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APPLICATION OF

ROBERT L. BAYLESS

FOR DESIGNATION OF THE CABRESTO AREA

OF THE PICTURED CLIFFS FORMATION

AS A TIGHT FORMATION

RIO ARRIBA COUNTY, NEW MEXICO

Case No. 10264 March 21, 1991

Prepared by:

KEVIN H. McCORD, P.E.

APPLICATION OF ROBERT L. BAYLESS
FOR DESIGNATION OF THE CABRESTO AREA OF THE
PICTURED CLIFFS FORMATION AS A TIGHT FORMATION,
RIO ARRIBA COUNTY, NEW MEXICO

Robert L. Bayless is applying for portions of the East Blanco, Choza Mesa, and Gobernador Pictured Cliffs gas pools to be designated as a tight formation under Section 107 of the Natural Gas Policy Act of 1978. The proposed Cabresto Tight Gas Area is located in the northeastern portion of the San Juan Basin. The area is located in Rio Arriba County, approximately 45 miles northeast of the town of Bloomfield in northwestern New Mexico.

Exhibit No. 1 displays the proposed Cabresto Tight Gas Area on the map showing the Pictured Cliffs formation wells in the San Juan Basin. The Cabresto Tight Gas Area includes approximately 193,090 acres described as follows:

T29N R2W	
All Sections	23,040 acres
T29N R3W	
All Sections	22,210 acres
T29N R4W	
All Sections	23,040 acres
T30N R2W	
All Sections	23,040 acres
T30N R3W	
All Sections	22,260 acres
T30N R4W	
Sections 1-2; 11-14; 23-26; 35-36	7,680 acres
T31N R2W	
Sections 2-36	22,400 acres
T31N R3W	
All Sections	22,210 acres
T32N R2W	
Sections 7-10; 15-22; 27-35	11,880 acres
T32N R3W	
All Sections	15,330 acres
	193,090 acres

The Pictured Cliffs formation in the Cabresto Area meets the criteria established in Section 107 of the Natural Gas Policy Act of 1978 to be designated as a tight gas formation in that (1) the estimated average in situ gas permeability throughout the pay section in expected to be 0.10 millidarcy or less, (2) the stabilized gas production rates, without stimulation, at atmospheric pressure of these gas wells are not expected to exceed the maximum allowable production rate of 105 MCFD for an **average depth of 3715 feet to the top of the Pictured Cliffs formation in this area,** and (3) no well drilled into the Pictured Cliffs formation in this area is expected to produce more than five barrels of crude oil per day prior to stimulation.

Exhibit No. 2 is a Pictured Cliffs formation completion and production map of the proposed Cabresto Tight Gas Area. Shown on this map are all the wells that penetrated the Pictured Cliffs formation in this area. The production figures presented for each producing well are date of initial potential, initial gas potential in MCF per day, the current production capability of the Pictured Cliffs well in MCF per day, and cumulative production for the well in MCF as of November 1, 1990. If the Pictured Cliffs well produced any oil or condensate, this production data is presented also. Exhibit No. 2 also presents completion and production data from some Pictured Cliffs wells surrounding the proposed tight gas area.

The average depth to the top of the Pictured Cliffs formation in the Cabresto Tight Gas Area is 3715 feet. A list of well name, operator and production data for Pictured Cliffs wells within the Cabresto Tight Gas Area is presented as Exhibit No. 3. The Cabresto Tight Gas Area contains 124 wells which have penetrated and evaluated the Pictured Cliffs formation. At this time 53 wells are capable of production producing from the Pictured Cliffs formation.

GEOLOGY

The Pictured Cliffs Sandstone is a marine, clay filled, fine grained sandstone. This sandstone was deposited as a beach and as nearshore bars generally aligned northwest - southeast with a

source generally to the southwest. These deposits represent the last marine strata in the northeasterly regression of the Cretaceous sea. There are two main zones within the Pictured Cliffs Sandstone. Each zone represents a regressive sequence separated by a marine tongue of Lewis Shale which represents a transgression. Production of gas in the Cabresto Tight Gas Area is from stratigraphic entrapment.

Sample examination indicates that the Pictured Cliffs formation in this area consists of very fine to fine grained, fairly well sorted, subrounded to subangular, slightly calcareous, salt and pepper sandstone. The dark grains are predominately glauconite, mica, and carbonaceous shale. Interbeds of the Lewis Shale are present in the lower part of each main zone, but become fewer and thinner upward. Microscopic examination of the Pictured Cliffs formation reveals that the sandstone grains are coated with mixed layer illite - smectite authigenic clay. These clay coatings are pervasive throughout the vertical extent of the Pictured Cliffs. The clay coatings of the sandstone grains reduce the effective permeability of the Pictured Cliffs sand in this area.

Exhibit No. 4 is a type log of the Pictured Cliffs formation in the Cabresto Tight Gas Area. This well is the Robert L. Bayless Jicarilla 464 No. 4 located in the NWSE of Section 31, T30N-R3W, Rio Arriba County, New Mexico. This type log is representative of potential pay in both the upper and lower zones of the Pictured Cliffs formation. The lower zone of the Pictured Cliffs is blanket - like in the southwest portion of the Cabresto Tight Gas Area but thins and pinches out a few miles northeast of the Jicarilla 464 No. 4 well. In contrast, the upper zone of the Pictured Cliffs is much more lenticular in nature.

Exhibit No. 5 is a cross section A-A' illustrating Pictured Cliffs sandstone development across the Cabresto Tight Gas Area. The datum for this cross section is the top of the Pictured Cliffs formation. The cross section shows that the Pictured Cliffs Sandstone is a continuous lithologic unit throughout the Cabresto Tight Gas Area.

STABILIZED UNSTIMULATED GAS PRODUCTION RATE

Obtaining stabilized unstimulated gas production rates for Pictured Cliffs wells is not a standard procedure used by operators when completing their wells in the San Juan Basin. Past experience has shown that these low permeability Pictured Cliffs wells must be stimulated to obtain commercial production. However, in preparation for this Cabresto Tight Gas Study, Robert L. Bayless performed a natural gas production test on a well before it was fracture stimulated. Exhibit No. 6 presents the data for this production test taken on the Robert L. Bayless Jicarilla 31-3-32 #1 well located in the NWSW of Section 32, T30N-R3W, Rio Arriba County, New Mexico. The average unstimulated natural gas production rate for this well is 22.0 MCF of gas per day. This rate is considered representative for the Cabresto Tight Gas Area and is well below the 105 MCFGPD allotted for tight formation gas wells having an average depth of 3715 feet.

It should be noted that this production test was taken after stimulation of the formation with acid. Acid was used to insure that the perforations in this well were open. Therefore, true unstimulated natural gas production, within its strict definition, would be less than this reported gas flowrate.

Not all of the natural production tests taken from this area were used to calculate the representative unstimulated natural production rate for the Cabresto Tight Gas Area. John E. Schalk conducted natural production tests on the Schalk 29-4 #6 and the Schalk 29-4 #10 wells in 1981 and 1982, respectfully. These wells are located in the SWSW of Section 25 and the SWSW of Section 23 of T29N-R4W, Rio Arriba County, New Mexico. Although both of these wells made some gas naturally, it was such a small amount that it was too small to measure. Rather than average in these two "zero values" the value of 22.0 MCF of gas per day from the Bayless well was used as the most representative natural unstimulated production rate for the Cabresto Tight Gas Area.

STABILIZED UNSTIMULATED OIL PRODUCTION RATE

The natural gas produced from the Pictured Cliffs formation in the Cabresto Tight Gas Area is virtually dry gas. There has been very little oil or condensate reported for the wells that have produced in the area. Some of these wells will have small amounts of oil or condensate production with the gas, but significant oil production is not common. Examination of the production data supplied in Exhibit #3 support these statements. These dry gas production figures indicate a well drilled in the Pictured Cliffs formation in the Cabresto Tight Gas Area is not expected to produce, without stimulation, more than 5 barrels of crude oil per day.

PERMEABILITY

The Pictured Cliffs formation in the San Juan Basin is dependent on stimulation techniques to be commercially productive due to the low permeability of the reservoir rock. Exhibit Nos. 7 through 10 present core analysis data used to determine the average laboratory permeability to air for the Pictured Cliffs formation in the Cabresto Tight Gas Area. The exhibits contain the actual core analysis reports plus selective analysis of the cores taken from only the productive portion of the Pictured Cliffs formation for each well. The cored intervals chosen for permeability averaging were determined by examination of the individual core analysis reports for each well. Only cored intervals of sand which had greater than 10% porosity from the core analysis were used for permeability averaging. The average permeability value determined for each well in Exhibit Nos. 7 through 10 are average laboratory determined permeability values. The actual in situ permeability of the formation is less than this laboratory determined value due to water saturation and net confining pressures found in the Pictured Cliffs reservoir.

Exhibit 11 is a summary of all laboratory core analysis results for the Cabresto Tight Gas Area. The average laboratory permeability to air obtained for the Cabresto Tight Gas Area from the four wells shown is 0.66 millidarcy.

Exhibit No. 12 presents a technical paper entitled "Effect of Overburden Pressure and Water Saturation on Gas Permeability of Tight Sandstone Cores" written by Thomas and Ward of the U.S. Bureau of Mines. This paper presents relationships between laboratory determined permeability in cores and actual in situ permeability found in reservoirs. Exhibit No. 13 explains how in situ permeability is calculated from the core analysis using the technical paper presented.

An average in situ permeability value of 0.035 millidarcy was calculated from the average laboratory permeability value of 0.66 millidarcy for the Cabresto Tight Gas Area. This 0.035 millidarcy permeability value calculated from core data is well below the 0.10 millidarcy cutoff for tight gas reservoirs.

Another method of determining reservoir permeability was performed as a check, making use of the representative unstimulated natural production test taken in the area. The average unstimulated gas flow rate of 20.0 MCF of gas per day, along with other Pictured Cliffs reservoir data for the Cabresto Tight Gas Area was used to calculate a reservoir permeability using Darcy's Law. This Darcy's Law calculation is presented as Exhibit No. 14. The use of Darcy's law calculates an average reservoir permeability value of 0.017 millidarcy for the Cabresto Tight Gas Area. This permeability value compares to the 0.035 millidarcy permeability value determined by core analysis methods. These two methods produce fairly similar permeability values both of which are well below the 0.10 millidarcy tight gas limitation.

From examination of the two sources of permeability data, the reservoir permeability value of 0.035 millidarcy determined by core analysis methods is thought to be the best estimate of reservoir permeability for the Cabresto Tight Gas Area because it uses actual core data from the Pictured Cliffs formation. Therefore, the estimated average is situ gas permeability throughout the Pictured Cliffs formation pay section is expected to be 0.10 millidarcy or less in the Cabresto Tight Gas Area.

FRESH WATER PROTECTION

Existing State and Federal regulations will assure that development of the Pictured Cliffs formation will not adversely affect or impair any fresh water acquifers that are being used or are expected to be used in the future for domestic or agricultural water supplies. Regulations require that casing programs be designed to seal off potential water bearing formations from oil and gas producing formations. These fresh water zones exist from the surface of the ground to the base of the Ojo Alamo Formation.

Most Pictured Cliffs wells drilled in the Cabresto Tight Gas Area are drilled with natural mud that will not contaminate fresh water zones. A normal casing design consists of 8 5/8" O.D. surface casing being set from the surface to a depth of 150 to 250 feet. The production casing normally used is 4 1/2 or 5 1/2" O.D. and is set from surface to total depth. The surface casing is cemented in place by circulating cement to the surface, protecting the near surface formations from downhole contamination. The production casing is cemented from total depth to the surface or to a depth sufficient to cover the Ojo Alamo formation in the older wells. The newer wells are required to circulate cement to the surface. This process protects the Pictured Cliffs and other hydrocarbon bearing formations from contaminating any fresh water acquifers. Therefore, productive and fresh water zones are protected by both casing and cement.

Stimulation of the Pictured Cliffs formation involves varied fracture treatments, depending on the operator. Fracture treatments usually consist of a one or two percent potassium chloride water base fluid with sand, or a nitrogen-water foam base fluid and sand. Either treatment will not harm a fresh water acquifer. Fresh water protection is assured during these fracture stimulation treatments due to zone isolation caused by cementation. A distance of well over 500 feet between the Pictured Cliffs formation and the closest fresh water acquifer in a ~~wellbore~~ is additional insurance that an existing fresh water zone will not be contaminated by stimulation of Pictured Cliffs wells in this area.

Therefore, New Mexico and Federal regulations will protect fresh water aquifers from the drilling, completing, and producing the Pictured Cliffs formation in the Cabresto Tight Gas Area.

CONCLUSION

Evidence presented in this report substantiates the following for the Cabresto Tight Gas Area proposed by Robert L. Bayless:

(1) For an average Pictured Cliffs well depth of 3715 feet, the stabilized production rate at atmospheric pressure of wells completed in the Pictured Cliffs formation, without stimulation, is not expected to exceed the maximum allowable rate of 105 MCF of gas per day.

(2) No well drilled into the Pictured Cliffs formation in the Cabresto Area is expected to produce, without stimulation, more than five barrels of crude oil per day.

(3) The estimated average in situ gas permeability, throughout the Pictured Cliffs pay section, is expected to be 0.10 millidarcy or less.

The proposed Cabresto Tight Gas Area meets all the specifications required as stated above and should be designated a tight formation in the Pictured Cliffs formation under Section 107 of the Natural Gas Policy Act of 1978.

CABRESTO TIGHT GAS AREA

LIST OF EXHIBITS

Exhibit Number	Exhibit Name	Exhibit Purpose
1.	Pictured Cliffs Reservoir Map	Show location of Cabresto Tight Gas Area with respect to San Juan Basin Pictured Cliffs Wells
2.	Pictured Cliffs Formation Completion and Production Map	Show Pictured Cliffs formation well activity and production figures in and around the tight formation area
3.	Cabresto Tight Gas Area Wells	List Pictured Cliffs formation well production figures in and around the tight formation area
4.	Cabresto Tight Gas Area Type Log Robert L. Bayless Jicarilla 464 #4 NWSE Sec 31 T30N R3W	Show log characteristics of the Pictured Cliffs formation in the tight formation area
5.	Cross Section A-A'	Show that the Pictured Cliffs formation is present throughout the tight formation area
6.	Unstimulated Natural Production Test Robert L. Bayless Jicarilla 31-3-32 #1 NWSW Sec 32 T31N R3W	Show the results of the unstimulated natural production test taken on this well
7.	Core Analysis Data Robert L. Bayless Conoco 29-4 #7 SWNW Sec 20 T29N R4W	Show the selective analysis data and the actual core analysis data from this well
8.	Core Analysis Data John E. Schalk Schalk 29-4 #6 SWSW Sec 25 T29N R4W	Show the selective analysis data and the actual core analysis data from this well
9.	Core Analysis Data Robert L. Bayless Jicarilla 459 #5 SESE Sec 19 T30N R3W	Show the selective analysis data and the actual core analysis data from this well
10.	Core Analysis Data El Paso Natural Gas Gasbuggy #1 NESW Sec 36 T29N R4W	Show the selective analysis data and the actual core analysis data from this well
11.	Core Analysis Summary	Show the summary of the core analysis data used to determine the average laboratory core permeability for the tight formation area
12.	Technical Paper "Effect of Overburden Pressure and Water Saturation on Gas Permeability of Tight Sandstone Cores"	Show the relationship between laboratory and in situ permeability
13.	Determination of In Situ Permeability	Show the method of determining in situ permeability from laboratory core analysis
14.	Darcy's Law Permeability Calculation	Show the determination of permeability from an unstimulated gas production test using Darcy's Law

3715 ft avg. depth

CABRESTO TIGHT GAS AREA - EXHIBIT #3

LIST OF WELLS WITHIN THE TIGHT GAS AREA THAT HAVE PENETRATED THE PICTURED CLIFFS FORMATION

124 wells — 53 well are capable of produce

WELL	LOCATION	OPERATOR	CURRENT STATUS	SPUD DATE	PC COMP DATE	PC IP (MCFD)	CURRENT GAS PROD CAPABILITY MCFD	CURRENT OIL PROD CAPABILITY BOPD	11/1/91 CUM GAS PROD	11/1/91 CUM OIL PROD	FIELD	DEPTH TO TOP OF P.C.
JIC H-9 #1	T29N R2W SEC 9 H SE NE	UNION OIL OF CALIF	D&A	6/86	8/87	0						3686
JIC #S-3	T29N R2W SEC 17 M SW SW	SMITH DRILLING	D&A	6/56	5/57	0						3594
JIC #S-1	T29N R2W SEC 19 N SE SW	SMITH DRILLING	D&A	12/55	3/56	800						3498
JIC 451 #1	T29N R3W SEC 4 K NE SW	ROBERT L. BAYLESS	PROD FRT	1/84								3762
JIC 451 #3	T29N R3W SEC 4 D NW NW	ROBERT L. BAYLESS	D&A	11/88								3782
JIC 452 #4	T29N R3W SEC 5 D NW NW	ROBERT L. BAYLESS	PROD PC	11/88	1/89	1305	21	0.0	21,734	0	E BLANCO PC	3747
JIC 452 #1-Y	T29N R3W SEC 6 P SE SE	ROBERT L. BAYLESS	PROD FRT	6/86								3744
INDIAN D-1	T29N R3W SEC 21 M SW SW	PHILLIPS PETROLEUM	D&A	5/53	7/60	0						3525
JIC 454 A-1	T29N R3W SEC 24 L NW SW	AMOCO PRODUCTION	P&A 1986	11/83								3665
LA JARA #1	T29N R3W SEC 25 M SW SW	JEROME P. MCHUGH	P&A 1985	11/71								3515
INDIAN A #1	T29N R3W SEC 29 A NE NE	NORTHWEST PIPELINE	P&A 1962	11/52								3600
INDIAN A #3	T29N R3W SEC 29 L NW SW	NORTHWEST PIPELINE	PROD PC	8/77	7/80	40						3750
INDIAN A #2	T29N R3W SEC 30 N SE SW	NORTHWEST PIPELINE	PROD PC	11/56	11/56	7984	59	0.0	876,842	17	CHOZA MESA	3646
BURKE #1	T29N R3W SEC 31 F SE NW	JEROME P. MCHUGH	P&A 1979	11/76	1/77	750			928	40	CHOZA MESA	3713
INDIAN E #1	T29N R3W SEC 31 B NW NE	PHILLIPS PETROLEUM	P&A 1985	4/54	5/54	0			357,932	0	CHOZA MESA	3688
INDIAN G #1	T29N R3W SEC 33 D NW NW	NORTHWEST PIPELINE	D&A	6/55	7/55	0						3618
INDIAN G #2	T29N R3W SEC 34 K NE SW	NORTHWEST PIPELINE	D&A	10/55								3604
TRUJILLO FED #1	T29N R4W SEC 1 H SE NE	SOUTHLAND ROYALTY	D&A	1/84								3615
BURNS RANCH 300	T29N R4W SEC 2 H SE NE	SOUTHLAND ROYALTY	PROD FRT	5/90								3729
CONOCO 29-4 #9	T29N R4W SEC 2 O SW SE	CONOCO OIL CO	D&A	4/78								3654
SJ 29-4 UNIT #9	T29N R4W SEC 3 D NW NW	NORTHWEST PIPELINE	D&A	9/55								4215
SJ 29-4 UNIT #21	T29N R4W SEC 5 K NE SW	MERIDIAN OIL	PROD PC/MV	9/77	7/78	1332			19,656	0	E BLANCO PC	4208
SJ 29-4 UNIT #11	T29N R4W SEC 6 P SE SE	NORTHWEST PIPELINE	D&A	8/56	9/56	0						4203
ROMERO FED #1	T29N R4W SEC 6 D NW NW	AMOCO PRODUCTION	PROD GAL	11/84								4222
VALDEZ A #1	T29N R4W SEC 7 N SE SW	STANDOLIND OIL & GAS	D&A	8/53								4445
SJ 29-4 UNIT #24	T29N R4W SEC 8 B NW NE	MERIDIAN OIL	PROD PC/GAL	10/81	2/83	1649	50	1.2	86,354	1,493	E BLANCO PC	4100
SJ 29-4 UNIT #7	T29N R4W SEC 8 D NW NW	MERIDIAN OIL	P&A 1988	8/55	12/55	1106						4002
SJ 29-4 UNIT #22	T29N R4W SEC 9 N SE SW	MERIDIAN OIL	PROD PC	11/78	12/78	1320	9	0.1	37,788	217	E BLANCO PC	3535
VALDEZ #2	T29N R4W SEC 10 M SW SW	STANDOLIND OIL & GAS	D&A	10/53								3605
CONOCO 29-4 #2	T29N R4W SEC 11 H SE NE	ROBERT L. BAYLESS	PROD GAL	8/73								3694
CONOCO 29-4 #5	T29N R4W SEC 12 H SE NE	ROBERT L. BAYLESS	PROD GAL	10/73								3774
BURNS RANCH #1	T29N R4W SEC 13 A NE NE	SOUTHLAND ROYALTY	PROD GAL	9/79								3595
CONOCO 29-4 #10	T29N R4W SEC 14 A NE NE	ROBERT L. BAYLESS	PROD PC	3/78	4/78	973	37	0.0	183,317	0	UNDES PC	4075
SJ 29-4 UNIT #23	T29N R4W SEC 15 J NW SE	MERIDIAN OIL	PROD PC	11/78	12/78	663	13	0.0	46,320	144	CHOZA MESA	4074
SJ 29-4 UNIT #12	T29N R4W SEC 18 B NW NE	MERIDIAN OIL	PROD MV	7/57								4410
CONOCO 29-4 #6	T29N R4W SEC 19 H SE NE	ROBERT L. BAYLESS	PROD PC	4/78	5/78	719	18	0.1	35,881	119	GOBERNADOR	3373
SCHALK 29-4 #5	T29N R4W SEC 20 O SW SE	JOHN E. SCHALK	PROD PC	7/76	8/78	631	12	0.0	18,730	0	GOBERNADOR	3870
CONOCO 29-4 #7	T29N R4W SEC 20 E SW NW	ROBERT L. BAYLESS	PROD PC	2/74	7/74	504	15	0.1	52,990	513	GOBERNADOR	3284
CONOCO 29-4 #1	T29N R4W SEC 22 K NE SW	CONOCO OIL CO	P&A	9/73	12/75	0						3828
SJ 29-4 UNIT #3	T29N R4W SEC 22 N SE SW	EL PASO NATURAL GAS	D&A	10/53	4/54	0						3610
SCHALK 29-4 #16	T29N R4W SEC 22 P SE SE	JOHN E. SCHALK	PROD PC	4/78	10/78	1448	4	0.0	29,269	0	CHOZA MESA	4035
SCHALK 29-4 #11	T29N R4W SEC 23 P SE SE	JOHN E. SCHALK	PROD PC	5/78	6/78	1019	6	0.0	44,109	186	CHOZA MESA	3701
SCHALK 29-4 #10	T29N R4W SEC 23 M SW SW	M.R. SCHALK	PROD PC	2/82	11/82	812	12	0.0	31,887	0	CHOZA MESA	4041
CONOCO 29-4 #4	T29N R4W SEC 24 N SE SW	ROBERT L. BAYLESS	PROD PC	12/73	4/78	5644	27	0.0	62,245	17	CHOZA MESA	3697
SJ 29-4 UNIT #15	T29N R4W SEC 25 G SW NE	EL PASO NATURAL GAS	D&A	7/58	10/58	0						3675

EXHIBIT #3 - PAGE 2

WELL	LOCATION	OPERATOR	CURRENT STATUS	SPUD DATE	PC COMP DATE	PC IP (MCFD)	CURRENT GAS PROD CAPABILITY MCFD	CURRENT OIL PROD CAPABILITY BOPD	11/1/91 CUM GAS PROD	11/1/91 CUM OIL PROD	FIELD	DEPTH TO TOP OF P.C.
SCHALK 29-4 #6	T29N R4W SEC 25 M SW SW	JOHN E. SCHALK	PROD PC	8/80	10/81	758	2	0.0	4,964	0	CHOZA MESA	4045
SCHALK 29-4 #17	T29N R4W SEC 25 I NE SE	JOHN E. SCHALK	PROD PC	7/78	8/78	1386	33	0.0	263,976	0	CHOZA MESA	3644
SCHALK 29-4 #14	T29N R4W SEC 26 B NW NE	JOHN E. SCHALK	PROD PC	4/78	9/78	1171	14	0.0	64,467	482	CHOZA MESA	4040
SCHALK 29-4 #7	T29N R4W SEC 26 K NE SW	JOHN E. SCHALK	PROD PC	5/79	6/79	1380	97	1.7	281,295	12,513	CHOZA MESA	3774
SCHALK 29-4 #15	T29N R4W SEC 27 P SE SE	JOHN E. SCHALK	PROD PC	4/78	10/78	2610	5	0.0	41,614	0	CHOZA MESA	3942
CONOCO 29-4 #3	T29N R4W SEC 28 L NW SW	ROBERT L. BAYLESS	PROD GAL	11/73								4192
SJ 29-4 UNIT #13	T29N R4W SEC 29 H SE NE	EL PASO NATURAL GAS	D&A	10/57								4091
SJ 29-4 UNIT #1	T29N R4W SEC 30 K NE SW	MERIDIAN OIL	PROD MV	8/53								4252
SJ 29-4 UNIT #14	T29N R4W SEC 31 A NE NE	MERIDIAN OIL	PROD MV	9/57								4153
SCHALK 29-4 #3	T29N R4W SEC 32 A NE NE	JOHN E. SCHALK	PROD PC	1/76	3/76	780	29	0.0	104,271	0	GOBERNADOR	4250
SCHALK 29-4 #1	T29N R4W SEC 32 M SW SW	JOHN E. SCHALK	PROD MV	4/75								4342
FED #29-4-32 #1	T29N R4W SEC 32 A NE NE	RICHMOND PETROLEUM	PROD FRT	8/89								4250
SCHALK 29-4 #2	T29N R4W SEC 32 P SE SE	JOHN E. SCHALK	PROD PC	12/75	2/76	1254	218	0.0	607,769	116	GOBERNADOR	4250
FED #29-4-32 #2	T29N R4W SEC 32 M SW SW	RICHMOND PETROLEUM	PROD FRT	9/89								4337
SCHALK 29-4 #4	T29N R4W SEC 32 D NW NW	JOHN E. SCHALK	PROD PC	9/75	12/75	505	103	0.0	299,221	0	GOBERNADOR	4249
SJ 29-4 UNIT #18	T29N R4W SEC 33 H SE NE	MERIDIAN OIL	PROD MV	9/59								4262
SJ 29-4 UNIT #8	T29N R4W SEC 34 H SE NE	NORTHWEST PIPELINE	PROD PC	6/57	7/57	376						3891
SJ 29-4 UNIT #4	T29N R4W SEC 35 B NW NE	MERIDIAN OIL	PROD PC	9/55	11/55	801	10	0.0	104,075	0	CHOZA MESA	3930
SJ 29-4 UNIT #2	T29N R4W SEC 35 K NE SW	MERIDIAN OIL	PROD FRT	9/53	10/53	6928			1,086,500	0	CHOZA MESA	3832
SH 29-4 UNIT #16	T29N R4W SEC 36 A NE NE	MERIDIAN OIL	PROD FRT	7/58	11/58	635			64,391	0	CHOZA MESA	3738
SJ 29-4 UNIT #10	T29N R4W SEC 36 K NE SW	EL PASO NATURAL GAS	P&A 1985	7/56	9/56	1348			81,854	0	CHOZA MESA	3902
GASBUGGY #2	T29N R4W SEC 36 N SE SW	EL PASO NATURAL GAS	D&A	4/67								3910
GASBUGGY #1	T29N R4W SEC 36 K NE SW	EL PASO NATURAL GAS	D&A	2/67								3916
GASBUGGY #3	T29N R4W SEC 36 K NE SW	EL PASO NATURAL GAS	D&A	8/69								3908
JIC S-4	T30N R2W SEC 6 E SW NW	SMITH DRILLING	D&A	10/56								3775
JIC 516 #1	T30N R2W SEC 7 O SW SE	ROBERT L. BAYLESS	PROD FRT/PC	11/87	1/88	368						3798
JIC 519 #1	T30N R2W SEC 18 O SW SE	ROBERT L. BAYLESS	PROD PC/GAL	11/85	7/87	754	9	0.0	24,812	0	E BLANCO PC	3596
JIC 522 #1	T30N R2W SEC 33 C NE NW	MALLON OIL CO	D&A	9/88								3814
JIC 458 #2	T30N R3W SEC 7 O SW SE	ROBERT L. BAYLESS	PROD PC	12/86	1/87	3221	148	0.0	230,656	0	E BLANCO PC	3633
JIC 458 #8	T30N R3W SEC 7 F SE NW	ROBERT L. BAYLESS	PROD PC	9/88	11/88	3510	250	0.0	199,103	0	E BLANCO PC	3710
JIC 458 #3	T30N R3W SEC 7 H SE NE	ROBERT L. BAYLESS	PROD PC	3/88	4/88	2633	198	0.0	181,533	0	E BLANCO PC	3713
JIC 457 #1	T30N R3W SEC 9 L NW SW	ROBERT L. BAYLESS	PROD DA	12/86	1/87	384	29	0.0	17,577	0	E BLANCO PC	3702
JIC 456 #1	T30N R3W SEC 11 N SE SW	ROBERT L. BAYLESS	PROD FRT	2/87								3730
JIC 461 #1	T30N R3W SEC 14 L NW SW	ROBERT L. BAYLESS	PROD PC	1/87	2/87	1055	31	0.0	43,766	0	E BLANCO PC	3651
JIC 459 #8	T30N R3W SEC 17 C NE NW	ROBERT L. BAYLESS	PROD PC	10/88	1/89	1586	33	0.0	24,406	0	E BLANCO PC	3663
JIC 459 #1	T30N R3W SEC 18 I NE SE	ROBERT L. BAYLESS	PROD PC	11/86	1/67	2355	171	0.0	211,802	0	E BLANCO PC	3677
JIC 459 #3	T30N R3W SEC 18 G SW NE	ROBERT L. BAYLESS	PROD DA/PC	10/88	1/89	2539	65	0.0	31,445	0	E BLANCO PC	3654
JIC 459 #4	T30N R3W SEC 19 B NW NE	ROBERT L. BAYLESS	PROD PC	10/88	1/89	4378	251	0.0	206,020	0	E BLANCO PC	3748
JIC 459 #5	T30N R3W SEC 19 P SE SE	ROBERT L. BAYLESS	PROD PC	12/88	4/90	1384	71	0.0	10,787	0	E BLANCO PC	3846
JIC 459 #2	T30N R3W SEC 20 E SW NW	ROBERT L. BAYLESS	PROD PC	11/87	12/87	3505	182	0.0	266,310	0	E BLANCO PC	3742
JIC 460 #2	T30N R3W SEC 21 M SW SW	ROBERT L. BAYLESS	PROD PC	12/86	1/87	408	11	0.0	26,041	0	E BLANCO PC	3687
JIC 462 #1	T30N R3W SEC 22 M SW SW	ROBERT L. BAYLESS	PROD PC	1/87	1/87	404	24	0.0	25,882	0	E BLANCO PC	3609
JIC 463 #1	T30N R3W SEC 25 E SW NW	ROBERT L. BAYLESS	PROD DA	3/87	4/87	443			9,071	0	E BLANCO PC	3600
JIC 464 #8	T30N R3W SEC 29 K NE SW	ROBERT L. BAYLESS	PROD PC	10/88	12/88	2524	121	0.0	65,900	0	E BLANCO PC	3770
JIC 464 #7	T30N R3W SEC 29 D NW NW	ROBERT L. BAYLESS	PROD PC	11/88	2/89	2428	164	0.0	93,069	0	E BLANCO PC	3814
JIC 464 #3	T30N R3W SEC 30 H SE NE	ROBERT L. BAYLESS	PROD PC	11/88	12/88	4801	112	0.0	97,391	0	E BLANCO PC	3808
JIC 464 #1	T30N R3W SEC 30 I NE SE	ROBERT L. BAYLESS	PROD PC	10/86	12/86	3923	262	0.0	483,271	0	E BLANCO PC	3740
JIC 464 #5	T30N R3W SEC 31 B NW NE	ROBERT L. BAYLESS	PROD PC	12/88	2/89	3510	60	0.0	43,879	0	E BLANCO PC	3725
JIC 464 #4	T30N R3W SEC 31 J NW SE	ROBERT L. BAYLESS	PROD PC	2/88	3/88	1006	15	0.0	21,303	0	E BLANCO PC	3698

EXHIBIT #3 - PAGE 3

WELL	LOCATION		OPERATOR	CURRENT STATUS	SPUD DATE	PC COMP DATE	PC IP (MCFD)	CURRENT GAS PROD CAPABILITY MCFD	CURRENT OIL PROD CAPABILITY BOPD	11/1/91 CUM GAS PROD	11/1/91 CUM OIL PROD	FIELD	DEPTH TO TOP OF P.C.
JIC 464 #2	T30N R3W SEC 32 D	NW NW	ROBERT L. BAYLESS	PROD PC	10/87	12/87	2481	89	0.0	315,095	0	E BLANCO PC	3734
JIC 464 #6	T30N R3W SEC 32 M	SW SW	ROBERT L. BAYLESS	PROD PC	8/88	9/88	3802	142	0.0	178,427	0	E BLANCO PC	3638
JIC TRIBAL #1	T30N R3W SEC 34 D	NW NW	SUNRAY DX OIL CO	D&A	3/64								3600
SIMMS FED #3	T30N R4W SEC 11 E	SW NW	SOUTHLAND ROYALTY	PROD PC	9/82	12/82	2002	10	0.0	35,818	0	E BLANCO PC	3650
SIMMS FED #2	T30N R4W SEC 11 O	SW SE	SOUTHLAND ROYALTY	PROD PC	10/81	12/81	1342						3666
SJ 30-4 UNIT #25	T30N R4W SEC 11 I	NE SE	EL PASO NATURAL GAS	P&A	9/58	11/58	179						3650
SIMMS #7	T30N R4W SEC 12 P	SE SE	ROBERT L. BAYLESS	PROD PC	7/90	8/90	3423	75	0.0	6,796	0	E BLANCO PC	3634
SIMMS FED #1	T30N R4W SEC 13 J	NW SE	SOUTHLAND ROYALTY	PROD GAL	6/81								3700
ALSUP B#1	T30N R4W SEC 14 P	SE SE	EL PASO NATURAL GAS	P&A 1959	11/51								
SJ 30-4 UNIT #31	T30N R4W SEC 14 D	NW NW	EL PASO NATURAL GAS	D&A	8/60								3803
SCHALK 49 #1	T30N R4W SEC 23 M	SW SW	SCHALK DEVELOPMENT	PROD PC	3/73	7/73	1613	27	0.0	228,785	0	E BLANCO PC	4144
SCHALK 49 #2	T30N R4W SEC 23 O	SW SE	SCHALK DEVELOPMENT	PROD PC	11/73	1/74	880	6	0.0	27,889	0	E BLANCO PC	4033
SCHALK 49 #3	T30N R4W SEC 23 A	NE NE	SCHALK DEVELOPMENT	PROD PC	12/73	1/74	2236	7	0.0	129,813	0	E BLANCO PC	3834
SCHALK 49 #4	T30N R4W SEC 23 D	NW NW	SCHALK DEVELOPMENT	PROD PC	1/74	5/74	713	7	0.0	25,936	0	E BLANCO PC	3872
SJ 30-4 UNIT #29	T30N R4W SEC 24 D	NW NW	EL PASO NATURAL GAS	D&A	9/58	10/58	0						4036
SCHALK 76 #1	T30N R4W SEC 25 E	SW NW	COASTLINE PETROLEUM	D&A	12/73								4085
BIXLER RANCH #1	T30N R4W SEC 26 E	SW NW	SOUTHLAND ROYALTY	PROD PC	9/81	11/81	449	15	0.0	74,951	0	E BLANCO PC	3986
SJ 30-4 UNIT #19	T30N R4W SEC 26 C	NE NW	EL PASO NATURAL GAS	D&A	6/57	8/57	0						4071
BIXLER RANCH #2	T30N R4W SEC 26 M	SW SW	SOUTHLAND ROYALTY	PROD PC	8/83	3/84	712	35	0.0	75,402	0	E BLANCO PC	4130
RUBEN CANYON #1	T30N R4W SEC 35 E	SW NW	SOUTHLAND ROYALTY	PROD PC	10/81	12/81	1250	78	0.0	206,764	0	E BLANCO PC	3835
SIMMS FED #4	T30N R4W SEC 36 P	SE SE	SOUTHLAND ROYALTY	PROD FRT	8/83	10/84	0						3794
JIC TRIBAL 525 #1	T31N R2W SEC 15 I	NE SE	AMOCO PRODUCTION	PROD GAL	11/85								969
JIC TRIBAL 29 #1	T31N R2W SEC 36 B	NW NE	HUMBLE OIL & REF	D&A	9/63								950
JIC TRIBAL 531 #1	T31N R3W SEC 5 K	NE SW	AMOCO PRODUCTION	PROD GAL	11/83								3830
JIC 31-3-32 #1	T31N R3W SEC 32 L	NW SW	ROBERT L. BAYLESS	DRILLED	2/91	2/91	NONE YET	0	0.0	0	0	E BLANCO PC	3779
JIC TRIBAL #1	T32N R3W SEC 21 M	SW SW	THE TEXAS CO	D&A	5/52								1380
TRIBAL #1	T32N R3W SEC 22 H	SE NE	STANOLIND	D&A	5/52								1105
PAGOSA JIC #1	T32N R3W SEC 23 D	NW NW	PAN AMERICAN PET	D&A	6/63								1054
TRIBAL #1	T32N R3W SEC 23 K	NE SW	FLORENCE DRILLING	D&A	6/47								
JIC NM 29 A #1	T32N R3W SEC 29 F	SE NW	AUSTRA-TEX OIL CO	D&A	6/88								2764

CABRESTO TIGHT GAS AREA - EXHIBIT #6

NATURAL UNSTIMULATED GAS PRODUCTION FLOWTEST

WELL: ROBERT L. BAYLESS
JICARILLA 31-3-32 #1
NWSW SEC 32 T31N R3W

DATE	TIME	TUBING FLOW PRESS CHART (PSI)	ORIFICE SIZE	FLOW RATE (MCFD)	GAS PRODUCED (MCF)	TOT GAS PRODUCED (MCF)
02/27/91	10:05 am	90	0.125	44.8	0.000	0.000
	10:10 am	86	0.125	43.1	0.153	0.153
	10:15 am	87	0.125	43.5	0.150	0.303
	10:20 am	85	0.125	42.7	0.150	0.453
	10:25 am	79	0.125	40.1	0.144	0.596
	10:30 am	73	0.125	37.5	0.135	0.731
	10:35 am	67	0.125	34.9	0.126	0.857
	10:40 am	65	0.125	34.0	0.120	0.976
	10:45 am	55	0.125	29.7	0.111	1.087
	10:50 am	60	0.125	31.9	0.107	1.194
	10:55 am	53	0.125	28.9	0.106	1.299
	11:00 am	50	0.125	27.6	0.098	1.398
	11:05 am	44	0.125	25.0	0.091	1.489
	11:10 am	46	0.125	25.8	0.088	1.577
	11:15 am	39	0.125	22.9	0.085	1.662
	11:20 am	32	0.125	19.9	0.074	1.736
	11:25 am	37	0.125	22.1	0.073	1.809
	11:30 am	30	0.125	19.0	0.071	1.880
	11:35 am	24	0.125	16.5	0.062	1.942
	11:40 am	33	0.125	20.3	0.064	2.006
	11:45 am	28	0.125	18.2	0.067	2.073
	11:50 am	22	0.125	15.5	0.059	2.131
	11:55 am	19	0.125	14.0	0.051	2.182
	12:00 pm	27	0.125	17.8	0.055	2.238
	12:05 pm	24	0.125	16.5	0.060	2.297
	12:10 pm	18	0.125	13.5	0.052	2.349
	12:15 pm	12	0.125	10.5	0.042	2.391
	12:20 pm	9	0.125	8.9	0.034	2.424
	12:25 pm	16	0.125	12.5	0.037	2.462
	12:30 pm	20	0.125	14.6	0.047	2.509
	12:35 pm	16	0.125	12.5	0.047	2.556
	12:40 pm	10	0.125	9.5	0.038	2.594
	12:45 pm	8	0.125	8.3	0.031	2.625
	12:50 pm	5	0.125	6.4	0.026	2.650
	12:55 pm	2	0.125	3.9	0.018	2.668
	1:00 pm	1	0.125	2.8	0.012	2.680

CALCULATED 24 HOUR FLOWRATE = 22.0 MCFD

CABRESTO TIGHT GAS AREA - EXHIBIT #7

PICTURED CLIFFS CORE ANALYSIS

OPERATOR: ROBERT L. BAYLESS
WELL: CONOCO 29-4 #7
LOCATION: SWNW SEC 20 T29N R4W

TOP OF PICTURED CLIFFS = 3284

ALL DATA USED IN THIS ANALYSIS IS >10% POROSITY REPORTED FROM CORE ANALYSIS

SAMP NUM	TOP INTERVAL	BOTTOM INTERVAL	FOOTAGE INTERVAL	HORIZONTAL PERMEABILITY	POROSITY	WATER SATURATION
	TOTAL		35	4.08	411.3	2069.0
	AVG			0.12	11.8	59.1
6	3369	3370	1	0.12	10.7	49.5
7	3370	3371	1	0.33	11.6	50.0
10	3373	3374	1	0.44	11.5	52.1
11	3374	3375	1	0.15	12.8	49.3
12	3375	3376	1	0.28	13.8	49.3
13	3376	3377	1	0.14	12.6	38.1
14	3377	3378	1	0.28	11.3	38.9
15	3378	3379	1	0.10	12.8	39.1
18	3381	3382	1	0.10	11.2	56.1
19	3382	3383	1	0.32	13.5	45.9
20	3383	3384	1	0.18	13.8	47.1
21	3384	3385	1	0.11	12.4	55.6
22	3385	3386	1	0.21	11.8	58.5
23	3386	3387	1	0.11	12.8	52.4
24	3387	3388	1	0.15	10.3	65.0
26	3389	3390	1	0.07	11.6	69.9
28	3391	3392	1	0.05	11.8	65.2
31	3394	3395	1	0.05	11.8	61.9
32	3395	3396	1	0.08	11.3	62.8
37	3400	3401	1	0.04	11.1	70.3
41	3404	3405	1	0.08	10.4	70.2
42	3405	3406	1	0.14	10.9	65.1
51	3414	3415	1	0.04	11.0	72.7
52	3415	3416	1	0.04	10.3	73.8
87	3461	3462	1	0.02	10.5	76.1
89	3463	3464	1	0.01	10.9	78.9
100	3474	3475	1	0.01	10.7	64.5
101	3475	3476	1	0.02	11.4	64.9
102	3476	3477	1	0.05	12.8	61.0
103	3477	3478	1	0.08	12.0	57.5
104	3478	3479	1	0.05	11.7	62.4
105	3479	3480	1	0.07	11.5	61.7
106	3480	3481	1	0.05	11.9	61.4
107	3481	3482	1	0.04	12.3	66.7
108	3482	3483	1	0.07	12.5	55.1

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

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CORE ANALYSIS RESULTS

Company CONTINENTAL OIL COMPANY Formation PICTURED CLIFFS File RP-3-2625
Well NO. 7 SAN JUAN 29-4 Core Type DIA. CONV. 4" Date Report 2-18-74
Field WILDCAT Drilling Fluid WBM Analysts RM
County RIO ARRIBA State N. MEX. Elev. 6578 KB Location NW 1/4 Sec. 20 T29N R4W

Lithological Abbreviations

SAND-SD, SHALE-SH, LIME-LM, DOLOMITE-DOL, CHERT-CH, GYPSUM-GYP, ANHYDRITE-ANHY, CONGLOMERATE-CONG, FOSSILIFEROUS-FOSS, SANDY-SDY, SHALY-SHY, LIMY-LMY, FINE-FN, MEDIUM-MED, COARSE-CSE, CRYSTALLINE-XLN, GRAIN-GRN, GRANULAR-GRNL, BROWN-BRN, GRAY-GY, VUGGY-VGY, FRACTURED-FRAC, LAMINATION-LAM, STYLOLITIC-STY, SLIGHTLY-SL, VERY-V/, WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HOR. K	VERT K	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER		SAMPLE DESCRIPTION AND REMARKS
1	3364-65	0.01	<0.01	3.3	0.0	72.7		Ss wh vfg cly s & p calc
2	3365-66	0.01	<0.01	4.0	0.0	82.5	VF	Ss wh vfg cly s & p sli calc
3	3366-67	0.04	0.01	8.2	2.4	74.4	VF	Ss wh vfg cly s & p sli calc
4	3367-68	0.04	0.01	7.2	6.9	51.4		Ss wh vfg cly s & p calc
5	3368-69	0.05	0.02	9.8	2.0	56.1	VF	Ss wh vfg cly s & p calc
6	3369-70	0.12	0.04	10.7	8.4	49.5		Ss wh vfg cly s & p calc
7	3370-71	0.33	0.07	11.6	7.8	50.0		Ss wh vfg cly s & p calc
8	3371-72	0.02	0.01	3.3	15.1	75.8	VF	Ss wh vfg cly s & p calc
9	3372-73	0.01	<0.01	2.3	0.0	82.6	VF	Ss wh vfg cly s & p calc
10	3373-74	0.44	0.11	11.5	6.1	52.1		Ss wh vfg cly s & p
11	3374-75	0.15	0.05	12.8	7.0	49.3		Ss wh vfg cly s & p
12	3375-76	0.28	0.07	13.8	8.0	49.3		Ss wh vfg cly s & p
13	3376-77	0.14	0.07	12.6	9.5	38.1	VF	Ss wh vfg cly s & p
14	3377-78	0.28	0.02	11.3	10.6	38.9	VF	Ss wh vfg cly s & p
15	3378-79	0.10	0.02	12.8	9.4	39.1	VF	Ss wh vfg cly s & p
16	3379-80	0.12	0.01	8.2	0.0	67.1		Ss wh vfg cly s & p
17	3380-81	0.05	0.01	8.9	0.0	73.0		Ss wh vfg cly s & p
18	3381-82	0.10	0.02	11.2	0.0	56.1		Ss wh vfg cly s & p calc
19	3382-83	0.32	0.07	13.5	9.6	45.9		Ss wh vfg cly s & p sli calc
20	3383-84	0.18	0.04	13.8	10.9	47.1	VF	Ss wh vfg cly s & p
21	3384-85	0.11	0.02	12.4	0.0	55.6		Ss wh vfg cly s & p
22	3385-86	0.21	0.02	11.8	0.0	58.5		Ss wh vfg cly s & p
23	3386-87	0.11	0.04	12.8	7.0	52.4		Ss wh vfg cly s & p
24	3387-88	0.15	0.01	10.3	1.0	65.0		Ss wh vfg cly s & p shly
25	3388-89	0.08	0.01	9.7	0.0	59.8		Ss wh vfg cly s & p
26	3389-90	0.07	0.02	11.6	0.9	69.9		Ss wh vfg cly s & p
27	3390-91	0.02	0.01	3.1	0.0	77.4	VF	Ss wh vfg cly s & p
28	3391-92	0.05	<0.01	11.8	0.0	65.2		Ss wh vfg cly s & p
29	3392-93	0.05	<0.01	8.0	0.0	80.0		Ss wh vfg cly s & p
30	3393-94	0.08	0.02	11.9	0.0	63.0		Ss wh vfg cly s & p
31	3394-95	0.05	0.01	11.8	0.0	61.9		Ss wh vfg cly s & p sli calc
32	3395-96	0.08	0.02	11.3	0.0	62.8		Ss wh vfg cly s & p sli calc
33	3396-97	0.02	<0.01	6.6	0.0	90.8		Ss wh vfg cly s & p
34	3397-98	0.05	0.01	8.7	0.0	80.5		Ss wh vfg cly s & p
35	3398-99	0.01	<0.01	6.8	1.5	89.7		Ss wh vfg cly s & p
36	3399-3400	0.04	0.01	9.1	0.0	78.0		Ss wh vfg cly s & p
37	3400-01	0.04	0.01	11.1	0.0	70.3		Ss wh vfg cly s & p sli calc
38	3401-02	0.01	<0.01	6.4	0.0	84.3		Ss wh vfg cly s & p
39	3402-03	0.04	<0.01	8.1	0.0	80.2		Ss wh vfg cly s & p
40	3403-04	0.04	<0.01	8.7	2.3	79.2		Ss wh vfg cly s & p sli calc

SERVICE NO. 5-A, 1-B. VF - VERTICAL FRACTURE.

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company CONTINENTAL OIL COMPANY Formation PICTURED CLIFFS File RP-3-2628
Well NO. 7 SAN JUAN 29-4 Core Type DIA. CONV. 4" Date Report 2-18-74
Field WILDCAT Drilling Fluid WEM Analysts RM
County SAN JUAN State N. MEX. Elev. 6578 KB Location NW 1/4 Sec. 20 T29N R4W

Lithological Abbreviations

SAND-SD, SHALE-SH, LIME-LM, DOLOMITE-DOL, CHERT-CH, GYPSUM-GYP, ANHYDRITE-ANHY, CONGLOMERATE-CONG, FOSSILIFEROUS-FOSS, SANDY-SDY, SHALY-SHY, LIMY-LMY, FINE-FN, MEDIUM-MED, COARSE-CSE, CRYSTALLINE-XLN, GRAIN-GRN, GRANULAR-GRNL, BROWN-BRN, GRAY-GY, VUGGY-VGY, FRACTURED-FRAC, LAMINATION-LAM, STYLOLITIC-STY, SLIGHTLY-SL/, VERY-V/, WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HOR. K_A	PERMEABILITY MILLIDARCYS VERT.	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER		SAMPLE DESCRIPTION AND REMARKS
41	3404-05	0.08	0.01	10.4	0.0	70.2		Ss wh vfg cly s & p sli calc
42	3405-06	0.14	0.04	10.9	0.0	65.1		Ss wh vfg cly s & p sli calc
43	3406-07	0.02	<0.01	7.1	0.0	84.5		Ss wh vfg cly s & p sli calc
44	3407-08	0.04	<0.01	7.7	0.0	81.8		Ss wh vfg cly s & p sli calc
45	3408-09	0.04	<0.01	8.4	0.0	85.6		Ss wh vfg cly s & p sli calc
46	3409-10	0.01	<0.01	8.2	0.0	83.0		Ss wh vfg cly s & p sli calc
47	3410-11	0.01	<0.01	6.9	0.0	89.9		Ss wh vfg cly s & p shly
48	3411-12	0.02	<0.01	8.1	0.0	86.5		Ss wh vfg cly s & p shly
49	3412-13	0.02	<0.01	8.8	0.0	78.4		Ss wh vfg cly s & p sli calc
50	3413-14	0.02	0.01	8.1	0.0	91.3		Ss wh vfg cly s & p sli calc
51	3414-15	0.04	0.02	11.0	0.0	72.7		Ss wh vfg cly s & p sli calc
52	3415-16	0.04	0.02	10.3	0.0	73.8		Ss wh vfg cly s & p sli calc
53	3416-17	0.04	0.02	9.8	0.0	77.5		Ss wh vfg cly s & p sli calc
54	3417-18	0.04	0.01	9.5	0.0	84.1		Ss wh vfg cly s & p sli calc
55	3418-19	0.04	0.04	9.8	0.0	71.4		Ss wh vfg cly s & p calc
56	3419-20	0.04	0.04	9.4	0.0	71.2		Ss wh vfg cly s & p calc
57	3420-21	0.04	0.02	9.7	0.0	71.1		Ss wh vfg cly s & p sli calc
58	3421-22	0.02	0.01	7.6	0.0	81.6		Ss wh vfg cly s & p sli calc
59	3423-24	0.02	0.02	5.6	8.9	78.5		Ss wh vfg cly s & p sli calc
60	3424-25	0.01	0.01	6.4	0.0	86.0		Ss wh vfg cly s & p sli calc
61	3425-26	0.01	0.01	4.5	40.0	49.0	VF	Ss brn vfg cly
62	3436-37	0.01	0.01	3.5	0.0	82.9		Ss wh vfg cly s & p sli calc
63	3437-38	0.01	0.01	5.2	0.0	82.6		Ss wh vfg cly s & p sli calc
64	3438-39	<0.01	0.01	4.5	0.0	84.4		Ss wh vfg cly s & p sli calc
65	3439-40	<0.01	0.01	5.4	0.0	88.9		Ss wh vfg cly s & p sli calc
66	3440-41	0.01	0.01	5.7	0.0	85.9		Ss wh vfg cly s & p sli calc shly
67	3441-42	0.02	0.01	5.5	0.0	89.0		Ss wh vfg cly s & p sli calc
68	3442-43	0.01	0.01	4.6	0.0	80.5		Ss wh vfg cly s & p sli calc
69	3443-44	<0.01	0.01	5.4	0.0	79.6		Ss wh vfg cly s & p sli calc
70	3444-45	<0.01	0.01	4.7	0.0	83.0		Ss wh vfg cly s & p sli calc
71	3445-46	<0.01	0.01	6.7	0.0	88.0		Ss wh vfg cly s & p sli calc
72	3446-47	0.01	<0.01	6.9	2.9	82.6		Ss wh vfg cly s & p sli calc
73	3447-48	0.01	<0.01	5.7	0.0	86.0		Ss wh vfg cly s & p sli calc
74	3448-49	0.04	0.01	6.2	0.0	83.9		Ss wh vfg cly s & p sli calc shly
75	3449-50	0.01	0.01	6.9	0.0	85.5		Ss wh vfg cly s & p sli calc

SERVICE NO. 5-A, 1-B. VF - VERTICAL FRACTURE.

These analyses, opinions or interpretations are based on observations and materials 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 operations, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CA-20

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company CONTINENTAL OIL COMPANY Formation PICTURED CLIFFS File RP-3-2628
Well NO. 7 SAN JUAN 29-4 Core Type DIA. CONV. 4" Date Report 2-18-74
Field WILDCAT Drilling Fluid WBM Analysts RM
County RIO ARRIBA State N. MEX. Elev. 6578 KB Location NW 1/4 Sec. 20 T29N R4W

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS HOR. K_A	VERT.	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER		SAMPLE DESCRIPTION AND REMARKS
76	3450-51	0.01	0.02	6.8	0.0	83.9		Ss wh vfg cly s & p sli calc
77	3451-52	0.02	0.01	7.2	0.0	84.7		Ss wh vfg cly s & p sli calc
78	3452-53	0.02	0.02	7.4	0.0	85.1		Ss wh vfg cly s & p sli calc
79	3453-54	0.04	0.02	8.6	0.0	81.4		Ss wh vfg cly s & p sli calc
80	3454-55	0.02	0.02	9.0	0.0	80.0		Ss wh vfg cly s & p sli calc
81	3455-56	0.02	0.01	8.2	0.0	82.9		Ss wh vfg cly s & p sli calc
82	3456-57	0.02	0.02	8.3	0.0	77.1		Ss wh vfg cly s & p sli calc
83	3457-58	0.01	<0.01	5.1	0.0	82.3		Ss wh vfg cly s & p calc
84	3458-59	0.01	<0.01	5.6	0.0	80.4		Ss wh vfg cly s & p calc
85	3459-60	1.0 *	0.02	9.4	0.0	78.7	VF	Ss wh vfg cly s & p calc
86	3460-61	0.04	0.02	9.1	0.0	75.8		Ss wh vfg cly s & p sli calc
87	3461-62	0.02	0.02	10.5	0.0	76.1		Ss wh vfg cly s & p sli calc
88	3462-63	0.02	0.04	9.7	0.0	76.2		Ss wh vfg cly s & p sli calc
89	3463-64	0.01	0.02	10.9	0.0	78.9		Ss wh vfg cly s & p sli calc
90	3464-65	0.01	0.02	9.9	0.0	80.8		Ss wh vfg cly s & p sli calc
91	3465-66	0.01	0.01	9.2	0.0	82.5		Ss wh vfg cly s & p sli calc
92	3466-67	0.01	0.01	9.9	0.0	78.8		Ss wh vfg cly s & p sli calc
93	3467-68	0.01	0.01	8.5	0.0	80.0		Ss wh vfg cly s & p sli calc
94	3468-69	0.01	<0.01	6.3	0.0	79.4	VF	Ss wh vfg cly s & p calc
95	3469-70	0.01	<0.01	6.0	0.0	81.6		Ss wh vfg cly s & p calc
96	3470-71	0.02	0.01	5.7	0.0	79.0		Ss wh vfg cly s & p sli calc
97	3471-72	0.01	0.01	8.7	0.0	78.1		Ss wh vfg cly s & p calc
98	3472-73	<0.01	<0.01	7.5	0.0	85.3		Ss wh vfg cly s & p sli calc
99	3473-74	<0.01	<0.01	4.3	0.0	72.1	VF	Ss wh vfg cly s & p calc
100	3474-75	0.01	0.04	10.7	0.0	64.5	VF	Ss wh vfg cly s & p calc
101	3475-76	0.02	0.04	11.4	0.0	64.9	VF	Ss wh vfg cly s & p calc
102	3476-77	0.05	0.07	12.8	0.0	61.0	VF	Ss wh vfg cly s & p calc
103	3477-78	0.08	0.08	12.0	0.0	57.5	VF	Ss wh vfg cly s & p sli calc
104	3478-79	0.05	0.05	11.7	0.0	62.4		Ss wh vfg cly s & p sli calc
105	3479-80	0.07	0.05	11.5	0.0	61.7		Ss wh vfg cly s & p sli calc
106	3480-81	0.05	0.07	11.9	0.0	61.4		Ss wh vfg cly s & p sli calc
107	3481-82	0.04	0.08	12.3	0.0	66.7	VF	Ss wh vfg cly s & p sli calc
108	3482-83	0.07	0.07	12.5	0.8	55.1	VF	Ss wh vfg cly s & p sli calc

* DENOTES FRACTURE PERMEABILITY.

SERVICE NO. 5-A, 1-B. VF - VERTICAL FRACTURE.

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CABRESTO TIGHT GAS AREA - EXHIBIT #8

PICTURED CLIFFS CORE ANALYSIS

OPERATOR: JOHN E. SCHALK
WELL: SCHALK 29-4 #6
LOCATION: SWSW SEC 25 T29N R4W

TOP OF PICTURED CLIFFS = 4045

ALL DATA USED IN THIS ANALYSIS IS)10% POROSITY REPORTED FROM CORE ANALYSIS

SAMP NUM	TOP INTERVAL	BOTTOM INTERVAL	FOOTAGE INTERVAL	HORIZONTAL PERMEABILITY	POROSITY	WATER SATURATION
	TOTAL		59	92.39	682.2	2401.9
	AVG			1.57	11.6	40.7
18	4057	4058	1	0.12	10.6	44.3
23	4062	4063	1	0.41	12.3	46.3
24	4063	4064	1	0.52	11.8	46.6
25	4064	4065	1	0.27	11.8	50.8
26	4065	4066	1	0.58	13.1	50.4
27	4066	4067	1	0.83	12.3	54.5
28	4067	4068	1	0.37	12.6	50.0
29	4068	4069	1	1.40	10.4	53.8
30	4069	4070	1	8.60	12.8	46.9
31	4070	4071	1	7.60	12.0	45.0
33	4072	4073	1	0.66	11.3	36.3
34	4073	4074	1	0.25	11.8	49.2
35	4074	4075	1	0.50	12.0	50.0
39	4078	4079	1	0.32	11.4	47.4
40	4079	4080	1	0.18	11.5	33.0
42	4081	4082	1	0.16	15.1	31.8
43	4082	4083	~~1~~	~~56.00~~	10.0	54.0
45	4084	4085	1	0.51	11.8	41.5
48	4087	4088	1	0.08	11.5	47.8
49	4088	4089	1	0.09	13.0	46.9
70	4119	4120	1	0.10	11.5	53.9
71	4120	4121	1	1.20	10.2	59.8
93	4146	4147	1	0.93	12.3	29.3
94	4147	4148	1	2.50	11.7	12.8
96	4149	4150	1	0.29	10.0	46.0
97	4150	4151	1	0.24	14.2	42.3
98	4151	4152	1	0.22	11.5	35.7
99	4152	4153	1	0.16	12.7	22.0
101	4154	4155	1	0.66	10.8	50.0
106	4159	4160	1	0.13	11.4	40.4
107	4161	4161	1	0.23	10.1	32.7
113	4166	4167	1	0.16	10.1	30.7
114	4167	4168	1	0.11	13.3	20.3
115	4168	4169	1	0.07	11.2	35.7
133	4186	4187	1	0.02	10.0	20.0
165	4223	4224	1	0.51	10.1	71.3
170	4228	4229	1	0.10	11.5	24.3
186	4244	4245	1	0.05	10.3	36.9
190	4248	4249	1	0.09	11.1	27.0

EXHIBIT #8 - PAGE 2

SAMP NUM	TOP INTERVAL	BOTTOM INTERVAL	FOOTAGE INTERVAL	HORIZONTAL PERMEABILITY	POROSITY	WATER SATURATION
204	4262	4263	1	0.38	10.1	38.6
210	4268	4269	1	0.15	10.8	31.4
211	4269	4270	1	0.12	11.7	47.8
212	4270	4271	1	0.15	11.5	48.7
213	4271	4272	1	0.09	10.4	33.7
214	4272	4273	1	0.13	11.2	48.2
215	4273	4274	1	0.06	10.6	35.8
223	4281	4282	1	0.15	11.3	53.1
224	4282	4283	1	0.97	11.4	28.9
225	4283	4284	1	0.17	11.9	47.1
226	4284	4285	1	0.24	13.6	25.0
227	4285	4286	1	0.18	11.8	39.0
228	4286	4287	1	0.17	11.8	32.2
229	4287	4288	1	0.18	11.0	30.9
232	4290	4291	1	0.11	11.2	34.8
241	4299	4300	1	0.06	11.2	34.8
268	4326	4327	1	0.26	11.6	37.9
270	4328	4329	1	0.14	11.3	49.6
272	4330	4331	1	0.26	11.6	37.9
274	4332	4333	1	1.20	13.1	48.9

PRELIMINARY REPORT

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company John E. Shalk Formation Pictured Cliffs Page 1 of 9
Well Shalk 29-4 #6 Cores Dia. Conv. 4" File RP-3-3016
Field Basin Dakota Drilling Fluid Starch & Gel Date Report 9-13-80
County Rio Arriba State N.M. Elevation 7347 GL Analysts Getz
Location Sec.25-29N-4W Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	PERMEABILITY MILLIDARCYS 90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	REMARKS
			WHOLE CORE ANALYSIS				
1	4020-21	0.03		9.7	52.6	40.2	COAL-BLK,vf grn,VF
	4021-22	-	-	-	-	-	RUBBLE - NO ANALYSIS
2	4022-23	0.01		11.8	80.5	12.7	COAL-BLK,vf grn
3	4023-24	*		14.3	88.1	16.8	SD-BLK,vf grn,w/coal
	4024-26	-	-	-	-	-	RUBBLE - NO ANALYSIS
4	4026-27	0.01		5.6	73.2	3.6	SD-BRN,vf grn,w/coal
5	4027-28	<0.01		6.4	7.8	68.8	SD-GRY,f grn,w/cly
6	4028-29	0.52	0.46	10.1	0.0	59.4	SD-GRY,f grn,w/cly
7	4029-30	0.20	0.19	9.3	0.0	59.1	SD-GRY,f grn,w/cly
8	4030-31	0.28	0.25	12.3	4.1	48.0	SD-GRY,f grn,w/cly
	4031-32	0.08	0.06	11.5	4.3	47.8	SD-GRY,f grn,w/cly
10	4032-33	0.10	0.08	12.0	5.8	37.5	SD-GRY,f grn,w/cly
11	4033-34	0.21	0.15	14.8	4.7	37.8	SD-GRY,f grn,w/cly
12	4034-35	0.32	0.10	12.5	4.0	44.0	SD-GRY,f grn,w/cly
13	4035-36	0.13	0.08	12.4	4.0	42.7	SD-GRY,f grn,w/cly
14	4036-37	0.05	0.03	11.7	4.3	50.4	SD-GRY,f grn,w/cly
15	4037-38	0.13	0.10	9.1	5.5	53.8	SD-GRY,f grn,w/cly
	4038-55	-	-	-	-	-	CORE LOSS
16	4055-56	3.1	0.68	2.6	3.8	50.0	SD-GRY,f grn,w/cly,VF
17	4056-57	0.21	0.07	9.7	6.2	57.7	SD-GRY,f grn,w/cly
18	4057-58	0.12		10.6	8.5	44.3	SD-GRY,f grn,w/cly
19	4058-59	1.7	1.2	5.1	78.4	2.0	SD-DK GRY,vf grn,w/coal,VF
20	4059-60	0.12		1.5	0.0	13.3	SD-DK GRY,vf grn,w/cly
21	4060-61	0.14	0.08	9.7	6.2	57.7	SD-GRY,f grn,w/cly
22	4061-62	0.26	0.22	9.1	1.1	52.7	SD-GRY,f grn,w/cly
23	4062-63	0.41	0.13	12.3	4.1	46.3	SD-GRY,f grn,w/cly
24	4063-64	0.52	0.10	11.8	1.7	46.6	SD-GRY,f grn,w/cly
25	4064-65	0.27	0.26	11.8	3.4	50.8	SD-GRY,f grn,w/cly
26	4065-66	0.58	0.25	13.1	1.5	50.4	SD-GRY,f grn,w/cly
27	4066-67	0.83	0.53	12.3	0.0	54.5	SD-GRY,f grn,w/cly
28	4067-68	0.37	0.27	12.6	0.0	50.0	SD-GRY,f grn,w/cly
29	4068-69	1.4	0.98	10.4	0.0	53.8	SD-GRY,f grn,w/cly
30	4069-70	8.6	0.23	12.8	0.0	46.9	SD-GRY,f grn,w/cly
31	4070-71	7.6	0.17	12.0	0.0	45.0	SD-GRY,f grn,w/cly
32	4071-72	0.24	0.14	9.9	0.0	38.4	SD-GRY,f grn,w/cly
	4072-73	0.66	0.19	11.3	0.0	36.3	SD-GRY,f grn,w/cly

NOTE:
(*) REFER TO ATTACHED LETTER.
(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESU

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CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

Company John E. Shalk	Formation Pictured Cliffs	Page 2 of 9	
Well Shalk 29-4 #6	Cores Dia. Conv. 4"	File RP-3-3016	
Field Basin Dakota	Drilling Fluid Starch & Gel	Date Report 9-13-80	
County Rio Arriba State N.M.	Elevation 7347 GL	Analysts Getz	
Location Sec.25-29N-4W	Remarks		

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	PERMEABILITY MILLIDARCYS 90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	REMARKS
34	4073-74	0.25	0.14	11.8	0.0	49.2	SD-GRY,f grn,w/cly
35	4074-75	0.50	0.26	12.0	0.0	50.0	SD-GRY,f grn,w/cly
36	4075-76	0.09	.	7.6	0.0	68.4	SD-GRY,f grn,w/cly
37	4076-77>	2.7	0.08	3.6	25.0	50.0	SD-GRY,f grn,w/cly,w/coal
38	4077-78>	1.7	0.52	9.0	53.3	35.6	SD-GRY,f grn,w/cly,w/coal
39	4078-79	0.32	0.14	11.4	0.9	47.4	SD-GRY,f grn,w/cly
40	4079-80	0.18	0.14	11.5	7.8	33.0	SD-GRY,f grn,w/cly
41	4080-81	0.19	0.07	9.0	0.0	50.0	SD-GRY,f grn,w/cly
42	4081-82	0.16	0.05	15.1	35.1	31.8	SD-GRY,f grn,w/cly,w/coal
43	4082-83	56	11	10.0	0.0	54.0	SD-GRY,f grn,w/cly,VF
44	4083-84	2.2	0.51	2.5	0.0	60.0	SD-GRY,f grn,w/cly
45	4084-85	0.51	0.41	11.8	5.9	41.5	SD-GRY,f grn,w/cly
	4085-86	0.32	0.30	9.5	0.0	44.2	SD-GRY,f grn,w/cly
47	4086-87	0.01		6.6	0.0	72.7	SD-GRY,f grn,w/cly
48	4087-88	0.08		11.5	0.0	47.8	SD-GRY,f grn,w/cly
49	4088-89	0.09		13.0	0.0	46.9	SD-GRY,f grn,w/cly
	4089-90	- -	- -	- -	- -	- -	RUBBLE - NO ANALYSIS
50	4090-91	0.04		8.5	0.0	65.9	SD-GRY,f grn,w/cly
51	4091-92	0.14	0.01	6.1	0.0	72.1	SD-GRY,f grn,w/cly
	4092-93	- -	- -	- -	- -	- -	RUBBLE - NO ANALYSIS
52	4093-94	0.01		6.5	0.0	70.8	SD-GRY,f grn,w/cly
53	4094-95	0.05	0.01	7.4	0.0	67.6	SD-GRY,f grn,w/cly
54	4095-96	1.1	0.05	7.5	0.0	62.7	SD-GRY,f grn,w/cly
55	4096-97	0.02		7.5	0.0	60.0	SD-GRY,f grn,w/cly
	4097-99	- -	- -	- -	- -	- -	RUBBLE - NO ANALYSIS
56	4099-00	0.16	0.07	7.3	0.0	65.8	SD-GRY,f grn,w/cly
57	4100-01	0.04	0.04	7.2	0.0	65.3	SD-GRY,f grn,w/cly
58	4101-02	0.07	0.03	6.7	0.0	62.7	SD-GRY,f grn,w/cly
	4102-08	- -	- -	- -	- -	- -	RUBBLE - NO ANALYSIS
59	4108-09	0.01		5.4	0.0	79.6	SD-GRY,f grn,w/cly,VF
60	4109-10	<0.01		5.3	0.0	50.9	SD-GRY,f grn,w/cly,VF
61	4110-11	<0.01		4.3	0.0	39.5	SD-GRY,f grn,w/cly,VF
62	4111-12	<0.01		4.1	0.0	36.6	SD-GRY,f grn,w/cly,VF
63	4112-13	0.01		6.9	0.0	62.3	SD-GRY,f grn,w/cly,VF
64	4113-14	0.01		6.7	0.0	61.2	SD-GRY,f grn,w/cly,VF
65	4114-15	<0.01		7.8	0.0	67.9	SD-GRY,f grn,w/cly,VF
66	4115-16	0.01		8.2	0.0	69.5	SD-GRY,f grn,w/cly,VF
	4116-17	0.64	0.04	8.2	0.0	69.5	SD-GRY,f grn,w/cly,VF

NOTE:
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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company: John E. Shalk | Formation: Pictured Cliffs | Page 3 of 9
Well: Shalk 29-4 #6 | Cores: Dia. Conv. 4" | File: RP-3-3016
Field: Basin Dakota | Drilling Fluid: Starch & Gel | Date Report: 9-13-80
County: Rio Arriba State: N.M. | Elevation: 7347 GL | Analysts: Getz
Location: Sec.25-29N-4W | Remarks:

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	TOTAL WATER % PORE	REMARKS
68	4117-18	0.01		7.0	2.9	60.0	SD-GRY,f grn,w/cly,shl lam
69	4118-19	0.09		7.1	1.4	62.0	SD-GRY,f grn,w/cly,shl lam
70	4119-20	0.10		11.5	0.9	53.9	SD-GRY,f grn,w/cly
71	4120-21	1.2	0.40	10.2	0.0	59.8	SD-GRY,f grn,w/cly
72	4121-22	0.32	0.20	7.9	0.0	75.9	SD-GRY,f grn,w/cly
73	4122-23	0.02		7.0	0.0	75.7	SD-GRY,f grn,w/cly
74	4123-24	0.02	0.02	7.0	0.0	74.3	SD-GRY,f grn,w/cly
75	4124-25	<0.01		9.0	0.0	75.7	SD-GRY,f grn,w/cly
	4125-29	- - -	- - -	- - -	- - -	- - -	DRILLED
76	4129-30	0.03		3.0	16.7	56.7	SD-DK GRY,vf grn,v/shl
77	4130-31	<0.01		3.7	13.5	62.2	SD-DK GRY,vf grn,v/shl
78	4131-32	0.07		4.1	0.0	63.4	SD-GRY,vf grn,v/shl
[illegible]	4132-33	0.03		7.0	0.0	51.4	SD-GRY,vf grn,v/shl
[illegible]	4133-34	<0.01		5.7	0.0	49.1	SD-GRY,f grn,w/shl,VF
81	4134-35	0.03		5.9	0.0	47.5	SD-GRY,f grn,w/shl,VF
82	4135-36	0.02		3.9	0.0	69.2	SD-DK GRY,vf grn,v/shl
83	4136-37	<0.01		4.1	12.8	61.0	SD-DK GRY,vf grn,v/shl,VF
84	4137-38	<0.01		4.0	12.5	60.0	SD-DK GRY,vf grn,v/shl,VF
85	4138-39	0.19		6.9	7.2	42.0	SD-GRY,f grn,w/shl
86	4139-40	0.08		2.0	25.0	30.0	SD-GRY,f grn,w/shl
87	4140-41	0.06		5.0	4.0	72.0	SD-GRY,f grn,w/shl
88	4141-42	0.02		4.9	0.0	57.1	SD-GRY,f grn,w/shl,VF
89	4142-43	0.07		4.1	0.0	80.5	SD-DK GRY,vf grn,v/shl
90	4143-44	0.04	0.01	5.2	0.0	73.1	SD-GRY,f grn,w/shl
91	4144-45	0.03	0.03	1.2	16.7	16.7	SD-GRY,f grn,w/shl
92	4145-46	0.01		6.5	0.0	36.9	SD-DK GRY,vf grn,v/shl
93	4146-47	0.93	0.77	12.3	0.0	29.3	SD-GRY,f grn,w/shl
94	4147-48	2.5	0.68	11.7	0.0	12.8	SD-GRY,f grn,w/cly
95	4148-49	9.6	0.68	13.5	0.0	30.4	SD-GRY,f grn,w/cly
96	4149-50	0.29	0.23	10.0	0.0	46.0	SD-GRY,f grn,w/cly
97	4150-51	0.24		14.2	0.0	42.3	SD-GRY,f grn,w/cly
98	4151-52	0.22		11.5	0.0	35.7	SD-GRY,f grn,w/cly
99	4152-53	0.16		12.7	0.0	22.0	SD-GRY,f grn,w/cly
100	4153-54	0.24		9.6	0.0	49.0	SD-GRY,f grn,w/cly
101	4154-55	0.66		10.8	0.0	50.0	SD-GRY,f grn,w/cly
102	4155-56	0.02		7.6	0.0	23.7	SD-GRY,f grn,w/cly
103	4156-57	0.35	0.14	3.1	0.0	80.6	SD-GRY,f grn,w/cly
1	4157-58	1.2	0.01	7.2	0.0	51.4	SD-GRY,f grn,w/cly

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NOTE:
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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company John E. Shalk | Formation Pictured Cliffs | Page 4 of 9
Well Shalk 29-4 #6 | Cores Dia. Conv. 4" | File RP-3-3016
Field Basin Dakota | Drilling Fluid Starch & Gel | Date Report 9-13-80
County Rio Arriba State N.M. | Elevation 7347 GL | Analysts Getz
Location Sec.25-29N-4W | Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	TOTAL WATER % PORE	REMARKS
105	4158-59	1.3	0.30	9.8	0.0	45.9	SD-GRY,f grn,w/cly
106	4159-60	0.13		11.4	0.0	40.4	SD-GRY,f grn,w/cly
107	4160-61	0.23	0.04	10.1	0.0	32.7	SD-GRY,f grn,w/cly
108	4161-62	0.09	0.08	9.3	0.0	35.5	SD-GRY,f grn,w/cly
109	4162-63	0.04	0.02	8.9	0.0	28.1	SD-GRY,f grn,w/cly
110	4163-64	0.08	0.03	9.2	0.0	20.7	SD-GRY,f grn,w/cly
111	4164-65	0.02		8.7	0.0	28.7	SD-GRY,f grn,w/cly
112	4165-66	0.26	0.21	9.1	0.0	20.9	SD-GRY,f grn,w/cly
113	4166-67	0.16		10.1	0.0	30.7	SD-GRY,f grn,w/cly
114	4167-68	0.11	0.01	13.3	0.0	20.3	SD-GRY,f grn,w/cly
115	4168-69	0.07	0.04	11.2	0.0	35.7	SD-GRY,f grn,w/cly
116	4169-70	0.09	0.01	9.5	0.0	18.9	SD-GRY,f grn,w/cly
1	4170-71	0.03		7.6	0.0	28.9	SD-GRY,f grn,w/cly
118	4171-72	0.04	0.01	7.8	0.0	32.1	SD-GRY,f grn,w/cly
119	4172-73	3.5	0.02	6.9	0.0	33.3	SD-GRY,f grn,w/cly
120	4173-74	0.17	0.05	8.9	0.0	37.1	SD-GRY,f grn,w/cly
121	4174-75	0.04		5.8	0.0	23.0	SD-GRY,f grn,w/cly
122	4175-76	0.24	0.01	8.7	0.0	13.8	SD-GRY,f grn,w/cly
123	4176-77	0.04		7.2	0.0	36.1	SD-GRY,f grn,w/cly,VF
124	4177-78	0.04		6.9	0.0	8.7	SD-GRY,f grn,w/cly,VF
125	4178-79	0.71		3.2	6.3	59.4	SD-DK GRY,vf grn,v/shl,VF
126	4179-80	0.05		3.7	5.4	37.8	SD-DK GRY,vf grn,w/shl,VF
127	4180-81	0.05		8.0	6.3	25.0	SD-GRY.f grn,w/cly,VF
128	4181-82	0.01		4.9	0.0	83.7	SD-DK GRY,vf grn,v/shl,VF
129	4182-83	0.02		3.9	2.6	48.7	SD-DK GRY,vf grn,v/shl,VF
130	4183-84	0.01		3.2	6.3	53.1	SD-DK GRY,vf grn,v/shl,VF
131	4184-85	0.01		3.8	21.1	52.6	SD-DK GRY,vf grn,v/shl,VF
132	4185-86	0.01		2.8	28.6	32.1	SD-DK GRY,vf grn,v/shl,VF
133	4186-87	0.02		1.0	10.0	20.0	SD-DK GRY,vf grn,v/shl,VF
	4187-88	-	-	-	-	-	RUBBLE - NO ANALYSIS
134	4188-89	<0.01		1.8	5.6	72.2	SD-DK GRY,vf grn,w/shl,VF
135	4189-90	<0.01		5.3	9.4	69.8	SD-DK GRY,vf grn,w/shl,VF
136	4190-91	<0.01		3.9	5.1	74.4	SD-DK GRY,vf grn,w/shl,VF
137	4191-92	<0.01		2.3	0.0	73.9	SD-DK GRY,vf grn,w/shl,VF
138	4192-93	<0.01		3.9	2.9	89.7	SD-DK GRY,vf grn,w/shl,VF
139	4193-94	<0.01		3.5	2.9	88.6	SD-DK GRY,vf grn,w/shl,VF
140	4194-95	<0.01		3.5	0.0	82.9	SD-DK GRY,vf grn,w/shl,VF
1	4195-96	<0.01		2.9	0.0	72.4	SD-DK GRY,vf grn,w/shl,VF
142	4196-97	<0.01		2.5	0.0	84.0	SD-DK GRY,vf grn,w/shl,VF

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company John E. Shalk — Formation Pictured Cliffs — Page 5 of 9
Well Shalk 29-4 #6 — Cores Dia. Conv. 4" — File RP-3-3016
Field Basin Dakota — Drilling Fluid Starch & Gel — Date Report 9-13-80
County Rio Arriba State N.M. — Elevation 7347 GL — Analysts Getz
Location Sec.25-29N-4W — Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	PERMEABILITY MILLIDARCYS 90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	REMARKS
143	4197-98	0.60	0.07	4.1	12.2	70.7	SD-DK GRY,vf grn,shl/lam
144	4198-99	<0.01		4.7	4.3	85.1	SD-DK GRY,vf grn,shl/lam
145	4199-00	1.0	0.12	3.2	3.1	84.4	SD-DK GRY,vf grn,shl/lam
146	4200-01	<0.01		4.5	3.1	88.9	SD-DK GRY,vf grn,shl/lam
147	4201-02	<0.01		4.0	12.5	77.5	SD-DK GRY,vf grn,shl/lam
	4202-03	- - -	- - -	- - -	- - -	- - -	SHALE & COAL - NO ANALYSIS
	4203-04	- - -	- - -	- - -	- - -	- - -	COAL - NO ANALYSIS
	4204-05	- - -	- - -	- - -	- - -	- - -	SHALE & COAL - NO ANALYSIS
	4205-06	- - -	- - -	- - -	- - -	- - -	COAL - NO ANALYSIS
148	4206-07	0.01		8.2	53.7	41.5	SD-DK BRN,vf grn,w/shl,w/coal
149	4207-08	0.01		5.4	29.6	55.6	SD-DK BRN,vf grn,w/shl
150	4208-09	0.01		7.2	26.4	61.1	SD-DK BRN,vf grn,w/shl
1	4209-10	0.07		6.8	10.3	66.2	SD-GRY,f grn,sl sh/lam
152	4210-11	0.15		6.1	0.0	72.1	SD-GRY,f grn,sl sh/lam,VF
153	4211-12	0.05		7.2	6.9	56.9	SD-GRY,f grn,w/cly
154	4212-13	0.04		7.8	8.9	52.6	SD-GRY,f grn,w/cly,VF
155	4213-14	0.07		9.8	11.2	34.7	SD-GRY,f grn,w/cly,VF
156	4214-15	0.15		8.7	9.0	46.0	SD-GRY,f grn,w/cly,VF
157	4215-16	0.06		4.8	0.0	81.3	SD-GRY,f grn,sl shl/lam,VF
158	4216-17	0.03		5.9	8.5	66.1	SD-GRY,f grn,sl shl/lam,VF
159	4217-18	0.31		5.9	3.4	76.3	SD-BRN,f grn,w/shl,w/coal,VF
160	4218-19	0.10		5.7	12.3	75.4	SD-BRN,f grn,w/shl,w/coal
161	4219-20	0.01		4.8	0.0	81.3	SD-GRY,f grn,sl shl,w/cly
162	4220-21	0.1	<0.01	5.1	0.0	80.4	SD-GRY,f grn,sl shl,w/cly
163	4221-22	0.22		5.2	0.0	80.8	SD-GRY,f grn,sl shl,w/cly,VF
164	4222-23	0.05		5.1	2.0	82.4	SD-GRY,f grn,sl shl,w/cly,VF
165	4223-24	0.51	0.05	10.1	2.0	71.3	SD-GRY,f grn,sl shl,w/cly
166	4224-25	0.05		4.0	2.5	77.6	SD-GRY,f grn,sl shl,w/cly,VF
167	4225-26	1.8	1.8	7.0	7.1	71.4	SD-GRY,f grn,sl shl,w/cly
168	4226-27	0.06		5.3	1.4	83.0	SD-GRY,f grn,sl shl,w/cly,VF
169	4227-28	0.05		6.2	3.2	71.0	SD-GRY,f grn,sl shl,w/cly,VF
170	4228-29	0.10		11.5	11.3	24.3	SD-GRY,f grn,sl shl,w/cly,VF
171	4229-30	0.07		4.1	2.4	75.6	SD-GRY,f grn,sl shl,w/cly,VF
172	4230-31	0.03		10.0	11.0	32.0	SD-GRY,f grn,sl shl,w/cly
173	4231-32	0.29		3.9	2.6	74.4	SD-GRY,f grn,sl shl,w/cly
174	4232-33	0.26	<0.01	5.1	0.0	76.5	SD-GRY,f grn,sl shl,w/cly
175	4233-34	0.32	0.31	4.6	0.0	80.4	SD-GRY,f grn,sl shl,w/cly
1	4234-35	0.01		5.4	0.0	81.5	SD-GRY,f grn,sl shl,w/cly
177	4235-36	0.57	0.09	5.1	0.0	78.4	SD-GRY,f grn,sl shl,w/cly

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company John E. Shalk — Formation Pictured Cliffs — Page 6 of 9
Well Shalk 29-4 #6 — Cores Dia. Conv. 4" — File RP-3-3016
Field Basin Dakota — Drilling Fluid Starch & Gel — Date Report 9-13-80
County Rio Arriba State N.M. — Elevation 7347 GL — Analysts Getz
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CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	PERMEABILITY MILLIDARCYS 90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	RESIDUAL SATURATION TOTAL WATER % PORE	REMARKS
178	4236-37	0.47	<0.01	4.9	0.0	75.5	SD-GRY,f grn,sl shl,w/cly
179	4237-38	0.03	<0.01	5.3	0.0	81.1	SD-GRY,f grn,sl shl,w/cly
180	4238-39	0.04	<0.01	5.1	0.0	70.6	SD-GRY,f grn,sl shl,w/cly
181	4239-40	<0.01		4.9	0.0	83.7	SD-GRY,f grn,sl shl,w/cly
182	4240-41	<0.01		5.1	0.0	78.6	SD-GRY,f grn,sl shl,w/cly
183	4241-42	<0.01		4.9	0.0	81.6	SD-GRY,f grn,w/shl
184	4242-43	<0.01		4.5	20.0	64.4	SD-DK GRY,vf grn,w/shl,sl co
185	4243-44	0.01		3.5	0.0	82.9	SD-DK GRY,f grn,sl shl,w/cly
186	4244-45	0.05		10.3	1.9	36.9	SD-GRY,f grn,sl shl,w/cly,VF
187	4245-46	0.03		9.0	1.1	42.2	SD-GRY,f grn,sl shl,w/cly,VF
188	4246-47	0.07		8.5	0.0	17.6	SD-GRY,f grn,sl shl,w/cly,VF
189	4247-48	0.05		9.6	1.0	34.4	SD-GRY,f grn,sl shl,w/cly
[illegible]	4248-49	0.09		11.1	4.5	27.0	SD-GRY,f grn,sl shl,w/cly
[illegible]	4249-50	0.02		9.9	5.1	25.3	SD-GRY,f grn,sl shl,w/cly
192	4250-51	0.13		9.4	0.0	38.3	SD-GRY,f grn,sl shl,w/cly
193	4251-52	0.02		6.0	1.7	66.7	SD-GRY,f grn,sl shl,w/cly
194	4252-53	0.03		6.9	7.2	49.3	SD-GRY,f grn,w/cly
195	4253-54	0.03		8.0	0.0	53.8	SD-GRY,f grn,w/cly
196	4254-55	0.02		6.5	3.1	50.8	SD-GRY,f grn,w/cly
197	4255-56	0.03		7.1	1.4	63.4	SD-GRY,f grn,w/cly
198	4256-57	0.04	<0.01	5.4	3.7	74.1	SD-GRY,f grn,w/cly
199	4257-58	0.03	0.01	6.3	1.6	57.1	SD-GRY,f grn,w/cly
200	4258-59	0.10	<0.01	6.6	0.0	80.3	SD-GRY,f grn,w/cly
201	4259-60	0.02		3.4	0.0	79.4	SD-GRY,f grn,w/cly
202	4260-61	0.01		3.0	3.3	76.7	SD-GRY,f grn,w/cly
203	4261-62	0.02		7.4	0.0	59.5	SD-GRY,f grn,w/cly
204	4262-63	0.38	0.12	10.1	0.0	38.6	SD-GRY,f grn,w/cly,VF
205	4263-64	0.17	0.15	6.1	1.6	72.1	SD-GRY,f grn,w/cly,VF
206	4264-65	2.2	0.55	8.5	0.0	52.9	SD-GRY,f grn,w/cly,VF
207	4265-66	0.31	0.08	9.0	0.0	32.3	SD-GRY,f grn,w/cly,VF
208	4266-67	0.07		4.6	0.0	71.7	SD-GRY,f grn,w/cly,VF
209	4267-68	0.78		8.3	0.0	45.8	SD-GRY,f grn,w/cly,VF
210	4268-69	0.15		10.8	0.0	31.4	SD-GRY,f grn,w/cly,VF
211	4269-70	0.12		11.7	0.0	47.8	SD-GRY,f grn,w/cly,VF
212	4270-71	0.15		11.5	0.0	48.7	SD-GRY,f grn,w/cly,VF
213	4271-72	0.09		10.4	0.0	33.7	SD-GRY,f grn,w/cly,VF
214	4272-73	0.13		11.2	0.0	48.2	SD-GRY,f grn,w/cly,VF
[illegible]	4273-74	0.06		10.6	0.0	35.8	SD-GRY,f grn,w/cly,VF

NOTE:
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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company John E. Shalk | Formation Pictured Cliffs | Page 7 of 9
Well Shalk 29-4 #6 | Cores Dia. Conv. 4" | File RP-3-3016
Field Basin Dakota | Drilling Fluid Starch & Gel | Date Report 9-13-80
County Rio Arriba State N.M. | Elevation 7347 GL | Analysts Getz
Location Sec.25-29N-4W | Remarks

CORE ANALYSIS RESULTS
(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	TOTAL WATER % PORE	REMARKS
216	4274-75	0.10		8.9	0.0	57.3	SD-GRY,f grn,w/cly,VF
217	4275-76	0.10		8.3	0.0	47.0	SD-GRY,f grn,w/cly,VF
218	4276-77	0.05		7.2	0.0	37.5	SD-GRY,f grn,w/cly,VF
219	4277-78	0.66	0.02	6.5	0.0	50.8	SD-GRY,f grn,w/cly,VF
220	4278-79	0.07	0.07	6.9	0.0	50.8	SD-GRY,f grn,w/cly,VF
221	4279-80	0.05		9.1	0.0	53.8	SD-GRY,f grn,w/cly,VF
222	4280-81	0.01		5.1	0.0	86.3	SD-GRY,f grn,w/cly,VF
223	4281-82	0.15		11.3	0.0	53.1	SD-GRY,f grn,w/cly,VF
224	4282-83	0.97		11.4	0.0	28.9	SD-GRY,f grn,w/cly,VF
225	4283-84	0.17		11.9	0.0	47.1	SD-GRY,f grn,w/cly,VF
226	4284-85	0.24		13.6	0.0	25.0	SD-GRY,f grn,w/cly,VF
227	4285-86	0.18		11.8	0.8	39.0	SD-GRY,f grn,w/cly,VF
2[illegible]	4286-87	0.17		11.8	0.0	32.2	SD-GRY,f grn,w/cly,VF
2[illegible]9	4287-88	0.18		11.0	0.0	30.9	SD-GRY,f grn,w/cly,VF
230	4288-89	0.05		8.1	0.0	48.1	SD-GRY,f grn,w/cly,VF
231	4289-90	0.09		9.2	0.0	59.8	SD-GRY,f grn,w/cly,VF
232	4290-91	0.11	0.04	11.2	0.9	34.8	SD-GRY,f grn,w/cly,VF
233	4291-92	0.05		8.9	1.1	59.6	SD-GRY,f grn,w/cly,VF
234	4292-93	0.04	<0.01	9.1	1.1	59.6	SD-GRY,f grn,w/cly
235	4293-94	0.04	<0.01	6.7	0.0	65.7	SD-GRY,f grn,w/cly
236	4294-95	9.64		6.1	3.3	86.9	SD-DK GRY,vf grn,v/shl,VF
237	4295-96	<0.01		4.8	4.2	87.5	SD-DK GRY,vf grn,v/shl,VF
238	4296-97	<0.01		2.2	0.0	95.5	SD-DK GRY,vf grn,v/shl
239	4297-98	0.05		7.0	1.4	58.6	SD-GRY,f grn,w/cly
240	4298-99	0.09		7.3	0.0	30.1	SD-GRY,f grn,w/cly
241	4299-00	0.06		11.2	0.0	34.8	SD-GRY,f grn,w/cly
242	4300-01	0.05		4.6	0.0	39.1	SD-GRY,f grn,w/cly
243	4301-02	<0.01		5.3	1.9	28.3	SD-DK GRY,vf grn,v/shl
244	4302-03	<0.01		3.9	0.0	58.9	SD-GRY,f grn,w/cly
245	4303-04	0.15	0.13	9.5	0.0	34.7	SD-GRY,f grn,w/cly
246	4304-05	0.06	0:06	6.7	0.0	38.8	SD-GRY,f grn,w/cly
247	4305-06	3.9	0.13	6.8	0.0	37.9	SD-GRY,f grn,w/cly
248	4306-07	0.05		8.6	0.0	39.8	SD-DK GRY,vf grn,v/shl
249	4307-08	0.04		6.7	0.0	46.3	SD-DK GRY,vf grn,v/shl
250	4308-09	0.02		4.3	2.3	88.4	SD-GRY,f grn,w/shl
251	4309-10	0.03		6.0	0.0	75.0	SD-GRY,f grn,sl shl
252	4310-11	1.88		9.2	0.0	45.7	SD-GRY,f grn,w/shl
2[illegible]	4311-12	<0.01		4.8	0.0	83.3	SD-GRY,f grn,w/shl
254	4312-13	<0.01		4.1	0.0	95.1	SD-DK GRY,f grn,v/shl

NOTE:
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(1) INCOMPLETE CORE RECOVERY—INTERPRETATION RESERVED.
(2) OFF LOCATION ANALYSES—NO INTERPRETATION OF RESU[illegible]

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company	John E. Shalk	Formation	Pictured Cliffs	Page	8 of 9
Well	Shalk 29-4 #6	Cores	Dia. Conv. 4"	File	RP-3-3016
Field	Basin Dakota	Drilling Fluid	Starch & Gel	Date Report	9-13-80
County	Rio Arriba State N.M.	Elevation	7347 GL	Analysts	Getz
Location	Sec.25-29N-4W	Remarks			

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	PERMEABILITY MILLIDARCYS 90°	POROSITY PERCENT	RESIDUAL SATURATION OIL % PORE	RESIDUAL SATURATION TOTAL WATER % PORE		REMARKS
255	4313-14	<0.01		1.5	6.7	46.7		SD-DK GRY,vf grn,v/shl
256	4314-15	<0.01		4.0	0.0	90.0		SD-DK GRY,vf grn,v/shl
257	4315-16	0.05		6.1	13.1	75.4		SD-DK GRY,vf grn,w/shl
258	4316-17	0.51		3.5	17.1	68.6		SD-DK GRY,vf grn,w/shl
259	4317-18	0.04		4.2	2.4	85.7		SD-DK GRY,vf grn,v/shl,VF
260	4318-19	0.06		1.9	0.0	78.9		SD-DK GRY,vf grn,v/shl
261	4319-20	<0.01		6.5	18.5	73.8		SD-DK GRY,vf grn,w/shl,VF
262	4320-21	<0.01		3.5	0.0	85.7		SD-DK GRY,vf grn,w/shl
263	4321-22	<0.01		6.2	0.0	64.5		SD-GRY,f grn,w/shl
264	4322-23	<0.01		7.8	0.0	51.3		SD-GRY,f grn,sl shl
265	4323-24	0.02		5.9	0.0	57.6		SD-GRY,f grn,w/cly
266	4324-25	0.01		5.7	0.0	63.2		SD-GRY,f grn,w/cly
26[illegible]	4325-26	0.22	0.08	6.6	0.0	63.6		SD-GRY,f grn,w/cly
26[illegible]	4326-27	0.26		11.6	6.0	37.9		SD-GRY,f grn,w/cly
269	4327-28	0.20		7.0	0.0	65.7		SD-GRY,f grn,w/cly,VF
270	4328-29	0.14		11.3	0.0	49.6		SD-GRY,f grn,w/cly,VF
271	4329-30	0.10	0.07	7.7	0.0	29.9		SD-GRY,f grn,w/cly,VF
272	4330-31	0.26		11.6	6.0	37.9		SD-GRY,f grn,w/cly,VF
273	4331-32	0.54	0.32	9.5	0.0	61.1		SD-GRY,f grn,w/cly,VF
274	4332-33	1.2		13.1	3.8	48.9		SD-GRY,f grn,w/cly,VF
275	4333-34	0.01		2.9	0.0	72.4		SD-GRY,f grn,w/shl,VF
276	4334-35	0.05		6.3	0.0	46.0		SD-GRY,f grn,w/shl,VF
277	4335-36	0.03		6.9	0.0	29.0		SD-GRY,f grn,w/shl,VF
278	4336-37	0.10		6.2	1.6	60.0		SD-GRY,f grn,w/shl,VF
279	4337-38	0.04		4.8	0.0	58.3		SD-GRY,f grn,w/shl,VF
280	4338-39	0.56	0.32	4.9	0.0	69.4		SD-DK GRY,vf grn,v/shl,VF
281	4339-40	0.03		4.7	0.0	83.0		SD-DK GRY,vf grn,v/shl,VF
282	4340-41	<0.01		5.0	0.0	82.0		SD-DK GRY,vf grn,v/shl,VF
283	4341-42	<0.01		4.2	0.0	69.0		SD-GRY,f grn,w/cly,VF
284	4342-43	0.04		4.8	0.0	54.2		SD-GRY,f grn,w/cly,VF
285	4343-44	0.03		4.9	2.0	77.6		SD-DK GRY,vf grn,v/shl,VF
286	4344-45	0.01		3.9	2.6	74.4		SD-DK GRY,vf grn,v/shl,VF
287	4345-46	<0.01		3.9	0.0	84.6		SD-DK GRY,vf grn,w/shl,VF
288	4346-47	<0.01		9.3	0.0	91.4		SD-DK GRY,vf grn,w/shl,VF
289	4347-48	<0.01		3.9	0.0	84.6		SD-DK GRY,vf grn,v/shl,VF
290	4348-49	<0.01		4.7	2.1	78.7		SD-DK GRY,vf grn,v/shl
291	4349-50	<0.01		1.7	5.9	58.8		SD-DK GRY,vf grn,v/shl,VF
2[illegible]	4350-51	<0.01		3.8	2.6	81.6		SD-DK GRY,vf grn,v/shl,VF
293	4351-52	0.02		2.7	3.7	77.8		SD-DK GRY,vf grn,v/shl,VF

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Company John E. Shalk — Formation Pictured Cliffs — Page 9 of 9
Well Shalk 29-4 #6 — Cores Dia. Conv. 4" — File RP-3-3016
Field Basin Dakota — Drilling Fluid Starch & Gel — Date Report 9-13-80
County Rio Arriba State N.M. — Elevation 7347 GL — Analysts Ge tz
Location Sec.25-29N-4W — Remarks

CORE ANALYSIS RESULTS

(Figures in parentheses refer to footnote remarks)

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS		POROSITY PERCENT	RESIDUAL SATURATION			REMARKS
		MAX.	90°		OIL % PORE	TOTAL WATER % PORE		
294	4352-53	<0.01		4.2	11.9	73.8		SD-DK GRY,vf grn,v/shl,VF
295	4353-54	0.07		1.1	0.0	36.4		SD-DK GRY,vf grn,v/shl,VF
296	4354-55	<0.01		2.7	0.0	70.4		SD-DK GRY,vf grn,v/shl,VF
297	4355-56	<0.01		2.3	8.7	65.2		SD-DK GRY,vf grn,v/shl,VF
298	4356-57	0.01		4.3	2.3	62.8		SD-DK GRY,vf grn,v/shl,VF
299	4357-58	<0.01		3.5	2.9	77.1		SD-DK GRY,vf grn,v/shl
300	4358-59	0.04		2.4	4.2	87.5		SD-DK GRY,vf grn,v/shl
301	4359-60	0.01		1.5	6.7	66.7		SD-DK GRY,vf grn,v/shl
302	4360-61	0.18		4.1	21.9	61.0		SD-GRY,f grn,w/shl
303	4361-62	<0.01		3.3	3.0	75.8		SD-GRY,f grn,w/shl
304	4362-63	<0.01		3.3	6.1	75.8		SD-GRY,f grn,w/shl
305	4363-64	<0.01		1.2	0.0	33.3		SD-GRY,f grn,w/shl
[illegible]	4364-65	<0.01		3.1	3.2	80.6		SD-GRY,f grn,w/shl
307	4365-66	0.01		2.8	3.6	82.1		SD-DK GRY,vf grn,v/shl,VF

Conventional plug used where whole core permeability was unsuitable for analysis.

Depths 4262-4293 may contain some induced vertical fractures.(VF).

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CABRESTO TIGHT GAS AREA - EXHIBIT #9

PICTURED CLIFFS CORE ANALYSIS

OPERATOR: ROBERT L. BAYLESS
WELL: JIC 459 #5
LOCATION: SESE SEC 19 T30N R3W

TOP OF PICTURED CLIFFS = 3846

ALL DATA USED IN THIS ANALYSIS IS >10% POROSITY REPORTED FROM CORE ANALYSIS

SAMP NUM	TOP INTERVAL	BOTTOM INTERVAL	FOOTAGE INTERVAL	HORIZONTAL PERMEABILITY	POROSITY	WATER SATURATION
	TOTAL		18	1.05	215.5	633.3
	AVG			0.06	12.0	35.2
1	3849	3850	1	0.03	10.9	66.5
2	3850	3851	1	0.06	13.8	67.2
6	3866	3867	1	0.02	11.1	22.3
10	3877	3878	1	0.08	13.3	18.7
11	3878	3879	1	0.09	13.1	17.6
12	3879	3880	1	0.11	12.9	25.0
13	3881	3882	1	0.12	13.7	16.9
14	3883	3884	1	0.03	11.0	34.2
15	3885	3886	1	0.12	13.2	21.5
16	3887	3888	1	0.04	12.4	41.0
17	3892	3893	1	0.04	10.7	40.5
18	3894	3895	1	0.04	12.8	26.6
19	3897	3898	1	0.03	11.1	49.1
20	3903	3904	1	0.03	11.2	54.2
22	3911	3912	1	0.04	10.9	37.6
23	3913	3914	1	0.08	10.9	33.3
24	3915	3916	1	0.06	12.4	18.4
25	3923	3924	1	0.03	10.1	42.7

CORE LABORATORIES

ompany : Robert L. Bayless
ell : Jicarilla 459 No. 5 Well
ocation : SE SE Sec. 19 T30N R3W
o,State : Rio Arriba, New Mexico

Field : Wildcat
Formation : As Noted
Coring Fluid : Water Base Mud
Elevation : 7274 KB

File No.: 57121-8279
Date : 27-Dec-1988
API No. :
Analysts: FD MW

C O R E   A N A L Y S I S   R E S U L T S

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	SATURATION (PORE VOLUME)		GRAIN DENSITY	DESCRIPTION
	ft	(MAXIMUM) Kair md	(90 DEG) Kair md	%	OIL %	WATER %	gm/cc	
		Core No.1 Fruitland Formation 3803.0-3833.0 Cut 30.0' Rec. 30.0'						
	3803.0- 33.0							Coal -- No Analysis Requested
		Core No.2 Fruitland Formation 3833.0-3842.0 Cut 9.0' Rec. 9.0'						
	3833.0- 42.0							No Analysis Requested
		Core No.3 Fruitland Formation 3842.0-3872.0 Cut 30.0' Rec. 30.0'						
	3842.0- 49.0							No Analysis Requested
1	3849.0- 50.0	0.03		10.9	5.9	66.5	2.69	Sst gry f gr arg sli sh sli calc sli glauc
2	3850.0- 51.0	0.06		13.8	14.7	67.2	2.67	Sst gry f gr arg sli sh sli calc sli glauc
	3851.0- 57.0							No Analysis Requested
3	3857.0- 58.0	<.01		6.6	13.4	76.9	2.70	Sst gry f gr arg sli sh sli calc sli glauc
	3858.0- 61.0							No Analysis Requested
4	3861.0- 62.0	<.01		6.2	21.9	60.2	2.70	Sst gry f gr arg sli sh sli calc sli glauc
	3862.0- 65.0							No Analysis Requested
5	3865.0- 66.0	0.02		8.9	0.4	77.5	2.69	Sst gry f gr arg sli sh sli calc sli glauc
6	3866.0- 67.0	0.02		11.1	3.7	22.3	2.67	Sst gry f gr arg sli sh sli calc sli glauc
	3867.0- 69.0							No Analysis Requested
7	3869.0- 70.0	0.01		7.0	0.0	35.3	2.69	Sst gry f gr arg sli sh sli calc sli glauc
	3870.0- 71.0							No Analysis Requested
8	3871.0- 72.0	0.03		9.0	0.2	17.1	2.69	Sst gry f gr arg sh sli calc sli glauc

CORE LABORATORIES

Company : Robert L. Bayless
Well : Jicarilla 459 No. 5 Well

Field : Wildcat
Formation : As Noted

File No.: 57121-8279
Date : 27-Dec-1988

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	SATURATION (PORE VOLUME)		GRAIN DENSITY	DESCRIPTION
		(MAXIMUM) Kair	(90 DEG) Kair		OIL	WATER		
	ft	md	md	%	%	%	gm/cc	
		Core No.4 Pictured Cliffs Formation 3872.0-3932.0 Cut 60.0' Rec. 60.0'						
	3872.0- 74.0							No Analysis Requested
9	3874.0- 75.0	0.02		8.7	0.2	28.9	2.70	Sst gry f gr arg sh sli calc sli glauc
	3875.0- 77.0							No Analysis Requested
10	3877.0- 78.0	0.08		13.3	0.0	18.7	2.68	Sst gry f gr arg sli calc sli glauc
11	3878.0- 79.0	0.09		13.1	0.0	17.6	2.68	Sst gry f gr arg sli calc sli glauc
+ 12	3879.0- 80.0	0.11	0.10	12.9	0.0	25.0	2.69	Sst gry f gr arg sli calc sli glauc
	3880.0- 81.0							No Analysis Requested
13	3881.0- 82.0	0.12		13.7	0.0	16.9	2.69	Sst gry f gr arg sli calc sli glauc
	3882.0- 83.0							No Analysis Requested
14	3883.0- 84.0	0.03		11.0	0.0	34.2	2.69	Sst gry f gr arg sli sh sli calc sli glauc
	3884.0- 85.0							No Analysis Requested
+ 15	3885.0- 86.0	0.12	0.12	13.2	0.0	21.5	2.67	Sst gry f gr arg sli calc sli glauc
	3886.0- 87.0							No Analysis Requested
16	3887.0- 88.0	0.04		12.4	0.0	41.0	2.70	Sst gry f gr arg sli calc sli glauc
	3888.0- 92.0							No Analysis Requested
17	3892.0- 93.0	0.04		10.7	0.0	40.5	2.72	Sst gry f gr arg sli calc sli glauc
	3893.0- 94.0							No Analysis Requested
18	3894.0- 95.0	0.04		12.8	0.0	26.6	2.70	Sst gry f gr arg sli calc sli glauc
	3895.0- 97.0							No Analysis Requested
19	3897.0- 98.0	0.03		11.1	0.0	49.1	2.71	Sst gry f gr arg sli calc sli glauc
	3898.0- 03.0							No Analysis Requested
20	3903.0- 04.0	0.03		11.2	0.0	54.2	2.72	Sst gry f gr arg sli calc sli glauc
	3904.0- 05.0							No Analysis Requested
21	3905.0- 06.0	0.03		9.1	0.0	57.7	2.72	Sst gry f gr arg sli calc sli glauc
	3906.0- 11.0							No Analysis Requested
22	3911.0- 12.0	0.04		10.9	0.0	37.6	2.72	Sst gry f gr arg sli calc sli glauc
	3912.0- 13.0							No Analysis Requested

CORE LABORATORIES

Company : Robert L. Bayless
Well : Jicarilla 459 No. 5 Well

Field : Wildcat
Formation : As Noted

File No.: 57121-8279
Date : 27-Dec-1988

C O R E   A N A L Y S I S   R E S U L T S

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	SATURATION (PORE VOLUME)		GRAIN DENSITY	DESCRIPTION
	ft	(MAXIMUM) Kair md	(90 DEG) Kair md	%	OIL %	WATER %	gm/cc	
+ 23	3913.0- 14.0	0.08	0.08	10.9	0.0	33.3	2.70	Sst gry f gr arg sli calc sli glauc
	3914.0- 15.0							No Analysis Requested
24	3915.0- 16.0	0.06		12.4	0.0	18.4	2.71	Sst gry f gr arg sli calc sli glauc
	3916.0- 23.0							No Analysis Requested
25	3923.0- 24.0	0.03		10.1	0.0	42.7	2.72	Sst gry f gr arg sli sh sli calc sli glauc
	3924.0- 32.0							No Analysis Requested

+ Denotes Full Diameter Sample

CABRESTO TIGHT GAS AREA - EXHIBIT #10

PICTURED CLIFFS CORE ANALYSIS

OPERATOR: EL PASO NATURAL GAS CO.
WELL: GASBUGGY #1
LOCATION: NESW SEC 36 T29N R4W

TOP OF PICTURED CLIFFS = 3916

ALL DATA USED IN THIS ANALYSIS IS >10% POROSITY REPORTED FROM CORE ANALYSIS

SAMP NUM	TOP INTERVAL	BOTTOM INTERVAL	FOOTAGE INTERVAL	HORIZONTAL PERMEABILITY	POROSITY	WATER SATURATION
	TOTAL		49	8.40	600.0	2291.2
	AVG			0.17	12.2	46.8
25	3916	3917	1	0.01	12.6	44.3
26	3918	3919	1	0.02	10.2	58.8
27	3920	3921	1	0.01	14.4	42.3
28	3922	3923	1	0.07	13.8	42.8
29	3924	3925	1	0.12	10.0	53.0
30	3926	3927	1	0.09	10.6	48.1
31	3928	3929	1	0.01	13.5	42.1
32	3930	3931	1	0.17	13.0	37.8
34	3934	3935	1	0.01	13.8	34.8
35	3936	3937	1	0.01	13.3	34.6
36	3938	3939	1	0.02	10.3	56.3
37	3940	3941	1	0.01	10.9	48.6
55	3977	3978	1	0.01	11.4	46.5
61	3989	3990	1	0.07	11.4	58.8
66	3999	4000	1	0.02	10.0	55.0
78	4023	4024	1	0.29	12.5	40.7
79	4025	4026	1	0.23	10.7	29.0
83	4033	4034	1	0.28	10.5	37.2
106	4082	4083	1	0.45	12.5	46.4
108	4086	4087	1	0.77	14.3	37.0
109	4088	4089	1	0.01	10.1	37.6
113	4096	4097	1	0.04	10.0	59.0
114	4098	4099	1	0.08	12.1	56.2
119	4108	4109	1	0.01	10.6	67.0
122	4114	4115	1	0.14	11.9	53.0
123	4116	4117	1	0.12	11.3	51.4
125	4120	4121	1	0.01	11.2	63.4
126	4122	4123	1	0.01	11.0	64.5
129	4128	4129	1	0.01	11.8	58.5
130	4130	4131	1	0.19	10.6	50.0
131	4132	4133	1	0.29	12.0	55.8
132	4134	4135	1	0.14	12.1	52.1
133	4136	4137	1	0.44	12.7	46.4
134	4138	4139	1	0.10	11.5	57.4
135	4140	4141	1	0.15	11.1	54.0
136	4142	4143	1	0.14	12.1	39.7
137	4144	4145	1	0.70	13.0	42.3
138	4146	4147	1	0.37	12.5	43.2
139	4148	4149	1	0.84	14.3	51.1

EXHIBIT #10 - PAGE 2

SAMP NUM	TOP INTERVAL	BOTTOM INTERVAL	FOOTAGE INTERVAL	HORIZONTAL PERMEABILITY	POROSITY	WATER SATURATION
141	4152	4153	1	0.43	12.3	35.0
142	4154	4155	1	0.45	18.9	38.8
144	4158	4159	1	0.22	12.4	42.7
145	4160	4161	1	0.11	13.1	42.7
146	4162	4163	1	0.10	13.0	43.1
147	4164	4165	1	0.02	11.4	43.0
148	4166	4167	1	0.02	11.9	42.8
149	4168	4169	1	0.15	16.0	35.0
150	4170	4171	1	0.22	14.9	38.3
152	4174	4175	1	0.22	14.5	33.1

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 5

CORE ANALYSIS RESULTS ILLEGIBLE

Company: EL PASO NATURAL GAS COMPANY — Formation: — File: RP-3-2180
Well: GAS BUGGY #1 — Core Type: D/C — Date Report: 3-10-67
Field: — Drilling Fluid: GAS — Analysts: STRICKLIN
County: RIO ARRIBA — State: N.M. — Elev.: — Location:

Core Analysis By Core Laboratory Beginning With Sample #81

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS K_A HORIZ.	VERT.	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS
58	3790-91	<0.01	<0.01	3.8	0.0	94.8	SLTY SH:ARGILL,LT GRY,CALC IN PT,HD,TITE.
59	3796-97	<0.01	<0.01	2.5	0.0	96.0	SLTY SH:ARGILL,LT GRY,CALC IN PT,HD,TITE.
60	3798-99	<0.01	<0.01	3.2	0.0	90.7	SANDY SLT:LT GRY,ARGILL,V/CALC,HD.
61	3806-07	<0.01	<0.01	11.1	4.5	94.5	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
62	3809-10	<0.01	<0.01	11.2	6.2	90.7	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
63	3822-23	0.12	<0.01	3.2	6.3	90.7	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
64	3826-27	<0.01	<0.01	6.7	0.0	98.6	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
65	3828-29	0.16	<0.01	3.5	14.3	83.0	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
66	3836-37	<0.01	<0.01	4.4	2.7	66.0	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
67	3837-38	<0.01	<0.01	3.9	17.9	71.8	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
68	3838-39	<0.01	<0.01	4.6	15.2	62.4	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
69	3838-40	<0.01	<0.01	4.1	12.2	68.2	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
70	3840-41	<0.01	<0.01	4.2	11.9	66.8	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
71	3841-42	<0.01	<0.01	4.0	12.5	70.1	SS:LT BRN,FNGR,CALC,BANDED W/CARB MTL.
72	3856-57	<0.01	<0.01	2.9	0.0	82.6	SS:LT GRY,FNGR, S&P,SLI CALC,ARGILL IN PT.
73	3857-58	<0.01	<0.01	2.6	0.0	76.9	SS:LT GRY,FNGR,S&P,SLI CALC,ARGILL IN PT.
74	3859-60	<0.01	<0.01	2.0	0.0	90.0	SS:LT GRY,FNGR,S&P,SLI CALC,ARGILL IN PT.
75	3864-65	<0.01	<0.01	3.9	0.0	74.4	SS:LT GRY,FNGR,S&P,SLI CALC,ARGILL IN PT.
76	3866-67	<0.01	<0.01	2.3	0.0	87.0	SS:LT GRY,FNGR,S&P,SLI CALC,ARGILL IN PT.
77	3867-68	<0.01	<0.01	3.3	0.0	88.0	SS:LT GRY,FNGR,S&P,SLI CALC,ARGILL IN PT.
78	3869-70	<0.01	<0.01	3.8	0.0	81.8	SS:LT GRY,FNGR,S&P,SLI CALC,ARGILL IN PT.
79	3873-74	0.01	<0.01	3.8	23.6	52.6	SS:LT GRY,FNGR,W/ABNT CARB SH PTNGS.
80	3876-77	<0.01	<0.01	2.7	7.4	89.0	SS:LT GRY,FNGR,W/ABNT CARB SH PTNGS.
81	3914-15	<0.01	<0.01	4.4	13.6	59.0	SS:LT BRN,FNGR,W/MOTT CARB MTL,S&P,ARGILL.
82	3916-17	<0.01	<0.01	12.6	1.6	44.3	SS:LT BRN,FNGR,W/MOTT CARB MTL,S&P,ARGILL.
83	3918-19	0.02	<0.01	10.2	0.0	58.8	SS:LT BRN,FNGR,W/MOTT CARB MTL,S&P,ARGILL.
84	3920-21	<0.01	<0.01	14.4	1.4	42.3	SS:LT BRN,FNGR,W/MOTT CARB MTL,S&P,ARGILL.
85	3922-23	0.07	<0.01	13.8	5.1	42.8	SS:LT GRY,FNGR,SLI CALC,S&P,ARGILL,GLAU.
86	3924-25	0.12	<0.01	10.0	2.0	53.0	SS:LT GRY,FNGR,SLI CALC,S&P,ARGILL,GLAU.
87	3926-27	0.09	0.01	10.6	4.7	48.1	SS:LT GRY,FNGR,SLI CALC, S&P,ARGILL,GLAU.
88	3928-29	<0.01	<0.01	13.5	3.7	42.1	SS:LT GRY,FNGR,SLI CALC,S&P,ARGILL,GLAU.
89	3930-31	0.17	<0.01	13.0	8.5	37.8	SS:LT GRY,FNGR,SLI CALC,S&P,ARGILL,GLAU.
90	3932-33	<0.01	<0.01	7.2	5.6	59.6	SS:DK BRN,MED-CSE GR,NON CALC,S&P,ARGILL.
91	3934-35	<0.01	<0.01	13.8	9.4	34.8	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
92	3936-37	<0.01	<0.01	13.3	5.3	34.6	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
93	3938-39	0.02	<0.01	10.3	0.0	56.3	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
94	3940-41	<0.01	<0.01	10.9	0.0	48.6	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
95	3942-43	<0.01	<0.01	9.0	0.0	62.3	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
96	3944-45	<0.01	<0.01	9.1	0.0	59.4	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.

SERVICE #5-A

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company EL PASO NATURAL GAS COMPANY Formation ______ File RP-3-2180
Well GAS BUGGY #1 Core Type D/C Date Report 3-10-67
Field ______ Drilling Fluid GAS Analysts STRICKLIN
County RIO ARRIBA State N.M. Elev. ______ Location ______

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS K_A		POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		SAMPLE DESCRIPTION AND REMARKS
		HORIZ	VERT.		OIL	TOTAL WATER	
97	3946-47	<0.01	<0.01	5.5	0.0	72.9	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
98	3948-49	<0.01	<0.01	5.3	0.0	71.8	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
99	3950-51	<0.01	<0.01	7.4	0.0	67.5	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
100	3952-53	<0.01	<0.01	7.3	0.0	71.3	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
101	3954-55	<0.01	<0.01	7.3	0.0	76.7	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
102	3956-57	<0.01	<0.01	4.8	0.0	66.6	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
103	3958-59	<0.01	<0.01	5.5	0.0	83.8	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
104	3960-61	<0.01	<0.01	5.0	0.0	66.0	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
105	3962-63	0.01	<0.01	8.3	0.0	66.4	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
106	3964-65	<0.01	<0.01	9.0	0.0	56.8	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
107	3966-67	<0.01	<0.01	8.3	0.0	61.5	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
108	3968-69	<0.01	<0.01	4.0	0.0	82.5	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
109	3971-72	<0.01	<0.01	7.9	0.0	65.9	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
110	3973-74	<0.01	<0.01	6.0	0.0	73.4	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
111	3975-76	<0.01	<0.01	9.4	0.0	50.0	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
112	3977-78	<0.01	<0.01	11.4	0.0	46.5	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
113	3979-80	0.02	<0.01	6.8	0.0	64.5	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
114	3981-82	<0.01	<0.01	5.9	0.0	74.6	SS:LT GRY,FNGR,ARGILL,S&P,SLI CALC.
115	3983-84	<0.01	<0.01	5.2	3.9	84.6	SS:LT BRN,FNGR,SLTY,NON CALC,MICACEOUS.
116	3985-86	<0.01	<0.01	4.6	1.7	71.9	SS:LT BRN,FNGR,SLTY,W/ABNT CARB SHALE.
117	3987-88	0.04	<0.01	9.9	0.0	63.7	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
118	3889-90	0.07	0.01	11.4	0.0	58.8	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
119	3991-92	0.04	<0.01	9.4	2.1	69.2	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
120	3993-94	0.01	<0.01	8.4	0.0	77.5	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
121	3995-96	0.01	<0.01	8.1	0.0	59.3	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
122	3997-98	0.07	<0.01	9.7	0.0	60.9	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
123	3999-4000	0.02	<0.01	10.0	0.0	55.0	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
124	4001-02	0.08	0.07	9.4	0.0	62.7	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
125	4003-04	0.07	0.01	9.0	0.0	61.0	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
126	4005-06	0.08	<0.01	8.3	0.0	47.0	BS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
127	4007-08	<0.01	<0.01	8.3	0.0	59.0	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
128	4009-10	0.11	<0.01	9.9	0.0	41.5	SS:LT GRY,FNGR,SLI CALC,S&P,SLI CALC.
129	4011-12	0.08	<0.01	9.8	0.0	35.8	SS:LT GRY,FNGR,SLI CALC,S&P.
130	4013-14	0.01	<0.01	8.3	0.0	42.2	SS:LT GRY,FNGR,SLI CALC,S&P.
131	4015-16	<0.01	<0.01	5.9	0.0	56.0	SS:LT GRY,FNGR,SLI CALC,S&P.
132	4017-18	<0.01	<0.01	7.8	0.0	54.0	SS:LT GRY,FNGR,SLI CALC,S&P.
133	4019-20	<0.01	<0.01	8.9	0.0	49.5	SS:LT GRY,FNGR,SLI CALC,S&P.
134	4021-22	0.11	<0.01	9.0	0.0	42.3	SS:LT GRY,FNGR,SLI CALC,S&P.
135	4023-24	0.29	0.12	12.5	0.0	40.7	SS:LT GRY,FNGR,SLI CALC,S&P.
136	4025-26	0.23	<0.01	10.7	0.0	29.0	SS:LT GRY,FNGR,SLI CALC,S&P.

SERVICE #50A

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company EL PASO NATURAL GAS COMPANY Formation ______ File RP-3-2180
Well GAS BUGGY #1 Core Type D/C Date Report 3-14-67
Field ______ Drilling Fluid GAS Analysts STRICKLIN
County RIO ARRIBA State N.M. Elev. ______ Location ______

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS K_A HORIZ.	VERT.	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS
137	4027-28	0.28	0.05	9.0	0.0	43.3	SS:LT GRY,FNGR,SLI CALC,S&P.
138	4029-30	0.12	0.01	8.5	0.0	56.5	SS:LT GRY,FNGR,SLI CALC,S&P.
139	4031-32	0.02	<0.01	3.8	0.0	65.9	SS:LT GRY,FNGR,SLI CALC,S&P.
140	4033-34	0.28	<0.01	10.5	0.0	37.2	SS:LT GRY,FNGR,SLI CALC,S&P.
141	4035-36	0.12	<0.01	8.7	0.0	31.1	SS:LT GRY,FNGR,SLI CALC,S&P.
142	4037-38	0.02	<0.01	8.2	0.0	37.8	SS:LT GRY,FNGR,SLI CALC,S&P.
143	4039-40	<0.01	<0.01	5.4	0.0	76.0	SS:LT GRY,FNGR,SLI CALC,S&P.
144	4041-42	<0.01	<0.01	3.1	0.0	93.6	SS:LT GRY,FNGR,SLI CALC,S&P.
145	4043-44	<0.01	<0.01	5.1	0.0	80.5	SS:LT GRY,FNGR,SLI CALC,S&P.
146	4045-46	<0.01	<0.01	3.1	6.4	87.3	SS:DK GRY,V/FNGR,SLTY,W/SM SH PTNGS.
147	4047-48	<0.01	<0.01	1.8	0.0	94.5	SS:DK GRY,V/FNGR,SLTY,W/SM SH PTNGS.
148	4049-50	<0.01	<0.01	2.7	55.6	40.8	SS:DK GRY,V/FNGR,SLTY,(CARB SHALE OIL).
149	4051-52	<0.01	<0.01	2.8	25.0	68.0	SS:DK GRY,V/FNGR,SLTY,(CARB SH OIL).
150	4053-54	<0.01	<0.01	7.1	16.9	79.0	SS:DK GRY,V/FNGR,SLTY,(CARB SHALE OIL).
151	4055-56	<0.01	<0.01	7.5	17.3	65.2	SS:DK GRY,V/FNGR,SLTY,(CARB SHALE OIL).
152	4057-58	<0.01	<0.01	3.2	28.1	65.5	SS:DK GRY,V/FNGR,SLTY,(CARB SHALE OIL).
153	4062-63	<0.01	<0.01	5.9	0.0	89.8	SS:DK GRY,FNGR,SLTY THU OUT,W/CARB PTNGS.
154	4064-65	0.05	<0.01	7.4	0.0	81.2	SS:LT GRY,FNGR,SLTY,S&P,SLI CALC.
155	4066-67	<0.01	<0.01	8.1	3.1	86.2	SS:LT GRY,FNGR,SLTY,S&P,SLI CALC.
156	4068-69	0.01	<0.01	6.4	0.0	75.0	SS:LT GRY,FNGR,S&P,SLI CALC.
157	4071-72	<0.01	<0.01	5.6	0.0	91.0	SS:LT GRY,FNGR,S&P,SLI CALC.
158	4072-73	<0.01	<0.01	4.6	0.0	78.3	SS:LT GRY,FNGR,S&P,SLI CALC.
159	4074-75	0.05	<0.01	5.1	0.0	88.4	SS:LT GRY,FNGR,S&P,SLI CALC.
160	4076-77	<0.01	<0.01	5.2	0.0	90.4	SS:LT GRY,FNGR,S&P,SLI CALC.
161	4078-79	<0.01	<0.01	5.5	0.0	89.2	SS:LT GRY,FNGR,S&P,SLI CALC.
162	4080-81	<0.01	<0.01	7.7	0.0	76.6	SS:LT GRY,FNGR,S&P,SLI CALC.
163	4082-83	0.45	0.15	12.5	4.0	46.4	SS:LT GRY,FNGR,S&P,SLI CALC.
164	4084-85	0.21	0.02	9.7	0.0	59.8	SS:LT GRY,FNGR,S&P,SLI CALC.
165	4086-87	0.77	0.45	14.3	6.3	37.0	SS:LT GRY,FNGR,S&P,SLI CALC,W/OCC MED SD.
166	4088-89	<0.01	<0.01	10.1	2.0	37.6	SS:LT GRY,FNGR,S&P,SLI CALC,W/OCC MED SD.
167	4090-91	0.07	<0.01	9.5	2.1	45.3	SS:LT GRY,FNGR,S&P,SLI CALC,W/OCC MED SD.
168	4092-93	0.08	<0.01	7.8	0.0	60.4	SS:LT GRY,FNGR,S&P,W/SM CARB SH STGS.
169	4094-95	<0.01	<0.01	6.8	2.9	69.3	SS:LT GRY,FNGR,S&P,SLI CALC.
170	4096-97	0.04	<0.01	10.0	2.0	59.0	SS:LT GRY,FNGR,S&P,SLI CALC.
171	4098-99	0.08	0.04	12.1	0.0	56.2	SS:LT GRY,FNGR,S&P,SLI CALC.
172	4100-01	0.01	<0.01	8.5	0.0	70.6	SS:LT GRY,FNGR,S&P,SLI CALC.
173	4102-03	0.02	0.01	8.9	2.2	67.5	SS:LT GRY,FNGR,S&P,SLI CALC.
174	4104-05	0.33	<0.01	8.1	0.0	69.2	SS:LT GRY,FNGR,S&P,SLI CALC.
175	4106-07	0.11	<0.01	9.1	0.0	42.8	SS:LT GRY,FNGR,S&P,SLI CALC.
176	4108-09	<0.01	<0.01	10.6	0.0	67.0	SS:LT GRY,FNGR,S&P,SLI CALC.

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CA-20

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company EL PASO NATURAL GAS COMPANY, Formation ______ File RP-3-2180
Well GAS BUGGY #1 Core Type D/C Date Report 3-15-67
Field ______ Drilling Fluid GAS Analysts STRICKLIN
County RIO ARRIBA State N.M. Elev. ______ Location ______

Lithological Abbreviations

SAND-SD	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SDY	FINE-FN	CRYSTALLINE-XLN	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL/
SHALE-SH	CHERT-CH	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS K_A HORIZ.	VERT.	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	TOTAL WATER	SAMPLE DESCRIPTION AND REMARKS
177	4110-11	0.11	0.07	7.9	0.0	49.3	SS:LT GRY,FNGR,S&P,SLI CALC.
178	4112-13	0.15	0.02	7.0	0.0	50.0	SS:LT GRY,FNGR,S&P,SLI CALC.
179	4114-15	0.14	<0.01	11.9	0.0	53.0	SS:LT GRY,FNGR,S&P,SLI CALC.
180	4116-17	0.12	0.08	11.3	3.5	51.4	SS:LT GRY,FNGR,S&P,SLI CALC.
181	4118-19	<0.01	<0.01	9.5	2.1	54.8	SS:LT GRY,FNGR,S&P,SLI CALC.
182	4120-21	<0.01	<0.01	11.2	0.0	63.4	SS:LT GRY,FNGR,S&P,SLI CALC.
183	4122-23	<0.01	<0.01	11.0	0.0	64.5	SS:LT GRY,FNGR,S&P,SLI CALC.
184	4124-25	0.01	<0.01	9.2	0.0	74.0	SS:LT GRY,FNGR,S&P,SLI CALC.
185	4126-27	<0.01	<0.01	4.5	0.0	82.3	SS:LT GRY,FNGR,S&P,SLI CALC.
186	4128-29	<0.01	<0.01	11.8	0.0	58.5	SS:LT GRY,FNGR,S&P,SLI CALC.
187	4130-31	0.19	0.07	10.6	0.0	50.0	SS:LT GRY,FNGR,S&P,SLI CALC.
188	4132-33	0.29	0.02	12.0	0.0	55.8	SS:LT GRY,FNGR,S&P,SLI CALC.
189	4134-35	0.14	<0.01	12.1	0.0	52.1	SS:LT GRY,FNGR,S&P,SLI CALC.
190	4136-37	0.44	<0.01	12.7	0.0	46.4	SS:LT GRY,FNGR,S&P,SLI CALC.
191	4138-39	0.10	<0.01	11.5	0.0	57.4	SS:LT GRY,FNGR,S&P,SLI CALC.
192	4140-41	0.15	0.01	11.1	0.0	54.0	SS:LT GRY,FNGR,S&P,SLI CALC.
193	4142-43	0.14	<0.01	12.1	0.0	39.7	SS:LT GRY,FNGR,S&P,SLI CALC.
194	4144-45	0.70	0.02	13.0	0.0	42.3	SS:LT GRY,FNGR,S&P,SLI CALC.
195	4146-47	0.37	<0.01	12.5	0.0	43.2	SS:LT GRY,FNGR,S&P,SLI CALC.
196	4148-49	0.84	<0.01	14.3	0.0	51.1	SS:LT GRY,FNGR,S&P,SLI CALC.
197	4150-51	<0.01	<0.01	4.2	2.4	90.5	SLT:DKGRY,SNDY IN PT,ABNT CARB MTL.
198	4152-53	0.43	<0.01	12.3	3.3	35.0	SS:LT GRY,FNGR,S&P,SLI CALC.
199	4154-55	0.45	<0.01	12.9	6.2	38.8	SS:LT GRY,FNGR,S&P,SLI CALC.
200	4156-57	<0.01	<0.01	3.4	0.0	47.0	SS:LT GRY,FNGR,S&P,ARGILL,W/CARB SH STGK.
201	4158-59	0.22	<0.01	12.4	3.2	42.7	SS:LT GRY,FNGR,S&P,ARGILL,W/CARB SH STKS.
202	4160-61	0.11	<0.01	13.1	1.5	42.7	SS:LT GRY,FNGR,S&P,ARGILL,W/CARB SH STKS.
203	4162-63	0.10	0.01	13.0	1.5	43.1	SS:LT GRY,FNGR,S&P,ARGILL,W/CARB SH STKS.
204	4164-65	0.02	<0.01	11.4	0.0	43.0	SS:LT GRY,FNGR,S&P,ARGILL,W/CARB SH STKS.
205	4166-67	0.02	<0.01	11.9	0.0	42.8	SS:LT GRY,FNGR,S&P,ARGILL.
206	4168-69	0.15	0.14	16.0	2.5	35.0	SS:LT GRY,FNGR,S&P,ARGILL.
207	4170-71	0.22	0.08	14.9	0.0	38.3	SS:LT GRY,FNGR,S&P,ARGILL,SLI CALC.
208	4172-73	0.01	<0.01	3.8	0.0	84.3	SS:LT GRY,FNGR,S&P,W/ABNT SH & SLT LAMS.
209	4174-75	0.22	0.11	14.5	0.0	33.1	SS:LT GRY,FNGR,S&P,ARGILL,SLI CALC.

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CABRESTO TIGHT GAS AREA - EXHIBIT #11

SUMMARY OF PICTURED CLIFFS CORE ANALYSIS DATA

NOTE:
ALL DATA USED IN AVERAGE IS >10% POROSITY FROM INDIVIDUAL PICTURED CLIFFS CORE ANALYSIS

WELL	FOOTAGE USED	PERMEABILITY TOTAL	PERMEABILITY AVG	POROSITY TOTAL	POROSITY AVG	WATER SATURATION TOTAL	WATER SATURATION AVG
CONOCO 29-4 #7	35	4.08	0.12	411.3	11.8	2069.0	59.1
SCHALK 29-4 #6	59	92.39	1.57	682.2	11.6	2401.9	40.7
JIC 459 #5	18	1.05	0.06	215.5	12.0	633.3	35.2
GASBUGGY #1	49	8.40	0.17	600.0	12.2	2291.2	46.8
ALL WELLS	161	105.92	0.66	1909.0	11.9	7395.4	45.9

AVERAGES:

AVERAGE LABORATORY PERMEABILITY: 0.66 md

AVERAGE POROSITY: 11.9 %

AVERAGE WATER SATURATION: 45.9 %

Effect of Overburden Pressure and Water Saturation on Gas Permeability of Tight Sandstone Cores

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↳ Presently w/ NIPER

Introduction

Research on the potential of nuclear explosions to stimulate gas production from low-permeability (tight) sandstone reservoirs is being conducted by the U. S. Bureau of Mines in cooperation with the Atomic Energy Commission. This report describes the part of that research that was conducted to establish correlation between permeability measured on dry cores at low external pressure (routine analysis) and permeability at reservoir conditions.

Cores used in this research were obtained from two Plowshare gas-stimulation projects. Project Gasbuggy cores from the Pictured Cliffs formation, Choza Mesa field, Rio Arriba County, N. M., can be described as very fine grained, slightly calcareous, well indurated sandstone. Project Wagon Wheel cores from the Fort Union formation, Pinedale field, Sublette County, Wyo., can be described as very fine grained, slightly calcareous, very well indurated sandstone.

Underground reservoirs are under considerable compressive stress as a result of the weight of overlying rocks (offset somewhat by internal-fluid pressure). The resultant net confining pressure or effective overburden pressure is referred to in this report simply as overburden pressure. The resulting effects on the physical properties of the reservoir rock have been studied.[1-3] Overburden pressure causes only a small decrease in porosity, which can usually be ignored.[4] This was confirmed for Project Gasbuggy and Project Wagon Wheel cores. A commercial laboratory found that the porosity of these cores is reduced by about 5 percent of the original porosity. The effect of overburden pressure on permeability, however, is appreciable and varies considerably for different reservoir rocks,[1-3] causing greater reductions in permeability for low-permeability rocks.[2,3] The effect of overburden pressure on relative permeability has been found to be small[4] or nonexistent.[5]

This report presents material that confirms and extends previous research findings on the effect that overburden pressure has upon the permeability of dry cores. Also presented are the results of research on the relative gas permeability of low-permeability cores under overburden pressure.

Apparatus and Procedure

Cylindrical cores 2.0 to 7.5 cm long and 2.5 cm in diameter were cut parallel to the bedding plane. After the cores were dried overnight in a vacuum oven (4.5 psia, 70°C), the gas (N_2) permeability of each core was measured in a Hassler cell. An external pressure of 100 psi over the inlet pressure was used to maintain a good seal between the rubber sleeve and the core.[6] Permeability was measured at inlet pressures of 45, 60, and 100 psia, with atmospheric pressure at the outlet. A bubble tube and timer were used to measure gas flow rate. Initial permeability (k_i) then was calculated by the Klinkenberg technique to correct for the effect of gas slippage. All other permeabilities reported here were calculated by this method.

In the same manner, permeability was measured at

Research conducted to determine the potential of nuclear explosions to stimulate gas production verifies that the gas permeability of tight sandstone cores is markedly decreased with increasing overburden pressure. Water saturation also reduces the gas permeability by a large amount. The relative permeability, however, does not change significantly with overburden pressure.

increasing external pressures of about 500, 1,000, 2,000, 3,000, 4,000, 5,000, and 6,000 psi. External pressures actually were somewhat higher to compensate for internal pressure. The core and staniless steel end pieces were placed in a rubber sleeve (piece of bicycle innertube) 0.1 cm thick. Rubber cement was used to seal the stainless steel end pieces to the rubber sleeve. Shrinkable plastic tubing proved unsatisfactory because high pressure was required to seal the core. The jacketed core was mounted in a high-pressure cell with distilled water as the external fluid.

Cores used in relative permeability studies were first subjected to high external pressure and then allowed to recover their initial permeability. Bulk volume, dry weight, and porosity were measured by conventional gas-expansion techniques. Cores then were subjected to a vacuum (0.3 psia) for 2 hours, immersed in water, and allowed to stand under a vacuum overnight. The cores were weighed and again subjected to vacuum overnight and weighed again to assure complete saturation. Most of the cores were completely saturated after one night. Porosity values calculated on the basis of water saturation are in good agreement with those measured by conventional gas-expansion techniques.

Water in the core was allowed to evaporate at atmospheric conditions to a saturation of about 70 percent and the core was placed in the holder for 2 hours under external pressure (100 psi above inlet) only so the water saturation was uniform. Gas permeability then was measured at three inlet pressures between 30 and 100 psia with atmospheric pressure at the outlet. This procedure was repeated for decreasing water saturations at the same external pressure. After the permeability was measured the core was weighed to determine if any water was lost. In all cases the amount lost was negligible. After the core was dried in a vacuum oven, the gas permeability at this external pressure was measured. The procedure was repeated for external pressures of 3,000 and 6,000 psi.

Results and Discussion

Effect of Overburden Pressure on Permeability

Core number, length, porosity, and initial permeability of the cores used in this research are shown in Table 1. The core number refers to the depth in feet at which the core was obtained. Typical plots of the effect of simulated overburden pressure on Gasbuggy cores are shown in Fig. 1. The permeability is decreased by about 75 percent at an overburden pressure of 3,000 psi and by 90 percent at 6,000 psi. The hydrostatic loading used in these experiments does not reproduce subsurface conditions exactly; in an actual reservoir the horizontal component of stress is usually less than the vertical component. Since the actual loading is not known, this method probably is as realtistic as any other. Cores that contain microfractures are affected to a greater extent, as shown in Fig. 2. In these cores the permeability is decreased by about 95 percent at a simulated overburden pressure of 3,000 psi, with most of the reduction occurring below 2,000 psi.

The data shown in Table 1 and Figs. 1 and 2 were obtained by subjecting the core to successive incre-

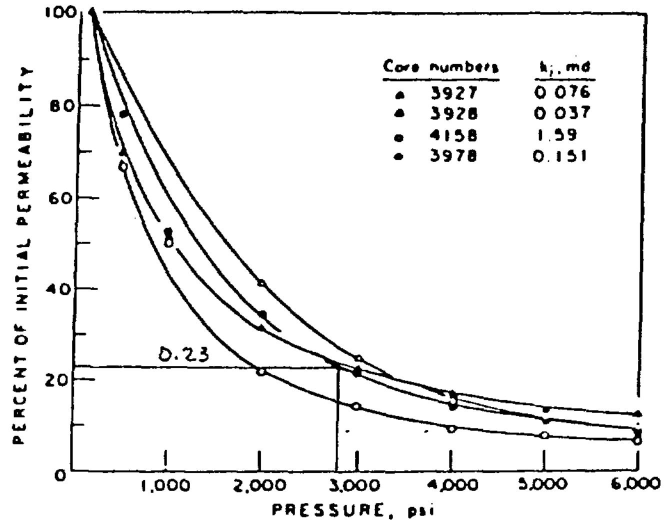

Fig. 1—Effect of overburden pressure on gas permeability of Gasbuggy cores.

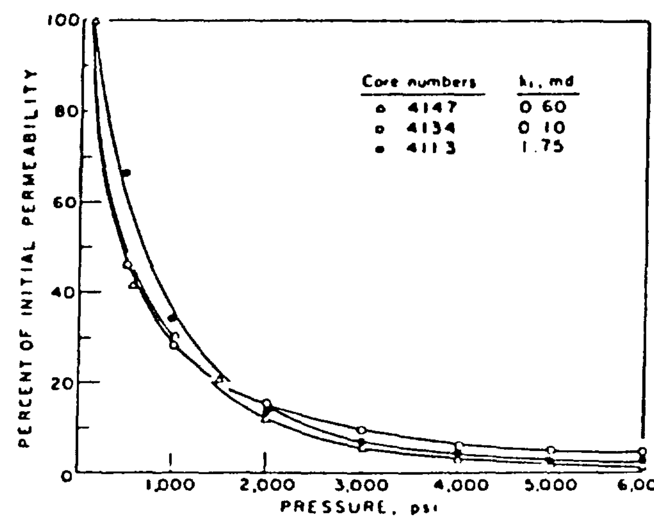

Fig. 2—Effect of overburden pressure on gas permeability of fractured Gasbuggy cores.

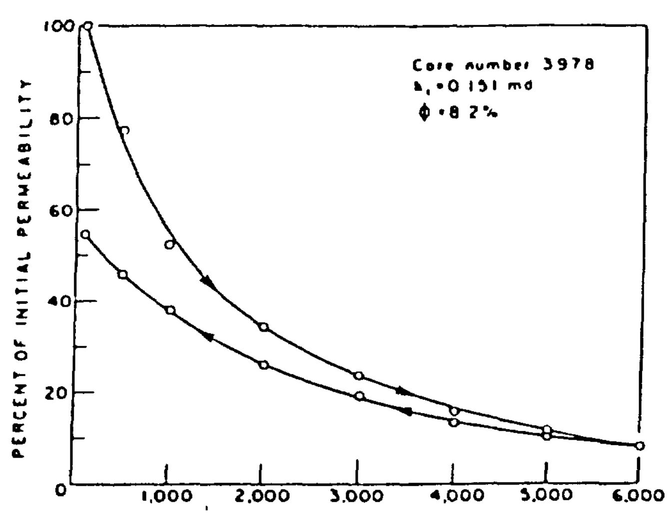

Fig. 3—Hysteresis effect at decreasing confining pressures.

TABLE 1—EFFECT OF OVERBURDEN PRESSURE ON GAS PERMEABILITY

Effective Overburden Pressure (psi):				500	1,000	2,000	3,000	4,000	5,000	6,000
Core Number*	Length (cm)	Porosity (percent)	k,†	Permeability (md)						
Gasbuggy										
3927	2.1	8.1	0.076	0.053	0.040	0.024	0.0175	0.0132	0.0105	0.0095
3928	7.5	8.3	0.037	0.031	0.024	0.015	0.0093	0.0059	0.0046	0.0035
3978	2.1	8.2	0.151	0.118	0.078	0.052	0.036	0.024	0.0175	0.0132
4113**	2.1	10.1	1.75	1.16	0.602	0.252	0.113	0.068	0.042	0.029
4134**	2.1	11.6	0.10	0.046	0.029	0.0153	0.0095	0.0065	0.0055	0.0047
4146**	7.5	11.6	2.40	1.73	1.32	0.31	0.14	0.069	0.052	0.022
4147**	7.5	11.3	0.60	0.247	0.181	0.071	0.034	0.0186	0.0118	0.0082
4158	2.1	13.6	1.59	1.06	0.80	0.35	0.225	0.152	0.116	0.100
Wagon Wheel										
8084	3.8	7.7	0.028	0.022	0.020	0.010	0.0070	0.0047	0.0035	0.0030
8122	3.8	11.4	0.071	0.055	0.048	0.034	0.027	0.024	0.021	0.019
8975**	3.8	8.7	0.039	0.029	0.024	0.0114	0.0073	0.0048	0.0032	0.0025
10156	3.8	8.5	0.088	0.067	0.051	0.032	0.025	0.022	0.018	0.016
10990**	3.8	9.0	0.048	0.020	0.0175	0.0080	0.0050	0.0040	0.0025	0.0019

*Number denotes depth in feet.
**Slightly fractured.
†Initial permeability.

mental increases in external pressure. The core was assumed to be in equilibrium at each pressure when permeability measurements remained constant for 15 minutes, which required between 1 and 2 hours. A period of 30 minutes to an hour was required to attain equilibrium when the inlet pressure was changed. Consequently, each external pressure was maintained for a minimum of 2 hours.

The effect of decreasing external pressure was determined on a few cores, and typical results are shown in Fig. 3. Other researchers[2,3] have observed and shown that this hysteresis is mainly dependent on the stress history of the core. Cores generally recover their original permeability after 3 to 6 weeks at atmospheric conditions. This time could be shortened by storing the core in an oven at 70°C.

The effect of overburden pressure on the permeability of cores from Project Wagon Wheel is similar to that on cores from Project Gasbuggy, and typical results are shown in Fig. 6. The permeability is decreased to about 30 percent of initial permeability at an overburden pressure of 3,000 psi and to 20 percent at 6,000.

A study of the data in Table 1 indicates that the original porosity of the core and the reduction in permeability caused by overburden pressure are not related. Pore structure (fractures to uniform pores) is probably the governing factor.

Water Saturation Effects

The data in Table 2 show that the permeability decreased with increasing water saturation. The values at 20-, 40-, and 60-percent water saturation were obtained from individual relative-permeability curves for Gasbuggy and Wagon Wheel cores. Relative-permeability curves for three cores from Project Gasbuggy are shown in Fig. 4 with the data points for Core 3978. Data points were omitted for the other cores to avoid confusion. This figure shows that although gas permeability is reduced, the relative gas permeability of Gasbuggy cores is not significantly affected by increased overburden pressure. This conclusion is in agreement with the results of others.[4,5]

Extremely low values of permeability that resulted from water saturation and overburden pressure required that either long flow times or high inlet pressures (high differential across the core) be used. Since a high inlet pressure increases the end effects by changing the distribution of water in the core, long flow times were required. Although end-effect problems were encountered with the short cores (Cores 3978 and 4158), the permeability of these cores was

TABLE 2—EFFECT OF OVERBURDEN PRESSURE AND WATER SATURATION ON GAS PERMEABILITY

Water Saturation (percent)		0	20	40	60
Core Number	Pressure (psi)	Permeability (md)			
Gasbuggy					
3927	100	0.115	0.099	0.041	0.0023
3927	3,000	0.026	0.023	0.009	0.0005
3927	6,000	0.012	0.010	0.003	0.0002
3978	100	0.112	0.080	0.034	0.011
3978	3,000	0.036	0.026	0.011	0.004
3978	6,000	0.013	0.009	0.004	0.0013
4158	100	0.447	0.335	0.156	0.045
4158	3,000	0.075	0.056	0.026	0.0074
4158	6,000	0.027	0.020	0.010	0.0026
Wagon Wheel					
8084	100	0.038	0.030	0.014	0.0042
8084	3,000	0.012	0.0096	0.0043	0.0013
8084	6,000	0.0070	0.0056	0.0025	0.0008
8122	100	0.074	0.054	0.017	0.006
8122	3,000	0.027	0.020	0.008	0.002
8122	6,000	0.025	0.015	0.006	0.002
10156	100	0.100	0.074	0.029	0.003
10156	3,000	0.028	0.020	0.008	0.0008
10156	6,000	0.017	0.013	0.005	0.0005

high enough to yield reasonable results. Permeability measurements for Core 4161 (7.5 cm long, 0.053 md) required more than 2 hours per reading. These extremely long flow times can cause errors.

End effects, long flow times, and changes in permeability due to water saturation tend to decrease the accuracy of permeability measurements, especially at the higher water saturations.

The initial permeability of many of the dry cores used in this research was not reproducible following saturation and drying. The changes probably were caused by solution of material in the pores and by particle movement. These caused both increases and decreases in permeability. The variation, although sometimes large, usually was less than 5 percent; however, we feel that the relative permeability curves are essentially correct. To eliminate the effects of solution and particle movement, the permeability of the dry core following saturation, rather than the permeability initially measured, was used in calculating relative permeability.

A composite of the relative permeability curves for Gasbuggy cores is shown in Fig. 5. These curves are representative of permeabilities encountered in this formation. At a water saturation of 50 percent, the relative permeability of the cores ranges from 15 to 20 percent and is not affected by overburden pressure.

Similar results were obtained on cores from Project Wagon Wheel, as shown in Table 2 and Fig. 6 with data points for Core 8122. These cores were cut to a length of 3.8 cm to alleviate some of the long flow time and end-effect difficulties encountered with Gasbuggy cores. These curves are representative of the permeabilities encountered in the formation. At a water saturation of 50 percent, the relative permeability of these cores ranges from 12 to 21 percent. The data in these figures show, as do the data from Gasbuggy cores, that relative gas permeability is not significantly affected by increased overburden pressure.

Correlation with Nuclear Stimulation Projects

Many of the basin areas of the Rocky Mountain region consist of thick, low-permeability sandstones containing large quantities of natural gas. This type of reservoir has been the object of the AEC's Plowshare Program experiments, Projects Gasbuggy and Rulison, and proposed Projects Wagon Wheel, WASP, and Rio Blanco. Because most wells in these reservoirs have not been commercial, only limited reservoir-analysis and production-test data are available. Reservoir analysis is most difficult because low permeability requires long-term testing. Also, it is difficult to determine permeability and net pay from these tests. Knowledge of the gas permeability is necessary in predicting gas recovery, and because it is not economical to define the characteristics of different strata by well test, it is desirable to be able to relate laboratory-measured permeability to the true in-situ permeability.

Conventional analysis by a commercial laboratory (confirmed in our laboratory) of about 200 Gasbuggy cores gave an average initial gas permeability of 0.16 md on dry cores and an average water saturation of 48 percent. The effective overburden pressure of this

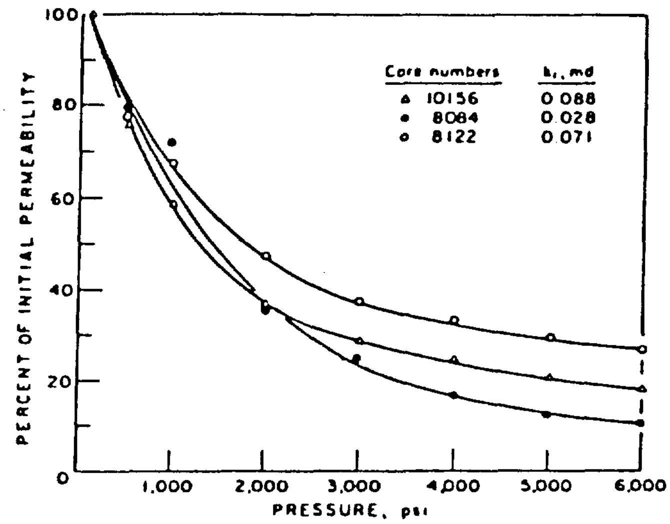

Fig. 4—Effect of overburden pressure on gas permeability of Wagon Wheel cores.

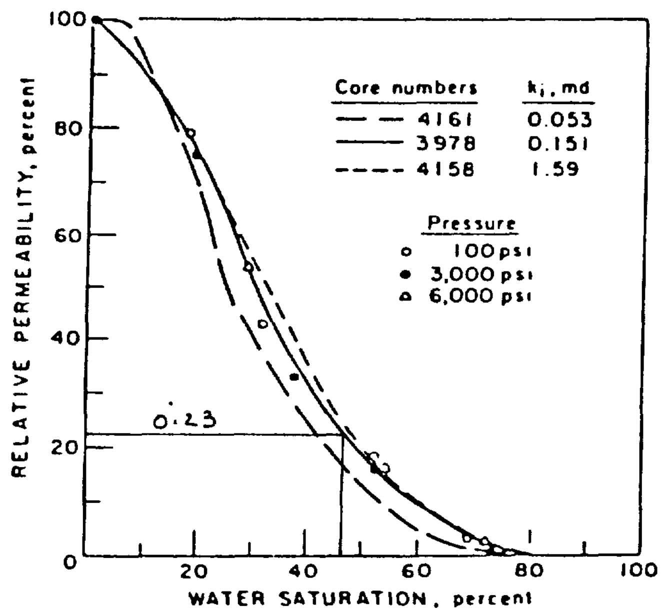

Fig. 5—Relative gas permeability of Gasbuggy cores.

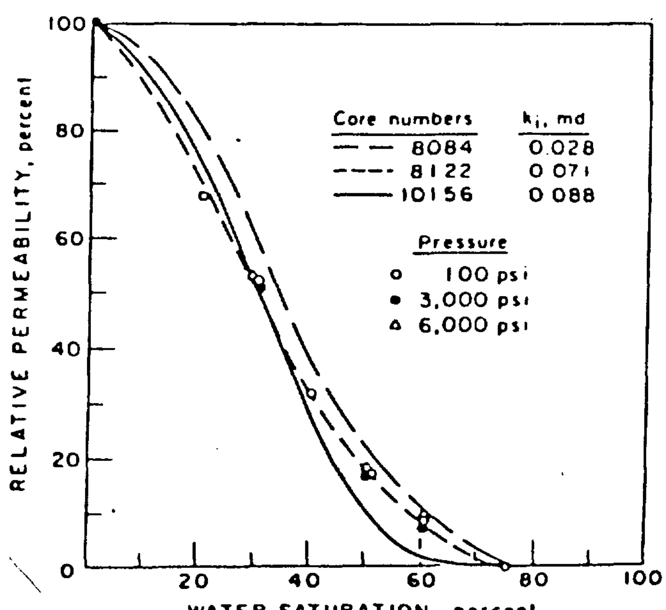

Fig. 6—Relative gas permeability of Wagon Wheel cores.

reservoir is about 3,000 psi. From Fig. 1, the reduction factor resulting from the overburden pressure is 0.25, and the reduction factor for a water saturation of 48 percent (Fig. 5) is 0.20; thus the total reduction is 5 percent of the initial permeability, or 0.008 md. This value compares favorably with permeability determinations of about 0.01 md from both preshot and postshot flow testing at Gasbuggy. The gas reservoir at Project Rulison is similar to that at Gasbuggy, having an average initial dry permeability of 0.11 md and an average water saturation of 45 percent. Simulated in-situ permeability has not yet been measured in the laboratory on Rulison cores; however, using an effective overburden pressure of 5,000 psi and curves of Gasbuggy core data (Figs. 1 and 5), the reduction factor because of overburden pressure would be 0.12 and that for water saturation 0.24. This results in a combined reduction to 3 percent of the initial permeability, or 0.003 md. Postshot production testing at Rulison is not complete, and the only preshot determination of permeability was made from tests of a 32-ft isolated zone that gave an average value of 0.008 md. No cores are available from this zone. Rulison reservoir rock is said to be less compressible than that of Gasbuggy; therefore Gasbuggy pressure-effect data would be expected to indicate a greater reduction for Rulison than actually exists.

The average initial permeability of dry Wagon Wheel cores is 0.068 md, with an average water saturation of 50 percent. An estimated effective overburden pressure of 3,000 psi gives a reduction factor of 0.28 (Fig. 4). Water saturation further reduces permeability by a factor of 0.18 (Fig. 6). Therefore, the total reduction in permeability is to approximately 5 percent of the initial permeability, or 0.0034 md.

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This value can be used to predict postshot gas recovery from the proposed Wagon Wheel experiment.

Cores are not yet available from Projects Rio Blanco and WASP.

Conclusions

The gas permeability of tight sandstone cores is markedly decreased with increasing overburden pressure. Most of the decrease takes place at pressures to 3,000 psi. At 3,000 psi, the permeability of unfractured samples ranges from 14 to 37 percent of the initial permeability. In fractured samples, permeability may be reduced to as low as 6 percent of initial permeability.

Water saturation also reduces the gas permeability greatly; however, the relative permeability does not change significantly with overburden pressure.

Permeability calculated from laboratory results are in good agreement with in-situ permeabilities determined from production test data. Although not confirmed, predictions for other projects appear to be reasonable.

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CABRESTO TIGHT GAS AREA - EXHIBIT NO. 13

DETERMINATION OF IN SITU FORMATION PERMEABILITY FROM LABORATORY CORE ANALYSIS DATA

The relationship needed to determine in situ permeability from laboratory core analysis data is published in a technical paper by Rex D. Thomas and Don C. Ward entitled "Effect of Overburden Pressure and Water Saturation on Gas Permeability of Tight Sandstone Cores", which is presented as Exhibit No. 12. The authors' studies involved taking routine laboratory air permeability measurements at the normal 100 psi or less external pressures. To simulate the effect of in situ conditions, these permeability measurements were then made at external pressures ranging from 500 to 6000 PSI. The results of these tests were then plotted on a graph of Percent of Initial Permeability (ratio of permeability at 100 psi to a permeability at a higher pressure) vs. Pressure.

Figure 1, on page 51 of Exhibit No. 12, is one such graph which presents results of tests run on cores taken from the Pictured Cliffs formation. These cores were taken from Project Gasbuggy, located in Choza Mesa Pictured Cliffs field, T28-29N, R3-4W, Rio Arriba County, New Mexico. These Gasbuggy cores are taken from wells within the Cabresto Tight Gas Area. In fact, one of the core analysis presented is from a well used in this study. Therefore, cores from the Pictured Cliffs formation from the Gasbuggy area used in this study should be representative of the cores from wells in the Cabresto Tight Gas Area.

The average laboratory air permeability for the Pictured Cliffs wells analyzed for the Cabresto Tight Gas Area is 0.66 millidarcy. This value most closely compares to the laboratory permeability value of 0.151 millidarcy for core 3978, as presented in Figure 1 of Exhibit No. 12. The characteristics of core 3978 are considered to best resemble the Pictured Cliffs formation in the Cabresto Tight Gas Area.

The net confining pressure due to overburden at a depth of 3715 feet in the Cabresto Tight Gas Area is approximately 2800 psi. Entering the graph in Figure 1 at 2800 psi results in a permeability reduction factor of 0.23 which is caused by the overburden pressure on the Pictured Cliffs formation.

The water present in the reservoir also causes the in situ permeability to be less than the laboratory determined permeability as discussed in Exhibit No. 12. The 0.23 permeability reduction factor resulting from overburden pressure was determined from cores having 100% gas saturation. Figure 5 on page 53 of Exhibit No. 12 indicates relative permeability changes that occurred with changes in water saturation within the sample cores. For the Pictured Cliffs cored wells within the Cabresto Tight Gas Area, the average core water saturation was 46%. Entering Figure 5 at 46% water saturation results in a permeability reduction factor of 0.23 for in situ water saturation.

The total permeability reduction factor used on laboratory core data to approximate reservoir conditions is obtained by multiplying the overburden reduction factor by the water saturation reduction factor. This product is 0.05 for the Pictured Cliffs wells analyzed. Therefore, the in situ permeability for this well is 5% of the 0.66 millidarcy laboratory determined permeability or 0.035 millidarcy.

The resulting 0.035 millidarcy in situ permeability obtained for the Cabresto Tight Gas Area compares favorably with the overall results of the 200 Gasbuggy cores described by the U.S. Bureau of Mines study. The in situ permeability of the 200 cores in the Gasbuggy study was determined to be 0.008 md.

CABRESTO TIGHT GAS AREA - EXHIBIT #14

CALCULATION OF FORMATION PERMEABILITY USING DARCY'S LAW

DARCY'S LAW:

$$Qg = \frac{0.703\ kh\ (Pe^2 - Pwf^2)}{(1000)\ Ug\ T\ Z\ \ln(0.61\ re/rw)}$$

or

$$k = \frac{Qg\ Ug\ T\ Z\ \ln(0.61\ re/rw)\ (1000)}{0.703\ h\ (Pe^2 - Pwf^2)}$$

where

k = unstimulated in situ permeability of formation - millidarcies
Qg = gas flowrate - MCF/day
Ug = average gas viscosity - calculated to be 0.0125 centipoise
T = bottom hole temperature - 135 degrees F, 595 degrees R
Z = average gas compressibility factor - calculated to be 0.925
re = drainage radius for 160 acre spacing - 1489 feet
rw = wellbore radius - 0.17 feet
h = net pay height - feet
Pe = bottom hole pressure at drainage radius re - average of 1175 psi
Pwf = flowing bottom hole pressure - assumed equal to bottom hole atmospheric - 14 psi

Natural Production Test Well:

Robert L. Bayless
Jicarilla 31-3-32 #1
NWSW Sec 32 T31N R3W

Calculated flowrate Q = 22.0 MCFD
Net pay height h = 78 perforated feet

$$k = \frac{(22.0)(0.0125)(595)(0.925)\ \ln(0.61*(1489/0.17))(1000)}{(0.703)(78)(1175^2-14^2)}$$

k = 0.017 md

note: This calculation assumes all 78 feet of pay is contributing gas.