200 MMSTB, as indicated in figure 30, this rise is linear.

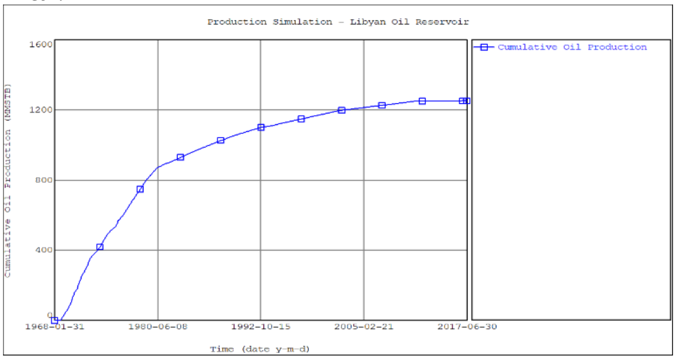


Figure 30: Cumulative Oil Production Results

Cumulative Water Production Results: The cumulative water production from 1968 to 2017 is shown against time in the accompanying figure. We see from the figure that the cumulative generation of water grows over time. Up until it stabilizes at about 300 MMSTB, as indicated in figure 31, this rise is linear.

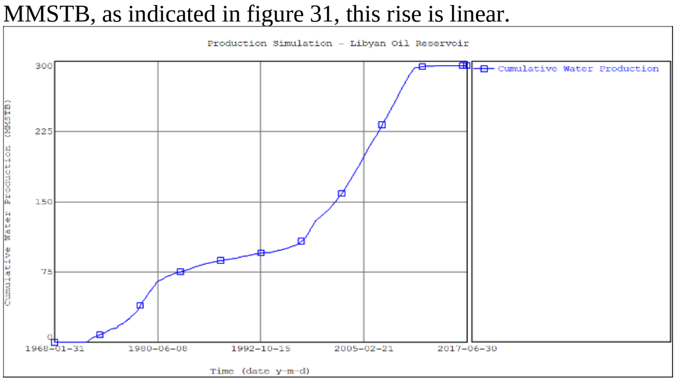


Figure 31: Cumulative Water Production Results

Cumulative Gas Production Results: The total amount of gas extracted from the reservoir throughout a specific time span of the field's existence. Wells, fields, and basins are responsible for a portion of the total gas production. The gas production total from 1968 to 2017 is depicted in the accompanying figure. From the image, we can see that over time, the total amount of gas produced grows. Direct increases are made until the figure 32 indicates that the volume stabilizes at around 3,500 million standard cubic feet.

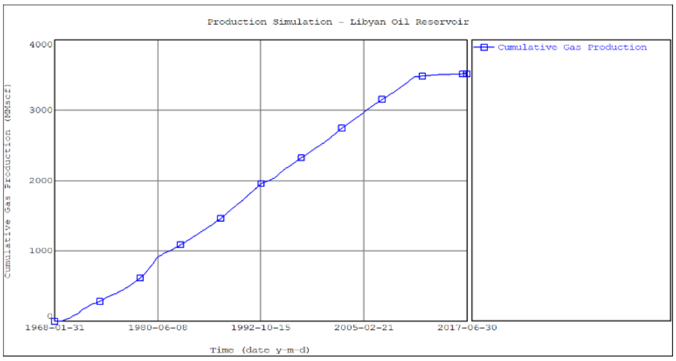


Figure 32: Cumulative Gas Production Results

Oil Recovery Factor Results: the initially present recoverable amount of hydrocarbon, usually given as a percentage. The displacement mechanism determines the recovery factor. Increasing the recovery factor is one of the main goals of enhanced oil recovery. The oil recovery coefficient from 1968 to 2017 is plotted against time in the following graphic. The figure shows that as oil production rises over time, so does the oil recovery coefficient. This is a direct increase, but as figure 33 illustrates, it settles to about 4.5%.

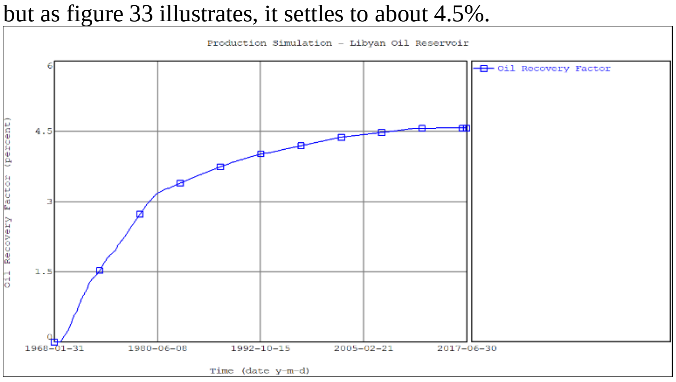


Figure 33: Oil Recovery Factor Results

Water Influx Model Results: the substitution of formation water for generated fluids. The majority of petroleum reservoirs have water underneath them, and when gas or oil is produced, water usually enters the reservoir at some rate. The proximity of the productive interval to the oil-water or gas-water contact, as well as the type of well—horizontal or vertical—determine whether significant water is produced in addition to gas or oil.

In the event that there is a water influx in the tank, the water influx model information are also entered. The project's model incorporates a water influx with a diffusivity of 503 RB/psi/day. Furthermore, as depicted in figure 34, the model that was chosen is displayed in the following figure.

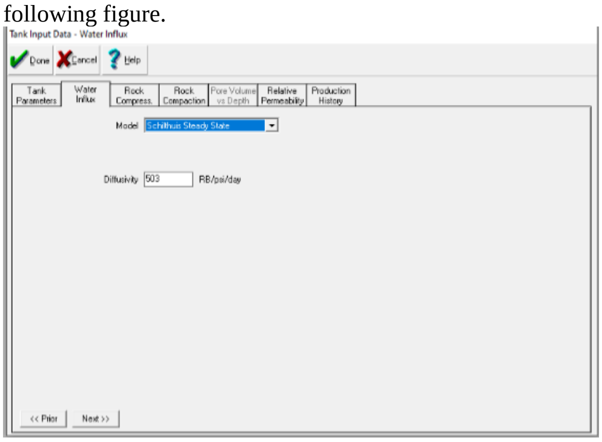


Figure 34: Water Influx Model Results

Energy Plot Results: The reservoir's primary energy systems, such as fluid expansion, pore size compression, ingestion, and water flow, are described by the energy plot. It explains the fractional contributions of these energy systems that are found in the reservoir and that, as figure 35 illustrates, are most noticeable at different times.

The following chart compares the energy sources in the reservoir and aquifer system in terms of their relative contributions throughout time. This reservoir produced under three different driving mechanisms from October 31, 1968, to June 30, 2017. The fluid expansion was initiated from 0 to 0.60, the PV compressibility was increased from 0.60 to 0.89, and the water ingress was increased from 0.89 to 1.

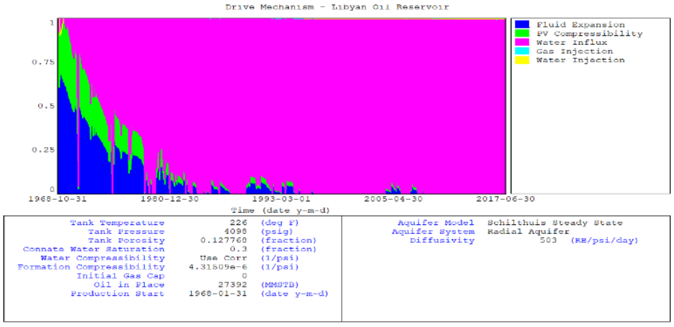


Figure 35: Energy Plot Results

5. Conclusion and Recommendation

After utilizing Material Balance Software (MBAL Software) to analyse the PVT analysis and key driving mechanisms for the Libyan Oil Reservoir, we came to the following conclusions:

1. This study depended on MBAL software to estimate the reservoir driving mechanisms to know the past and the future performance of the reservoir.
2. It helps us to understand reservoirs, and the mechanism of this reservoir work during the well life.
3. The history reservoir pressure curve is matching to the stimulation curve, this gives a good allusion of the input data that has been entered to the model.
4. The driving mechanism for all those reservoirs it comes from three natural forces. Fluid expansion, PV Compressibility, and Water influx.
5. It has been started with the fluid expansion from 0 to 0.60, with the PV compressibility from 0.60 to 0.89, and with the water influx from 0.89 to 1 is water influx.
6. Matching was achieved with high percentage in compared with measured pressure, and this is an important indicator that the modelling with MBAL is precise and simulates reality.
7. Aquifer volume model was selected and we got quite good match in the historical pressure data.

RECOMMENDATION:

1. MBAL software is good and reliable software in estimating the reservoir driving mechanisms and predicting the performance of the reservoir in the future.
2. When using software, it is preferable to choose more than one reservoir and also choose more than one reservoir in order to compare the characteristics of the reservoirs and the different companies.
3. Al least three models should be used to confirm the results and compare them with each other.
4. In the event that more than one reservoir is used, the results must be separated and stored from each other to compare each reservoir and determine the best reservoir.

6. References:

[1]- Clark, N. J., 1969, Elements of petroleum reservoirs: Dallas, TX, Society of Petroleum Engineers, AIME, p. 66–84.

[2]- Odeh, A. S., 1986, Reservoir fluid flow and natural drive mechanisms, in IHRDC Video Library for Exploration and Production Specialists, Manual for Module PE502: Boston, MA, IHRDC, p. 69–120.

[3]- Dake, L. P., 1978, Fundamentals of Reservoir Engineering: The Netherlands, Elsevier Science Publishers, p. 79–102.

[4]- Ahmed, T. Hydrocarbon Phase Behavior. Houston: Gulf Publishing company, 1989

[5]- Dake, L. P. The Practice of Reservoir Engineering, Elsevier, Amsterdam, NJ, 1994

[6]- Dake L.P. Fundamentals of Reservoir Engineering, Elsevier, 1983

[7]- Fetkovich, M. J, "A Simplified Approach to Water Influx Calculations- Finite Aquifer Systems", JPT, 1971

[8]- Frank W. Cole "Reservoir Engineering Manual", Gulf Publishing; 2Rev Ed edition, June 1969

[9]- Glaso, O., "Generalized Pressure Volume-Temperature Correlations", May 1980

[10]- Nnaemeka Ezekwe, Petroleum Reservoir Engineering Practice, Prentice-Hall, USA,2011

[11]- Petroleum experts, MBAL, Hand Tool Kit, version 8.1, December 2005

[12]- Shah MD. Sirajus Salekin, "Optimization of a Saldanadi gas field of Bangladesh", University of Stavanger, Norway, 2011

[13]- http://www.petex.com/products/ipm-suite/mbal/

[14]- Vilela, M. J., Gharsalla, Mohammed, Elghmari, Mohamed, and Abdulhamid Majdoub. "Performance Evaluation of a Reservoir Under EOR Recovery: Intisar 'D' Reef, Concession 103, Libya.." Paper presented at the SPE Middle East Oil and Gas Show and Conference, Manama, Bahrain, March 2007. doi: https://doi.org/10.2118/104619-MS

[15]- Madi Abdullah Naser , Omar Ibrahim Azouza, Faraj Meftah Abousedrah, Estimation of driving mechanisms for oil reservoir using Material Balance (MBAL Software) "A Case Study of Libyan Oil Field, SebhaUniversity Journal of Pure & Applied Sciences, 2021.