Investigating the Effect of Input Data Uncertainties in Material Balance Calculations for Hydrocarbon Reservoirs

Hazim N. Dmour, Mohammed S. Bageri and Mostafa M. Kinawy
Petroleum and Natural Gas Engineering, King Saud University, Riyadh, Saudi Arabia
Email: hdmour@ksu.edu.sa, msb84@live.com, mkinawy@ksu.edu.sa

***Abstract*—Material balance analysis is an interpretation method used to determine the original oil and gas in place and to predict petroleum reservoir performance based on production and static pressure data analysis, also to evaluate the remaining reserves by applying the principle of material balance to rate-time decline analysis. Material balance techniques are widely used throughout all phase of reservoir development, providing a dynamic measure of hydrocarbon volumes and an estimate of key reservoir parameters. The purpose of this study was the quantification of the uncertainties in the estimation of original hydrocarbon in place. An extensive sensitivity analysis was conducted to provide an insight into the features that must be accurately determined in order to obtain the value of the OGIP. Common tools that are frequently used in the petroleum industry such as Material Balance and Monte Carlo were used in combination to support investment decisions for field development. To deal with this challenge, an automated concept has been developed using Petroleum Experts MBAL™ software. The results showed that the estimation of OGIP by material balance calculations was very sensitive to the pressure and aquifer models data uncertainties. Therefore, the error in pressure data identified as the most significant source of the uncertainty in material balance estimations. Errors in Porosity distribution and net pay thickness are the main source of uncertainty in the properties of reservoir characteristics. Permeability was the important sources of uncertainty but not significant. Finally, encroachment angel and compressibility were the parameter with less uncertainty on material balance calculations. Therefore, the significant of this study is to investigate the effect of reservoir data uncertainties on material balance calculation.**

***Index Terms*—reservoir properties, data uncertainties, material balance calculation, OGIP estimation, tank model, simulation by MBAL, history matching, transmissibility**

NOMENCLATURE

B_{gi} = Initial gas formation volume factor, bbl/scf
B_g = Gas formation volume factor, bbl/scf
B_w = Water formation volume factor, bbl/scf
C_f = Formation compressibility, psi-1
C_w = Water compressibility, psi-1
G = Volume of gas originally in place, scf
G_{inj}= Gas injection, scf
G_p= Cumulative gas production, scf
GWC = Gas water contact, ft
OGIP = Original gas in place
P = Current reservoir pressure, psi
P_i= Initial reservoir pressure, psi
RF= Recovery Factor
RMSE = Root mean square error
S_{wi} = Initial water saturation,
W_e = Cumulative water influx, ft^3
W_{inj} =Water injection, ft^3
W_p =Cumulative water production, stb/ ft^3

I. INTRODUCTION

Reservoir Characterization is an important step before conducting any reservoir simulation studies. This step is needed to identify uncertainty range that we have in reservoir. This issue has been addressed by several authors in the previous years and their main objective has been to reduce the level of uncertainty in OGIP estimation.

Accurately estimating hydrocarbon reserves is important, because it affects every phase of the oil and gas business. Quantifying the uncertainties in original hydrocarbon in place (OHIP) estimates can support development and investment decisions for individual reservoirs. Thus, uncertainty quantification is an extremely important step. Common tools that are frequently used in the petroleum industry such as Material Balance and Monte Carlo were used in combination to support investment decisions for field development [1].

Mc-Ewen presented a statistical method which takes care of uncertainty in pressure data. The method forecasted the materials balance equation so that it gives the equation of a straight line through the origin thereby isolating the uncertainty in the dependent variable. The least square fitting technique was used to obtain results [2].

L. Mattar and R. McNeil introduced a new procedure called the flowing material balance to estimate original gas-in-place (OGIP). This procedure consists of a p/z plot of the flowing pressure (as opposed to the average shut-in reservoir pressure) versus cumulative production. A straight line drawn through the flowing pressure data and then, a parallel line, drawn through the initial reservoir

Manuscript received January 25, 2014; revised April 18, 2014.

doi: 10.12720/jiii.2.4.289-296

pressure will give the original gas-in-place. The study presented several methods for estimating the original gas in-place without shutting in a well [3].

Heather and Robert concluded the uncertainty comes from several sources: measurement errors, mathematical model errors, and incomplete data sets. All field and laboratory measurements, such as production and PVT data, involve some degree of error or inaccuracy, which may result from poor tool calibration or even human error. This kind of error can be reduced to some extent by using more accurate tools or increased human effort, but it will never be eliminated [4].

The most successful of the methods to calculate the aquifer productivity index in the Fetkovitch approach is one important parameter used to predict the water influx. It is determined by the reservoir properties, reservoir geometry, and fluid properties [5].

The major aim of this study is to investigate the impact of uncertainty in input variables on the production forecast and on reservoir original gas in place, OGIP estimation. Also to quantify the error in the fluid transmissibility across the fault and layers and to approximate the error between pressure data history matching and simulation.

To achieve the research objectives, the following approach is adopted:

- A combination of several software packages was utilized. These include: Petroleum Experts' suite of tools; MBAL™ and KAPPA's, Rubis™.
- Material balance models representing the layered reservoirs were constructed using Petroleum Experts MBAL software. An iterative nonlinear regression is used to automatically find the best mathematical fit for a given model. An error calculation tool was developed to determine the error limit between the computed and historical pressure data.

II. Mathematical Background

Material balance has been conventionally used as a useful method of estimating original oil in place and reservoir drive mechanisms [6] and [7]. Latest work has proven the material balance is a valuable tool in evaluating and analyzing complex hydrocarbon reservoir behavior and compartmentalization by means of single and multi-tank models [8]-[10].

A. Generalized MBE as a Straight Line

Havlena and Odeh [11] expressed the material balance in terms of gas production, the fluid expansion, and water influx, mathematically as:

$$G_pB_g + W_pW_p = G(B_g - B_{gi}) + GB_{gi}\frac{(C_wS_{wi} - C_f)}{1 - S_{wi}}\Delta P + W_e + (W_{inj}B_w + G_{inj}B_{ginj}) \quad (1)$$

Assuming no water or gas injection i.e.,$W_{inj} and G_{inj} = 0$, the above generalized MBE reduces to:

$$G_pB_g + W_pW_p = G(B_g - B_{gi}) + GB_{gi}\frac{(C_wS_{wi} - C_f)}{1 - S_{wi}}\Delta P + W_e \quad (2)$$

Using the nomenclature of Havlena and Odeh, "Eq. (1)" can be written in the following form:

$$F = G(E_g + E_{f,w}) + W_e \quad (3)$$

With the terms $F, E_g, and E_{f,w}$as defined by:
Underground fluid withdrawal

$$F = G_pB_g + W_pB_w \quad (4)$$

Gas expansion term:

$$E_g = B_g - B_{gi} \quad (5)$$

Water and rock expansion:

$$E_{f,w} = B_{gi}\frac{(C_wS_{wi} - C_f)}{1 - S_{wi}}\Delta P \quad (6)$$

"Eq. (2)" can be further simplified by introducing the total system expansion term E_t that combined both compressibilities $E_g$and $E_{f,w}$ as defined by:

$$E_t = E_g + E_{f,w} \quad (7)$$

To give:

$$F = GE_t + W_e \quad (8)$$

B. Error in History Match and Simulation (RMSE)

The Root Mean Square Error, (also called the root mean square deviation, RMSD, is a frequently used measure of the difference between values predicted by a model and the values actually observed from the environment that is being modeled. These individual differences are also called residuals, and the RMSE serves to aggregate them into a single measure of predictive power [12].

The RMSE of a model prediction with respect to the estimated variable Xmodel is defined as the square root of the mean squared error:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs,i} - X_{model,i})^2}{n}} \quad (9)$$

where Xobs is observed values and Xmodel is modeled values at time/place i.

A series of simulation models; A, B and C; are generated to different scenarios of leaking and sealing fault blocks. Commercially available simulator, MBAL, is used for modeling. The reservoir is divided by a leaking fault and modeled as two communicating tanks, where both tanks are joined by an aquifer as shown in "Fig. 1,".Petrophysical properties of the two reservoirs are identical except the original gas in place.

Once the application is run, the error of each solution can be reviewed by using the Root Mean Square Error to measure the difference between history pressure and simulation pressure.

III. Case Field Study

A real field data of gas reservoirs was used in this study in order to achieve realistic results. The field consists of four sedimentary rock layers and the fault divides two of them into downthrown and upthrown. The downthrown part is represented by one reservoir A. And the upthrown part is represented by two reservoirs B and C, also the field consists of reservoir D and E. It has a maximum gross thickness of 121ft and porosity range from 22 to 34%.

Five producer wells were drilled during the early life of the field in which it contains dry gas and the initial reservoir pressure was 3097 psi. The production started on March 2003 and produces hydrocarbons from two separate reservoirs A and C. The gas production rate is around 285 and 190 MM scf/day respectively. Also gas water contact, GWC, is 6552ft and 5925ft in reservoir A and C.

Reservoirs A and C have been producing for about 7 years. The data which the study focuses in about dry gas reservoirs. The Data include 5 reservoirs A, B, C, D and E. Reservoir A consists of 3 wells W3, W4 and W5. Reservoir C consists of 2 wells W1, and W2. And the other reservoirs B, D and E are not produce up to now.

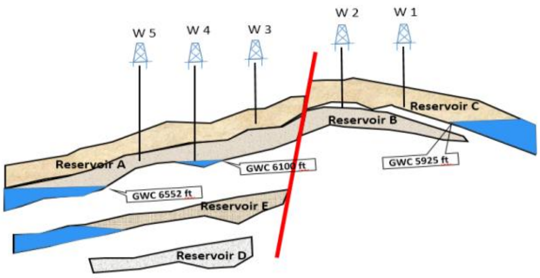

Figure 1. Field vertical cross-section map

A. Reservoir Model Design

By using the graphical interface of MBAL, the modeling of the gas reservoir can be facilitated. For building the model, the reservoir various components should be sketched. All the reservoir components such as tanks, wells and transmissibilities (communication between tanks) are represented by unique graphical objects which may be easily manipulated on the screen. As components are added, the relevant input screens and fields are displayed prompting for the appropriate data to be entered. As shown in the section above.

1) Model A

The first set of MBAL model built addressed each of the reservoirs as individual reservoir units with no communication between them. The models were properly calibrated using the known reservoir properties and production history "Fig. 2,"

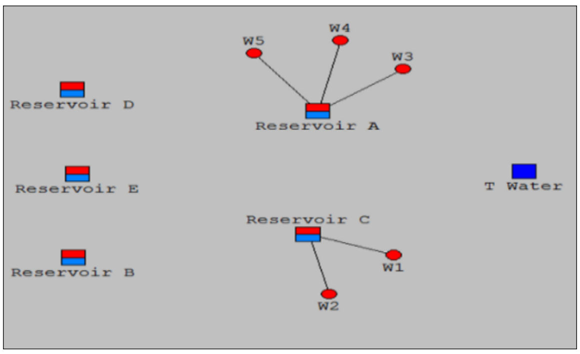

Figure 2. Model A, no communication between the tanks

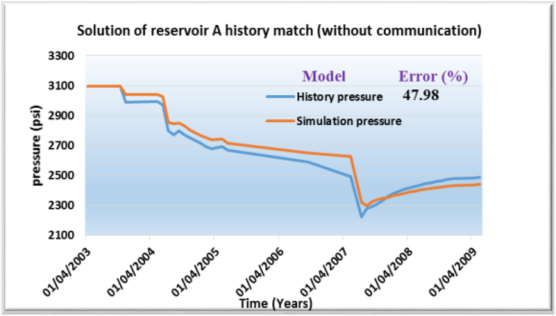

Figure 3. Pressure history match, with no communication between the tanks "reservoir A"

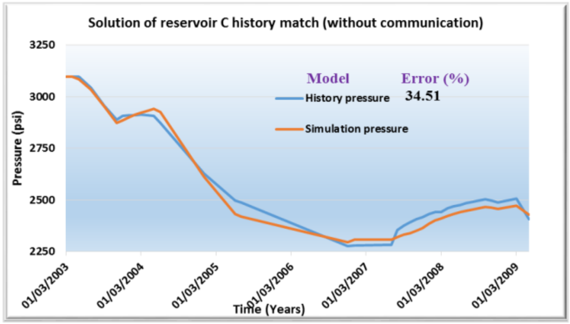

Figure 4. The pressure history matching, with no communication between the tanks "reservoir C"

The "Fig. 3" and "Fig. 4," highlighted that the reservoir performance solution obtained were poorly matched to history for the individual reservoir models produced unrealistic results, which were not representative of known reservoir properties, even after severally repeated regressions that the concept of single tank representation of these reservoirs was discarded. Also, the fit case without communication had significant error when compared to the observed pressure trend.

2) Model B

In this model, the predominant drive mechanism in the gas reservoirs with aquifer models has been investigated. Several models have been developed for estimating water influx, based on assumptions that describe the characteristics of the aquifer. Due to inherent uncertainties in the aquifer characteristics, all the proposed models require historical reservoir performance data to evaluate constants representing aquifer property parameters.

The mathematical water influx models that are commonly used in this study include:

- Hurst-van Everdingen -Dake Linear
- Hurst-van Everdingen -Dake Radial
- Fetkovich Steady State Linear
- Fetkovich Steady State Radial
- Fetkovich Semi Steady State Linear
- Fetkovich Semi Steady State Radial
- Carter-Tracy

Also the uncertainty of the reservoir transmissibility and material balance, MBAL, data was used to assess likelihood of cross-fault communication and to build a multi tank model with potential intra-tank transmissibility's "Fig. 5." The reservoirs net pay thickness is 410 and 250ft and the porosity is 22% for both reservoirs A and C respectively.

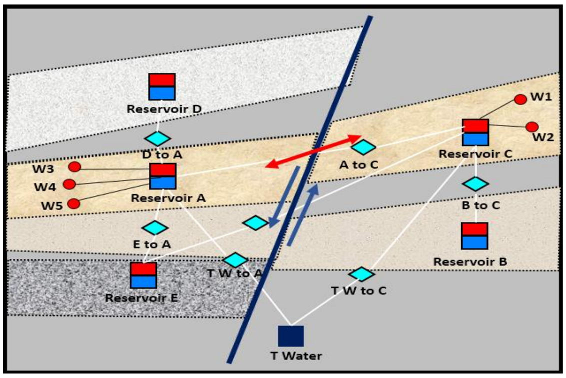

Figure 5. MBAL Multi-tanks model

3) 3D Model

An interactive 3D reservoir numerical model was built in order to visualize the field dimensions, wells location and fault position as it looks by using Rubis software from KAPPA package.

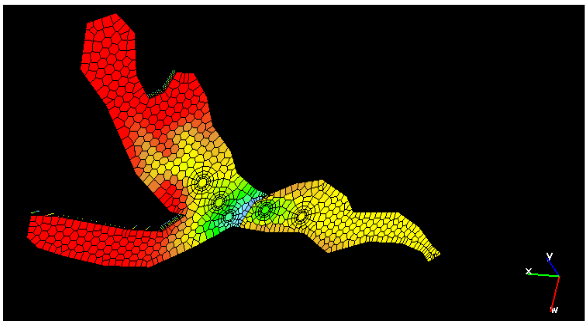

Figure 6. The 3D Model illustrates the pressure distribution

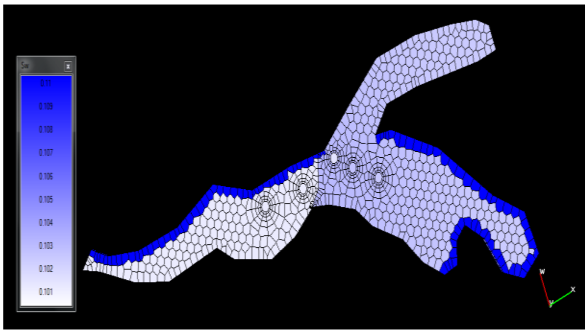

Figure 7. The aquifer during the life of the field

Tanks properties such as OGIP, Porosity, Saturation, Aquifer size/strength and fluid properties were considered as variables. Transmissibility between tanks was also considered as a variable.

The result of the runs is illustrated by the "Fig. 6," and "Fig. 7", The aquifer models used in the reservoirs A and C is linear aquifer models from Fetkovich, steady state, and Hurst-van Everdingen and Dake, Linear. The results show that the OGIP will be less than the cumulative gas production. The "Fig. 8," and Table I shows the results of the all aquifer driving models that has been used in quantifying the OGIP and the percentage of error in estimating the OGIP.

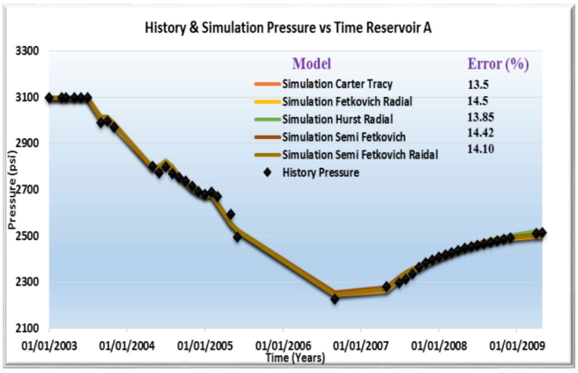

Figure 8. History matching and simulation with different aquifer models for reservoir A

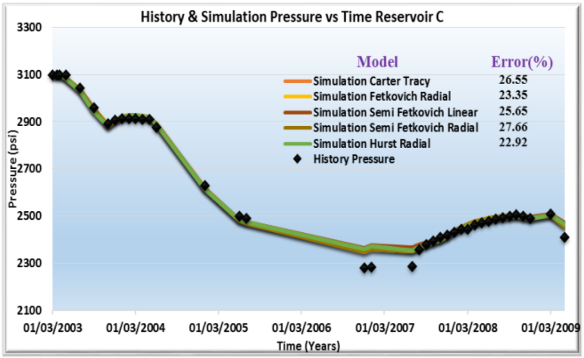

Figure 9. History matching and simulation with different aquifer models for reservoir C

TABLE I. THE PRESSURE ERROR IN DIFFERENT AQUIFER MODELS IN MODEL B

Aquifer Models	Root Mean Square Error (RMSE)	OGIP Volum. (Bscf)	Cum Gas Production (Bscf)	OGIP Material Balance (Bscf)	RF
Carter Tracy Reservoir A	13.5	570	285.7	350.7	81.4
Fetkovich Radial Reservoir A	14.2	570	285.7	431.9	66.1
Hurst Radial Reservoir A	13.8	570	285.7	375.9	76.0
Semi Fetkovich Linear Reservoir A	14.4	570	285.7	407.4	70.1
Semi Fetkovich Radial Reservoir A	14.1	570	285.7	407.4	70.1
Carter Tracy Reservoir C	26.5	310	190.1	254.7	74.6
Fetkovich Radial Reservoir C	23.3	310	190.1	246.5	77.1
Hurst Radial Reservoir C	25.6	310	190.1	238.9	79.5
Semi Fetkovich Linear Reservoir C	27.6	310	190.1	231.9	81.9
Semi FetkovichRadial Reservoir C	22.9	310	190.1	242.6	78.3

4) Model C

Various analytical aquifer models were tested in a bid to model the geometry of the reservoir. After selecting a representative aquifer model that captures the physics of the reservoir in this case, the aquifer models selected for reservoir A linear aquifer model from Semi-Fetkovich steady state and reservoir C represented by the radial aquifer model from Fetkovich steady state. In this model the thickness is 12 and 88 ft and the porosity is 34% for reservoirs A and C respectively "Fig. 9,"

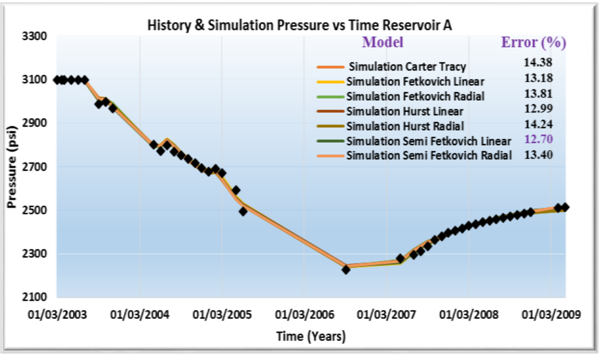

Figure 10. History matching and simulation with different aquifer models for reservoir A

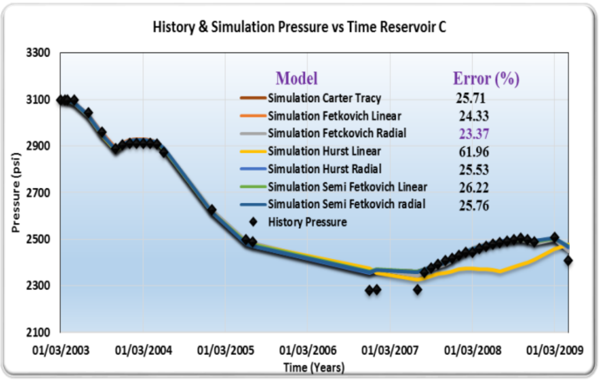

Figure 11. History matching and simulation with different aquifer models for reservoir C

The solution with the least minimum % error was selected with the corresponding set of new reservoir properties. The material balance model was re-calibrated using the new set of reservoir properties.

TABLE II. THE PRESSURE ERROR IN DIFFERENT AQUIFER MODELS IN MODEL C

Aquifer Models	Root Mean Square Error, RMSE	OGIP Volum. (Bscf)	Cum Gas Production (Bscf)	OGIP MB (Bscf)	R F
Carter Tracy Reservoir A	14.3	570	285.7	418.6	68.2
Fetkovich linear Reservoir A	13.1	570	285.7	372.3	76.7
Fetkovich Radial Reservoir A	13.8	570	285.7	394.1	72.4
Hurst linear Reservoir A	12.9	570	285.7	358.3	79.7
Hurst Radial Reservoir A	14.2	570	285.7	404.6	70.6
Semi Fetkovich Linear Reservoir A	12.7	570	285.7	360.1	79.3
Semi Fetkovich Radial Reservoir A	13.4	570	285.7	369.7	77.2
Carter Tracy Reservoir C	25.7	310	190.1	279.5	67.9
Fetkovich linear Reservoir C	24.3	310	190.1	200.9	94.5
Fetkovich Radial Reservoir C	23.37	310	190.1	232.3	81.8
Hurst linear Reservoir C	61.9	310	190.1	260.8	72.8
Hurst Radial Reservoir C	25.5	310	190.1	263.1	72.2
Semi Fetkovich Linear Reservoir C	26.2	310	190.1	260.6	72.9
Semi FetkovichRadial Reservoir C	25.7	310	190.1	268.9	70.6

The best match of history pressure with simulation pressure and minimum error of pressure difference, "Fig. 10," and "Fig. 11". The aquifer models used in the reservoir A linear aquifer model from Semi-Fetkovich steady state and reservoir C represented by the radial aquifer model from Fetkovich steady state. Aquifer models are shown in Table II.

Values on transmissibilities are presented in Table III and other regressed parameters for each tank in Table III. It is important to bring to attention that parameters such as OGIP, permeability, reservoir thickness and porosity for the reservoir A and C were not allowed to iterate during the regression as they tend to grow out of proportion giving unrealistic geological results.

Analyzing the results from the transmissibilities in Table IV and Table V one can infer that in order to history match the data and the regressions results. The value of T1 indicates that there is communication between the reservoir A and reservoir C which corresponds to the fault. However, the values of T2, T3 and T4 indicate that there is strong communication between the reservoir B to c and reservoirs E and D to A. Furthermore the value of T 5 indicates that there is no communication between the reservoir E and reservoir C. T6 shows communication between the reservoir A and Tank TW, aquifer. The value of T7 indicates that there is almost communication between the reservoir C and Tank TW, aquifer.

TABLE III. THE RESULTS OF REGRESSION OF MBAL MODEL WITH DIFFERENT TRANSMISSIBILITIES VALUES

Parameters	**Transmissibility**(RB/day*cp/psi)			
		T 1	**T 2**	**T 3**
	The Method	A to C	B to C	D to A
Input	Before	3.5	1.5	1.5
Output	After	10.7	79.9	5.9

Parameters	**Transmissibility**(RB/day*cp/psi)			
	T 4	**T 5**	**T 6**	**T 7**
The Method	E to A	E to C	T W to A	T W to C
Before	1.5	1.5	115	115
After	3.7	1.09E-80	174.1	3.19E+02

A summary of the results obtained from reservoir A and C which had become accepted as representative of both reservoir are as shown in "Fig. 12," and "Fig. 13".

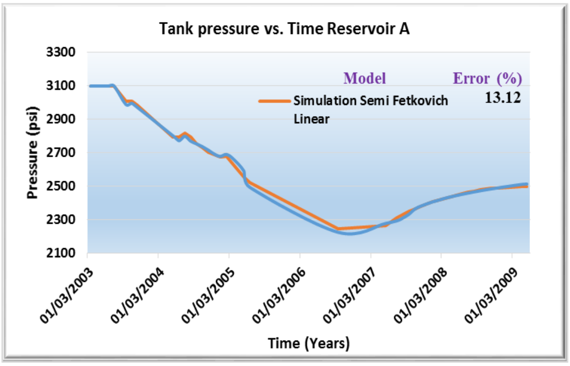

Figure 12. The best match for reservoir A with min. error

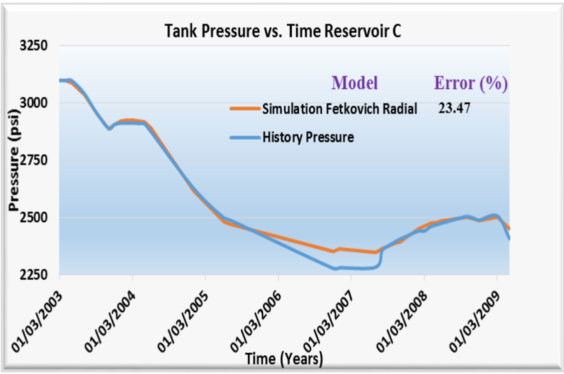

Figure 13. Best match for reservoir C with min. error

TABLE IV. THE RESULTS OF REGRESSION ANALYSIS OF A DIFFERENT TANK PARAMETERS FOR RESERVOIR A

Parameters	Before	After
Root Mean Square Error (RMSE)		13.12
OGIP (Bscf)	570	376.5
Cum Gas Production (Bscf)	285.7	
Recovery Factor (%)	50.12281	75.8
Aquifer Volume (MMft3)	26500	
Reservoir Width(feet)	4950	
Reservoir Thickness(feet)	121	115
Porosity (%)	34	34
Aquifer Permeability (mD)	200	208.3
Formation Compressibility (psi-1)	2 e-05	1.91e-05

TABLE V. THE RESULTS OF REGRESSION ANALYSIS OF A DIFFERENT TANK PARAMETERS FOR RESERVOIR C

Parameters	Before	After
Root Mean Square Error (RMSE)		23.4
OGIP (Bscf)	310	225.4
Cum Gas Production (Bscf)	190.1	
Recovery Factor (%)	61.3	84.3
Outer/Inner radius	2.5	
Encroachment Angel (deg)	60	
Reservoir Radius (feet)	17500	
Reservoir Thickness(feet)	88	77.8
Porosity (%)	34	34
Aquifer Permeability (mD)	200	240.4
Formation Compressibility (psi-1)	2 e-05	2 e-05

The total gas in place value of gas reservoirs A and C by using MBAL software calculation are 376.5 BCF and 225.47 BCF and previous gas reserve estimate were 570 BCF and 310 BCF respectively. In May 2009, the cumulative production of the reservoirs A and C are 285 BCF and 190 BCF. Thus the overall gas in place recovery of the reservoirs respectively is 75.87% and 84.31%.

B. Reservoir Drive Mechanism

The reservoir drive mechanism is established after obtaining the right reservoir model through the history match procedure which was stated above. The plot of historical drive mechanism for both reservoirs with three primary energy sources is shown in "Fig. 14," and "Fig. 15". The graphical representation of the historical fractional, contribution of energy from the aquifer, fluid expansion and pore volume compressibility are shown in "Fig. 16" and "Fig. 17".

The result of the material balance evaluation shows that reservoir A is supported by fluid expansion with little aquifer support. On the other hand reservoir C is supported by fluid expansion 60% with strong aquifer support 40%.

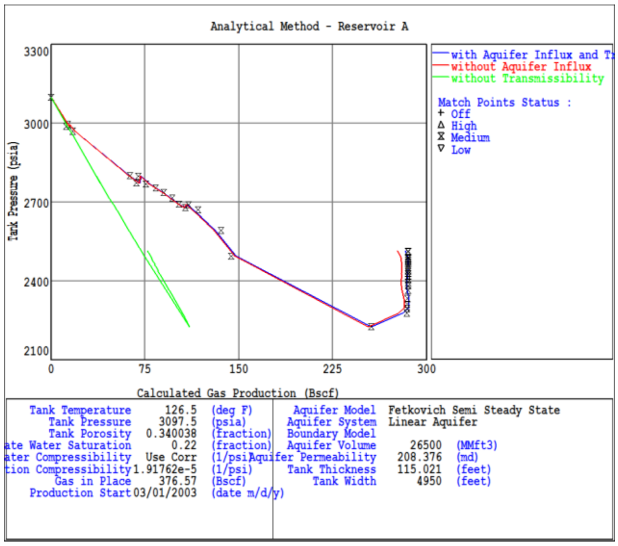

Figure 14. The analytical regression with aquifer influx and transmissibility for reservoir A

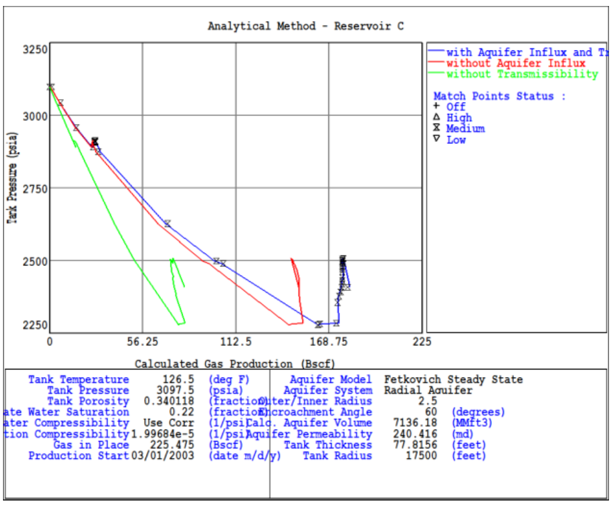

Figure 15. The analytical regression with aquifer and transmissibility for reservoir C

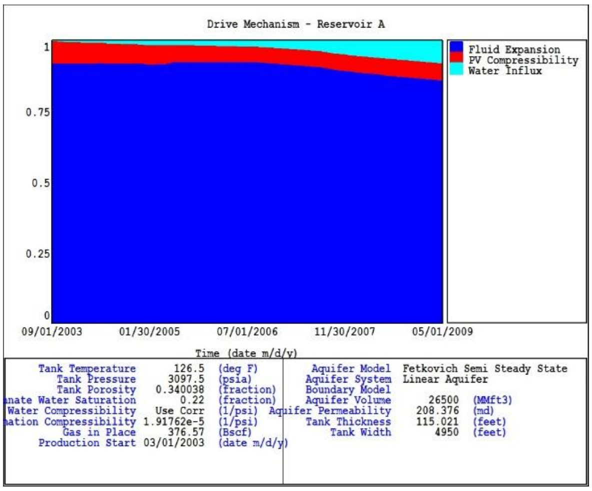

Figure 16. Energy plot of historical drive mechanism of reservoirs A

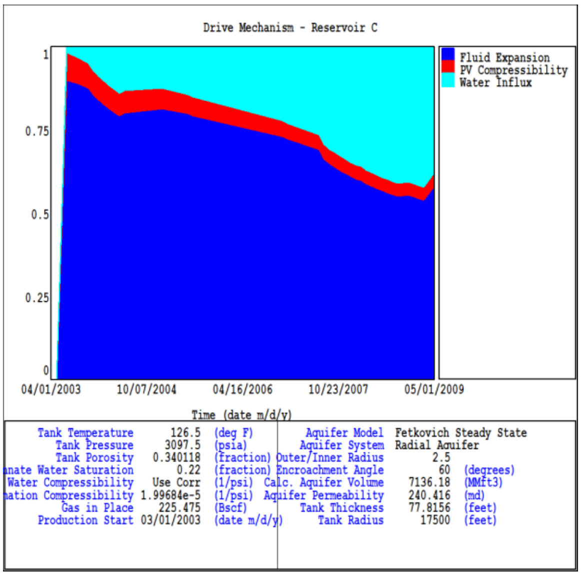

Figure 17. Energy plot of historical drive mechanism of reservoirs C

IV. Conclusion and Recommendation

The results showed that the estimation of the OGIP by material balance calculations is very sensitive to pressure and aquifer models data uncertainties. Therefore, the error in pressure data identified as the most significant source of the uncertainty in material balance estimations. In model A the fit case without communication between the tanks had significant error when compared to the observed pressure trend. Also the result highlighted that the reservoir performance solution obtained were poorly matched to history for the individual reservoir models produced unrealistic results, which were not representative of known reservoir properties, even after severally repeated regressions that the concept of single tank representation of these reservoirs was discarded.

In model C analyzing the results from the transmissibilities on Table IV and Table V can infer that in order to history match data and the regressions results. The value of T1 indicates that there is communication between the reservoir A and reservoir C which corresponds to the fault.

Fetkovich method is much simpler than the van Everdingen-Hurst method or the Carter-Tracy method, and doesn't require the use of superposition. The Fetkovich method neglects the effects of any transient period. The evaluation of pressure and aquifer models uncertainty indicates that estimation of OGIP is sensitive to the material balance calculation. Pressure errors were the most source of the uncertainty in material balance estimations. Porosity and thickness of errors were also significant. Encroachment angle and compressibility were less significant.

Acknowledgements

The authors of this paper would like to acknowledge the Research Center of College of Engineering, Deanship of Scientific Research, at King Saud University for providing the finance support for this study also our further appreciation goes to Petroleum Experts and KAPPA for granting the academic software licenses.

References

[1] V. R .Gina, L. Saputelli, J. Patino, A. Chacon, and R. Solis, "Reserves estimation uncertainty in a mature naturally-fractured carbonate field located in Latin America," *OTC presented at the Offshore Technology Conference Brasil held in Rio de Janeiro*, Brazil, October, 2011.PP.20

[2] P. Jozsef, *Development of Petroleum Reservoirs: Theory and Practice*, Akademiai Kiado Budapest, Hungary, October 2003.

[3] L. Mattar and R. McNeil, "The flowing gas material balance," *Journal of Canadian Petroleum Technology*, vol. 37, no. 2, February 1998.

[4] R. A. Heather, "Characterizing uncertainty in oil and gas evaluations," *SPE*, Texas, 2001.

[5] M. J. Fetkovich, "Simplified approach to water influx claculations-finite aquifer systems," *JPT*, p. 814-828, 1971.

[6] B. A. Craft, *Applied Petroleum Reservoir Engnieering*, Englewood Cliffs: Prentice-Hall Inc., 1991.

[7] E. Esor *et al.*, "Use of material balance to enhance 3D reservoir simulation: A case study," in *Proc. SPE Annual Technical Conference and Exhibtion*, Houston,Tx: SPE 90362, September 2004.

[8] M. A. E. Ela, "Reservoir characterization from material balance results analysis," in *Proc. International Oil Conference and Exhibtion*, Veracruz Mexico: SPE 108648, June 2007.

[9] J. Mazloom, *et al.*, "Capture complex dyanmic behavior in a material balance model," *International Petroleum Technology Conference*, Dubai: IPTC, 2007.

[10] A. Dobbyn, *et al.*, "Material balance: A poweful tool for understanding the early peformance of the schiehallion field," Aberdeen Scotland : SPE 71819, September 2001.

[11] A. Tarek, *Advanced Reservoir Engineering*, USA: Gulf Professional Publishing, 2005.

[12] J. Wiley, *Analysis of Financial Time Series*, 2nd ed., Canada: John Wiley&Sons, Inc., 2005.

Hazim N. Dmour is an Associate Professor of Petroleum and Natural Gas Engineering at King Saud University, Saudi Arabia. Dr. Dmour Holds B.S., M.Sc. and Ph.D. Degrees in Petroleum and Natural Gas Engineering from Miskolc University, Hungary. He Received his Ph.D. Degree in 1995. At King Saud University; his Undergraduate and Postgraduate Teaching Areas Include Petroleum Engineering Fundamentals, Reservoir Simulation, Advance Well Testing, Advance Gas Technology, Numerical Methods, Gas Reservoir Engineering and Development of Numerical Reservoir Simulation Technology. His Research Interest Includes Design and Evaluation of Well Testing, Well Performance, Stimulated Gas and Oil Wells and

Enhanced Of Different Computational Techniques. He has Several Dozen-Research Papers in Well-Known International Technical Journals Such as Petroleum Science and Technology, Nafta, and SPE Journal. Dr. Dmour Previously Practiced in Industry as a Senior Reservoir Engineer with NPC of Jordan and MOL Rt. of Hungary, and he is a Registered Professional Engineer in Jordan and SA with 18 years of Industrial experience.

Mohammed S. Bageri is a Petroleum Engineer and M.Sc. Students at the Department of Petroleum and Natural Gas Engineering, King Saud University. He was graduated from Hadramout University, Yemen. The Field of his Research: Gas Reservoir Engineering (MBE), Reservoir Simulation and Production Engineering.

Mostafa M. Kinawy is an Assistant Professor of Reservoir Engineering at King Saud University, Department of Petroleum and Natural Gas Engineering. He Holds B.Sc., M.Sc. and PhD. Degree in Reservoir Engineering from AlAzhar University, Egypt. He has More than 20 Years of Teaching Experience in the Field of Reservoir Engineering, Petrophysics Analysis and Water Flooding. Mainly his research interests in reservoir engineering.