

Division of Geological & Geophysical Surveys

RAW-DATA FILE 2002-2

**HIGH PRESSURE METHANE ADSORPTION  
ISOTHERMS, PETROGRAPHY AND VITRINITE  
REFLECTANCE ANALYSES**

by

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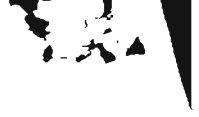
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High Pressure Methane Adsorption  
Isotherms, Petrography and Vitrinite  
Reflectance Analyses

*Samples:*

**00DL28 32.5**

**00DL28-1.0**

**00DL28-17**

**00DL28-44**

**00DL30B**

**00DL32A**

**00DL33**

**00DL33E**

**00DL34D**

**00DL34F**

**00DL43A**

**00DL49 326-327.5**

**00DL58 36-39.5**

For David LePain  
Department of Natural Resources  
State of Alaska

*Analyses carried out by R.M.B. Earth Science Consultants  
Ltd.*  
1/3/2001





This raw data-file was prepared by Dr. Mark Bustin, University of British Columbia, under contract with the Alaska Division of Geological & Geophysical Surveys (DGGS). The data presented here were collected as part of a one-year project to evaluate the shallow gas potential of the Tertiary Holitna basin, located in the northern Sleetmute and northwestern Lime Hills quadrangles. This raw data-file is part of a series of reports addressing the stratigraphy and shallow gas potential of the Holitna basin.

Forthcoming reports from this project include a geophysical interpretation of aeromagnetic and gravity datasets that cover the Holitna Lowland region (including the Holitna basin) and a summary report addressing the shallow gas potential of the Holitna basin (Winter 2001-2002). A regional gravity dataset covering the Holitna Lowland region was released as Alaska Division of Geological & Geophysical Surveys GPR 2001-1 and is available from DGGS.

David L. LePain  
Project Manager  
December 28, 2001



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## INTRODUCTION

Organic petrography, vitrinite reflectance and high-pressure methane adsorption analyses were carried on samples provided by Mr. David LePain.

Reflectance and organic petrography were carried on samples:

00DL28 32.5  
00DL28-1.0  
00DL28-17  
00DL28-44  
00DL30B  
00DL32A  
00DL33  
00DL33E  
00DL34D  
00DL34F  
00DL43A  
00DL49 326-327.5  
00DL58 36-39.5

High pressure methane adsorption isotherms were carried out on samples:

00DL30B  
00DL28-1.0  
00DL43A  
00DL58 36-39.5  
00DL33E  
00DL28-44

## Methods

On receipt of the samples they were crushed if necessary and split. A -20 or -60 mesh split was utilized for maceral and vitrinite reflectance depending on as received size of the samples. A -60 mesh split of the samples was used for adsorption analyses and helium density determination.

The samples for methane adsorption analyses were placed over a  $\text{KSO}_4$  bath in an inert atmosphere at 40° C (reservoir temperature provided by Dave LePain) for a minimum of 12 days. Equilibrium moisture and ash was determined of a 10 gram split of these samples. It these ash and moisture values that are used in the adsorption isotherms not the results of the proximate analyses.

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A detailed description and overview of the adsorption measurement procedure is provided in Appendix XIV.

## Results

### Petrography

The petrographic composition of the samples is summarized in Table 1. Many of the samples are very rich in mineral matter and probably are best described as carbargillites or argillaceous coals. Histograms of the vitrinite reflectance data are shown in Appendix XIII. All samples are predominately comprised of vitrinite groups macerals (about 90%) with minor amounts of inertinite (<2%) and generally trace amounts of liptinite.

The fabric of the coals are all remarkably similar. The collodetrinite is characterized by very fine-grained mineral matter (sub-micron). The microlithotype bands vary from a few micrometres to tens of micrometres and are interbanded with claystone.

The mean vitrinite reflectance of the samples is between .19 and .62.

### Adsorption Analyses

The adsorption analyses of the samples is summarized on the attached pages in both SI and Imperial units. The results are detailed in Appendices I through XII.

**Note that STP in SI units is at 0°C. In Imperial units standard (oil industry convention) STP is at a temperature of 60° F. Reported pressures are absolute.**

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Organic Petrology Mineral Matter Free (vol. %)

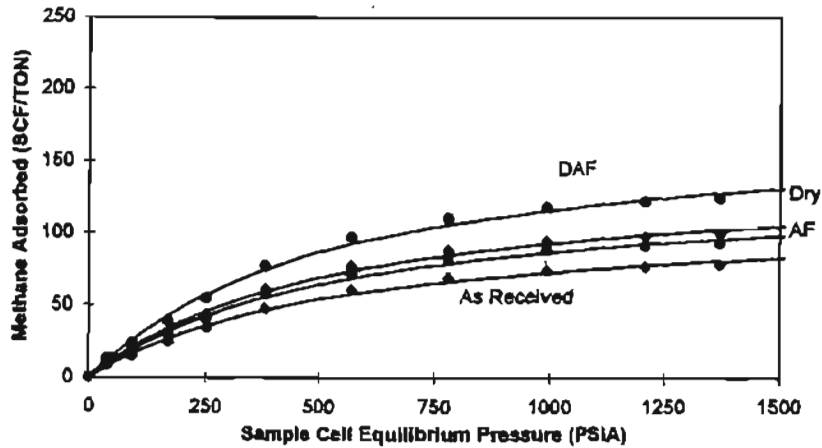
Sample Location	Vitrinite				Inertinite			Lipinite			Pyrite	Vitrinite	
	Collo- telinite	Collo- detritite	Corpo- gelinite	Semi- fusinite	Fung- fusinite	Macri- nile	cutinite	resinite	suberinite	sporinite		Mean Ro. %	Std. Dev.
00DL28 32.5	95.0	50.0	50.7	1.9 trace	trace		0.4		trace	0.5	trace	0.19	0.03
00DL28-1.0	46.3	50.7	43.5	1.0	0.5 trace			0.5			trace	0.22	0.05
00DL28-17	53.8	43.5		0.9 trace			trace	trace	trace			0.22	0.04
00DL28-44	96.2	3.9		0.5			4				trace	0.18	0.04
00DL30B	73.5	22.9									trace	0.42	0.03
00DL32A	71.0	28.9										0.62	0.04
00DL33	95.2	4.7		trace			trace	trace	trace	1		0.47	0.03
00DL33E	60.8	35.5		1.0	1.0		1		trace			0.53	0.04
00DL34D	88.3	11.6		trace	trace		trace		trace			0.46	0.04
00DL34F	92.4	5.8 trace		1.6 trace					trace			0.42	0.03
00DL43A	95.0	5.0		trace					trace			0.14	0.03
00DL49 328-327.5	97.2	2.7										0.48	0.03
00DL58 36-39.5	61.1	38.8					trace		trace			0.47	0.05

Organic Petrology Mineral Matter Included (vol. %)

Sample Location	Vitrinite				Inertinite			Lipinite			Pyrite	Mineral Matter (vol. %)	Ash Wt. %
	Collo- telinite	Collo- detritite	Corpo- gelinite	Semi- fusinite	Fung- fusinite	Macri- nile	cutinite	resinite	suberinite	sporinite			
00DL28 32.5	89.0	4.7		1.8	trace	trace	0.4			trace	trace	6.3	12.5
00DL28-1.0	44.5	48.8		1.0	0.5	trace		0.5		0.5	trace	3.8	7.7
00DL28-17	61.6	41.7		0.6	trace		trace	trace		trace		4.1	8.2
00DL28-44	67.6	2.7		0.6			3.8				trace	28.7	58.4
00DL30B	69.2	21.6										5.8	11.7
00DL32A	51.8	21.1										27.0	54.1
00DL33	76.8	3.8		0.9	trace		trace	trace		trace		19.4	38.8
00DL33E	54.7	31.9		trace	trace		0.9		trace	0.9		10.1	20.1
00DL34D	75.0	9.8	trace	1.1			trace		trace	trace		16.1	30.2
00DL34F	65.2	4.0										29.4	58.9
00DL43A	87.8	4.6		trace						trace		7.6	15.2
00DL49 328-327.5	73.0	2.0										24.9	49.7
00DL58 36-39.5	43.1	27.4					trace			trace		28.5	58.0

TABLE 1. ORGANIC PETROLOGY

## 00DL30B



Pressure (PSIA)	Adsorbed Methane (ft <sup>3</sup> /ton)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
39	9	11	10	14
90	15	19	18	24
187	25	32	30	40
251	35	44	41	55
380	49	62	58	77
571	61	78	72	97
779	69	88	82	110
993	74	95	88	118
1209	77	98	91	122
1370	78	100	93	124

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (ft <sup>3</sup> /ton)	110	140	131	175
Pressure (PSIA)	512	512	512	512

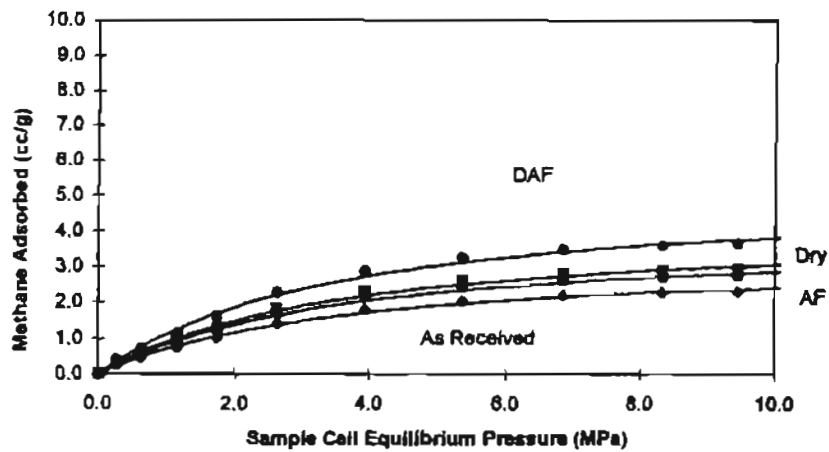
Isotherm Temperature: 104 °F

Goodness of fit of Langmuir regression: 0.99

% Ash= 15.78      % Moisture= 21.38

**SUMMARY OF ADSORPTION ANALYSES IMP. UNITS**

## 00DL30B



Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.27	0.25	0.32	0.30	0.41
0.62	0.44	0.57	0.53	0.71
1.15	0.74	0.94	0.87	1.17
1.73	1.02	1.29	1.21	1.62
2.62	1.43	1.82	1.70	2.27
3.93	1.79	2.28	2.13	2.85
5.37	2.04	2.60	2.42	3.25
6.85	2.18	2.78	2.59	3.47
8.33	2.25	2.87	2.68	3.59
9.45	2.30	2.93	2.73	3.68

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	3.24	4.13	3.85	5.16
Pressure (MPa)	3.53	3.53	3.53	3.53

Isotherm Temperature:

40.0 °C

Goodness of fit of Langmuir regression:

0.98

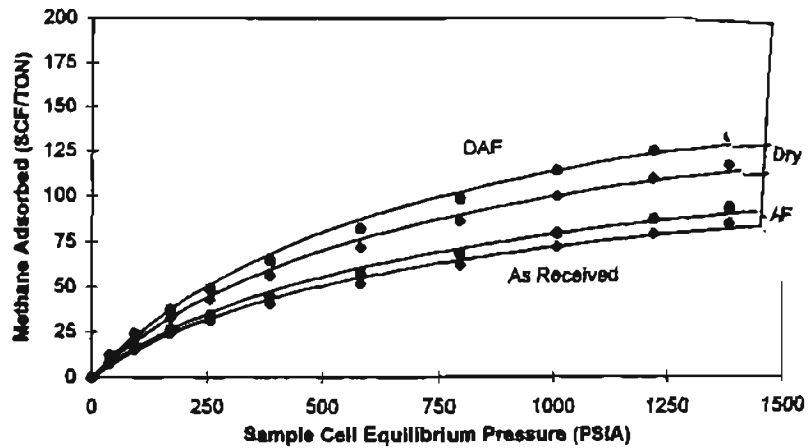
% Ash = 16.78

% Moisture =

21.38

**SUMMARY OF ADSORPTION ANALYSES SI UNITS**

## 00DL28-1.0



Pressure (PSIA)	Adsorbed Methane (ft <sup>3</sup> /ton)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
40	8	11	8	12
92	15	21	17	24
170	24	33	26	38
256	31	43	34	49
386	41	56	45	64
582	52	72	57	82
793	62	86	68	98
1008	72	100	79	114
1222	79	109	86	124
1383	84	117	92	133

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (ft <sup>3</sup> /ton)	123	170	135	194
Pressure (PSIA)	711	711	711	711

Isotherm Temperature: 164 °F

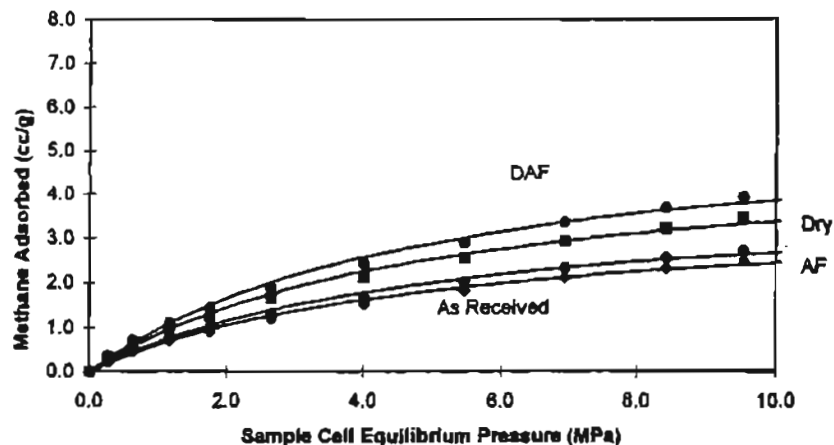
Goodness of fit of Langmuir regression: 0.98

% Ash= 8.95

% Moisture= 27.77

**SUMMARY OF ADSORPTION ANALYSES IMP. UNITS**

## 00DL28-1.0



Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.27	0.22	0.31	0.24	0.35
0.63	0.45	0.62	0.49	0.71
1.17	0.70	0.97	0.77	1.10
1.77	0.91	1.26	1.00	1.44
2.66	1.20	1.66	1.31	1.89
4.01	1.53	2.11	1.66	2.41
5.47	1.83	2.53	2.01	2.89
6.95	2.11	2.93	2.32	3.34
8.42	2.31	3.20	2.54	3.65
9.54	2.47	3.43	2.72	3.91

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	3.61	5.00	3.97	5.71
Pressure (MPa)	4.90	4.90	4.90	4.90

Isotherm Temperature:

40.0 °C

Goodness of fit of Langmuir regression:

0.98

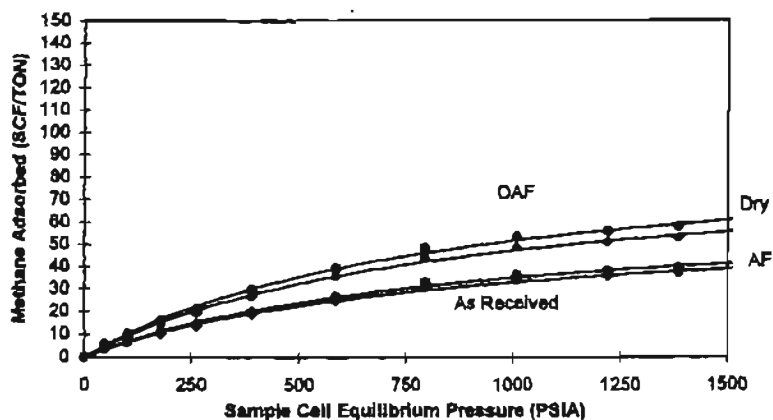
% Ash= 8.95

% Moisture =

27.77

**SUMMARY OF ADSORPTION ANALYSES SI UNITS**

00DL43A



Pressure (PSIA)	Adsorbed Methane (ft <sup>3</sup> /ton)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
48	4	5	4	8
100	7	9	7	10
178	10	14	11	18
282	14	18	14	21
391	19	27	20	30
585	25	38	27	39
794	31	44	33	48
1008	34	48	36	53
1221	38	51	38	56
1383	37	53	39	58

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (ft <sup>3</sup> /ton)	80	86	64	94
Pressure (PSIA)	828	828	828	828

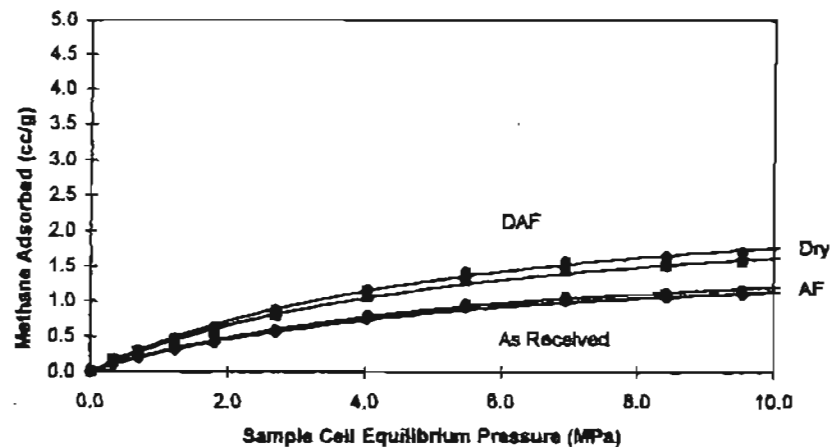
Isotherm Temperature: 104 °F

Goodness of fit of Langmuir regression: 0.99

% Ash= 8.01      % Moisture= 38.23

**SUMMARY OF ADSORPTION ANALYSES IMP. UNITS**

## 00DL43A



Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.33	0.11	0.15	0.11	0.17
0.89	0.19	0.28	0.20	0.30
1.23	0.30	0.43	0.32	0.47
1.81	0.40	0.57	0.42	0.62
2.70	0.56	0.80	0.59	0.87
4.03	0.74	1.06	0.79	1.18
5.48	0.90	1.29	0.96	1.41
8.95	1.00	1.43	1.06	1.57
8.42	1.05	1.50	1.12	1.64
9.54	1.06	1.55	1.15	1.70

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	1.77	2.54	1.88	2.77
Pressure (MPa)	5.71	5.71	5.71	5.71

Isotherm Temperature:

40.0 °C

Goodness of fit of Langmuir regression:

0.99

% Ash = 6.01

% Moisture =

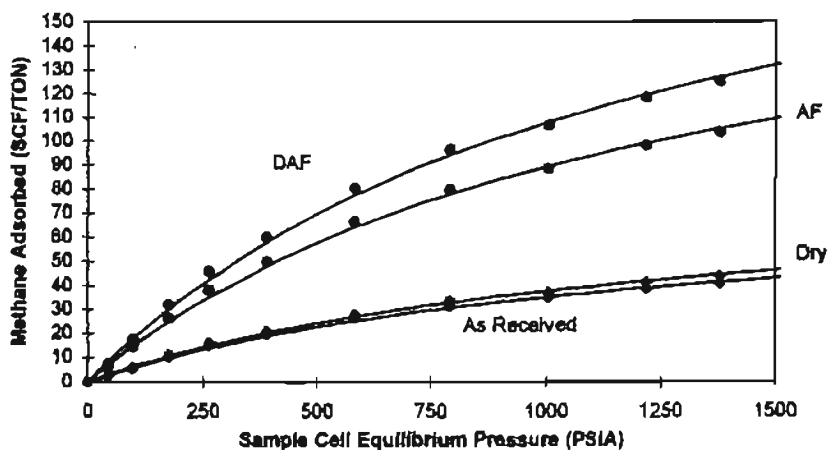
30.23

SUMMARY OF ADSORPTION ANALYSES SI UNITS





## 00DL58 36-39 .5



Pressure (PSIA)	Adsorbed Methane (ft <sup>3</sup> /ton)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
45	2	3	6	7
98	6	8	14	17
176	10	11	27	32
261	15	18	38	48
389	20	21	50	60
582	26	28	67	80
791	32	34	80	97
1004	35	37	88	107
1217	39	41	98	118
1379	41	44	104	125

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (ft <sup>3</sup> /ton)	78	83	197	238
Pressure (PSIA)	1201	1201	1201	1201

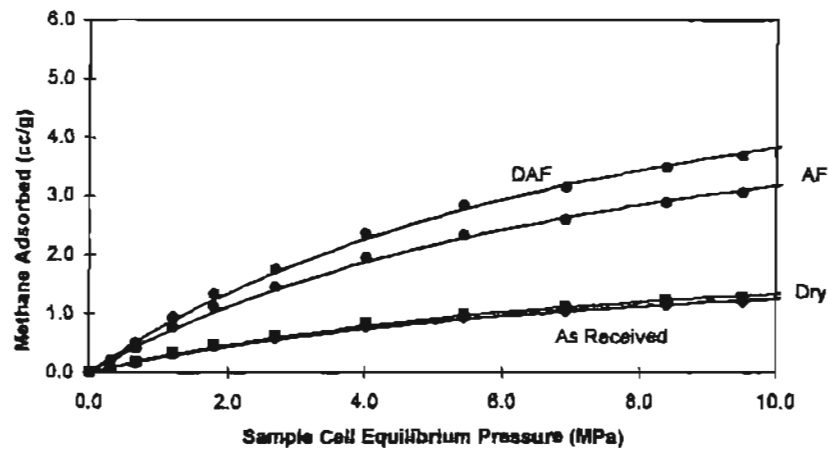
Isotherm Temperature: 104 °F

Goodness of fit of Langmuir regression: 0.97

% Ash= 60.60 % Moisture= 6.77

**SUMMARY OF ADSORPTION ANALYSES IMP. UNITS**

### 00DL58 36-39.5



Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.31	0.07	0.08	0.18	0.22
0.68	0.17	0.18	0.42	0.51
1.21	0.31	0.33	0.78	0.94
1.80	0.44	0.47	1.12	1.35
2.68	0.58	0.62	1.46	1.77
4.01	0.77	0.83	1.96	2.36
5.45	0.93	0.99	2.35	2.84
8.92	1.02	1.10	2.60	3.14
8.39	1.13	1.21	2.87	3.47
9.51	1.20	1.29	3.04	3.67

#### Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	2.28	2.44	5.78	6.98
Pressure (MPa)	8.28	8.28	8.28	8.28

Isotherm Temperature: 46.0 °C

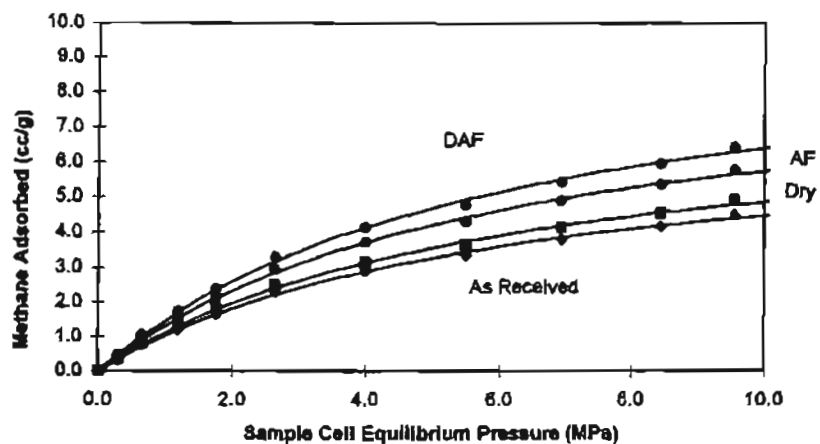
Goodness of fit of Langmuir regression: 0.97

% Ash= 60.60      % Moisture = 8.77

**SUMMARY OF ADSORPTION ANALYSES SI UNITS**



## 00DL33-E



Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.29	0.31	0.34	0.40	0.45
0.63	0.74	0.80	0.95	1.05
1.17	1.21	1.31	1.56	1.73
1.78	1.67	1.81	2.15	2.39
2.85	2.30	2.50	2.98	3.30
3.99	2.90	3.15	3.73	4.15
5.50	3.35	3.84	4.30	4.79
6.95	3.81	4.13	4.89	5.45
8.44	4.17	4.53	5.38	5.97
9.58	4.51	4.89	5.79	6.45

## Langmuir Parameters

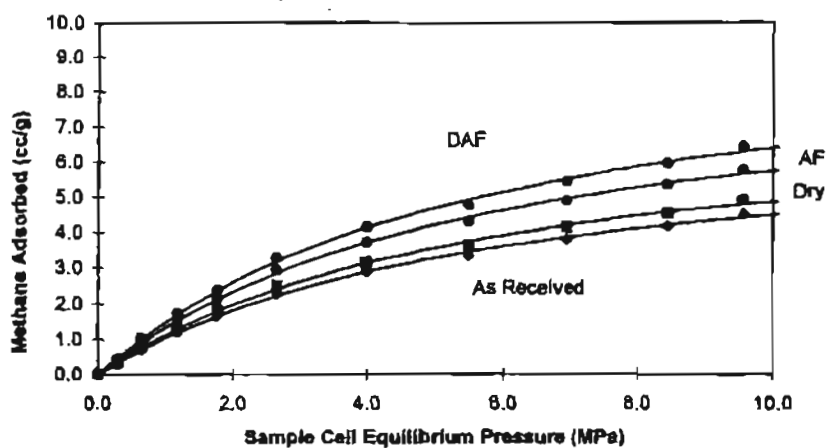
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	7.06	7.87	9.07	10.10
Pressure (MPa)	5.74	5.74	5.74	5.74

Isotherm Temperature: 40.0 °C

Goodness of fit of Langmuir regression: 0.99

% Ash= 22.21      % Moisture = 7.92

**SUMMARY OF ADSORPTION ANALYSES SI UNITS**

**00DL33-E**

Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.29	0.31	0.34	0.40	0.45
0.83	0.74	0.80	0.95	1.05
1.17	1.21	1.31	1.56	1.73
1.76	1.67	1.81	2.15	2.39
2.65	2.30	2.50	2.96	3.30
3.99	2.90	3.15	3.73	4.15
5.50	3.35	3.64	4.30	4.79
6.95	3.81	4.13	4.89	5.45
8.44	4.17	4.53	5.36	5.97
9.56	4.51	4.89	5.79	6.45

**Langmuir Parameters**

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	7.06	7.67	9.07	10.10
Pressure (MPa)	5.74	5.74	5.74	5.74

Isotherm Temperature:

40.0 °C

Goodness of fit of Langmuir regression:

0.99

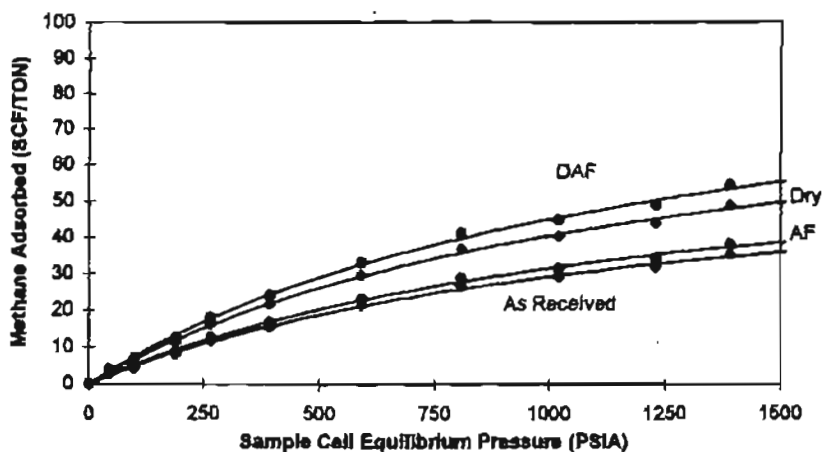
% Ash= 22.21

% Moisture =

7.92

**SUMMARY OF ADSORPTION ANALYSES SI UNITS**

## 00DL28-44



Pressure (PSIA)	Adsorbed Methane (ft <sup>3</sup> /ton)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
45	3	4	3	4
98	4	6	5	7
190	8	11	9	13
285	12	16	13	18
393	16	22	17	24
590	22	30	23	33
808	27	37	29	41
1020	29	40	31	45
1229	32	44	34	49
1389	35	48	38	54

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (ft <sup>3</sup> /ton)	85	80	70	100
Pressure (PSIA)	1221	1221	1221	1221

Isotherm Temperature:

104 °F

Goodness of fit of Langmuir regression:

0.97

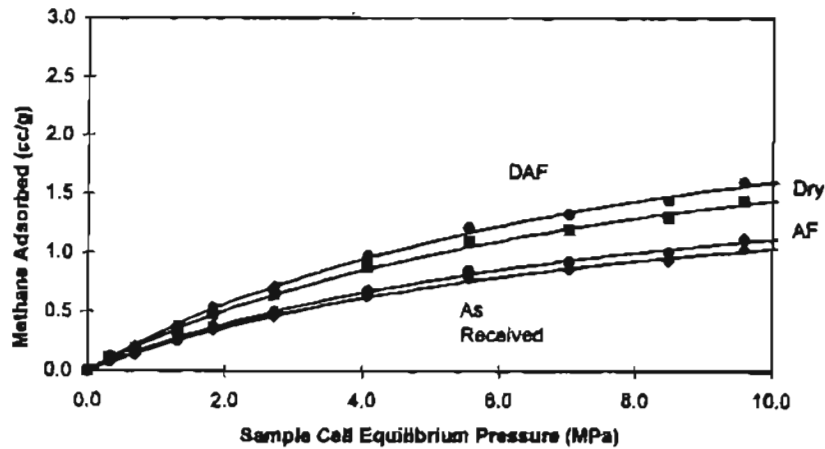
% Ash= 7.26

% Moisture=

27.89

**SUMMARY OF ADSORPTION ANALYSES IMP. UNITS**

00DL28-44



Pressure (MPa)	Adsorbed Methane (cc/g)			
	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
0.31	0.08	0.11	0.08	0.12
0.68	0.13	0.18	0.14	0.20
1.31	0.24	0.33	0.26	0.37
1.83	0.35	0.48	0.37	0.53
2.71	0.46	0.64	0.50	0.71
4.07	0.63	0.88	0.68	0.97
5.56	0.79	1.09	0.85	1.21
7.03	0.86	1.19	0.92	1.32
8.47	0.93	1.29	1.00	1.44
9.58	1.03	1.43	1.11	1.59

## Langmuir Parameters

	As Received	Dry with Ash	Moist Ash Free	Dry Ash Free
Vol. (cc/g)	1.91	2.65	2.06	2.94
Pressure (MPa)	8.42	8.42	8.42	8.42

Isotherm Temperature:

40.0 °C

Goodness of fit of Langmuir regression:

0.97

% Ash= 7.26

% Moisture =

27.89

**SUMMARY OF ADSORPTION ANALYSES SI UNITS**

**APPENDIX I****00DL30B*****Methane Adsorption Isotherm  
Imperial Units******Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	110	176
Langmuir Pressure MPa	512	512
Goodness of fit Langmuir		
Equation R-squared	0.99	0.99
Ash Content Wt. %	15.75	15.75
Equilibrium Moisture Wt. %	21.38	21.38

**Contents of Appendix*****Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL30B****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL30B	Moisture Content (EQ) % :	21.38
Isotherm Temperature ° F:	104	Ash Content, % :	15.75
		Helium Density g/cc	1.378

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
39	8.88	4.50
90	15.13	5.98
167	25.02	8.89
251	34.60	7.25
380	48.60	7.82
571	61.06	9.35
779	69.46	11.22
993	74.32	13.36
1209	76.70	15.78
1370	78.27	17.51

Saturated Monolayer Volume (SCF/ton): 110

Langmuir Pressure (PSIA): 512

**DRY ASH FREE BASIS**

39	13.80	2.83
90	24.07	3.75
167	39.80	4.21
251	55.04	4.56
380	77.30	4.91
571	97.12	5.88
779	110.48	7.05
993	118.21	8.40
1209	122.00	9.91
1370	124.49	11.01

Saturated Monolayer Volume (SCF/ton, daft): 176

Langmuir Pressure (PSIA): 512

Correlation Coefficient: 0.99



**00DL30B****METHANE ADSORPTION ISOTHERM CFG UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL30B	Moisture Content (EQ) % :	21.38
Isotherm Temperature ° F:	104	Ash Content, % :	15.75
		Helium Density g/cc	1.378

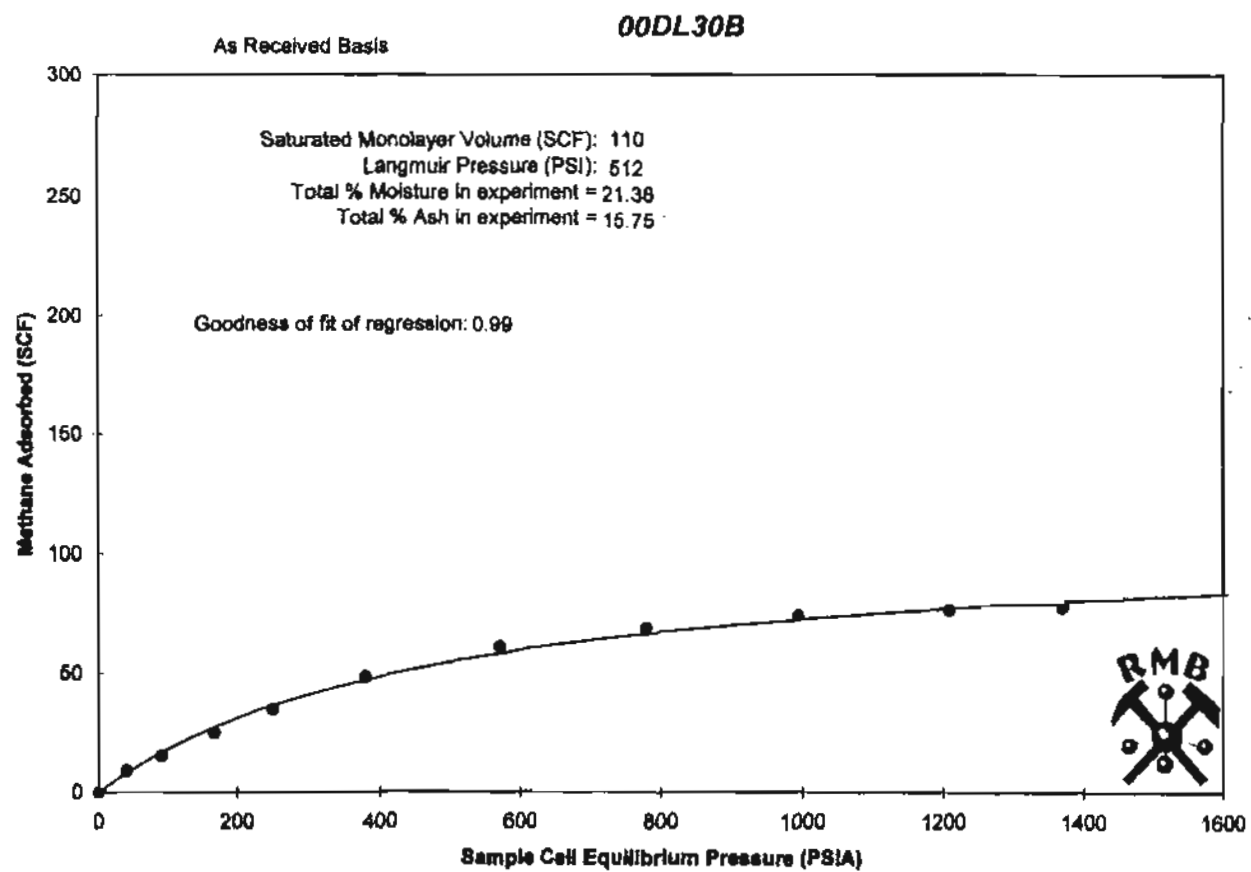
PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
39	11	3.54
90	19	4.89
187	32	5.28
251	44	5.70
380	82	6.14
571	78	7.35
779	88	8.82
993	95	10.50
1209	98	12.39
1370	100	13.78

Saturated Monolayer Volume (SCF/ton):	140
Langmuir Pressure (PSIA):	512

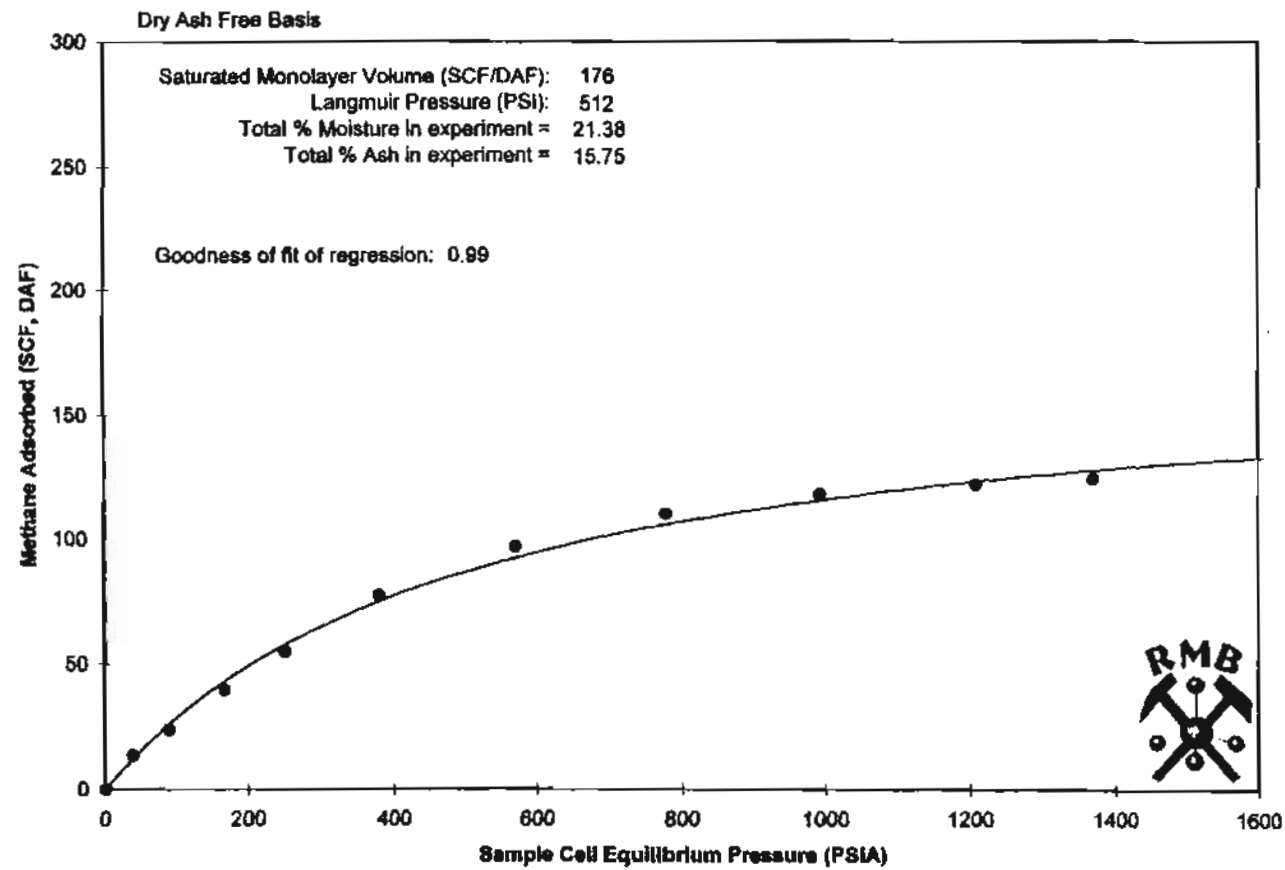
**MOIST ASH FREE BASIS**

39	10	3.79
90	18	5.02
187	30	5.84
251	41	6.10
380	58	6.59
571	72	7.87
779	82	9.45
993	88	11.25
1209	91	13.28
1370	93	14.75

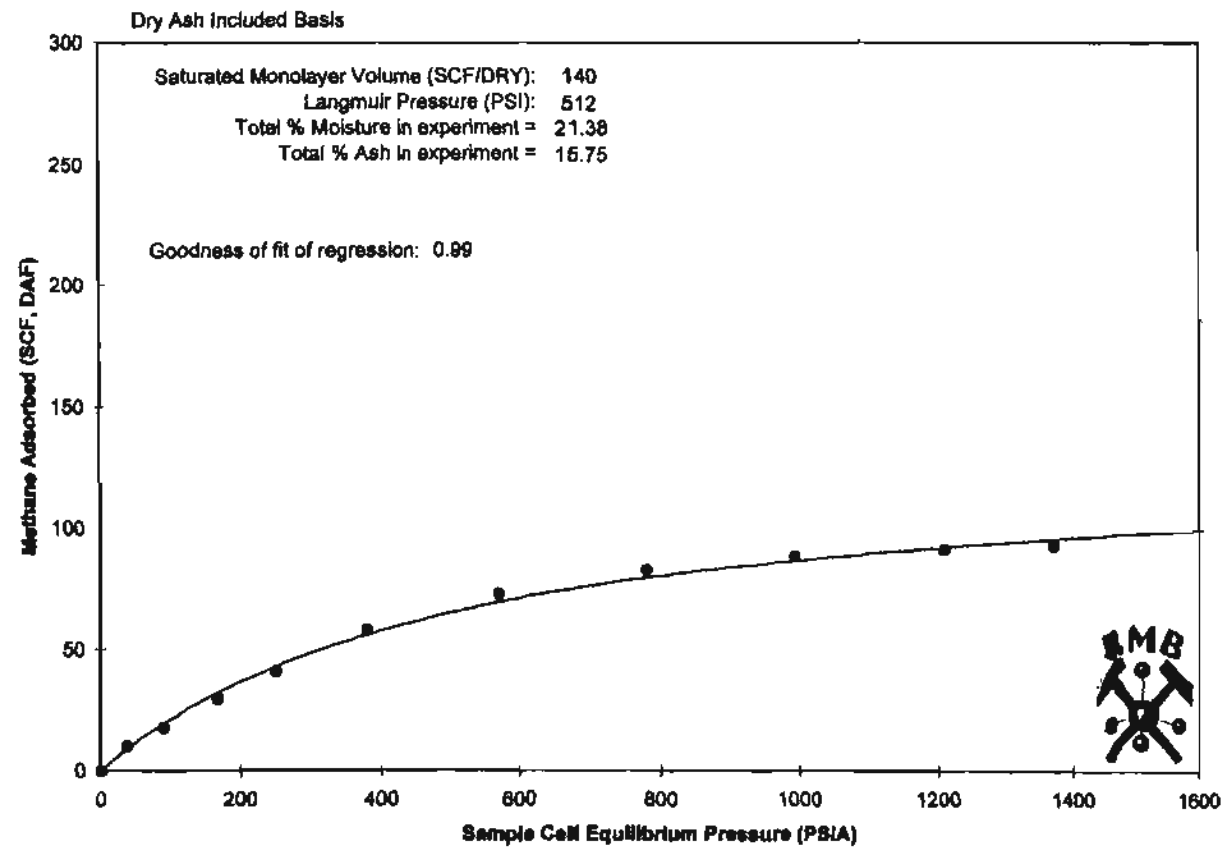
Saturated Monolayer Volume (SCF/ton, daf):	131
Langmuir Pressure (PSIA):	512
Correlation Coefficient:	0.99



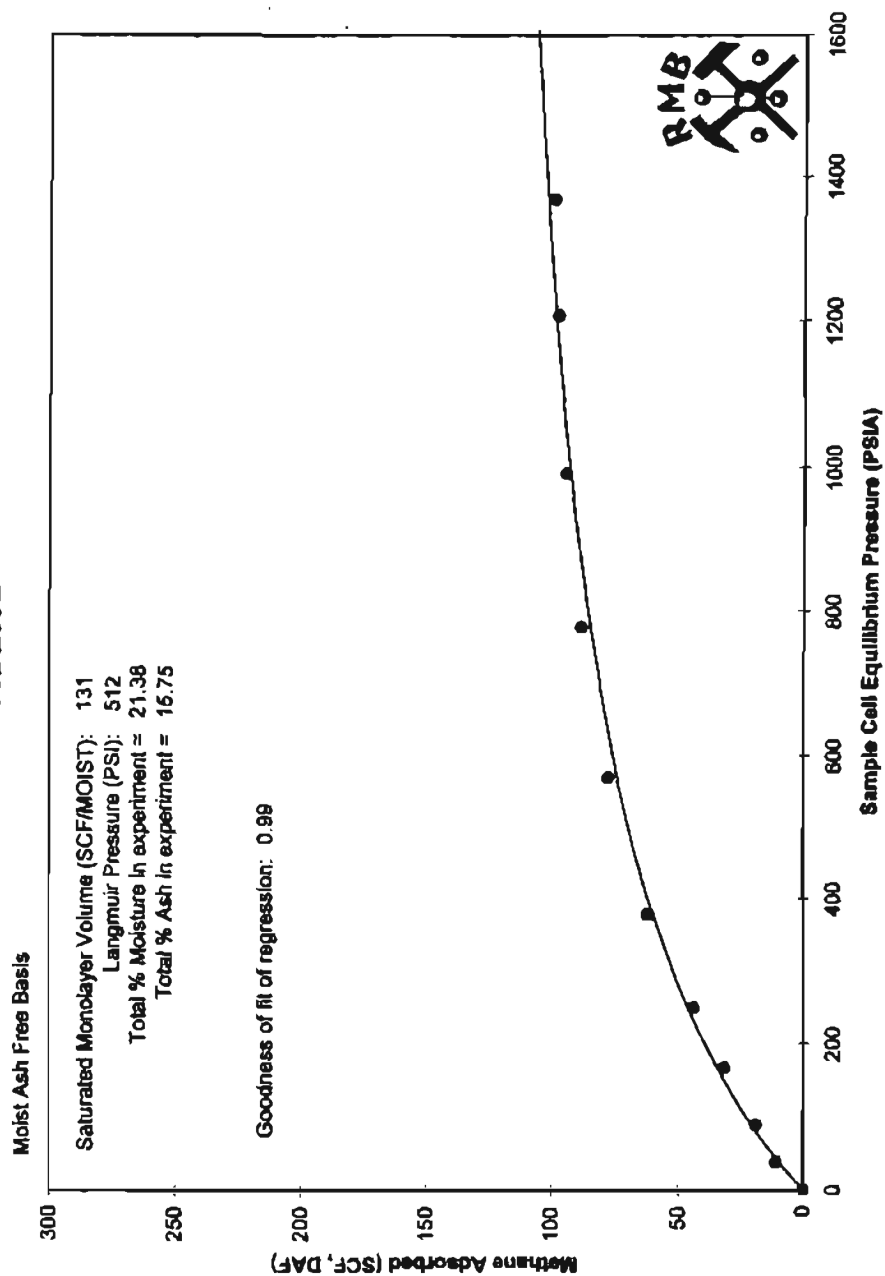
# 00DL30B



# 00DL30B



00DL30B

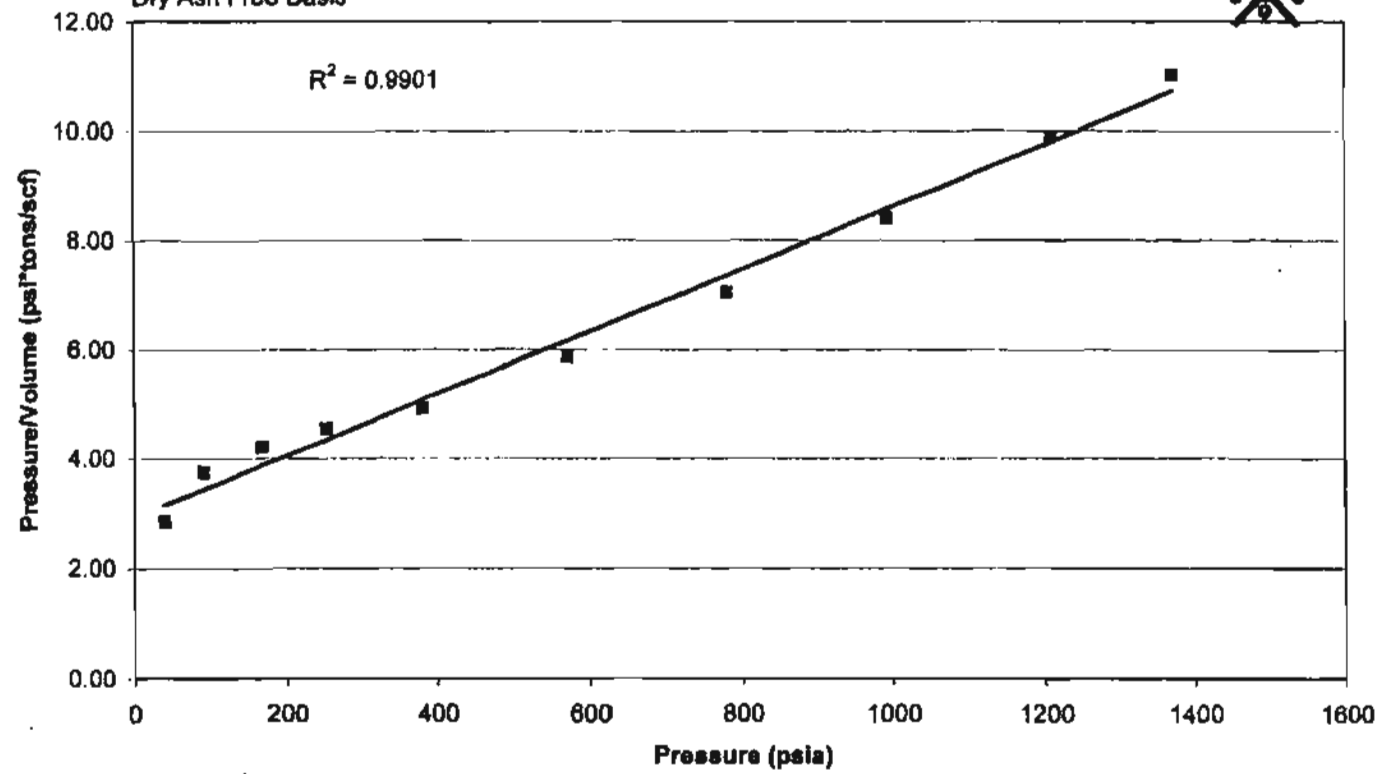


**Adsorption Langmuir Plot  
Methane Imperial Units**

**00DL30B**



Dry Ash Free Basis



**APPENDIX II****00DL30B*****Methane Adsorption Isotherm SI Units******Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	3.24	5.16
Langmuir Pressure MPa	3.53	3.53
Goodness of fit Langmuir		
Equation R-squared	0.99	0.99
Ash Content Wt %	15.75	15.75
Equilibrium Moisture Wt %	21.38	21.38

***Contents of Appendix******Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL30B****METHANE ADSORPTION ISOTHERM SI UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL30B	Moisture Content (EQ) % :	21.38
Isotherm Temperature ° C:	40	Ash Content % :	15.75
		Helium Density g/cc	1.378

PRESSURE (MPa)	ADSORBED METHANE (cc/g @STP)	P / V
0.289	0.25	1.057
0.622	0.44	1.398
1.154	0.74	1.569
1.729	1.02	1.700
2.619	1.43	1.834
3.935	1.79	2.193
5.373	2.04	2.832
6.845	2.18	3.134
8.333	2.25	3.697
9.447	2.30	4.107

Saturated Monolayer Volume (cc/g @ STP):	3.24
Langmuir Pressure (MPa):	3.53

**DRY ASH FREE BASIS**

0.289	0.41	0.664
0.622	0.71	0.879
1.154	1.17	0.987
1.729	1.62	1.069
2.619	2.27	1.163
3.935	2.65	1.379
5.373	3.25	1.655
6.845	3.47	1.970
8.333	3.59	2.324
9.447	3.66	2.682

Saturated Monolayer Volume (cc/g @ STP, daf):	5.18
Langmuir Pressure (MPa):	3.53
Correlation Coefficient	0.99



**00DL30B****METHANE ADSORPTION ISOTHERM SI UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL30B	Moisture Content (EQ) % :	21.38
Isotherm Temperature ° C:	40	Ash Content %	15.75
		Helium Density g/cc	1.378

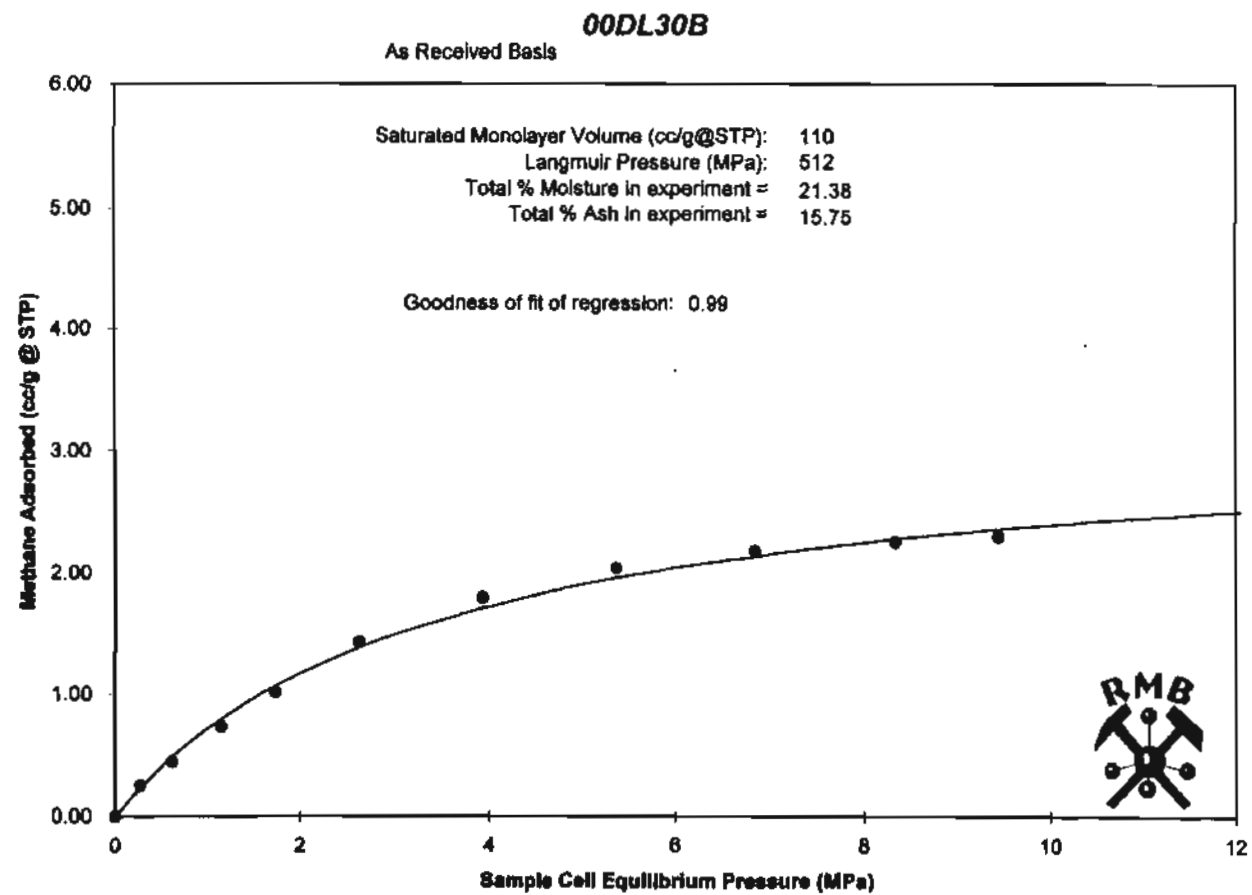
PRESSURE (MPa)	ADSORBED METHANE (cc/g@STP)	P / V
0.269	0.32	0.83
0.822	0.57	1.10
1.154	0.94	1.23
1.729	1.29	1.34
2.619	1.82	1.44
3.935	2.28	1.72
5.373	2.60	2.07
8.845	2.78	2.48
8.333	2.87	2.91
9.447	2.93	3.23

Saturated Monolayer Volume (cc/g, dry):	4.13
Langmuir Pressure (MPa):	3.53

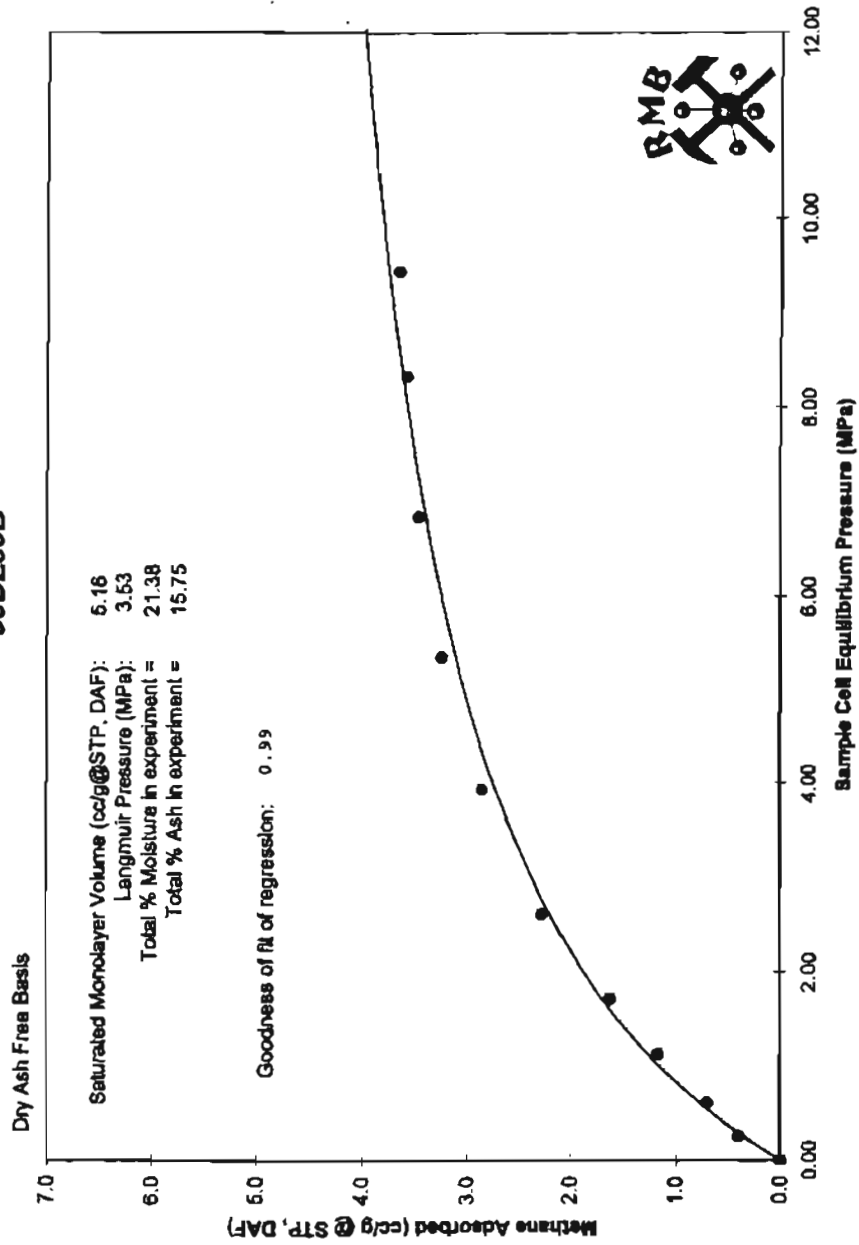
**MOIST ASH FREE BASIS**

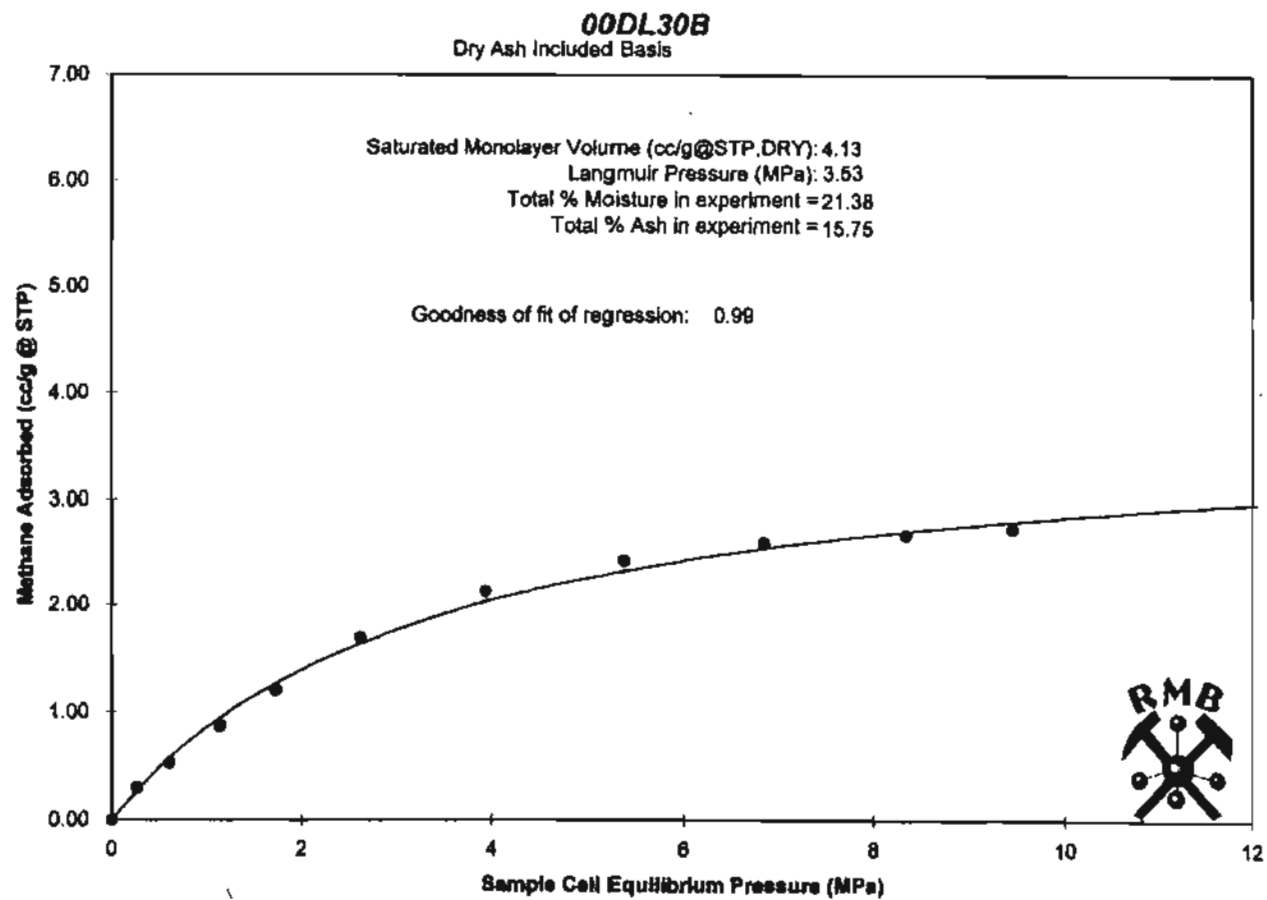
0.2694	0.30	0.00
0.8218	0.53	1.18
1.1538	0.87	1.32
1.7287	1.21	1.43
2.6189	1.70	1.54
3.9349	2.13	1.85
5.3733	2.42	2.22
8.8451	2.59	2.64
8.3334	2.68	3.11
9.4488	2.73	3.48

Saturated Monolayer Volume (cc/g, ash free):	3.85
Langmuir Pressure (MPa):	3.53
Correlation Coefficient:	0.99



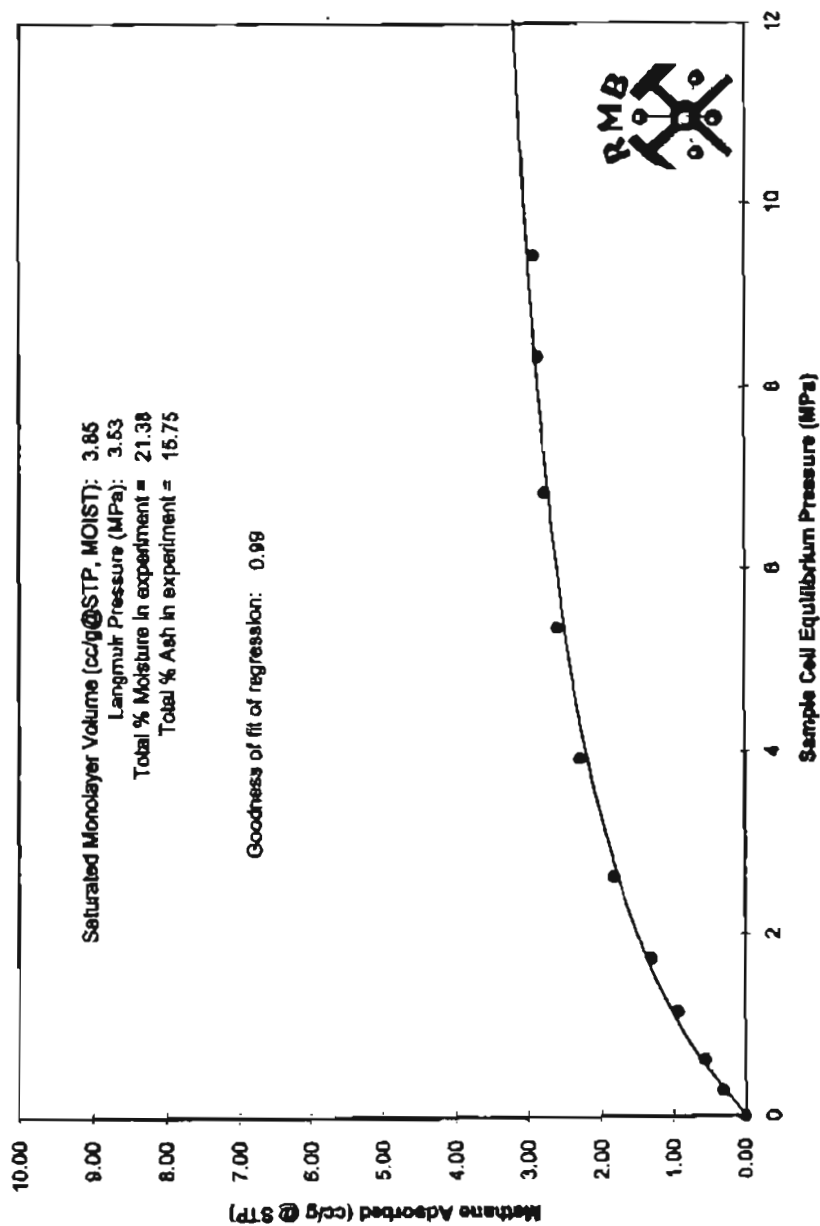
00DL30B





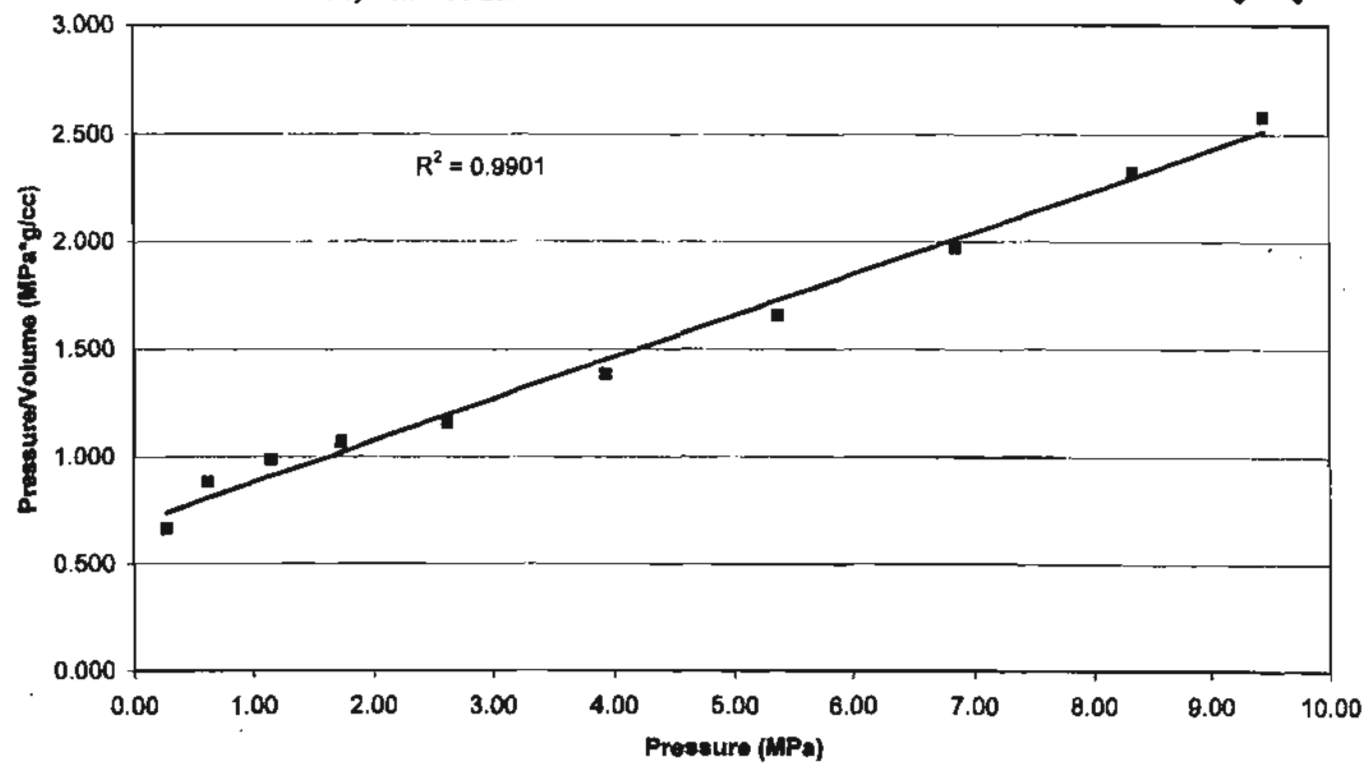
00DL30B

Mold Ash Free Basis



**Adsorption Langmuir Plot 00DL30B**  
**Methane SI Units**

Dry Ash Free Basis



### **APPENDIX III**

## **00DL28-1.0**

***Methane Adsorption Isotherm  
Imperial Units***

<b><i>Summary of Analyses</i></b>		
	<b>As Received</b>	<b>DAF basis</b>
Langmuir Volume cc/g	123	184
Langmuir Pressure MPa	711	711
Goodness of fit Langmuir		
Equation R-squared	0.98	0.98
Ash Content Wt. %	8.95	8.95
Equilibrium Moisture Wt. %	27.77	27.77

#### **Contents of Appendix**

##### ***Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

##### ***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL28-1.0****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. : 00DL28-1.0 Moisture Content (EQ) % : 27.77

Isotherm Temperature ° F: 104 Ash Content, % : 8.95

Helium Density g/cc 1.311

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
40	7.59	5.24
92	15.30	6.02
170	23.78	7.17
258	31.05	8.26
386	40.72	9.48
582	51.90	11.22
793	62.29	12.74
1008	71.93	14.01
1222	78.66	15.53
1383	84.19	16.43

Saturated Monolayer Volume (SCF/ton): 123

Langmuir Pressure (PSIA): 711

**DRY ASH FREE BASIS**

40	11.99	3.32
92	24.18	3.81
170	37.55	4.54
258	49.06	5.23
386	64.36	6.00
582	82.02	7.10
793	98.44	8.06
1008	113.67	8.87
1222	124.31	9.83
1383	133.05	10.40

Saturated Monolayer Volume (SCF/ton, daf): 194

Langmuir Pressure (PSIA): 711

Correlation Coefficient: 0.98



**00DL28-1.0****METHANE ADSORPTION ISOTHERM CFG UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL28-1.0	Moisture Content (EQ) % :	27.77
Isotherm Temperature ° F:	104	Ash Content, % :	8.85
		Helium Density g/cc	1.311

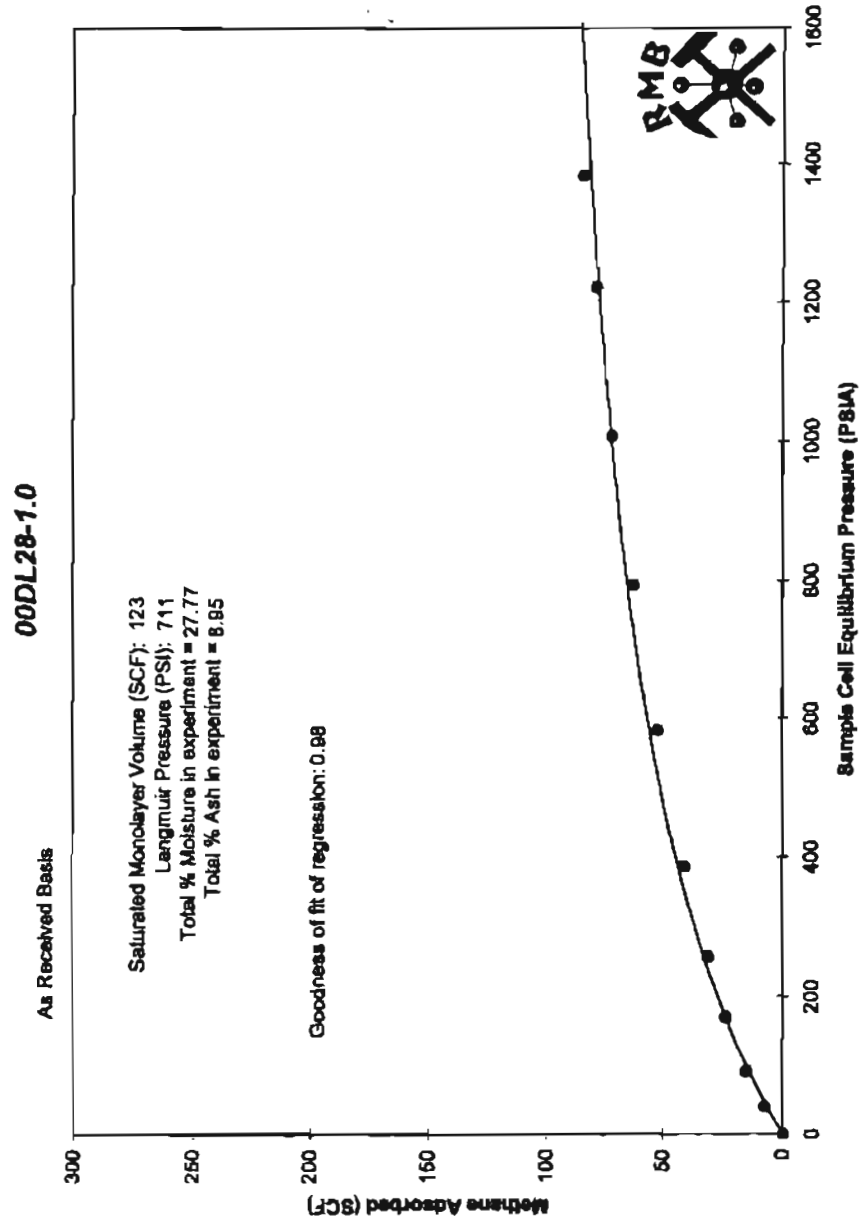
PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
40	11	3.79
92	21	4.35
170	33	5.18
258	43	5.98
388	56	6.84
582	72	8.10
793	86	9.20
1008	100	10.12
1222	109	11.22
1383	117	11.87

Saturated Monolayer Volume (SCF/ton):	170
Langmuir Pressure (PSIA):	711

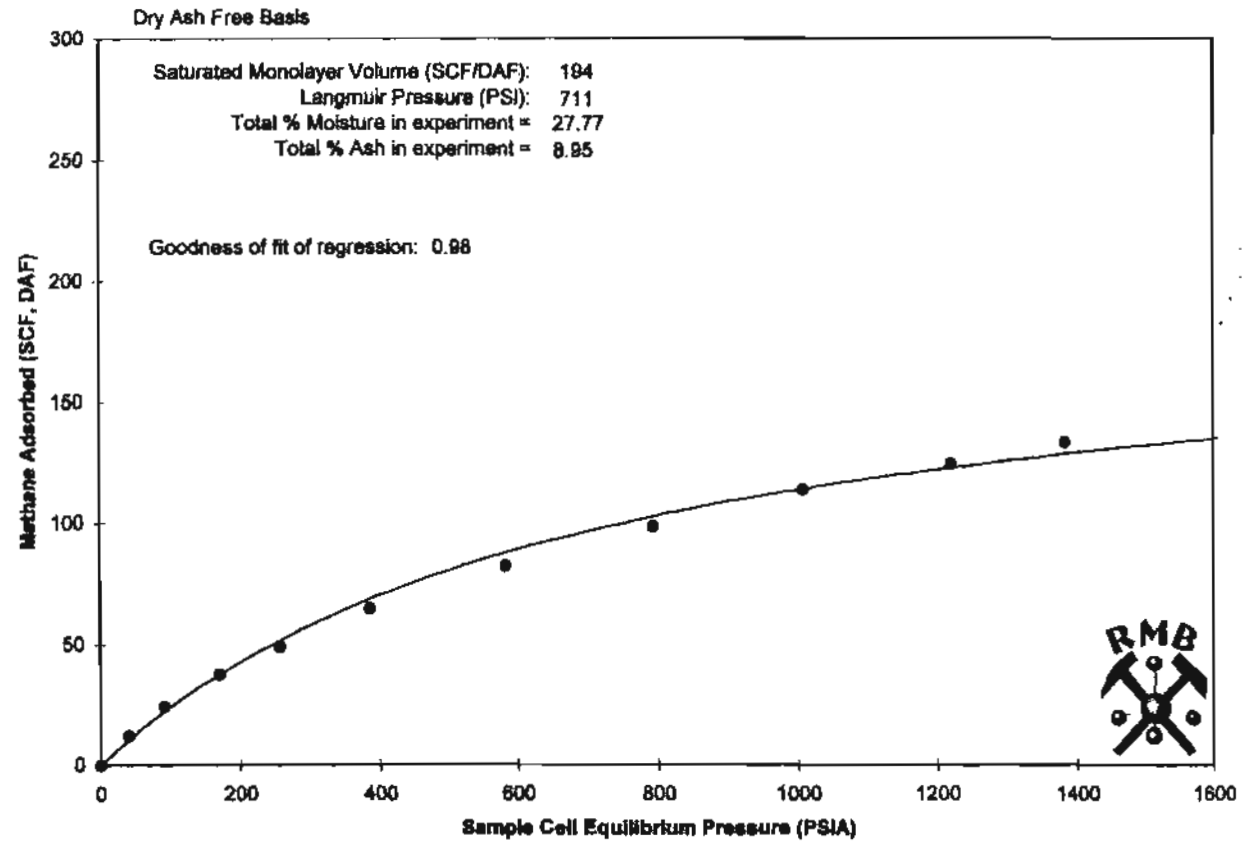
**MOIST ASH FREE BASIS**

40	8	4.78
92	17	5.48
170	26	6.53
258	34	7.52
388	45	8.63
582	57	10.21
793	68	11.60
1008	79	12.78
1222	86	14.14
1383	92	14.98

Saturated Monolayer Volume (SCF/ton, daf):	135
Langmuir Pressure (PSIA):	711
Correlation Coefficient:	0.98

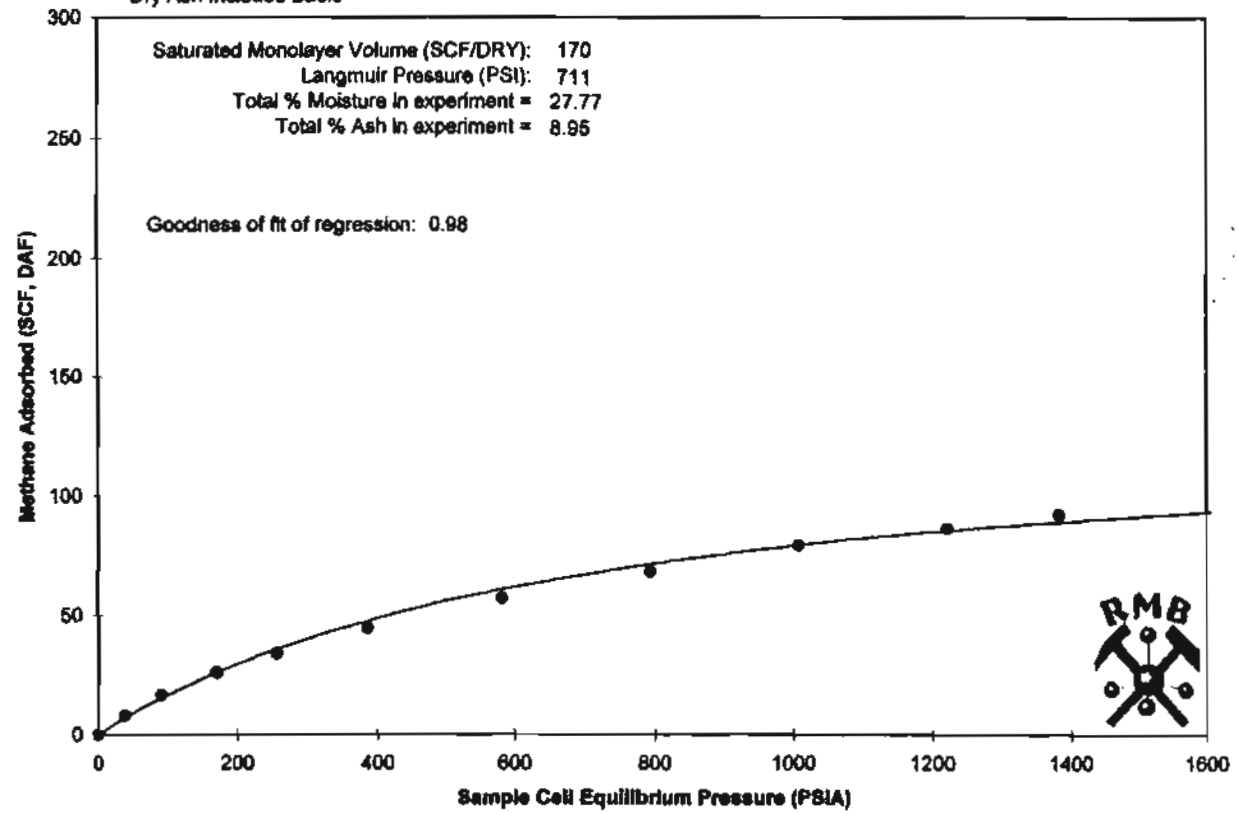


# 00DL28-1.0

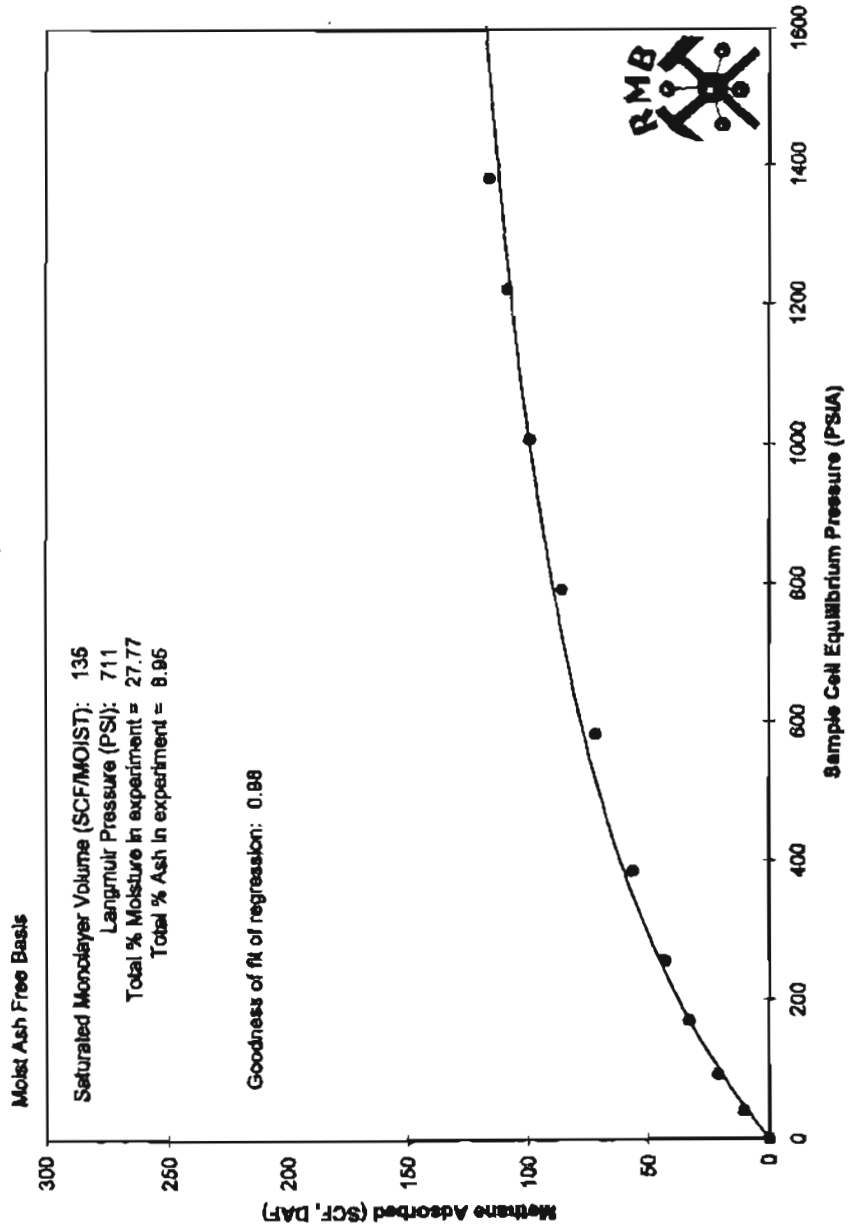


# 00DL28-1.0

Dry Ash Included Basis

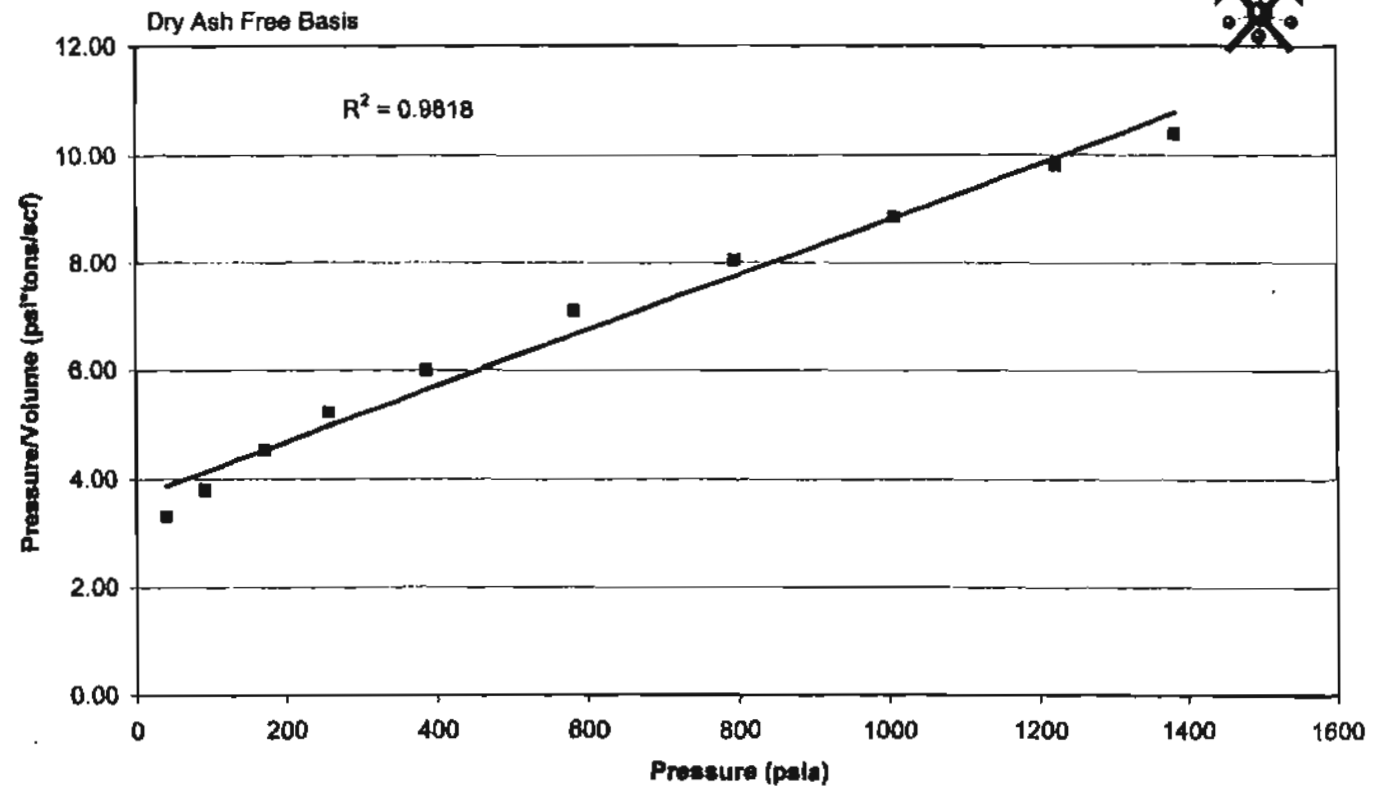


# 00DL28-1.0



**Adsorption Langmuir Plot  
Methane Imperial Units**

**00DL28-1.0**



# **APPENDIX IV**

## **00DL28-1.0**

***Methane Adsorption Isotherm SI Units***

### ***Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	3.61	5.71
Langmuir Pressure MPa	4.90	4.90
Goodness of fit Langmuir		
Equation R-squared	0.98	0.98
Ash Content Wt %	8.95	8.95
Equilibrium Moisture Wt %	27.77	27.77

### ***Contents of Appendix***

#### ***Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

#### ***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL28-1.0****METHANE ADSORPTION ISOTHERM SI UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL28-1.0	Moisture Content (EQ) % :	27.77
Isotherm Temperature ° C:	40	Ash Content % :	8.95
		Helium Density g/cc	1.311

PRESSURE (MPa)	ADSORBED METHANE (cc/g @STP)	P / V
0.274	0.22	1.230
0.635	0.45	1.412
1.175	0.70	1.682
1.768	0.91	1.937
2.661	1.20	2.223
4.014	1.53	2.631
5.470	1.83	2.988
6.949	2.11	3.287
8.422	2.31	3.643
9.536	2.47	3.854

Saturated Monolayer Volume (cc/g @ STP):	3.81
Langmuir Pressure (MPa):	4.90

**DRY ASH FREE BASIS**

0.274	0.35	0.779
0.635	0.71	0.893
1.175	1.10	1.065
1.768	1.44	1.226
2.661	1.89	1.407
4.014	2.41	1.685
5.470	2.89	1.891
6.949	3.34	2.080
8.422	3.65	2.305
9.538	3.91	2.439

Saturated Monolayer Volume (cc/g @ STP, daf):	5.71
Langmuir Pressure (MPa):	4.90
Correlation Coefficient:	0.98



**00DL28-1.0****METHANE ADSORPTION ISOTHERM SI UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL28-1.0	Moisture Content (EQ) % :	27.77
Isotherm Temperature ° C:	40	Ash Content %	8.95
		Helium Density g/cc	1.311

PRESSURE (MPa)	ADSORBED METHANE (cc/g@STP)	P / V
0.274	0.31	0.89
0.635	0.62	1.02
1.175	0.97	1.22
1.788	1.28	1.40
2.681	1.68	1.61
4.014	2.11	1.90
5.470	2.53	2.16
6.949	2.93	2.37
8.422	3.20	2.63
9.536	3.43	2.78

Saturated Monolayer Volume (cc/g, dry):	5.00
Langmuir Pressure (MPa):	4.90

**MOIST ASH FREE BASIS**

0.2744	0.24	0.00
0.6348	0.49	1.29
1.1748	0.77	1.53
1.7677	1.00	1.78
2.6808	1.31	2.02
4.0137	1.68	2.40
5.4700	2.01	2.72
6.9488	2.32	2.99
8.4221	2.54	3.32
9.5363	2.72	3.51

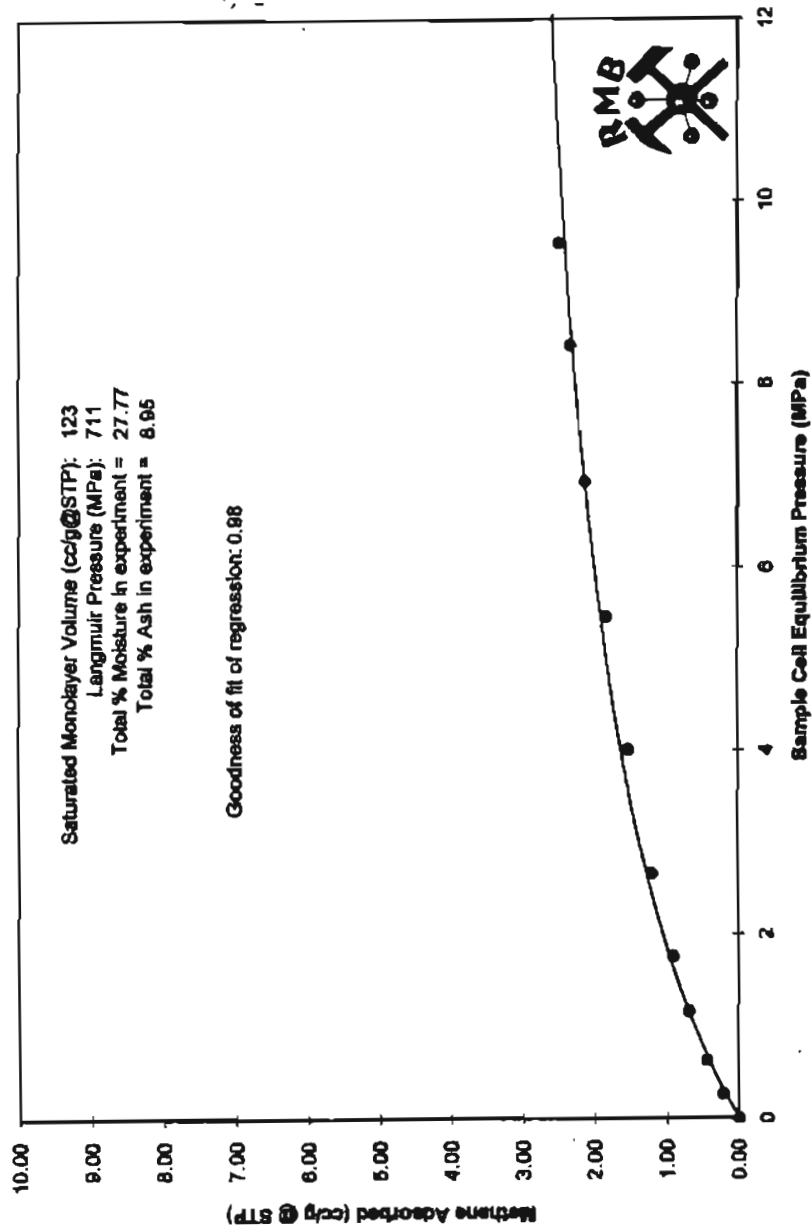
Saturated Monolayer Volume (cc/g, ash free):	3.97
Langmuir Pressure (MPa):	4.90
Correlation Coefficient:	0.98

# 00DL28-1.0

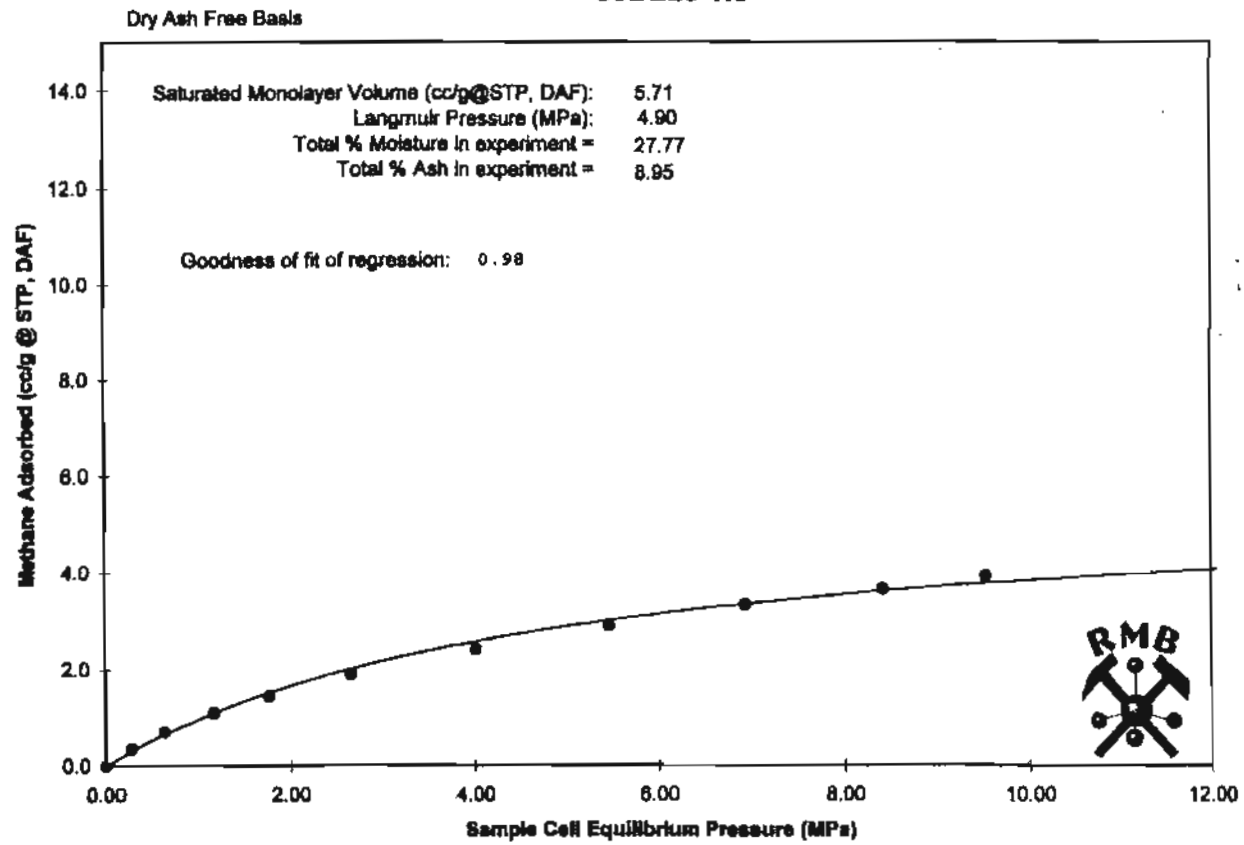
As Received Basis

Saturated Monolayer Volume (cc/g@STP): 123  
Langmuir Pressure (MPa): 711  
Total % Moisture in experiment = 27.77  
Total % Ash in experiment = 8.95

Goodness of fit of regression: 0.98



00DL28-1.0

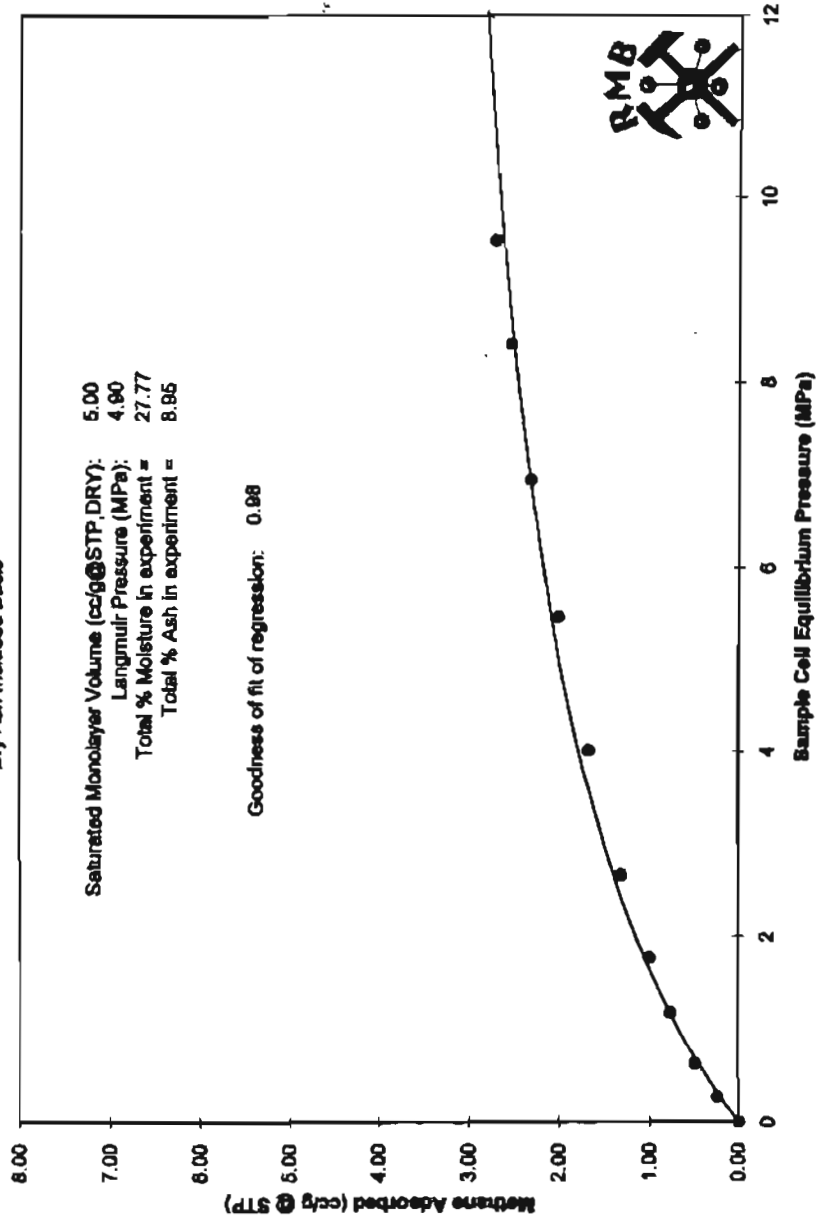


**00DL28-1.0**

Dry Ash Included Basis

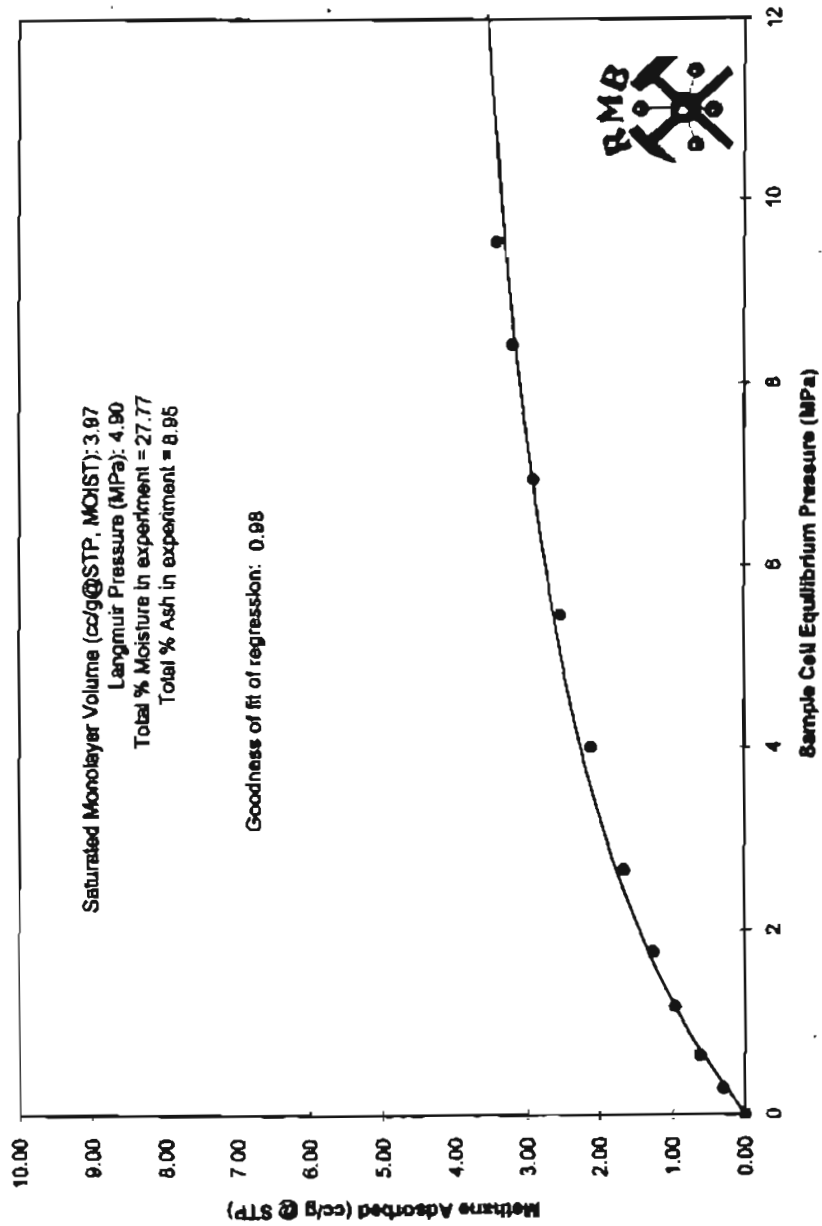
Saturated Monolayer Volume (cc/g @ STP, DRY): 5.00  
 Langmuir Pressure (MPa): 4.90  
 Total % Moisture in experiment = 27.77  
 Total % Ash in experiment = 8.95

Goodness of fit of regression: 0.98



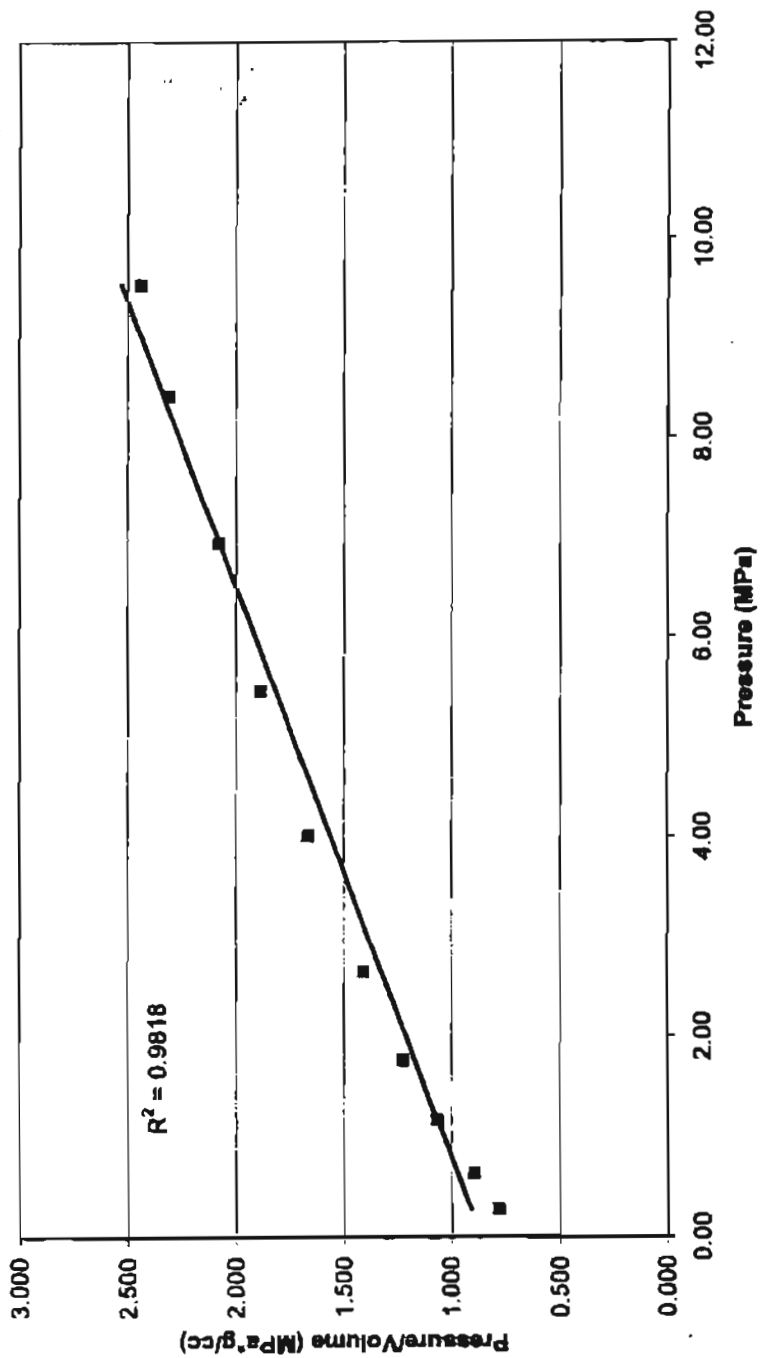
# 00DL28-1.0

Moist Ash Free Basis



**Adsorption Langmuir Plot**      **00DL28-1.0**  
**Methane SI Units**

Dry Ash Free Basis



## **APPENDIX V**

# **00DL43A**

***Methane Adsorption Isotherm  
Imperial Units***

### ***Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	80	94
Langmuir Pressure MPa	828	828
Goodness of fit Langmuir		
Equation R-squared	0.99	0.99
Ash Content Wt. %	6.01	6.01
Equilibrium Moisture Wt. %	30.23	30.23

#### **Contents of Appendix**

##### ***Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

##### ***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL43A****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL43A	Moisture Content (EQ) % :	30.23
Isotherm Temperature ° F:	104	Ash Content, % :	6.01
		Helium Density g/cc	1.334

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
48	3.58	13.28
100	6.54	15.38
178	10.12	17.62
262	13.55	19.33
391	18.90	20.70
585	25.19	23.22
794	30.89	25.88
1008	33.97	29.66
1221	35.89	34.20
1383	36.89	37.49

Saturated Monolayer Volume (SCF/ton):	60
Langmuir Pressure (PSIA):	828

**DRY ASH FREE BASIS**

48	5.63	8.47
100	10.28	9.80
178	15.87	11.24
262	21.28	12.33
391	29.64	13.20
585	38.50	14.81
794	48.14	16.50
1008	53.27	18.91
1221	55.97	21.81
1383	57.85	23.91

Saturated Monolayer Volume (SCF/ton, daf):	94
Langmuir Pressure (PSIA):	828
Correlation Coefficient:	0.99



**00DL43A****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL43A	Moisture Content (EQ) % :	30.23
Isotherm Temperature ° F:	104	Ash Content, % :	6.01
		Helium Density g/cc	1.334

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
48	3.59	13.29
100	6.54	15.38
178	10.12	17.62
262	13.55	19.33
391	18.90	20.70
585	25.19	23.22
794	30.69	25.88
1008	33.97	29.68
1221	35.89	34.20
1383	36.89	37.49

Saturated Monolayer Volume (SCF/ton):	80
Langmuir Pressure (PSIA):	828

**DRY ASH FREE BASIS**

48	5.83	8.47
100	10.26	9.80
178	15.87	11.24
262	21.28	12.33
391	29.64	13.20
585	39.50	14.81
794	48.14	16.50
1008	53.27	18.91
1221	55.97	21.81
1383	57.85	23.91

Saturated Monolayer Volume (SCF/ton, daf):	94
Langmuir Pressure (PSIA):	828
Correlation Coefficient:	0.99

**00DL43A****METHANE ADSORPTION ISOTHERM CFG UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL43A	Moisture Content (EQ) % :	30.23
Isotherm Temperature ° F:	104	Ash Content, % :	8.01
		Helium Density g/cc	1.334

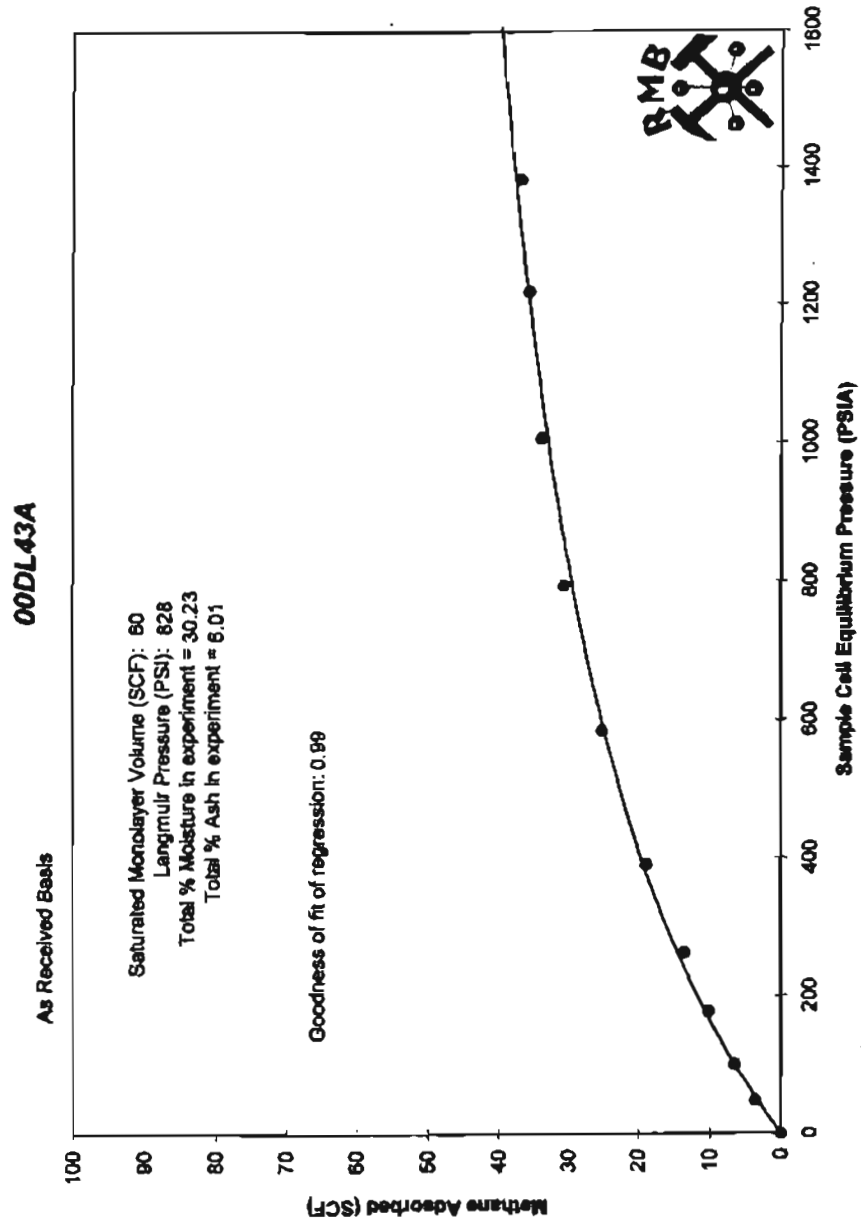
PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
48	5	9.27
100	9	10.72
178	14	12.30
262	19	13.49
391	27	14.44
585	36	16.20
794	44	18.06
1008	49	20.70
1221	51	23.86
1383	53	26.16

Saturated Monolayer Volume (SCF/ton):	86
Langmuir Pressure (PSIA):	828

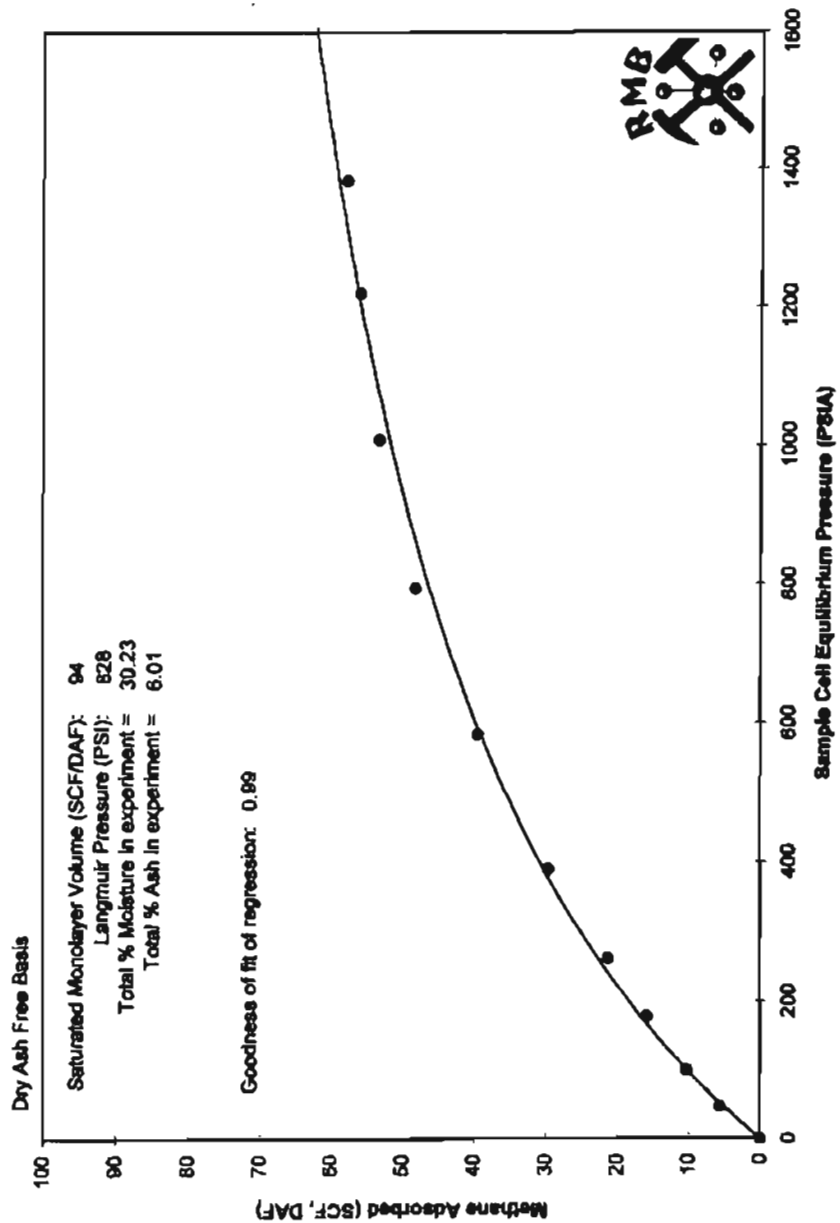
**MOIST ASH FREE BASIS**

48	4	12.49
100	7	14.44
178	11	16.56
262	14	18.17
391	20	19.46
585	27	21.83
794	33	24.33
1008	38	27.88
1221	38	32.15
1383	39	35.24

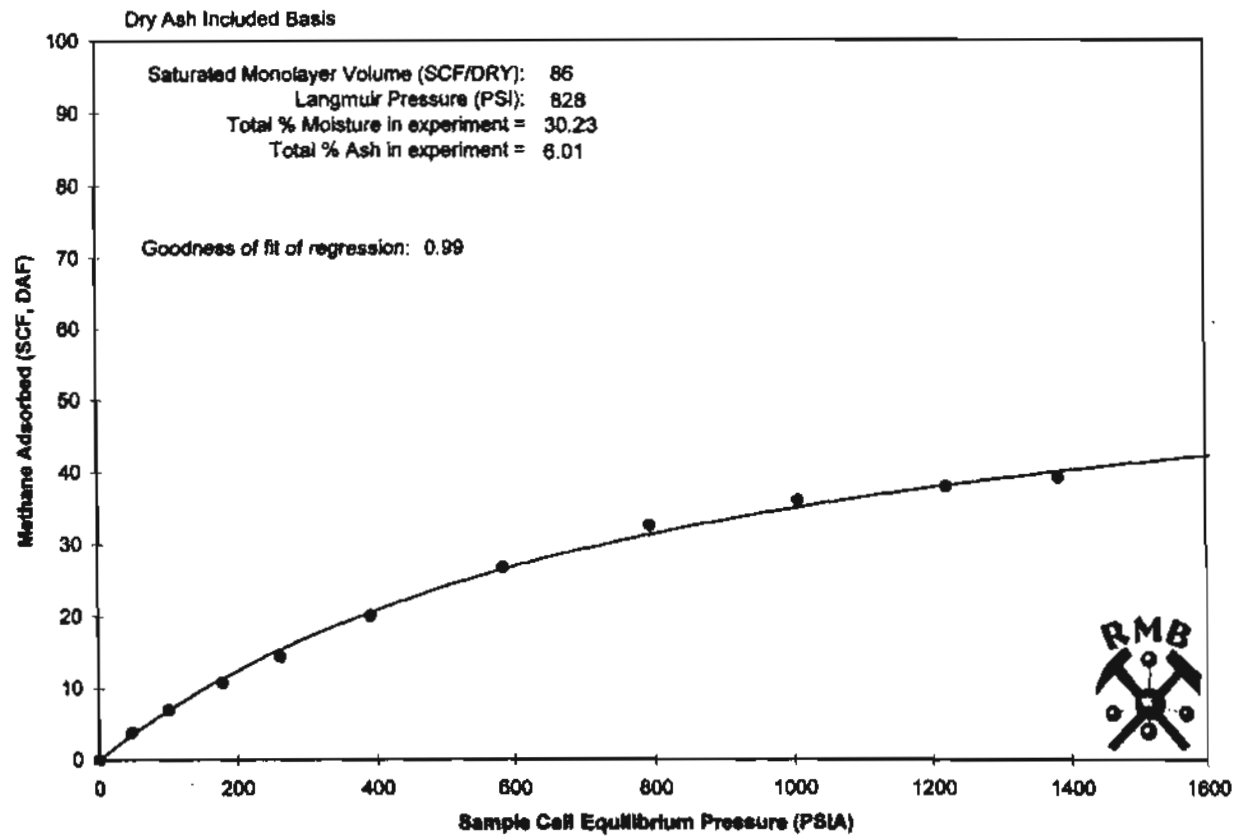
Saturated Monolayer Volume (SCF/ton, daf):	84
Langmuir Pressure (PSIA):	828
Correlation Coefficient:	0.99



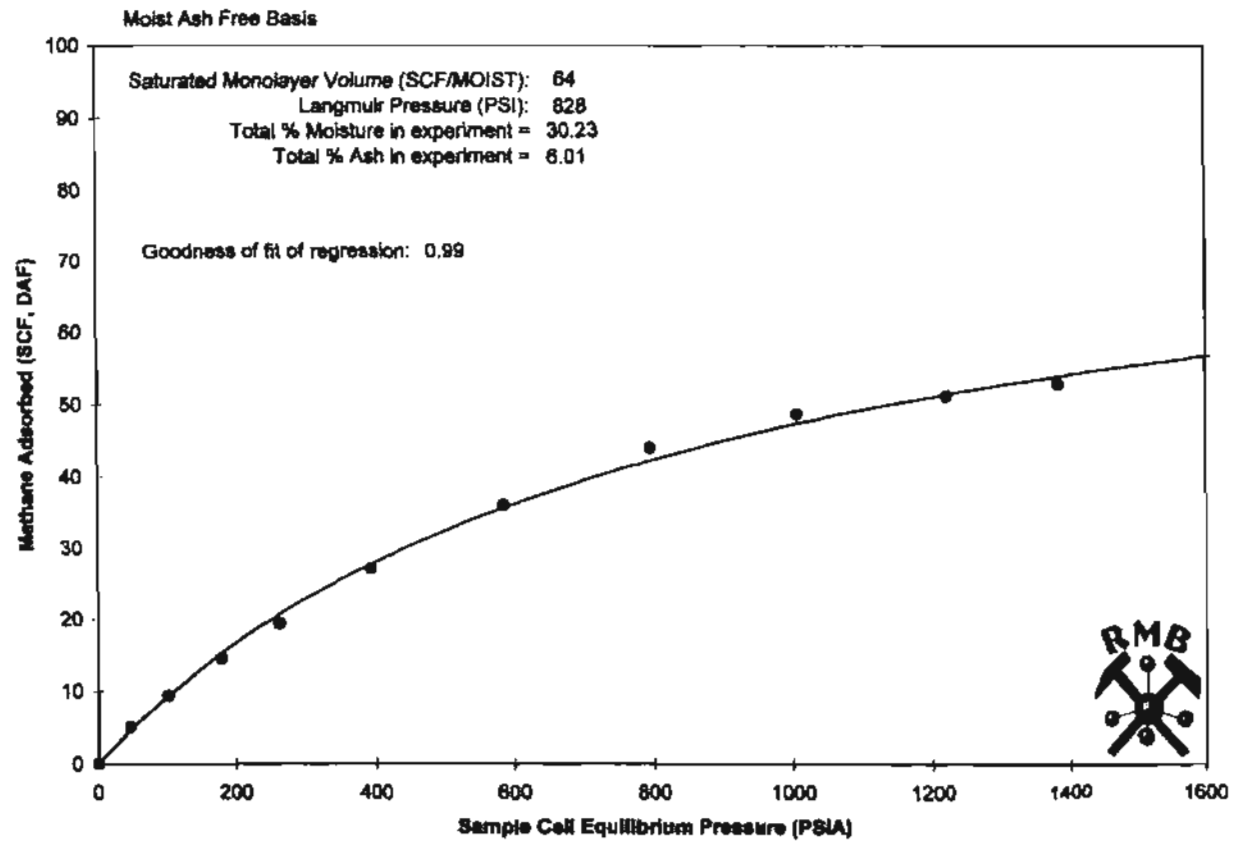
# 00DL43A



00DL43A

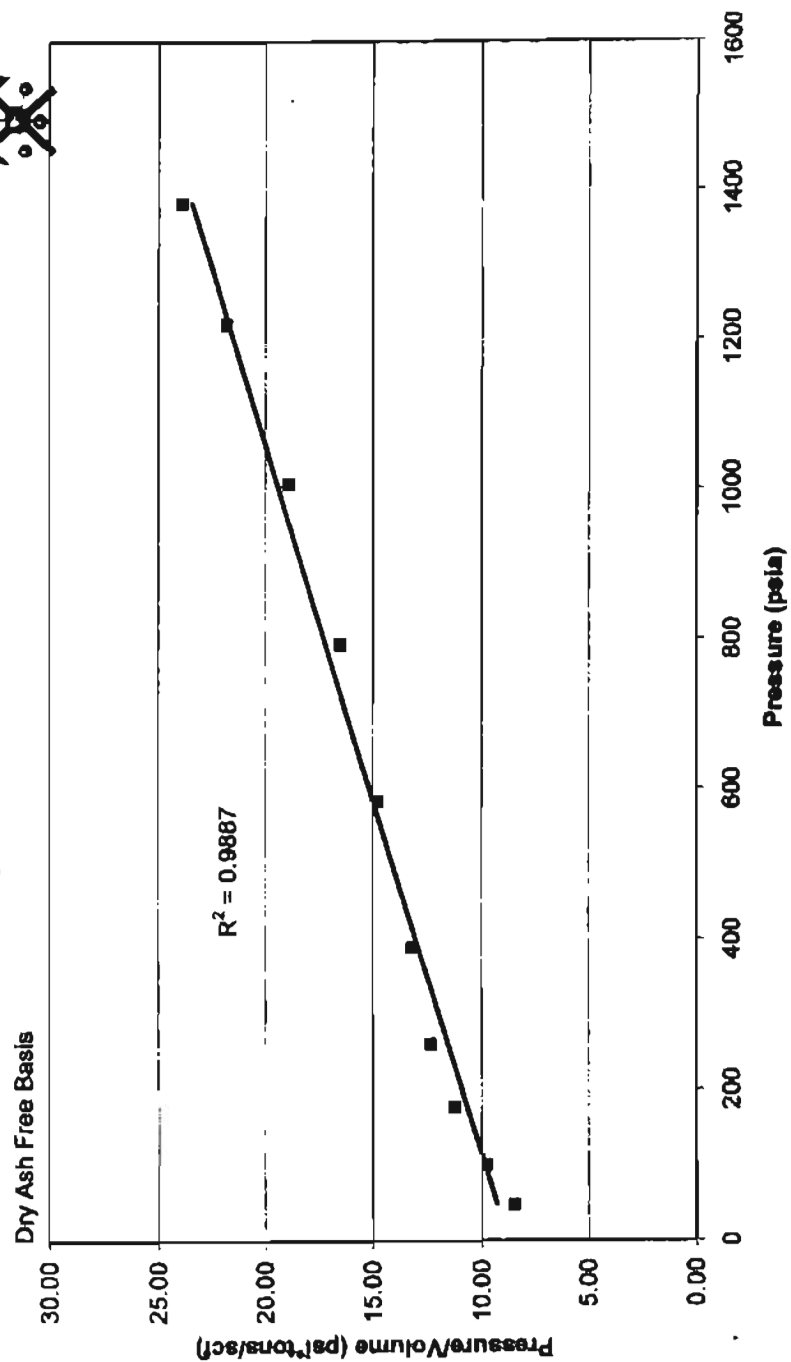


00DL43A



**Adsorption Langmuir Plot**  
**Methane Imperial Units**

**00DL43A**



**APPENDIX VI****00DL43A*****Methane Adsorption Isotherm SI Units******Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	1.77	2.77
Langmuir Pressure MPa	5.71	5.71
Goodness of fit Langmuir		
Equation R-squared	0.99	0.99
Ash Content Wt. %	6.01	6.01
Equilibrium Moisture Wt. %	30.23	30.23

***Contents of Appendix******Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free





**00DL43A****METHANE ADSORPTION ISOTHERM SI UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL43A	Moisture Content (EQ) % :	30.23
Isotherm Temperature ° C:	40	Ash Content % :	6.01
		Helium Density g/cc	1.334

PRESSURE (MPa)	ADSORBED METHANE (cc/g @STP)	P / V
0.329	0.11	3.118
0.693	0.19	3.804
1.229	0.30	4.135
1.807	0.40	4.536
2.697	0.58	4.857
4.032	0.74	5.448
5.477	0.90	6.072
8.947	1.00	6.969
8.416	1.05	8.024
9.536	1.08	8.796

Saturated Monolayer Volume (cc/g @ STP):	1.77
Langmuir Pressure (MPa):	5.71

**DRY ASH FREE BASIS**

0.329	0.17	1.988
0.693	0.30	2.298
1.229	0.47	2.636
1.807	0.62	2.892
2.697	0.87	3.097
4.032	1.16	3.474
5.477	1.41	3.872
8.947	1.57	4.437
8.416	1.84	6.116
9.536	1.70	5.608

Saturated Monolayer Volume (cc/g @ STP, daf):	2.77
Langmuir Pressure (MPa):	5.71
Correlation Coefficient:	0.99

**00DL43A****METHANE ADSORPTION ISOTHERM SI UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL43A	Moisture Content (EQ) % :	30.23
Isotherm Temperature ° C:	40	Ash Content %	8.01
		Helium Density g/cc	1.334

PRESSURE (MPa)	ADSORBED METHANE (cc/g@STP)	P / V
0.328	0.15	2.18
0.693	0.28	2.51
1.229	0.43	2.88
1.807	0.57	3.16
2.697	0.80	3.39
4.032	1.06	3.80
5.477	1.29	4.24
6.947	1.43	4.66
8.416	1.50	5.60
9.538	1.55	6.14

Saturated Monolayer Volume (cc/g, dry):	2.54
Langmuir Pressure (MPa):	5.71

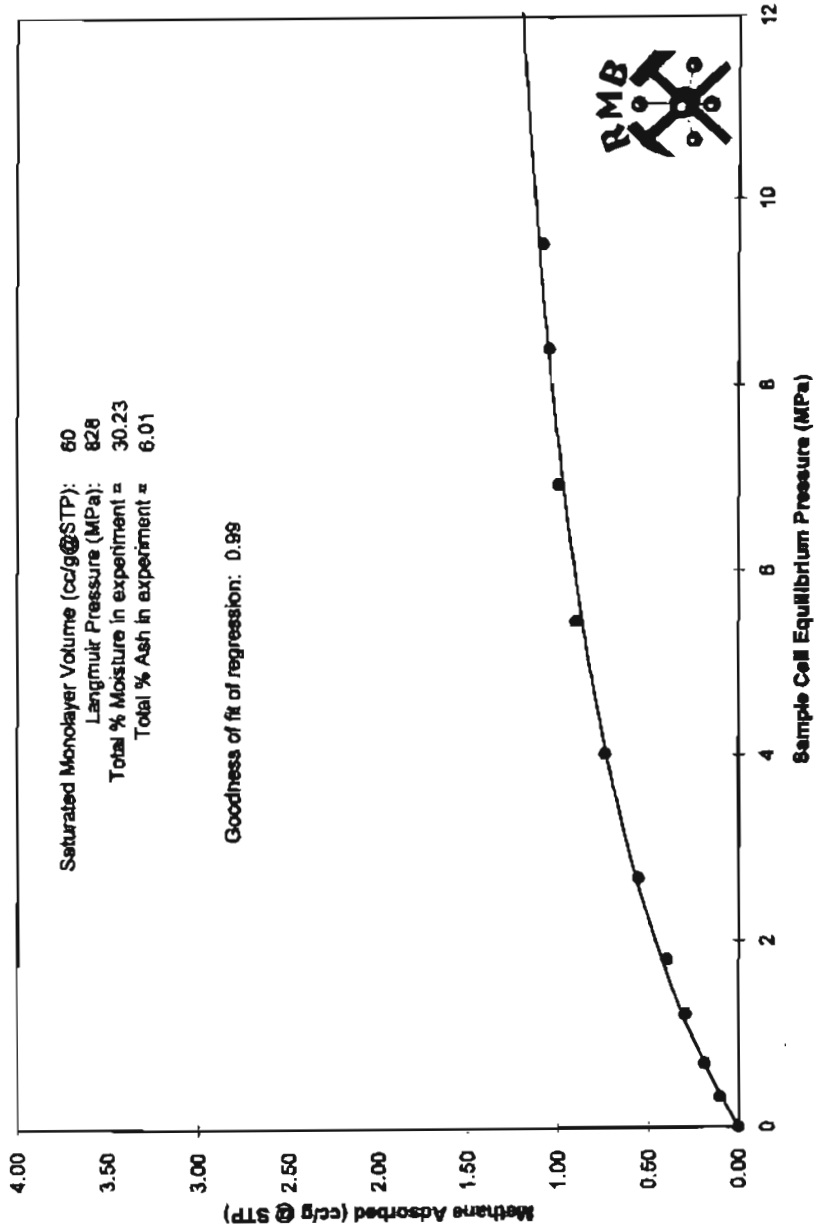
**MOIST ASH FREE BASIS**

0.3291	0.11	0.00
0.6927	0.20	3.39
1.2292	0.32	3.89
1.8089	0.42	4.28
2.6970	0.59	4.56
4.0324	0.79	5.12
5.4775	0.96	5.71
6.9473	1.06	6.54
8.4158	1.12	7.54
9.5359	1.15	8.27

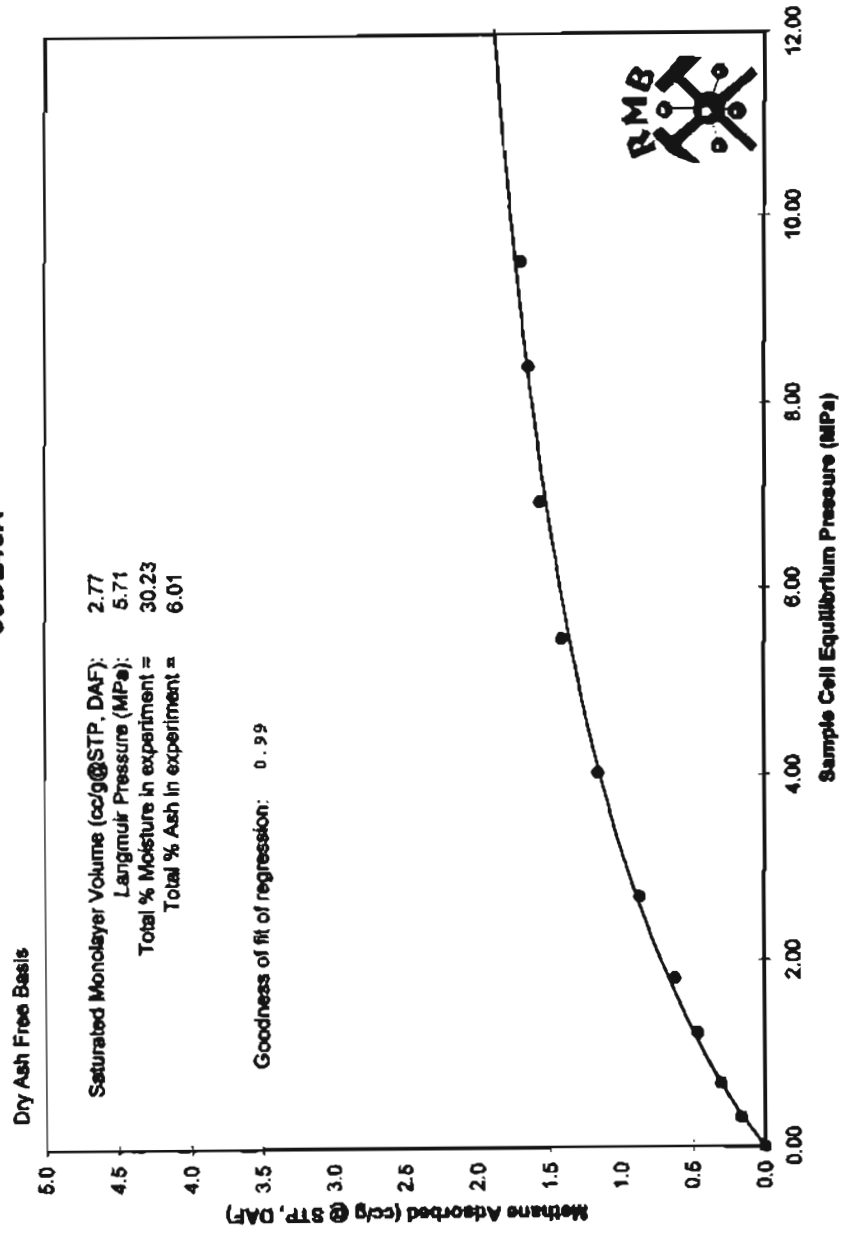
Saturated Monolayer Volume (cc/g, ash free):	1.88
Langmuir Pressure (MPa):	5.71
Correlation Coefficient:	0.99

# 00DL43A

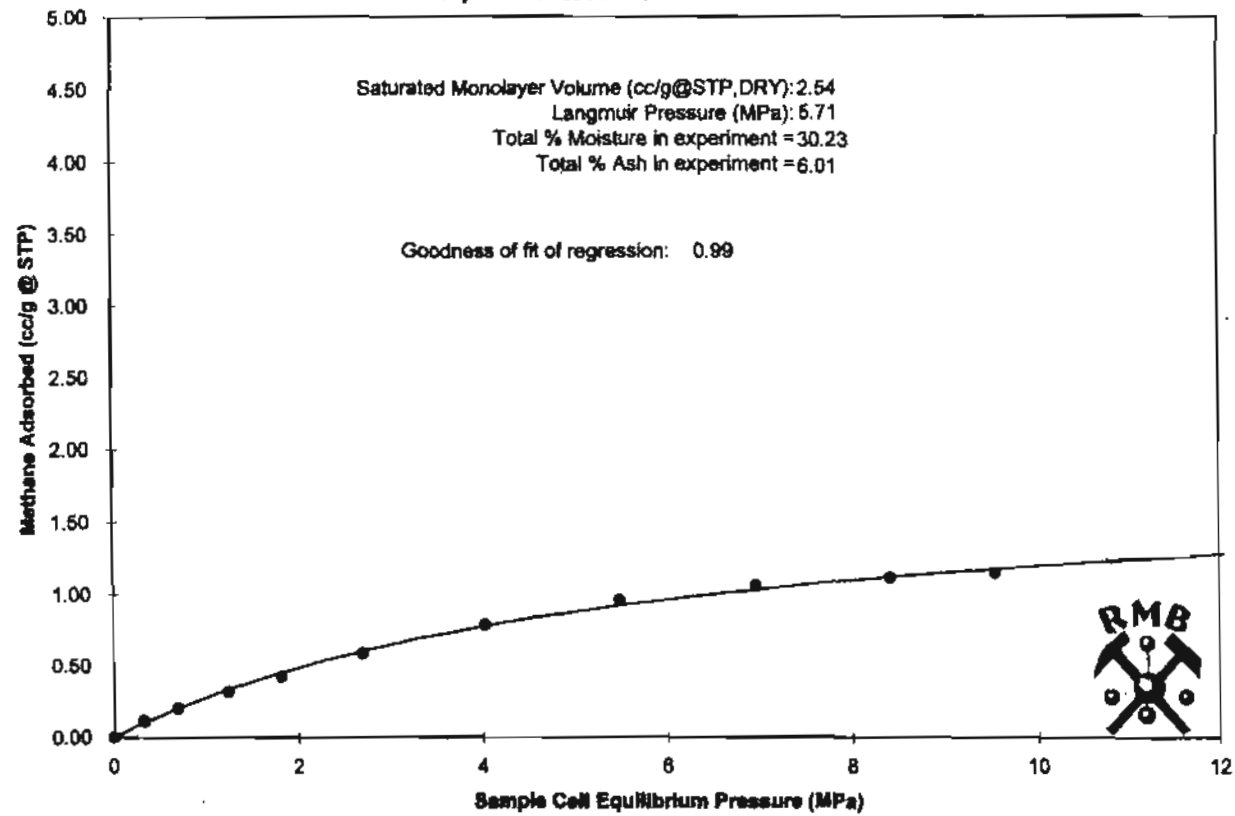
As Received Basis



# 00DL43A

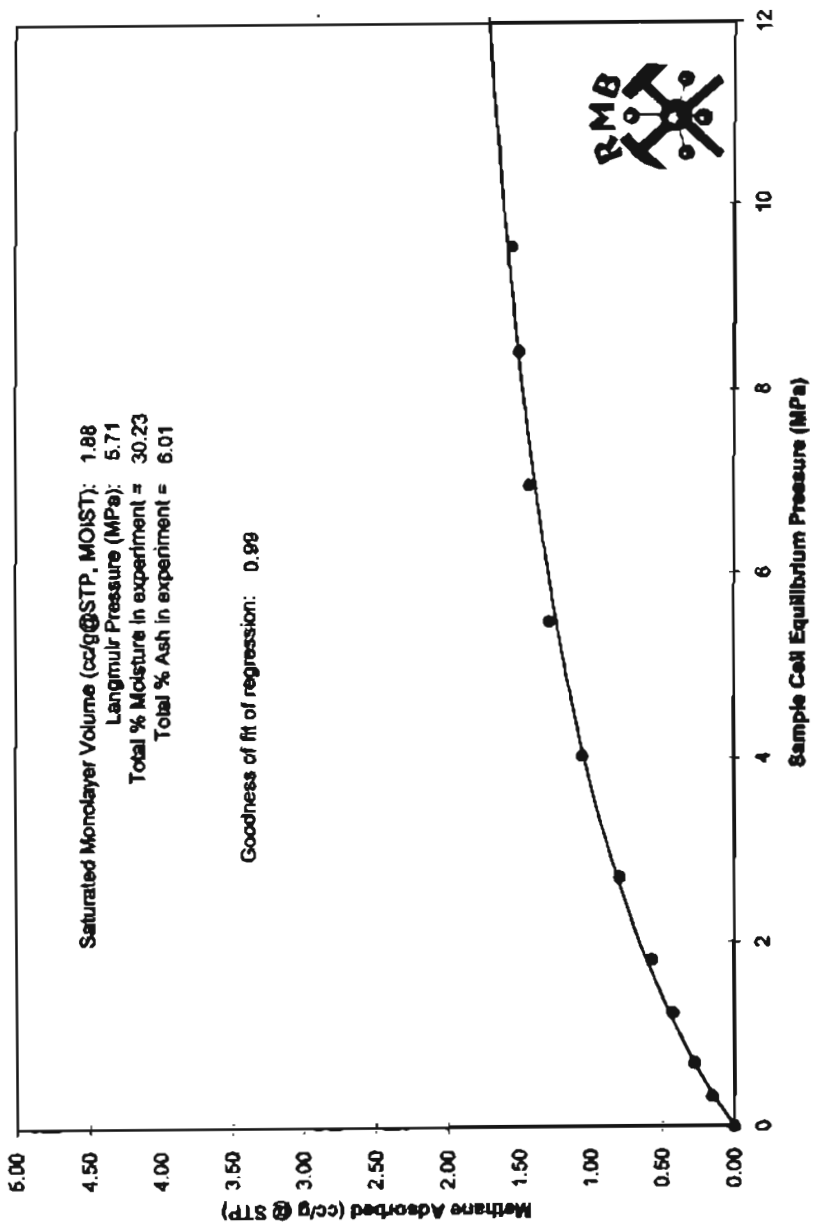


**00DL43A**  
Dry Ash Included Basis



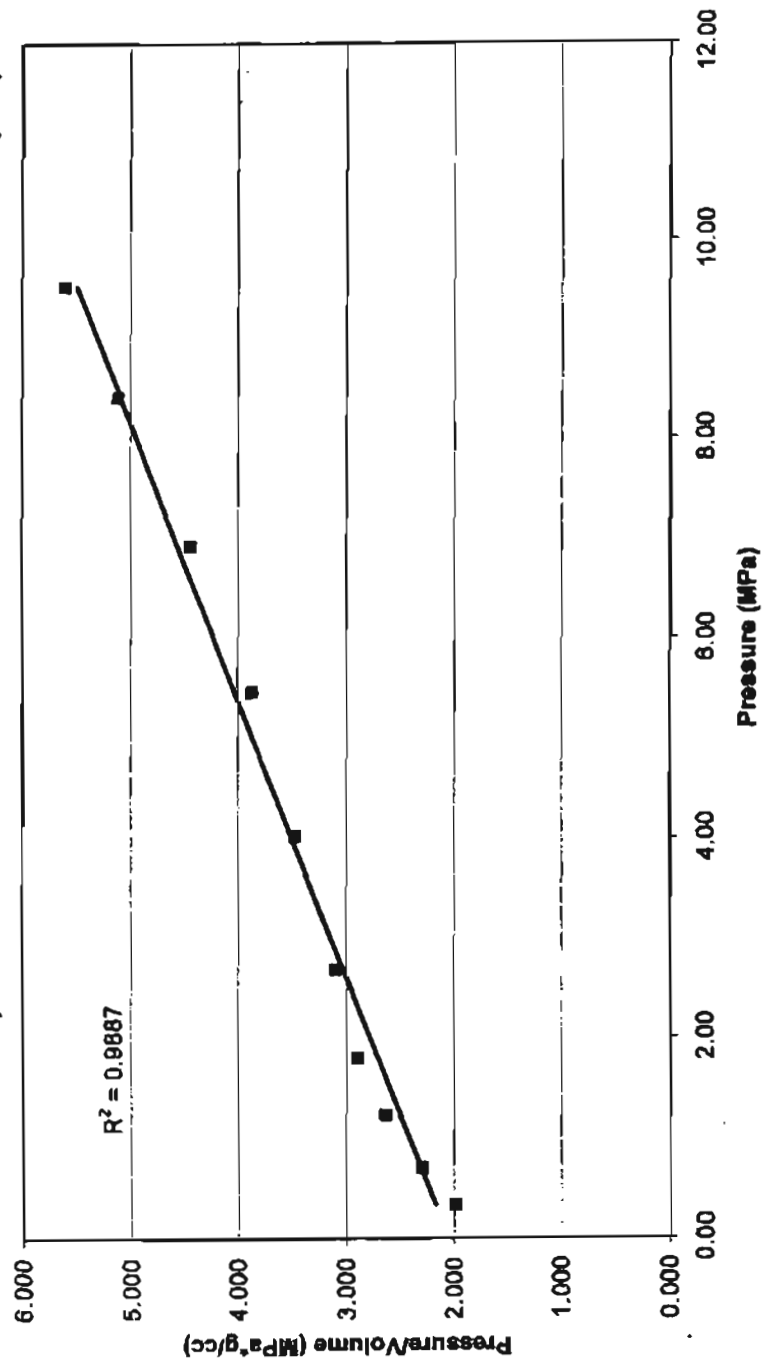
00DL43A

Moist Ash Free Basis



**Adsorption Langmuir Plot 00DL43A**  
**Methane SI Units**

Dry Ash Free Basis



**APPENDIX VII****00DL58 36-39 .5*****Methane Adsorption Isotherm  
Imperial Units******Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	78	238
Langmuir Pressure MPa	1201	1201
Goodness of fit Langmuir		
Equation R-squared	0.97	0.97
Ash Content Wt. %	60.60	60.60
Equilibrium Moisture Wt. %	6.77	6.77

***Contents of Appendix******Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free





**00DL58 36-39 .5****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL58 36-39 .5	Moisture Content (EQ) % :	8.77
Isotherm Temperature ° F:	104	Ash Content, % :	60.60
		Helium Density g/cc	1.923

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
45	2.40	18.69
98	5.67	17.30
176	10.45	16.84
261	14.97	17.43
389	19.64	19.82
582	26.22	22.20
791	31.51	25.10
1004	34.81	28.84
1217	38.52	31.58
1379	40.79	33.80

Saturated Monolayer Volume (SCF/ton):	78
Langmuir Pressure (PSIA):	1201

**DRY ASH FREE BASIS**

45	7.37	6.10
98	17.37	5.65
176	32.02	5.49
261	45.89	5.89
389	60.18	6.47
582	80.36	7.24
791	96.58	8.19
1004	106.69	9.41
1217	118.05	10.31
1379	125.02	11.03

Saturated Monolayer Volume (SCF/ton, daf):	238
Langmuir Pressure (PSIA):	1201
Correlation Coefficient:	0.97

**00DL58 36-39 .5****METHANE ADSORPTION ISOTHERM CFG UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. : 00DL58 36-39 .5 Moisture Content (EQ) % : 6.77

Isotherm Temperature ° F: 104 Ash Content, % : 80.80

Helium Density g/cc 1.823

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
45	3	17.43
98	6	16.13
176	11	15.70
281	16	16.25
389	21	18.47
582	28	20.70
791	34	23.40
1004	37	26.69
1217	41	29.45
1379	44	31.51

Saturated Monolayer Volume (SCF/ton): 83

Langmuir Pressure (PSIA): 1201

**MOIST ASH FREE BASIS**

45	6	7.36
98	14	6.82
176	27	6.63
281	38	6.87
389	50	7.81
582	67	8.75
791	80	9.89
1004	88	11.38
1217	96	12.44
1379	104	13.32

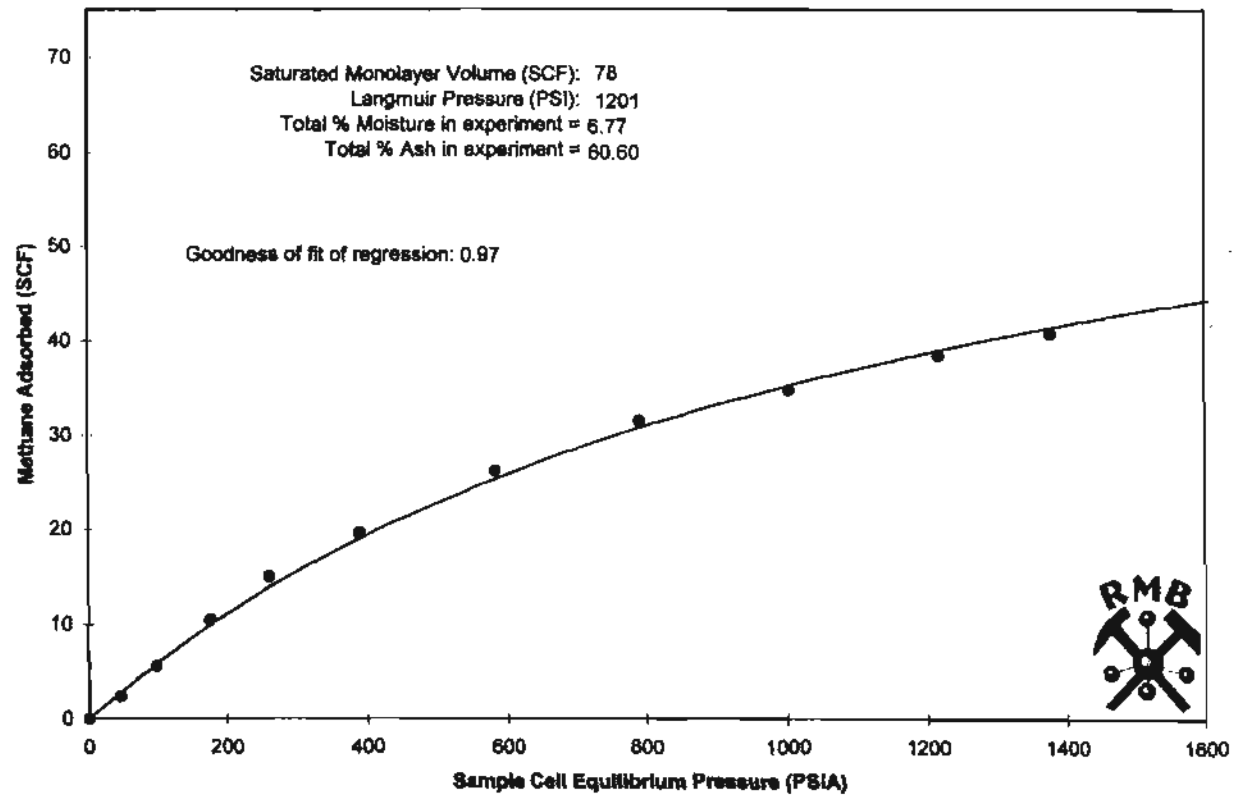
Saturated Monolayer Volume (SCF/ton, daf): 197

Langmuir Pressure (PSIA): 1201

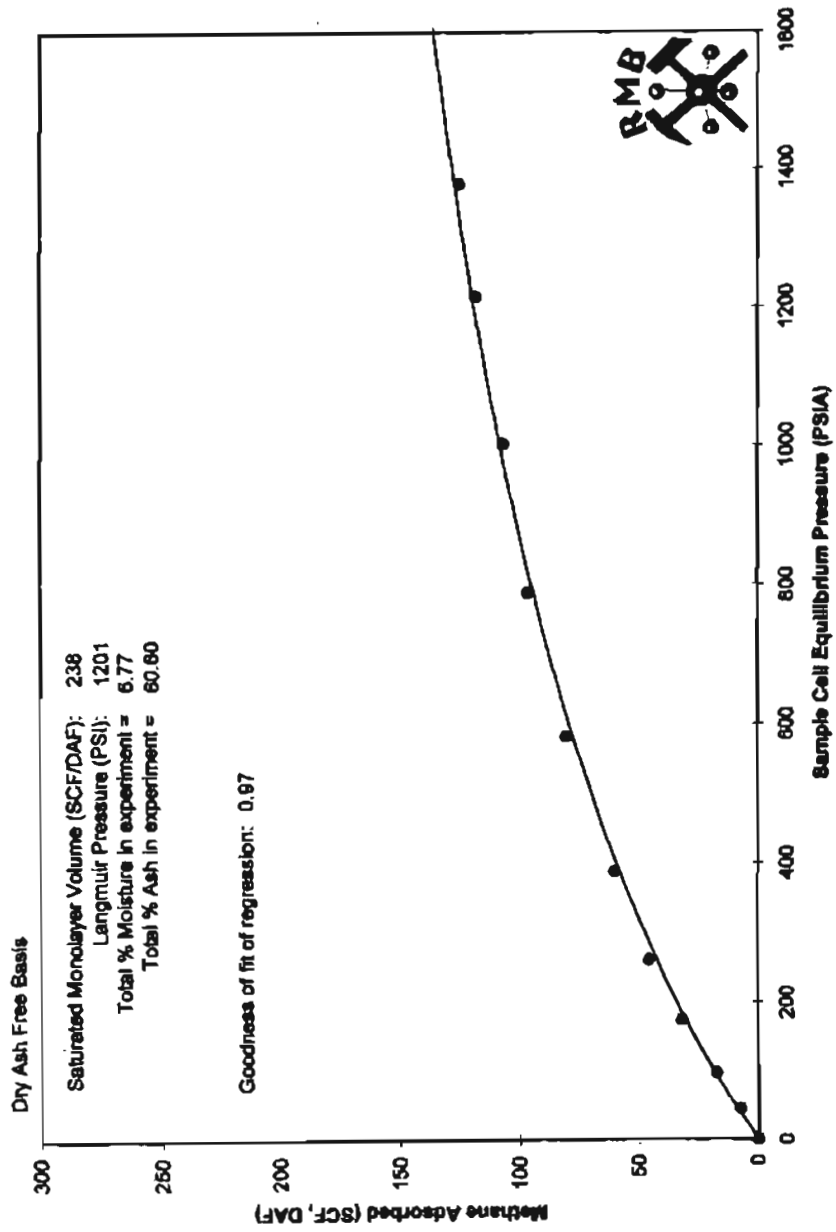
Correlation Coefficient: 0.97

00DL58 36-39 .5

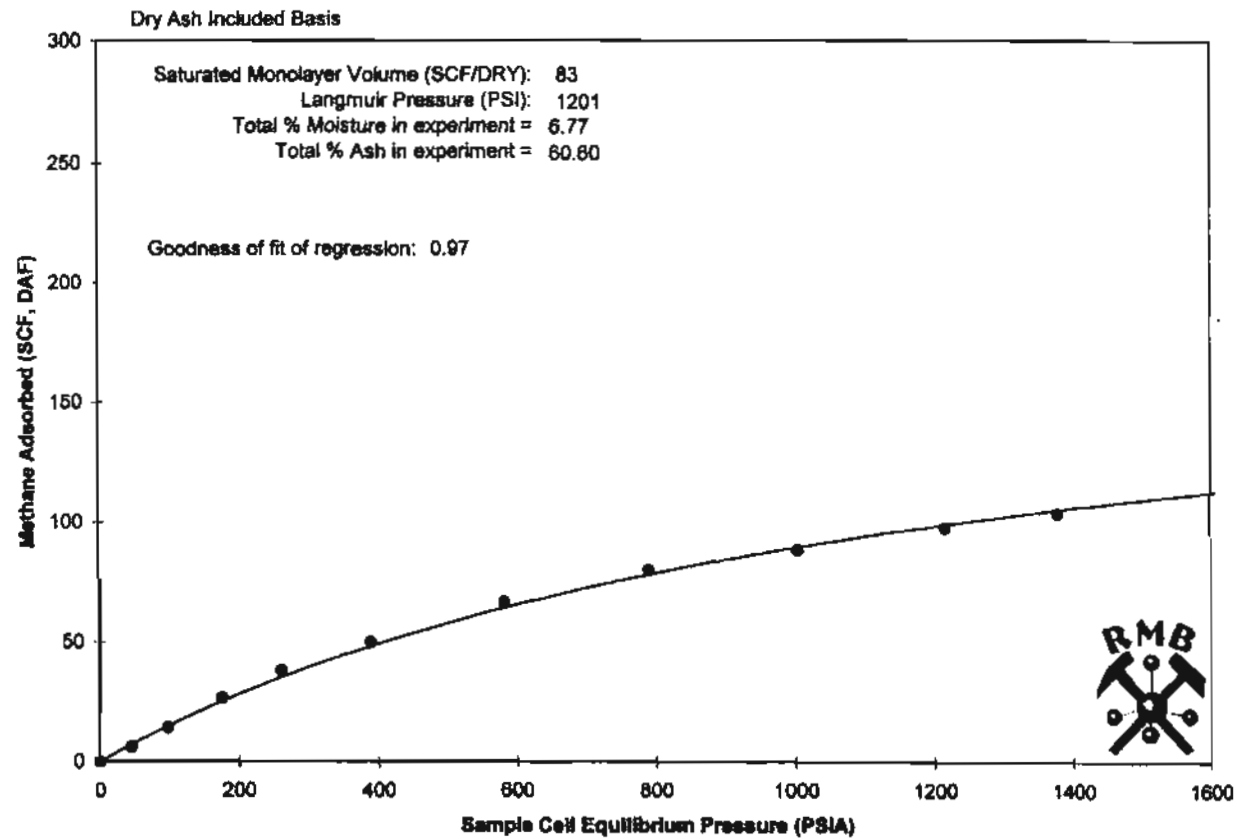
As Received Basis



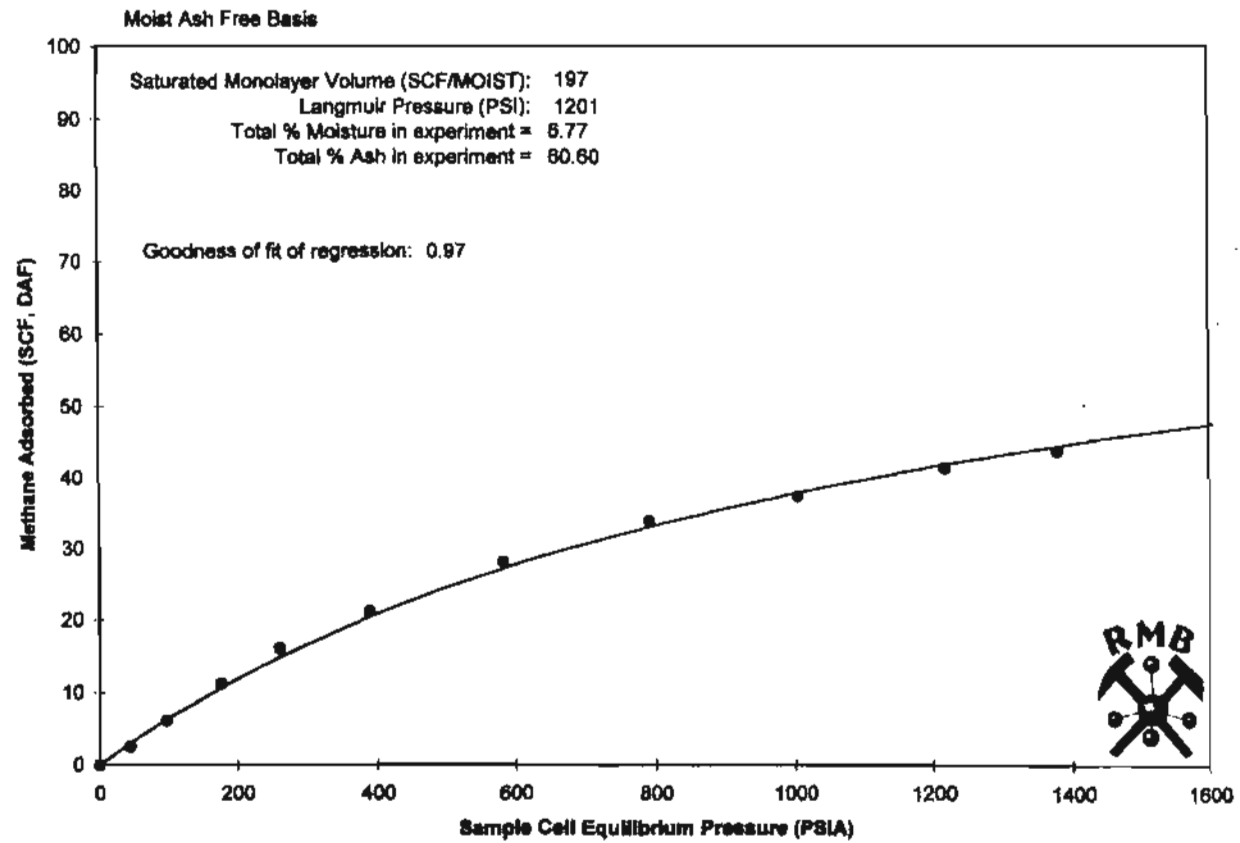
00DL58 36-39.5



**00DL58 36-39 .5**

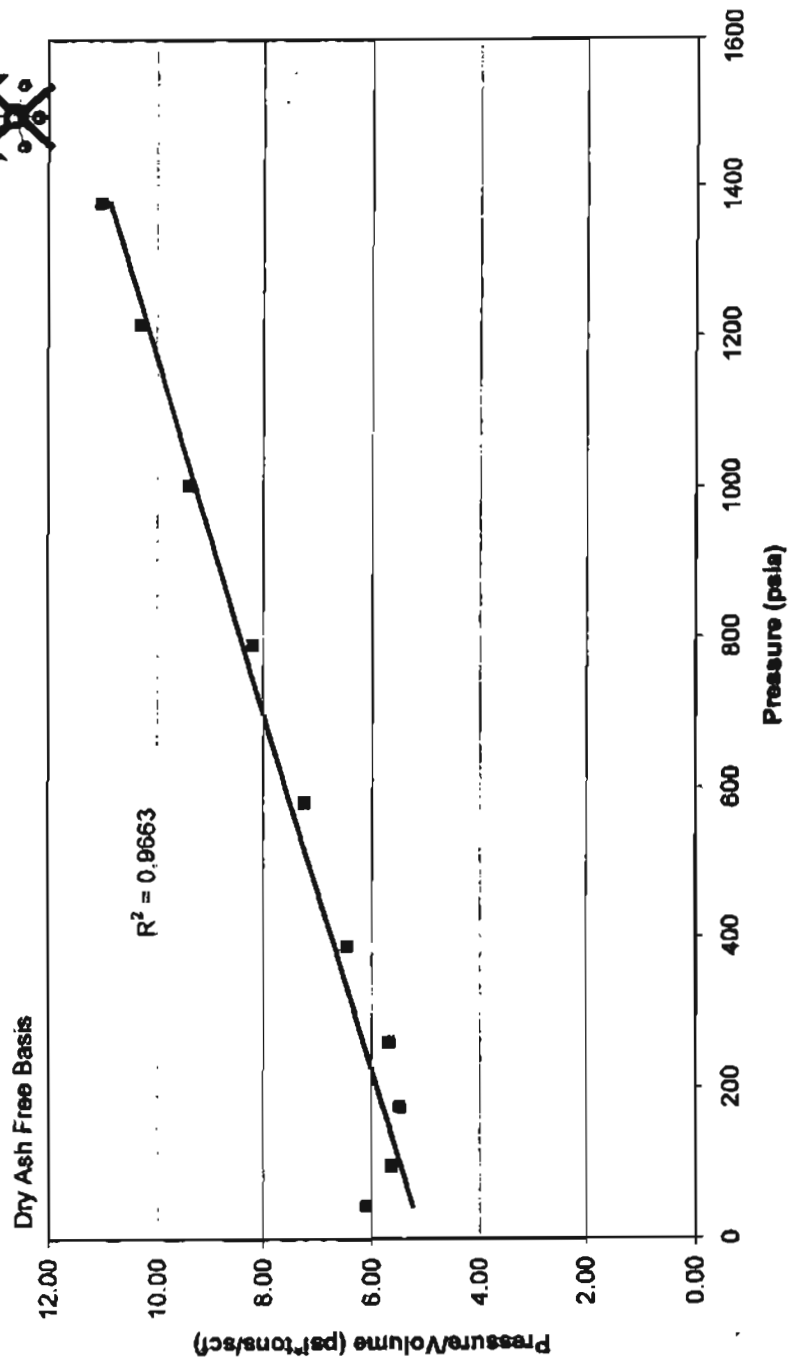


**00DL58 38-39 .5**



Adsorption Langmuir Plot  
Methane Imperial Units

00DL58 36-39 .5



**APPENDIX VIII****00DL58 36-39 .5*****Methane Adsorption Isotherm SI Units******Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	2.28	8.98
Langmuir Pressure MPa	8.28	8.28
Goodness of fit Langmuir		
Equation R-squared	0.97	0.97
Ash Content Wt %	60.60	60.60
Equilibrium Moisture Wt %	6.77	6.77

***Contents of Appendix******Data Sheets******As Received******Dry Ash Free******Dry Ash Included******Moist Ash Free******Charts******As Received******Dry Ash Free******Dry Ash Included******Moist Ash Free***



**00DL58 36-39 .5****METHANE ADSORPTION ISOTHERM SI UNITS****AS RECEIVED BASIS**

Sample I.D. : 00DL58 36-39 .5 Moisture Content (EQ) % : 6.77  
 Isotherm Temperature ° C: 40 Ash Content % : 60.60  
 Helium Density g/cc 1.923

PRESSURE (MPa)	ADSORBED METHANE (cc/g @STP)	P / V
0.310	0.07	4.385
0.678	0.17	4.059
1.213	0.31	3.950
1.799	0.44	4.089
2.683	0.58	4.649
4.013	0.77	5.208
5.452	0.93	5.888
6.922	1.02	6.768
8.388	1.13	7.410
9.506	1.20	7.929

Saturated Monolayer Volume (cc/g @ STP): 2.28  
 Langmuir Pressure (MPa): 8.28

**DRY ASH FREE BASIS**

0.310	0.22	1.431
0.678	0.51	1.325
1.213	0.94	1.289
1.799	1.35	1.334
2.683	1.77	1.517
4.013	2.38	1.700
5.452	2.84	1.921
6.922	3.14	2.208
8.388	3.47	2.418
9.506	3.67	2.587

Saturated Monolayer Volume (cc/g @ STP, daf): 6.98  
 Langmuir Pressure (MPa): 8.28  
 Correlation Coefficient: 0.97

**00DL58 36-39 .5****METHANE ADSORPTION ISOTHERM SI UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. : 00DL58 36-39 .5 Moisture Content (EQ) % : 6.77  
 Isotherm Temperature ° C: 40 Ash Content % 60.60  
 Helium Density g/cc 1.923

PRESSURE (MPa)	ADSORBED METHANE (cc/g@STP)	P / V
0.310	0.08	4.09
0.676	0.18	3.78
1.213	0.33	3.68
1.799	0.47	3.81
2.683	0.62	4.33
4.013	0.83	4.88
5.452	0.99	5.49
6.922	1.10	6.31
8.388	1.21	6.91
9.508	1.29	7.39

Saturated Monolayer Volume (cc/g, dry): 2.44  
 Langmuir Pressure (MPa): 8.28

**MOIST ASH FREE BASIS**

0.3098	0.18	0.00
0.6760	0.42	1.60
1.2127	0.78	1.56
1.7994	1.12	1.81
2.6830	1.48	1.83
4.0135	1.98	2.05
5.4518	2.35	2.32
6.9219	2.60	2.67
8.3885	2.87	2.92
9.5082	3.04	3.12

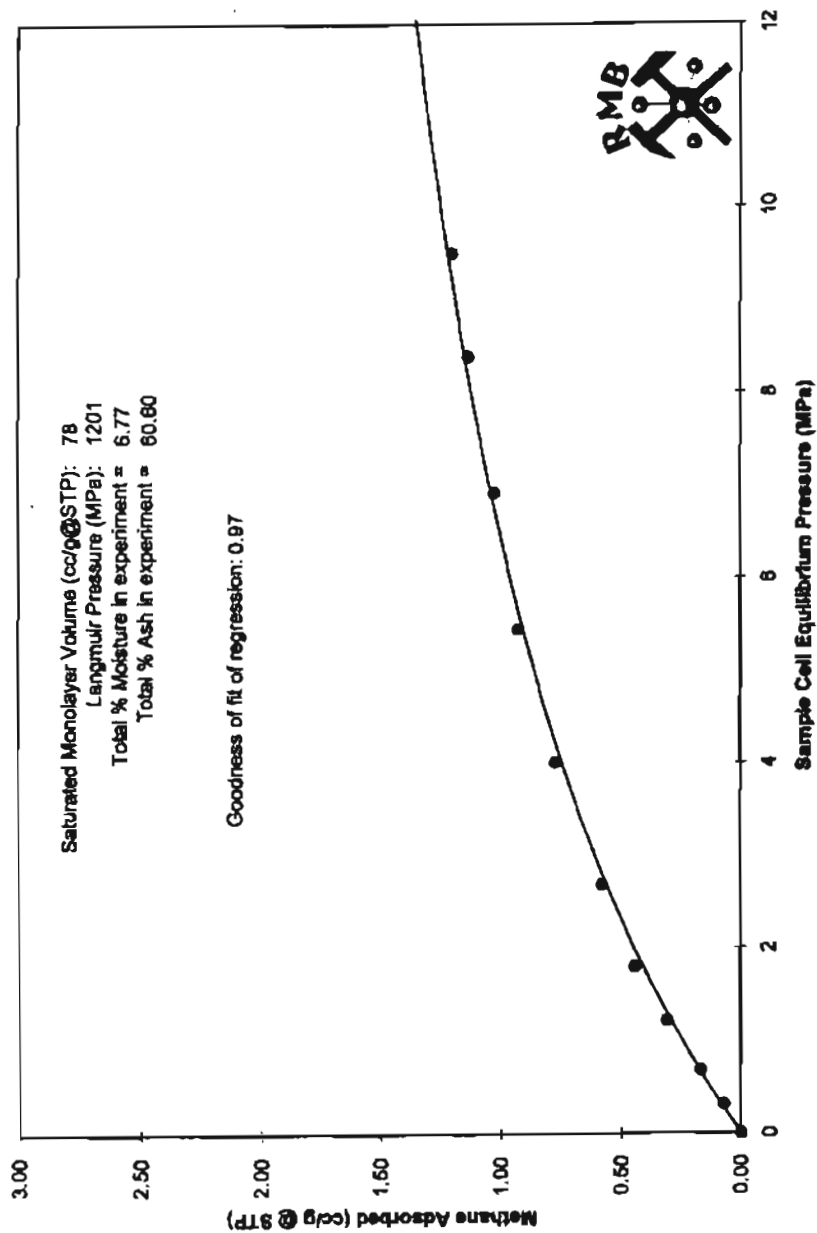
Saturated Monolayer Volume (cc/g, ash free): 5.78  
 Langmuir Pressure (MPa): 8.28  
 Correlation Coefficient: 0.97

00DL58 36-39 .5

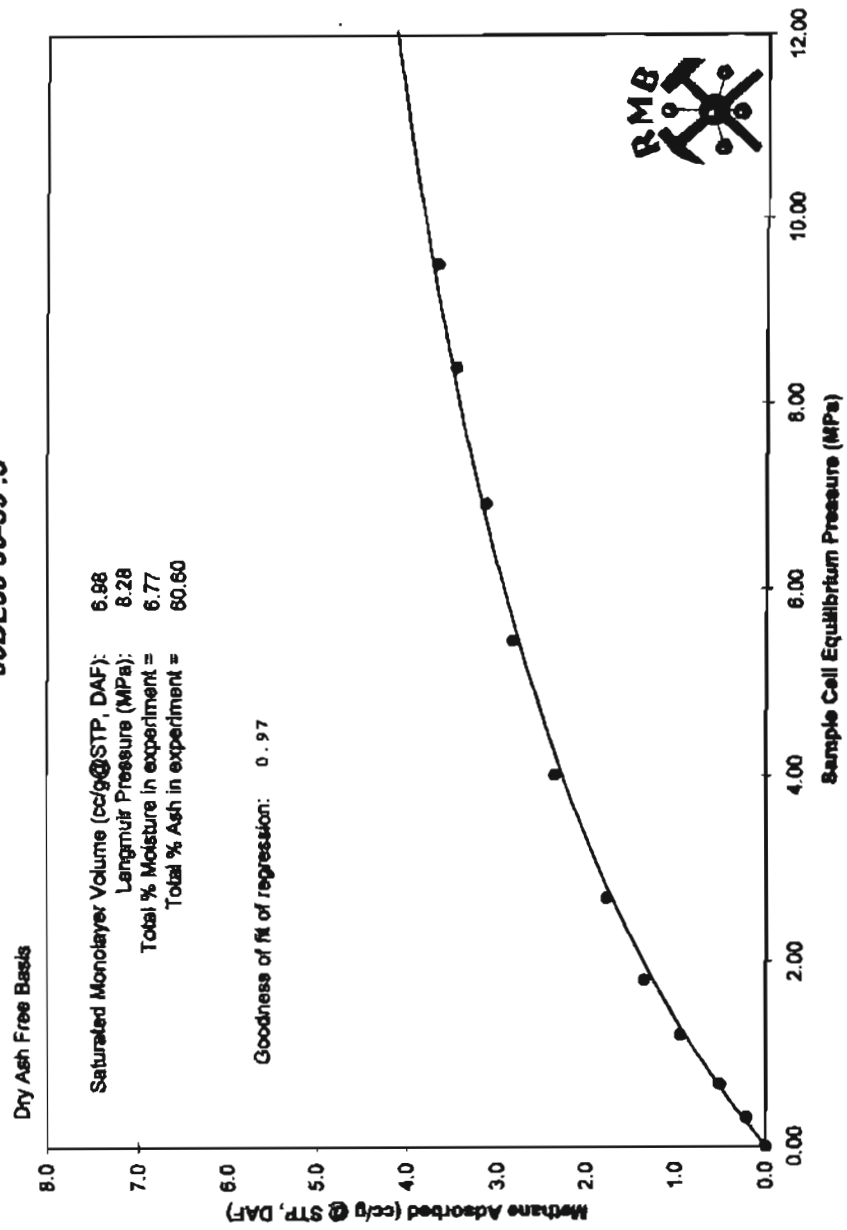
As Received Basis

Saturated Monolayer Volume (cc/g @ STP): 78  
Langmuir Pressure (MPa): 1201  
Total % Moisture in experiment = 6.77  
Total % Ash in experiment = 60.60

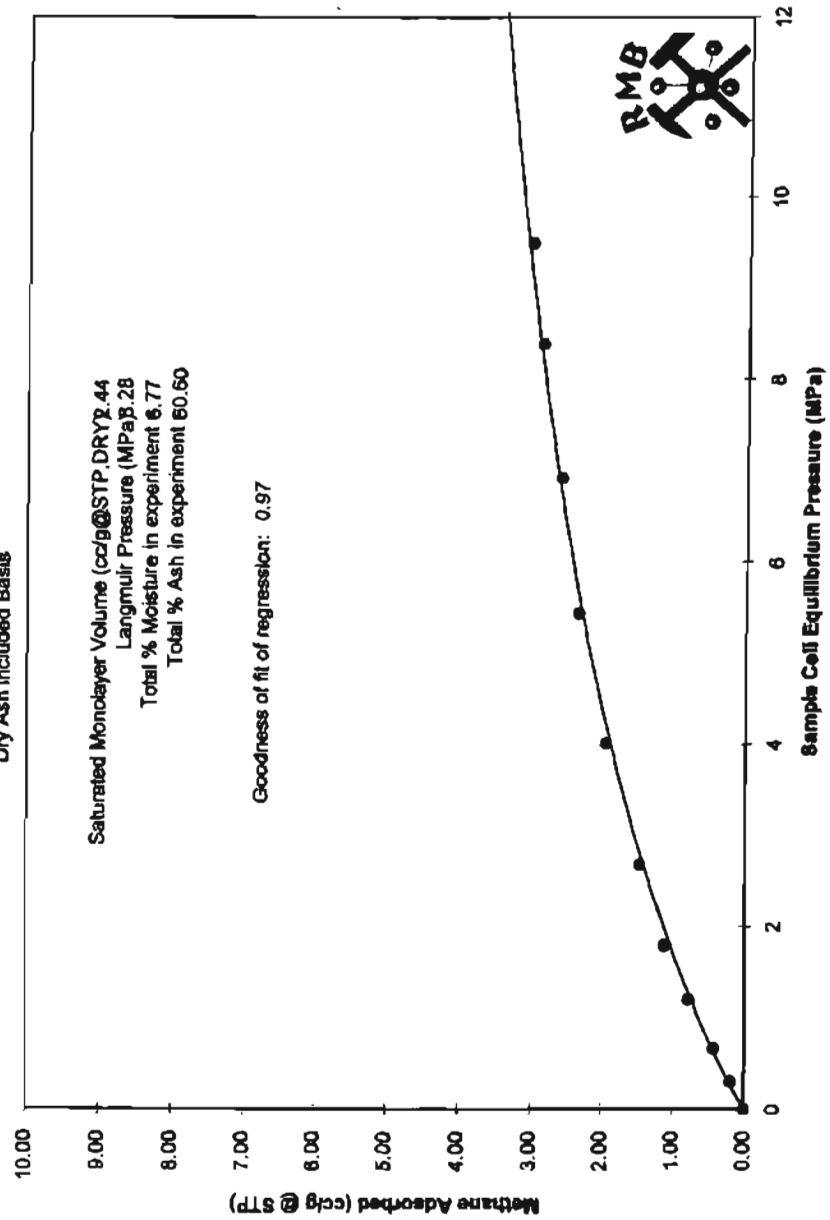
Goodness of fit of regression: 0.97



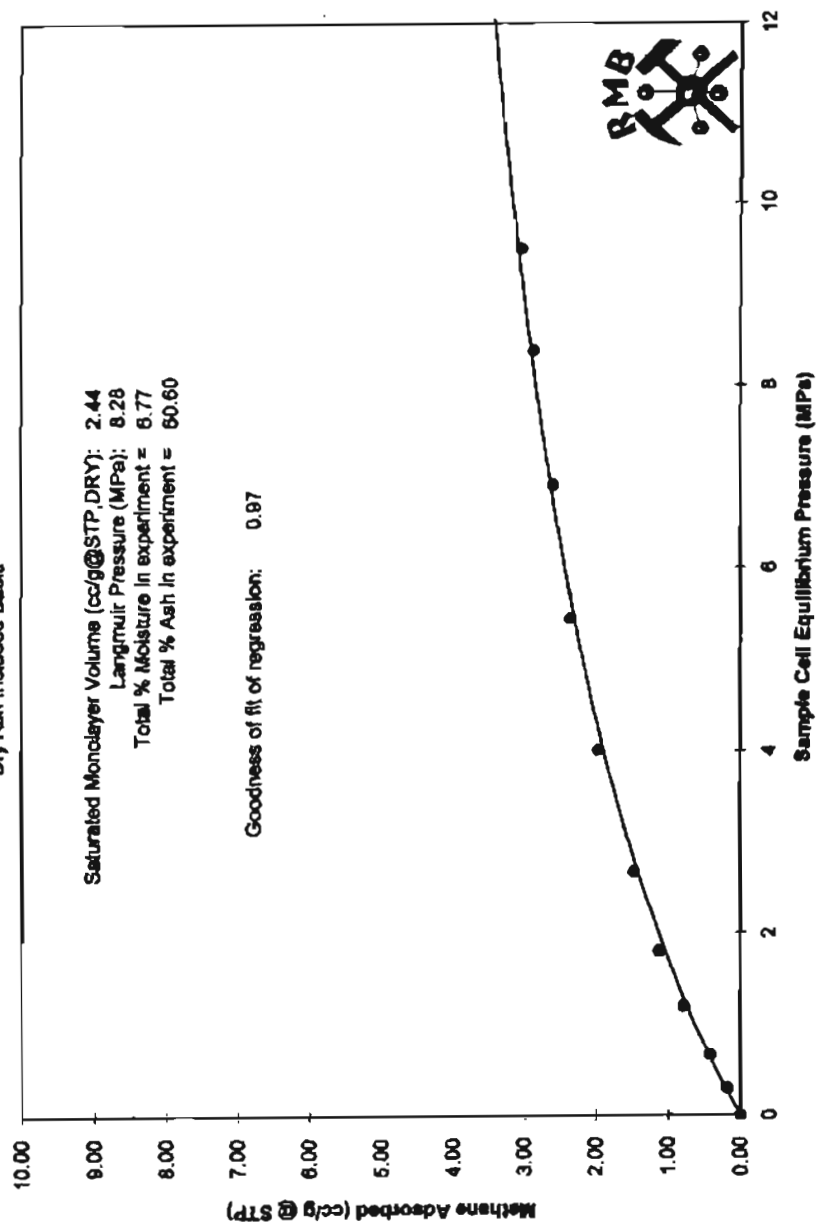
00DL58 36-39 .5



**00DL58 36-39 .5**  
Dry Ash Included Basis

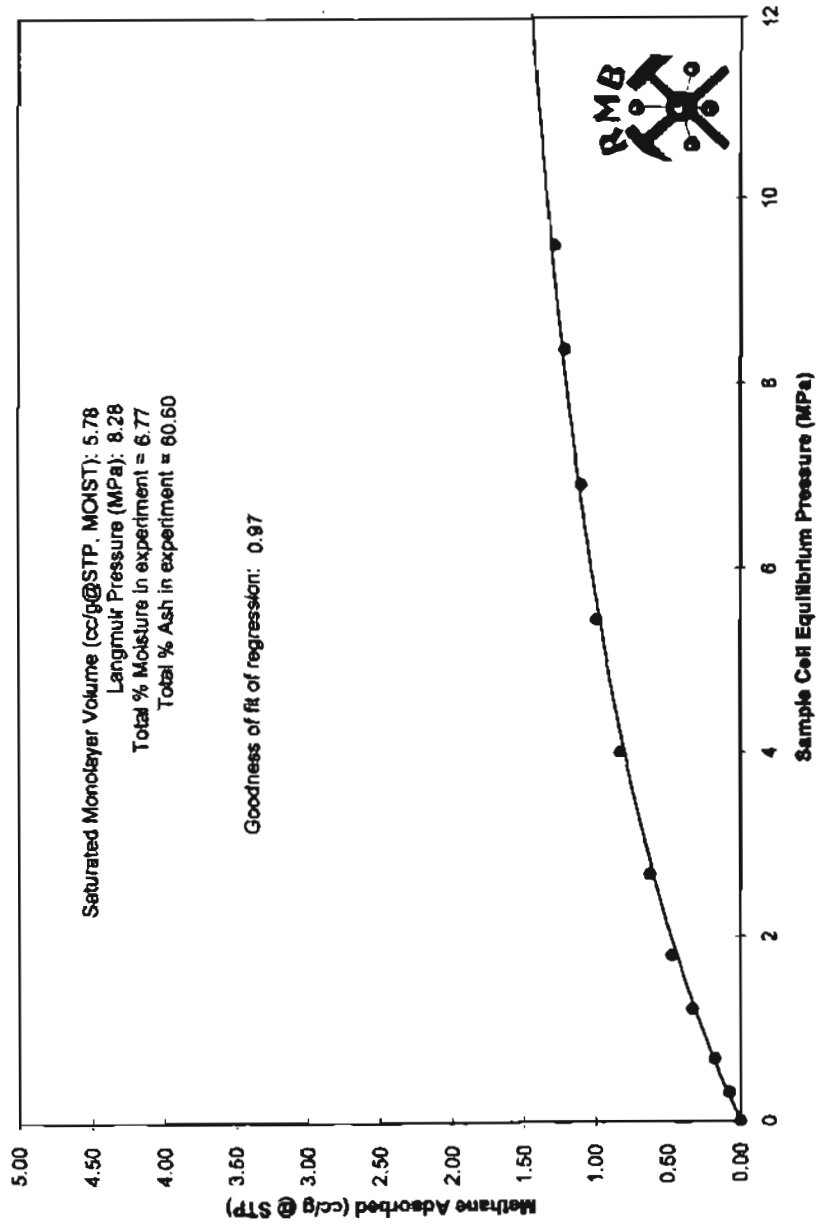


**00DL58 36-39 .5**  
Dry Ash Included Basis



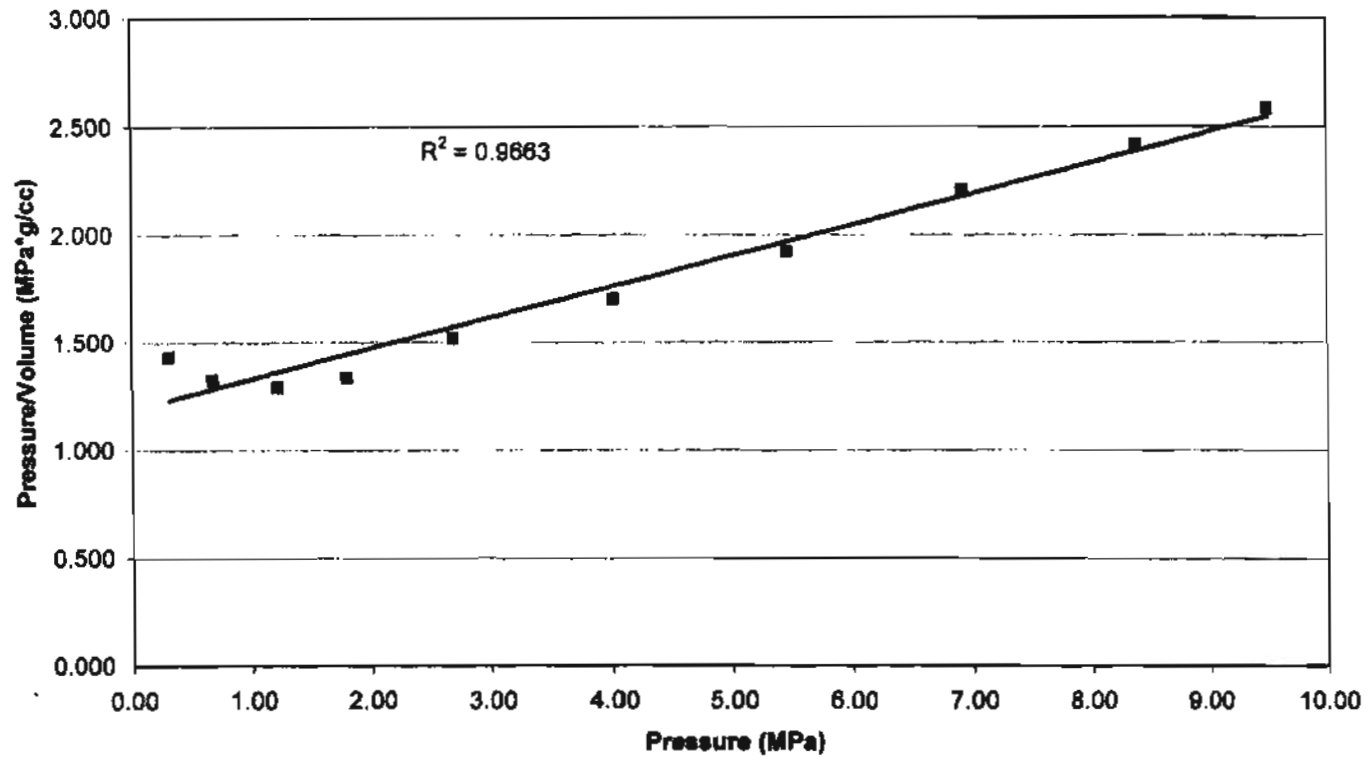
# 00DL58 36-39 .5

Moist Ash Free Basis



**Adsorption Langmuir Plot    00DL58 36-39 .5**  
**Methane SI Units**

Dry Ash Free Basis





## **APPENDIX IX**

# **00DL33-E**

***Methane Adsorption Isotherm  
Imperial Units***

<b>Summary of Analyses</b>		
	<b>As Received</b>	<b>DAF basis</b>
Langmuir Volume cc/g	240	344
Langmuir Pressure MPa	833	833
Goodness of fit Langmuir		
Equation R-squared	0.99	0.99
Ash Content Wt. %	22.21	22.21
Equilibrium Moisture Wt. %	7.92	7.92

### **Contents of Appendix**

#### ***Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

#### ***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL33-E****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL33-E	Moisture Content (EQ) % :	7.92
Isotherm Temperature ° F:	104	Ash Content, % :	22.21
		Helium Density g/cc	1.485

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
41	10.64	3.89
92	25.06	3.66
170	41.17	4.13
256	56.60	4.50
384	78.34	4.90
579	98.65	5.87
797	113.91	7.00
1007	129.50	7.76
1224	141.86	8.83
1387	153.31	9.05

Saturated Monolayer Volume (SCF/ton):	240
Langmuir Pressure (PSIA):	833

**DRY ASH FREE BASIS**

41	15.23	2.72
92	35.87	2.56
170	58.93	2.89
256	81.29	3.14
384	112.12	3.42
579	141.19	4.10
797	163.03	4.89
1007	185.35	5.44
1224	203.03	6.03
1387	219.42	6.32

Saturated Monolayer Volume (SCF/ton, def):	344
Langmuir Pressure (PSIA):	833
Correlation Coefficient:	0.99

**00DL33-E****METHANE ADSORPTION ISOTHERM CFG UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL33-E	Moisture Content (EQ) % :	7.92
Isotherm Temperature ° F:	104	Ash Content, % :	22.21
		Helium Density g/cc	1.485

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
41	12	3.58
82	27	3.37
170	45	3.81
256	62	4.14
384	85	4.51
579	107	5.41
797	124	6.44
1007	141	7.16
1224	154	7.95
1387	166	8.33

Saturated Monolayer Volume (SCF/ton):	281
Langmuir Pressure (PSIA):	833

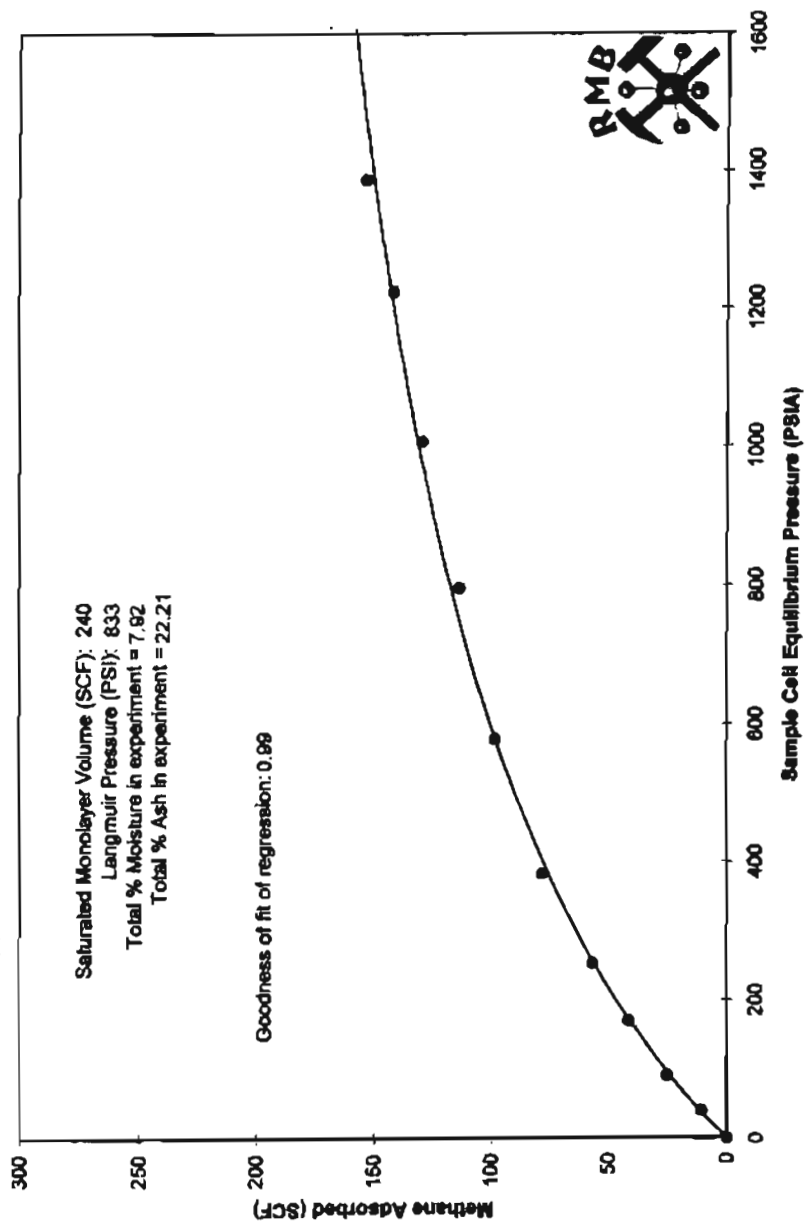
**MOIST ASH FREE BASIS**

41	14	3.02
92	32	2.85
170	53	3.21
256	73	3.50
384	101	3.81
579	127	4.57
797	146	5.44
1007	166	6.05
1224	182	6.71
1387	197	7.04

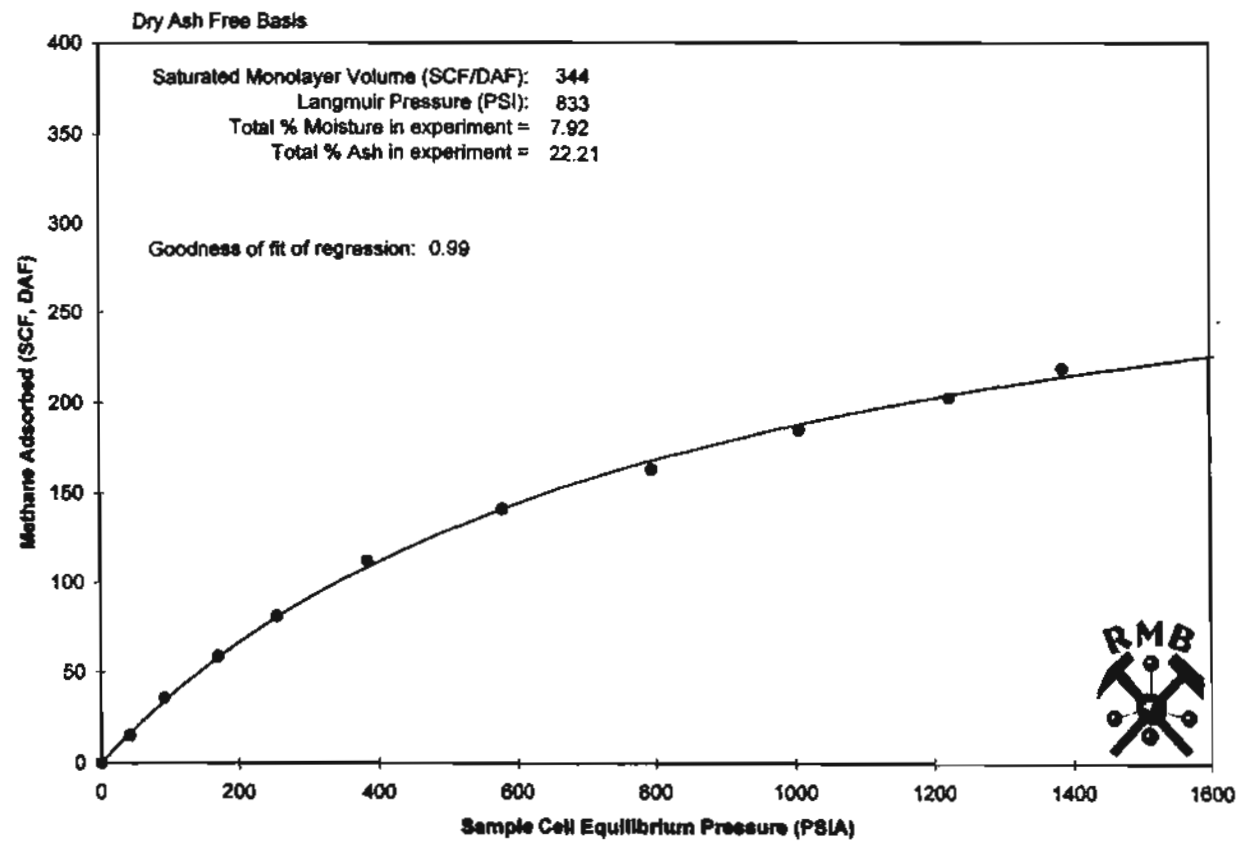
Saturated Monolayer Volume (SCF/ton, def):	309
Langmuir Pressure (PSIA):	833
Correlation Coefficient:	0.99

00DL33-E

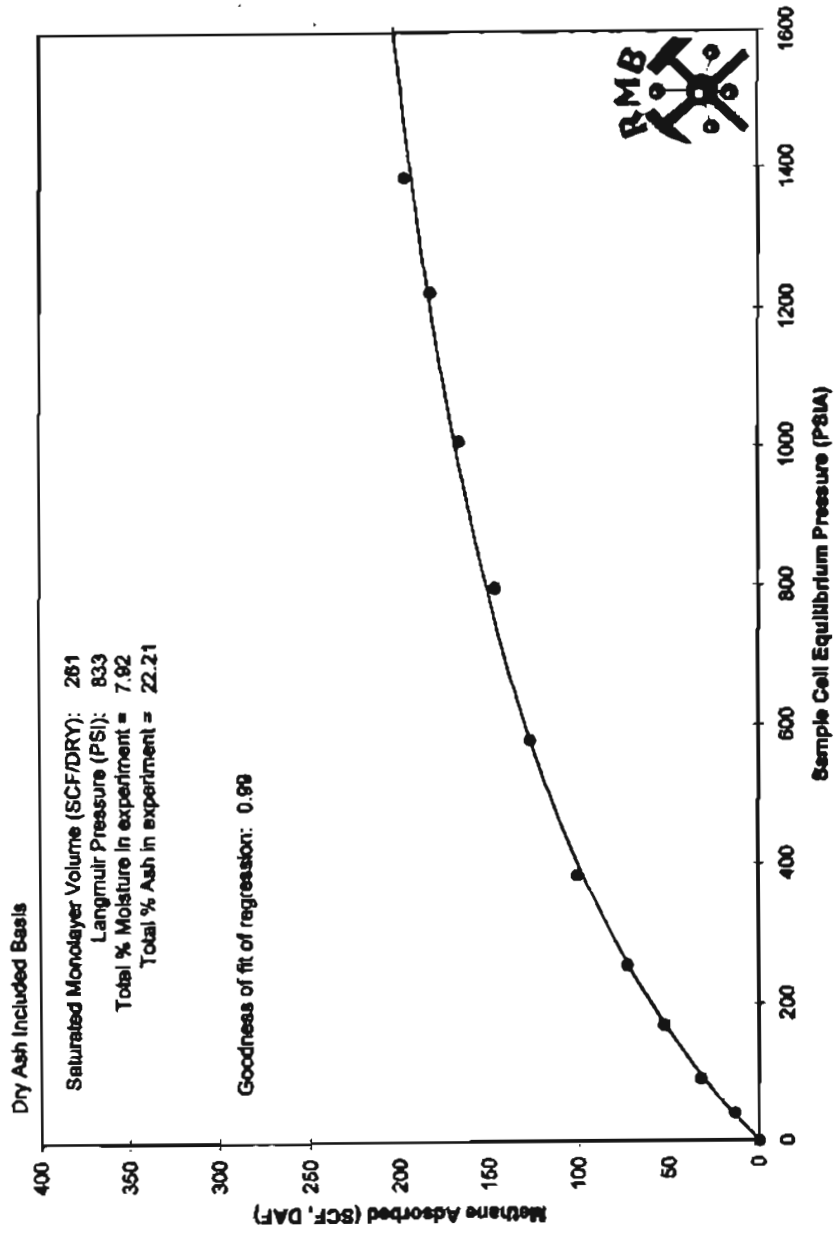
As Received Basis



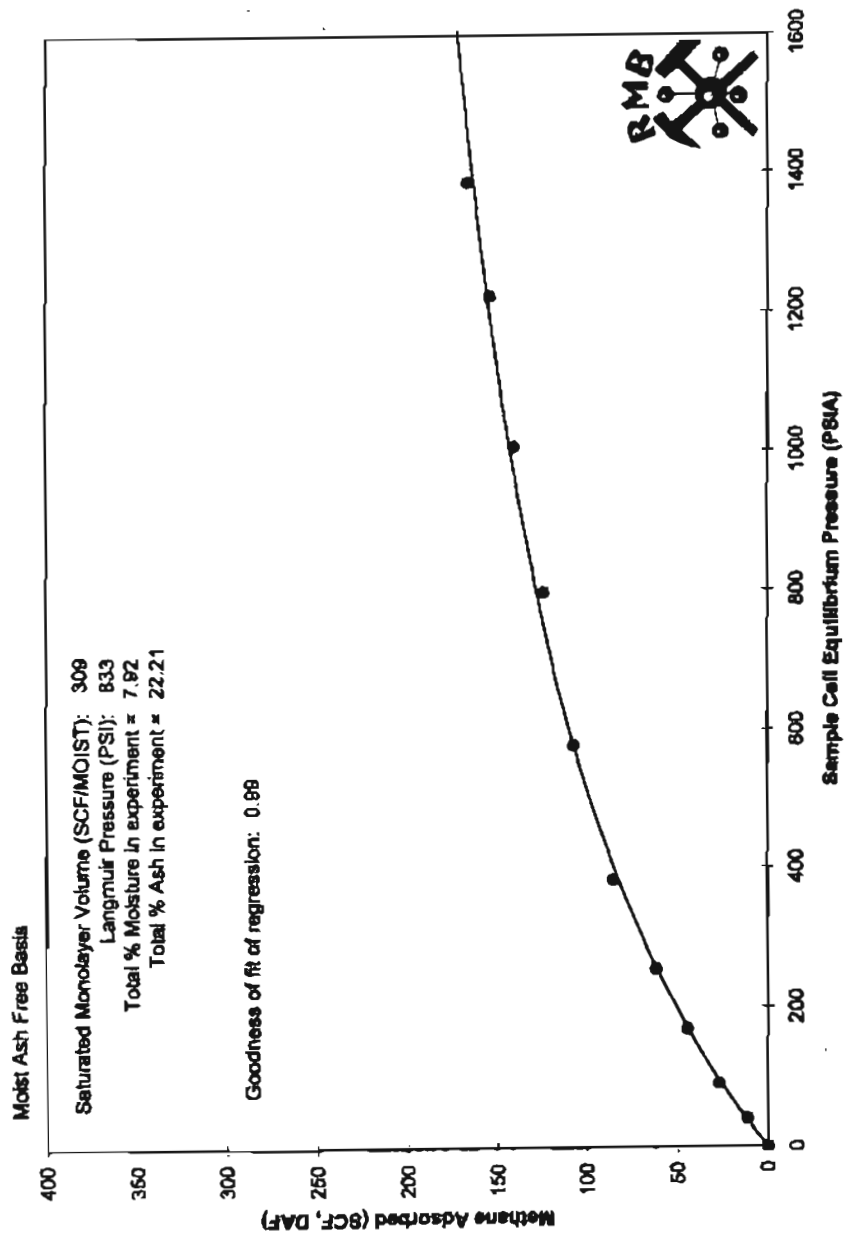
00DL33-E



00DL33-E

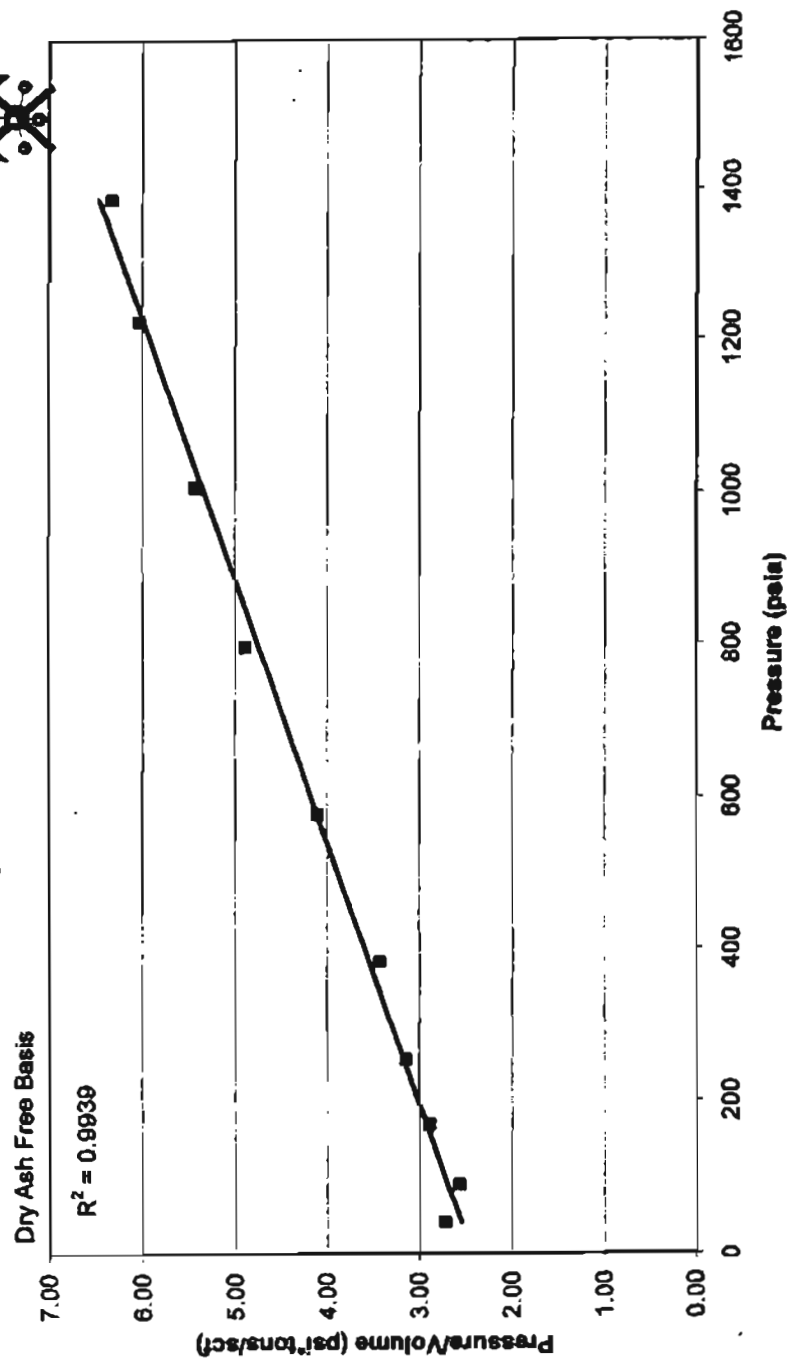


# 00DL33-E



**Adsorption Langmuir Plot**  
**Methane Imperial Units**

**00DL33-E**





**APPENDIX X****00DL33-E*****Methane Adsorption Isotherm SI Units******Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	7.06	10.10
Langmuir Pressure MPa	5.74	5.74
Goodness of fit Langmuir		
Equation R-squared	0.99	0.99
Ash Content Wt %	22.21	22.21
Equilibrium Moisture Wt %	7.92	7.92

**Contents of Appendix*****Data Sheets***

As Received  
 Dry Ash Free  
 Dry Ash Included  
 Moist Ash Free

***Charts***

As Received  
 Dry Ash Free  
 Dry Ash Included  
 Moist Ash Free



**00DL33-E****METHANE ADSORPTION ISOTHERM SI UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL33-E	Moisture Content (EQ) % :	7.92
Isotherm Temperature ° C:	40	Ash Content % :	22.21
		Helium Density g/cc	1.465

PRESSURE (MPa)	ADSORBED METHANE (cc/g @STP)	P / V
0.285	0.31	0.912
0.633	0.74	0.859
1.173	1.21	0.970
1.762	1.67	1.055
2.647	2.30	1.150
3.994	2.90	1.378
5.497	3.35	1.642
8.946	3.81	1.825
8.442	4.17	2.025
9.564	4.51	2.123

Saturated Monolayer Volume (cc/g @ STP):	7.06
Langmuir Pressure (MPa):	5.74

**DRY ASH FREE BASIS**

0.285	0.45	0.637
0.633	1.05	0.600
1.173	1.73	0.677
1.762	2.39	0.737
2.647	3.30	0.803
3.994	4.15	0.963
5.497	4.79	1.147
8.946	5.45	1.275
8.442	5.97	1.415
9.564	6.45	1.483

Saturated Monolayer Volume (cc/g @ STP, daf):	10.10
Langmuir Pressure (MPa):	5.74
Correlation Coefficient:	0.99

**00DL33-E****METHANE ADSORPTION ISOTHERM SI UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL33-E	Moisture Content (EQ) % :	7.82
Isotherm Temperature ° C:	40	Ash Content %	22.21
		Helium Density g/cc	1.485

PRESSURE (MPa)	ADSORBED METHANE (cc/g@STP)	P / V
0.285	0.34	0.84
0.633	0.80	0.79
1.173	1.31	0.89
1.762	1.81	0.97
2.647	2.50	1.06
3.994	3.15	1.27
5.497	3.64	1.51
6.948	4.13	1.68
8.442	4.53	1.86
9.564	4.69	1.85

Saturated Monolayer Volume (cc/g, dry):	7.67
Langmuir Pressure (MPa):	5.74

**MOIST ASH FREE BASIS**

0.2852	0.40	0.00
0.6328	0.95	0.67
1.1732	1.58	0.75
1.7619	2.15	0.82
2.6470	2.96	0.89
3.9943	3.73	1.07
5.4965	4.30	1.28
6.9463	4.69	1.42
8.4419	5.36	1.58
9.5641	5.79	1.65

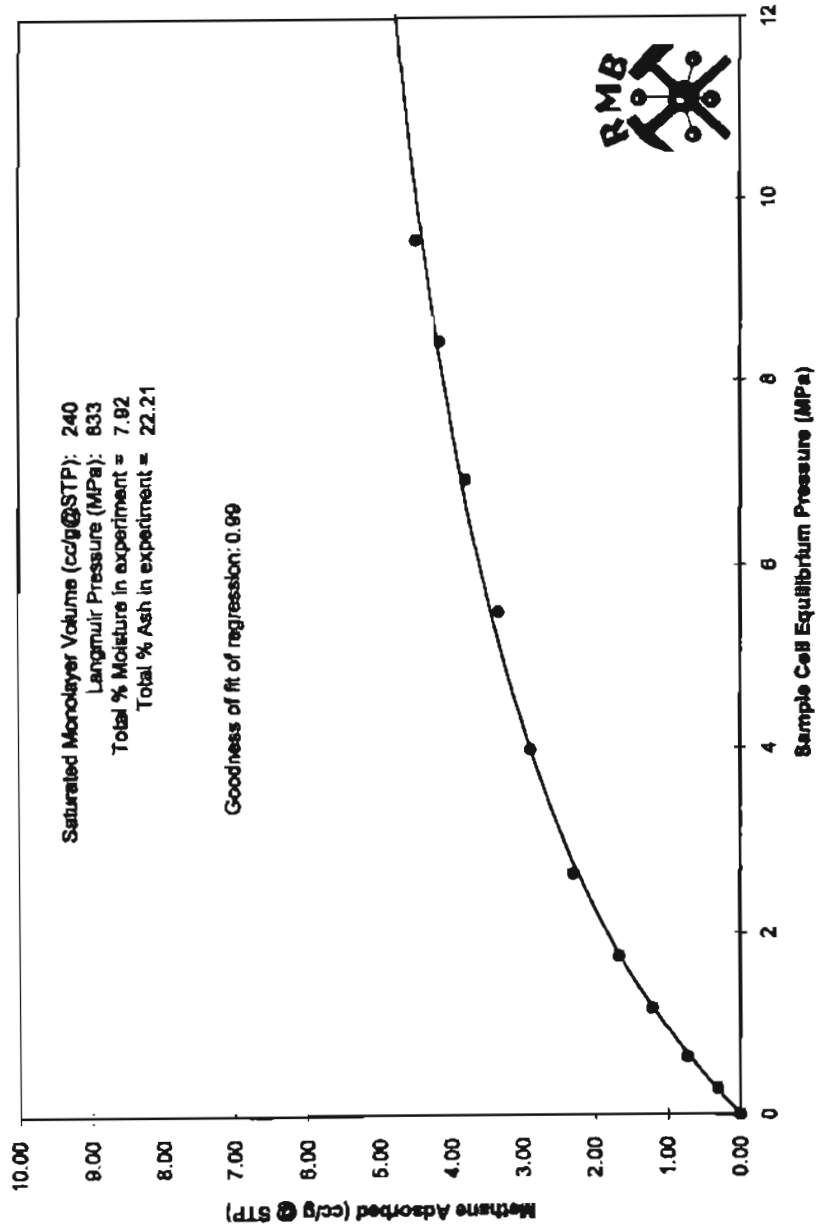
Saturated Monolayer Volume (cc/g, ash free):	9.07
Langmuir Pressure (MPa):	5.74
Correlation Coefficient:	0.99

# 00DL33-E

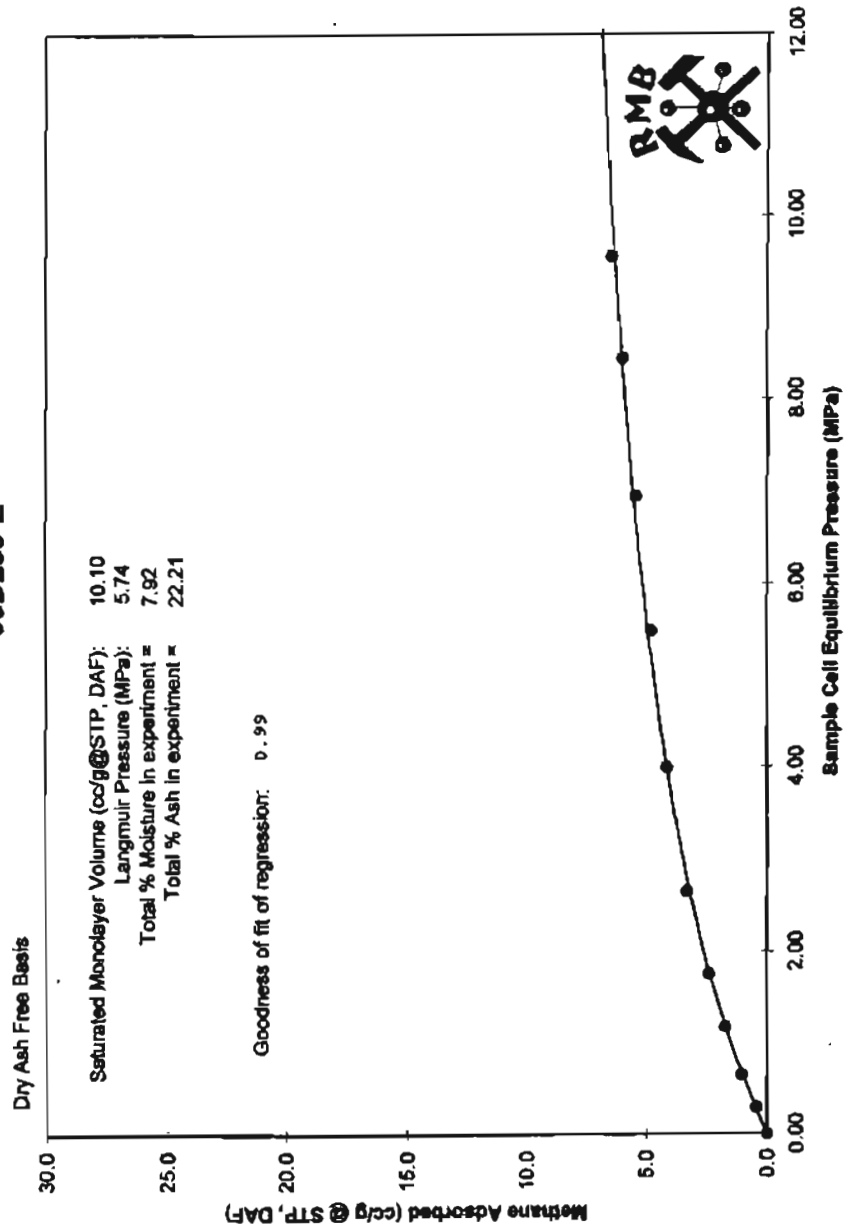
As Received Basis

Saturated Monolayer Volume (cc/g@STP): 240  
Langmuir Pressure (MPa): 833  
Total % Moisture in experiment = 7.92  
Total % Ash in experiment = 22.21

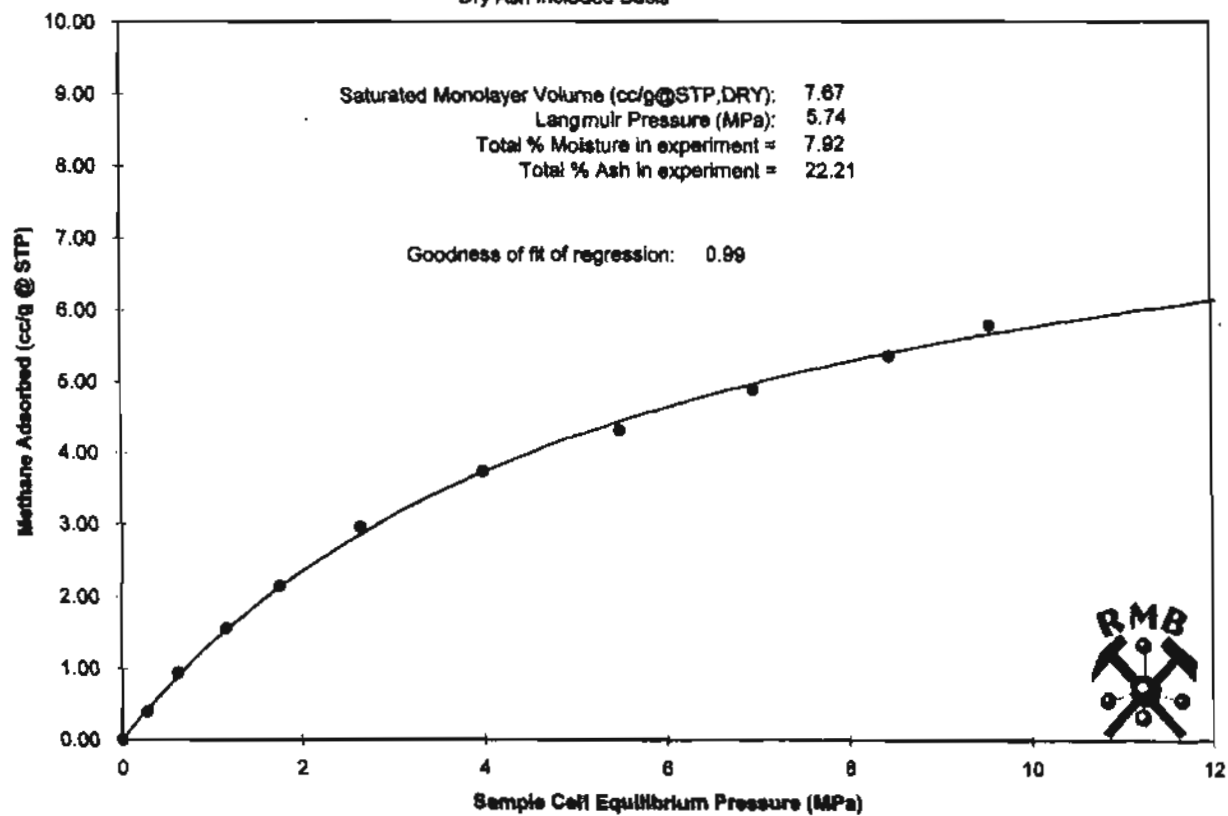
Goodness of fit of regression: 0.99



# 00DL33-E

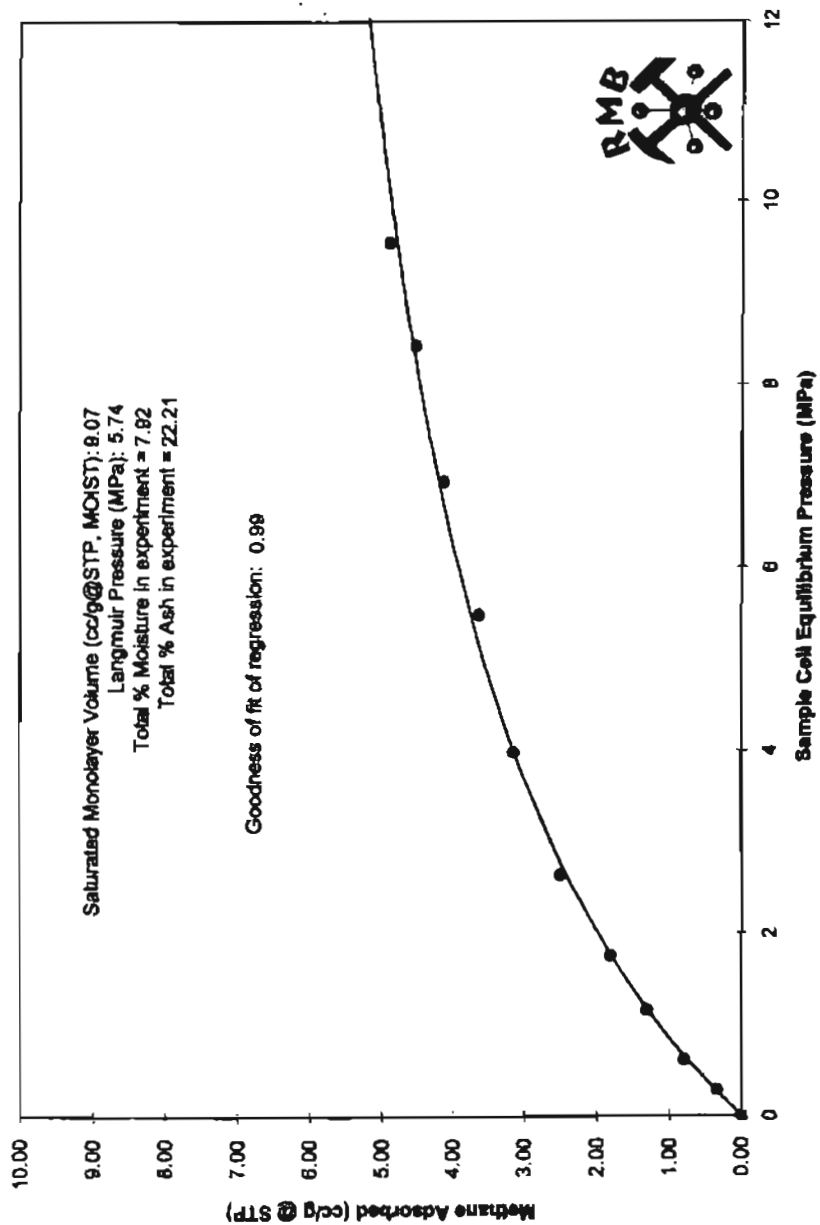


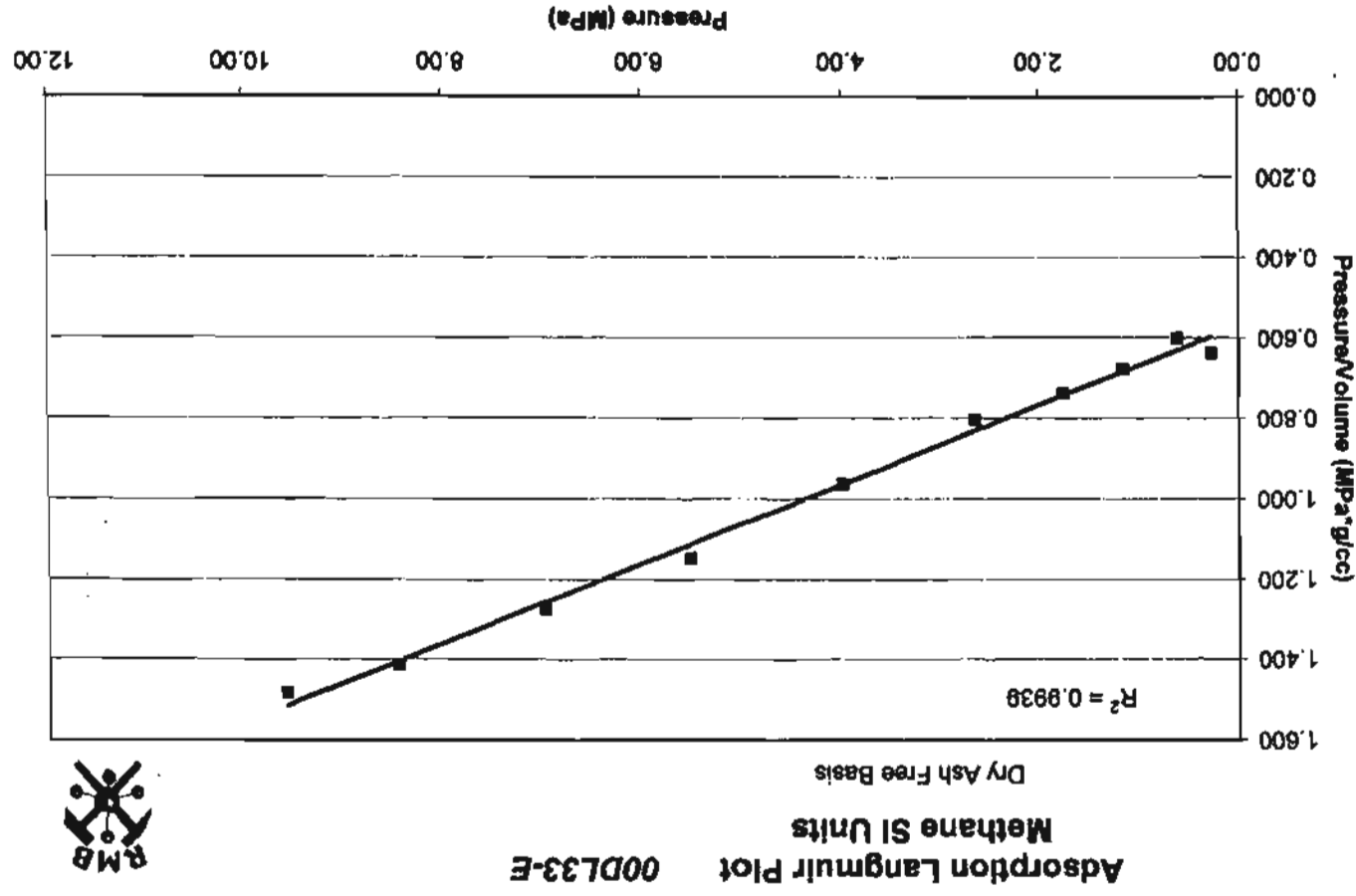
**00DL33-E**  
Dry Ash Included Basis



# 00DL33-E

Moist Ash Free Basis







## **APPENDIX XI**

**00DL28-44**

***Methane Adsorption Isotherm  
Imperial Units***

### ***Summary of Analyses***

	As Received	DAF basis
Langmuir Volume cc/g	85	100
Langmuir Pressure MPa	1221	1221
Goodness of fit Langmuir		
Equation R-squared	0.97	0.97
Ash Content Wt. %	7.28	7.28
Equilibrium Moisture Wt. %	27.89	27.89

#### **Contents of Appendix**

##### ***Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

##### ***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



## **APPENDIX XI**

# **00DL28-44**

***Methane Adsorption Isotherm  
Imperial Units***

<b><i>Summary of Analyses</i></b>		
	<b>As Received</b>	<b>DAF basis</b>
Langmuir Volume cc/g	65	100
Langmuir Pressure MPa	1221	1221
Goodness of fit Langmuir		
Equation R-squared	0.97	0.97
Ash Content Wt. %	7.26	7.26
Equilibrium Moisture Wt. %	27.89	27.89

### **Contents of Appendix**

#### ***Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

#### ***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL28-44****METHANE ADSORPTION ISOTHERM CFG UNITS****AS RECEIVED BASIS**

Sample I.D. : 00DL28-44 Moisture Content (EQ) % : 27.89

Isotherm Temperature \* F: 104 Ash Content, % : 7.28

Helium Density g/cc 1.351

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
45	2.83	17.11
98	4.44	22.18
190	8.21	23.08
285	11.74	22.55
393	15.72	25.02
590	21.51	27.45
808	26.75	30.14
1020	29.18	34.98
1229	31.70	38.77
1389	35.17	39.51

Saturated Monolayer Volume (SCF/ton): 65

Langmuir Pressure (PSIA): 1221

**DRY ASH FREE BASIS**

45	4.08	11.10
98	8.84	14.38
190	12.67	14.97
285	18.11	14.62
393	24.24	16.23
590	33.17	17.80
808	41.25	19.55
1020	44.97	22.68
1229	48.89	25.14
1389	54.23	25.62

Saturated Monolayer Volume (SCF/ton, daf): 100

Langmuir Pressure (PSIA): 1221

Correlation Coefficient: 0.97

**00DL28-44****METHANE ADSORPTION ISOTHERM CFG UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL28-44	Moisture Content (EQ) % :	27.89
Isotherm Temperature ° F:	104	Ash Content, % :	7.28
		Helium Density g/cc	1.351

PRESSURE (PSI)	ADSORBED METHANE (SCF/ton)	P / V
45	4	12.34
98	6	15.99
190	11	16.64
265	16	16.26
393	22	18.04
590	30	19.79
806	37	21.73
1020	40	25.22
1229	44	27.96
1389	49	28.49

Saturated Monolayer Volume (SCF/ton):	90
Langmuir Pressure (PSIA):	1221

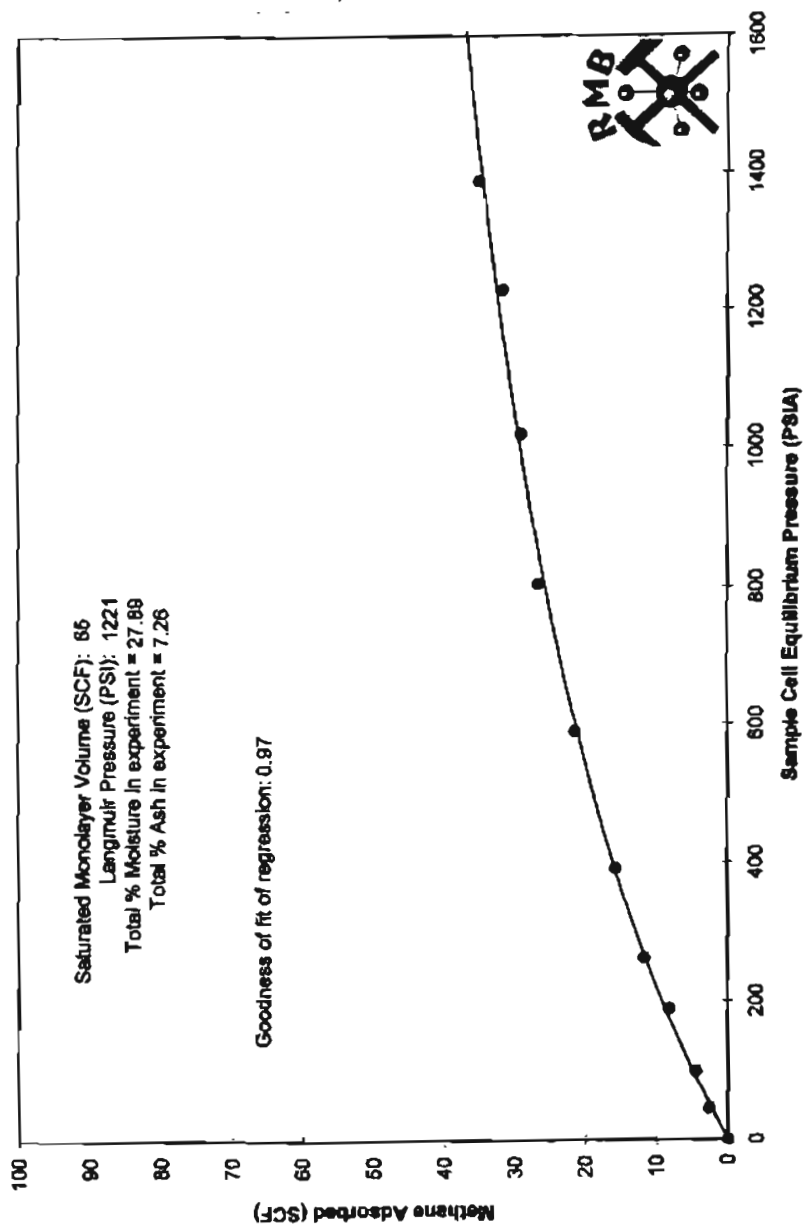
**MOIST ASH FREE BASIS**

45	3	15.87
98	5	20.57
190	9	21.41
265	13	20.91
393	17	23.21
590	23	25.46
806	29	27.95
1020	31	32.44
1229	34	35.96
1389	38	36.64

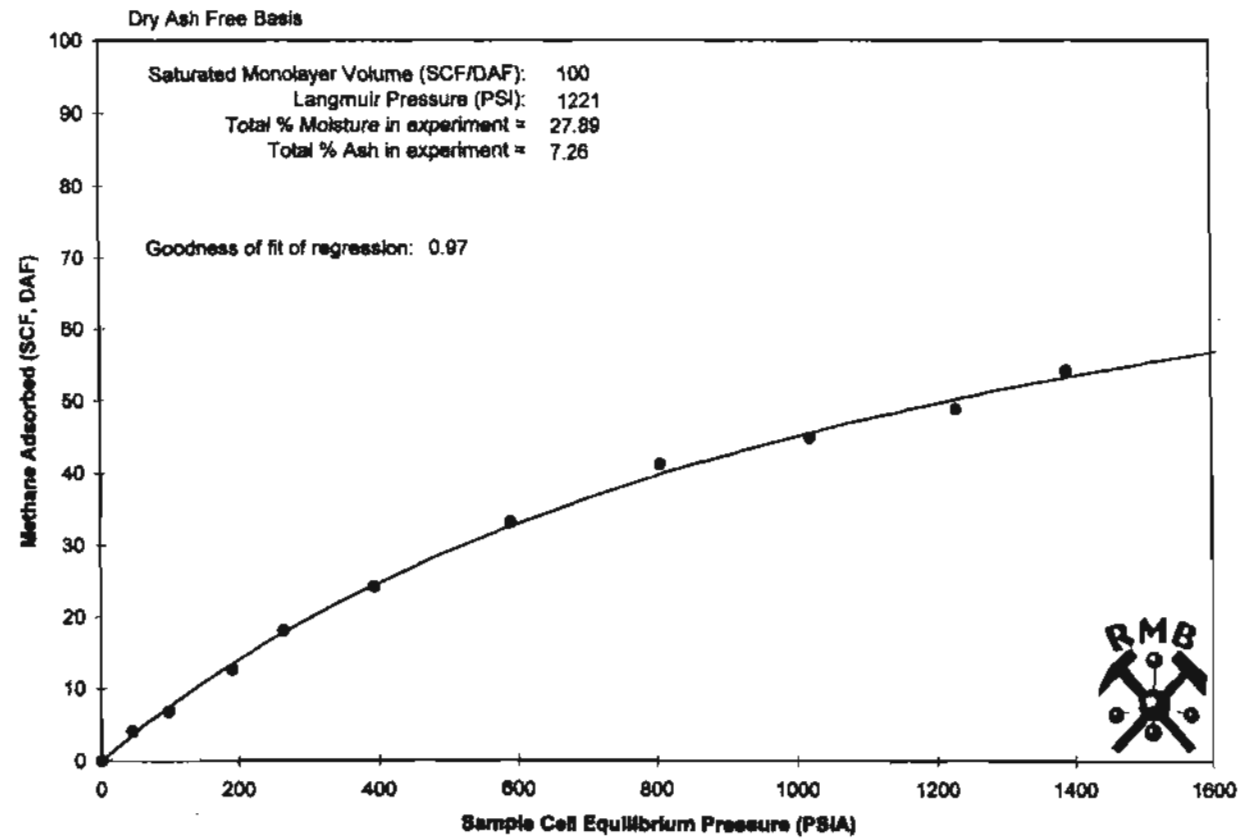
Saturated Monolayer Volume (SCF/ton, daf):	70
Langmuir Pressure (PSIA):	1221
Correlation Coefficient:	0.97

00DL28-44

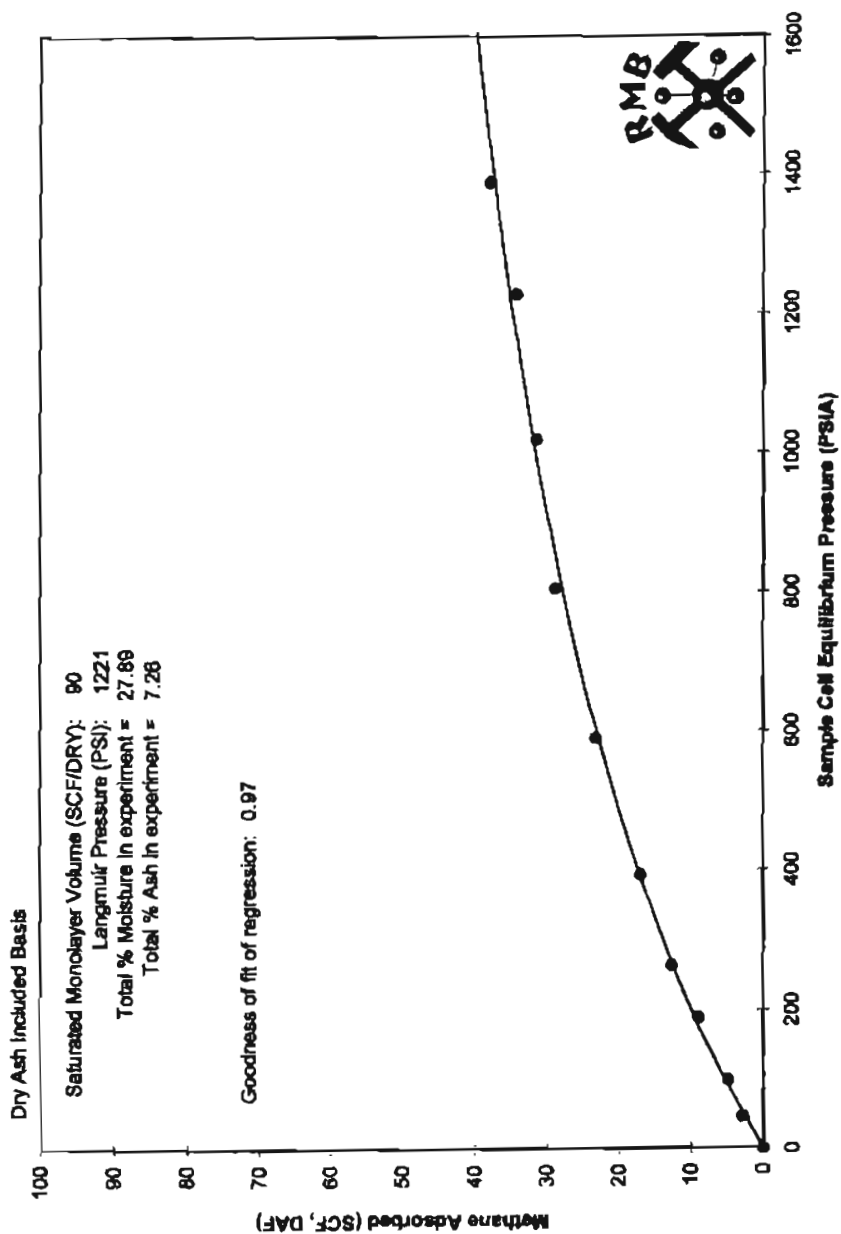
As Received Basis



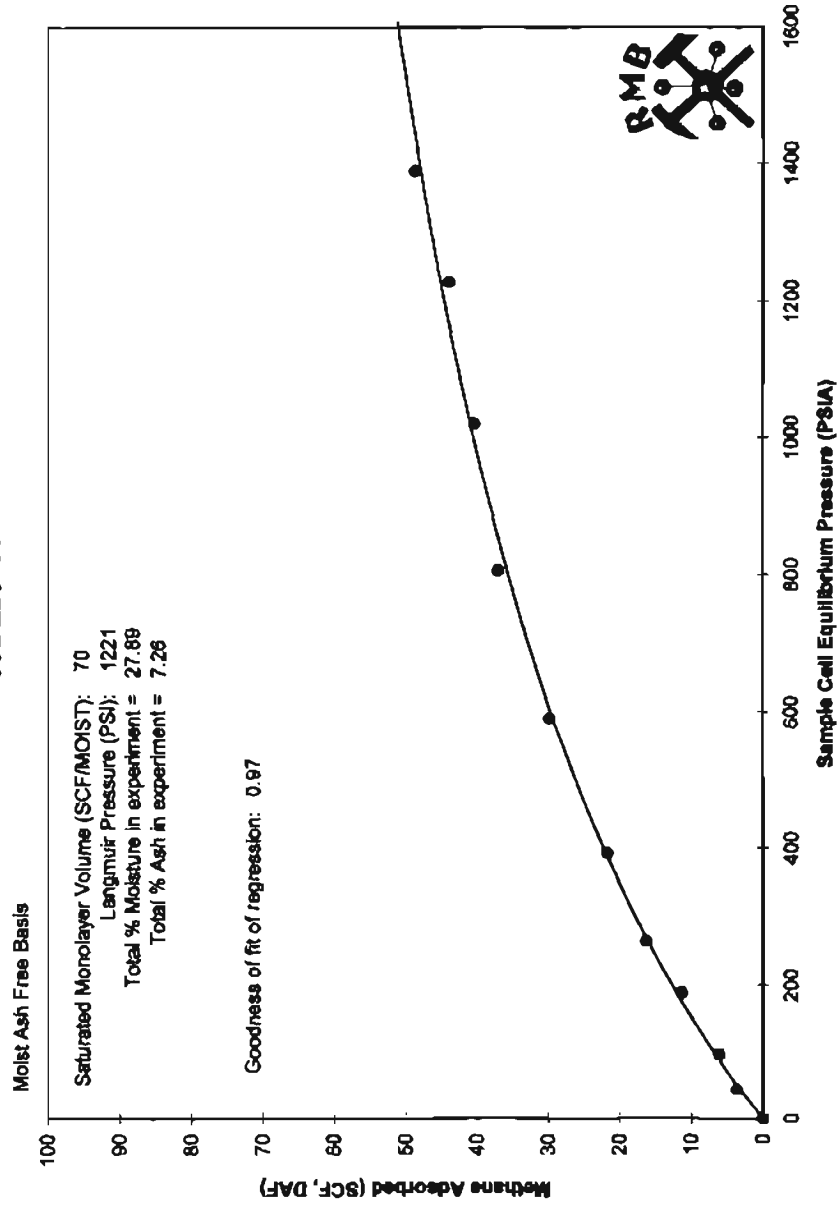
00DL28-44



00DL28-44

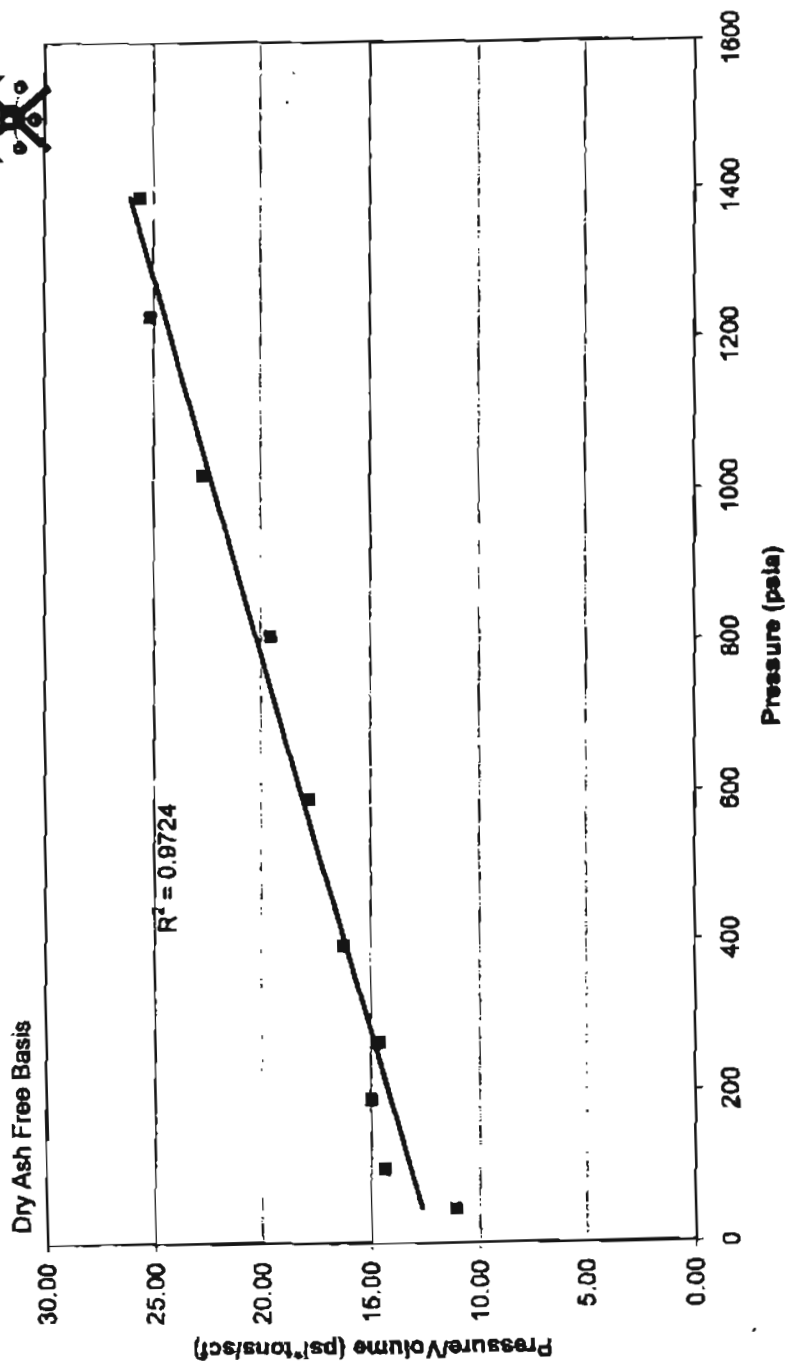


00DL28-44





Adsorption Langmuir Plot  
Methane Imperial Units  
00DL28-44



**APPENDIX XII****00DL28-44*****Methane Adsorption Isotherm SI Units***

<b>Summary of Analyses</b>		
	<b>As Received</b>	<b>DAF basis</b>
Langmuir Volume cc/g	1.91	2.94
Langmuir Pressure MPa	8.42	8.42
Goodness of fit Langmuir		
Equation R-squared	0.97	0.97
Ash Content Wt %	7.26	7.26
Equilibrium Moisture Wt %	27.89	27.69

**Contents of Appendix*****Data Sheets***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free

***Charts***

As Received

Dry Ash Free

Dry Ash Included

Moist Ash Free



**00DL28-44****METHANE ADSORPTION ISOTHERM SI UNITS****AS RECEIVED BASIS**

Sample I.D. :	00DL28-44	Moisture Content (EQ) % :	27.89
Isotherm Temperature ° C:	40	Ash Content % :	7.26
		Helium Density g/cc	1.351

PRESSURE (MPa)	ADSORBED METHANE (cc/g @STP)	P / V
0.311	0.08	4.015
0.678	0.13	5.203
1.307	0.24	5.416
1.826	0.35	5.289
2.712	0.46	5.870
4.071	0.63	6.439
5.559	0.79	7.071
7.032	0.86	8.205
8.475	0.93	9.098
9.580	1.03	9.268

Saturated Monolayer Volume (cc/g @ STP):	1.91
Langmuir Pressure (MPa):	8.42

**DRY ASH FREE BASIS**

0.311	0.12	2.604
0.678	0.20	3.374
1.307	0.37	3.512
1.826	0.53	3.430
2.712	0.71	3.807
4.071	0.97	4.178
5.559	1.21	4.586
7.032	1.32	5.321
8.475	1.44	5.898
9.580	1.59	6.011

Saturated Monolayer Volume (cc/g @ STP, daf):	2.94
Langmuir Pressure (MPa):	8.42
Correlation Coefficient:	0.97

**00DL28-44****METHANE ADSORPTION ISOTHERM SI UNITS****DRY ASH INCLUDED BASIS**

Sample I.D. :	00DL28-44	Moisture Content (EQ) % :	27.89
Isotherm Temperature ° C:	40	Ash Content %	7.28
		Helium Density g/cc	1.351

PRESSURE (MPa)	ADSORBED METHANE (cc/g @ STP)	P / V
0.311	0.11	2.90
0.678	0.18	3.75
1.307	0.33	3.90
1.828	0.48	3.81
2.712	0.64	4.23
4.071	0.68	4.64
5.559	1.09	5.10
7.032	1.19	5.92
8.475	1.28	6.58
9.580	1.43	6.68

Saturated Monolayer Volume (cc/g, dry):	2.65
Langmuir Pressure (MPa):	8.42

**MOIST ASH FREE BASIS**

0.3109	0.08	0.00
0.6782	0.14	4.82
1.3072	0.26	5.02
1.8255	0.37	4.91
2.7115	0.50	5.44
4.0707	0.68	5.97
5.5586	0.85	6.58
7.0323	0.92	7.61
8.4749	1.00	8.44
9.5797	1.11	8.60

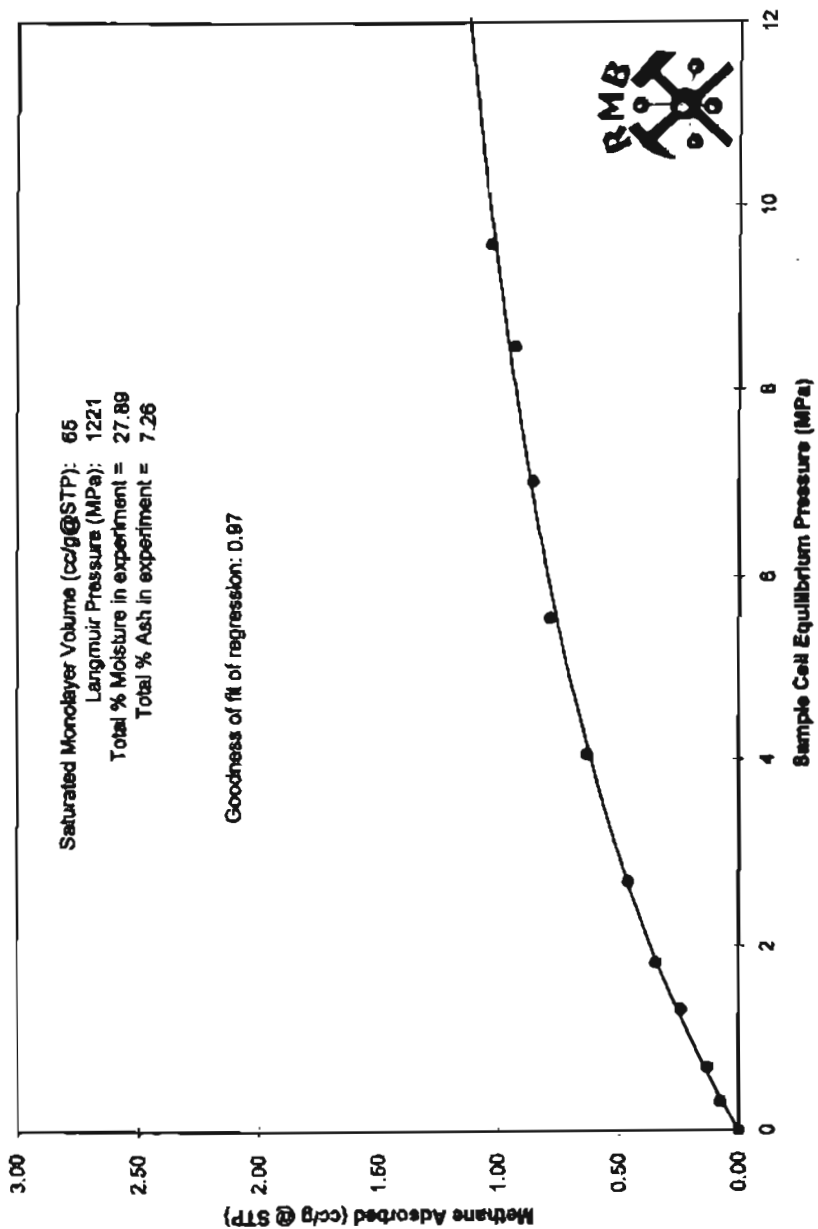
Saturated Monolayer Volume (cc/g, ash free):	2.08
Langmuir Pressure (MPa):	8.42
Correlation Coefficient:	0.97

00DL28-44

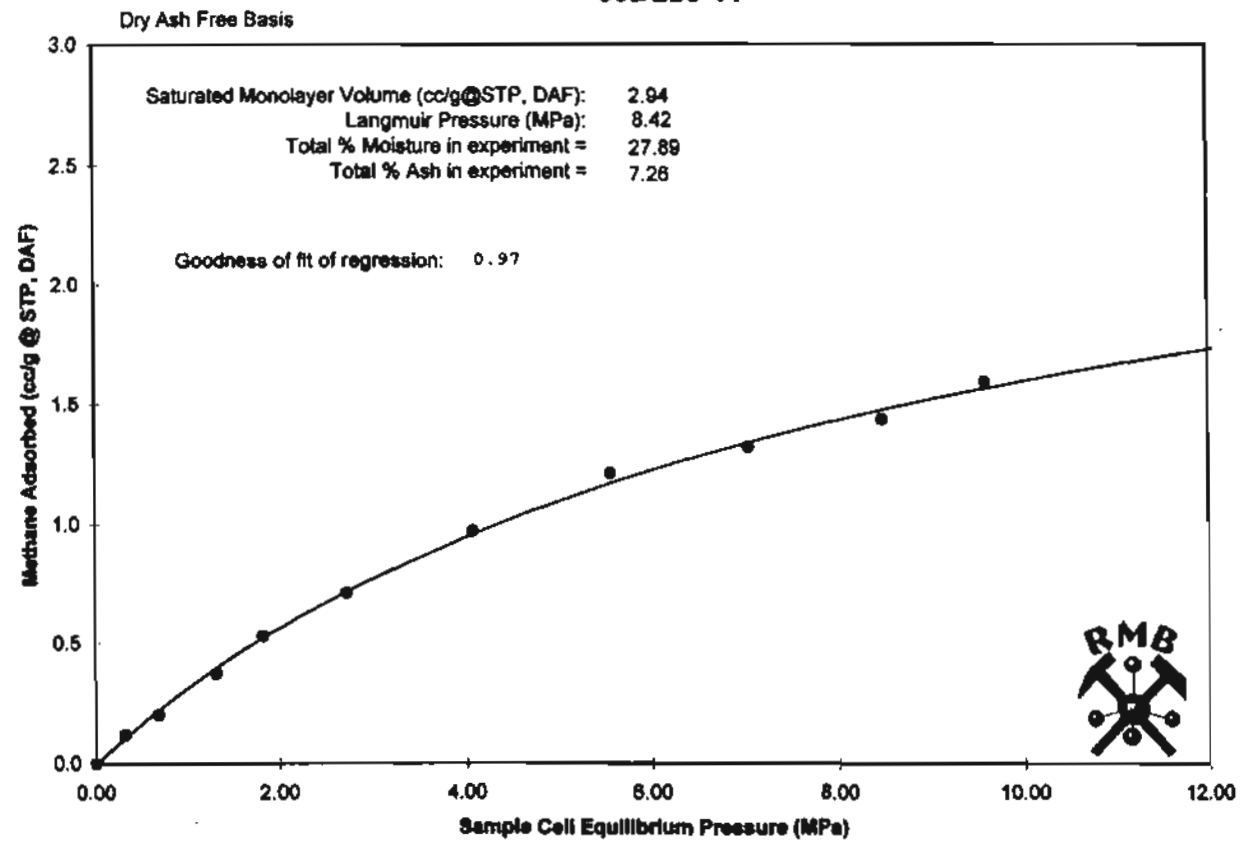
As Received Basis

Saturated Monolayer Volume (cc/g@STP): 65  
Langmuir Pressure (MPa): 1221  
Total % Moisture in experiment = 27.89  
Total % Ash in experiment = 7.26

Goodness of fit of regression: 0.97

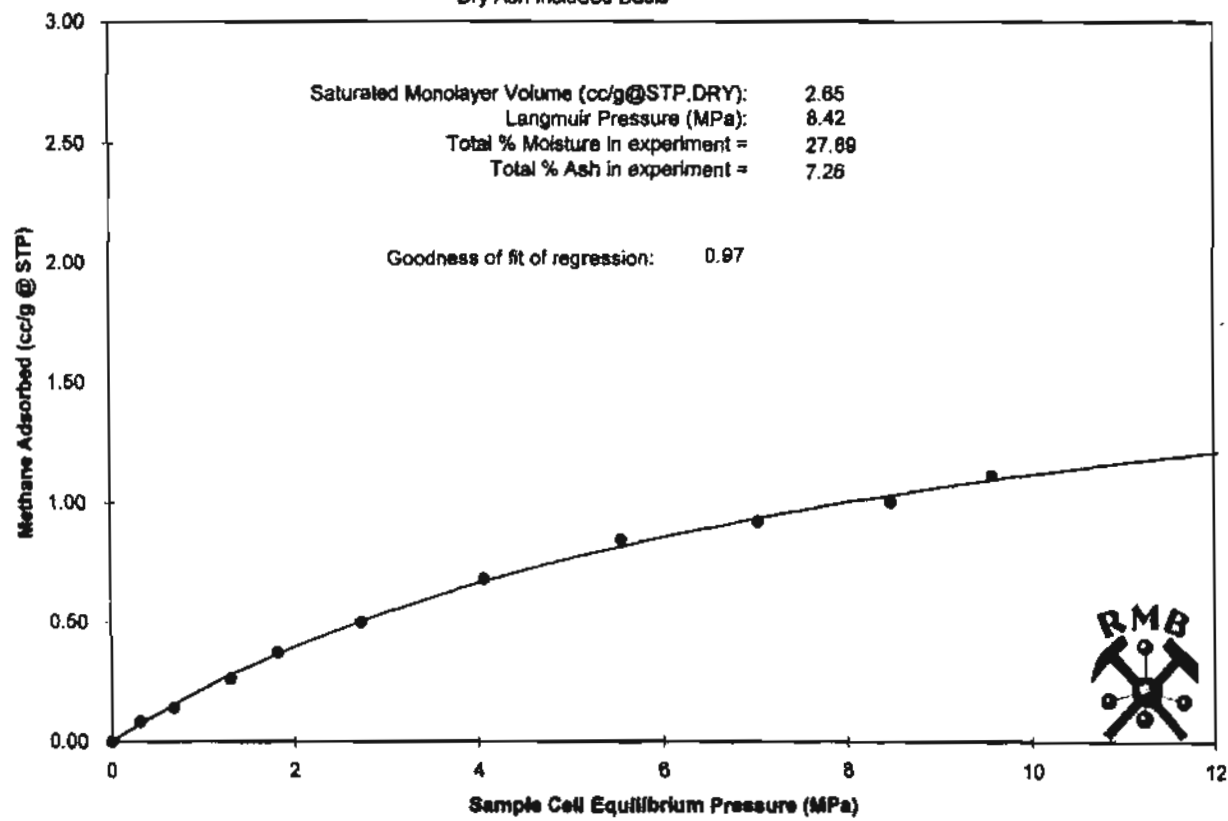


00DL28-44



**00DL28-44**

Dry Ash Included Basis

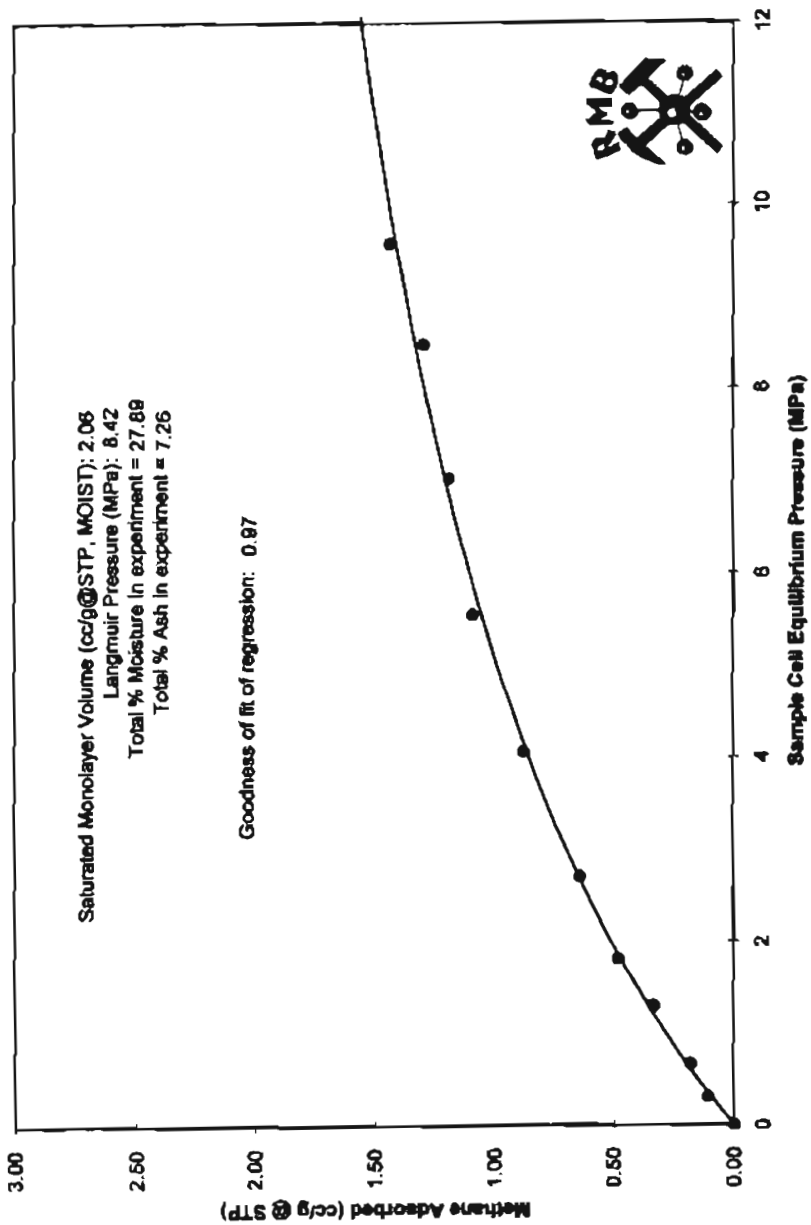


00DL28-44

Moist Ash Free Basis

Saturated Monolayer Volume (cc/g@STP, MOIST): 2.06  
Langmuir Pressure (MPa): 8.42  
Total % Moisture in experiment = 27.88  
Total % Ash in experiment = 7.26

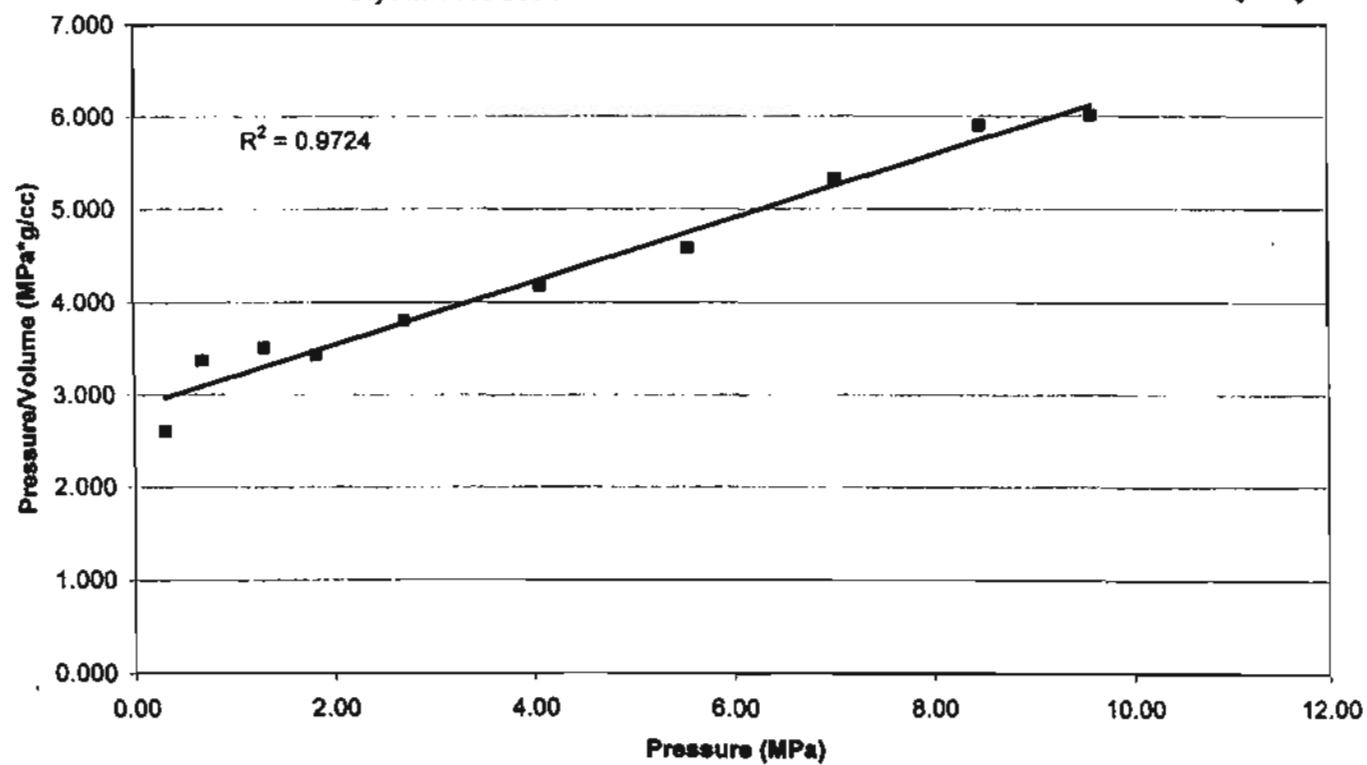
Goodness of fit of regression: 0.97





**Adsorption Langmuir Plot    00DL28-44**  
**Methane SI Units**

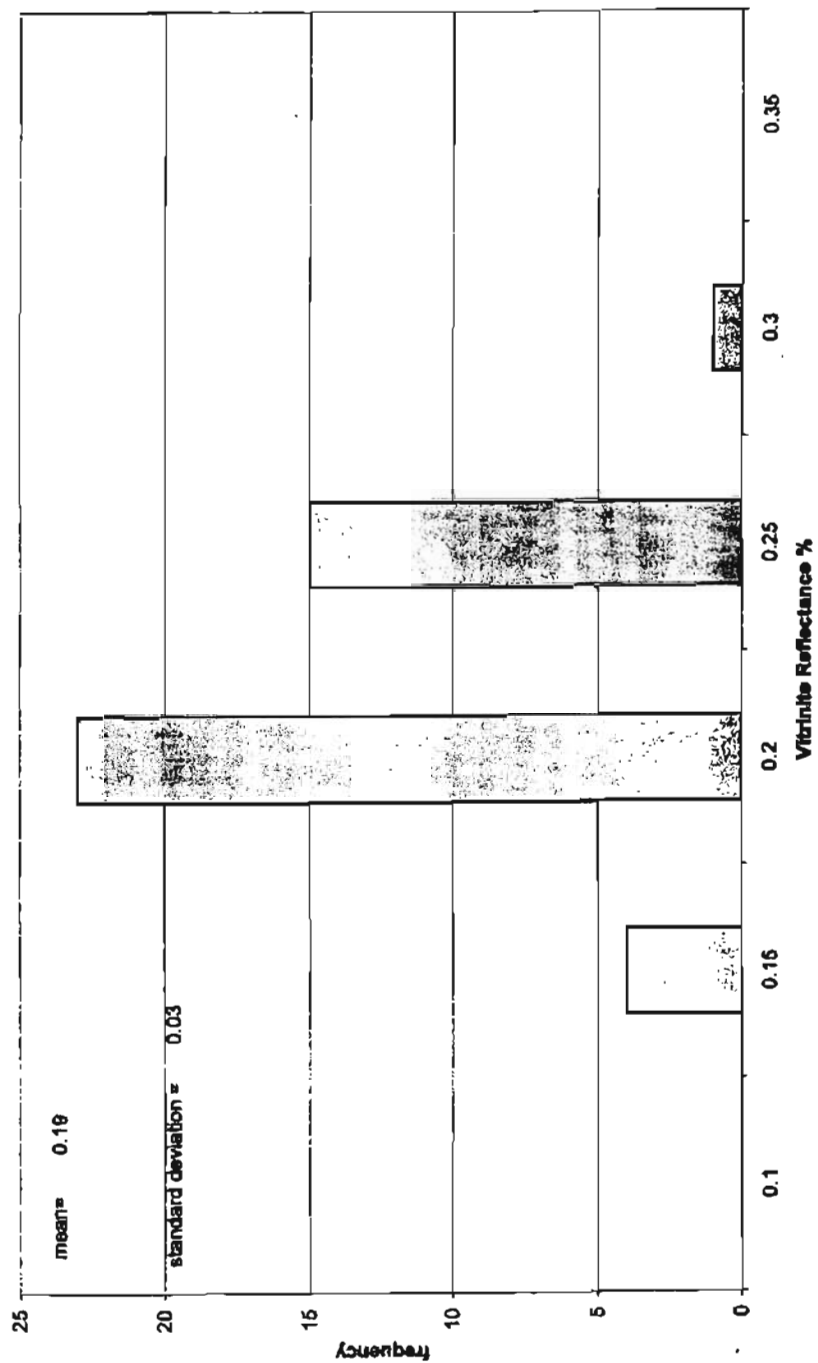
Dry Ash Free Basis



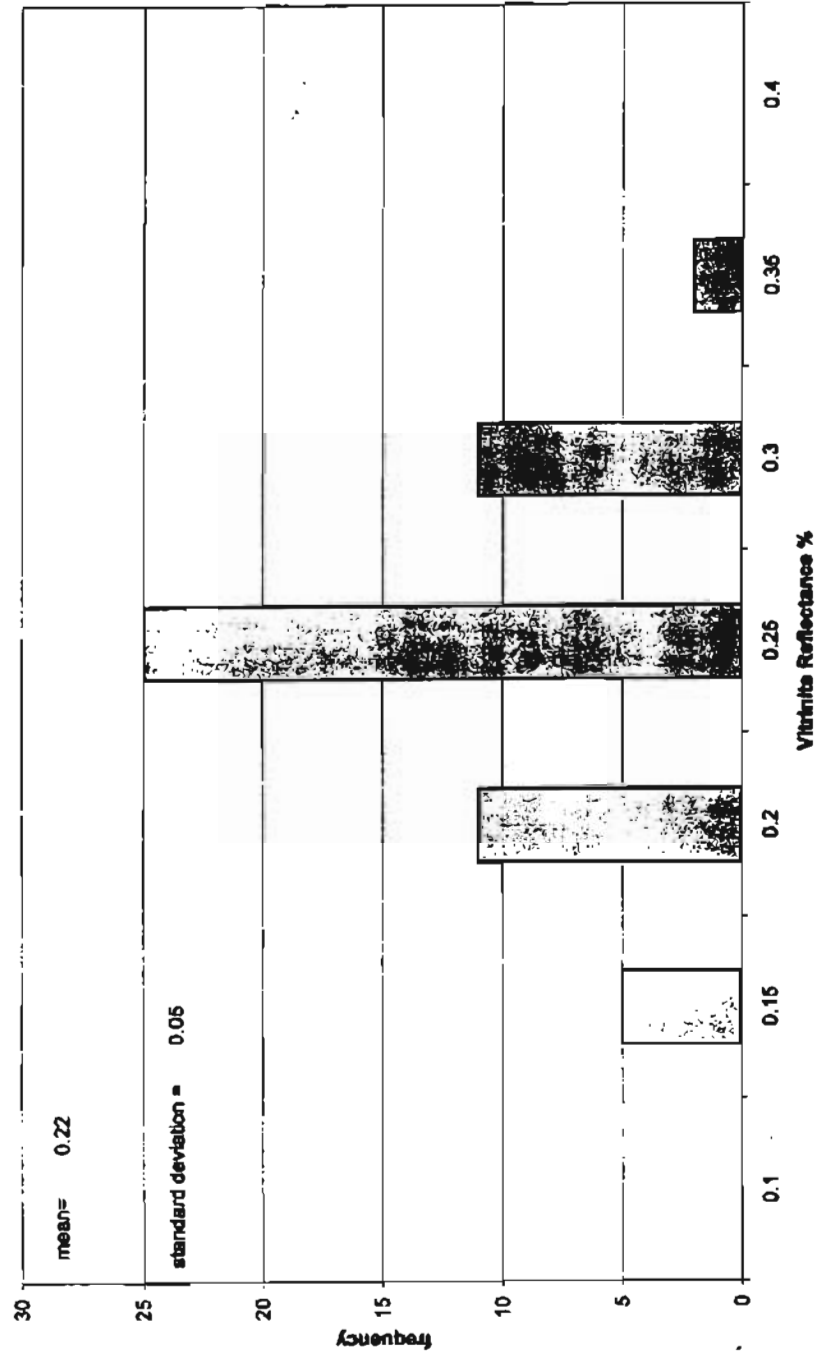
## **APPENDIX XIII**

### **Histograms of vitrinite reflectance measurements**

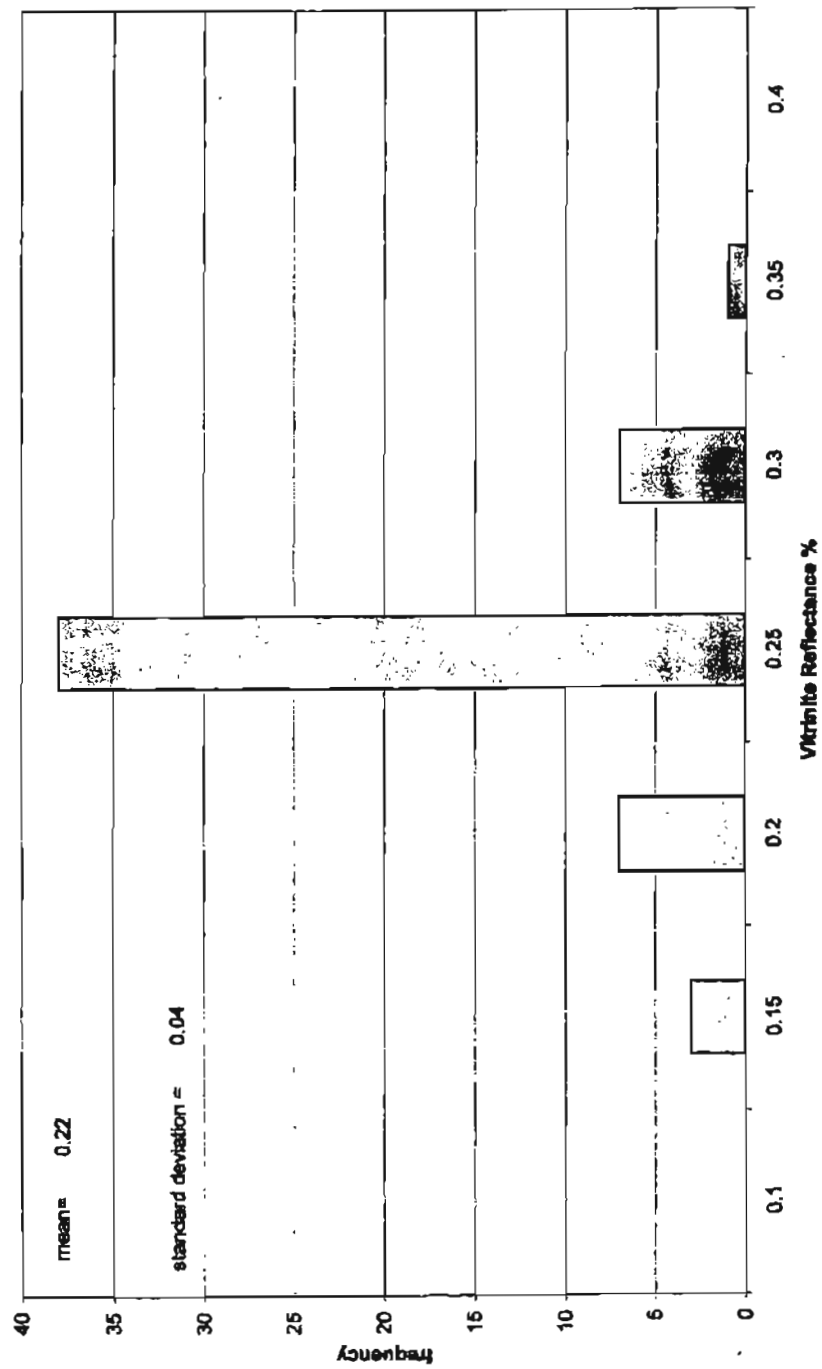
00DL28 32.5



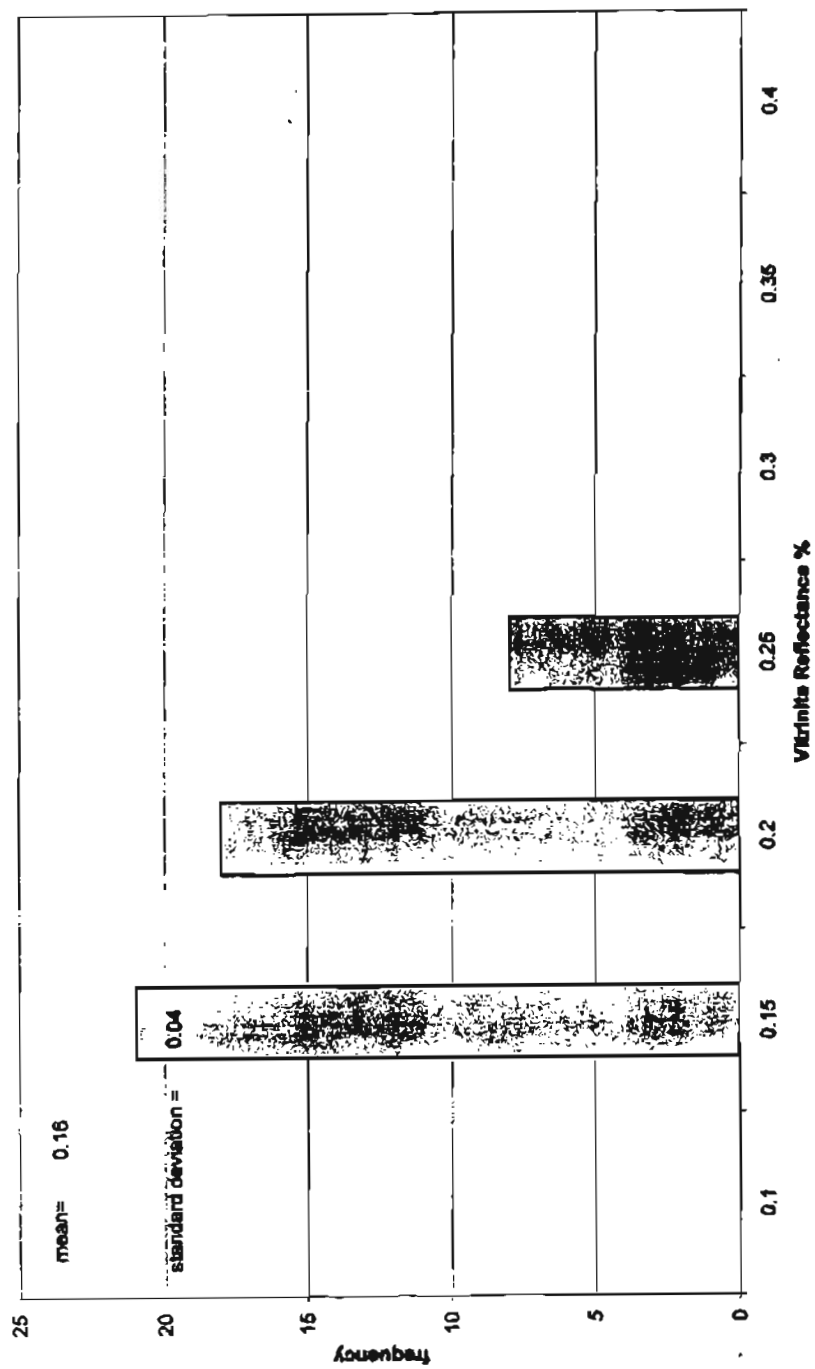
00DL28 1.0



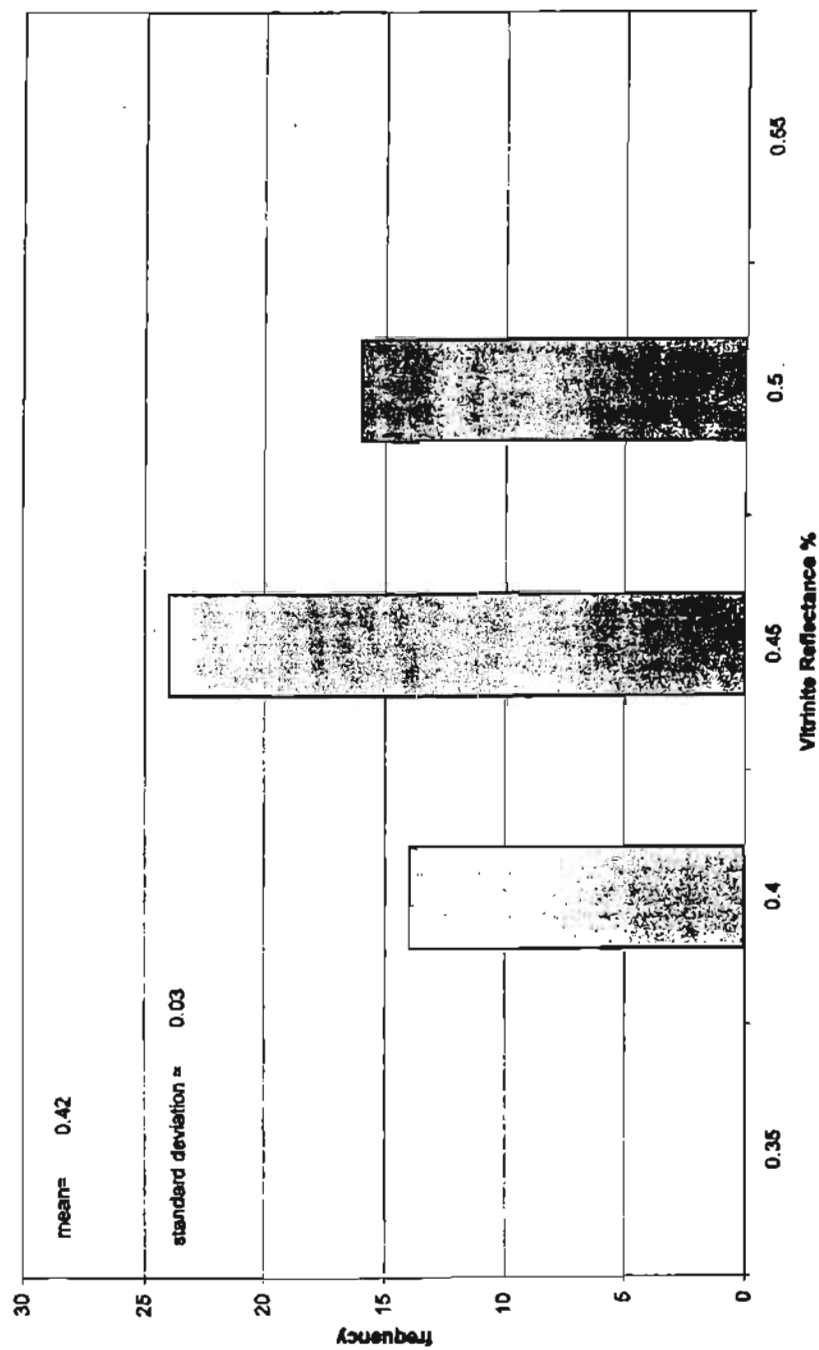
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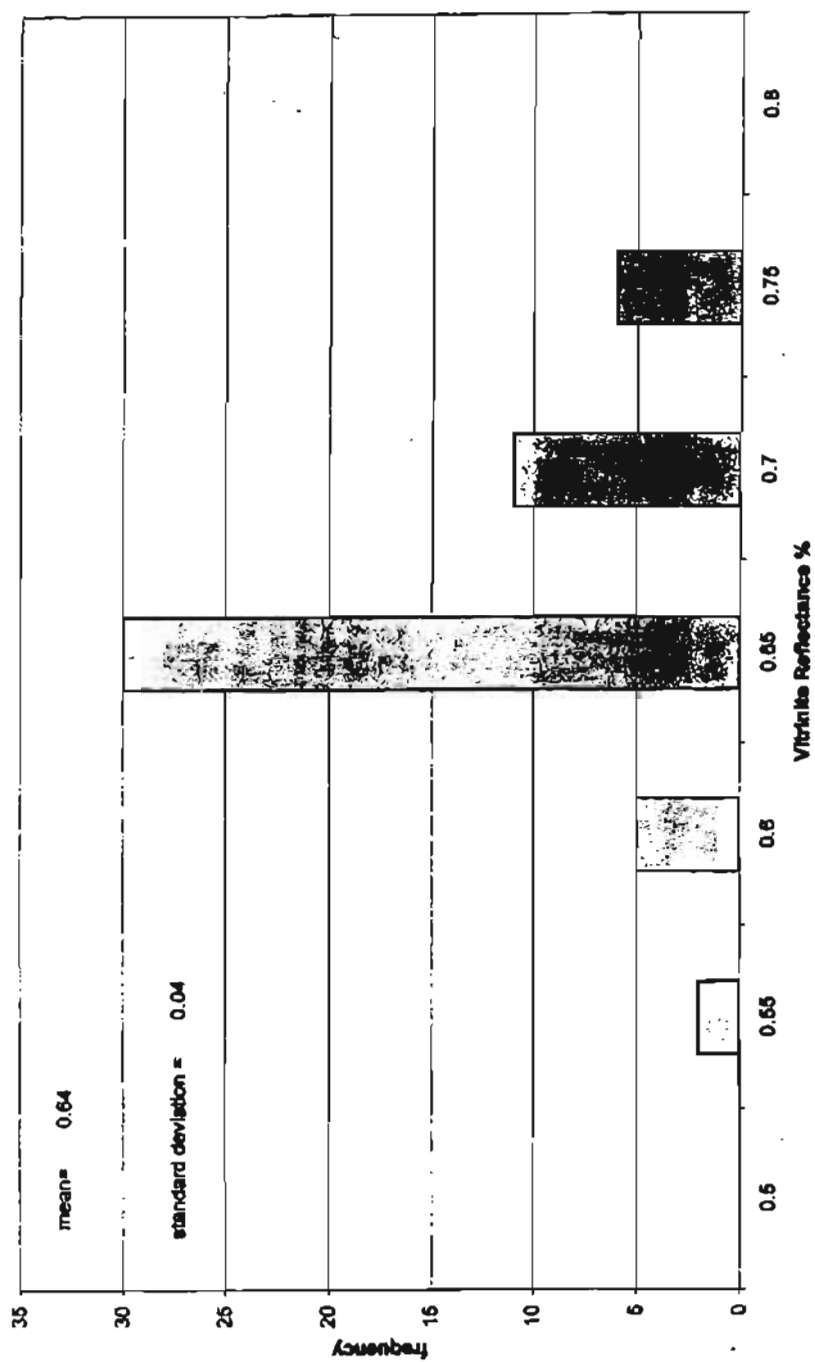
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00DL30B

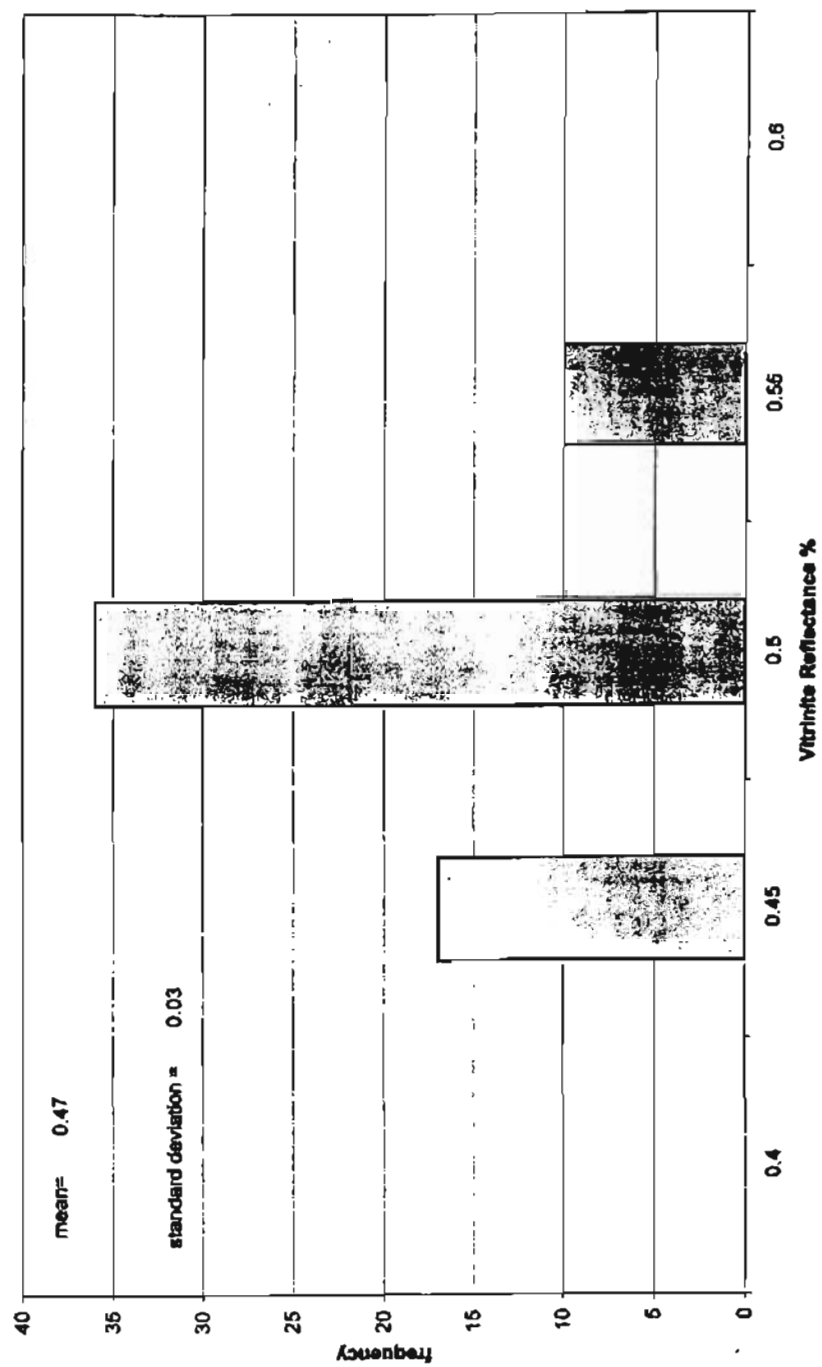


00DL32A

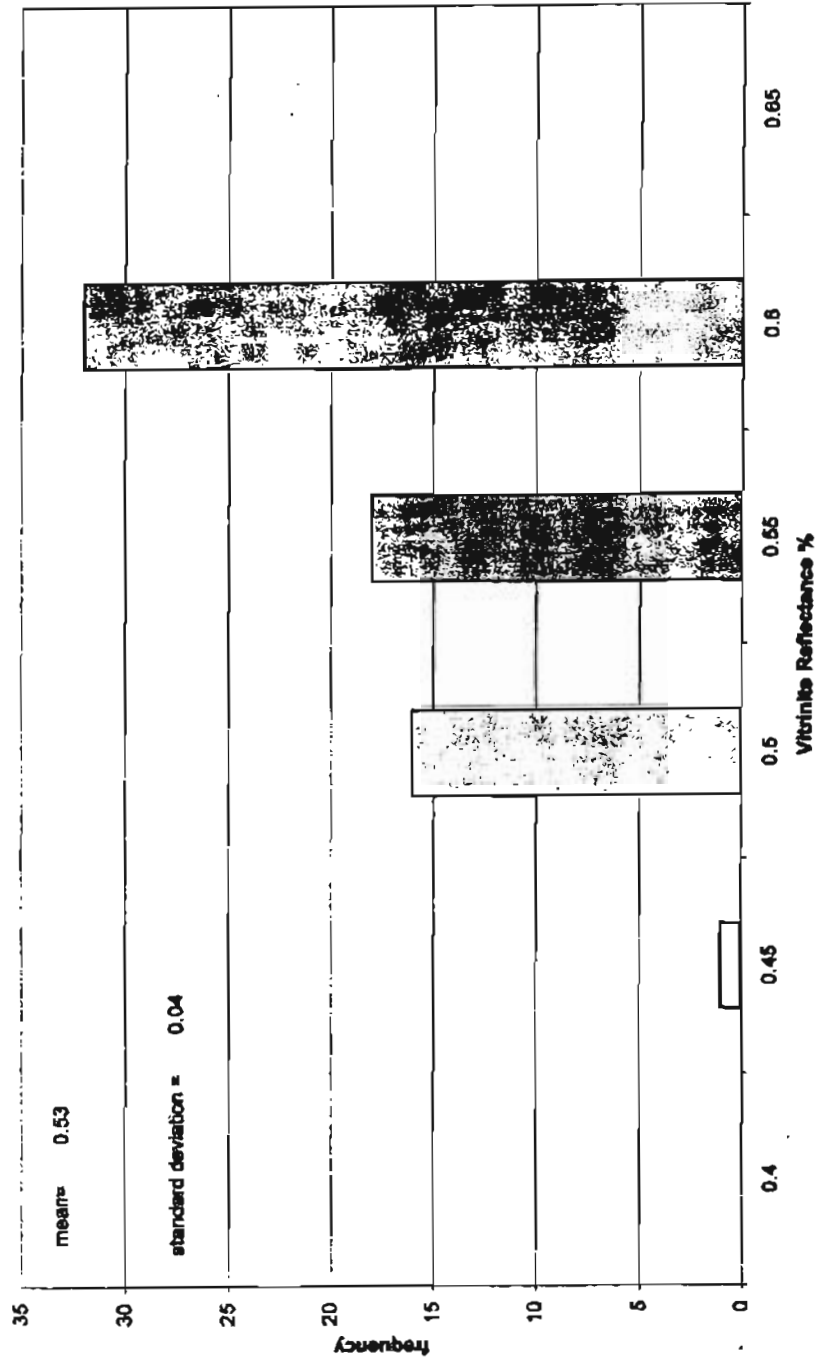




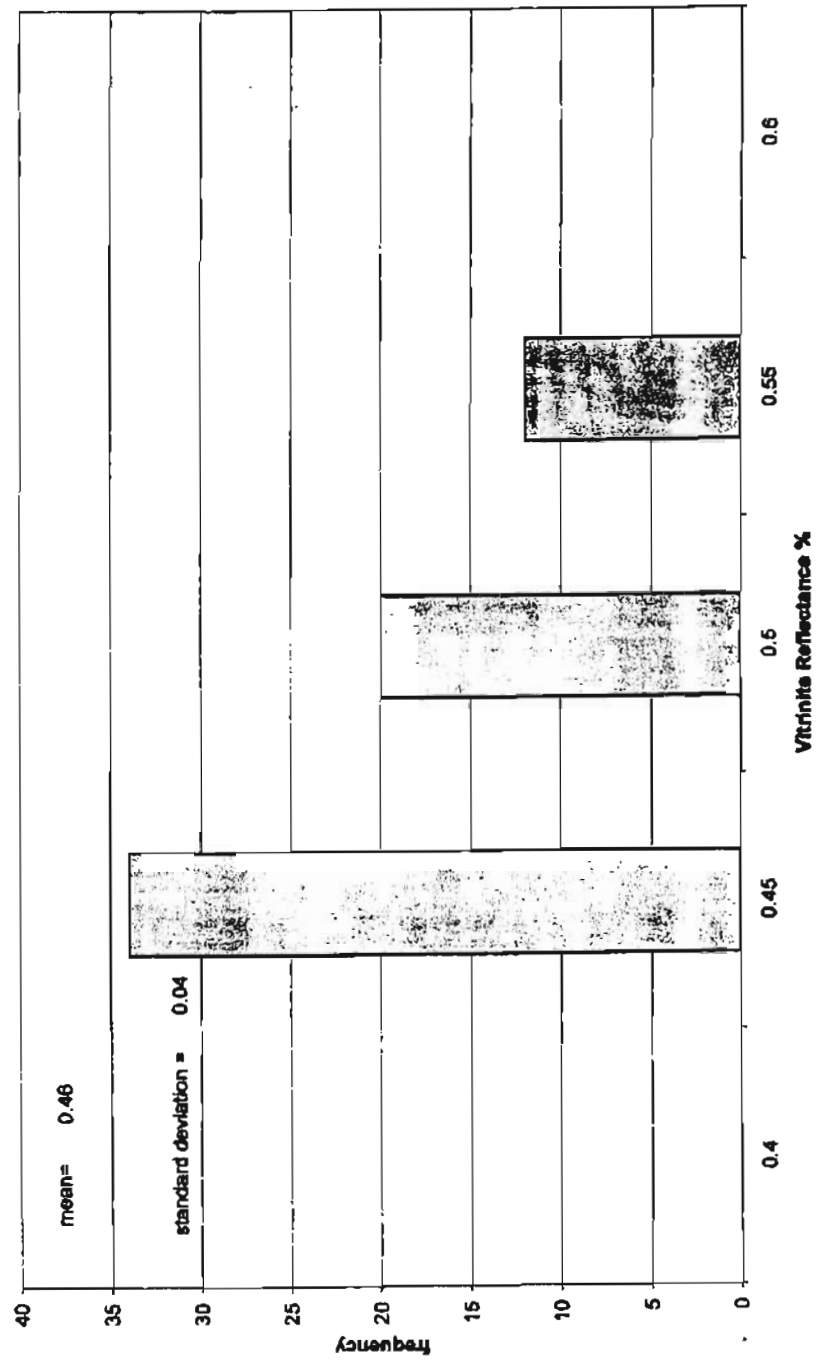
00DL33



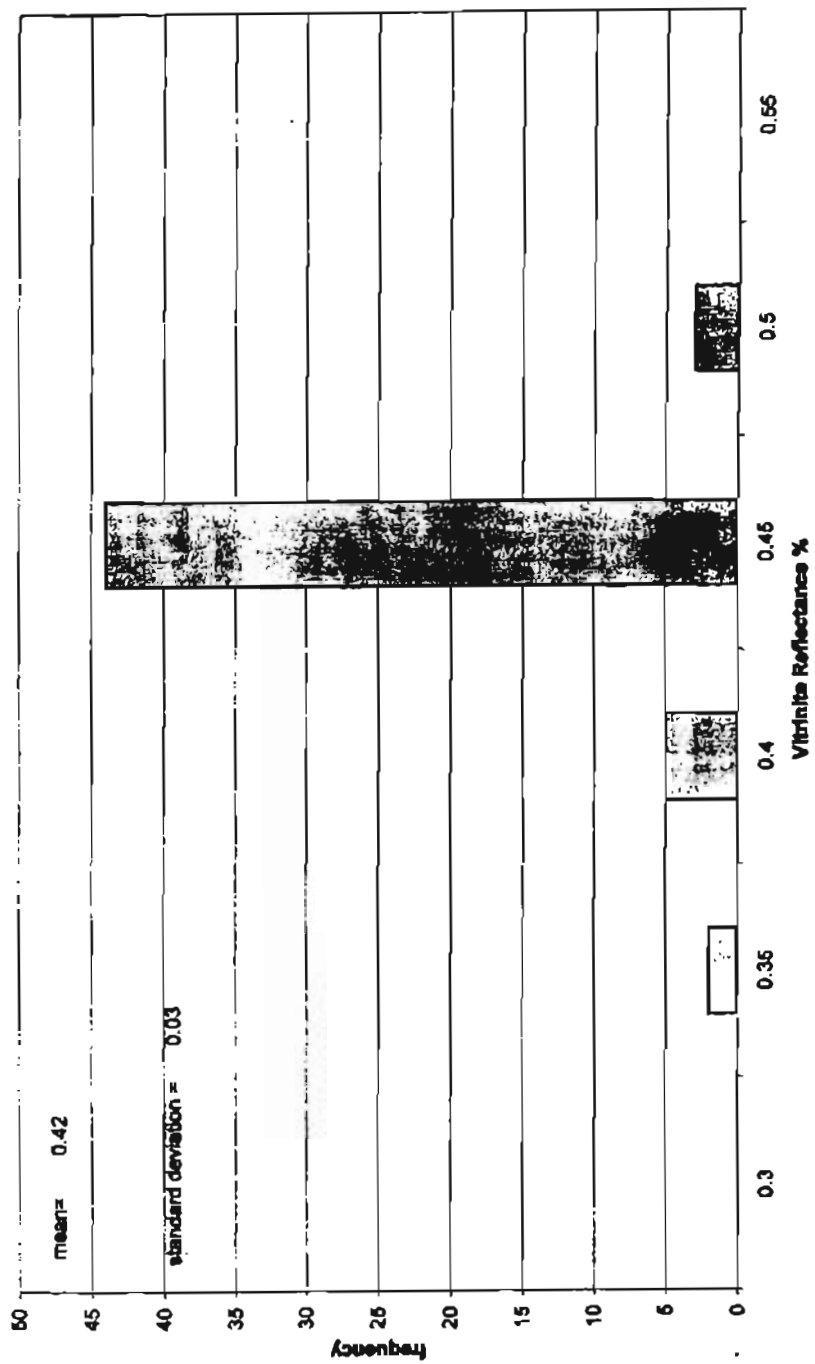
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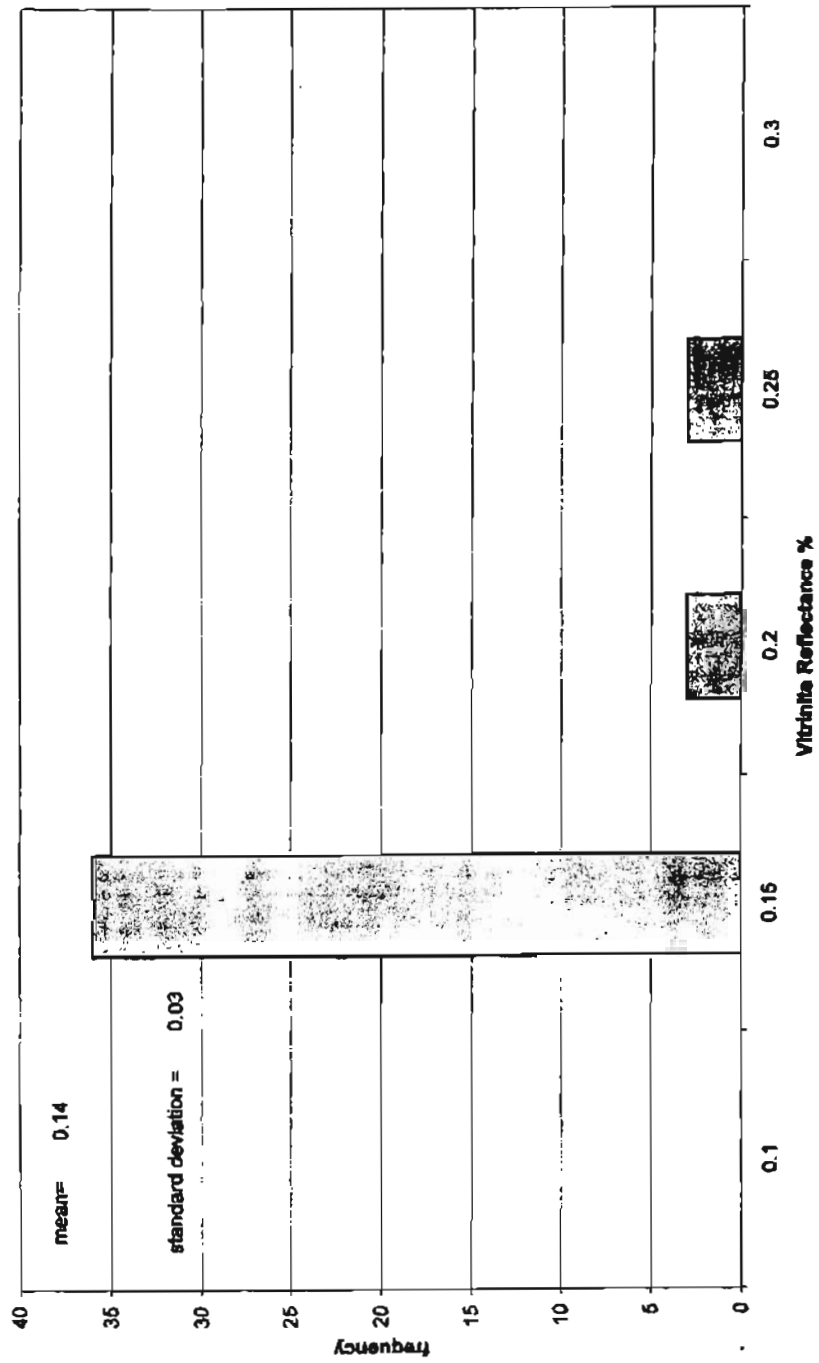
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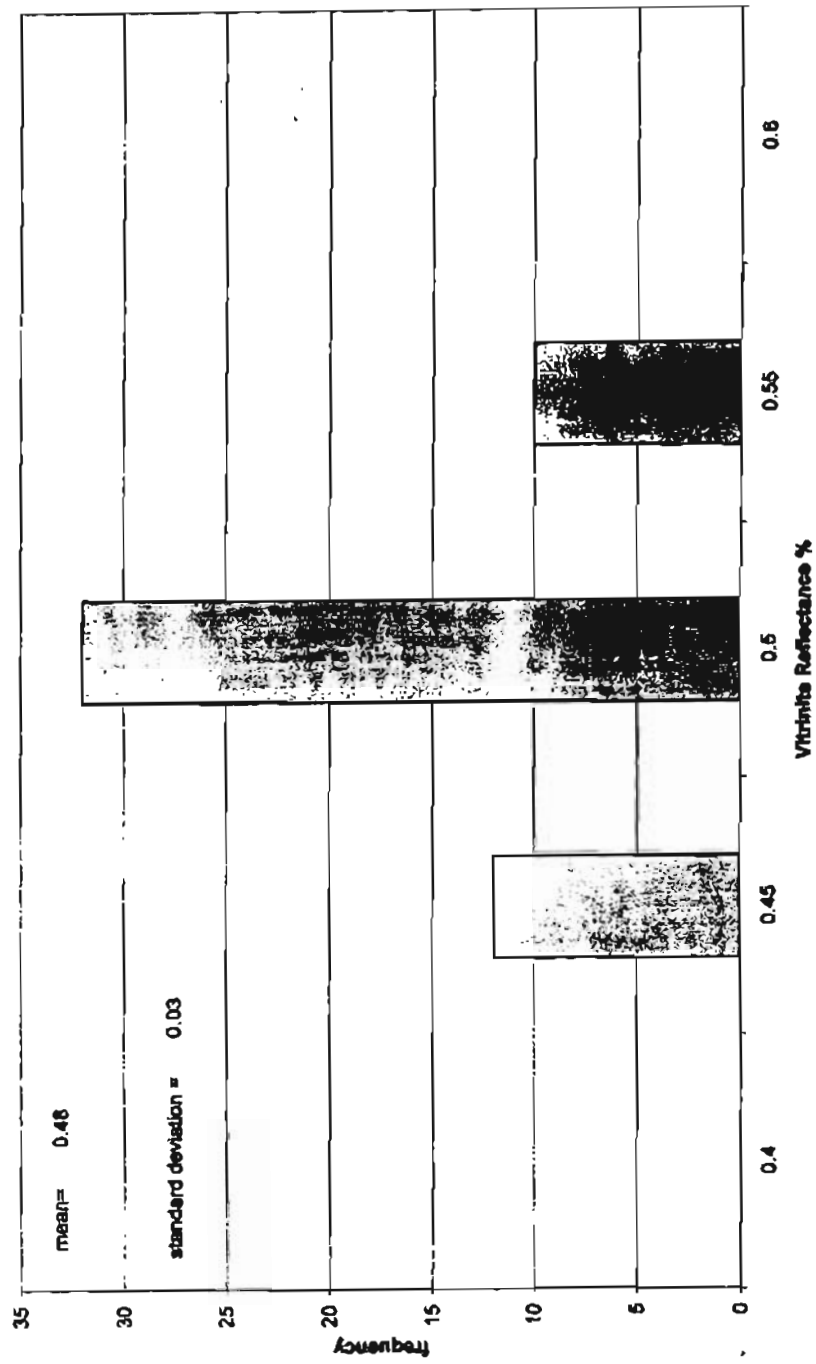
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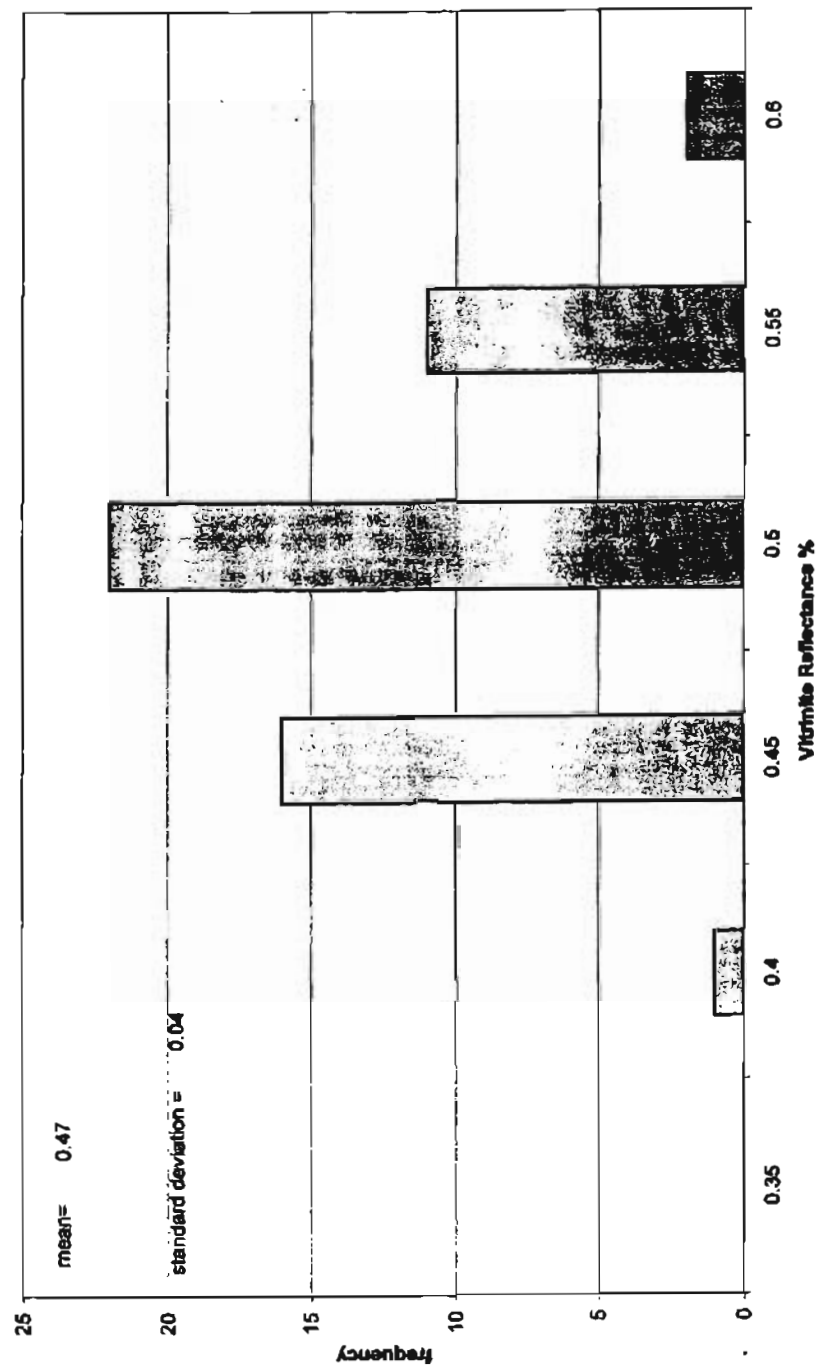
00DL43A



00DL49 326-327.5



00DL58 36-39.6



## APPENDIX XIV

### **Your Isotherms**

To help you interpret your data I have prepared a few short paragraphs to tell you how your data was obtained. If you have any questions please do not hesitate to contact us.

#### ***Obtaining and interpreting isotherm data and Langmuir Isotherms***

Your high-pressure methane, carbon dioxide or mixed gas adsorption analyses were performed using a high-pressure volumetric adsorption technique similar to that described by Mavor et al. (1990). Your isotherms were measured on a custom made apparatus modeled after an apparatus designed and built at CSIRO Lucas Heights, Australia. The apparatus is based on Boyles Law. Simply, a known volume of gas within a reference cell is used to dose a sample cell containing your sample. The amount of gas adsorbed, using the real gas law, in the sample cell is then determined based on change in pressure in the sample cell. Normally 100 g of sample is utilized in such analyses. Tests show that reproducible results can be obtained on samples as small as 25 g but the larger samples yield better quality data. Our instrument has four sample cells.

The pressures in the reference and four samples cells are measured using pressure transducers that are interfaced to a computer equipped with specialized boards and software for this purpose. The computer monitors the transducers and determines when equilibrium is reached as well as controls valves and switches for dosing and purging the references and sample cells. Following dosing of the sample cell with a known volume of gas, the pressure in the sample cell is monitored. As gas is adsorbed by the sample the pressure drops until equilibrium is reached; that is no more gas can be adsorbed by the samples at that particular specified pressure. Critical to obtaining quality isotherms is deciding when the equilibrium is reached. In our instrument we set a stringent test-equilibrium is reached only when the pressure in the cell does not change over a designated period of time. When equilibrium is reached the sample is dosed at the next highest pressure. We normally collect 12 separate pressure points selected such that the best Langmuir regression can be obtained. We can of course collect data at points selected by the client before hand. The temperature of the references and sample cells is maintained at the exact temperature requested by the client. The temperature is maintained within a tolerance less than 1/10 of one degree centigrade.

For a routine adsorption analyses about five to six days are required once equilibrium moisture has been determined.



***How we assure the quality of the isotherms- potential sources of error and recognition of problems***

With an apparatus such as ours the only potential error is a change in the characteristics of the pressure transducers, a leak in the system or non-isothermal conditions.

Our pressure transducers were selected for optimum performance within the range of pressures that isotherms are collected. They are not only factory guaranteed we cross-calibrate our transducers periodically to test for drift. The accuracy of our transducers is better than 0.001 MPa.

Prior to running your experiment the reference and sample cells and plumbing are pressure tested for leaks using helium. We do our leak tests at 9 MPa. Because the He molecule is smaller than either methane or carbon dioxide (the gases we normally do adsorption work with) using He assures us of a leak free system. If a leak were to develop during analyses (one never has) it would be readily apparent because the cells would never come to equilibrium at a given pressure (the leak would appear as an infinitely adsorbing material).

Non-isothermal conditions are not a potential problem utilizing our instrument unless a prolonged power failure occurs. Our bath temperature is maintained by a submerged electric heater and a circulating power. The heater is controlled by a temperature controller to a tolerance less than 1/10 of a degree centigrade.

We periodically run a standard sample in our apparatus to confirm that all is well.

***Understanding Your Isotherms***

The classic theory used to describe the Type I isotherm for microporous materials with small external surface area is based on the Langmuir equation (1916). The Type I isotherm displays a steep increase in adsorption at low relative pressures due to enhanced adsorption caused by the overlapping adsorption potentials between walls of pores whose diameters are commensurate in size with the adsorbate molecule. The Type I isotherm then flattens out into a plateau region at higher relative pressure, which is believed to be due to the completion of a monolayer of adsorbed gas. The micropore volume is then thought to be filled by only a few molecular layers of adsorbate, and further uptake is limited by the dimensions of the micropores.

The Langmuir model assumes that a state of dynamic equilibrium is established between the adsorbate vapor and the adsorbent surface and that adsorption is restricted to a single monolayer (Gregg and Sing, 1982). The adsorbent surface is thought to be composed of a regular array of energetically homogeneous adsorption sites upon which an adsorbed monolayer is assumed to form. The rate of condensation is assumed to be equal to the rate of evaporation from the adsorbed monolayer at a given relative pressure and

constant temperature. The Langmuir equation was developed with these assumptions and takes the following form:

$$\frac{P}{V} = \frac{1}{BV_m} + \frac{P}{V_m}$$

where  $P$  is the equilibrium pressure,  $V$  is the volume of gas adsorbed at equilibrium,  $V_m$  is the volume of adsorbate occupying a monolayer, and  $B$  is an empirical constant. A plot of  $P/V$  Vs relative pressure should yield a straight line whose slope will yield  $V_m$  from which the surface area may be obtained. As shown on your figures a best fit Langmuir isotherm and the data points have been plotted for each sample.

The Langmuir Isotherm can be written:

$$V(P) = \frac{P P_L}{P_L + P}$$

$P$  = gas pressure

$V(P)$  = predicated amount of gas adsorbed at  $P$

$V_L$  = Langmuir volume parameter

$P_L$  = Langmuir pressure parameter

The difference between the measured amount of gas adsorbed ( $V(P)$ ) and that predicted using the Langmuir Equation ( $V_i(P)$ ) is a measure of error and is given as:

$$\text{Err}(P) = V_i(P) - V(P)$$

This error may be positive or negative. The square of the error is always positive and is a measure of the how well the calculated isotherm matches the data. This error can be calculate for each point and summed giving a measure of the overall error:

$$SSE = \sum_{i=1}^N \text{Err}_i^2$$

$N$  = number of measured points.

We express the goodness of fit of the isotherm by calculation the correlation coefficient between the measured points and the calculate points. Our results generally yield correlation's that are better than  $r^2 = 0.99$ . and standard errors of Langmuir volumes of  $\pm 2\%$ . The errors for your samples can be found on the bottom of the data sheets that are included with each sample.

In examining your data you should note that adsorption values are provided for the raw data and corrected for ash content. The ash content will also be corrected for equilibrium moisture content.

***When does adsorption not fit a Langmuir Equation?***

The Langmuir equation has been found to provide an excellent fit for almost all samples under most reservoir conditions. The Langmuir equation is based on the assumption of monolayer filling of pores. Under conditions of low temperature and very high pressures however multilayer pore filling is suspected (by some researchers) to take place which results in a deflection (step) in the isotherm which marks the onset of multilayer pore filling. This 'step' occurs at pressures and temperatures that are not realistic in terms of natural reservoirs however since we routinely run our isotherms to pressures in excess of 12 MPa and many clients request low temperatures, the step may be present in your isotherm. If we encounter multilayer pore filling in your samples the regression will have been performed with out including the 'step'; although the data points are included in the plot and data set.

**References**

ICCP (International Committee for Coal and Organic Petrology), 1998, The new vitrinite classification (ICCP System, 1994), Fuel, vol. 77, p. 349-358.

Langmuir, I., 1916. The constitution and fundamental properties of solids and liquids. Journal of the American Chemical Society, 38: 2221-2295.

Mavor, M.J., Owen, L.B., and Pratt, T.J., 1990. Measurement and evaluation of isotherm data; Proceedings of 65th Annual Technical Conference and Exhibition of the Society of Petroleum Engineers, SPE 20728: 157-170.