DEPARTMENT OF THE INTERIOR
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Summary of vitrinite reflectance and Rock-Eval pyrolysis data, Eagle Basin, Northwestern Colorado

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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INTRODUCTION

The purpose of this study is to identify possible hydrocarbon source rocks in the Eagle Basin of Northwestern Colorado (plate 1) and evaluate their thermal maturity. The study area is roughly defined by the Gore Range to the east, the Sawatch Range and McClure Pass to the south, the Grand Hogback to the west, and the Williams Fork Mountains to the north. Samples were obtained from rocks ranging in age from Pennsylvanian through Cretaceous over the greater part of the study area (fig. 1). However, large tracts of the study area, such as the White River uplift, are devoid of these rocks, or are covered by alluvium or vegetation.

This paper contains the analytical data on 112 samples collected from the study area. The data are being interpreted at this time, and the interpretations will be presented in a forthcoming paper. Table 1 lists the formation name, age, location and lithology for each sample, as well as the mean random vitrinite reflectance (Rm) and Rock-Eval pyrolysis geochemistry data. Vitrinite reflectance analyses were performed on all samples to determine the level of thermal maturation. Table 1 contains the Rm values, the sample population (number of vitrinite reflectance measurements per sample), and the standard deviation for each sample. The quality of each sample can be judged by the size of the sample population and the standard deviation; the larger the sample population and the lower the standard deviation, the better quality of sample. Total organic carbon (TOC), a measure of present-day source-rock richness, was determined on all samples using Rock-Eval pyrolysis. This technique also provided additional data on each sample, such as Tmax, hydrogen index, oxygen index, production index, values for the S1, S2, and S3 peaks and other data.

All samples are from the outcrop. Dark gray or black mudstones, fine-grained sandstones, shales, and gypsum were collected where possible, after digging into the outcrop to obtain relatively fresh, unweathered samples.

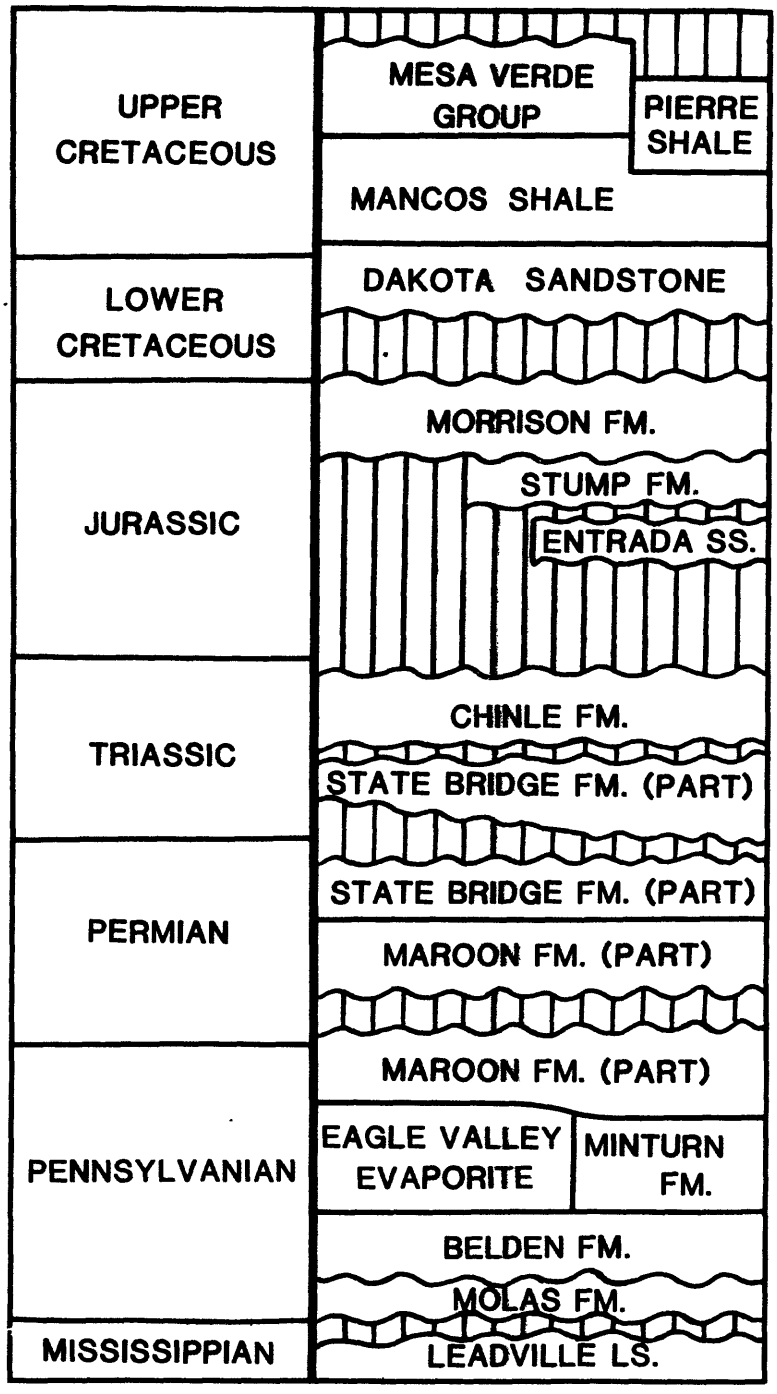

Figure 1.--Pennsylvanian to Cretaceous stratigraphy of the Eagle Basin, Northwestern Colorado. The Colorado Group, (locally mapped as a separate unit in the Eagle basin) includes all of the Cretaceous units in the study area, hence is not shown in the stratigraphic column.

Table 1. Vitrinite Reflectance and Rock-Eval pyrolysis data for the Eagle Basin, Northwestern Colorado.
[Dashes,---, indicate data not available]

Formation	Age	Location Sec.	T.	R.	County	Lithology	Sample No.	TOC (wt.%)	Rm (%)	N	σ	Tmax	HI	OI	PI	PC	Weight (mg)	S1 mg/g	S2 mg/g	S3 mg/g	S2/S3
Belden	Early and	12	6S	81W	Eagle	Mudstone	1	2.03	3.37	11	0.33	0	0	38	0.00	0.00	160.9	0.01	0.00	0.78	0.00
	Middle	12	6S	81W	Eagle	Sandstone	2	0.49	3.72	80	0.23	0	0	40	0.00	0.00	235.8	0.01	0.00	0.20	0.00
	Pennsylvanian	12	6S	81W	Eagle	Carbonate	3	0.91	4.09	19	0.29		4	23	0.25	0.00	250.0	0.01	0.04	0.21	0.19
		5	5S	84W	Eagle	Mudstone	15	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		12	6S	81W	Eagle	Mudstone	H	0.80	3.64	56	0.24	0	0	28	0.00	0.00	243.3	0.00	0.00	0.23	0.00
		9	8S	84W	Eagle	Mudstone	Y	0.77	4.12	60	0.18	0	0	31	0.00	0.00	213.3	0.00	0.00	0.24	0.00
		10	8S	84W	Eagle	Mudstone	Z	0.83	3.70	78	0.27	0	0	16	0.00	0.00	232.7	0.00	0.00	0.14	0.00
		11	8S	84W	Eagle	Mudstone	2A	3.63	3.77	73	0.17	542	0	13	0.25	0.00	207.0	0.01	0.03	0.50	0.06
		9	4S	86W	Eagle	Mudstone	3X	2.10	2.47	60	0.19	581	8	5	0.00	0.01	249.4	0.00	0.17	0.12	1.41
		17	4S	86W	Eagle	Mudstone	3Y	2.30	1.32	21	0.15	575	2	28	0.17	0.00	220.8	0.01	0.06	0.65	0.09
		31	4S	86W	Eagle	Mudstone	3Z	1.85	2.68	52	0.22	419	3	16	0.37	0.00	230.7	0.03	0.06	0.31	0.19
Minturn	Middle	16	2S	83W	Eagle	Mudstone	8	3.48	1.20	81	0.10	527	14	22	0.04	0.04	211.8	0.02	0.49	0.79	0.62
	Pennsylvanian	5	2S	83W	Eagle	Mudstone	9	0.59	1.27	37	0.09	0	0	30	0.00	0.00	238.3	0.00	0.00	0.18	0.00
		3	5S	82W	Eagle	Mudstone	20	5.84	1.90	107	0.26	586	6	34	0.03	0.03	132.6	0.01	0.37	2.02	0.18
		20	5S	79W	Eagle	Sandstone	B	0.05	0.94	31	0.24	0	100	60	0.33	0.00	226.8	0.02	0.05	0.03	1.66
		15	5S	81W	Eagle	Mudstone	C	0.70	1.03	74	0.10	517	2	64	0.00	0.00	230.7	0.00	0.02	0.45	0.04
		15	5	81W	Eagle	Mudstone	D	0.09	1.08	34	0.09	0	33	77	0.50	0.00	190.2	0.02	0.03	0.07	0.42
		25	5S	81W	Eagle	Mudstone	E	1.45	2.62	49	0.23	563	2	7	0.00	0.00	232.9	0.00	0.04	0.11	0.36
		25	5S	81W	Eagle	Mudstone	F	0.78	2.52	50	0.19	0	16	16	0.19	0.01	245.0	0.03	0.13	0.13	1.00
		1	6S	81W	Eagle	Sandstone	G	0.13	1.11	48	0.07	0	15	69	0.75	0.00	227.8	0.03	0.02	0.09	0.22
		12	6S	81W	Eagle	Mudstone	I	0.96	0.97	100	0.10	0	1	71	0.50	0.00	183.3	0.01	0.01	0.69	0.01
		13	6S	81W	Eagle	Mudstone	J	0.49	1.03	62	0.13	0	8	55	0.25	0.00	203.4	0.01	0.04	0.27	0.14
		21	5S	81W	Eagle	Mudstone	K	0.45	1.27	31	0.18	496	4	117	0.00	0.00	245.0	0.00	0.02	0.53	0.03
		5	8S	84W	Eagle	Mudstone	U	0.83	1.26	62	0.11	499	3	79	0.00	0.00	230.3	0.00	0.03	0.66	0.04
		5	8S	84W	Eagle	Mudstone	V	1.08	1.16	50	0.12	489	4	58	0.00	0.00	226.4	0.00	0.05	0.63	0.07
		9	8S	84W	Eagle	Mudstone	X	0.40	0.83	50	0.07	0	2	120	0.50	0.00	205.3	0.01	0.01	0.48	0.02
		10	1S	84W	Routt	Mudstone	3M	5.22	0.69	45	0.05	450	7	93	0.03	0.03	186.6	0.01	0.37	4.88	0.07
		1	2S	84W	Eagle	Mudstone	3N	0.48	1.05	75	0.08	0	37	102	0.06	0.01	234.4	0.01	0.18	0.49	0.36
		2	2S	84W	Eagle	Mudstone	30	3.11	0.82	100	0.09	476	15	53	0.06	0.04	200.7	0.03	0.49	1.67	0.29
		3	2S	84W	Eagle	Mudstone	3P	1.23	0.71	53	0.13	447	53	39	0.17	0.06	173.5	0.14	0.66	0.49	1.34
		3	2S	84W	Eagle	Mudstone	3Q	0.04	1.01	50	0.08	0	50	125	0.50	0.00	241.8	0.02	0.02	0.05	0.40
Eagle	Middle	26	4S	85W	Eagle	Mudstone	11	0.93	1.12	15	0.11	510	7	123	0.12	0.00	239.9	0.01	0.07	1.15	0.06
Valley	Pennsylvanian	26	4S	85W	Eagle	Mudstone	12	---	1.17	49	0.09	---	---	---	---	---	---	---	---	---	---
Evaporite		33	4S	85W	Eagle	Mudstone	14	5.65	1.24	53	0.12	493	0	32	0.25	0.00	173.0	0.01	0.03	1.84	0.01
		24	4S	84W	Eagle	Mudstone	16	---	1.40	48	0.13	---	---	---	---	---	---	---	---	---	---
		5	5S	85W	Eagle	Mudstone	17	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		24	4S	84W	Eagle	Mudstone	18	0.31	1.18	50	0.10	0	3	74	0.00	0.00	232.5	0.00	0.01	0.23	0.04
		4	5S	85W	Eagle	Mudstone	21	---	1.86	102	0.25	---	---	---	---	---	---	---	---	---	---
		4	5S	85W	Eagle	Mudstone	22	4.40	1.85	75	0.16	596	2	74	0.08	0.01	169.3	0.01	0.11	3.26	0.03
		24	4S	84W	Eagle	Mudstone	23	1.66	1.20	50	0.10	0	0	112	0.00	0.00	155.8	0.00	0.00	1.87	0.00
		24	4S	84W	Eagle	Mudstone	24	---	1.24	50	0.10	---	---	---	---	---	---	---	---	---	---

Formation	Age	Location Sec.	T.	R.	County	Lithology	Sample No.	TOC (wt.%)	Rm (%)	N	σ	Tmax	HI	OI	PI	PC	Weight (mg)	S1 mg/g	S2 mg/g	S3 mg/g	S2/S3
Eagle Valley Evaporite (cont.)	Middle Pennsylvanian	24	4S	84W	Eagle	Mudstone	26	0.23	0.96	33	0.14	0	17	113	0.00	0.00	244.8	0.00	0.04	0.26	0.15
		24	4S	84W	Eagle	Mudstone	27	0.68	1.08	75	0.06	0	2	94	0.00	0.00	221.6	0.00	0.02	0.64	0.03
		24	4S	84W	Eagle	Mudstone	28	0.43	1.10	73	0.06	0	6	102	0.00	0.00	205.8	0.00	0.03	0.44	0.06
		29	4S	86W	Eagle	Mudstone	30	0.18	1.18	51	0.11	484	172	916	0.30	0.03	222.1	0.13	0.13	1.65	0.18
		29	4S	86W	Eagle	Mudstone	31	0.45	1.17	55	0.07	496	4	117	0.00	0.00	245.0	0.00	0.02	0.53	0.03
		11	5S	82W	Eagle	Mudstone	L	0.35	1.35	53	0.11	549	11	91	0.00	0.00	238.5	0.00	0.04	0.32	0.12
		33	4S	84W	Eagle	Mudstone	M	0.36	---	---	---	453	11	30	0.25	0.00	213.8	0.01	0.04	0.11	0.36
		7	7S	88W	Garfield	Mudstone	N	0.30	1.12	50	0.05	0	13	86	0.33	0.00	242.5	0.02	0.04	0.26	0.15
		7	7S	88W	Garfield	Mudstone	O	0.09	1.19	25	0.14	0	0	155	0.00	0.00	248.0	0.00	0.00	0.14	0.00
		30	7S	87W	Garfield	Sandstone	Q	0.08	1.13	14	0.11	0	37	150	0.00	0.00	205.2	0.00	0.03	0.12	0.25
		5	8S	84W	Eagle	Gypsum	W	0.05	1.10	5	0.31	0	0	40	0.00	0.00	146.5	0.00	0.00	0.02	0.00
		8	1S	91W	RioBlanco	Mudstone	2Q	0.28	0.73	43	0.14	0	7	103	0.50	0.00	233.8	0.01	0.02	0.29	0.06
		26	1N	91W	RioBlanco	Mudstone	2V	0.26	1.20	50	0.12	0	19	92	0.00	0.00	204.8	0.00	0.05	0.24	0.20
		10	4S	84W	Eagle	Mudstone	3W	0.47	1.10	36	0.10	0	4	117	0.92	0.01	234.8	0.11	0.02	0.55	0.03
		17	7S	88W	Garfield	Gypsum	4A	0.46	2.46	40	0.21	0	0	45	0.00	0.00	226.0	0.00	0.00	0.21	0.00
		18	6S	86W	Eagle	Gypsum	4C	2.93	1.30	60	0.14	537	3	109	0.00	0.00	102.5	0.00	0.11	3.20	0.03
		6	6S	86W	Eagle	Mudstone	4D	0.91	1.06	50	0.11	0	3	113	0.25	0.00	201.5	0.01	0.03	1.03	0.02
		29	5S	86W	Eagle	Mudstone	4E	0.66	0.53	34	0.07	496	6	54	0.00	0.00	235.4	0.00	0.04	0.36	0.11
		20	5S	85W	Eagle	Gypsum	4F	0.30	2.33	50	0.13	0	3	53	0.00	0.00	241.1	0.00	0.01	0.16	0.06
		5	5S	84W	Eagle	Gupsum	4H	0.14	1.55	62	0.14	0	0	42	0.00	0.00	228.3	0.00	0.00	0.06	0.00
		24	5S	84W	Eagle	Mudstone	4J	1.44	1.08	45	0.18	0	37	131	0.25	0.01	212.7	0.04	0.12	0.42	0.28
Maroon	Pennsylvanian and Permian	24	4S	84W	Eagle	Mudstone	19	0.61	1.15	81	0.11	0	0	67	0.00	0.00	207.2	0.00	0.00	0.41	0.00
		18	4S	83W	Eagle	Mudstone	25	---	1.10	48	0.08	---	---	---	---	---	---	---	---	---	---
		31	4S	85W	Eagle	Mudstone	29	0.19	1.13	24	0.10	0	15	147	0.00	0.00	213.1	0.00	0.03	0.28	0.10
		27	7S	88W	Garfield	Sandstone	P	0.02	---	---	---	0	150	100	0.62	0.00	234.1	0.05	0.03	0.02	1.50
		29	4S	91W	Garfield	Sandstone	2P	0.02	1.09	9	0.14	0	150	450	0.50	0.00	230.4	0.02	0.03	0.09	0.33
		18	1S	91W	Garfield	Sandstone	2R	0.05	1.15	20	0.34	451	200	440	0.29	0.01	238.9	0.04	0.10	0.22	0.45
		20	1S	92W	RioBlanco	Sandstone	2S	0.09	0.73	5	0.13	0	88	166	0.12	0.00	223.6	0.01	0.08	0.15	0.53
		15	1N	90W	RioBlanco	Sandstone	2W	0.11	0.81	8	0.13	0	9	154	0.50	0.00	228.2	0.01	0.01	0.17	0.05
		6	3S	85W	Eagle	Mudstone	3V	0.24	0.66	24	0.07	462	41	95	0.17	0.01	246.6	0.02	0.10	0.23	0.43
		5	6S	85W	Eagle	Sandstone	4G	0.11	0.91	50	0.09	0	18	81	0.75	0.00	242.1	0.03	0.02	0.09	0.22
Chinle and State Bridge	Triassic and Permian	14	1N	90W	RioBlanco	Sandstone	2X	0.19	0.94	8	0.21	0	0	78	0.00	0.00	242.1	0.00	0.00	0.15	0.00
Chinle	Late Triassic	35	5S	84W	Eagle	Sandstone	4I	0.04	1.08	16	0.15	0	0	200	0.00	0.00	237.0	0.00	0.00	0.08	0.00
Morrison	Late Jurassic	6	9S	85W	Pitkin	Mudstone	2E	0.06	---	---	---	534	150	800	0.33	0.01	202.8	0.04	0.09	0.48	0.18
		26	1N	84W	Routt	Sandstone	3J	0.01	0.89	11	0.18	0	300	0	0.25	0.00	228.5	0.01	0.03	0.17	0.17
		9	2S	84W	Eagle	Sandstone	3R	0.03	---	---	---	0	66	333	0.00	0.00	234.1	0.00	0.02	0.10	0.20
		8	2S	84W	Eagle	Sandstone	3S	0.00	---	---	---	0	0	0	0.00	0.00	235.8	0.01	0.00	0.02	0.00
Dakota Sandstone	Early Cretaceous	15	4S	83W	Eagle	Mudstone	4	5.72	0.74	65	0.09	445	98	15	0.04	0.49	185.2	0.26	5.65	0.86	6.42
		9	5S	91W	Garfield	Mudstone	2O	1.19	0.98	14	0.07	438	18	74	0.00	0.01	179.5	0.00	0.22	0.89	0.24
		10	1S	93W	RioBlanco	Mudstone	2T	0.04	---	---	---	0	0	100	0.00	0.00	246.1	0.01	0.00	0.04	0.00

Formation	Age	Location Sec.	T.	R.	County	Lithology	Sample No.	TOC (wt.%)	Rm (%)	N	σ	Tmax	HI	OI	PI	PC	Weight (mg)	S1 mg/g	S2 mg/g	S3 mg/g	S2/S3
Colorado Group	Late Cretaceous	15	4S	83W	Eagle	Mudstone	5	1.89	1.06	76	0.13	437	104	30	0.14	0.19	232.3	0.32	1.98	0.58	3.41
		10	4S	83W	Eagle	Mudstone	6	2.85	0.74	32	0.08	441	262	17	0.11	0.69	247.5	0.89	7.49	0.51	14.6
		15	4S	83W	Eagle	Mudstone	10	---	0.61	103	0.11	---	---	---	---	---	---	---	---	---	---
Mancos and Pierre Shales	Late Cretaceous	15	3S	83W	Eagle	Mudstone	7	0.46	0.50	67	0.04	433	67	39	0.03	0.02	247.8	0.01	0.31	0.18	1.72
		12	8S	87W	Eagle	Mudstone	R	1.40	0.74	63	0.09	435	86	76	0.09	0.11	216.5	0.12	1.21	1.07	1.13
		7	8S	86W	Eagle	Mudstone	S	1.26	0.77	50	0.10	440	91	44	0.31	0.13	250.0	0.52	1.15	0.56	2.05
		33	8S	86W	Pitkin	Mudstone	2B	1.42	1.66	56	0.14	486	39	49	0.17	0.05	243.1	0.11	0.56	0.70	0.80
		9	9S	86W	Pitkin	Mudstone	2C	0.54	1.25	33	0.12	520	18	50	0.25	0.01	228.3	0.03	0.10	0.27	0.37
		28	9S	85W	Pitkin	Mudstone	2D	0.52	1.27	51	0.11	465	42	17	0.34	0.02	249.8	0.11	0.22	0.09	2.44
		33	5S	90W	Garfield	Mudstone	2I	3.27	0.87	75	0.14	447	345	7	0.12	1.07	140.1	1.54	11.3	0.24	47.1
		30	5S	90W	Garfield	Mudstone	2J	1.95	0.54	60	0.08	434	128	33	0.11	0.23	205.8	0.31	2.50	0.66	3.78
		23	5S	91W	Garfield	Mudstone	2K	2.35	0.40	50	0.07	434	148	46	0.07	0.31	228.7	0.25	3.49	1.10	3.17
		22	5S	91W	Garfield	Mudstone	2L	0.57	0.51	40	0.08	437	59	92	0.08	0.03	234.2	0.03	0.34	0.53	0.64
		16	5S	91W	Garfield	Mudstone	2M	2.52	0.57	57	0.09	443	113	64	0.04	0.24	147.3	0.11	2.85	1.62	1.75
		9	5S	91W	Garfield	Mudstone	2N	0.58	0.56	33	0.07	442	36	68	0.05	0.01	244.1	0.01	0.21	0.40	0.52
		3	1S	93W	RioBlanco	Mudstone	2U	0.68	1.07	60	0.15	443	29	48	0.21	0.02	213.8	0.05	0.20	0.33	0.60
		21	2N	88W	RioBlanco	Mudstone	2Y	3.01	0.42	50	0.17	432	362	17	0.06	0.96	232.6	0.67	10.92	0.52	21.0
		36	3N	88W	RioBlanco	Mudstone	2Z	1.07	0.52	71	0.07	433	55	44	0.03	0.05	226.2	0.02	0.59	0.48	1.22
		31	3N	87W	RioBlanco	Mudstone	3A	0.27	0.42	50	0.06	424	55	40	0.00	0.01	250.0	0.00	0.15	0.11	1.36
		35	3N	87W	RioBlanco	Mudstone	3C	0.57	0.47	50	0.04	431	66	54	0.00	0.03	225.6	0.00	0.38	0.31	1.22
		30	3N	86W	RioBlanco	Mudstone	3D	0.35	0.41	50	0.04	436	42	137	0.12	0.01	246.2	0.02	0.15	0.48	0.31
		21	3N	86W	RioBlanco	Mudstone	3E	0.26	0.42	54	0.03	439	61	138	0.00	0.01	236.2	0.00	0.16	0.36	0.44
		31	3N	85W	Routt	Mudstone	3F	1.31	0.48	52	0.05	435	53	83	0.03	0.06	231.0	0.02	0.70	1.09	0.64
		23	2N	85W	Routt	Mudstone	3G	2.48	0.57	40	0.11	427	118	103	0.03	0.25	230.9	0.09	2.94	2.56	1.14
		16	1N	84W	Routt	Mudstone	3H	1.68	0.57	52	0.09	436	98	120	0.03	0.14	196.8	0.05	1.66	2.03	0.81
		15	1N	84W	Routt	Mudstone	3I	3.68	0.70	35	0.15	442	186	16	0.02	0.58	207.1	0.12	6.87	0.61	11.2
		17	2S	84W	Eagle	Mudstone	3T	---	0.96	61	0.11	---	---	---	---	---	---	---	---	---	---
Mesaverde Group	Late Cretaceous	7	5S	92W	Garfield	Mudstone	13	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		18	11S	88W	Gunnison	Mudstone	2F	0.47	0.89	40	0.06	490	17	63	0.00	0.00	225.8	0.00	0.08	0.30	0.26
		12	11S	89W	Gunnison	Mudstone	2G	5.81	0.71	102	0.06	445	206	5	0.04	1.04	177.5	0.53	11.9	0.34	35.2
		6	11S	88W	Pitkin	Mudstone	2H	0.57	0.75	49	0.07	450	80	33	0.17	0.04	237.8	0.09	0.46	0.19	2.42

ABBREVIATIONS USED:
Sec.--Section
T.--Township
R.--Range
TOC (wt. %)--Total Organic Carbon (weight percent).
Rm (%)--Mean random vitrinite reflectance (percent).
N--Sample population.
σ--Standard deviation.
Tmax--Temperature at which maximum yield of hydrocarbons occurs during the pyrolysis of organic matter.
HI--Hydrogen Index--S2 divided by organic carbon.
OI-- Oxygen Index--S3 divided by organic carbon.
PI--Production Index--S1/(S1+S2).
PC--Pyrolyzed carbon--weight percent of recoverable carbon after pyrolysis.
S1--Integral of first peak--existing hydrocarbons volatized at 250°C for 5 minutes.
S2--Integral of second peak--hydrocarbons produced by pyrolysis of solid organic matter (kerogen) from 250° to 550°C.
S3--Integral of third peak--CO2 produced by pyrolysis of kerogen from 250° to 390°C.