CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Columbia 20403

File SCAL-7665

Whole Core Permeability and Porosity Data

Sample Number	Depth, Feet	Air Permeability, Millidarcies	Porosity, Per Cent	Grain Density, gm/cc
		Gray Shale		
8	2725	0.006	0.9	2.63
1	2750	0.004	1.3	2.75
2	2885'6"	0.006	1.6	2.73
9	2930	0.001	0.4	2.65
~~5~~	~~3050~~	~~906~~	~~1.2~~	~~2.70~~
		Brown Shale		
~~13~~	~~3440~~	~~502~~	~~0.6~~	~~2.45~~
10	3480'6"	0.001	0.6	2.63
11	3495	0.001	0.2	2.69
12	3585'6"	0.023	0.5	2.61
~~14~~	~~3605~~	~~73~~	~~0.7~~	~~2.53~~
		White Slate		
18	3660	0.0002	0.2	2.63
15	3825'6"	0.0006	0.3	2.66
16	3865'6"	0.0002	0.2	2.65
19	3875	0.015	0.3	2.60
17	3895'6"	0.0002	0.3	2.65
7	3930'6"	0.0025	0.9	2.64
		Marcellus		
20	3950'6"	0.001	0.4	2.60
48A	4000	0.00028	0.16	2.73
49A	4020'6"	0.00025	0.21	2.62

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

Formation Factor Data

Resistivity of Saturating Brine, Ohm-Meters: 0.203 @ 75°F.

Sample Number	Porosity, Per Cent	Formation Factor
	Gray Shale	
25	0.4	58.3
23	0.2	417
	Brown Shale	
32	0.2	1292
49	0.4	1009
	White Slate	
35	0.3	48.1
37	3.4	72.4
	Marcellus	
43	1.3	30.9
45	0.6	39.7

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Acoustic Velocity Data

	Gray Shale		Brown Shale		White Slate		Marcellus	
Sample Number:	9V	11V	29V	28V	34V	33V	40V	39V
Porosity, Per Cent:	1.0	0.9	0.3	0.1	1.3	0.5	1.1	0.7
Effective Overburden Pressure, PSI	Transit Time, Micro-Seconds/Ft.							
300	80.9	79.3	66.7	67.1	93.9	94.8	92.2	93.5
600	80.1	77.9	66.1	65.7	93.6	94.4	91.1	91.2
900	79.2	76.2						
1000			65.5	64.3	92.7	93.9	90.6	88.8
1200	77.5	75.3						
1500	76.6	74.5	64.9	63.4	91.9	93.5	89.6	86.9
2000			64.3	62.9	91.5	93.1	89.1	85.9

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

Liquid Permeability Data

Brown Shale

Sample Number: 30 Porosity, Per Cent: 0.5

Air Permeability, Md.: 0.41

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
3% Potassium Chloride Solution		
? <0.0000009 (estimated)		
(No Flow after 50 hours @ 5000 PSI)		

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Liquid Permeability Data

Brown Shale

Sample Number: 50 Porosity, Per Cent: 0.4

Air Permeability, Md.: 0.01

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
3% Potassium Chloride Solution		
<0.0000009 (estimated)	(No Flow after 43 hours @ 5000 PSI)	

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-7665

Liquid Permeability Data

Brown Shale

Sample Number: 36 Porosity, Per Cent: 0.7

Air Permeability, Md.: 0.01

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio

3% Potassium Chloride Solution

(Testing Discontinued - Sample Fractured)

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-7665

Liquid Permeability Data

White Slate

Sample Number: 48 Porosity, Per Cent: 1.2

Air Permeability, Md.: 1.3

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
	3% Potassium Chloride Solution	
0.000028	1.08	0.000022
0.000029	1.92	0.000022
0.000029	2.50	0.000022
0.000016	12.8	0.000012
0.000022	15.2	0.000017
	5% Potassium Chloride Solution	
0.000020	0.583	0.000015
0.000019	1.17	0.000015
0.000019	2.08	0.000015
0.000015	2.83	0.000012
0.000017	9.17	0.000013
0.000017	10.3	0.000013

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-7665

Liquid Permeability Data

Marcellus

Sample Number: 42 Porosity, Per Cent: 1.0

Air Permeability, Md.: 0.52

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
	3% Potassium Chloride Solution	
.00024	1.00	0.00046
.00014	2.05	0.00027
.00014	2.10	0.00027
.00012	2.50	0.00023
	5% Potassium Chloride Solution	
.000040	2.50	0.000077
.000044	8.00	0.000085
.000049	13.5	0.000094
.000025	64.5	0.000048
.000033	76.5	0.000063

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Liquid Permeability Data

Marcellus

Sample Number: 46 Porosity, Per Cent: 0.2

Air Permeability, Md.: 0.08

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
0.000014	4.00	0.00018
0.000013	5.50	0.00016
0.0000071	18.5	0.000089

(Testing Discontinued - Sample Fractured)

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS. TEXAS

File SCAL-7665

Liquid Permeability Data

Sample Number: 8 Porosity, Per Cent: 0.7

Air Permeability, Md.: 0.002

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
	3% Potassium Chloride Solution	
0.0000108	0.14	0.0054
0.0000049	0.17	0.0024
0.0000027	0.32	0.0013
0.0000022	0.33	0.0011
	5% Potassium Chloride Solution	
0.00000108	0.12	0.0009
0.0000009	0.31	0.0005

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Liquid Permeability Data

Sample Number: 14 Porosity, Per Cent: 1.3

Air Permeability, Md.: 0.026

Liquid Permeability, Md.	Throughput, Pore Volumes	Liquid/Air Permeability Ratio
	3% Potassium Chloride Solution	
0.0000314	0.11	0.0012
0.0000290	0.19	0.0011
0.0000122	0.24	0.0005
	5% Potassium Chloride Solution	
0.0000097	0.13	0.0004
0.0000089	0.26	0.0003
0.0000080	0.41	0.0003
0.0000065	0.66	0.0003

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

File SCAL-7665
Well No. 20403

Mineral Content Determination
(by x-ray diffraction)

Sample Depth, Feet:	Gray Shale		Brown Shale		White Slate	Marcellus	
	2985	3050	3380	3570	3845	3950	4020
Mineral	**Per Cent of Total Sample**						
Quartz	73	72	25	78	68	56	68
Feldspars	4	3	Trace	3		2	3
Calcite	1	2	50	1	3		6
Illite	3	3	Trace	3	3	4	5
Montmorillonite	Trace		Trace		2		1
Dolomite	<1	2	9	1	2	2	1
Chlorite	10	9	4	9	9	7	8
Pyrite	8	9		5	8	29	6
Siderite			11		5		
Galena							2

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, [illegible] tion, or profitableness of any oil, gas or other mineral [illegible]

PERMEABILITY MEASUREMENTS

Permeability measurements were made on three samples with the following results.

Sample Depth (feet)	Confining Pressure (psi)	Pore Pressure (psi)	Permeability (microdarcies)	Comments
3965	500	350	15	Sample had visible fractures running the length of the flow path.
3675	500	350	<0.1	Permeability was below the resolution of the equipment.
3626	1000	600	8.7	
3626	4000	600	2.8	
3626	4000	350	2.7	

On November 16th, a meeting was held in Salt Lake City between Columbia and Terra Tek personnel. The purposes of the meeting were: (1) to plan the final phase of their work which involves the measurement of fluid permeability through fractures under in-situ conditions, (2) to review the results of the stress measurements and their relation to elastic properties logs, and (3) to investigate why induced fractures might have propagated vertically rather than horizontally resulting in the observed communication between the adjacent frac intervals in Well No. 20403; and to investigate possible means of avoiding a repetition of this vertical fracturing.

The meeting commenced with a presentation of the theory upon which the analysis is based and a review of the progress made to date. It was estimated that the budget of the project would limit the in-situ permeability study to four measurements. We decided that the frac parameters whose effects we wished to study were (1) concentration of sand proppant, (2) mesh size of sand, and (3) confining pressure. Although it would be desirable to run several other trials, the following test program should provide adequate information on the various possible conditions which might be encountered:

1. permeability measurement of an unpropped fracture (This assumes complete settling of the sand.);
2. permeability measurement of a fracture one-inch wide propped with 20-40 mesh sand (This should be an extreme case which would practically be a measurement of the permeability of the sand.);
3. permeability measurement of a fracture propped with a .5 lb. per square foot concentration of 100 mesh sand (This corresponds to a situation where fluid loss plugging occurs in small fractures.)

4. permeability measurement of a fractu... lb. per square foot concentration of 20-40 mesh sand (This assumes perfect transport of proppant.).

Terra Tek has agreed to make the above measurements at two confining pressures which would be expected in Well No. 20403 at the upper and lower fracturing intervals--2900 psi and 3900 psi.

Terra Tek then demonstrated how Young's modulus values can be used to determine which horizons could be considered as barriers to fracture propagation. It can be shown that where a layer of rock with a modulus of E_2 is bounded by rocks with a modulus of E_1, it will become increasingly difficult to extend a fracture toward the lithologic boundary as the fracture approaches this boundary if the value E_2 is greater than E_1. However, it requires less pressure to approach the boundary where E_2 is less than E_1.

It was also shown that for a rock type with a mean stress of S_1 surrounded by rock with a mean stress of S_2, the pressure required to extend a fracture from the first rock type into the surrounding rock increases as S_2-S_1 increases. By plotting the fracture extension pressure versus the length of the extended fracture, one finds that a much greater pressure increment is required to extend a fracture initially than is required for progressively greater distances. It would appear that a large body of data is necessary before the effectiveness of a possible fracture barrier can be determined.

When asked whether it could have been predicted that the first fracture of Well No. 20403 would extend vertically rather than horizontally, all of the Terra Tek personnel responded in the affirmative. Terra Tek explained that where the vertical pressure gradient of the frac fluid is less than the total stress gradient of the surrounding rock (usually approximately 1 psi per foot) the preferred direction of propagation will be upward. If a higher density fluid is used such that the gradient exceeds the total stress gradient, the fracture should propagate downwards. Our best chance for lateral extension is when the density of the fluid results in an equal gradient (approximately hydrostatic gradient). In this case, the fracture should have no preferred extension direction and should extend for equal distances along the fracture plane in all directions.

Lawrence Livermore Meeting

On November 19, Merle Hanson, Richard Carlson and Joseph Hearst met Eric Smith and presented some of their results on the logs and core samples from our Devonian Shale wells. The goal of the research being done at Lawrence Livermore Laboratory is to obtain a maximum amount of information (fracture locations, gas content and rock properties) from a 3-D sonic log. A film densitometer has been used to contour the data from a log run using a long-time sweep with a short spacing configuration. This information will be compared to the data from their rock mechanics analyses in order to develop models for interpreting the logs.