OPEN-FILE REPORT 82-4

SOUTHERN UTE/ DEPARTMENT OF ENERGY COALBED METHANE TEST WELLS

by

Bruce S. Kelso

Peter Rushworth

COLORADO GEOLOGICAL SURVEY

1313 Sherman Street, Room 715

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Disclaimer

This report was prepared with the support of the U.S. Geological Survey, Agreement No. 14-08-0001-A-0108.

However, any opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Geological Survey.

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Location

The Southern Ute/Department of Energy test wells are located in the north-central portion of the San Juan Basin, Colorado, on the Southern Ute Indian Reservation. The Southern Ute Indian Reservation is a parcel measuring about 15 miles north-south and 72 miles east-west, bounded on the south by the Colorado-New Mexico state line.

The two project wells are located on the Oxford Tract, approximately three miles northwest of Ignacio, Colorado. The Oxford No. 1 is located C/NE SE Sec. 25-T34N-R8W, La Plata County, Colorado, and the Oxford No. 2 is located NE SE SW Sec. 25-T34N-R8W, La Plata County, Colorado. Both wells are located on Figure 1, a composite map of the project area.

Regional Geology of the Project Site

The target horizon on both project wells is the basal Fruitland Formation. The Upper Cretaceous Fruitland Formation is dominantly composed of carbonaceous shales, siltstones, sandstones and coals. At least two sources of gas are hosted in the Fruitland Formation, carbonaceous shales and coals. In general, formation thickness in the project area is 340 feet. Overall formation thickness in the Basin ranges from 100 to 600 feet.

Sandstones in the Fruitland Formation are soft to hard and gray-white to brown in color. Shales are typically well-indurated, and gray-black and black to brown in color. Coals range in thickness from less than two to 30 feet. Typically the basal coals exhibit the greatest thickness and lateral continuity.

The Fruitland Formation overlies the fine- to medium-grained sandstones of the Pictured Cliffs Formation. The upper contact of the Fruitland Formation with the Kirtland Formation is defined as the top of the uppermost coal in the Fruitland. Figure 2 is a time-stratigraphic chart of the Upper Cretaceous sediments of the San Juan Basin (modified from Kauffman, 1969 and 1977).

Coal Characteristics and Petrography

Tables 1 through 6 present proximate and ultimate coal analyses for Colorado Geological Survey (CGS) samples 204 through 209, respectively. Also shown are Parr Formula calculations of fixed carbon, volatile matter and heating value. These analyses are from desorbed coal samples from both Oxford wells. Tables 7 through 9 are analyses run on core samples from both wells. Sample intervals for the nine samples from the Oxford No. 1 and No. 2 are indicated on Figures 3 and 4, respectively.

Figure 5 is a cross-plot of volatile matter content on a dry-ash free basis versus Parr Formula basis. Of the nine analyses, seven show an apparent rank of medium volatile bituminous on the dry-ash free basis. Based on the Parr Formula, seven samples are ranked low volatile bituminous, one sample is ranked medium volatile, and one is ranked semi-anthracite. The sample ranked semi-anthracite is of extremely high ash content and should not be considered a coal sample.

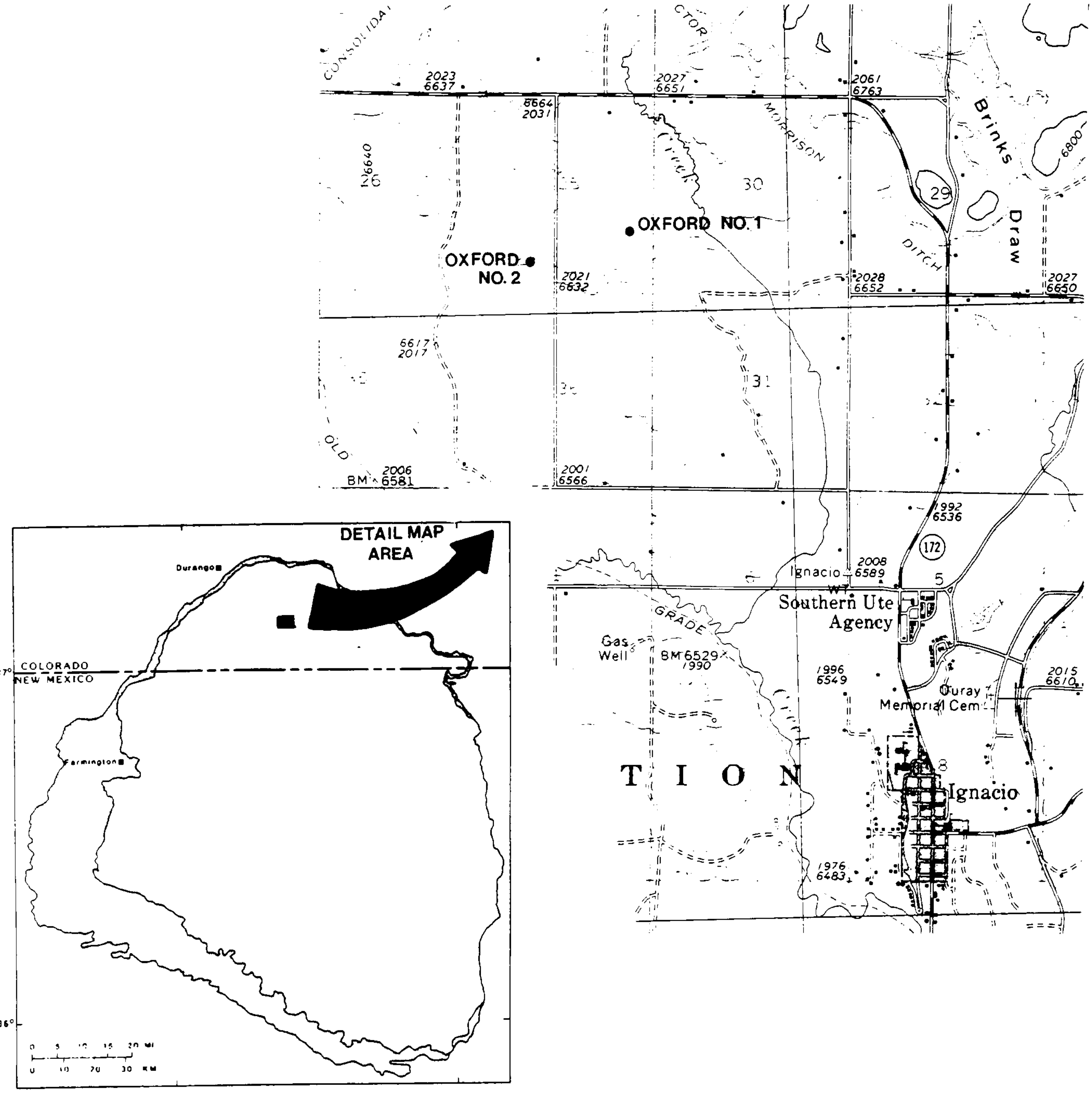

Figure 1. Location Map of the Project Area. (Scale approx. 1:50 000)

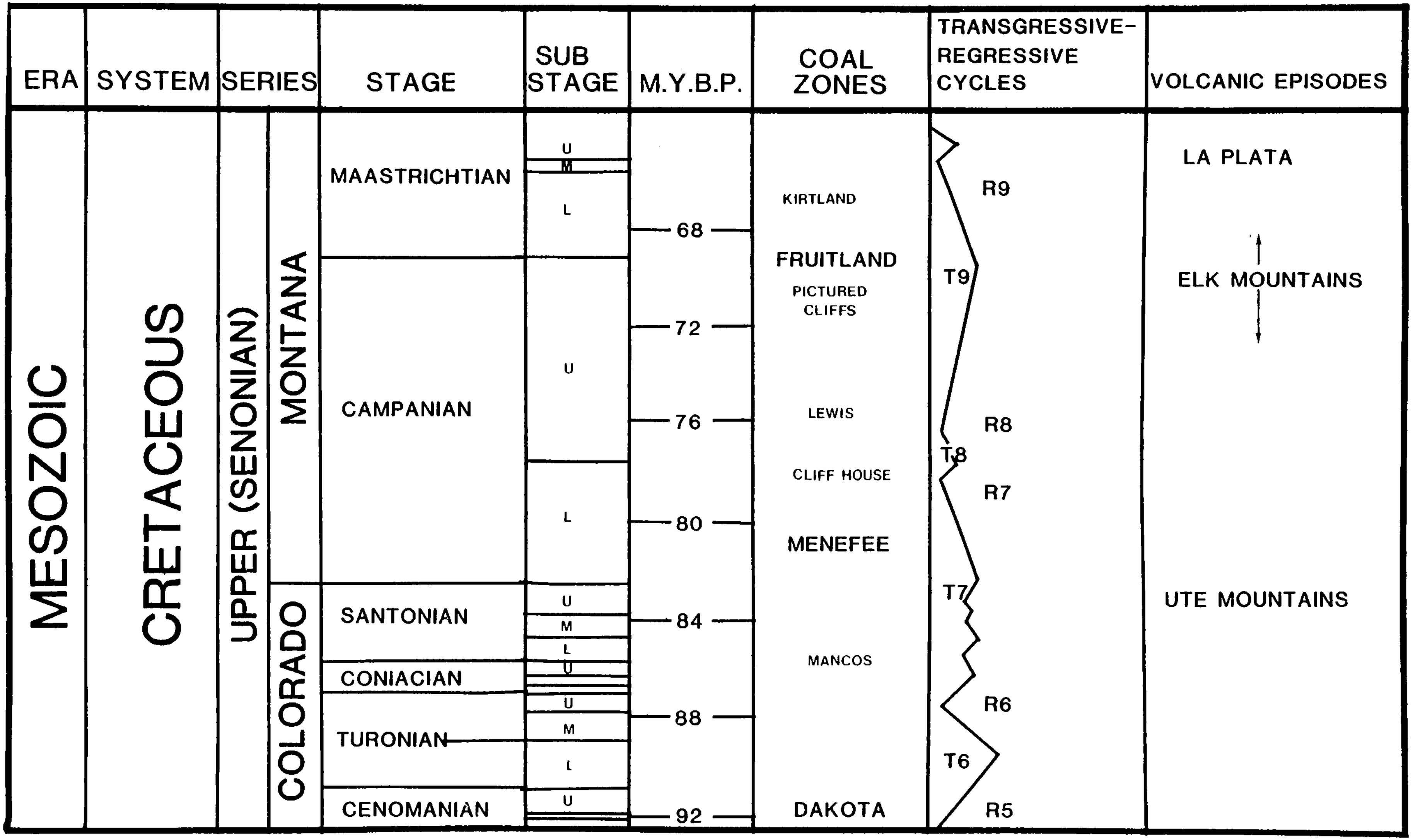

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Figure 2. Time-Stratigraphic Chart--San Juan Basin

TABLE 1

COAL ANALYSIS

COLORADO GEOLOGICAL SURVEY
SAMPLE NUMBER 204
OXFORD NO. 1

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	1.1	--	--
Volatile Matter	16.4	16.6	22.6
Fixed Carbon	56.1	56.7	77.4
Ash	26.4	26.7	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	11,280	11,410	15,560

ULTIMATE

Hydrogen	4.03	3.95	5.39
Carbon	64.45	65.17	88.90
Nitrogen	0.78	0.79	1.06
Oxygen	3.90	2.94	4.03
Sulfur	0.45	0.46	0.62
Ash	26.39	26.69	--
TOTAL	100.00	100.00	100.00

PARR FORMULA

Fixed Carbon (%) -	79.89
Volatile Matter (%) -	20.11
Heating Value (Btu/lb) -	15,802

TABLE 2

COAL ANALYSIS

COLORADO GEOLOGICAL SURVEY
SAMPLE NUMBER 205
OXFORD NO. 1

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	1.4	--	--
Volatile Matter	7.7	7.8	26.4
Fixed Carbon	21.6	21.9	73.6
Ash	69.3	70.3	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	3,380	3,430	11,550

ULTIMATE

Hydrogen	1.83	1.70	5.72
Carbon	25.11	25.46	85.76
Nitrogen	0.32	0.32	1.09
Oxygen	3.12	1.92	6.44
Sulfur	0.29	0.29	0.99
Ash	69.33	70.31	--
TOTAL	100.00	100.0	100.00

PARR FORMULA

Fixed Carbon (%) -	91.35
Volatile Matter (%) -	8.65
Heating Value (Btu/lb) -	13,463

TABLE 3

COAL ANALYSIS

COLORADO GEOLOGICAL SURVEY
SAMPLE NUMBER 206
OXFORD NO. 1

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	1.7	--	--
Volatile Matter	15.6	15.8	22.1
Fixed Carbon	54.7	55.7	77.9
Ash	28.0	28.5	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	10,850	11,040	15,440

ULTIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Hydrogen	3.84	3.71	5.19
Carbon	62.23	63.29	88.52
Nitrogen	0.78	0.79	1.11
Oxygen	4.61	3.18	4.44
Sulfur	0.52	0.53	0.74
Ash	28.02	28.50	--
TOTAL	100.00	100.00	100.00

PARR FORMULA

Fixed Carbon (%) -	80.59
Volatile Matter (%) -	19.41
Heating Value (Btu/lb) -	15,580

TABLE 4

COAL ANALYSIS

COLORADO GEOLOGICAL SURVEY
SAMPLE NUMBER 207
OXFORD NO. 2

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	0.7	--	--
Volatile Matter	15.4	15.5	21.5
Fixed Carbon	56.1	56.5	78.5
Ash	27.8	28.0	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	11,200	11,280	15,660

ULTIMATE

Hydrogen	3.94	3.89	5.40
Carbon	63.89	64.36	89.37
Nitrogen	0.82	0.83	1.15
Oxygen	3.01	2.38	3.30
Sulfur	0.56	0.56	0.78
Ash	27.78	27.98	--
TOTAL	100.00	100.00	100.00

PARR FORMULA

Fixed Carbon (%) -	81.22
Volatile Matter (%) -	18.78
Heating Value (Btu/lb) -	16,036

TABLE 5

COAL ANALYSIS

COLORADO GEOLOGICAL SURVEY
SAMPLE NUMBER 208
OXFORD NO. 2

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	1.7	--	--
Volatile Matter	14.3	14.6	22.3
Fixed Carbon	50.0	50.8	77.7
Ash	34.0	34.6	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	9,960	10,130	15,480

ULTIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Hydrogen	3.99	3.87	5.91
Carbon	56.07	57.03	87.15
Nitrogen	0.70	0.71	1.09
Oxygen	4.82	3.38	5.15
Sulfur	0.45	0.46	0.70
Ash	33.97	34.55	--
TOTAL	100.00	100.00	100.00

PARR FORMULA

Fixed Carbon (%) -	81.41
Volatile Matter (%) -	18.59
Heating Value (Btu/lb) -	15,766

TABLE 6

COAL ANALYSIS

COLORADO GEOLOGICAL SURVEY
SAMPLE NUMBER 209
OXFORD NO. 2

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	0.9	--	--
Volatile Matter	15.1	15.3	20.4
Fixed Carbon	59.1	59.6	79.6
Ash	24.9	25.1	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	11,580	11,680	15,590

ULTIMATE

Hydrogen	4.01	3.95	5.27
Carbon	66.71	67.30	89.85
Nitrogen	0.83	0.84	1.12
Oxygen	2.95	2.18	2.92
Sulfur	0.62	0.63	0.84
Ash	24.88	25.10	--
TOTAL	100.00	100.00	100.00

PARR FORMULA

Fixed Carbon (%) -	82.10
Volatile Matter (%) -	17.90
Heating Value (Btu/lb) -	15,871

TABLE 7

COAL ANALYSIS

U.S. GEOLOGICAL SURVEY
SAMPLE NUMBER 1
OXFORD NO. 1

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	1.4	--	--
Volatile Matter	15.71	15.95	27.78
Fixed Carbon	40.86	41.43	72.22
Ash	42.03	42.63	--
TOTAL	100.00	100.00	100.00
Heating Value(Btu/lb)	8,404	8,424	14,857

ULTIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Hydrogen	3.12	3.01	5.25
Carbon	47.85	48.53	84.59
Nitrogen	0.96	0.98	1.71
Oxygen	4.38	3.17	5.52
Sulfur	1.66	1.68	2.93
Ash	42.03	42.63	--
TOTAL	100.00	100.00	100.00

FORMS OF SULFUR

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Sulfate	0.06	0.06	0.10
Pyritic	1.23	1.25	2.18
Organic	0.37	0.37	0.65

PARR FORMULA

Fixed Carbon (%) -	76.8
Volatile Matter (%) -	23.2
Heating Value (Btu/lb) -	15,393

TABLE 8

COAL ANALYSIS

U.S. GEOLOGICAL SURVEY
SAMPLE NUMBER 2
OXFORD NO. 1

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	2.07	--	--
Volatile Matter	14.82	15.13	28.21
Fixed Carbon	37.70	38.50	71.79
Ash	45.41	46.37	--
TOTAL	100.0	100.0	100.0
Heating Value(Btu/lb)	7,637	7,798	14,539

ULTIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Hydrogen	2.96	2.79	5.20
Carbon	43.59	44.51	82.99
Nitrogen	0.91	0.93	1.73
Oxygen	5.07	3.30	6.16
Sulfur	2.06	2.10	3.92
Ash	45.41	46.37	--
TOTAL	100.00	100.00	100.00

FORMS OF SULFUR

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Sulfate	0.04	0.04	0.07
Pyritic	1.60	1.63	3.04
Organic	0.42	0.43	0.81

PARR FORMULA

Fixed Carbon (%) -	78.29
Volatile Matter (%) -	21.71
Heating Value (Btu/lb) -	15,121

TABLE 9

COAL ANALYSIS

U.S. GEOLOGICAL SURVEY
SAMPLE NUMBER 3
OXFORD NO. 2

PROXIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Moisture	0.89	--	--
Volatile Matter	13.65	13.77	25.02
Fixed Carbon	40.89	41.26	74.98
Ash	44.57	44.97	--
TOTAL	100.00	100.00	100.00
Heating Value(Btu/lb)	8,368	8,443	15,342

ULTIMATE

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Hydrogen	2.84	2.76	5.02
Carbon	47.88	48.31	87.79
Nitrogen	0.93	0.94	1.71
Oxygen	3.38	2.62	4.75
Sulfur	0.40	0.40	0.73
Ash	44.57	44.97	--
TOTAL	100.00	100.00	100.00

FORMS OF SULFUR

	AS RECEIVED	MOISTURE FREE	MOISTURE AND ASH FREE
Sulfate	0.00	0.00	0.00
Pyritic	0.01	0.01	0.02
Organic	0.39	0.39	0.71

PARR FORMULA

Fixed Carbon (%) -	80.44
Volatile Matter (%) -	19.56
Heating Value (Btu/lb) -	16,164

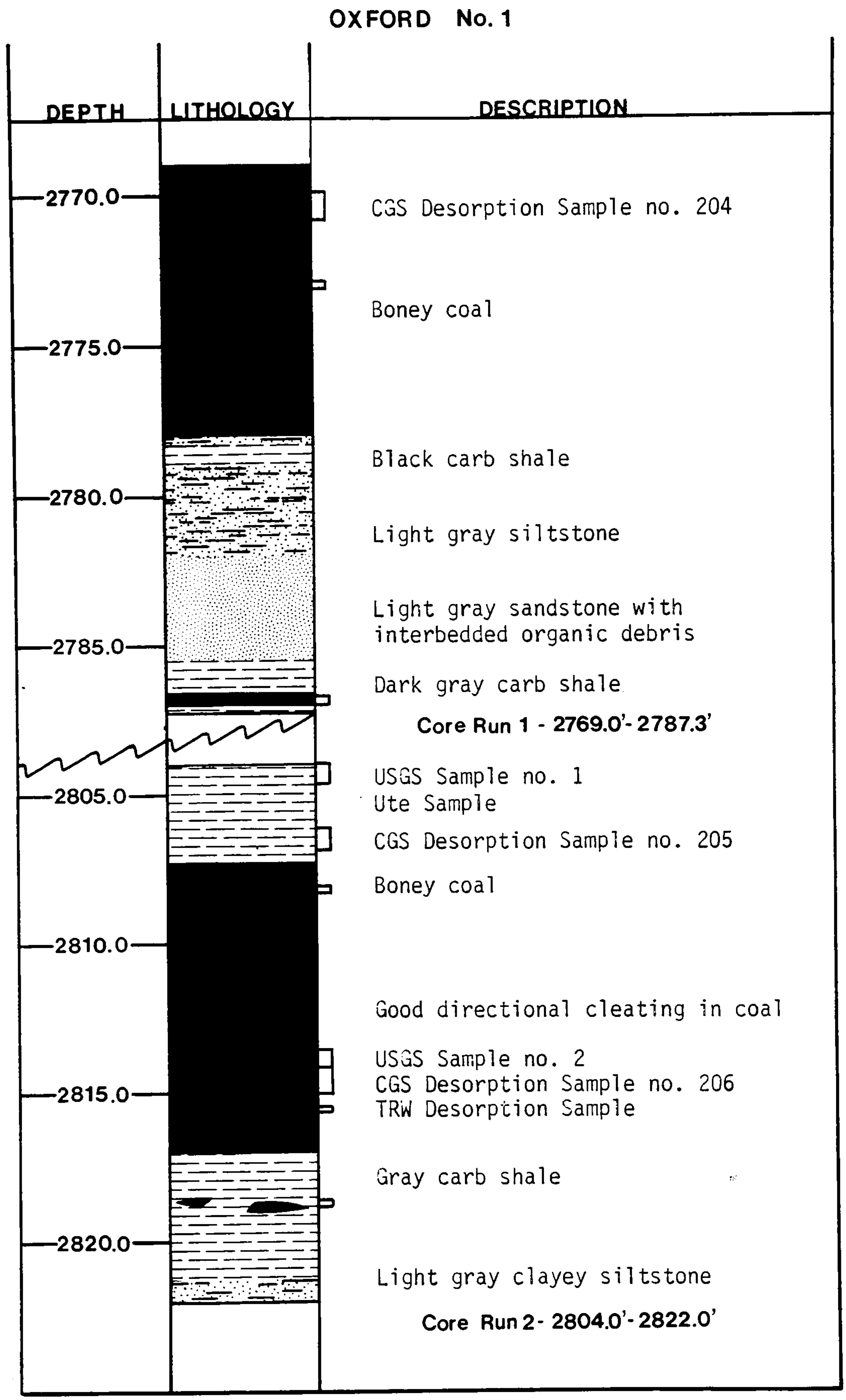

Figure 3. Oxford No. 1, Core Run Descriptive Log

OXFORD No. 2

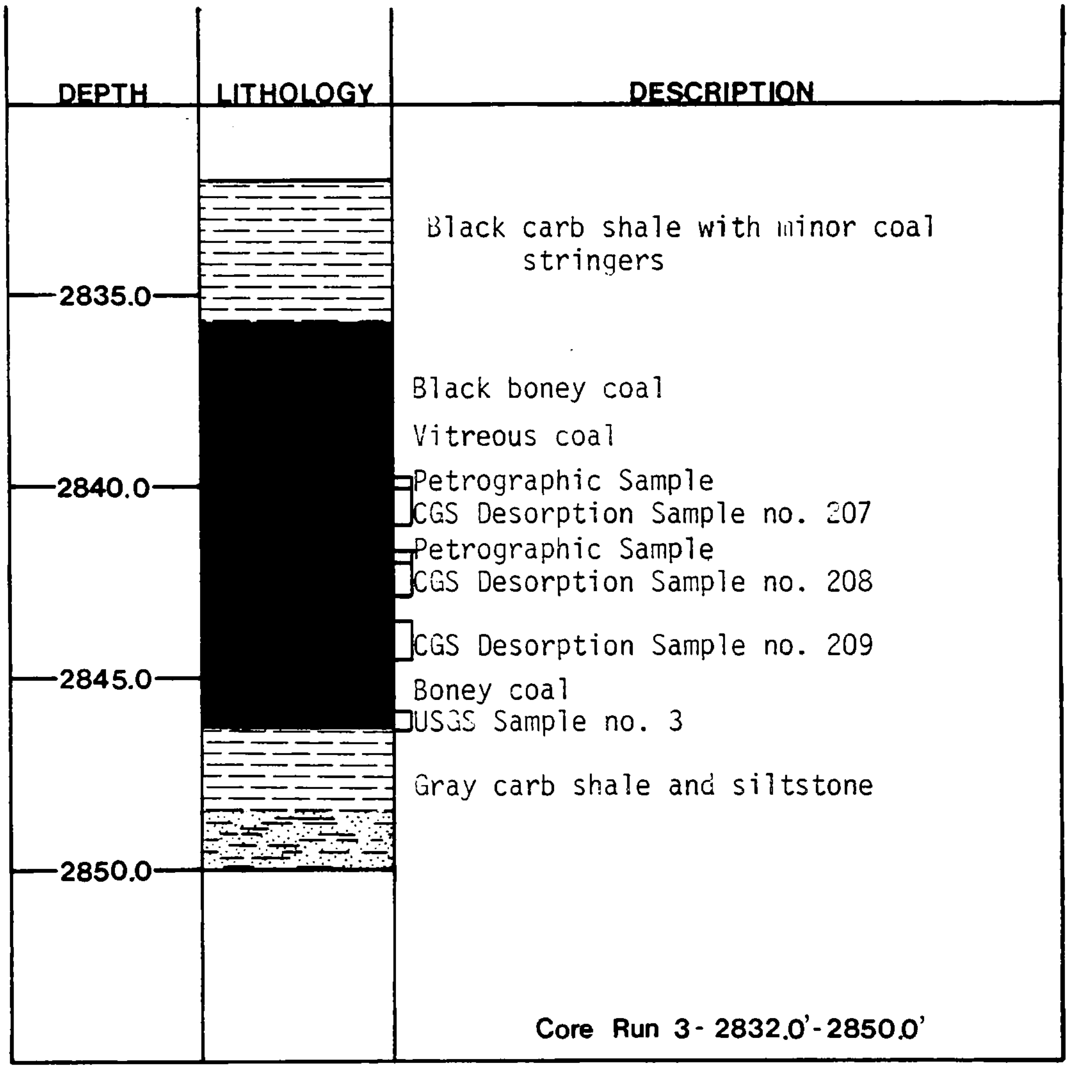

Figure 4. Oxford No. 2, Core Run Descriptive Log

Diagnostic vitrinite reflectance of six samples presented in Tables 10 and 11 indicate coal ranks of medium volatile bituminous. Therefore, it is concluded that the Parr Formula can be misleading in assigning rank values to Western coals.

Figure 6 shows the variation in vitrinite reflectance in the San Juan Basin. Also shown on the map are the mapped gas fields of the Fruitland Formation. Coalification increases rapidly toward the north from the center of the basin along the Colorado border. Asymmetry of vitrinite reflectance values with respect to areas of greatest subsidence indicates that the geothermal gradient did not follow subsidence directly but was influenced by other localized heat sources to a greater extent.

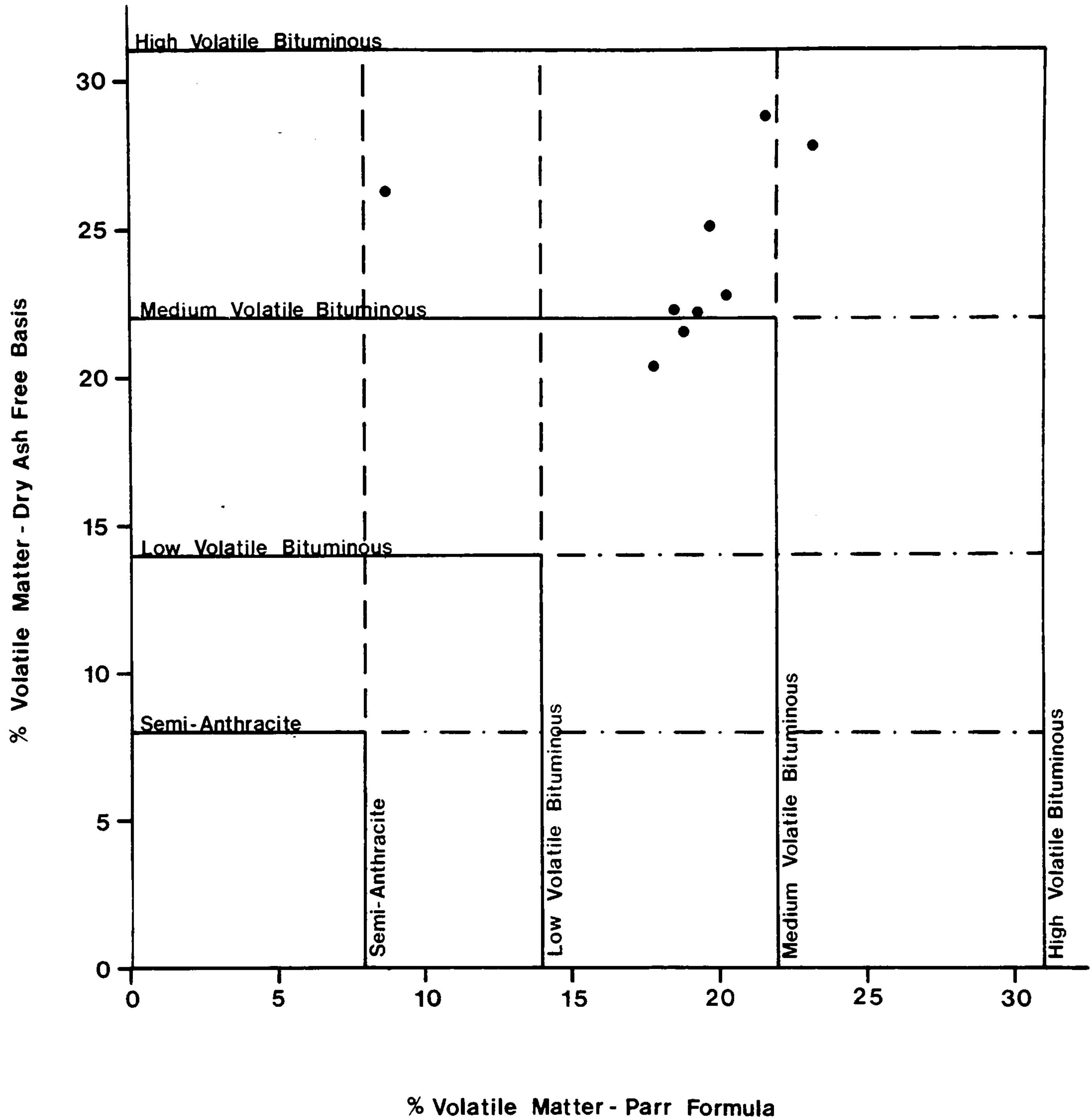

Figure 5. Cross Plot of Volatile Matter on Dry, Ash Free and Parr Formula Basis

TABLE 10

VITRINITE REFLECTANCE
OXFORD NO. 1

SAMPLE OF DEPTH (FEET)	MEAN VITRINITE REFLECTANCE
2772.9	1.33
2786.7	1.31
2815.5	1.38
2818.6	1.37

TABLE 11

VITRINITE REFLECTANCE
OXFORD NO. 2

SAMPLE OF DEPTH (FEET)	MEAN VITRINITE REFLECTANCE
2839.8-2840.0	1.44
2841.7-2842.0	1.38

Desorption Results

Six core samples were collected (three from the Oxford No. 1 and three from Oxford No. 2) for methane gas content determinations (desorption) using the U.S. Bureau of Mines Direct Method (Diamond and Levine, 1981). The lost gas values for the samples were generated similarly to the Direct Method and a linear regression method was used to determine the y-intercept (lost gas number). Table 12 presents the gas content data for the six samples and it should be noted that the contents are measured in cubic feet per ton (cf/t). To convert the measured volumes to an approximate standard cubic feet per ton (scf/t) value, multiply the cf/t value by 0.80. This calculation is based upon numerous other sample corrections undertaken by the Colorado Geological Survey (Tremain, 1983).

Gas Analyses

Table 13 presents coal gas analyses taken from desorbed samples of the Oxford No. 1 and Oxford No. 2. The high δ C13 values are compatible with a coal-derived gas. Heavier hydrocarbons are lost with increasing temperature, and according to Rice (1983) the "isotopic composition of methane approaches that of the original organic matter (δ C13 values are heavier than -35‰)."

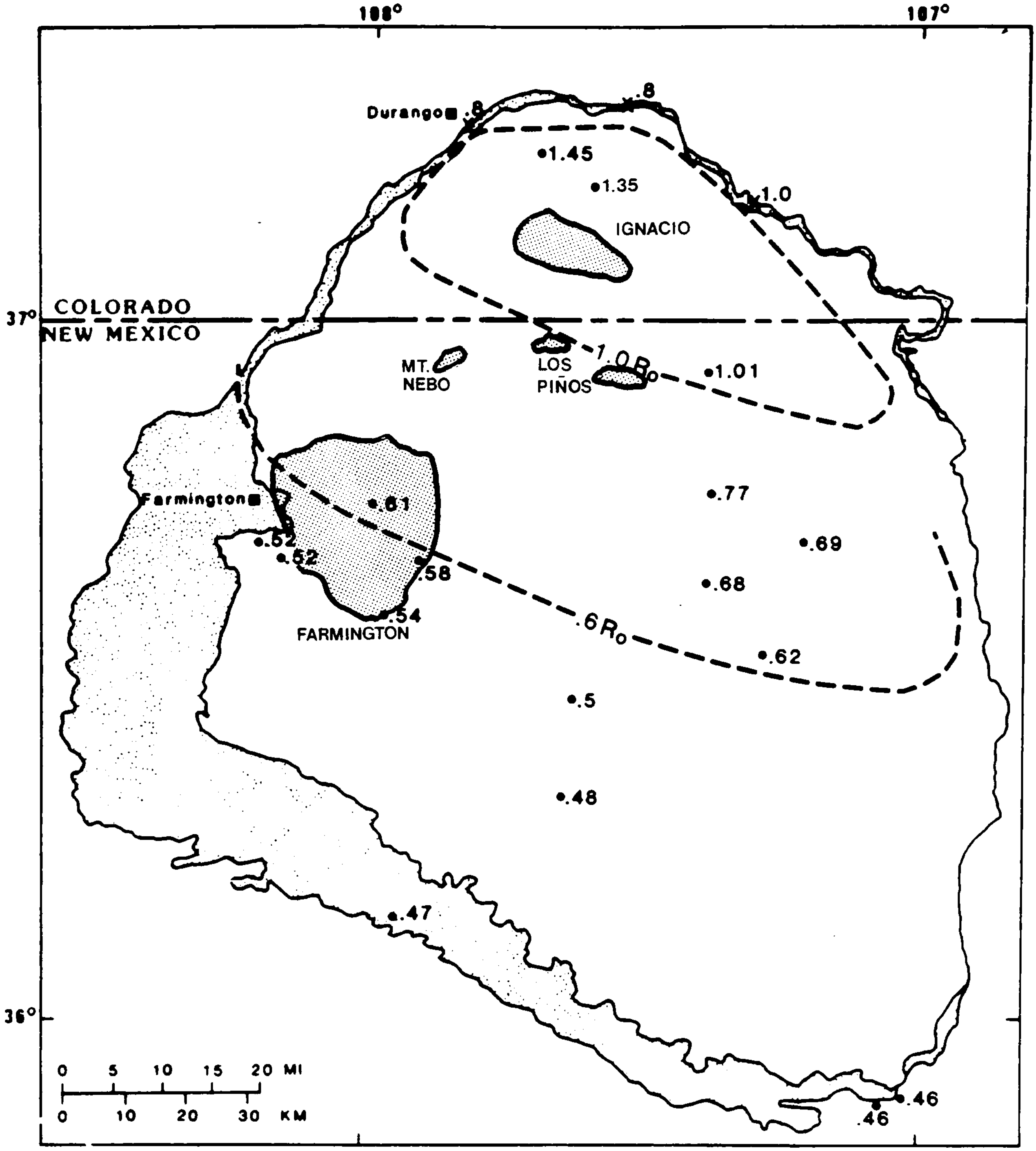

Figure 6. Vitrinite Reflectance (R_0) and Fruitland Gas Fields

TABLE 12
DESORBED GAS CONTENT

OXFORD NO. 1

Sample Interval	Sample Number	Weight (g)	Lost Gas* (cc)	Desorbed Gas(cc)	Residual Gas(cc/g)	Gas Content (cc/g)	Gas Content (cf/t)
2769.8'-2770.7'	CGS 204	1,085	2,860	9,375	0.2	11.48	367.36
2806.1'-2806.8'	CGS 205	1,603	1,851	5,990	0.1	4.99	159.68
2814.2'-2815.1'	CGS 206	1,744	6,582	17,390	0.2	13.95	446.40

OXFORD NO. 2

Sample Interval	Sample Number	Weight (g)	Lost Gas* (cc)	Desorbed Gas(cc)	Residual Gas(cc/g)	Gas Content (cc/g)	Gas Content (cf/t)
2840.1'-2841.0'	CGS 207	1,676	5,687	12,250	0.1	10.80	345.60
2842.0'-2842.8'	CGS 208	1,756	6,647	12,090	0.2	10.87	347.84
2843.5'-2844.6'	CGS 209	1,849	8,959	18,550	0.1	14.98	479.36

*linear regression method used to determine y-intercept (lost gas)

TABLE 13

GAS COMPOSITION ANALYSES AND CARBON 13 ISOTOPE DATA (THRELKELD, 1982)

Well Name	CGS Sample No.	C13	N2+Air (%)	C1 (%)	CO2 (%)	C2 (%)	Heating Value (Btu/cu ft)
Oxford No. 1	204	-34.32	4.17	93.65	1.97	0.21	951.48
	205	-36.28	5.34	92.15	2.34	0.17	935.59
	206	-38.57	10.38	87.10	2.33	0.19	884.84
Oxford No. 2	207	-33.23	3.36	93.41	2.98	nil	945.31
	208	-32.87	3.56	92.74	3.41	0.29	943.70
	209	-33.27	2.50	94.29	2.98	0.22	958.13

Figure 7 is a plot of δ C13 versus C1/C1-C5. Shown on the graph are two populations relating to different gas sources. Colorado Geological Survey samples display high C1/C1-C5 ratios and are generally heavier than other samples plotted on the graph. The remaining data plotted on Figure 7 are abstracted from Rice (1983) and are representative gas samples from the Fruitland and Pictured Cliffs Formations.

Table 14 is a wellhead gas analysis from Oxford No. 1. The isotopic ratio is plotted on Figure 7. Characteristics of both thermogenic gas and coal gas are observed in its relation to the population of gas samples. The wellhead gas sample shown in Table 14 was collected from the open-hole intervals 2802 feet to 2854 feet and may not represent a pure coal gas analysis.

TABLE 14

Wellhead Gas Composition Analyses
and Carbon 13 Isotope Data from the Oxford No. 1

C13	N2+Air (%)	C1 (%)	CO2 (%)	C2 (%)	Heating Value Btu/cu ft
-41.39	8.39	89.21	2.35	0.15	905

Well Completion

An initial attempt to open-hole complete the two wells was made with the little remaining monies from the Department of Energy funding and Tribal funds. Both wells have 9-5/8 inch surface casing set below 300 feet. The Oxford No. 1 has 7-inch production casing set at 2,802 feet and the Oxford No. 2 has 5-1/2 inch production casing set at 2,833 feet. In both wells, the production casing is set on top of a thick basal Fruitland coal. Each well has 2-7/8 inch production tubing run to the casing shoe with 10 feet of homemade gas anchor set opposite the coals. The Oxford No. 1 and No. 2 were under-reamed beneath the casing to minimize the skin damage (mud penetration into the coal) to a size of 13-1/2 inch and 9-1/2 inch, respectively. Both wells have been opened to atmospheric pressures for various time intervals and detergent has been used to aid in unloading water from the wells. To date, there has not been enough gas pressure to lift the water and permit commercial gas production rates. Operation of the wells has been assumed by HJK, a local operator, and further completion efforts are underway.

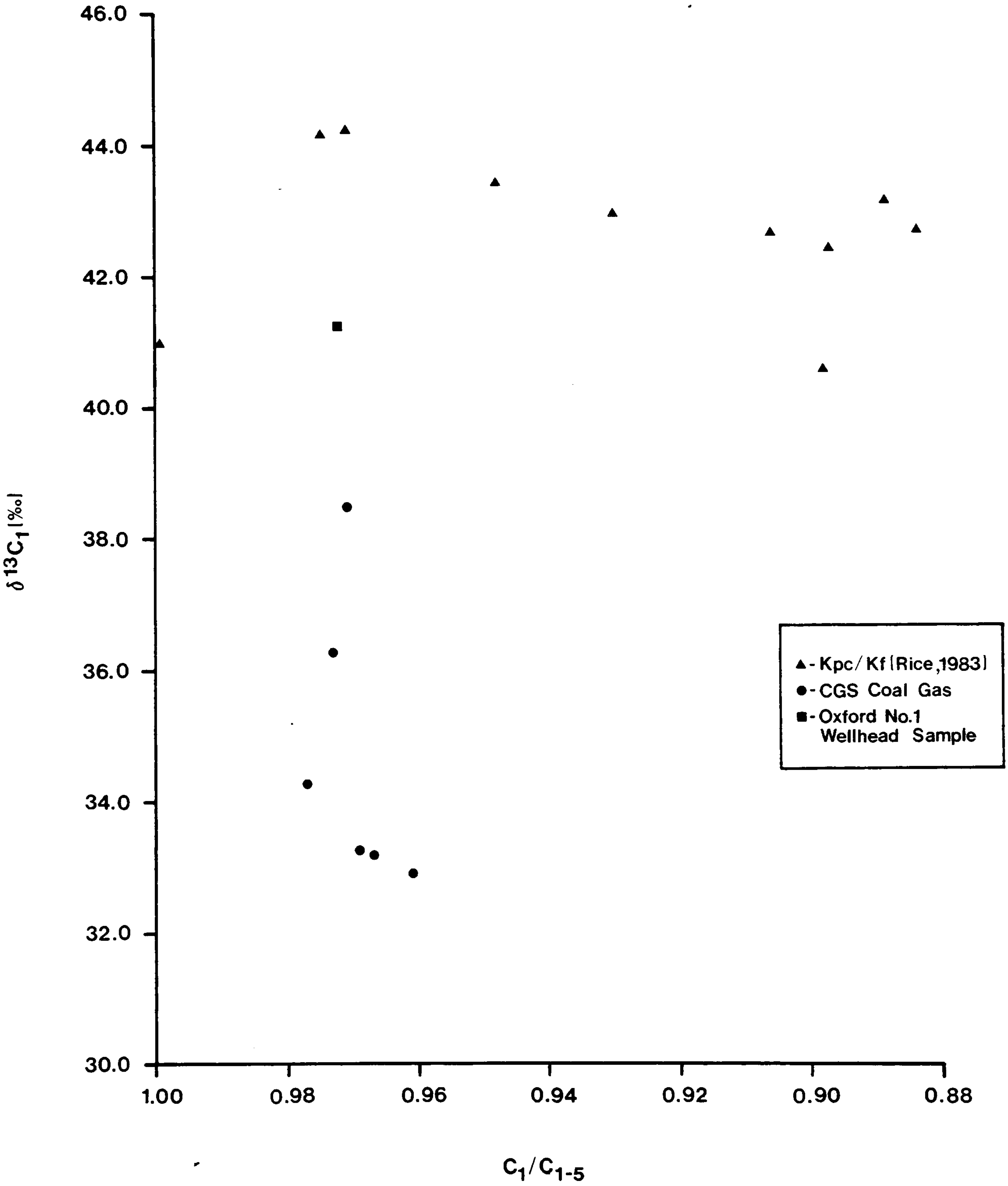

Figure 7. Gas Analysis Plot-- $\delta^{13}C_1$ versus C1/C1-5

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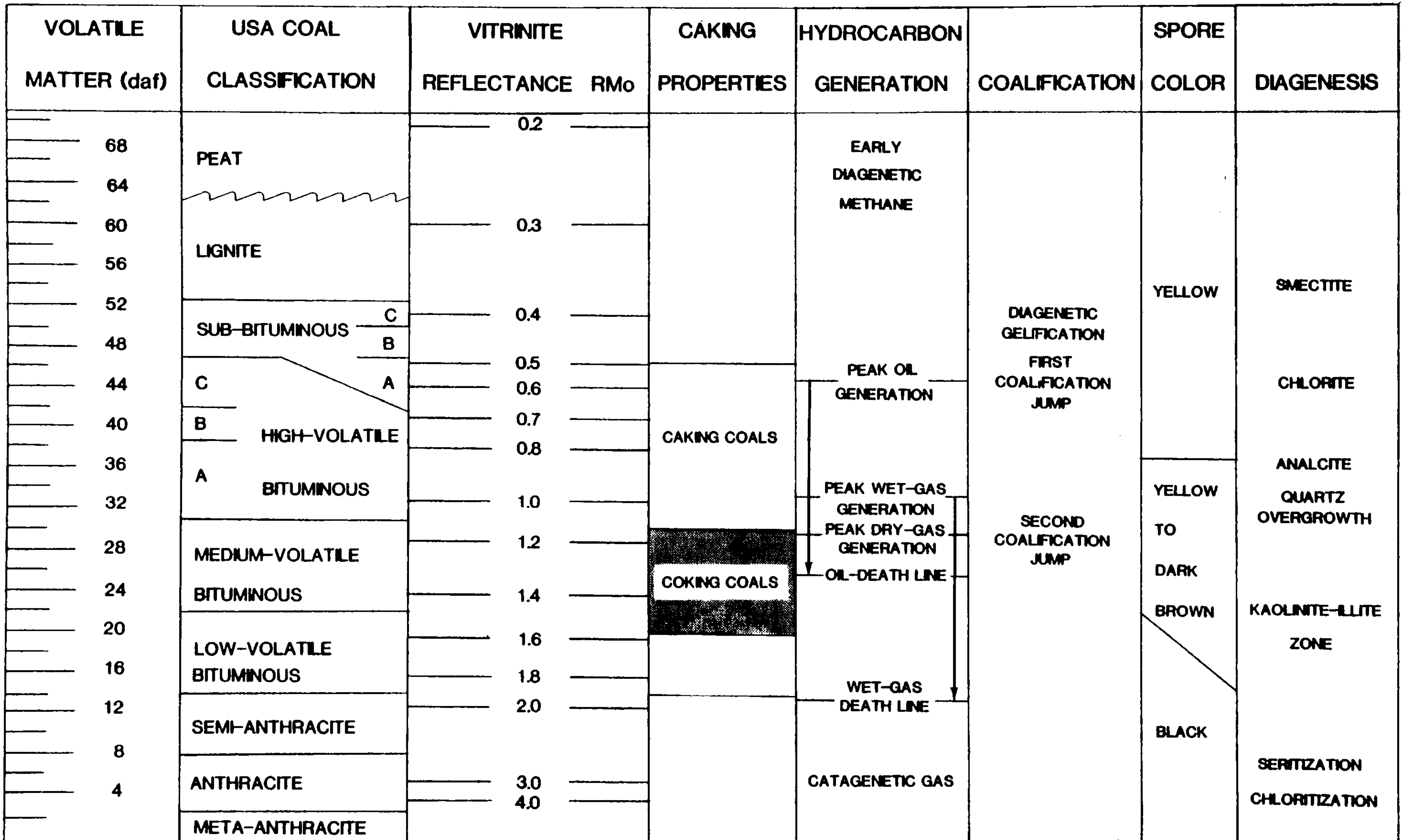

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(MODIFIED FROM HANDBOOK OF COAL PETROLOGY, 1975)