STUDY OF HYDROCARBON - SHALE INTERACTION

PROGRESS REPORT #10

PART IV

APPENDICES

Appendix B (continued)

Appendix C

Appendix D

Appendix E

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Juniata College

Huntingdon, Pennsylvania 16652

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ISOTHERM

Page **3228**

Date 9/4/1978

Sample ID : WV#5-EGSP:3030

Gas : Helium

Initials : PDS

Book : 1

Page : 60

NOTICE

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SAMPLE DATA

Weight : 4.9754 (grams)

Density : 2.4288 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm) ^F

DATA COLLECTED

SLOPE OF ISOTHERM

4.91279E-05 Vol Gas/Vol Rock/Torr

2.54064E-03 Vol Gas/Vol rock/PSI

3.73372E-02 Vol Gas/Vol Rock/ATM

9.02421E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 3.82259 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
242.819	1.74129E-07	15.7176	1	0
538.544	4.32305E-07	8.96909	1	0
829.678	8.02791E-07	5.92548	1	0
894.225	8.54268E-07	6.436	1	0

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RFA

ISOTHERM

Page **B229**

Date 9/ 4/1978

Sample ID : WU#5-EGSP-3030

Gas : Methane

Initials : PDS

Book : 1

Page : 60

SAMPLE DATA

Weight : 4.9754 (grams)

Density : 2.4288 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

3.01485E-04 Vol Gas/Vol Rock/Torr

1.55913E-02 Vol Gas/Vol rock/PSI

.229128 Vol Gas/Vol Rock/ATM

5.53792E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .626743 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
239.592	1.30796E-06	2.09587	1	0
526.439	2.91574E-06	1.33306	1	0
821.483	4.4493E-06	1.07271	2	82.331
913.735	5.2001E-06	1.0615	1	0

DIFFUSION

Page B230

Date 9/ 4/1978

Sample ID : WU#5-EGSP-3030

Gas : Methane

Initials : PDS

Book : 1

Page : 60

SAMPLE DATA

Weight : 4.9754 (grams)

Density : 2.4288 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 911.531

P equilibrium : 198.618

P o : 192.83

SPECIFIC DEGASIBILITY 7.27127E-08

UNCERTAINTY 4.97407E-02 %

System d Moles/ dP 1.99076E-06

ISOTHERM

Page B231

Date 9/ 7/1978

Sample ID : WV#5-EGSP:2823

Gas : Helium

Initials : PDS

Book : 1

Page : 63

SAMPLE DATA

Weight : 4.81121 (grams)

Density : 2.7044 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

8.37048E-05 Vol Gas/Vol Rock/Torr

4.32879E-03 Vol Gas/Vol rock/PSI

6.36156E-02 Vol Gas/Vol Rock/ATM

1.38087E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 2.64428 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
235.187	2.73519E-07	10.4075	1	0
524.231	6.55972E-07	6.14761	1	0
815.949	1.19207E-06	4.15016	1	0
887.261	1.28039E-06	4.46587	1	0

ISOTHERM

Page **B232**

Date 9/7/1978

Sample ID : WV#5-EGSP:2823

Gas : Methane

Initials : PDS

Book : 1

Page : 63

SAMPLE DATA

Weight : 4.81121 (grams)

Density : 2.7044 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

3.20943E-04 Vol Gas/Vol Rock/Torr

1.65975E-02 Vol Gas/Vol rock/PSI

.243916 Vol Gas/Vol Rock/ATM

5.29455E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .699201 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
232.981	1.25755E-06	2.26729	1	0
514.957	2.69246E-06	1.50141	1	0
808.969	4.30401E-06	1.15329	1	0
879.982	4.6478E-06	1.23498	1	0

DIFFUSION

Page B233

Date 9/ 7/1978

Sample ID : WV#5-EGSP:2823

Gas : Methane

Initials : PDS

Book : 1

Page : 63

SAMPLE DATA

Weight : 4.81121 (grams)

Density : 2.7044 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 879.954

P equilibrium : 214.054

P o : 211.88

SPECIFIC DEGASIBILITY 2.02002E-07

UNCERTAINTY 3.85142 %

System d Moles/ dP 2.05768E-06

BET

Page **B234**

Date 9/ 7/1978

Sample ID : WU#5-EGSP:2823

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 63

SAMPLE DATA

Weight : 4.81121 (grams)

Density : 2.7044 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

9.41991E-05 Moles/Gram
3.48318E-05 Moles/ml.
5.70645 ml. gas/ml. rock
8.96305 Specific Area (sq.meters/gram)

UNCERTAINTY : .105487 %

C : 303.543

UNCERTAINTY IN C : .108926 %

BAROMETRIC PRESSURE 739.908 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
3.80231	5.80763E-05	.225794	1	0
73.6195	9.47821E-05	.195681	1	0
136.625	1.13836E-04	.199565	1	0
188.736	1.28765E-04	.20374	1	0
240.753	1.43475E-04	.204454	1	0

DIFFUSION

Page B235

Date 9/ 7/1978

Sample ID : WV#5-EGSP:2823

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 63

SAMPLE DATA

Weight : 4.81121 (grams)

Density : 2.7044 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 239.76

P equilibrium : 49.4543

P o : 37.1207

SPECIFIC DEGASIBILITY 8.13711E-06

UNCERTAINTY 2.53656E-02 %

System d Moles/dP 8.41052E-06

ISOTHERM

Page **B236**

Date 9/ 8/1978

Sample ID : WV#5-EGSP:2723

Gas : Helium

Initials : PDS

Book : 1

Page : 64

SAMPLE DATA

Weight : 4.4986 (grams)

Density : 2.4882 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

3.82728E-05 Vol Gas/Vol Rock/Torr
1.97928E-03 Vol Gas/Vol rock/PSI
2.90873E-02 Vol Gas/Vol Rock/ATM
6.86243E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 5.64709 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
236.827	1.19402E-07	25.4527	1	0
531.053	2.88955E-07	14.9	1	0
820.044	6.20091E-07	8.51799	1	0
888.814	6.76299E-07	9.02681	1	0

Date 9/ 8/1978

Sample ID : WU#5-EGSP-2723

Gas : Methane

Initials : PDS

Book : 1

Page : 64

SAMPLE DATA

Weight : 4.4986 (grams)

Density : 2.4882 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.06636E-04 Vol Gas/Vol Rock/Torr

1.06862E-02 Vol Gas/Vol rock/PSI

157044 Vol Gas/Vol Rock/ATM

3.70505E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1.06245 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
234.94	7.84676E-07	3.87927	1	0
518.594	1.83119E-06	2.35685	1	0
812.268	3.06992E-06	1.72624	1	0
880.521	3.38776E-06	1.80888	1	0

Date 9/ 8/1978

Sample ID : WV#5-EGSP:2723

Gas : Methane

Initials : PDS

Book : 1

Page : 64

SAMPLE DATA

Weight : 4.4986 (grams)

Density : 2.4882 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 879.926

P equilibrium : 204.627

P o : 201.675

SPECIFIC DEGASIBILITY 5.9476E-08

UNCERTAINTY .088324 %

System d Moles/ dP 2.0387E-06

BET

Page **B239**

Date 9/ 8/1978

Sample ID : WU#5-EGSP-2723

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 64

SAMPLE DATA

Weight : 4.4986 (grams)

Density : 2.4882 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

3.36501E-05 Moles/Gram
 1.35239E-05 Moles/ml.
 1.87551 ml. gas/ml. rock
 3.2018 Specific Area (sq.meters/gram)

UNCERTAINTY : 10.0863 %

C : 4.97274

UNCERTAINTY IN C : 39.5318 %
 BAROMETRIC PRESSURE 738.409 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
48.8513	9.64436E-06	1.45411	1	0
107.797	1.76351E-05	1.12473	1	0
160.559	2.47316E-05	.98234	1	0
210.43	3.14374E-05	.892434	1	0
254.833	3.74266E-05	.838172	2	987528

DIFFUSION

Page **B240**

Date 9/8/1978

Sample ID : WU#5-EGSP-2723

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 64

SAMPLE DATA

Weight : 4.4986 (grams)

Density : 2.4882 (gm/cc)

Sample Temp : -196 (cont)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 254.661

P equilibrium : 33.0622

P o : 32.9926

SPECIFIC DEGRADABILITY 3.0433E-08

UNCERTAINTY 3.32511 %

System 4 Moles / df 8.35642E-06

Date 9/12/1978

Sample ID : 20403-2946.3

Gas : Helium

Initials : HOS

Book : 1

Page : 65

SAMPLE DATA

Weight : 6.7100g (grams)

Density : 2.73234 (gm/cc)

Sample Temp : 273.16 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

8.39178E-05 Vol Gas/Vol Rock/Torr
 4.3398E-03 Vol Gas/Vol Rock/PSI
 6.32775E-02 Vol Gas/Vol Rock/NIM
 1.37623E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1.00% %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
233.745	2.94259E-07	2.63457	1	0
519.637	6.68161E-07	2.26773	1	0
812.46	1.14801E-06	1.61936	1	0
982.999	1.2469E-06	1.28329	1	0

Date 9/12/1978

Sample ID : 28403:2946.2

Gas: Methane

Initials : PDS

Book : 1

Page : 65

SAMPLE U070

Weight : 6.71004 (grams)

Density : 2.73234 (gm/cc)

Sample Temp : 0 (cch+)

Particle Size : .085 (cm)

U070 COLLECTED

SLOPE OF ISOTHERM

3.43217E-04 Vol Gas/Vol Rock/Torr
 1.77494E-02 Vol Gas/Vol Rock/PSI
 .260845 Vol Gas/Vol Rock/07M
 5.60011E-05 Moles Gas/gram Rock/Torr

UNCERTAINTY : .47617 %

DEFINIED U070 4 POINTS TAKEN

PRESSURE Torr	MDS LOG Moles/gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
228.793	1.35686E-06	1.62803	1	0
513.675	2.82781E-06	1.0226	1	0
805.324	4.50329E-06	.781298	1	0
879.132	4.95466E-06	.82295	1	0

DIFFUSION

Page **B243**

Date 9/12/1978

Sample ID : 20403 2946.3

Gas : Methane

Initials : PDS

Book : 101

Page : 65

SAMPLE DATA

Weight : 5.71000 (grams)

Density : 2.73234 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P Initial : 876.989

P Equilibrium : 221.713

P 0 : 215.636

SPECIFIC DECOMPOSIBILITY 2.54089E-07

UNCERTAINTY 1.39477 %

System 4 MOLOS/ GH 2.07195E-06

Date 9/12/1978

Sample ID : 20003-2916.2

Gas Nitrogen

Initials PDS

Book 1

Page 65

SAMPLE DATA

Moisture : 6.71894 (grams)

Density : 2.73234 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

6.93733E-05 Moles/Gram
 2.53899E-05 Moles/Ml.
 4.24698 ml. sec/ml rock
 6.50092 Specific Area (sq meters/gram)

UNCERTAINTY : .110933 %

C : 138.03

UNCERTAINTY IN C : .13227 %
 BAROMETRIC PRESSURE : 748.702 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE
TorrGDS GDS
Moles/GramUNCERTAINTY
%

FLAG

FLAG
Parameter

P	U	U	U	U	U
11.0006	4.82092E-05	194876	1	0	
85.0017	7.06708E-05	188181	1	0	
147.0259	8.29515E-05	194039	1	0	
203.141	9.54015E-05	19718	1	0	
250.899	1.05732E-04	19892	1	0	

Date 9/12/1978

Sample ID : 20403:2946.3

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 65

SAMPLE DATA

Weight : 5.71004 (grams)

Density : 2.73234 (gm/cc)

Sample Temp : -195 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 250.147

P equilibrium : 51.0327

P o : 39.5259

SPECIFIC DECOMPOSIBILITY 3.8759E-06

UNCERTAINTY R 74347E-02 %

System d Moles/ dp 8.47178E-06

Date 9/14/1978

Sample ID : 20403-3186.2

Gas : Helium

Initials : PDS

Book : 1

Page : 66

SAMPLE DATA

Weight : 4.0562 (grams)

Density : 2.64718 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : 085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

3.26162E-03 Vol Gas/Vol Rock/Torr
 1.68674E-03 Vol Gas/Vol Rock/PSI
 2.47883E-02 Vol Gas/Vol Rock/min
 5.49696E-10 Vol Gas/Gram Rock/Torr

UNCERTAINTY : 7.84351 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS moles/gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
238.128	2.47973E-08	135.937	1	0
527.245	1.31578E-07	36.2649	1	0
818.832	5.51395E-07	19.6247	1	0
884.84	6.65854E-07	10.169	1	0

Date 9/14/1978

Sample ID : 20403-3186.3

Gas : Methane

Initials : PDS

Book : 1

Page : 86

SAMPLE DATA

Weight : 4.0562 (grams)

Density : 2.64718 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : 0.085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

1.24578E-04 Vol Gas/Vol Rock/Torr
 6.44252E-03 Vol Gas/Vol Rock/PSI
 9.46791E-02 Vol Gas/Vol Rock/ATM
 2.09957E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 2.07541 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	MOLES GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
234.734	4.86532E-07	6.93921	1	0
520.868	9.28349E-07	5.15644	1	0
813.622	1.79185E-06	3.2988	1	0
881.863	1.95433E-06	3.46025	1	0

DIFFUSION

Page B248

Date 9/14/1978

Sample ID : 20403-3186.3

Gas : Methane

Initials : PDS

Book : 1

Page : 66

SAMPLE DATA

Weight : 4.0562 (grams)
Density : 2.54718 (gm/cc)
Sample Temp : 0 (cont)
Particle Size : .085 (cm)

DATA COLLECTED

P initial : 976.387
P equilibrium : 203.039
P o : 200.799

SPECIFIC DECOMPOSIBILITY 4.16632E-08

UNCERTAINTY 273519 %

System d Moles/dP 2.02941E-06

Date 9/14/1978

Sample ID : 20403-3186.3

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 66

SAMPLE DATA

Weight : 4.0552 (grams)
 Density : 2.54718 (gm/cc)
 Sample Temp : 0 (cent)
 Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

3.61869E-05 Moles/Gram
 1.367E-05 Moles/ml
 2.14577 ml/gas/ml rock
 3.44319 Specific Area (sq meters/gram)

UNCERTAINTY : 5.27502 %

6.41552

UNCERTAINTY IN C : 33.0928 %
 BAROMETRIC PRESSURE 742.957 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
34.0739	3.56943E-06	1.62552	1	0
92.6546	1.85972E-05	1.18299	1	0
143.78	2.6407E-05	1.02038	1	0
195.283	3.42775E-05	907773	1	0
244.777	4.18979E-05	830491	1	0

DIFFUSION

Page B250

Date 9/14/1978

Sample ID : 204933185.3

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 55

SAMPLE DATA

Weight : 4.0562 (grams)

Density : 2.64718 (gm/cc)

Sample Temp : -125 (cont)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 242.96

P equilibrium : 31.6592

P o : 31.1056

SPECIFIC DEGASIBILITY 2.06349E-07

UNCERTAINTY 575745 %

System d Moles/ dP 8.35152E-05

Date 9/18/1978

SAMPLE ID : COLONS B019

Gas : Helium

INITIALS : FWS

BOOK : 1

PAGE : 67

SAMPLE DATA

Weight : 5.83586 (grams)

Density : 2.623 (gm/cc)

SAMPLE TEMP : 0 (cent)

Particle size : .085 (cm)

DATA COLLECTED

SLOPE OF ISO1HEKM

5.733355E-05 Vol Gas/Vol Rock/Torr
 2.965055E-03 Vol Gas/Vol Rock/PSI
 4.35742E-02 Vol Gas/Vol Rock/ATM
 9.75192E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 3.14699 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	MDS GAS Moles/Gram	UNCERTAINTY %	FLNG	FLNG Paramotor
0	0	0	0	0
228.455	1.70518E-07	13.856	1	0
518.116	4.28689E-07	7.80703	1	0
895.143	8.54506E-07	4.80477	1	0
890.149	9.18939E-07	5.16383	1	0

ISOTHERM

Page **B252**

Date 9/18/1978

Sample ID : COLGNS B019

Gas : Methane

Initials : HDS

Book : 1

Page : 67

SAMPLE DATA

Weight : 5.83685 (grams)

Density : 2.523 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.10927E-04 Vol Gas/Vol Rock/Torr
 .010908 Vol Gas/Vol Rock/PSI
 .160304 Vol Gas/Vol Rock/ATM
 3.58761E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .869207 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	NDS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Description
0	0	0	0	
224.026	8.28413E-07	2.85625	1	0
566.162	1.74121E-06	1.92658	1	0
797.278	2.6782E-06	1.4311	1	0
873.792	3.17405E-06	1.50867	1	0

DIFFUSION

Page B253

Date 9/18/1978

Sample ID : COLGAS-B019

Gas : Methane

Initials : PDS

Book : 1

Page : 67

SAMPLE DATA

Weight : 5.83585 (grams)

Density : 2.523 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P Initial : 871.521

P equilibrium : 231.982

P o : 227.639

SPECIFIC DECOMPOSIBILITY 1.099998E-07

UNCERTAINTY : 304683 %

System d Moles/ dP 2.12756E-06

Date 9/18/1978

SAMPLE ID : COLGNS-BU19

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 67

SAMPLE UNIT

Weight : 5.93586 (grams)

Density : 2.623 (gm/cc)

SAMPLE Temp : 0 (CenF)

Particle Size : 085 (cm)

DATA COLLECTED

INTERNAL AREA

4.56798E-05 Moles/Gram
1.74117E-05 Moles/ml

2.68834 ml. gas/ml. rock
4.34558 Specific Area (cm²/mole/gm)

UNCERTAINTY : .096502 %

0 12.9564

UNCERTAINTY IN C. : 2.42973 %
BAROMETRIC PRESSURE : 744.53 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE	NO. GAS	UNCERTAINTY	PLUG	PLUG
Torr	Moles/Gram	%		Permeator
0	0	0	0	0
27.2108	1.65863E-05	662031	1	0
86.7942	3.00373E-05	509232	1	0
140.689	4.06359E-05	461055	1	0
191.72	5.08280E-05	425663	1	0
242.637	6.06382E-05	39895	1	0

DIFFUSION

Page **B255**

Date 9/18/1978

Sample ID : COLONE B019

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 57

SAMPLE DATA

Weight : 5.83585 (grams)

Density : 2.523 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

UNIT COLLECTED

P Initial : 241.759

P equilibrium : 44.6485

P o : 40.1504

SPECIFIC DECOMBIBILITY 1.32925E-06

UNCERTAINTY 103507 %

Custom id Mojoc/ GP 8.69099E-06

ISOTHERM

Page B256

Date 9/19/1978

Sample ID : COLGAS-B021

Gas : Helium

Initials : PDS

Book : 1

Page : 68

SAMPLE DATA

Weight : 4.46326 (grams)

Density : 2.6112 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

3.13743E-05 Vol Gas/Vol Rock/Torr
 1.62252E-03 Vol Gas/Vol Rock/PSI
 2.38444E-02 Vol Gas/Vol Rock/MTM
 5.36051E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 7.27902 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	MOLES GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
239.01	6.86505E-08	44.5933	1	0
530.127	1.95205E-07	22.217	1	0
820.752	5.39762E-07	9.85721	1	0
887.877	5.24112E-07	11.733	1	0

Date 9/19/1978

Sample ID : COLGNS:B021

Gas : Methane

Initials : PDS

Book : 1

Page : 68

SAMPLE DATA

Weight : 4.46326 (grams)

Density : 2.6112 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

1: 67823E-04 Vol Gas/Vol Rock/Torr
 8: 67894E-03 Vol Gas/Vol Rock/PSI
 127545 Vol Gas/Vol Rock/ATM
 2: 86737E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1.37666 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
237.571	5.95832E-07	5.13767	1	0
521.871	1.32241E-06	3.28759	1	0
815.51	2.44419E-06	2.18411	1	0
882.703	2.69865E-06	2.28747	1	0

Date 9/19/1978

Sample ID : COLGAS-B021

Gas : Methane

Initials : PDS

Book : 1

Page : 68

SAMPLE DATA

Weight : 4.46326 (grams)

Density : 2.6112 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 881.506

P equilibrium : 201.848

P o : 198.67

SPECIFIC DEGRADABILITY 7.2069E-08

UNCERTAINTY 42321 %

System d Moles/ dP 2.02114E-06

Date 9/19/1978

Sample ID : COLGNS:8021

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 68

SAMPLE DATA

Weight : 4.46326 (grams)

Density : 2.6112 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

3.73231E-05	Moles/Gram
1.42935E-05	Moles/ml.
2.18306	ml. gas/ml. rock
3.5513	Specific Area (sq.meters/gram)

UNCERTAINTY : 1.78886 %

C : 9.7379

 UNCERTAINTY IN C : 13.6121 %
 BAROMETRIC PRESSURE 744.759 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	NDS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
32.9444	1.28482E-05	1.10013	1	0
93.2902	2.32366E-05	.860349	1	0
144.789	3.12716E-05	.783037	1	0
195.235	3.95787E-05	.714462	1	0
246.013	4.7565E-05	.664732	1	0

DIFFUSION

Page B3260

Date 9/19/1978

Sample ID : COLGAS-B021

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 68

SAMPLE DATA

Weight : 4.46326 (grams)

Density : 2.6112 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .005 (cm)

DATA COLLECTED

P initial : 252.235

P equilibrium : 34.3876

P o : 32.0468

SPECIFIC DECOMPOSIBILITY 6.29589E-07

UNCERTAINTY 115178 %

System d Moles/ dP 8.31841E-06

ISOTHERM

Page **B261**

Date 9/22/1978

Sample ID : COLGAS MK2

Gas : Helium

Initials : PDS

Book : 1

Page : 71

SAMPLE DATA

Weight : 4.13302 (grams)

Density : 2.6567 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

1.16093E-04 Vol Gas/Vol Rock/Torr

6.00376E-03 Vol Gas/Vol rock/PSI

8.82309E-02 Vol Gas/Vol Rock/ATM

1.94956E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 2.18256 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
236.603	4.36478E-07	7.59354	1	0
522.801	9.11826E-07	5.14921	1	0
815.631	1.66524E-06	3.45982	1	0
885.391	1.78794E-06	3.72354	1	0

ISOTHERM

Page **B262**

Date 9/22/1978

Sample ID : COLGAS:MK2

Gas : Methane

Initials : PDS

Book : 1

Page : 71

SAMPLE DATA

Weight : 4.13302 (grams)

Density : 2.6567 (gm/cc)

Sample Temp : 0 (cont)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

4.10495E-04 Vol Gas/Vol Rock/Torr
2.12287E-02 Vol Gas/Vol Rock/PSI
3.11197E-04 Vol Gas/Vol Rock/ATM
6.89348E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .625175 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
230.548	1.4559E-06	2.28004	1	0
518.447	3.41667E-06	1.37757	1	0
800.690	5.6012E-06	1.02007	1	0
879.13	6.28262E-06	1.06372	1	0

DIFFUSION

Page B263

Date 9/22/1978

Sample ID : COLGAS-MK2

Gas : Methane

Initials : PDS

Book : 1

Page : 71

SAMPLE DATA

Weight : 4.13302 (grams)

Density : 2.6567 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 879.033

P equilibrium : 215.892

P o : 214.702

SPECIFIC DEGRADABILITY 8.92853E-08

UNCERTAINTY 963022 %

System d Moles/ dP 2.0593E-06

Date 9/22/1978

Sample ID : COLGDS-MK2

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 71

SAMPLE DATA

Weight : 4.13202 (grams)

Density : 2.6567 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

1.29457E-04 Moles/Gram
 4.87287E-05 Moles/ml
 7.70402 ml. gas/ml. rock
 12.3179 Specific Area (sq. meters/gram)

UNCERTAINTY : 8.78038E-02 %

C : 471.674

UNCERTAINTY IN C : 8.83157E-02 %
 BROMETHIC PRESSURE 751.638 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GMS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	
1.9553	7.18372E-05	21251	1	0
65.4583	1.30395E-04	165588	1	0
133.758	1.56546E-04	168942	1	0
189.688	1.76782E-04	172764	1	0
240.759	1.94771E-04	175333	1	0

DIFFUSION

Page B265

Date 9/22/1978

Sample ID : COLGAS-MK2

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 71

SAMPLE DATA

Weight : 4.13302 (grams)

Density : 2.6567 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 240.334

P equilibrium : 51.1775

P o : 34.1674

SPECIFIC DEGASIBILITY 1 47148E-05

UNCERTAINTY .226197 %

System d Moles/ dP 8.41532E-06

ISOTHERM

Page B266

Date 9/21/1978

Sample ID : COLGAS MK3

Gas : Helium

Initials : PDS

Book : 1

Page : 70

SAMPLE DATA

Weight : 3.83108 (grams)

Density : 2.64787 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

7.02506E-05 Vol Gas/Vol Rock/Torr

.003633 Vol Gas/Vol rock/PSI

5.33905E-02 Vol Gas/Vol Rock/ATM

1.18366E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 3.86187 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
239.222	2.76826E-07	12.9021	1	0
525.795	5.1825E-07	9.74969	1	0
817.405	1.0413E-06	5.86094	1	0
885.376	1.08737E-06	6.59768	1	0

ISOTHERM

Page B267

Date 9/21/1978

Sample ID : COLGAS MK3

Gas : Methane

Initials : PDS

Book : 1

Page : 70

SAMPLE DATA

Weight : 3.83108 (grams)

Density : 2.64787 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.46138E-04 Vol Gas/Vol Rock/Torr
.012729 Vol Gas/Vol rock/PSI
187065 Vol Gas/Vol Rock/ATM
4.14719E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1.11316 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
233.428	8.97999E-07	3.98349	1	0
522.633	2.00603E-06	2.52842	1	0
813.555	3.49318E-06	1.78291	1	0
881.527	3.77693E-06	1.90679	1	0

DIFFUSION

Page B268

Date 9/21/1978

Sample ID : COLGAS-MK3

Gas : Methane

Initials : PDS

Book : 1

Page : 70

SAMPLE DATA

Weight : 3.83108 (grams)

Density : 2.64787 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 881.083

P equilibrium : 208.577

P o : 207.956

SPECIFIC DEGASIBILITY 3.65867E-08

UNCERTAINTY 2.28588 %

System d Moles/ dP 2.04763E-06

BET

Page **B269**

Date 9/21/1978

Sample ID : COLGAS MK3

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 70

SAMPLE DATA

Weight : 3.83108 (grams)

Density : 2.64787 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

9.47694E-05	Moles/Gram
3.57908E-05	Moles/ml.
5.62099	ml. gas/ml. rock
9.01731	Specific Area (sq. meters/gram)

UNCERTAINTY : .148644 %

C : 111.259

UNCERTAINTY IN C : .222331 %

BAROMETRIC PRESSURE 748.019 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
12.0812	6.28796E-05	.261894	1	0
84.7376	9.27875E-05	.25102	1	0
142.735	1.1136E-04	.256186	1	0
192.145	1.273E-04	.258802	1	0
242.212	1.43772E-04	.256222	1	0

DIFFUSION

Page B270

Date 9/21/1978

Sample ID : COLGAS-MK3

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 70

SAMPLE DATA

Weight : 3.83108 (grams)

Density : 2.64787 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 242.135

P equilibrium : 46.3038

P o : 34.3229

SPECIFIC DEGASIBILITY 1.45086E-05

UNCERTAINTY .62656 %

System d Moles/ dP 8.4167E-06

ISOTHERM

Page B271

Date 9/20/1978

Sample ID : COLGAS B022

Gas : Helium

Initials : PDS

Book : 1

Page : 69

SAMPLE DATA

Weight : 4.71034 (grams)

Density : 2.735 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.11062E-05 Vol Gas/Vol Rock/Torr

1.09151E-03 Vol Gas/Vol rock/PSI

1.60407E-02 Vol Gas/Vol Rock/ATM

3.44292E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 10.7853 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
239.553	1.54221E-08	188.489	1	0
529.417	8.49202E-08	48.4925	1	0
817.752	3.62369E-07	13.9414	1	0
885.574	3.95388E-07	14.7675	1	0

DIFFUSION

Page B272

Date 9/20/1978

Sample ID : COLGOS-B022

Gas : Methane

Initials : PDS

Book : 1

Page : 69

SAMPLE DATA

Weight : 4.71024 (grams)

Density : 2.735 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 879.453

P equilibrium : 210.681

P o : 206.524

SPECIFIC DEGSORABILITY 2.68157E-07

UNCERTAINTY 1.81418 %

System d Moles/ dP 2.05503E-06

ISOTHERM

Page B273

Date 9/20/1978

Sample ID : COLGAS-B022

Gas : Methane

Initials : PDS

Book : 1

Page : 69

SAMPLE DATA

Weight : 4.71034 (grams)

Density : 2.735 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : 085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.13196E-04 Vol Gas/Vol Rock/Torr
1.10254E-02 Vol Gas/Vol Rock/PSI
1.152029 Vol Gas/Vol Rock/ATM
3.47772E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1.08549 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
232.82	7.03137E-07	4.14051	1	0
517.03	1.70157E-06	2.42589	1	0
810.077	2.89233E-06	1.75241	1	0
880.018	3.19657E-06	1.83355	1	0

Date 9/20/1978

Sample ID : COLGMS-B022

Gas : Nitrogen

Initials : POS

Book : 1

Page : 169

SAMPLE DATA

Weight : 4.71034 (grams)

Density : 2.735 (gm/cc)

Sample Temp : 0 (cent)

Pore Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

7.14237E-05 Moles/Gram
 2.61147E-05 Moles/ml
 4.3757 ml gas/ml rock
 5.79597 Specific Area (cm²/meters/gm)

UNCERTAINTY : .166117 %

0 99.7122

UNCERTAINTY IN C : .289528 %

BAROMETRIC PRESSURE 741.872 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLNG Parameter	FLNG Parameter
0	0	0	0	0
13.0225	4.51079E-05	296937	1	0
83.4994	6.98599E-05	275114	1	0
140.796	8.32655E-05	278678	1	0
191.806	9.55538E-05	280433	1	0
241.82	1.07567E-04	278543	1	0

DIFFUSION

Page **B275**

Date 9/20/1978

Sample ID : COLGNS:B022

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 69

SAMPLE DATA

Weight : 4.71034 (grams)

Density : 2.735 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

R Initial : 239.973

P equilibrium : 43.3198

P o : 32.2845

SPECIFIC DEGSUSIBILITY 4.74353E-06

UNCERTAINTY 9.38653E-02 %

System d Moles/ dp 8.4152E-06

Date 9/24/1978

Sample ID : COLGAS MK1

Gas : Helium

Initials : PDS

Book : 1

Page : 72

SAMPLE DATA

Weight : 4.31258 (grams)

Density : 2.6422 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

7.51536E-05 Vol Gas/Vol Rock/Torr
3.88656E-03 Vol Gas/Vol rock/PSI
5.71167E-02 Vol Gas/Vol Rock/ATM
1.26899E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 3.1733 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
240.749	2.52235E-07	12.5571	1	0
530.253	5.51495E-07	8.13603	1	0
823.095	1.14883E-06	4.79162	1	0
889.993	1.20406E-06	5.28409	1	0

Date 9/24/1978

Sample ID : COLGAS:MK1

Gas : Methane

Initials : PDS

Book : 1

Page : 72

SAMPLE DATA

Weight : 4.31258 (grams)

Density : 2.6422 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.55402E-04 Vol Gas/Vol Rock/Torr
1.32081E-02 Vol Gas/Vol rock/PSI
.194105 Vol Gas/Vol Rock/ATM
4.31252E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .924238 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
266.832	7.27228E-07	4.36487	1	0
540.621	2.11706E-06	2.12557	1	0
821.184	3.86753E-06	1.42852	1	0
888.756	4.20766E-06	1.51828	1	0

Date 9/24/1978

Sample ID : COLGAS-MK1

Gas : Methane

Initials : PDS

Book : 1

Page : 72

SAMPLE DATA

Weight : 4.31258 (grams)

Density : 2.6422 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 888.012

P equilibrium : 204.29

P o : 200.351

SPECIFIC DEGASIBILITY 1.21983E-07

UNCERTAINTY : 677794 %

System d Moles/ dP 2.02724E-06

Date 9/24/1978

Sample ID : COLGAS MK1

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 72

SAMPLE DATA

Weight : 4.31258 (grams)

Density : 2.6422 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

5.1773E-05	Moles/Gram
1.95946E-05	Moles/ml
3.0642	ml. gas/ml. rock
4.9262	Specific Area (sq. meters/gram)

UNCERTAINTY : .402933 %

C : 22.9997

UNCERTAINTY IN C : 2.44704 %

BAROMETRIC PRESSURE 745.706 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
25.9981	2.52508E-05	.579388	1	0
89.9765	4.10919E-05	.503559	1	0
142.938	5.24791E-05	.482955	1	0
192.818	6.31545E-05	.463443	1	0
244.962	7.379E-05	.443504	1	0

Date 9/24/1978

Sample ID : COLGAS MK1

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 72

SAMPLE DATA

Weight : 4.31258 (grams)

Density : 2.6422 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 244.275

P equilibrium : 37.0824

P o : 30.421

SPECIFIC DEGASIBILITY 2.59778E-06

UNCERTAINTY .101445 %

System d Moles/ dP 8.32531E-06

Date 9/26/1978

Sample ID : COLGAS MK4

Gas : Helium

Initials : PDS

Book : 1

Page : 73

SAMPLE DATA

Weight : 4.96204 (grams)

Density : 2.6417 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

1.32971E-04 Vol Gas/Vol Rock/Torr

6.87659E-03 Vol Gas/Vol rock/PSI

.101058 Vol Gas/Vol Rock/ATM

2.24567E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1.57542 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
237.658	4.99019E-07	5.52806	1	0
525.216	1.09132E-06	3.58087	1	0
815.575	1.89759E-06	2.52646	1	0
884.285	2.04727E-06	2.70655	1	0

Date 9/26/1978

Sample ID : COLGAS MK4

Gas : Methane

Initials : PDS

Book : 1

Page : 73

SAMPLE DATA

Weight : 4.96204 (grams)

Density : 2.6417 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

3.23153E-04 Vol Gas/Vol Rock/Torr

1.67118E-02 Vol Gas/Vol rock/PSI

.245596 Vol Gas/Vol Rock/ATM

5.45755E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .655831 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
230.88	1.09442E-06	2.52445	1	0
519.33	2.74655E-06	1.4263	1	0
810.535	4.52904E-06	1.06207	1	0
881.35	4.96035E-06	1.12136	1	0

Date 9/26/1978

Sample ID : COLGAS MK4

Gas : Methane

Initials : PDS

Book : 1

Page : 73

SAMPLE DATA

Weight : 4.96204 (grams)

Density : 2.6417 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 881.35

P equilibrium : 260.281

P o : 259.72

SPECIFIC DEGASIBILITY 1.34609E-08

UNCERTAINTY 2.74901 %

System d Moles/ dP 1.30487E-06

Date 9/26/1978

Sample ID : COLGAS MK4

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 73

SAMPLE DATA

Weight : 4.96204 (grams)

Density : 2.6417 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

INTERNAL AREA

9.83521E-05 Moles/Gram
3.72306E-05 Moles/ml.
5.8199 ml. gas/ml. rock
9.35821 Specific Area (sq. meters/gram)

UNCERTAINTY : 9.96971E-02 %

C : 238.954

UNCERTAINTY IN C : 102903 %
BAROMETRIC PRESSURE 747.007 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
4.04203	5.61333E-05	226517	1	0
68.8232	9.95286E-05	18069	1	0
136.315	1.18721E-04	185544	1	0
190.175	1.32965E-04	191314	1	0
241.771	1.46667E-04	193931	1	0

Date 9/26/1978

Sample ID : COLGAS MK4

Gas : Nitrogen

Initials : PDS

Book : 1

Page : 73

SAMPLE DATA

Weight : 4.96204 (grams)

Density : 2.6417 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 242.389

P equilibrium : 47.6423

P o : 33.3621

SPECIFIC DEGASIBILITY 1.4211E-05

UNCERTAINTY .698523 %

System d Moles/ dP 8.38979E-06

GC

Attention

p. B105R and B106R

After p. B285

left axis

Date 6/15/ 78

Sample ID : 20403:3036

Gas : Methane

Initials : DLW

Book : 1

Page : 6

SAMPLE DATA

Weight : 4.92634 (grams)

Density : 2.744 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

2.61503E-04 Vol Gas/Vol Rock/Torr

1.35236E-02 Vol Gas/Vol rock/PSI

.198742 Vol Gas/Vol Rock/ATM

4.25173E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1 %

DETAILED DATA 3 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
237.983	1.0764E-06	2.57747	1	0
524.799	2.24416E-06	1.7518	1	0
817.579	3.44363E-06	1.40095	1	0
884.5	3.71525E-06	150106	1	0

Date 6/15/ 78

Sample ID : 20403:3036

Gas : Helium

Initials : DLW

Book : 1

Page : 6

SAMPLE DATA

Weight : 4.92634 (grams)

Density : 2.744 (gm/cc)

Sample Temp : 0 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

SLOPE OF ISOTHERM

6.68738E-05 Vol Gas/Vol Rock/Torr
3.45837E-03 Vol Gas/Vol rock/PSI
5.08241E-02 Vol Gas/Vol Rock/ATM
1.08729E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 1 %

DETAILED DATA 3 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
242.343	2.81637E-07	9.83515	1	0
530.856	5.53159E-07	7.08938	1	0
824.241	9.02192E-07	5.32938	1	0
893.133	9.72565E-07	5.71204	1	0

ORO-5197-10
Appendix C

SLAB DATA

Juniata College

Huntingdon, Pennsylvania 16652

SLAB DATA

Legend and Explanations

Date

Date sample was placed on apparatus.

Sample ID

Well ID : depth in feet; suffix L - slab cut so that exposed faces are parallel to bedding.
P - slab cut so that exposed surfaces are perpendicular to bedding.
F - fracture.

Thickness

Slab thickness.

Area

Total area of unmasked surfaces.

P_{initial}

Pressure (torr) before pressure jump. Equilibrated for at least a week.

P_{end of jump}

Pressure (torr) at end of applied discontinuous pressure change.

Specific Degasibility

Ml gas degassed/(sec)^{1/2}/torr/cm² area.

Uncertainty

Least square uncertainty of above measurement.

System d Moles/dP

Calculated system response in terms of # moles gas necessary to raise system pressure 1 torr.

SLAB DIFFUSION

Page C1

Date 7/17/1978

Sample ID : C-336:3231L

Gas : Methane

Initials : JCN

Book : 3

Page : 40

SAMPLE DATA

THICKNESS: 1.125 CM

AREA: 51.11 SQUARE CM

Sample Temp : 0 (cent)

DATA COLLECTED

P initial : 740.478

P end of jump : 340.132

SPECIFIC DEGASIBILITY 9.43273E-06

UNCERTAINTY 9.60649E-02 %

System d Moles/ dP 1.71009E-05

SLAB DIFFUSION

Page C2

Date 7/18/1978

Sample ID : C-336:2579P

Gas : Methane

Initials : JCN

Book : 3

Page : 41

SAMPLE DATA

THICKNESS: 0 CM

AREA: 79.51 SQUARE CM

Sample Temp : 0 (cent)

DATA COLLECTED

P initial : 745.874

P end of jump : 176.616

SPECIFIC DEGASIBILITY 9.23334E-08

UNCERTAINTY .144327 %

System d Moles/ dP 9.41262E-06

SLAB DIFFUSION

Page C3

Date 7/18/1978

Sample ID : C-336:2781F

Gas : Methane

Initials : JCN

Book : 3

Page : 42

SAMPLE DATA

THICKNESS: 1.53 CM

AREA: 21.04 SQUARE CM

Sample Temp : 0 (cent)

DATA COLLECTED

P initial : 746.268

P end of jump : 178.637

SPECIFIC DEGASIBILITY 3.22223E-08

UNCERTAINTY 131384 %

System d Moles/ dP 9.66199E-06

SLAB DIFFUSION

Page C4

Date 8/ 8/1978

Sample ID : C-336:2781L

Gas : Methane

Initials : JCN

Book : 3

Page : 41

SAMPLE DATA

THICKNESS: 1.26 CM

AREA: 64.11 SQUARE CM

Sample Temp : 0 (cent)

DATA COLLECTED

P initial : 745.125

P end of jump : 224.289

SPECIFIC DEGASIBILITY 9.10059E-08

UNCERTAINTY 1.92212 %

System d Moles/ dP 1.08529E-05

SLAB DIFFUSION

Page C5

Date 8/ 8/1978

Sample ID : C-336:3131F

Gas : Methane

Initials : JCN

Book : 3

Page : 42

SAMPLE DATA

THICKNESS: 2 CM

AREA: 51.24 SQUARE CM

Sample Temp : 0 (cent)

DATA COLLECTED

P initial : 745.303

P end of jump : 220.759

SPECIFIC DEGASIBILITY 1.21399E-07

UNCERTAINTY 1.49094 %

System d Moles/ dP 1.07795E-05

THE ESTIMATION OF RESERVES IN TIGHT SHALES

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THE ESTIMATION OF RESERVES IN TIGHT SHALES

Abstract

A method for estimating reserves of tight reservoir by use of laboratory kinetic and thermodynamic data is detailed. It is shown that reserve estimations obtained by considering the hydrocarbon content of the rock will ordinarily overestimate and estimation from the fracture volume alone drastically underestimates reserves. Account of the diffusion of gas through the rock matrix must be taken into account. Assuming an average fracture spacing of 100 feet, a rock pressure of 16 atm and a wellhead pressure of 3 atm, the reserves calculated by this dynamic method are 2×10^6 MCF/square mile/1000 feet thickness, or about 2% of the total gas present.

The determination of usable reserves in tight formations such as Devonian shale is not a simple task because specific account must be taken of the relatively complex processes resulting in production and the several parameters involved in this process must be estimated. The most direct approach would be to estimate the volume of rock drained by an (average) well and to estimate the total production to be expected from a test well on the basis of its initial productivity. In this approach the reserves associated with a reservoir would be calculated from the estimation of the volume of rock drained from a given well and the estimate of total well productivity. However, the total production of a given well does not seem to be a definable quantity because the productivity vs. time curves are (typically) very flat after the first few years and thus how much gas one eventually obtains is strongly dependent upon the length of time considered. Since the volume of gas associated with a given quantity of rock is a well defined (definite) quantity, one is led inexorably to the conclusion that the volume of rock drained by a given well also cannot be well defined. If neither the total production of a well nor the volume of rock that is drained are definable properties, it would appear that the behavior of a single well is not a good predictor of the reserves that can be associated with a reservoir.

Clearly the total amount of gas in the reservoir can be taken as an estimate of the potential reserves and this can be estimated from samples of the rock either by direct outgassing studies or by isotherm measurements. We estimate that Devonian shales that we have studied contain approximately 8.2×10^7 MCF of gas per square mile per thousand feet thickness of shale by virtue of our averaged isotherm measurements (3×10^{-4} v/v/torr) and assuming the average rock pressure to be 16 atm with draw down to 3 atm possible. ⁽¹⁾ Estimates of reserves obtained in this manner are, however, upper bounds that may be grossly optimistic. Not all the gas present in the rock will be produced during the practical life of the wells and the question of the percentage of the total gas that can be produced

in practice becomes an important one. One obvious contributor to unproducible gas is enclosed voids within rock with no connection to the open pore system. A more important contributor, however, is gas that lies too far from a macroscopic fracture that can serve as a conduit to the well bore. The diffusion constant of methane in shale is approximately $5 \times 10^{-7} \text{ cm}^2/\text{sec}$ (average) and this corresponds roughly to an average migration distance for methane through the rock of only 2 feet in 100 years. It thus seems clear that gas in shale that is more than a few feet away from a natural fracture is to all intents unproducible except insofar as the natural fracture system may be augmented by artificial fractures.

Whereas useful reserves of a tight reservoir are overestimated by simply calculating the total amount of gas in the rock, it has become apparent that the gas contained in the open volume of the fractures contributes only negligibly to the total gas produced. This is because this gas is small in comparison to the gas that diffuses into the fracture through its faces. The amount of gas, M_0 , produced from the volume associated with a fracture is

$$1) \quad M_0 = \frac{A}{2} X (P_S - P_0)$$

where X is the fracture width, A is its area and P_S is the initial rock pressure in atmospheres and P_0 is the final pressure at the end of production. (The $A/2$ appears because of the two faces of the fracture.) However, the amount of gas diffusing through the side of the fracture is ⁽²⁾

$$2) \quad M_T = 2AG(P_S - P_0)t^{\frac{1}{2}}$$

where M_T = gas produced in time t

G = specific degasibility.

As a well begins to produce gas is obtained by simple PV expansion from the fractures. This is followed subsequently by production due to diffusion through the surfaces. The time that transition from the first process to the second

occurs can be defined as that when $M_T = M_0$ from which 1) and 2) yield

$$3) \quad t_0 = \left(\frac{X}{4G} \right)^2$$

Both typical and extreme values of G give t_0 's that are very small in comparison to the lifetime of a well. Using an average value of degasibility of 2×10^{-7} $\text{cm}^3/\text{cm}^2/\text{torr}/\text{sec}^{1/2}$ and a mean fracture width of .01 cm, t_0 equals 4 minutes. For a worst case of $G = 2 \times 10^{-8}$ and $X = .1$ cm, t_0 equals 32 days. This means that the time associated with draining of the fractures is ordinarily of the order of minutes after which the source of the gas is the rock matrix. Because the time scale for production is years it would appear that although fractures are vitally important as conduits to the well bore they contain only negligible amounts of gas in comparison to that obtained by diffusion through the matrix.

As has been discussed⁽²⁾ an accurate model to describe the productivity of a shale well must be at least pseudo two step if the model is expected to be complete in the sense of predicting optimal well spacing, etc. Specific account must be taken of both the permeability through the fractures as well as diffusion through the rock to the fractures and neither step is rate limiting for all cases. Some progress has been made with such a two pseudo step theory⁽³⁾ but more fundamental theoretical work remains in order to develop solutions that are easily applicable. However, certain questions are readily dealt with by a pseudo one step model and in our present opinion the question of the usable reserves associated with a tight reservoir is among them.

Whereas the effect of the diffusion of gas through the rock is a constant factor that always must be dealt with for any calculation involving production or reserves in tight formation, the effect of the permeability of the fractures depends upon the fracture length, width, proppants used during stimulation and so forth. Given this state of affairs it seems that one measure of useful reserves is simply the total amount of gas that can diffuse into the natural fracture system from the matrix in some standard time such as 100 years for some assumed uniform

pressure drop in the fracture system (due to well drilling). In this case the more general 2 step model reduces to a pseudo one step model which involves only the effects of matrix diffusion. The solution to the differential equations for this case are well known and can be expressed as⁽⁴⁾

$$M_T = 2VsG(P_2 - P_0)t^{\frac{1}{2}}$$

where V is the volume of rock involved and s is the fracture frequency expressed in area/volume. (Vs is the total natural fracture area of the reservoir.)

If one associates M_T with the total producible gas in a volume square mile by 1000 feet thick

$$M_T = 2.0 \times 10^8 \times \text{MCF}$$

where s is to be expressed in sq. ft. area/cu. ft. For plane fractures s may be taken as the reciprocal of the average spacing. The equation applies only for low values of s corresponding to the fracture spacing being larger than the depletion zones extending out from the fracture faces (2 x 2 ft for the average case after 100 years of production). For its region of validity M_T calculated in this way will be less than M_T estimated from the total methane content and represents a more reasonable upper bound to the amount of gas obtainable from a reservoir.

References

1. The following progress reports for Contract No. EY-76-S-05-5197 on "Study of Hydrocarbon Shale Interaction" contain most of our laboratory kinetic and thermodynamic measurements: Annual Report #1, ORO-5197-6; Progress Report #9, ORO-5197-9; Progress Report #10, ORO-5197-10.
2. "The Implications of Specific Degasibility for Models of Gas Production from Shale," Paul D. Schettler, Proceedings of the Second Annual Eastern Gas Shales Symposium, Morgantown, West Virginia, October 1978.
3. "Gas Production in Wells: Constrictive and Geometric Effects," Paul D. Schettler, with Progress Report #1, ORO-5197-1 of Contract No. EY-76-S-05-5197.
4. "The Concept of Specific Degasibility and Its Application to the Gas Bearing Tight Formations as Represented by the Devonian Shales of Appalachia," Paul D. Schettler, Proceedings of the Fourth Annual DOE Symposium on Enhanced Oil & Gas Recovery, VII, G8/1.

PROGRESS REPORT

INFRARED AND X-RAY STUDIES

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PROGRESS REPORT
INFRARED AND X-RAY STUDIES

Preliminary studies were initiated with the aim of investigating possible correlations between gas interaction parameters and infrared spectral characteristics of shale samples. Progress to date has been limited to developing appropriate sampling techniques, acquiring a familiarity with the techniques generally, assessing the probable importance of various spectral regions, and selecting a series of samples for further analysis, these being chosen to reflect both typical and extreme values of diffusion and isotherm parameters. The long wavelength (KBr) region of the infrared spectrum appears to show considerable promise in providing spectral diversity, and initial efforts will be directed toward pursuing this prospect.

It is the goal of this phase of the project to find rapid, routine analysis techniques which will allow a degree of prediction of gas interaction parameters, and it is hoped that the results of infrared analysis can be combined in a meaningful way with X-ray diffraction measurements to yield additional insight into the causes of variation from sample to sample.