Coalbed methane production in Nigeria: Onyeama coalbed

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ABSTRACT: Coalbed methane production from Onyeama coalbed field in Nigeria Anambra basin was simulated using Eclipse 300 simulator. Proximate and ultimate analyses showed ash content, fixed carbon, volatile matter, moisture content and elemental components. Vertical and horizontal coalbed well orientations were examined with volume of gas produced and recovery efficiency of 6501.8MMSCF, 4.99% and 19866.1MMSCF, 15.2% respectively.

Index Terms: Coalbed methane, Onyeama coal, vertical coalbed well, Horizontal coalbed well, Eclipse 300 simulator, Proximate analysis, Ultimate analysis, Gas content, Gas in place.

1. INTRODUCTION

Coalbed Methane (CBM) is an unconventional hydrocarbon resource that fundamentally differs in its accumulation processes and production technology when compared to conventional natural gas resources. Coalbed methane is generated during coalification process, that is, the chemical transformation process from vegetation into coal, which involves the transformation of the complex biological and molecular structures in the cells of plants into the chemical fragments and structures seen in coal that gets adsorbed on coal at higher pressure. Presence of CBM in underground mine not only makes mining works difficult and risky, but also makes it costly and its ventilation to atmosphere adds greenhouse gas causing global warming[1]. Methane constitutes the highest percentage of the natural gas and is produced when organic material is geologically turned into coal. In an effort to reduce the hazards posed by the generation of CBM both to the coal mine and atmosphere, the idea of CBM production was envisaged[2].Coalbed Methane production started as a way to keep coal mining safe from explosions. Not only does it provide the same service now, it also decreases emissions of the greenhouse gases from mines, decrease air pollution because it is a clean burning fuel and satisfies the need for conventional fossil fuels[3].

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Natural gas with methane as its main constituent is a clean burning energy source well suited for heating residences, boiler fuel, power generation, vehicle fuel and other domestic applications, hence the need for research on its exploitation cannot be overemphasize. Also, the increasing demand for clean energy forces the world to search for alternatives to conventional energy resources such as CBM, tight gas sand, shale gas, gas hydrates etc, CBM is less polluting compared to oil or coal.

The key challenges to fully maximizing the potential of CBM in the world ranges from the country's specific fiscal policy regulation and minimizing the development cost (particularly drilling and completion cost)[4].

Technically, there is need to design a completion system that will maximize the area of coalbed drawdown to optimize the rate of desorption that will in turn provide the highest production rate. There is need to also understand the factors that controls how methane is trapped in coal beds and whether it can be recovered economically[5].
The unique characteristics of Coalbed reservoirs demand a novel approach in well construction, formation evaluation, completion and stimulation fluids, modeling and reservoir development. Considering the unique nature of the various coal basins in Nigeria, the problems associated with exploitation of coalbed methane (CBM) in Nigeria includes mapping coal bed methane reservoirs, identifying factors that influence reservoir heterogeneity and permeability, hydrologic factors that control storage and release of methane in a coal seam, dewatering process for disposal of produced water at the lowest possible cost and in an environmental friendly manner, obtaining critical reservoir

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parameters that control production and calculating reserves and making long-term production forecast[6][7].

According to EPA (2006) report, CBM emissions in Nigeria as a result of mining activities increased from 126MMCM in 1990 to 203MMCM in 1995, then to about 97MMCM in 2000 and decreasing to a low value of about 87MMCM in 2005. This decline in CBM emission in Nigerian coal mines was attributed to the shutdown of most of Nigerian coal producing mines[8].

This study is based on Onyeama coal field situated within the Nigerian Anambra basin. The Onyeama coalbed methane mine is situated on the western edge of the Cross river plain and is dominated by the Enugu escarpment just west of the town. For the first 122 – 152m, the escarpment is steep, but it then rises more gently to about 427m above sea level and about 183m above Enugu. Further west, several large but low hills attain an elevation of nearly 518m. The field is located within the coordinates long 7^0 27″ E, Lat 6^0 29′′ N; Long 7^0 25′′E, Lat 6^0 25′′N; Long 7^0 29′′E, Lat 6^0 25′′N; Long 7^0 29′′E, Lat 6^0 22′′N covering area of about 4013.853 Hectares[9].

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Table 1: Reservoir Data for Onyeama Coalbed Field

PARAMETER	ONYEAMA
Reportable Coal Resources -Measured -Indicated Demonstrated (M+I)	49
Non-Reportable Coal Resources -Inferred -Hypothetical Subtotal	 111 111
Total Coal Resources	160
Estimated reserves (Milltonnes)	40
Proven reserves (Mill tonnes)	40
Rock density for Rock Stress balance	1434
Area of coal deposit (hectare)	81,080
Area of coal deposit (m)	9,404,948.72
Average Thickness (m)	1.76
Deposit dept (m)	100.20
Specific gravity	1.33
Porosity (%)	1.90
Permeability (mD)	45
Gs (scf/ton) on DAF basis	229.464
Approx. Density (g/m3)	1.4

This study and its geological characterization was carried out on Onyeama coalbed methane fields in the Nigerian Anambra basin, the status of CBM extraction in Nigeria, estimation of gas content, gas in place and evaluation of various mechanisms that influences CBM recovery. Eclipse 300 simulator was applied to simulate or estimate coalbed methane recovery in both vertical and horizontal production platform and recovery efficiency compared.

2. METHODOLOGY

An adsorption isotherm of Onyeama field was analyzed with gas content and gas in place estimated. Simulation design model was considered for CBM with vertical well and horizontal well using Eclipse 300 simulator by using the reservoir data available on Onyeama coalbed field. Proximate and ultimate analyses were used to determine ash content, fixed carbon, volatile matter and moisture and elemental components.

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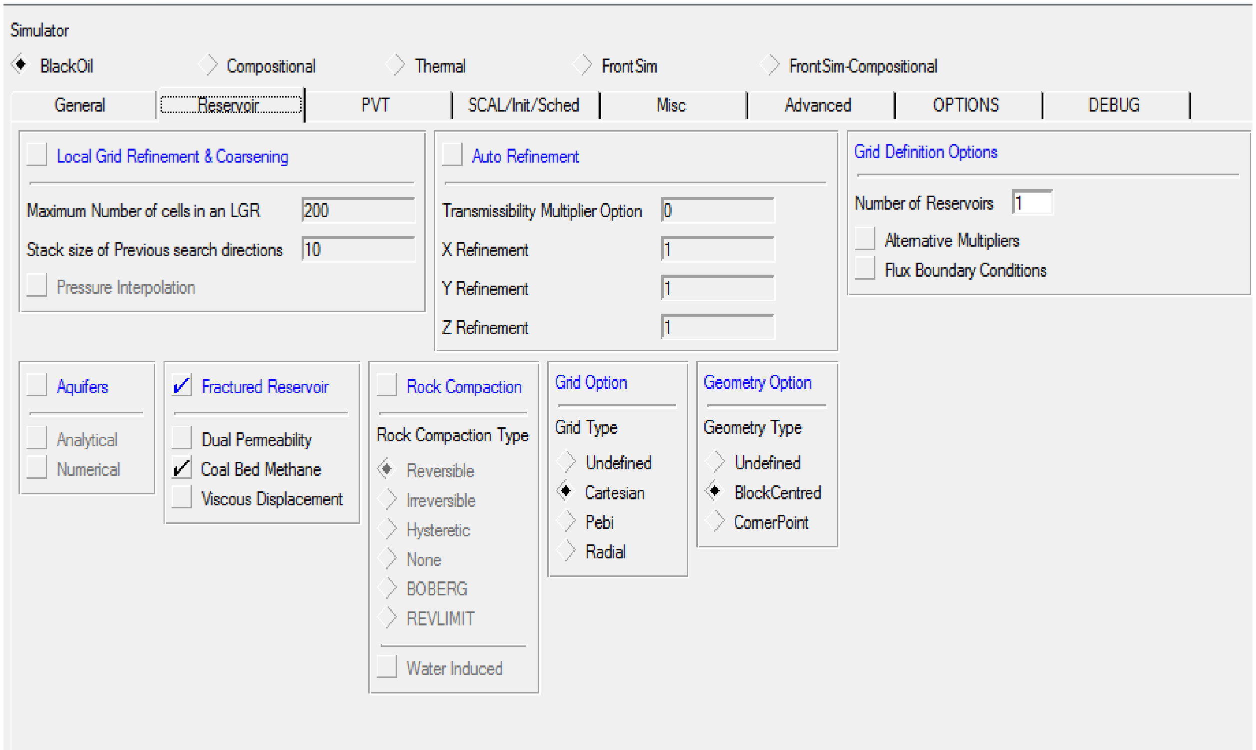

Figure 1: Eclipse 300 simulator system

CBM model was construed using grid data with grid dimension 8 by 8 by 2 and both Cartesian and corner grids were applied for more accurate coalbed reservoir modeling and hydrocarbon phase for CBM was defined to be single phase. Onyeama coalbed reservoir was divided into fourteen grids, the average depth of each grid obtained and the pressure at each average depth is determined using the pressure depth relationship (Pressure = average depth multiply by 0.433) and Langmuir Equations was applied in deducing the volume of gas content for each grid.

Table 2: Summary of Proximate and Ultimate Analyses for Onyeama Coalbed Field

Sample	Proximate and Ultimate Analysis (Wt/%)						
	Moisture	Ash	Volatile Matter	Fixed Carbon	Heating Value	Sulfur	Coal Rank
Onyeama	12.61	3.67 4.20	36.64 41.93 43.76	47.08 53.87 56.24	12088 13832 14439	0.52 0.60 0.62	High Volume Bituminous C
	Moisture	Ash	Hydrogen	Carbon	Nitrogen	Sulfur	Oxygen
	12.61	3.67 4.20	4.19 4.79 5.00	68.17 78.01 81.43	1.55 1.77 1.85	0.52 0.60 0.62	9.29 10.63 11.10

Table 3: Gas in place deduction for Onyeama Coalbed Field

Grid no	Area (acres)	Average depth (ft)	Average coal Thickness (ft)	P(psi)= 0.433* Average depth	V=401.2*P/ (P+872)	GIP (Mscf)
1	344.4	0	0	0	0	0
2	344.4	0	0	0	0	0
3	344.4	543.3	6.37	71.72	30.49	1.20E+08
4	574	0	0	0	0	0
5	574	860.3	2.75	113.6	46.23	1.31E+08
6	574	526.7	4.75	69.53	29.63	2.6865E+06
7	574	578.8	4.79	76.4	32.32	1.59E+08
8	574	913.2	4.27	120.6	48.73	2.15E+08
9	574	600.2	3	79.23	33.42	1.04E+08
10	574	228	4.81	30.1	13.39	1.2369E+08
11	574	728.4	2.58	96.16	39.85	1.06E+06
12	574	0	0	0	0	0
13	574	0	0	0	0	0
14	574	0	0	0	0	0

2.1 Gas Content Estimation

The characterization of the Langmuir isotherm commonly used to model the gas content, which provides a guide to gas content of the coal of any field at any time as pressure is decreased while production proceeds through the life cycle of the well is expressed as:

$GC\_L = L_C * \{1-M_C+A_C\}/\{P_R/(P_R+P_C)\}$

2.2 Gas in Place (GIP) Estimation

The total gas in place (GIP) is expressed in terms of project area, coal tonnage, and gas content as shown thus:

$GIP = GC\_L * CT_PA * A$

Alternatively, GIP can be estimated as

GIP=GAS CONTENT x COAL THICKNESS x AREA x Coal density

Similarly, coal tonnage is determined from below expression

$CTpA = 1359.7 * h * RHOB$

3. RESULTS ANALYSIS

3.1 Coalbed Methane Model with Vertical Well

In this case, the model looked at methane gas production from coalbed reservoir and its possible recovery efficiency using a vertical well. The well was made to flow in January 2015 and 25 years forecast was made with gas well production control rate, produced water rate, economic constraints of minimum gas rate, expected gas recovery,

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bottomhole pressure and recovery factor of 100MMSCF/DAY, 100STB/DAY, 5MSCF/DAY, 6501.8075MMSCF, 200PSIA and 4.99% respectively.

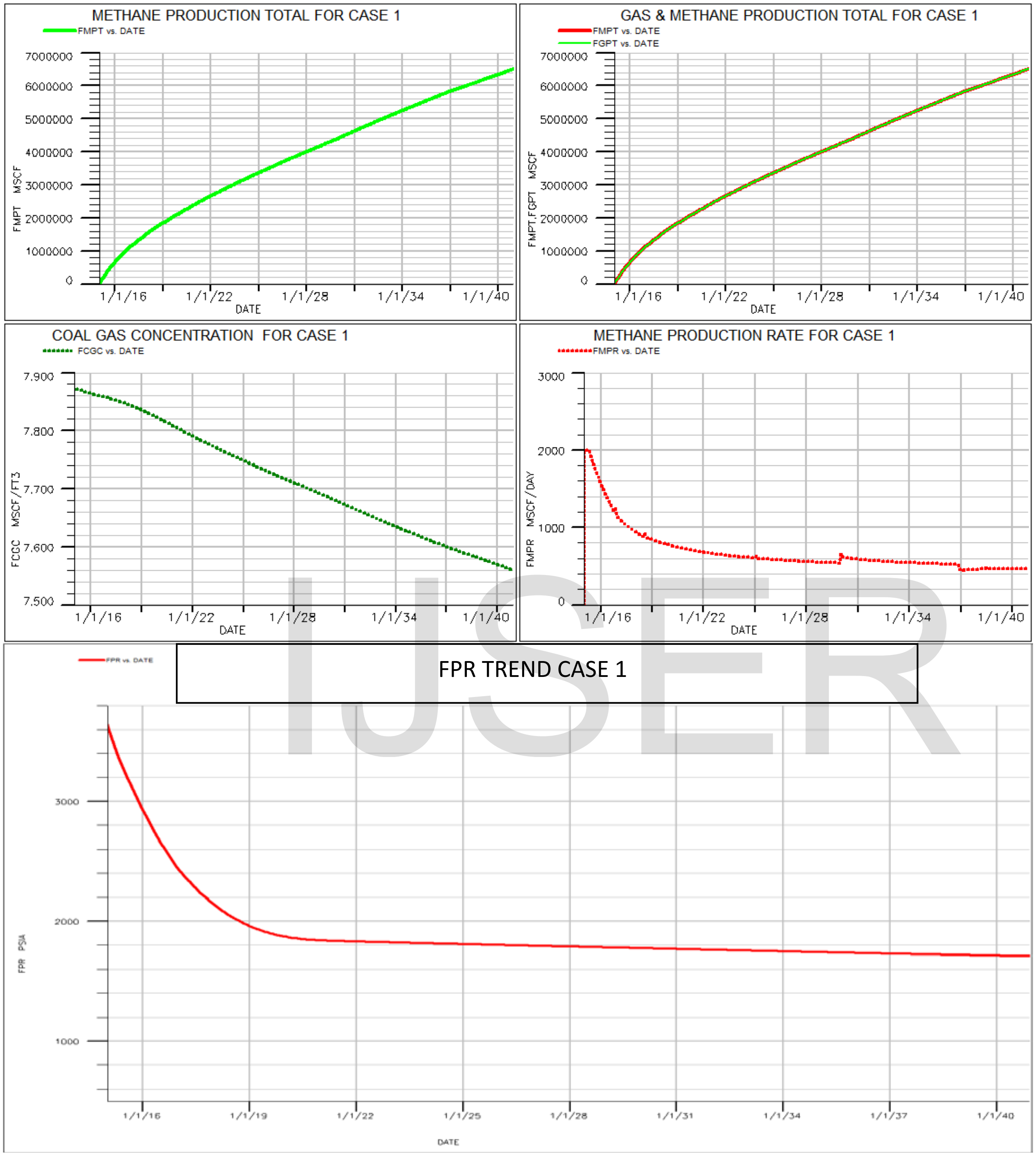

Figure 1: Showing simulated result of pressure, gas rate, coal concentration & cumulative coal methane gas produced for vertical well

3.2 Coalbed Methane Model with Horizontal Well

Horizontal well coalbed methane production analysis was evaluated in a similar manner as the vertical well analysis stated above by using Eclipse 300 simulator for analysis of future production. Expected gas recovery and recovery factor at the end of forecast are 19866.1MMSCF and 15.2% respectively.

Figure 2: Showing simulated result of pressure, gas rate, coal concentration & cumulative coal methane gas produced for horizontal well

4. DISCUSSION

The demand for energy source has increased in the last decade and has lead to the exploitation of all possible sources of energy including the coalbed methane. A comparative analysis study was performed on Onyeama coalbed to ascertain the viability of methane gas in the coalbed field and its recovery efficiency. The analysis yields volume of gas produced or simulated for 25 years for vertical and horizontal well orientation to be 6501.8MMSCF and 19866.1MMSCF and recovery efficiency of 4.99%and 15.2% respectively.

5. CONCLUSION

As highlighted above in terms of volume of gas produced and its recovery efficiency, horizontal coalbed field orientation for CBM production from Onyeama coalbed field is preferable to vertical coalbed production field as simulated by Eclipse 300 simulator for a single phase gas. Further analysis can also be carried out in enhancing CBM production from Onyeama coalbed field by injection of new gas that can promote CBM recovery from Onyeama coalbed field.

6. NOMENCLATURE

CT_PA: Coal tonnage per acre

H: Coal thickness, feet

RHOB: minimum bulk density in the coal, g/cc

GIP: Gas in Place

GC_L: Langmuir gas content scf/ton

A: Total area in acres

CT_PA : Coal tonnage per Acre

GC_L : Langmuir desorbed gas content, scf/ton

L_C : Langmuir gas content scf

M_C: Moisture content in coal %

A_C: Ash content in coal %

P_C : Langmuir Pressure Psia

P_R : Reservoir Pressure Psia

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