Available online at http://ijcpe.uobaghdad.edu.iq and www.iasj.net
Iraqi Journal of Chemical and Petroleum Engineering
Vol.21 No.1 (March 2020) 33 – 38
EISSN: 2618-0707, PISSN: 1997-4884

Using Different Methods to Predict Oil in Place in Mishrif Formation / Amara Oil Field

Mohammed Najeeb[a], Fadhil Sarhan Kadhim[a] and Ghazwan Noori Saed[b]

[a]University of Technology / Petroleum Technology Department
[b]University of Kufa / Chemical Engineering Department

Abstract

The reserve estimation process is continuous during the life of the field due to risk and inaccuracy that are considered an endemic problem thereby must be studied. Furthermore, the truth and properly defined hydrocarbon content can be identified just only at the field depletion. As a result, reserve estimation challenge is a function of time and available data. Reserve estimation can be divided into five types: analogy, volumetric, decline curve analysis, material balance and reservoir simulation, each of them differs from another to the kind of data required. The choice of the suitable and appropriate method relies on reservoir maturity, heterogeneity in the reservoir and data acquisition required. In this research, three types of reserve estimation used for the Mishrif formation / Amara oil field volumetric approach in mathematic formula (deterministic side) and Monte Carlo Simulation technique (probabilistic side), material balance equation identified by MBAL software and reservoir simulation adopted by Petrel software geological model. The results from these three methods were applied by the volumetric method in the deterministic side equal to (2.25 MMMSTB) and probabilistic side equal to (1.24, 2.22, 3.55) MMMSTB P90, P50, P10 respectively. OOIP was determined by MBAL software equal to (2.82 MMMSTB). Finally, the volume calculation of OOIP by using the petrel static model was (1.92 MMMSTB). The percentage error between material balance and the volumetric equation was equal to 20% while the percentage error between the volumetric method and petrel software was 17%.

Keywords: OOIP, reserve estimation, Monte Carlo Simulation, HIIP

Received on 25/06/2019, Accepted on 22/09/2019, published on 30/03/2020

https://doi.org/10.31699/IJCPE.2020.1.5

1- Introduction

The amount of crude oil that exists in the subsurface related to the deposition of organic matter which in turn attributed to the sediments. The type and amount of hydrocarbon generated in the trap depend on several factors: quality of organic matter in the sediments, the abundance of organic matter, the area and size of organic matter was matured during burial and also circumstances of the environment (pressure and temperature) in which organic matter accumulated [1].

The reservoir engineer is under the challenges to accomplish accurate estimation of hydrocarbon contents that existed in the reservoir and evaluate quantitatively recoverable hydrocarbon from a field, zone or area. Petroleum engineering science contains one of the highest uncertainty problems because it deals with invisible or not touchable subjects. Along with this matter, all of the data used in the estimation process is burdened with uncertainty problem and this problem regarded endemic problem [2].

Risks and uncertainties play a curial role along with all-time phases of field life. Specifically, in the early life of the field when uncertainty presence is quite major thereby, erratic quantifying of uncertainty leads to underestimation or underestimation of reserves [2].

Therefore, the level of uncertainty is impacted by the following factors: [3]

1. Reservoir type
2. Source of the reservoir drive mechanism
3. Amount and accuracy data used
4. Available technology and
5. Knowledge and experience of the estimator.

However, the uncertainty problem is decreased with time until the field reaches abandonment point. Consequently, reserve estimation is a function of time and data as shown in Fig. **1**.

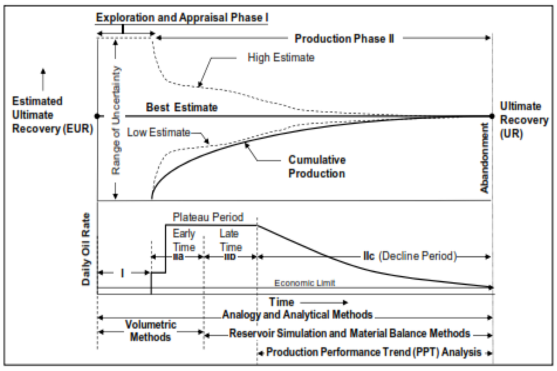

Fig. 1. Changes in reserve estimation along time and suitable method [4]

Corresponding Authors: Name: Mohammed Najeeb , Email: mo6613979@gmail.com, Name: Fadhil Sarhan Kadhim, Email: FadhilKadhim47@yahoo.com, Name: Ghazwan Noori Saed , Email: ghazwanj@gmail.com

Fundamentally, the main objective of this work is carried out to find out the appropriate and consistent method for hydrocarbon in place estimation pertinent taking in the account easily using computers and the petroleum software which is helps us to achieve accurate reserve estimation.

In this paper, three major approaches; volumetric, material balance calculation and reservoir simulation technique to determine volume of oil in place and compare stock tank oil in place (STOIP) results obtained for analyses of possible variation in estimation process this comparison can be lead to a reasonable and reliable estimate of oil reserves according to reservoir characteristics.

1.1. Reserves and Resources Definition

The diagram in Fig. **2** illustrates the classification and categorization of reserves and petroleum resources systems according to the Petroleum Resources and Management System (PRMS) [5] definitions established by SPE/ WPC /SEG /SPEE/ AAPG/ SPWLA/ EAGA.

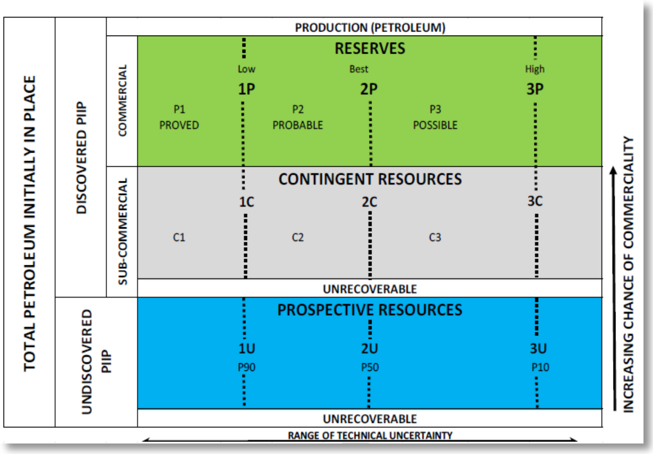

Fig. 2. Recourses Classification systems framework [5]

The terms "reserve" and "resource" have a specific meaning in petroleum qualification and therefore distinguish between them are essential.

Reserves in the PRMS definition are "these amounts of hydrocarbon can be obtained from commercial processes after implementation of these projects in order to identified accumulations under the specific date and defined Conditions". Reserves can be classified into discovered, recoverable, commercial, and remaining depends on projects applied. Also, reserves can be sub-classified according to the level of uncertainty into Proved, Probable and Possible reserves.

Proved reserves in PRMS definition are "these amounts of hydrocarbon can be estimated with appropriate certainty under available data that are related to the reservoir has commercial benefits".

Probable reserves in PRMS definition are "these extra reserves are referred to less than Proved Reserves but increasingly accurate than Possible Reserves".

Possible reserves in PRMS definition are "these more reserves are considered are less recoverable than Probable Reserves".

On the other side, resources in the PRMS definition are "all amounts of hydrocarbon normally happening in the subsurface formations, discovered and undiscovered (recoverable and unrecoverable), as well as these amounts already produced. At last, It contains all kinds of petroleum regarded Conventional or Unconventional". In addition, the resources can be sub-classified into two kinds: contingent resources and prospective resources.

Contingent resources in the PRMS definition are "these amounts of hydrocarbon are computed, at a specific date, to be possibly recoverable from identified accumulations, by applying projects that not regarded inside commercial process because of more than contingencies".

Prospective resources in the PRMS definition are "these amounts of hydrocarbon determined, at a particular date, as possibly taken from unknown accumulations".

If the Initial petroleum in – place (IPIP) is divided in reserves, this terminology can be classified as 1P (proved), 2P (proved and probable), and 3P (proved, probable and possible) reserves, the contingent resources are classified into 1C, 2C, and 3C, while the term 1U, 2U, and 3U are used for perspective resources.

Hence, reserves compose subdivision of resources as shown in Fig. **3** below:

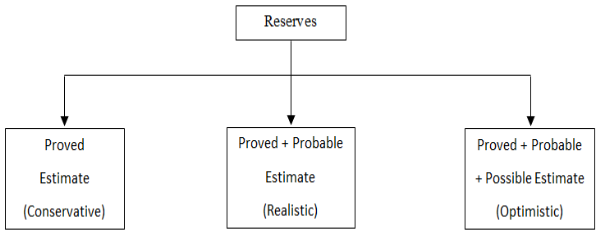

Fig. 3. Resources classification tree [6]

1.2. Reserves estimation framework

Reserves estimation procedure in petroleum basin involves several aspects summarized below: [7]

1) Seismic surveys, to identify subsurface structures comprising hydrocarbon accumulation.
2) Drilling exploration wells, to discover subsurface circumstances (geologically and petro – physically).
3) Valuation of hydrocarbon accumulations, which involves;
   a) Determine amounts of hydrocarbon trap in the discovered structure area.
   b) Fluid properties (to identify physical characteristics for oil, water, and gas formation)
   c) Core analysis, to study different petrophysical
   d) Parameters for reservoir rocks. Finally, reserves estimation to calculate hydrocarbon content in place existed in the reservoir.

1.3. Reserves Estimations Methods

Reserves estimation methods can be broadly classified in to: [8]

1- Analogy method
2- Volumetric method
3- Material balance calculations
4- Decline Curve analysis
5- Reservoir simulation method

Reserves estimation can be categorized relating to pre- and post-production stages i.e. (static and dynamic). The static methods indicate to analogy and volumetric calculation which used before the start of production in the reservoir and generally used geologic and engineering data while dynamic methods involved performance techniques applied after production started in the field and typically need production data and pressure of wells. Fig. **4** below illustrates reserves estimation methods.

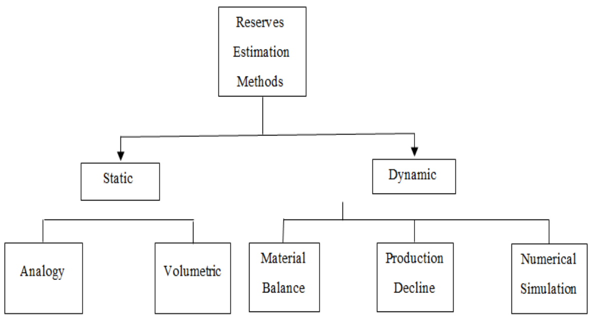

Fig. 4. Reserves estimation methods [8]

1.4. Reservoir Description

Amara oil field is located at southeastern Iraq in Maysan governorate, the distance of around 10 km southeastern of Amara city. It is surrounded by different oil fields about 25 Km east of the Al-Rafedain field, and 30 Km southeastern Al Kumait field. The field lies on the unstable shelf at the Mesopotamian basin at coordinate (UTM38R 694628.72mE, 3520629.67mN) and (706121.34mE, 3516859.11mN). [9] As shown in Fig. **5** below.

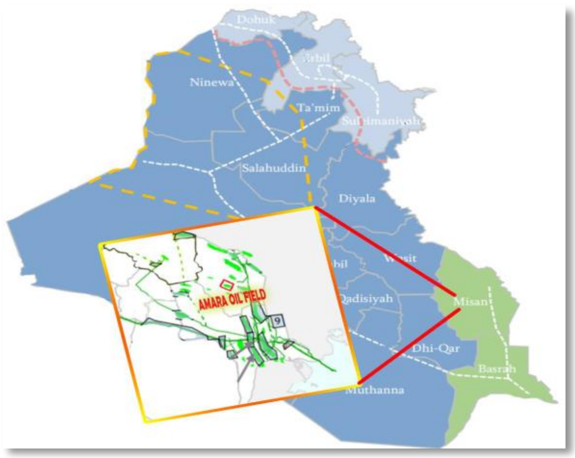

Fig. 5. Location of Amara oil field [9]

2- Methodology

In this study, three methods of hydrocarbon initially in place (HIIP) are used, the result obtained with the select most suitable and confidence method according to reservoir characteristics for Mishrif formation / Amara oil field as a case study as follow:

In this study, three methods of hydrocarbon initially in place (HIIP) are used, the result obtained with the select most suitable and confidence method according to reservoir characteristics for Mishrif formation / Amara oil field as a case study as follow:

1- Volumetric Method:

The conventional volumetric equation is:

$$STOOIP = 7758*A*h*Ø*(1-Swi) / Boi \quad (1)$$

It is obvious, the volumetric equation based on area, net pay, effective porosity, water saturation, and formation volume factor. Deterministic and Stochastic approach used to estimate hydrocarbon amount. In deterministic approach single best value input to obtain one value for reserve while, in probabilistic approach involves the following procedure: firstly input all reservoir variables as max, min, mode then select the suitable distribution for each input parameter such triangular, rectangle and normal after that run Monte Carlo Simulation (MCS) by Model Risk Analysis to obtain Pessimistic, most likely and optimistic reserve value (P90, P50, P10) and quantify error percentage for each parameter by Tornado plot.

2- Material Balance Equation:

The material balance equation has been considered for many years as a basic tool for reservoir engineers for predicting and interpreting reservoir performance. The material balance (MB) equation can be used to calculate hydrocarbon content (N), water influx (We), predict future reservoir performance, forecast reservoir pressure, and predict ultimate hydrocarbon recovery under many types of the drive mechanism.

$$m_{initial} + m_{add} - m_{removed} = m_{remaining} \quad (2)$$

One of the intrinsic principles used in petroleum engineering is the Law of Conservation of Mass. The application of this law to a petroleum reservoir is known as the "material balance equation". It is necessary for reservoir engineers to understand realistically the material balance during its depletion history. MBAL software was adapted to accomplish Material Balance Equation calculations.

3- Reservoir Simulation:

The term "reservoir simulation" commonly refers to the building and execution of a particular model that represents the actual reservoir behavior in other words, it is a tool used to mirrors the activities that happen in producing a reservoir.

This process includes the integration of production data, petrophysics, PVT data, rock and fluid properties, and geology…..etc. so on to obtain the best view of reservoir behavior. The model may be a mathematical or physical model subject to limitations and conditions depending on the nature of the reservoir.

Petrel software was adapted to establish the geological model to reach volume calculation step after entered all wellhead, well tops and contour map to construct structural model for each unit of mishrif then upscaling all well logs by arithmetic average and division each layer according to hydrocarbon accumulation after that distribution all petrophysical parameters by Sequential Gaussian distribution for each zone of mishrif to create property modeling finally, estimate original oil in place (OOIP) by simulator run.

3- Results and Discussion

Volumetric equation method applied by using a deterministic and stochastic approach. In deterministic method, all volumetric equation parameters calculated by IP software of detected depth of Mishrif formation / Amara oil field (2840-3600) m of well (Am5, Am6, Am7, Am8, Am10, Am11, Am12, Am13, Am14, Am15) as shown in Table **1** the resulted OOIP was (2.25 MMMSTB) while, the probabilistic manner, Monte Carlo Simulation (MCS) adapted by Model Risk Analysis software after inputs each of static volumetric parameters in max, min, and average or mode values as shown in Table **2** then select triangular distribution function for each of them for (10000 samples) number of iterations to generate proved (P90), proved plus probable (P50) proved plus probable plus possible (P10) was (1.24, 2.22, 3.55) MMMSTB respectively the obtained result by volumetric equation equal mode or P50 it is an indication the estimation process was true.

The material balance equation was estimated by MBAL software after inputs all reservoir properties: Tank parameters, water influx, rock compressibility, relative permeability, and production history the resultant OOIP is equal (2.82 MMMSTB) Fig. **7** illustrates Havlena – Odeh approach x-axis was F / Et and the y-axis was We / Et.

Finally, Petrel static model established by constructing a structural contour map for each unit of Mishrif formation then imported well logs information by IP software then upscaling, layering, and distribution reservoir properties by Sequential Gaussian Distribution (SGD) statistical method to accomplish volume calculation step the obtained totally hydrocarbon accumulation for all zone of Mishrif was (1.92 MMMSTB).

Table 1. Static volumetric parameters

Well	Net Thickness (m)	Av PHI	Av S_w
Am-5	91.91	0.22833333	0.284333333
Am-6	71.08	0.1885	0.283
Am-7	13.95	0.167	0.337
Am-8	44.08	0.204	0.289
Am-10	55.17	0.33016667	0.324
Am-11	89.55	0.1935	0.2445
Am-12	55.62	0.18825	0.27325
Am-13	126.41	0.187	0.274
Am-14	39.26	0.1665	0.235
Am-15	33.48	0.1395	0.279
$A_{vg.}$	73.37875	0.23165625	0.318010417

Table 2. Uncertainty volumetric data

	Net Thickness (m.)	Av PHI	Av S_w	Area (acre)	B_{oi} (bbl./STB)
Min	13.95	0.1395	0.235	10670	1.35
Mode	71.635	0.210781	0.275885	11000	1.38
Max	126.41	0.330167	0.337	11330	1.41

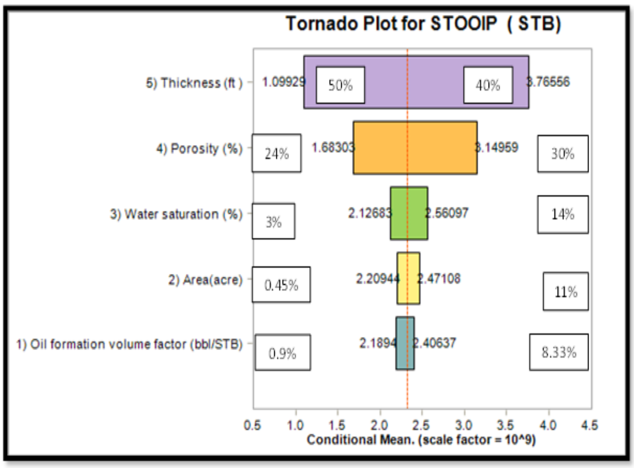

Fig. 6. Tornado plot for sensitivity analysis

Table 3. Comparisons of OOIP by three methods

Formation	Volumetric Method	MBAL Software	Petrel software
Mishrif	2.25 MMM STB	2.82 MMM STB	1.92 MMM STB

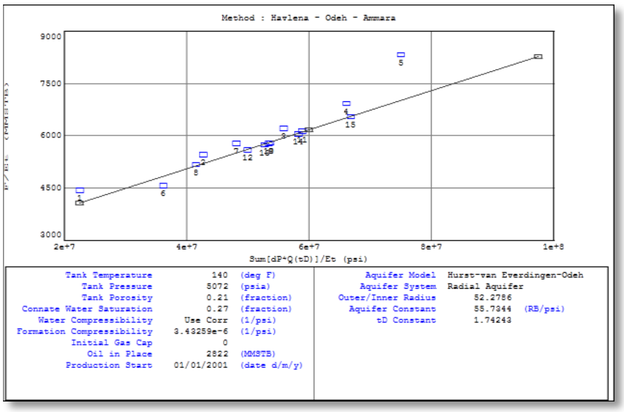

Fig. 7. Havlena – Odeh Method of Amara Oil Field

4- Conclusion

According to this study, the main conclusion is: The most reliable and reasonable method of Original oil in place (OOIP) estimation in the Mishrif formation / Amara oil field was the reservoir geological Model which was (1.92 MMMSTB). Because was used well logs data resulted from IP software, structural model of each unit of Mishrif reservoir (MA, MB11, MB12, MB13, MB21, MC1, and MC2), scale-up well logs, make horizons, petrophysical distribution, detect oil-water contact level to obtain the volume calculation result of OOIP. Hence, the MA unit represents the best zone in the Mishrif formation because it contains the biggest amount of hydrocarbon accumulation of (1.53 MMMSTB).

Nomenclature

PRMS:	Petroleum Resources and Management System
SPE:	Society of Petroleum Engineering
WPC:	World Petroleum Council
SEG:	Society of Exploration Geophysicists
SPEE:	Society of /petroleum Evaluation Engineers
AAPG:	Association of Petroleum Geologists
SPWLA:	Society of Petrophysicists and Well Log Analysis
EAGA:	European Association of Geoscientists and Engineers
A:	Area (acre)
Am:	Amara
B:	Billon
Boi:	initial oil formation volume factor
BSTB:	Billon Stock Tank Barrel
H:	net pay (ft.)
HIIP:	Hydrocarbon initially in place
IP:	Interactive Petrophysics
MB:	Material Balance
MCS:	Monte Carlo Simulation
Ø:	effective porosity (percent)
OOIP:	Original oil in place
P10:	10% confidence 90% error
P50:	50% confidence 50% error
P90:	90% confidence 10% error
Sw:	water saturation (percent)

References

[1] Igbokwe and L. Chidozie, "Comparative analysis of reserve estimation using volumetric method and Mbal on Niger Delta oil fields", University of Technology of Owerri, published Thesis, Nigeria, 2011.

[2] Maksim Y. Nazarenko, "Probabilistic production forecasting and reserves estimation in water flooded oil reservoirs", Texas A&M University, published Thesis, USA. 2016.

[3] Robert Kosova, Adrian Naco and Irakli Prifti, "Deterministic and Stochastic methods of oil field reserves estimation: A case study from KA. Oil field", Interdisplinary Journal of Research and Development, Vol. (IV), No.2, 2017, pp226-231.

[4] Petroleum Resources Management System (PRMS) , Society of Petroleum Engineers (SPE), American Association of Petroleum Geologists (AAPG), World Petroleum Council (WPC), Society of Petroleum Evaluation Engineers (SPEE), Society of Exploration Geophysicists (SEG), Society of Petro physicists and Well Log Analysts (SPWLA), European Association of Geoscientists & Engineers (EAGE). 2017.

[5] Kosova Robert, Shehu Valentina, Naço Adrian, Xhafaj Evgjeni, Stana Alma, Ymeri Agim, "Monte Carlo Simulation For Estimating Geologic oil Reserves. A Case Study Kuçova Oil Field In Albania" 2015, pp. 20-25

[6] P.F. Worthington, "Reserves—Getting It Right", International Petroleum Technology Conference, IPTC 10809, Doha, Qatar. 2005.

[7] Hugo Araujo and Aquiles Rattia, "Reserves Follow-up Using an Integrated Deterministic-Probabilistic Approach", SPE 143843, Colorado, USA. 2011.

[8] Buraq Adnan Al-Baldawi, "Applying the cluster analysis technique in logfacies determination for Mishrif Formation, Amara oil field, South Eastern Iraq" , Arabian Journal of Geosciences, Volume 8, Issue 6, 2014, pp3767-3776.

[9] Jawad K. Radhy AlBahadily and Medhat E. Nasser, "Petrophysical Properties and Reservoir Modeling of Mishrif Formation at Amara Oil Field, Southeast Iraq", Iraqi Journal of Science, Vol. 58, No.3A, 2017, pp1262-1272.

استخدام طرق مختلفة للتنبؤ بالخزين النفطي الاصلي في تكوين مشرف / حقل عمارة النفطي

محمد نجيب[1], فاضل سرحان[1] و غزوان نوري[2]

[1]الجامعة التكنولوجية, قسم هندسة النفط
[2]جامعة الكوفة, قسم الهندسة الكيمياوية

الخلاصة

عملية تقدير الاحتياطي مستمرة خلال حياة الحقل بسبب المخاطر وعدم الدقة التي تعتبر مشكلة متوطنة وبالتالي يجب دراستها. علاوة على ذلك ، يمكن تعريف المحتوى الهيدروكاربوني الحقيقي والمعروف بشكل صحيح فقط عند نفاد الحقل. ونتيجة لذلك ، فإن التحدي المتمثل في تقدير الاحتياطي هو دالة الوقت والبيانات المتوفرة. يمكن تقسيم تقدير الاحتياطي إلى خمسة أنواع من القياس: التشابة ، الحجمي ، تحليل منحنى الانحدار ، توازن المواد ومحاكاة المكمن ، يختلف كل منهما من نوع لآخر عن نوع البيانات المطلوبة. يعتمد اختيار الطريقة المناسبة والملائمة على نضج المكمن وعدم التجانس في المكمن والحصول على البيانات المطلوبة. في هذا البحث ، تم استخدام ثلاثة أنواع من تقدير الاحتياطيات المستخدمة في تكوين مشرف / حقل عمارة النفطي الطريقة الحجمية في صيغة رياضية (الجانب الحسابي) وتقنية مونت كارلو للمحاكاة (الجانب الاحتمالي) ، معادلة توازن المواد المحددة بواسطة برنامج MBAL ومحاكاة المكمن بواسطة برنامج Petrel المعتمد الجانب الجيولوجي. تم تطبيق نتائج هذه الطرق الثلاثة بالطريقة الحجمي في الجانب الحسابي الذي يساوي (2.25 MMMSTB) والجانب الاحتمالي يساوي (1.24 ، 2.22 ، 3.55) MMMSTB P90، P50 ، P90 على التوالي. تم تحديد OOIP بواسطة برنامج MBAL يساوي (2.82 MMMSTB). وأخيرا حساب حجم OOIP باستخدام الموديل الجيولوجي بترال كانت (1.92 MMMSTB). وكانت النسبة المئوية للخطأ بين توازن المواد والمعادلة الحجمية تساوي 20٪ بينما كانت النسبة المئوية للخطأ بين المعادلة الحجمية و الموديل الجيولوجي هي 17٪.

الكلمات الدالة: حساب المخزون, محاكاة مونت كارلو