

ANALYTICAL REPORT

METHANE AND CARBON DIOXIDE ADSORPTION ISOTHERMS

LAST CHANCE #3

PREPARED FOR
GASSY COAL COMPANY NL

APRIL 2050



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EXAMPLE ISOTHERM REPORT

ADSORPTION ISOTHERM ANALYSIS

INTRODUCTION

Twelve samples were received from the Gassy Coal Company NL Last Chance #3 well (see table below) to be evaluated for adsorption isotherm properties (composites only), vitrinite reflectance (composites only) and maceral content (all samples). Adsorption isotherm data are reported herein.

Last Chance #3 Samples and Composites

Sample No.	From (m)	To (m)	Mass (g)	Isotherm No.	Temperature (°C)
A	526.04	526.78	2616	n/a	n/a
B	557.43	557.81	4040	Iso. 1	33.3
C	558.91	559.77	3324		
D	563.64	564.02	2456		
E	565.96	566.91	3442		
F	569.41	570.36	3134		
G	619.48	619.83	1930	n/a	n/a
H	620.12	621.03	1342	n/a	n/a
I	621.36	622.29	3702	n/a	n/a
J	652.08	653.05	3602	n/a	n/a
K	663.83	664.33	2518	n/a	n/a
L	667.93	668.43	2054	n/a	n/a

ADSORPTION ISOTHERMS

Sample Preparation

Individual samples were as -6 mm coal which had been crushed elsewhere. Approximately 200 g of each sample was received. Composites were made by weighting each sample by mass of coal before combining the individual samples to produce a composite of total weight of 150 g. This 150 g sample was sub-sampled to obtain around 25 g for petrographic analysis. The remaining sample was then crushed to less than 0.212 mm and brought to an equilibrium moist state (AS 1038.17-1989) for methane adsorption isotherm analysis.

Moisture Content and Ash Yield

Equilibrium moisture content, ash yield and helium density (for evaluation of dead volume of the system) were determined prior to methane adsorption isotherm analysis.

Moisture content was determined by weighing approximately 0.5 to 1 g of coal in a 4 digit balance (i.e to 0.1 mg), heating it to 110 °C in a nitrogen atmosphere, and then re-weighing the

dry sample. The method is similar to AS1038.3-1989 "Methods for the analysis and testing of coal and coke. Part 3: Proximate analysis of higher rank coal."

Ash yield was determined on dry coal by weighing approximately 0.5 to 1 g of dry coal in a 4 digit balance (i.e. to 0.1 mg), heating it to 500 °C and holding it there for one hour and then raising the heat to 815 °C and maintaining this for a further one hour. The ash yield is then determined following re-weighing at room temperature. The method is similar to AS1038.3-1989 "Methods for the analysis and testing of coal and coke. Part 3: Proximate analysis of higher rank coal."

Adsorption Isotherm

Isotherm determination used at least nine pressure steps up to a maximum pressure of around 8 MPa (1160 psia) where the coals are at 800 m or shallower and additional pressure steps may be used for deeper coals. Analysis was performed as close as possible to formation temperature as advised. The procedure is detailed as follows:

1. adsorption isotherm cells are weighed
2. the equilibrium moist coal is placed in the cells and the cells weighed
3. the cells are evacuated and weighed
4. helium is introduced into the cells at pressures of approximately 2, 4, 6 and 8 MPa; this data is used to calculate the free volume of the cells and consequently the helium density of the coal
5. the cells are evacuated
6. a fixed volume of methane is introduced into the cell and the pressure monitored to the nearest 1 kPa until there is no change in pressure for a period of at least one hour
7. the adsorption is determined
8. steps 6 and 7 are repeated for each pressure step

RESULTS

Isotherm results are tabulated and presented graphically as follows. Absolute isotherms are calculated. Isotherm results are calculated to standardised conditions of 20°C and 1 atmosphere (101.3 kPa) pressure per gram of coal as well as in standard cubic feet (scf) at 60 °F and 1 atmosphere (14.7psia) per short ton (2000 lb) of coal.

Note, samples are retained by Energy Resources Consulting Pty Ltd for a period of 12 months following the reporting date. They may be discarded after this time.

Extended Langmuir Modelling

Both methane and carbon dioxide adsorption isotherms were determined. The adsorption isotherm of gas mixtures can be assessed using the extended Langmuir model:

$$V_i = \frac{V_{Li} P y_i}{P_{Li} \left(1 + \sum_{j=1}^n \frac{1}{P_{Lj}} y_j P \right)}$$

where :

V_i = storage capacity of component i (cc/g or m³/t or scft/t)

P_{Li} = Langmuir pressure of the ith phase obtained from the single component data

V_{Li} = Langmuir volume of the ith phase obtained from the single component data

P = pressure (kPa or psi)

y_i = the mole fraction of species i in the free gas phase

n = number of components

This modelling has been carried out for a mixture of CH₄:CO₂ = 50:50 for the free gas phase.

Methane (CH₄) Adsorption

Client	Gassy Coal Company NL		
Sample Details	Last Chance #3 (557.43 - 570.36 m) Iso. 1		
	Sample Properties		
Inherent Moisture (% ad)	n.d.	Isotherm Sample Mass (g) [lb]	113.17 [0.24950]
Ash (% ad)	n.d.	Particle Size (mm) [US mesh]	-0.212 [70]
Volatile Matter (% ad)	n.d.	Helium density (g/cc)	1.566
Fixed Carbon (% ad)	n.d.	Test Temperature (°C) [°F]	33.3 [91.9]
Ash (% at Equilibrium Moisture)	37.9	Analysis date	25-Jan-12
Equilibrium Moisture (%)	13.0	Test Gas	Methane

Methane Absolute Adsorption at Equilibrium Moisture Basis

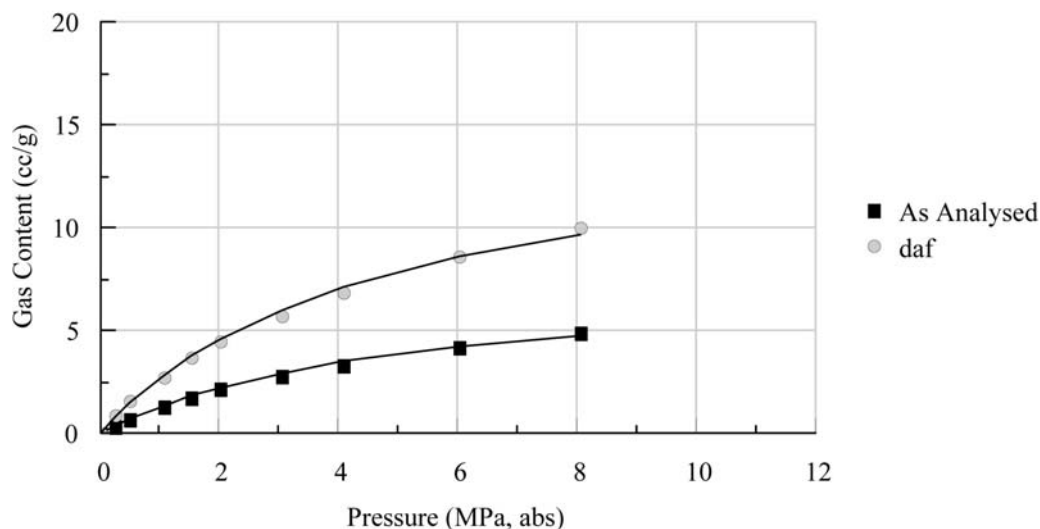
at 20°C; 101.1kPa (1 atm)			at 60°F, 14.7 psia		
Pressure (MPa) (absolute)	Gas Content (cc/g) (as analysed)	Gas Content (cc/g) (daf)	Pressure (psia)	Gas Content (scf/t) (as analysed)	Gas Content (scf/t) (daf)
0.259	0.44	0.89	38	14	28
0.516	0.78	1.59	75	25	50
1.065	1.38	2.80	154	43	89
1.526	1.82	3.71	221	57	117
2.028	2.21	4.50	294	70	142
3.043	2.84	5.79	441	90	183
4.086	3.38	6.88	593	107	217
6.044	4.24	8.65	877	134	273
8.054	4.94	10.06	1168	156	317

Langmuir Isotherm Coefficients

	P (MPa, abs)	V (cc/g)	P (psia)	V (scf/t)
As analysed	4.70	7.55	681	238
daf	4.70	15.38	681	486

EXAMPLE ISOTHERM REPORT

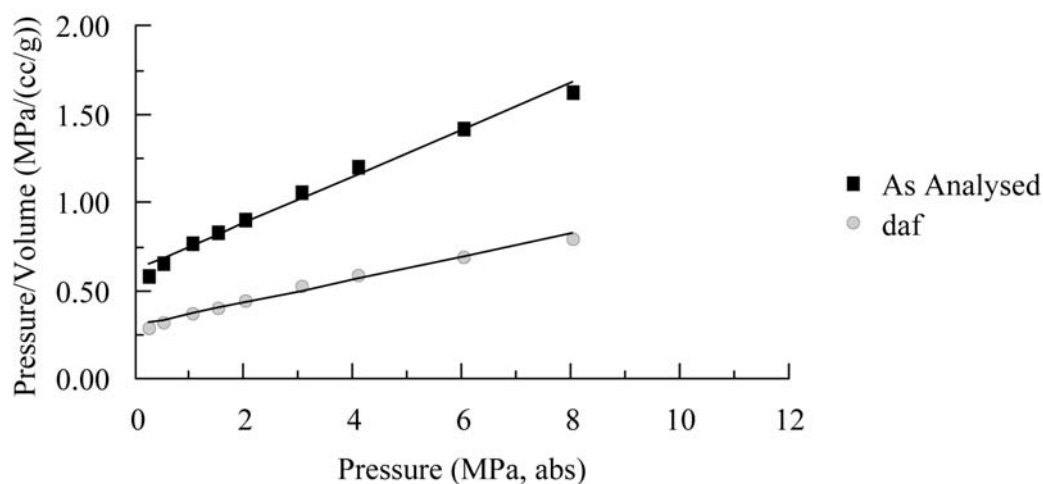
Methane Absolute Adsorption Isotherm (20 °C, 101.3 kPa)
Last Chance #3 (557.43 - 570.36 m) Iso. 1
Analysis Temperature 33.3 °C



$$V = 7.55 P / (P + 4.70) \quad (\text{As analysed})$$

$$V = 15.38 P / (P + 4.70) \quad (\text{daf})$$

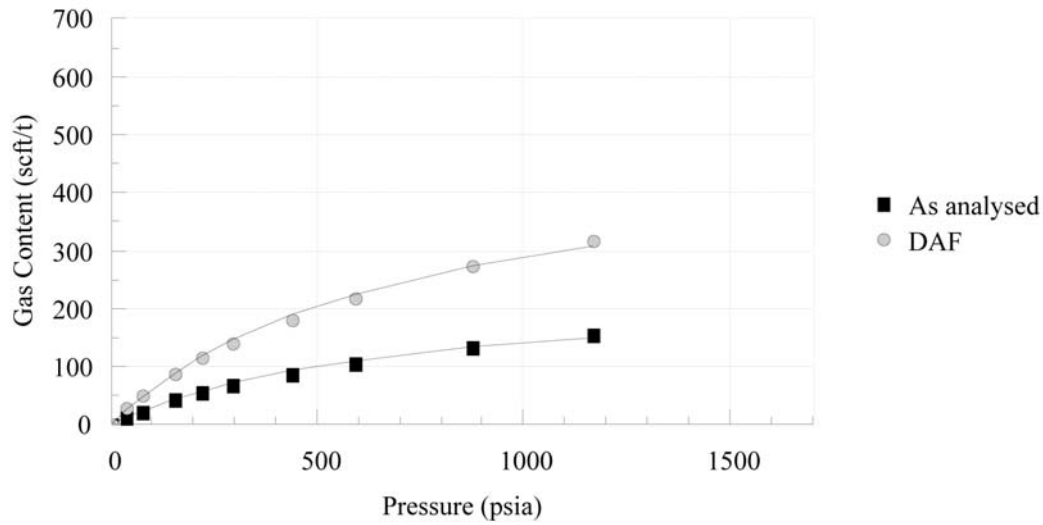
Methane Absolute Adsorption Isotherm (20 °C, 101.3 kPa)
Last Chance #3 (557.43 - 570.36 m) Iso. 1
Analysis Temperature 33.3 °C



$$P/V = 0.132 P + 0.622; \quad r^2 = 0.986 \quad (\text{As analysed})$$

$$P/V = 0.065 P + 0.305; \quad r^2 = 0.986 \quad (\text{daf})$$

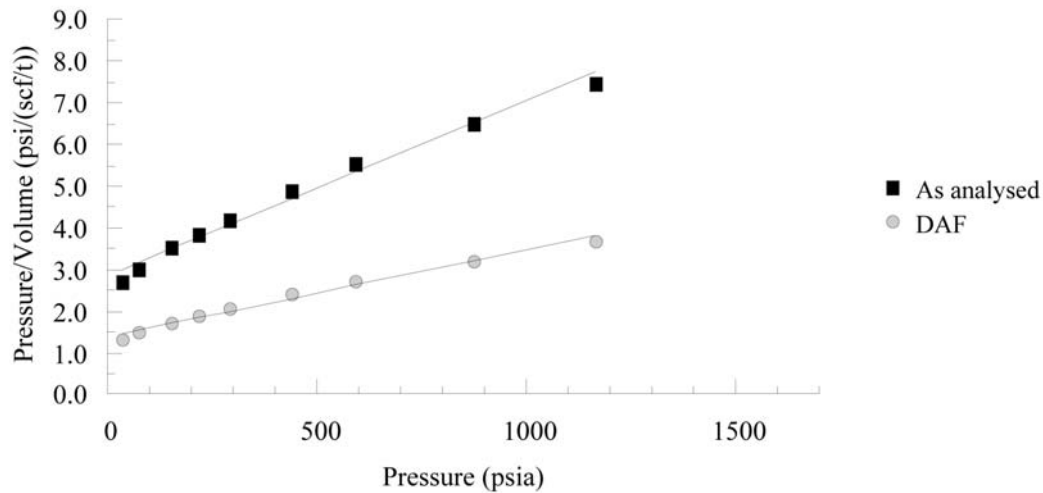
Methane Absolute Adsorption Isotherm (60 °F, 14.7 psia)
 Last Chance #3 (557.43 - 570.36 m) Iso. 1
 Analysis Temperature 91.9 °F



$$V = 238 P / (P + 681) \quad (\text{As analysed})$$

$$V = 486 P / (P + 681) \quad (\text{daf})$$

Methane Absolute Adsorption Isotherm (60 °F, 14.7 psia)
 Last Chance #3 (557.43 - 570.36 m) Iso. 1
 Analysis Temperature 91.9 °F



$$P/V = 0.00419 P + 2.857; \quad r^2 = 0.986 \quad (\text{As analysed})$$

$$P/V = 0.00206 P + 1.403; \quad r^2 = 0.986 \quad (\text{daf})$$

Carbon Dioxide (CO₂) Adsorption

Client	Gassy Coal Company NL		
Sample Details	Last Chance #3 (557.43 - 570.36 m) Iso. 1		
	Sample Properties		
Inherent Moisture (% ad)	n.d.	Isotherm Sample Mass (g) [lb]	107.30 [0.23656]
Ash (% ad)	n.d.	Particle Size (mm) [US mesh]	-0.212 [70]
Volatile Matter (% ad)	n.d.	Helium density (g/cc)	1.582
Fixed Carbon (% ad)	n.d.	Test Temperature (°C) [°F]	33.3 [91.9]
Ash (% at Equilibrium Moisture)	37.7	Analysis date	06-Feb-12
Equilibrium Moisture (%)	13.0	Test Gas	Carbon Dioxide

Carbon Dioxide Absolute Adsorption at Equilibrium Moisture Basis

at 20°C; 101.1kPa (1 atm)

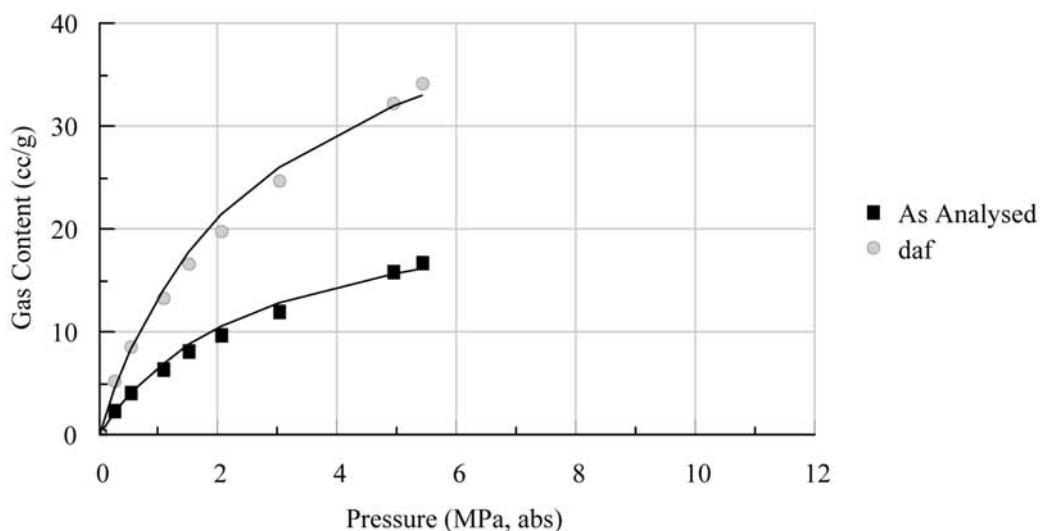
at 60°F, 14.7 psia

Pressure (MPa) (absolute)	Gas Content (cc/g) (as analysed)	Gas Content (cc/g) (daf)	Pressure (psia)	Gas Content (scf/t) (as analysed)	Gas Content (scf/t) (daf)
0.261	2.62	5.31	38	83	168
0.535	4.26	8.65	78	135	273
1.078	6.65	13.48	156	210	426
1.518	8.30	16.83	220	262	531
2.048	9.85	19.98	297	311	630
3.010	12.27	24.88	437	387	785
4.931	16.00	32.45	715	505	1024
5.428	16.91	34.29	787	534	1082

Langmuir Isotherm Coefficients

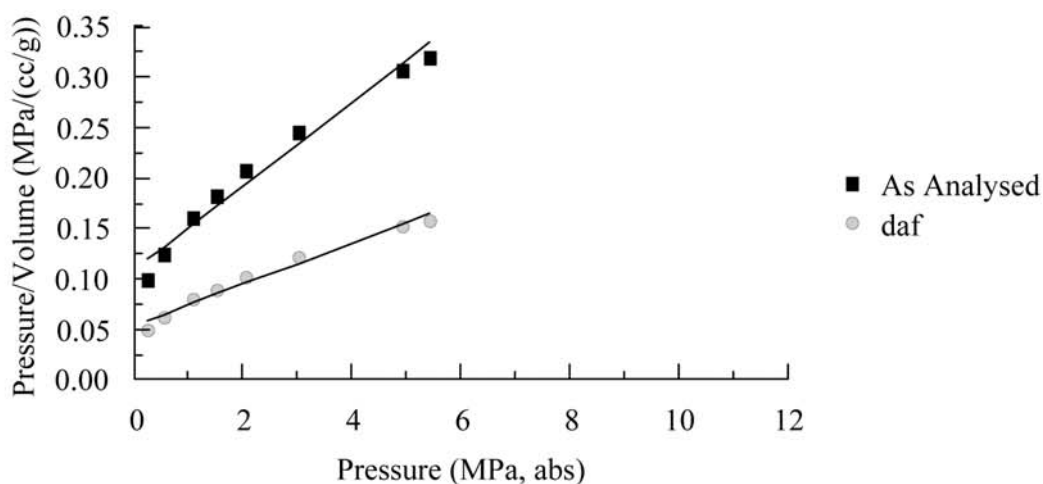
	P (MPa, labs)	V (cc/g)	P (psia)	V (scf/t)
As analysed	2.65	24.20	384	764
daf	2.65	49.08	384	1549

Carbon Dioxide Absolute Adsorption Isotherm (20 °C, 101.3 kPa)
Last Chance #3 (557.43 - 570.36 m) Iso. 1
Analysis Temperature 33.3 °C



$$V = 24.20 P / (P + 2.65) \quad (\text{As analysed}) \quad V = 49.08 P / (P + 2.65) \quad (\text{daf})$$

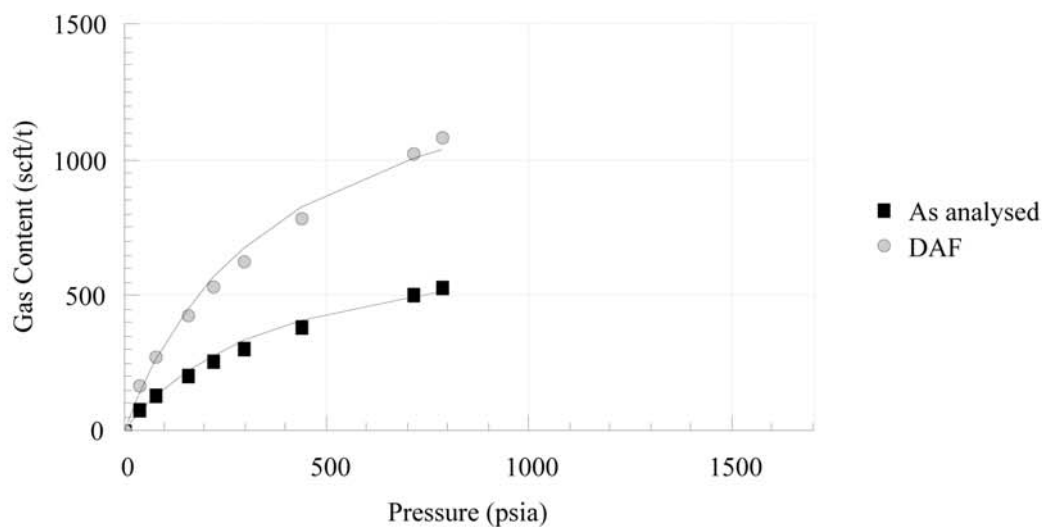
Carbon Dioxide Absolute Adsorption Isotherm (20 °C, 101.3 kPa)
Last Chance #3 (557.43 - 570.36 m) Iso. 1
Analysis Temperature 33.3 °C



$$P/V = 0.041 P + 0.109; \quad r^2 = 0.975 \quad (\text{As analysed})$$

$$P/V = 0.020 P + 0.054; \quad r^2 = 0.975 \quad (\text{daf})$$

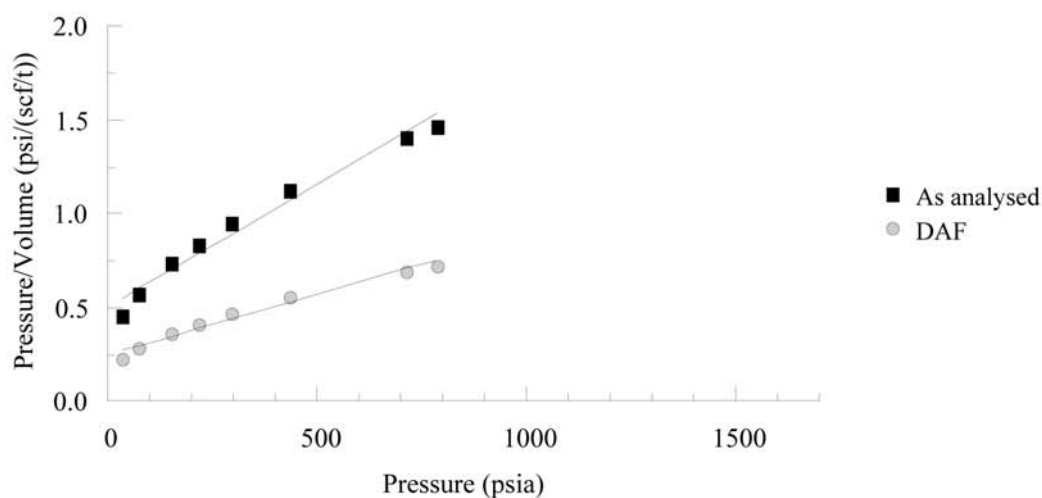
Carbon Dioxide Absolute Adsorption Isotherm (60 °F, 14.7 psia)
Last Chance #3 (557.43 - 570.36 m) Iso. 1
Analysis Temperature 91.9 °F



$$V = 764 P / (P + 384) \quad (\text{As analysed})$$

$$V = 1549 P / (P + 384) \quad (\text{daf})$$

Carbon Dioxide Absolute Adsorption Isotherm (60 °F, 14.7 psia)
Last Chance #3 (557.43 - 570.36 m) Iso. 1
Analysis Temperature 91.9 °F



$$P/V = 0.00131 P + 0.503; \quad r^2 = 0.975 \quad (\text{As analysed})$$

$$P/V = 0.00065 P + 0.248; \quad r^2 = 0.975 \quad (\text{daf})$$

Extended Langmuir Modelling

Client	Gassy Coal Company NL
Sample Details	Last Chance #3 (557.43 - 570.36 m) Iso. 1

Pure CH4 Langmuir Adsorption Isotherm Coefficients			
	P_L (MPa, abs)	V_L (cc/g)	
As analysed	4.70	7.55	
daf	4.70	15.38	

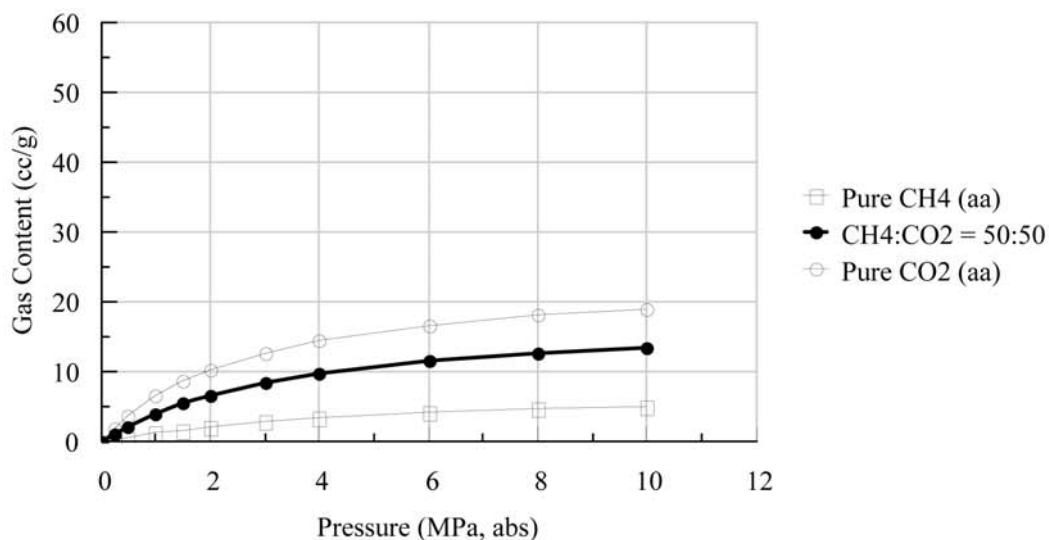
Pure CO2 Langmuir Adsorption Isotherm Coefficients			
	P_L (MPa, abs)	V_L (cc/g)	
As analysed	2.65	24.20	
daf	2.65	49.08	

Modelled Extended Langmuir Adsorption Isotherm for CH4:CO2 = 50:50					
at 20°C; 101.1kPa (1 atm)			at 60°F, 14.7 psia		
Pressure (MPa) (absolute)	Gas Content (cc/g) (as analysed)	Gas Content (cc/g) (daf)	Pressure (psia)	Gas Content (scf/t) (as analysed)	Gas Content (scf/t) (daf)
0.250	1.25	2.54	36	39	80
0.500	2.34	4.75	73	74	150
1.000	4.15	8.42	145	131	266
1.500	5.59	11.34	218	176	358
2.000	6.76	13.71	290	213	433
3.000	8.55	17.35	435	270	547
4.000	9.85	20.00	580	311	631
6.000	11.63	23.61	870	367	745
8.000	12.78	25.95	1160	403	819
10.000	13.59	27.59	1450	429	871

Extended Langmuir Adsorption Isotherm Coefficients			
	P_L (MPa, abs)	V_L (cc/g)	
As analysed	3.39	18.20	
daf	3.39	36.93	

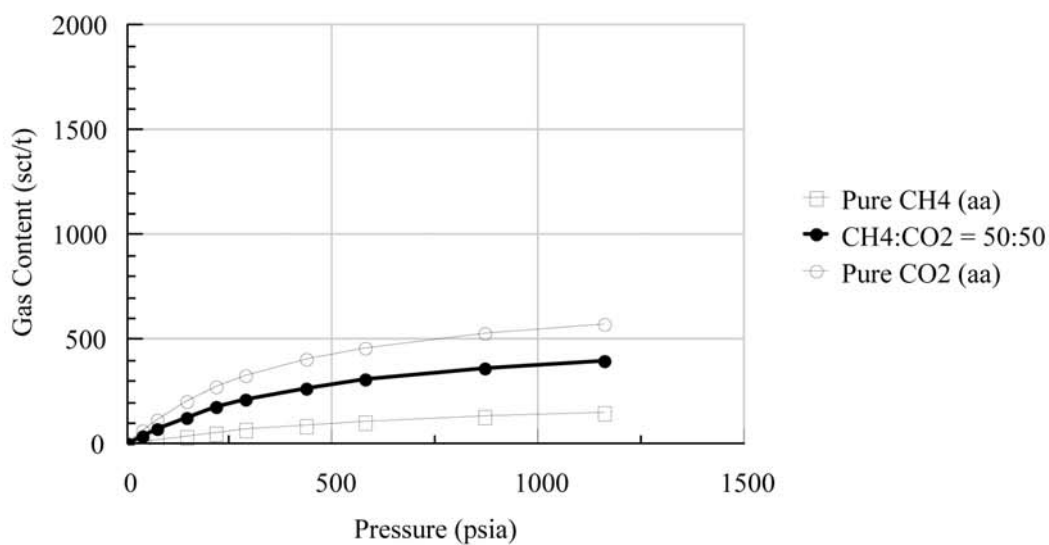
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Extended Langmuir Adsorption Isotherm - CH₄:CO₂ = 50:50 (20 °C, 14.7 psia)
 Last Chance #3 (557.43 - 570.36 m) Iso. 1
 Analysis Temperature 33.3 °C



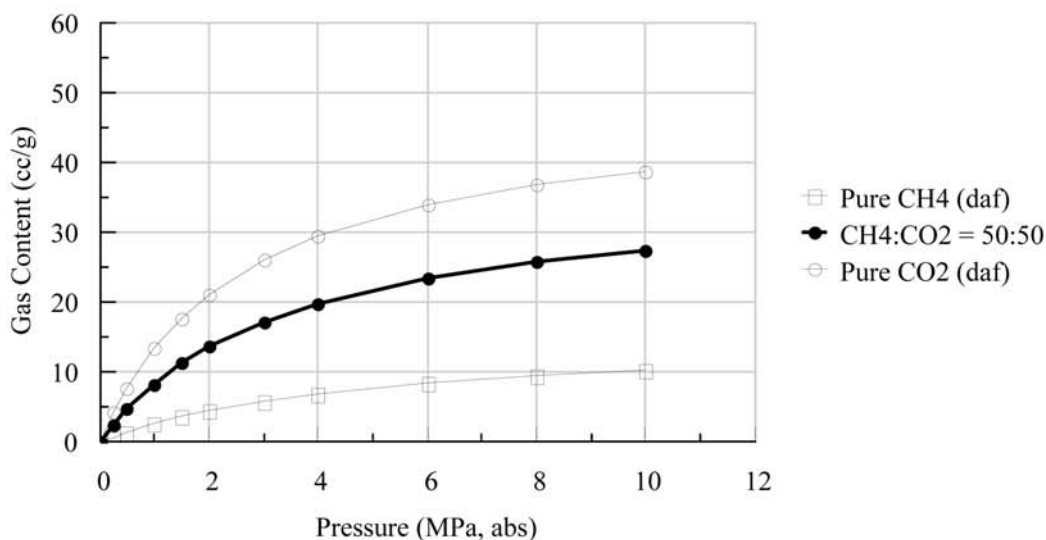
$$V = 18.20 P / (P + 3.39) \quad (\text{As analysed})$$

Extended Langmuir Adsorption Isotherm - CH₄:CO₂ = 50:50 (60 °F, 14.7 psia)
 Last Chance #3 (557.43 - 570.36 m) Iso. 1
 Analysis Temperature 91.9 °F



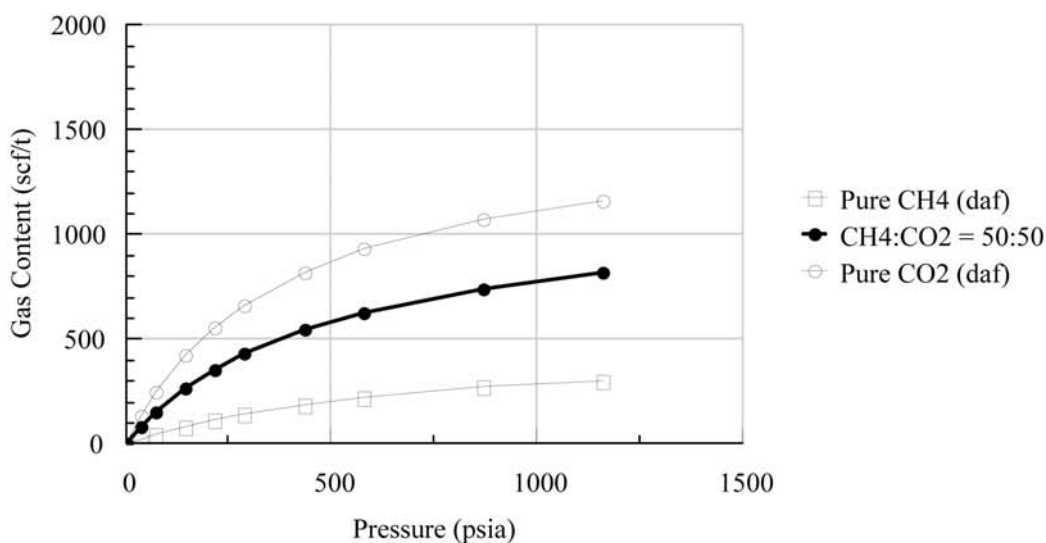
$$V = 574 P / (P + 491) \quad (\text{As analysed})$$

Extended Langmuir Adsorption Isotherm - CH₄:CO₂ = 50:50 (20 °C, 14.7 psia)
 Last Chance #3 (557.43 - 570.36 m) Iso. 1
 Analysis Temperature 33.3 °C



$$V = 36.93 P / (P + 3.39) \quad (\text{daf})$$

Extended Langmuir Adsorption Isotherm - CH₄:CO₂ = 50:50 (60 °F, 14.7 psia)
 Last Chance #3 (557.43 - 570.36 m) Iso. 1
 Analysis Temperature 91.9 °F



$$V = 1165 P / (P + 491) \quad (\text{daf})$$

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1st April, 2050