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Production Performance Prediction in Coalbed Methane Reservoir

Based on Actual Production Data (Gas Water Ratio Plotting)

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***Abstract* - Energy demand in the world in general and in Indonesia in particular is growing rapidly. Coal Bed Methane (CBM-Coalbed Methane) can be used as an alternative energy accompanying fossil energy (oil and gas). Indonesian CBM resources could potentially have a very large (estimated at 450 TSCF) are spread in various islands in Indonesia. CBM exploitation and development methods (unconventional gas) is different from the usual in gas reservoirs (conventional gas). So many methods or technical issues that still need to be investigated. Forecasting the behavior (performance) production of both gas and water in the reservoir unconventional Coalbed Methane (CBM) reservoir found at the beginning or during production is always necessary to be able to better manage the future reservoir. The flow rate is a function of reservoir characteristics of coal (both static and dynamic characteristics). The purpose of this research is to develop methods and procedures or guidelines (guidelines) in predicting the flow rate of gas and water, based on a plotting function for example: Cumulative Water Gas Ratio, Gp (Cumulative Gas Production), and time, for a production that has been advanced (mature),**

Keywords : Coalbed Methane, Gas Water Ratio Plotting, Production Performance Prediction,

I.INTRODUCTION

After various experiments conducted on the development of the plots of this method GWR vs. Time, it produces a straight line on a linear scale while the QW vs. Time, produces a straight line on a logarithmic scale, so that the two are plotting the results, it can be used as a method of production flow rate prediction in the future integrated (gas and water) at the time of the gas
and the water has undergone initial production decline. Difference of this method compared with the development of Decline Curve method that has been widely used for this is the gas flow rate and water in an integrated predictable. Water flow rate is also predicted also can be used to anticipate the amount of water produced, so that the corresponding surface facility (water treatment, etc.) can be prepared in advance. Figure 1 shows a flow diagram of the development methods in this study.
The data used for the calculation of the study are:
Plotting of Production Ratio (Gas - Water Ratio Plotting).

1. Single wellbore Simulation Model for Plotting GWR.
2. Linearity of CBM Pilot Performance for GWR Plot - Indian Field Data (Pilot Project).
3. Linearity of CBM-Field Data for GWR Plot - Fekette's Field Data.
4. Linearity of CBM-Field Data for GWR Plot – the "Z" Basin, Colorado Field's Data (5 wells).

Method of Testing Results

The results of the development of this method using data CBM field in America and India. Necessary to explain that the data from the field of CBM in Indonesia has not been available until now, because there is no field of CBM production.

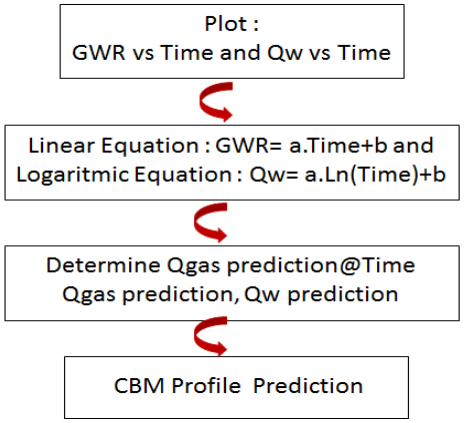

Figure 1 *Procedure of The Prediction of CBM production profiles.*

Plotting Production Ratio Method

The purpose of this method is to find a relationship or function, in order to obtain gas production forecasting and integrated water. This method is different from the "Decline Curve", which on the prediction method to predict gas and water separately.

1. Synthetic Data of CBM Reservoir Simulation in the Field 'X' Kaltim.
   This method is used to test the reservoir simulator with the input data used for the East Kalimantan region (sub-bituminous).
   In Figure 2 is a simulation model of the field 'X' in East Kalimantan, which will predict the water flow rate and gas phase when using GWR Plotting decline curve.

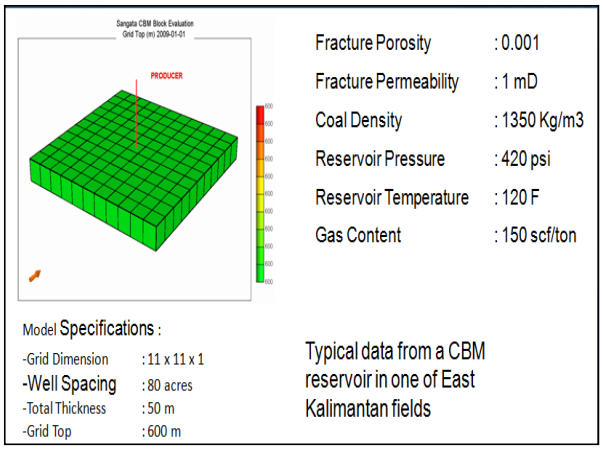

Figure 2 *CBM reservoir data from the field 'X' East Kalimantan.*

In Figure 3 is a CBM production profiles with the predictions of its gas and water rate by using a reservoir simulator.
Seen in Figure 4 plots the trendline from the Water Gas Rate with Time is a straight line on a linear scale. The results of the line equation: **Y = X-9.97609E +00 8.1875E +02.**

Seen in Figure 5 plots the trendline from the Water Rate with Time is a straight line on a logarithmic scale. The results of the line equation: **Y = X ^ 1.26209E +09 2.30793E +00**

In Figure 6 is a comparison between the proposed method (GWR - Water Rate Plotting) Prediction with simulation results. Results of the two curves are very comparable. This indicates that GWR - Water

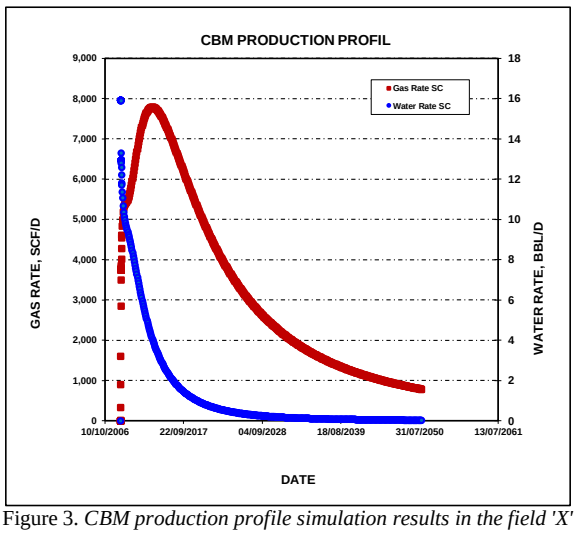

Figure 3. *CBM production profile simulation results in the field 'X' East Kalimantan*

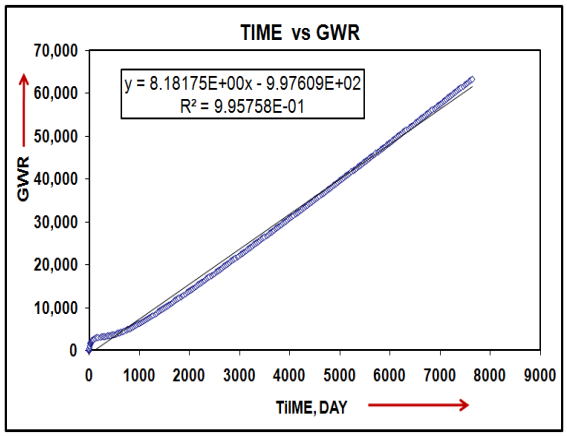

Figure 4 *Trendline from water gas ratio vs. time*

Rate decent Plotting used to predict the rate of gas-water wells have been in production conditions to reach peak or maximum production and production is in decline (decline curve).

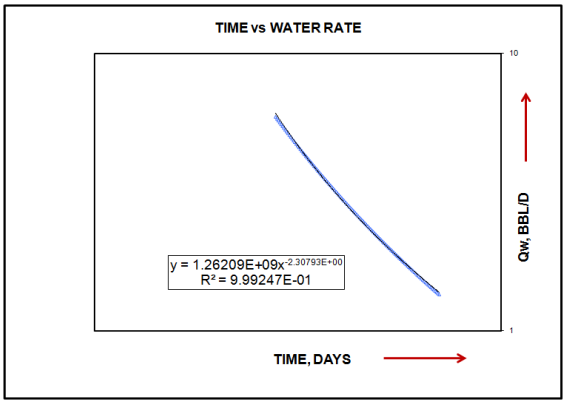

Figure 5 *Trendline of water rate vs. time*

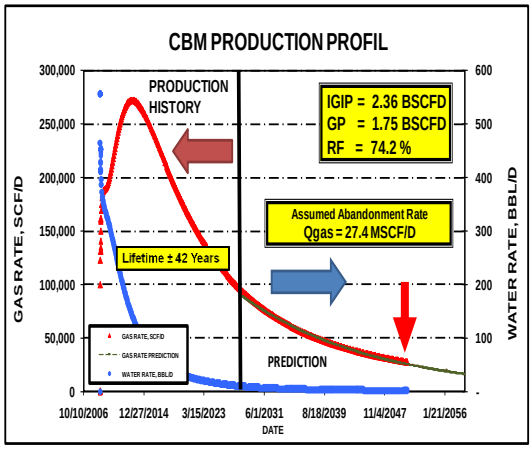

Figure 6 *Predicted behavior of CBM produc-tion in the field 'X' East Kalimantan.*

2. Linearity of CBM Pilot Performance for GWR Plot-Indian Field Data In Figure 7 is the actual production profiles of wells from CBM pilot project in India. In the pilot project, the gas production peaked after approximately 5 and after that began to decline in production. Water production began to fall in the months to.
3. In Figure 8a is a plot between GWR vs. Time, while Figure 8b is from GWR Plotting trendline indicating a linear line.

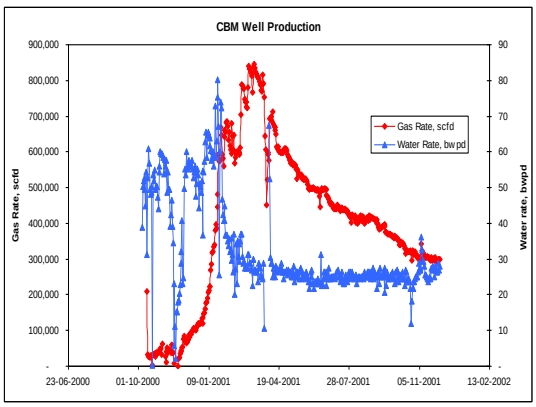

Figure 7 *Profile of CBM production in the field 'Y' India.*

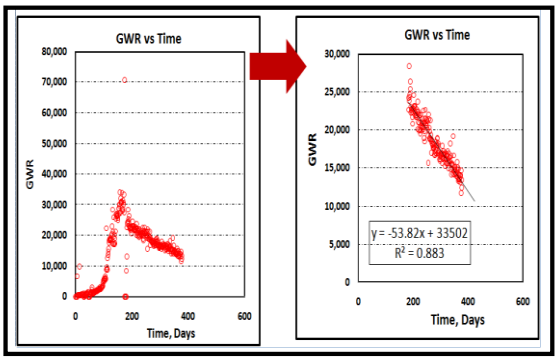

Figure 8 *Trendline from water gas ratio vs. time.*

In Figure 9a is a plot between the Water Rate vs. Time, while Figure 9b is the trendline from the Water Rate Plotting showing linear line on a log scale.

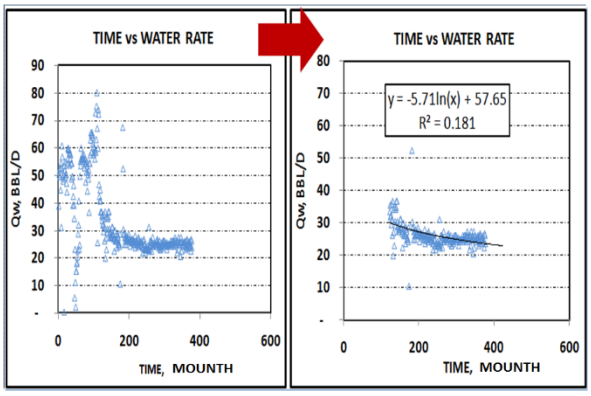

Figure 9 *Trendline of water rate vs. time.*

In Figure 10 is a production history followed by Gas-Water Rate Prediction results of the proposed methods wells 'Y' of CBM in India namely GWR - Water Rate Plotting.

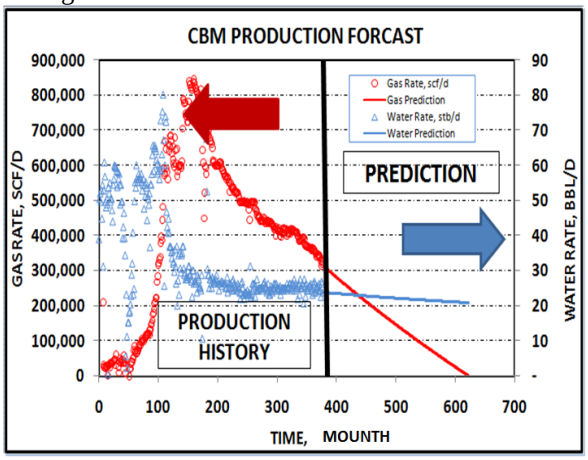

Figure 10 *Predicted behavior of CBM production in the field 'Y' India.*

4. Linearity of CBM-Field Data for GWR Plot-Colorado's Field Data.

There are 4 pieces CBM wells into data from Water Gas Ratio Method in the field plotting "Z", Colorado.

a. Plotting Water Gas Ratio Method for Colorado's well CBM Field Data

In Figure 11 is the actual production profile of the well No. 7 from the field of CBM in the "Z" Basin, Colorado Field, where his gas-water rate will be predictable.

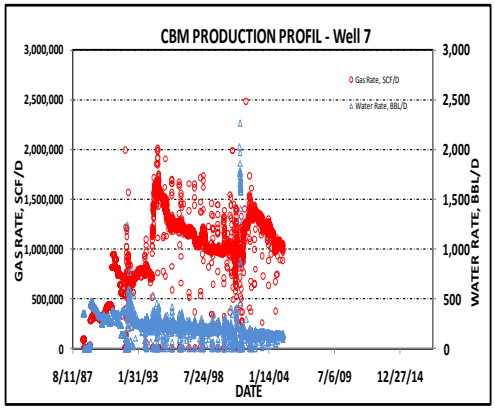

Figure 11 *Profile of CBM production wells 7 Colorado Field.*

In Figure 12 is a plot between GWR vs. Time, well no 7 from the field in the "Z" Basin, CBM Field, Colorado Field which produces a linear line.

In Figure 13 is a plot between the Water Rate vs. Time, well no 7 from the field in the "Z" Basin CBM, Colorado Field which produces a linear line on a loga-rithmic scale.

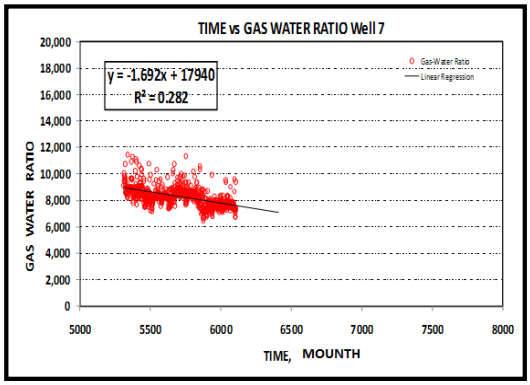

Figure 12 *Trendline from water gas ratio vs. time well 7 Colorado.*

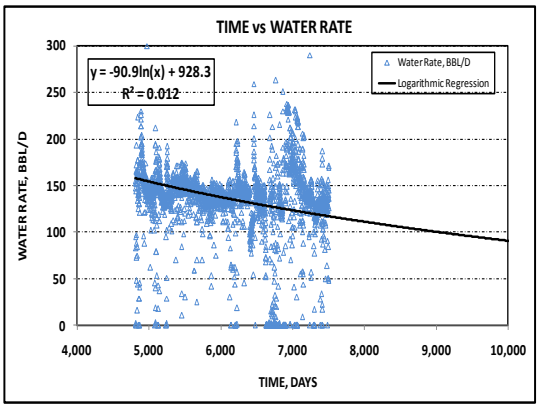

Figure 13 *Trendline from water gas ratio vs. time well 7 Colorado.*

In Figure 14, a production history followed by Gas-Water Rate Prediction results of the proposed methods wells No. 7 from the field in the "Z" Basin CBM well, Colorado Field the GWR - Water Rate Plotting.

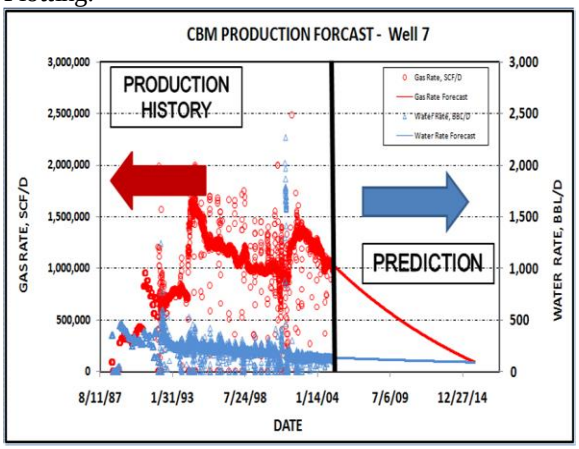

Figure 14 *Predicted behavior of CBM production wells 7 Colorado.*

b. Plotting Water Gas Ratio Method at 19 CBM wells Colorado's Field

In Figure 15 is the actual production profile of the well no 19 from the field in "Z" Basin, CBM Field, Colorado Field, where his gas-water rate will be predictable.

c. In Figure 16 is a plot between GWR vs. Time, wells no 19 from the field in the "Z" Basin, CBM well, Colorado Field which produces a linear line.

d. In Figure 17 is a plot between the Water Rate vs. Time, wells no 19 from the field in the "Z" Basin, CBM Well, Colorado Field which produces a linear line on a loga-rithmic scale.

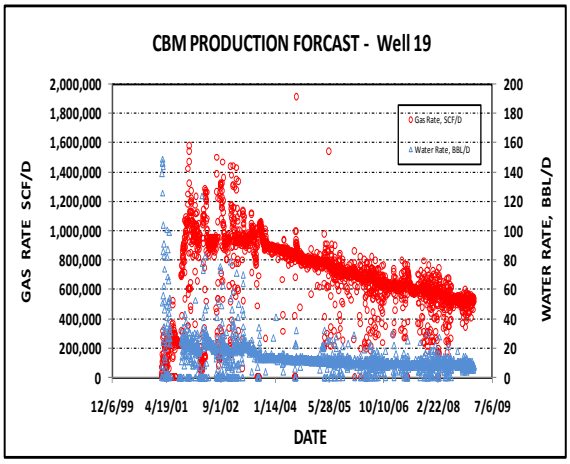

Figure 15 *Profiles 19 CBM production wells Colorado.*

In Figure 18, a production history followed by Gas-Water Rate Prediction results of the proposed methods wells no 19 from the

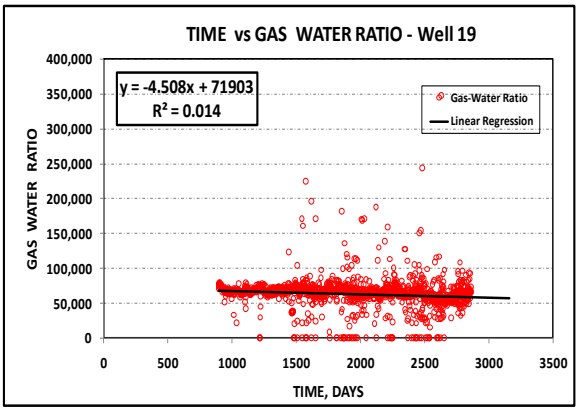

Figure 16 *Trendline from water gas ratio vs. time 19 wells Colorado.*

field in the "Z" Basin, CBM Well, Colorado Field the GWR - Water Rate Plotting.

e. Plotting Water Gas Ratio Method 11 CBM wells Colorado's Field In Figure 19 is the actual production profile of the well no 11

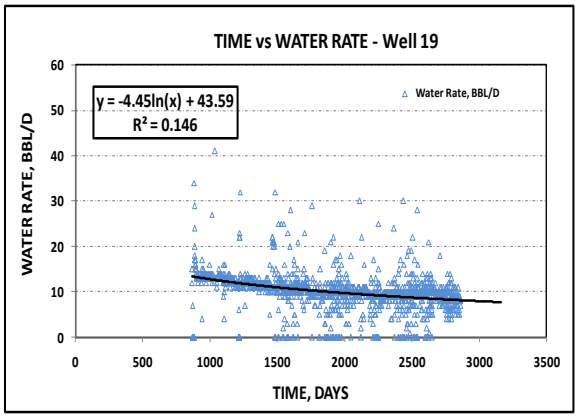

Figure 17 *Water rate vs. time 19 wells Colorado.*

from the field in the "Z" Basin, CBM Field, Colorado Field, where his gas-water rate will be predictable.

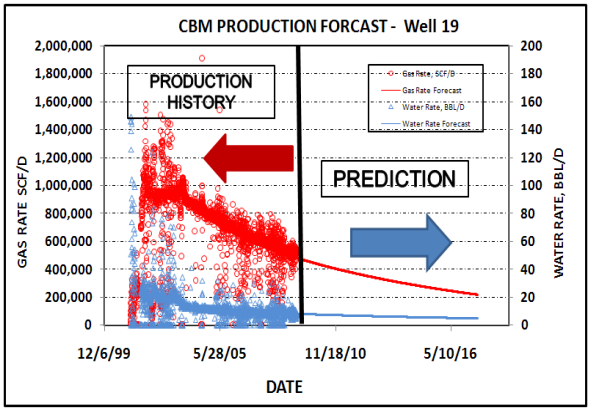

Figure 18 *Predicted behavior of CBM production wells 19 Colorado.*

In the figure 20 is a plot between GWR vs. Time, wells no 11 from the field in the "Z" Basin, CBM Field, Colorado Field produces a linear line.

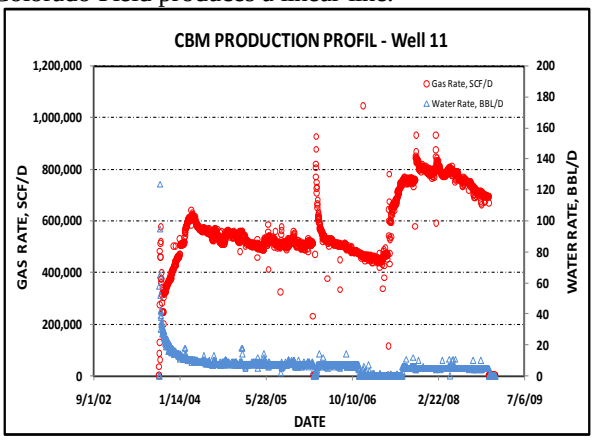

Figure 19 *Profiles 11 CBM production wells Colorado.*

In Figure 21 is a plot between the Water Rate vs. Time, wells no 11 from the field in the "Z" Basin, CBM Field, Colorado Field which produces a linear line on a logarithmic scale.

In Figure 22, a production history followed by Gas-Water Rate Prediction results of the proposed methods wells no 11 from the field in The "Z" Basin, CBM Field, Colorado Field the GWR - Water Rate Plotting.

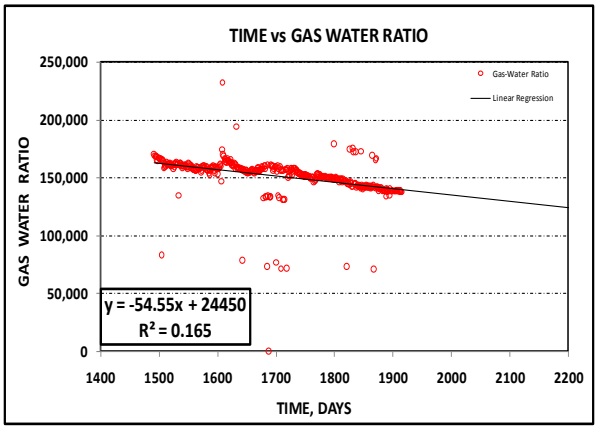

Figure 20 *Trendline from water gas ratio vs. time 11 wells Colorado.*

d. Plotting Water Gas Ratio Method 15 CBM wells Colorado's Field in Figure 23 is the actual production profile of the well no 15 from the field in the "Z" Basin, CBM Field, Colorado Field, where it gas-water rate will be predictable.

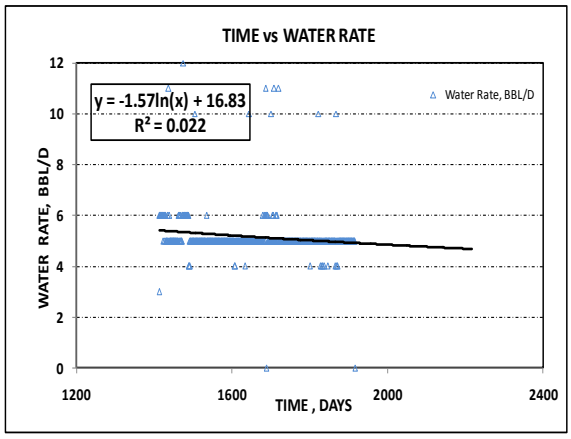

Figure 21 *Trendline water rate vs. time from 11 wells Colorado.*

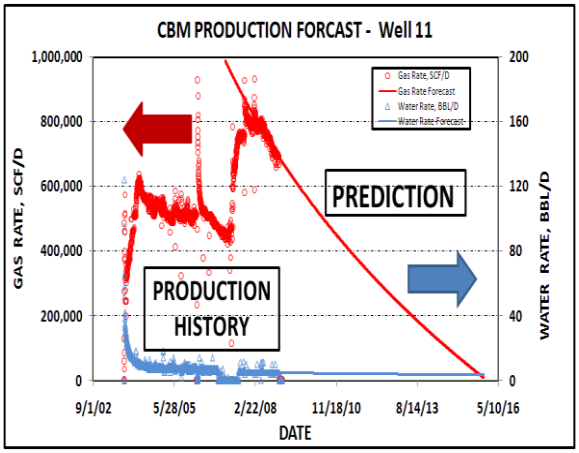

Figure 22 *Predicted behavior of CBM production wells 11 Colorado.*

In Figure 24 is a plot between GWR vs. Time, wells no 11 from the field in the "Z" Basin, CBM Well, Colorado Field which produces a linear line.

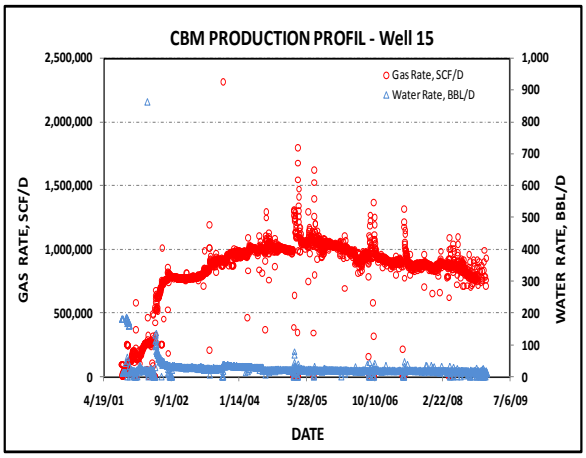

Figure 23 *Profiles 15 CBM production wells.*

In Figure 25 is a plot between the Water Rate vs. Time, wells no 15 from the field in The "Z" Basin, CBM Field, Colorado Field which produces a linear line on a logarithmic scale.

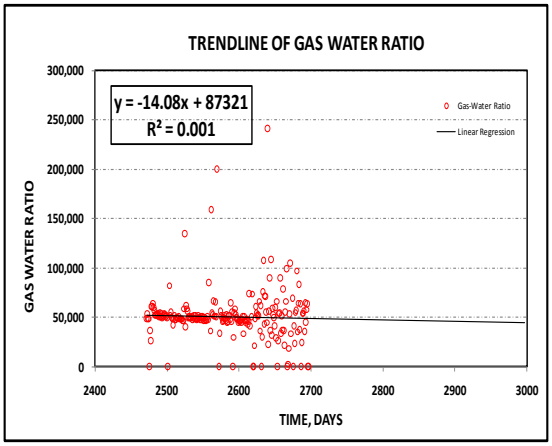

Figure 24 *Trendline from water gas ratio vs. time 15 wells Colorado.*

In Figure 26, a production history followed by Gas-Water Rate Prediction results of the proposed methods wells no 15 from the field in "Z" Basin, CBM Field, Colorado Field the GWR - Water Rate Plotting.

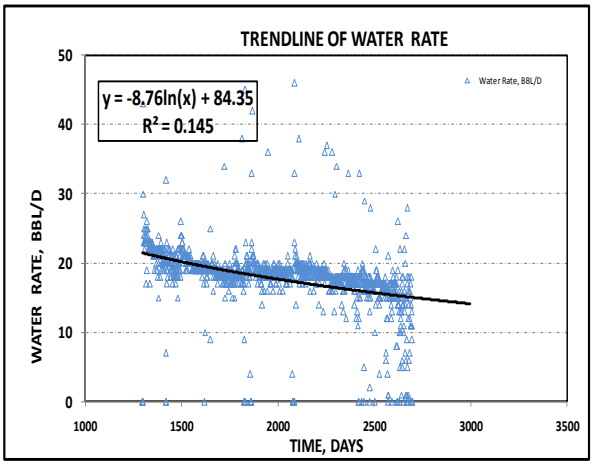

Figure 25 *Trendline water rate vs. time from 15 wells Colorado.*

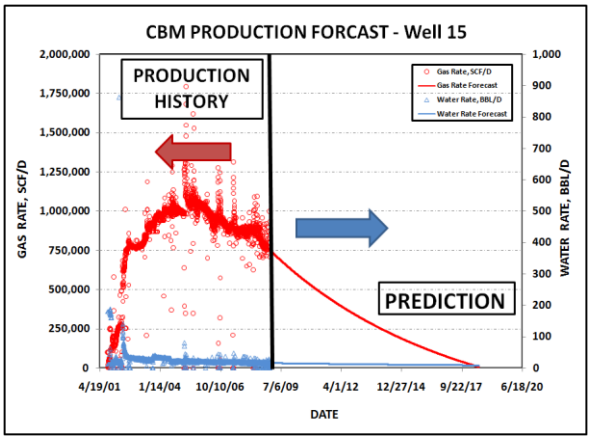

Figure 26 *Predicted Behavior 15 CBM production wells Colorado.*

a. Water Gas Ratio Data Plotting Method Using Fekette.

In Figure 27 is the actual production profile using the data Fekette, which his gas-water rate will be predictable. Increase in gas flow rate on the picture is as a result of stimulation using hydraulic fracturing stimulation process which is commonly done on CBM reservoir to be able to increase the production of which has been dropped because of the possibility of cleats that are sensitive permeability resulting in decreased permeability cleats.

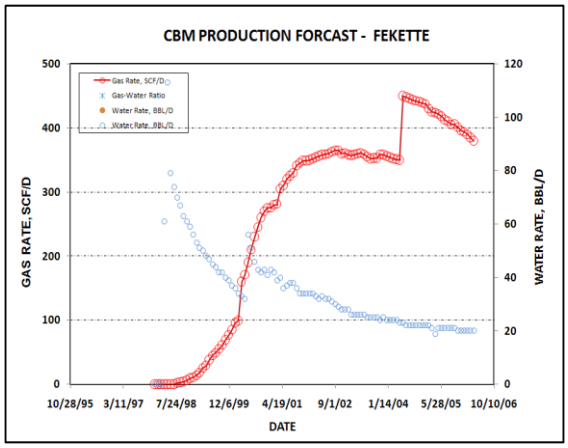

Figure 27 *Profile use a data Fekette CBM production.*

In the figure 28 is a plot between GWR vs. Time, using Fekette's data, which produces a linear line.

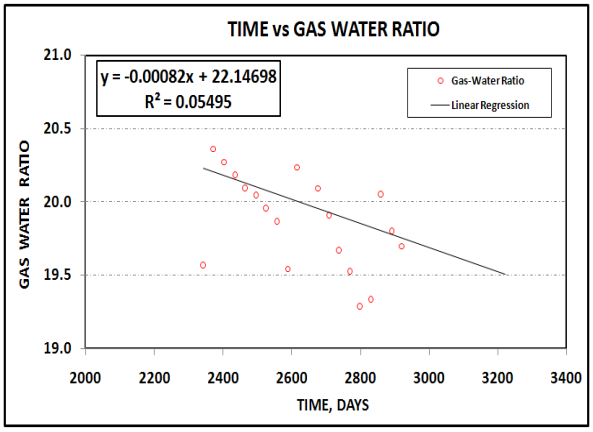

Figure 28 *Trendline of GWR using the data Fekette.*

In Figure 29 is a plot between the Water Rate vs. Time, using the data Fekette, which produces a linear line on a logarithmic scale.

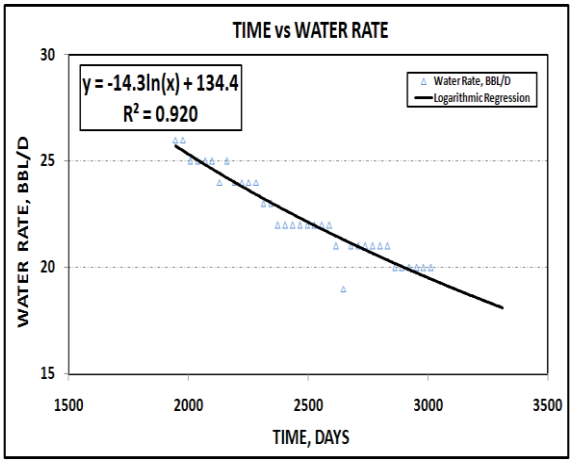

Figure 29 *Trendline from the water using a data rate Fekette.*

In Figure 30, a production history followed by Gas-Water Rate Prediction results of the proposed method using the data Fekette GWR - Water Rate Plotting.

From the plot between GWR against time previously observed, it appears that slope or slope GWR magnitude varies with time. This likelihood is a function of reservoir charac- teristics such as porosity, permeability, gas content and well spacing.

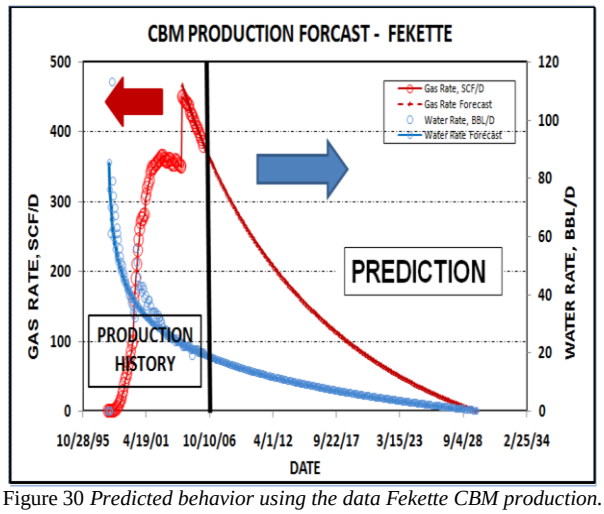

Figure 30 *Predicted behavior using the data Fekette CBM production.*

Further research is recommended to observe it in depth, so as to estimate the characteristics of CBM reservoirs by inclination or slope of the time the GWR.

II.DISCUSSION

For this method, the concept of the idea is the actual production function is a function of time, which can be obtained by a linear relationship. So it can be used to predict the gas-water rate in the future, after the CBM wells or CBM reservoir is undergoing production mature level. Have investigated several relationships, among others: Cum GWR vs. Time, Cum GWR and GWR vs vs Gp Gp. The results show a good consistency, as a reference in the production of CBM is forecasting relationship Water Gas and Water Rate Ratio Plotting. In this study the proposed prediction method is fast, practical and reasonably accurate based on Water Gas and Water Rate Ratio Plotting. The purpose of these studies to predict the future behavior of CBM production through production data correlation in order to obtain a linear regression equation. This method was applied to some actual data as follows:

a. Synthetic Data (From Reservoir Simulation CBM).
b. Data Pilot Project of India.
c. Data from The "Z" Basin, CBM Field.
d. Data from Fekette

From testing with the above data, Production Ratio Method Plotting give good results to predict the rate of gas production and for water rate, yield and Late Initial Water Rate Time Rate her very fit. In other words, the predicted results with this method, has been compared with the simulation, and the results of Gas Rate and Long Life Time fit. This method is very handy and quick use. Limitation of this method is:

- The more data, the better the outcome will be.
- Gas production rate has reached a maximum (the beginning of the decline in production).

III. CONCLUSION

1. Single Well Model Based Simulation, GWR gained versus Time straight line while the QW vs Time obtained a straight line on a logarithmic scale. Based on the two plotting this function, can be obtained CBM production forecasting. The results of this method have been compared with simulation results, and obtained comparable results.
2. Data pilot project (India) showed that GWR versus Time gives a straight line, while the QW vs Time obtained a straight line on a logarithmic scale. By plotting these functions, can be obtained CBM production forecasting.
3. From production data on the wells in the "Z" Field, GWR gained versus Time straight line while the QW vs Time obtained a straight line on a scale logarithmic. Based on the two plotting this function, can be obtained CBM production forecasting.
4. Operational changes during CBM production (data from Fekette) showed that GWR versus Time, Σ GWR versus Time and Gp/ Wp versus Time shows a straight line. By plotting these functions have been compiled CBM production forecasting methods.
5. Advantage of this method is the GWR plotting function we can simultaneously predict CBM production and integrated water. In the previous methods, such as decline curve analysis, forecasting gas and water carried separately.
6. GWR slope of the time is a function of reservoir characteristics such as porosity, permeability, gas content and well spacing. Further research is recommended to observe it in depth, so as to estimate the characteristics of CBM reservoirs by the slope of the time the GWR.

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