New Mexico Bureau of Mines & Mineral Resources
Socorro, NM 87801

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

Information: 505/835-5420
Publications: 505/835-5410

OPEN-FILE REPORT 300

HYDROCARBON SOURCE ROCK EVALUATION OF PHILLIPS PETROLEUM CO., NO. 6 LEAMEX, SEC. 23, T17S, R33E, LEA COUNTY, NEW MEXICO

By G. S. Bayliss and R. R. Schwarzer

July 1987

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION PROJECT

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API NO. 30-025-01515
SOUTHEAST AREA
GEOCHEM JOB NO. 3556

Prepared

for

PROGRAM PARTICIPANTS

by

Dr. Geoffrey S. Bayliss
and
Dr. Rudy R. Schwarzer

GEOCHEM LABORATORIES, INC.
1143-C BRITTMOORE ROAD
HOUSTON, TEXAS 77043
(713) 467-7011

CONFIDENTIAL
JULY, 1987

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

WELL NAME: PHILLIPS PETROLEUM CO., NO.6 LEAMEX
API NO.: 30-025-01515
AREA: SOUTHEAST
LOCATION: LEA COUNTY, NEW MEXICO SEC.23, T17S, R33E
GEOCHEM JOB NO.: 3556
TOTAL DEPTH: 16,842 ft.
INTERVAL SAMPLED: 4150-16580 ft.
TOTAL NUMBER OF SAMPLES: 40

GEOCHEM SAMPLE NUMBER	SAMPLE DEPTH	STRATIGRAPHIC INTERVAL	ANALYSES				
			LITHO	TOC	ROCK-EVAL	KEROGEN	OTHER
3556-001	4150-4200	Queen	X	X	X	X	
3556-002	5030-5080	San Andres	X	X	X	X	
3556-003	5080-5120	San Andres	X	X	X	X	
3556-004	5120-5170	San Andres	X	X	X	X	
3556-005	5840-5870	San Andres	X	X	X	X	
3556-006	5870-5910	San Andres	X	X	X	X	
3556-007	5960-6010	San Andres	X	X	X	X	
3556-008	6070-6130	Glorieta	X	X	X	X	
3556-009	6210-6220	Glorieta	X	X	X	X	
3556-010	6750-6790	Yesso	X	X	X	X	
3556-011	7270-7360	Yesso	X	X	X	X	
3556-012	7540-7620	Yesso	X	X	X	X	
3556-013	8500-8590	Abbo	X	X	X	X	
3556-014	9200-9270	Abbo	X	X	X	X	
3556-015	9600-9660	Abbo	X	X	X	X	
3556-016	9870-9900	Wolfcamp	X	X	X	X	
3556-017	10720-10850	Wolfcamp	X	X	X	X	
3556-018	11170-11220	Wolfcamp	X	X	X	X	
3556-019	11460-11530	Wolfcamp	X	X	X	X	
3556-020	11720-11820	Wolfcamp	X	X	X	X	
3556-021	11880-11920	Penn.- Cisco Canyon	X	X	X	X	
3556-022	12040-12100	Penn.- Cisco Canyon	X	X	X	X	
3556-023	12270-12320	Penn. - Canyon	X	X	X	X	
3556-024	12390-12440	Penn. - Canyon	X	X	X	X	
3556-025	12480-12530	Penn. - Canyon	X	X	X	X	
3556-026	12630-12710	Strawn	X	X	X	X	
3556-027	12910-12980	Atoka	X	X	X	X	
3556-028	12990-13050	Atoka	X	X	X	X	
3556-029	13070-13140	Atoka	X	X	X	X	

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION
(continued)

WELL NAME: PHILLIPS PETROLEUM CO., NO.6 LEAMEX
API NO.: 30-025-01515
AREA: SOUTHEAST
LOCATION: LEA COUNTY, NEW MEXICO SEC.23, T17S, R33E
GEOCHEM JOB NO.: 3556
TOTAL DEPTH: 16,842 ft.
INTERVAL SAMPLED: 4150-16580 ft.
TOTAL NUMBER OF SAMPLES: 40

GEOCHEM SAMPLE NUMBER	SAMPLE DEPTH	STRATIGRAPHIC INTERVAL	ANALYSES				
			LITHO	TOC	ROCK-EVAL	KEROGEN	OTHER
3556-030	13510-13600	Morrow	X	X	X	X	
3556-031	13600-13680	Morrow	X	X	X	X	
3556-032	14080-14160	Barnett	X	X	X	X	
3556-033	14220-14270	Barnett	X	X	X	X	
3556-034	14970-15010	Woodford	X	X	X	X	
3556-035	15010-15060	Woodford	X	X	X	X	
3556-036	15060-15100	Woodford	X	X	X	X	
3556-037	15650-15740	Fusselman	X	X	X	X	
3556-038	16150-16200	Montoya	X	X	X	X	
3556-039	16200-16240	Montoya	X	X	X	X	
3556-040	16510-16580	Simpson	X	X	X	X	

PHILLIPS #6 LEAMEX
JOB NUMBER 3556

SUMMARY FIGURE 1

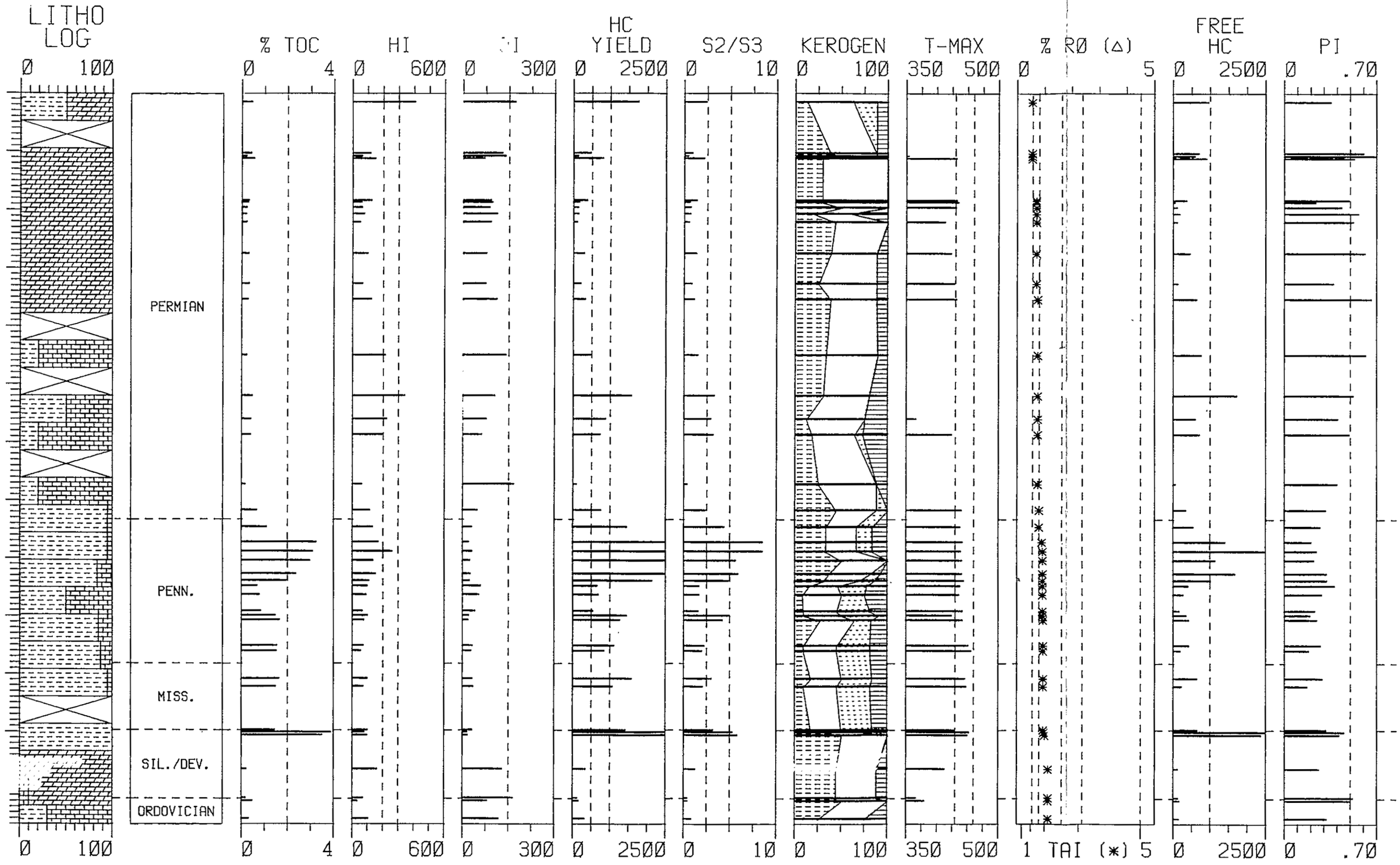


TABLE I

RESULTS OF TOTAL ORGANIC CARBON

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	TOTAL ORGANIC CARBON (% of Rock)
3556-001	4150-4200	0.43
3556-002	5030-5080	0.40
3556-003	5080-5120	0.21/0.23
3556-004	5120-5170	0.54
3556-005	5840-5870	0.30
3556-006	5870-5910	0.27
3556-007	5960-6010	0.21
3556-008	6070-6130	0.19
3556-009	6210-6220	0.21/0.21
3556-010	6750-6790	0.29
3556-011	7270-7360	0.31
3556-012	7540-7620	0.27
3556-013	8500-8590	0.22
3556-014	9200-9270	0.46
3556-015	9600-9660	0.39
3556-016	9870-9900	0.38
3556-017	10720-10850	0.15/0.16
3556-018	11170-11220	0.66
3556-019	11460-11530	1.10
3556-020	11720-11820	3.25
3556-021	11880-11920	3.08
3556-022	12040-12100	2.97
3556-023	12270-12320	2.36
3556-024	12390-12440	1.95
3556-025	12480-12530	0.67/0.67
3556-026	12630-12710	0.77
3556-027	12910-12980	0.83
3556-028	12990-13050	1.47
3556-029	13070-13140	1.66
3556-030	13510-13600	1.54
3556-031	13600-13680	1.52
3556-032	14080-14160	1.64
3556-033	14220-14270	1.49/1.50

TABLE I (continued)

RESULTS OF TOTAL ORGANIC CARBON

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	TOTAL ORGANIC CARBON (% of Rock)
3556-034	14970-15010	1.45
3556-035	15010-15060	3.88
3556-036	15060-15100	3.50
3556-037	15650-15740	0.21
3556-038	16150-16200	0.17
3556-039	16200-16240	0.46
3556-040	16510-16580	0.31

TABLE II

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-001	4150-4200			0.43
-A		50% Dolomite, sucrosic, pale yellow-brown.	10YR-6/2	
-B		50% Mudstone, noncalcareous, grayish red.	10R-4/2	
		Trace gray shale, sandstone.		
3556-002	5030-5080			0.40
-A		100% Dolomite, sucrosic, limely, very pale orange.	10YR-8/2	
3556-003	5080-5120			0.21/0.23
-A		100% Dolomite, sucrosic, limely, very pale orange.	10YR-8/2	
3556-004	5120-5170			0.54
-A		100% Dolomite, fine to medium crystalline, limely, grayish brown.	5YR-3/2	
3556-005	5840-5870			0.30
-A		100% Dolomite, fine to medium crystalline, limely, grayish brown.	5YR-3/2	
3556-006	5870-5910			0.27
-A		100% Dolomite, fine to medium crystalline, limely, grayish brown.	5YR-3/2	
3556-007	5960-6010			0.21
-A		100% Dolomite, fine to medium crystalline, limely, grayish brown.	5YR-3/2	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-008	6070-6130			0.19
-A		100% Dolomite, sucrosic, medium gray.	N5	
3556-009	6210-6220			0.21/0.21
-A		100% Dolomite, sucrosic, medium gray.	N5	
3556-010	6750-6790			0.29
-A		100% Dolomite, sucrosic, pale yellow-brown.	10YR-6/2	
3556-011	7270-7360			0.31
-A		100% Dolomite, sucrosic, pale yellow-brown.	10YR-6/2	
3556-012	7540-7620			0.27
-A		100% Dolomite, sucrosic, pale yellow-brown.	10YR-6/2	
3556-013	8500-8590			0.22
-A		80% Limestone, dolomitic, finely crystalline, pale yellowish brown.	10YR-6/2	
-B		20% Shale, noncalcareous, dark greenish gray.	5G-4/1	
3556-014	9200-9270			0.46
-A		50% Limestone, dolomitic, finely crystalline, pale yellowish brown.	10YR-6/2	
-B		50% Shale, noncalcareous, dark greenish gray to dark gray.	5G-4/1 to N3	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-015	9600-9660			0.39
-A		50% Limestone, dolomitic, finely crystalline, pale yellowish brown.	10YR-6/2	
-B		50% Shale, noncalcareous, dark greenish gray to dark gray.	5G-4/1 to N3	
3556-016	9870-9900			0.38
-A		80% Limestone, finely crystalline, pale yellowish brown.	10YR-6/2	
-B		20% Shale, noncalcareous, dark greenish gray to dark gray.	5G-4/1 to N3	
3556-017	10720-10850			0.15/0.16
-A		80% Limestone, finely crystalline, pale yellowish brown.	10YR-6/2	
-B		20% Shale, noncalcareous, dark greenish gray to dark gray.	5G-4/1 to N3	
3556-018	11170-11220			0.66
-A		100% Shale, noncalcareous, dark gray.	N3	
3556-019	11460-11530			1.10
-A		90% Shale, noncalcareous, dark gray.		
-B		10% Limestone, finely crystalline, pale yellowish brown.	10YR-6/2	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-020	11720-11820			3.25
-A		Shale, calcareous, brownish black.	5YR-2/1	
3556-021	11880-11920			3.08
-A		90% Shale, silty, noncalcareous, dark gray.	N3	
-B		10% Limestone, finely crystalline, pale yellowish brown.	10YR-6/2	
3556-022	12040-12100			2.97
-A		100% Shale, micaceous, calcareous, dark gray.	N3	
3556-023	12270-12320			2.36
-A		95% Shale, micaceous, calcareous, dark gray.	N3	
-B		5% Limestone, finely crystalline, pale yellowish brown.	10YR-6/2	
3556-024	12390-12440			1.95
-A		100% Shale, silty, calcareous, dark gray.	N3	
3556-025	12480-12530			0.67/0.67
-A		60% Limestone, fine to medium crystalline, very light gray to pale yellowish brown.	N8 to 10YR-6/2	
-B		40% Shale, silty, calcareous, dark gray.	N3	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-026	12630-12710			0.77
-A		60% Limestone, fine to medium crystalline, light gray to dark gray.	N7 to N3	
-B		40% Shale, slightly, calcareous, dark gray.	N3	
3556-027	12910-12980			0.83
-A		60% Shale, slightly, calcareous, dark gray.	N3	
-B		40% Limestone, finely crystalline, medium gray. Trace sandstone.	N5	
3556-028	12990-13050			1.47
-A		80% Shale, slightly, calcareous, dark gray.	N3	
-B		20% Limestone, finely crystalline, medium gray. Trace sandstone.	N5	
3556-029	13070-13140			1.66
-A		90% Shale, slightly calcareous, dark gray.	N3	
-B		10% Limestone, finely crystalline, medium gray.	N5	
3556-030	13510-13600			1.54
-A		80% Shale, slightly, calcareous, dark gray.	N3	
-B		20% Limestone, finely crystalline, medium gray. Trace sandstone.	N5	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-031	13600-13680			1.52
-A		95% Shale, micaceous, slightly calcareous, dark gray.	N3	
-B		5% Limestone, finely crystalline, medium gray.	N5	
3556-032	14080-14160			1.64
-A		95% Shale, micaceous, slightly calcareous, dark gray.	N3	
-B		5% Limestone, finely crystalline, medium gray.	N5	
3556-033	14220-14270			1.49/1.50
-A		95% Shale, micaceous, slightly calcareous, dark gray.	N3	
-B		5% Limestone, finely crystalline, medium gray.	N5	
3556-034	14970-15010			1.45
-A		95% Shale, micaceous, slightly calcareous, dark gray.	N3	
-B		5% Limestone, finely crystalline, medium gray.	N5	
3556-035	15010-15060			3.88
-A		100% Shale, noncalcareous, brownish black.	5YR-2/1	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM CO., NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)		LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3556-036	15060-15100				3.50
-A		100%	Shale, noncalcareous, micaceous, brownish black.	5YR-2/1	
			Trace limestone.		
3556-037	15650-15740				0.21
-A		100%	Dolomite, limely, finely crystalline, light brownish gray.	5YR-6/1	
3556-038	16150-16200				0.17
-A		100%	Dolomite, limely, fine to medium crystalline, light brownish gray.	5YR-6/2	
			Trace shale.		
3556-039	16200-16240				0.46
-A		80%	Dolomite, limely, finely crystalline, medium to dark gray.	N5 to N3	
-B		20%	Limestone, fine to medium crystalline, very light gray.	N8	
3556-040	16510-16580				0.31
-A		70%	Limestone, finely crystalline, medium gray.	N5	
-B		30%	Shale, calcareous, dark gray.	N3	
			Trace sandstone.		

TABLE III

SUMMARY OF ORGANIC CARBON AND VISUAL KEROGEN DATA

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM COMPANY, NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	TOTAL ORGANIC CARBON	ORGANIC MATTER TYPE	VISUAL ABUNDANCE NORMALIZED PERCENT					ALTERATION STAGE	THERMAL ALTERATION INDEX
				Al	Am	H	W	I		
3556-001	4150-4200	0.43	H;W;Am-I	0	13	50	25	12	2- to 2	2.1
3556-002	5030-5080	0.40	H;Am;I	0	38	50	0	12	2- to 2	2.1
3556-003	5080-5120	0.21/0.23	Am;H;I	0	57	29	0	14	2- to 2	2.1
3556-004	5120-5170	0.54	H;Am;-	0	29	71	0	0	2- to 2	2.1
3556-005	5840-5870	0.30	H;Am;-	0	29	71	0	0	2 to 2+	2.3
3556-006	5870-5910	0.27	H;Am;-	0	29	71	0	0	2 to 2+	2.3
3556-007	5960-6010	0.21	Am-H;-;-	0	50	50	0	0	2 to 2+	2.3
3556-008	6070-6130	0.19	H-I;-;Am	0	20	40	0	40	2 to 2+	2.3
3556-009	6210-6220	0.21/0.21	H;Am;-	0	43	57	0	0	2 to 2+	2.3
3556-010	6750-6790	0.29	H;Am;I	0	38	50	0	12	2 to 2+	2.3
3556-011	7270-7360	0.31	H;Am;I	0	25	63	0	12	2 to 2+	2.3
3556-012	7540-7620	0.27	H;Am;I	0	38	50	0	12	2 to 2+	2.4
3556-013	8500-8590	0.22	H;Am;I	0	33	56	0	11	2 to 2+	2.4
3556-014	9200-9270	0.46	H;Am;I	0	30	50	0	20	2 to 2+	2.4
3556-015	9600-9660	0.39	H;I;Am	0	12	63	0	25	2 to 2+	2.4
3556-016	9820-9900	0.38	H;I;Am(W)	0	18	46	9	27	2 to 2+	2.4
3556-017	10720-10850	0.15/0.16	H;Am;I	0	25	63	0	12	2 to 2+	2.4
3556-018	11170-11220	0.66	Am-H;-;W	0	44	44	12	0	2 to 2+	2.5
3556-019	11460-11530	1.10	Am-H;W-I;-	0	33	33	17	17	2 to 2+	2.5
3556-020	11720-11820	3.25	Am-H;W-I;-	0	33	33	17	17	2+	2.6
3556-021	11880-11920	3.08	Am-H;W-I;-	0	33	33	17	17	2+ to 3-	2.7
3556-022	12040-12100	2.97	Am-H;-;-	0	50	50	0	0	2+ to 3-	2.7
3556-023	12270-12320	2.36	H;Am;W-I	0	36	46	9	9	2+ to 3-	2.7

LEGEND:

KEROGEN KEY

Predominant;	Secondary;	Trace
50-100%	20-40%	0-20%

Al = Algal
Am = Amorphous-Sapropel
Am* = Relic Amorphous-Sapropel
H = Herbaceous-Spore/Pollen
H* = Degraded Herbaceous
W = Woody-Structured
U = Unidentified Material
I = Inertinite
C = Coaly

TABLE III (continued)

SUMMARY OF ORGANIC CARBON AND VISUAL KEROGEN DATA

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM COMPANY, NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	TOTAL ORGANIC CARBON	ORGANIC MATTER TYPE	VISUAL ABUNDANCE NORMALIZED PERCENT					ALTERATION STAGE	THERMAL ALTERATION INDEX
				Al	Am	H	W	I		
3556-024	12390-12440	1.95	H;Am;W-I	0	31	39	15	15	2+ to 3-	2.7
3556-025	12480-12530	0.67/0.67	H-W;I;Am	0	15	31	31	23	2+ to 3-	2.7
3556-026	12630-12710	0.77	H;W-I;Am	0	8	42	25	25	2+ to 3-	2.7
3556-027	12910-12980	0.83	H-W;-;I(Am)	0	9	36	36	19	2+ to 3-	2.7
3556-028	12990-13050	1.47	H-W;-;Am-I	0	10	40	40	10	2+ to 3-	2.7
3556-029	13070-13140	1.66	H;Am;W-I	0	27	37	18	18	2+ to 3-	2.8
3556-030	13510-13600	1.54	H-W;-;I(Am)	0	9	36	36	19	2+ to 3-	2.8
3556-031	13600-13680	1.52	H-W;-;I(Am)	0	9	36	36	19	2+ to 3-	2.8
3556-032	14080-14160	1.64	H-W;-;Am-I	0	17	33	33	17	2+ to 3-	2.8
3556-033	14220-14270	1.49/1.50	H-W;-;I(Am)	0	9	36	36	19	2+ to 3-	2.8
3556-034	14970-15010	1.45	H-W;Am-I;-	0	17	33	33	17	2+ to 3-	2.8
3556-035	15010-15060	3.88	Am-H;-;W(I)	0	36	36	19	9	2+ to 3-	2.9
3556-036	15060-15100	3.50	Am-H;-;-	0	50	50	0	0	3-	3.0
3556-037	15650-15740	0.21	Am-H;-;I	0	44	44	0	12	3- to 3	3.1
3556-038	16150-16200	0.17	Am-H;-;I	0	44	44	0	12	3- to 3	3.1
3556-039	16200-16240	0.46	Am-H;-;-	0	50	50	0	0	3- to 3	3.1
3556-040	16510-16580	0.31	H;Am-I;-	0	25	50	0	25	3- to 3	3.1

LEGEND:

KEROGEN KEY

Predominant;	Secondary;	Trace
60-100%	20-40%	0-20%

Al = Algal
Am = Amorphous-Sapropel
Am* = Relic Amorphous-Sapropel
H = Herbaceous-Spore/Pollen
H* = Degraded Herbaceous
W = Woody-Structured
U = Unidentified Material
I = Inertinite
C = Coaly

TABLE IV

RESULTS OF ROCK-EVAL PYROLYSIS ANALYSIS

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

PHILLIPS PETROLEUM COMPANY, NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (Feet)	TMAX (c)	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	PI	PC*	T.O.C. (wt.%)	HYDROGEN INDEX	OXYGEN INDEX
3556-001	4150-4200	322	0.96	1.75	0.73	0.36	0.22	0.43	406	169
3556-002	5030-5080	330	0.70	0.46	0.51	0.60	0.09	0.40	115	127
3556-003	5080-5120	354	0.59	0.13	0.29	0.82	0.06	0.22	59	131
3556-004	5120-5170	432	0.91	0.80	0.37	0.54	0.14	0.54	148	68
3556-005	5840-5870	432	0.36	0.37	0.27	0.50	0.06	0.30	123	90
3556-006	5870-5910	435	0.05	0.16	0.26	0.25	0.01	0.27	59	96
3556-007	5960-6010	431	0.10	0.13	0.18	0.45	0.01	0.21	61	85
3556-008	6070-6130	340	0.18	0.14	0.21	0.56	0.02	0.19	73	110
3556-009	6210-6220	413	0.11	0.10	0.19	0.55	0.01	0.21	47	90
3556-010	6750-6790	423	0.46	0.29	0.22	0.62	0.06	0.29	100	75
3556-011	7270-7360	429	0.12	0.20	0.23	0.37	0.02	0.31	64	74
3556-012	7540-7620	432	0.64	0.33	0.30	0.67	0.08	0.27	122	111
3556-013	8500-8590	310	0.76	0.47	0.31	0.62	0.10	0.22	213	140
3556-014	9200-9270	307	1.72	1.57	0.48	0.52	0.27	0.46	341	104
3556-015	9600-9660	366	0.60	0.87	0.30	0.41	0.12	0.39	223	76
3556-016	9820-9900	424	0.71	0.73	0.23	0.49	0.12	0.38	192	60
3556-017	10720-10850	308	0.06	0.09	0.25	0.43	0.01	0.16	56	156
3556-018	11170-11220	440	0.34	0.75	0.32	0.31	0.09	0.66	113	48
3556-019	11460-11530	438	0.54	1.45	0.33	0.27	0.16	1.10	131	30
3556-020	11720-11820	442	1.41	5.54	0.65	0.20	0.57	3.25	170	20

T.O.C. = Total organic carbon, wt.%
S1 = Free hydrocarbons, mg Hc/g of rock
S2 = Residual hydrocarbon potential (mg HC/g or rock)
S3 = CO2 produced from kerogen pyrolysis (mg CO2/g of rock)
PC* = 0.083 (S1 + S2)
Hydrogen Index = mg HC/g organic carbon
Oxygen Index = mg CO2/g organic carbon
PI = S1/S1 + S2
TMAX = Temperature Index, degrees C.

TABLE IV (continued)

RESULTS OF ROCK-EVAL PYROLYSIS ANALYSIS

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

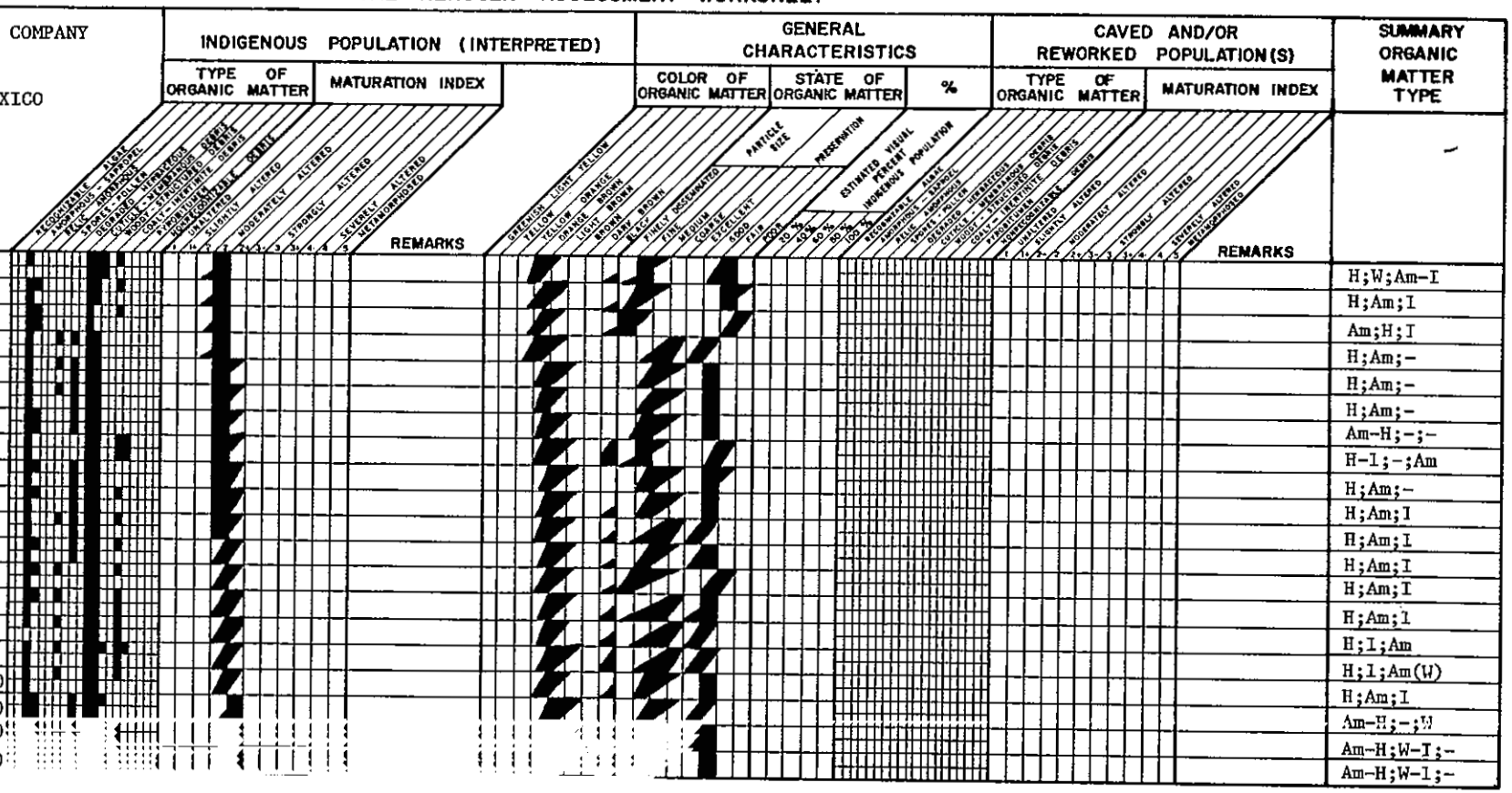
PHILLIPS PETROLEUM COMPANY, NO.6 LEAMEX
SEC.23, T17S, R33E, LEA COUNTY, NEW MEXICO
API #30-025-01515

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (Feet)	TMAX (c)	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	PI	PC*	T.O.C. (wt.%)	HYDROGEN INDEX	OXYGEN INDEX
3556-021	11880-11920	439	2.57	8.01	0.94	0.24	0.88	3.08	260	30
3556-022	12040-12100	441	1.13	3.95	0.70	0.22	0.42	2.97	132	23
3556-023	12270-12320	441	1.68	3.59	0.61	0.32	0.43	2.36	152	25
3556-024	12390-12440	444	1.01	2.13	0.44	0.32	0.26	1.95	109	22
3556-025	12480-12530	438	0.40	0.65	0.39	0.38	0.08	0.67	97	58
3556-026	12630-12710	436	0.27	0.69	0.41	0.28	0.08	0.77	89	53
3556-027	12910-12980	442	0.16	0.54	0.34	0.23	0.05	0.83	65	40
3556-028	12990-13050	424	0.35	1.45	0.29	0.19	0.15	1.47	98	19
3556-029	13070-13140	442	0.41	1.26	0.30	0.25	0.13	1.66	75	18
3556-030	13510-13600	451	0.42	1.11	0.50	0.28	0.12	1.54	72	32
3556-031	13600-13680	456	0.19	0.84	0.43	0.19	0.08	1.52	55	28
3556-032	14080-14160	446	0.64	1.59	0.53	0.29	0.18	1.64	96	32
3556-033	14220-14270	448	0.22	1.07	0.52	0.17	0.10	1.50	71	34
3556-034	14970-15010	428	0.65	1.42	0.45	0.32	0.17	1.45	97	31
3556-035	15010-15060	453	2.55	3.11	0.59	0.45	0.47	3.88	80	15
3556-036	15060-15100	450	2.37	3.36	0.58	0.41	0.47	3.50	96	16
3556-037	15650-15740	413	0.12	0.34	0.27	0.26	0.03	0.21	161	128
3556-038	16150-16200	366	0.13	0.12	0.28	0.54	0.02	0.17	70	164
3556-039	16200-16240	380	0.16	0.16	0.37	0.50	0.02	0.46	34	80
3556-040	16510-16580	343	0.15	0.32	0.37	0.33	0.03	0.31	103	119

T.O.C. = Total organic carbon, wt.%
S1 = Free hydrocarbons, mg Hc/g of rock
S2 = Residual hydrocarbon potential (mg HC/g or rock)
S3 = CO2 produced from kerogen pyrolysis (mg CO2/g of rock)
PC* = 0.083 (S1 + S2)
Hydrogen Index = mg HC/g organic carbon
Oxygen Index = mg CO2/g organic carbon
PI = S1/S1 + S2
TMAX = Temperature Index, degrees C.

TABLE V
VISUAL KEROGEN ASSESSMENT WORKSHEET

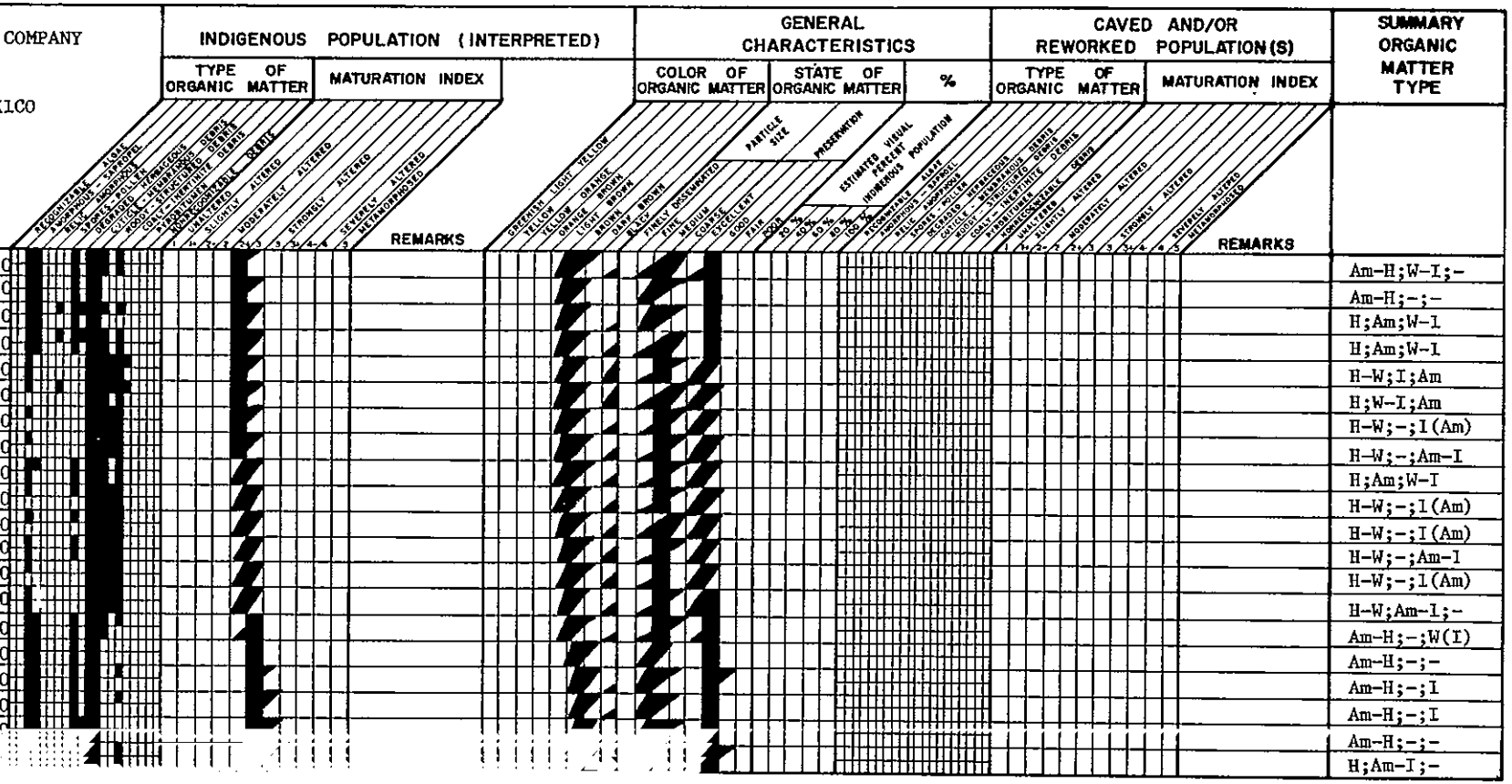
PHILLIPS PETROLEUM COMPANY
NO.6 LEAMEX
SEC.23, T17S, R33E
LEA COUNTY, NEW MEXICO
API #30-025-01515



GEOCHEM No.	DEPTH	SUMMARY ORGANIC MATTER TYPE
3556-001	4150-4200	H;W;Am-I
3556-002	5030-5080	H;Am;I
3556-003	5080-5120	Am;H;I
3556-004	5120-5170	H;Am;-
3556-005	5840-5870	H;Am;-
3556-006	5870-5910	H;Am;-
3556-007	5960-6010	Am-H;-;-
3556-008	6070-6120	H-I;-;Am
3556-009	6210-6220	H;Am;-
3556-010	6750-6790	H;Am;I
3556-011	7270-7360	H;Am;I
3556-012	7540-7620	H;Am;I
3556-013	8500-8590	H;Am;I
3556-014	9200-9270	H;Am;I
3556-015	9600-9660	H;I;Am
3556-016	9820-9900	H;I;Am(W)
3556-017	10720-10850	H;Am;I
3556-018	11170-11220	Am-H;-;W
3556-019	11460-11530	Am-H;W-I;-
3556-020	11720-11820	Am-H;W-I;-

TABLE V
VISUAL KEROGEN ASSESSMENT WORKSHEET

PHILLIPS PETROLEUM COMPANY
NO.6 LEAMEX
SEC.23, T17S, R33E
LEA COUNTY, NEW MEXICO
API #30-025-01515



GEOCHEM No.	DEPTH	SUMMARY ORGANIC MATTER TYPE
3556-021	11880-11920	Am-H;W-I;-
3556-022	12040-12100	Am-H;-;-
3556-023	12270-12320	H;Am;W-I
3556-024	12390-12440	H;Am;W-I
3556-025	12480-12530	H-W;I;Am
3556-026	12630-12710	H;W-I;Am
3556-027	12910-12980	H-W;-;I(Am)
3556-028	12990-13050	H-W;-;Am-I
3556-029	13070-13140	H;Am;W-I
3556-030	13510-13600	H-W;-;I(Am)
3556-031	13600-13680	H-W;-;I(Am)
3556-032	14080-14160	H-W;-;Am-I
3556-033	14220-14270	H-W;-;I(Am)
3556-034	14970-15010	H-W;Am-I;-
3556-035	15010-15060	Am-H;-;W(I)
3556-036	15060-15100	Am-H;-;-
3556-037	15650-15740	Am-H;-;I
3556-038	16150-16200	Am-H;-;I
3556-039	16200-16240	Am-H;-;-
3556-040	16510-16550	H;Am-I;-

LEGEND FOR SUMMARY DIAGRAM

DEPTH:	in feet
LITHO LOG:	see lithology symbols
STRATIGRAPHY:	by age
% TOC:	percent total organic carbon
HI:	Rock-Eval, Hydrocarbon Index = 100 S2(0/00 Wt)/TOC
OI:	Rock-Eval, Oxygen Index = 100 S3 (0/00 Wt)/TOC
HC YIELD:	Rock-Eval, S2 peak (ppm)
S2/S3:	Rock-Eval, Ratio of S2 to S3 peak
KEROGEN:	see Kerogen symbols
T-MAX:	Rock-Eval, maximum temperature of S2 peak, in degrees Centigrade
%RO (△):	Vitrinite Reflectance (scale 0 to 5)
TAI (*):	Thermal Alteration Index (Scale 1 to 5)
FREE HC:	Rock-Eval, S1 peak (ppm)
PI:	Rock-Eval, Productivity Index = S1/(S1+S2)

LITHOLOGIES

- SHALE
- MUDSTONE
- SILTSTONE
- SANDSTONE
- CONGLOMERATE
- BRECCIA
- LIMESTONE
- DOLOMITE
- MARL
- SILICEOUS ROCKS
- EVAPORITES
- COAL
- IGNEOUS ROCKS
- VOLCANICS
- METAMORPHIC ROCKS
- BASEMENT
- OTHER
- MISSING SECTION

KEROGEN TYPES

- AMORPHOUS
- HERBACEOUS
- WOODY
- INERTINITE

APPENDIX A

Brief Description of Organic Geochemical analyses Carried Out by GeoChem

C_1-C_7 Hydrocarbon

The C_1-C_7 hydrocarbon content and composition of sediments reflects source type, source quality and thermal maturity.

The C_1-C_7 hydrocarbon content of well cuttings is determined by analyzing both a sample of the cuttings and the air space at the top of the can. The results of the two analyses are summed to give an inventory of the C_1-C_7 hydrocarbon content of the well cuttings prior to any losses from the cuttings during the lapsed time period between collection at the wellsite and laboratory analysis.

The air space C_1-C_7 hydrocarbon analysis involves taking a measured volume of the air space gas out of the can with a syringe and injecting same into a gas chromatograph. GeoChem uses a Varian Aerograph Model 1400 instrument equipped with a Porapec Q column. The gas sample is taken through the column by a carrier gas and before reaching the detector is separated into its various C_1 (methane), C_2 (ethane), C_3 (propane), iC_4 (isobutane), nC_4 (normal butane), and C_5, C_6, C_7 hydrocarbon components.

This particular analysis gives a complete separation of the C_1-C_4 gas-range hydrocarbons and a partial separation of the C_5-C_7 gasoline-range hydrocarbons. (A detailed C_4-C_7 analysis, to be discussed later, involving a capillary column, effects a complete separation of this molecular range into its several individual molecular species.)

The electrical response of the various hydrocarbons as they reach the detector is recorded on a paper strip chart as a peak. This response is simultaneously fed to an integrator which computes the area of each peak. The concentration of C_1-C_7 hydrocarbons in the air space, expressed as volumes of gas per million volumes of cuttings, is determined by a calculation involving the volume of cuttings, volume of air space in the can, volume of sample injected, volume of standard gas sample used in the calibration, calibration factor for C_1, C_2, C_3, etc. determined by gc analysis of a standard gas sample, and the gc peak response.

The C_1-C_7 hydrocarbon content of the cuttings is determined by degasification of a measured volume of cuttings (in a medium of a measured volume of water) in a closed blender, sampling of the air space at the top of the blender, and injection of a measured volume of gas into the gas chromatograph.

The C_1-C_7 hydrocarbon data from the air space and cuttings gas analyses are summed to give a "restored" C_1-C_7 hydrocarbon content of the cuttings.

Sample Washing and Hand-Picking of Uncaved Lithology Samples

The cuttings samples are washed to remove all drilling mud from the cuttings. Care is taken in the washing procedure not to remove any soft clays, claystones, etc. and any loose fine sand and silt. The washed cuttings are usually kept under water cover until picked, to prevent loss of any gasoline-range hydrocarbons. Using the C_1-C_7 hydrocarbon data profile and the electrical well log supplied to us and our visual examination of the cuttings material under the binocular microscope, we carefully hand-pick and describe a suite of uncaved lithologies representative of the various stratigraphic zones penetrated by the well. The lithological data is used to compile a gross litho percentage log which is shown on all Figures. The 2-4 gram picked lithology samples are stored under water in small glass vials in those instances where we wish to run detailed C_4-C_7 hydrocarbon analyses. This sample set is used not only for the C_4-C_7 hydrocarbon analysis, but also for the visual kerogen and total organic carbon analyses. All remaining cuttings material is dried and packaged in labelled plastic bags for possible C_{15+} soxhlet extraction and/or eventual return to the client. Sample material from this study will be retained at GeoChem until advised of disposition.

Detailed C_4-C_7 Hydrocarbon

The C_4-C_7 gasoline-range hydrocarbon content of sediments reflects source quality, thermal maturation and organic facies. Compositional data can be used in crude oil-parent rock correlation work.

The C_4-C_7 hydrocarbon content and detailed molecular composition of hydrocarbon, in hand-picked lithologies, is determined by a gc analysis of the light hydrocarbon extracted from 1-2 gram cuttings samples macerated in a microblender. A measured volume of sample is placed in a sealed microblender along with a measured volume of hot water. The rock sample is pulverized by the blades of the blender. A sample of the liberated light hydrocarbons which collect in the air space at the top of the blender is injected into our Varian Aerograph 1400 gc unit which is equipped with a capillary column. Data recording, computations, etc. are comparable to those used for the C_1-C_7 analysis discussed previously in this report. Hydrocarbon concentration is expressed as volume gas per million volumes of cuttings.

Organic Carbon

The total organic carbon content of a rock is a measure of its total organic richness. This data is used, in conjunction with visual kerogen and C_1-C_4, C_4-C_7 and C_{15+} hydrocarbon content of a rock, to indicate the hydrocarbon source quality of rocks.

The procedure for determining the total organic carbon content of a rock involves drying the sample, grinding to a powder, weighing out 0.2729 gram sample into a crucible, acidizing with hot and cold hydrochloric acid to remove calcium and magnesium carbonate, and carbon analysis by combustion in a Leco carbon analyzer.

We run several blank crucibles, standards (iron rings of known carbon content) and duplicate rock samples in this analysis at no additional charge to the client for purposes of data quality control.

C_{15+} Soxhlet Extraction, Deasphaltening and Chromatographic Separation

The amount and composition of the organic matter which can be solvent-extracted from a rock reflects source quality and source type. C^{13}/C^{12} carbon isotopic, high mass spectrometric and gc analyses of the paraffin-naphthene and aromatic hydrocarbon fractions of the soluble extract gives data which is used in crude oil-parent rock correlations.
This analysis involves grinding of a dry rock sample to a powder and removal of the soluble organic matter by soxhlet extraction using a co-distilled toluene-methanol azeotrope solvent. Where the amount of available sample material permits, we like to use at least 100 grams of rock for this analysis.

The extracted bitumen is separated into an asphaltene (ASPH) and a pentane soluble fraction by normal pentane precipitation. The pentane soluble components are separated into a C_{15+} paraffin-naphthene (P-N) hydrocarbon, C_{15+} aromatic hydrocarbon (AROM) and C_{15+} nitrogen-sulfur-oxygen containing fraction (NSO) by adsorption chromatography on a silica gel-alumina column using pentane, toluene and toluene-methanol azeotrope eluants.

GC Analysis of C_{15+} Paraffin-Naphthene (P-N) Hydrocarbons

The content and molecular composition of the heavy C_{15+} paraffin-naphthene (P-N) hydrocarbons of rocks, as determined by gc analysis, reflects source quality, source type and degree of thermal maturation.

In this analysis, we subject a very small fraction of the total amount of the P-N fraction extracted from a rock sample to gc analysis. The gas chromatograph is a Varian Aerograph Model 1400 equipped with a solid rod injection system and a eutectic column.

The calculated C.P.I. (carbon preference index) values for the normal paraffin data is defined as the mean of two ratios which are determined by dividing the sum of concentrations of odd-carbon numbered n-paraffins by the sum of even-carbon numbered n-paraffins. The C.P. Indices A and B were obtained by the formulas:

$$\text{C.P. Index A} = \frac{\dfrac{C_{21}+C_{23}+C_{25}+C_{27}}{C_{22}+C_{24}+C_{26}+C_{28}} + \dfrac{C_{21}+C_{23}+C_{25}-C_{27}}{C_{20}+C_{22}+C_{24}+C_{26}}}{2}$$

$$\text{C.P. Index B} = \frac{\dfrac{C_{25}+C_{27}+C_{29}+C_{31}}{C_{26}+C_{28}+C_{30}+C_{32}} + \dfrac{C_{25}+C_{27}+C_{29}+C_{31}}{C_{24}+C_{26}+C_{28}+C_{30}}}{2}$$

Visual Kerogen

A visual study of kerogen, the insoluble organic matter in rocks, can indicate the relative abundance, size, and state of preservation of the various recognizable kerogen types and thereby indicate the hydrocarbon source character of a rock. The color of the kerogen can be used to indicate the state of thermal maturity of the sediments (i.e. their time-temperature history). Thermal maturation plays an important role in the generation of hydrocarbons from organic matter, and also affects the composition of reservoired hydrocarbons.

Our procedure for visual kerogen slide preparation involves isolation of the organic matter of a rock by removal of the rock material with hydrochloric and hydrofluoric acid treatment and heavy liquid separation. This procedure is comparable to that used by the palynologist except it does not include an oxidation stage. (The oxidation treatment is deleted from our procedure because it removes a great deal of kerogen and blanches any remaining kerogen to an extent whereby it is useless for our kerogen color observations.) The kerogen residue is mounted on a glass slide and is examined visually under a high power microscope.

Vitrinite Reflectance

Measurement of the reflectivity of vitrinite particles ($\%R_o$) present in the kerogen isolated from sedimentary rocks provides a method of determining the state of maturation, and the diagenetic (time-temperature) history of the organic matter present in the sediments.

The kerogen, obtained from a 25 gram aliquot of crushed rock by the acid procedure previously discussed, is dried and embedded in a Bioplastic plug. The surface of the plug is polished using 0.05 micron alumina and the reflectivity determined under oil using a Zeiss high resolution microscope. A minimum of 40 values are required to adequately determine the Maturation Rank.

Fluorescence Spectrophotometric Analysis

Fluorescence spectrophotometry can be used to characterize and fingerprint crude oils, establish crude oil-source rock relationships, and to measure the hydrocarbon source potential of fine-grained sediments.

A one (1) microliter aliquot of either (i) a crude oil or (ii) the solvent extractable rock bitumen, is passed through an alumina silica gel micro column and the C_{10+} aromatic hydrocarbons isolated. The aromatic hydrocarbon is diluted and the emission and excitation spectra determined at 240 nm and 420 nm using a Perkin-Elmer Model 512 Double Beam Fluorescence Spectrophotometer.

GEOTHERMAL DIAGENETIC CRITERIA

(GEOCHEM LABORATORIES, INC.)