GEOCHEMICAL SERVICE REPORT

HYDROCARBON SOURCE ROCK EVALUATION STUDY

ORGANIC GEOCHEMICAL ANALYSES OF CANNED CUTTINGS

KCM NO. 1 COCHISE - STATE A WELL

HIDALGO COUNTY, NEW MEXICO

(2500± Feet to 5300± Feet)

GeoChem Laboratories, Inc.

Prepared

for

New Mexico Bureau of

Mines and Mineral Resources

March, 1976

1143-C BRITTMORE ROAD, HOUSTON, TEXAS 77043

GeoChem Laboratories, Inc.

GEOCHEMICAL ANALYSES
SOURCE ROCK EVALUATION

CRUDE OIL—SOURCE ROCK CORRELATION

CRUDE OIL CHARACTERIZATION
GEOCHEMICAL PROSPECTING

1143-C BRITTMORE ROAD • HOUSTON, TEXAS 77043 • 713/467-7011

March 9, 1976

Mr. Sam Thompson III
Petroleum Geologist
New Mexico Bureau of Mines
& Mineral Resources
Socorro, New Mexico 87801

Dear Sam:

Please find enclosed the results of the organic geochemical analyses carried out on seventeen (17) canned cuttings samples retrieved from the KCM No. 1 Cochise - State A Well which is located in Hidalgo County, New Mexico. Instructions for geochemical analyses to be performed on these samples were transmitted in your letter of October 29, 1975.

Upon arrival at GeoChem Laboratories, Inc., the samples were assigned the GeoChem Job No. 553- with each sample being further identified by a sequential number -001 through -017.

The C_1-C_7 hydrocarbon content of all seventeen (17) cuttings samples was determined by analyzing both a sample of the cuttings and the air space at the top of the can (Table I-A, I-B, and I-C; Figure 1). The cuttings samples were washed, dried and individually picked to exclude any obvious cavings. After making a gross lithological description of the picked cuttings, all seventeen (17) samples were analyzed for total organic carbon richness (Table II; Figure 1). Utilizing these data and incorporating the information and suggestions from your letter of October 29, 1975, only nine (9) samples were selected for detailed, organic geochemical analyses.

The organic geochemical analyses performed on samples 553-002, -004, -005, -006, -007, -009, -011, -012, -014 and -016 comprised C_{15+} soxhlet extraction, deasphaltening and quantitative liquid chromatographic analyses (Tables III-A, III-B and III-C), C_{15+} paraffin-naphthene (P-N) analysis by gas chromatography (Table IV; Figure 2) and visual assessment of kerogen type and degree of maturation (Table V).

All remaining used and unused, picked and unpicked cuttings material, a set of glass miscroscope slides of the kerogen, and the C_{15+} hydrocarbon and nonhydrocarbon chromat fractions will be retained at GeoChem until advised about their disposition.

RESULTS AND INTERPRETATIONS

A. Geological Zonation

The sedimentary sequence penetrated by the KCM No. 1 Cochise - State A Well has not, at this time, been divided into a number of discrete geological formations or lithologic units over the gross well interval 0 to 5300± feet. The grayish black carbonaceous shale from 2350± feet to 3850± feet has been suggested by Mr. Sam Thompson to be:

1) ~~the Devonian Percha = Woodford~~
or 2) the Ringbone Formation
or 3) ~~the Colorado = Mancos~~

The samples from 3900± feet to 5300± feet are thought to represent the Cretaceous Mojado Formation.

B. Geochemical Zonation

The stratigraphic section, penetrated by the KCM No. 1 Cochise - State A Well, can be subdivided into two (2) major zones based primarily on the C_1-C_7 light hydrocarbon contents, the organic carbon contents and the type and abundance of kerogen types found in the various samples. The geochemical zonation, which is independent of the formation tops, is as follows:

Zone A----------2400± feet to 3850± feet
Zone B----------3850± feet to 5300± feet

In general, the grayish black carbonaceous shales of Zone A (2400± feet to 3850± feet) are characterized by low amounts of C_2-C_4 "wet" gas (19 ppm to 144 ppm, mean 94 ppm; Table I-C; Figure 1), by zero amounts of C_5-C_7 gasoline-range hydrocarbons (Table I-C; Figure 1), by fair organic carbon contents (0.29% to 0.98%, mean 0.58%; Table II; Figure 1) by very low C_{15+} solvent extractable bitumen contents (70 ppm to 193 ppm, mean 123 ppm; Table III-B), and by a predominance of the woody and coaly type kerogens.

The predominantly igneous rocks (with traces of the Cretaceous Mojado Formation) of Zone B (3850± feet to 5300± feet) are characterized by low to fair amounts of C_2-C_4 "wet" gas and C_5-C_7 gasoline-range hydrocarbons (26 ppm to 541 ppm, mean 231 ppm and 0 ppm to 479 ppm, mean 216 ppm, respectively; Table I-C; Figure 1) by the poor organic carbon contents (0.06% to 0.16%, mean 0.10%; Table II; Figure 1) and by the lack of any meaningful amount of in place kerogens.

C. Thermal Maturity and Hydrocarbon Source Character of Sediments

1. Zone A Sediments (2400+ feet to 3850± feet)

The grayish black carbonaceous shales of Zone A (2400± feet to 3850± feet) have an extremely mature, very poor oil source character, a very poor to poor "wet" gas and condensate source character, and a fair, to possibly good, "dry" gas source character. With the exception of possibly the shallowest sample at 2400± feet, the entire section has been thermally matured beyond the liquid generating stage. The Zone A sediments have experienced an advanced geothermal history by the fact the C_{15+} solvent extractable bitumen contents are very low (70 ppm to 193 ppm, mean 123 ppm; Table III-B), the C_{15+} total hydrocarbon contents are extremely low (Table III-B), the C_{15+} paraffin-naphthene hydrocarbons have a mature character (see gas chromatograms 553-002, -004, -005, -006, -007, -009, and -011; Table IV; Figure 2) and because the predominately black coloration of the recognizable plant cuticle contained in the kerogen isolated from these sediments (Table V) is consistent with severely altered Maturation Indices of Stage 4-.

The fair organic carbon contents (0.29% to 0.98%, mean 0.58%; Table II; Figure 1), which consists of predominately woody and coaly type kerogens, suggests that "dry" methane gas should be the only objective within the Zone A sediments. The methane (C_1) gas content of these sediments is overall fair (average 1377 ppm with the exception of the sample at 3200± feet; Table I-C; Figure 1). This fair amount of methane gas, and in particular, the very good amount of methane gas (35,360 ppm; Table I-C; Figure 1) in the sample at 3200± feet leads the author to conclude that Zone A sediments have moderate to possibly good (?) prospectiveness for indigenously generated, thermal methane gas.

Zone A sediments offer encouragement for "dry" thermal methane gas reserves in the local area of the KCM No. 1 Cochise - State A Well, provided that a reservoir and trap are available. I want to caution the reader that only one sample contained very good amounts of methane gas. Obviously, gas prospectiveness would be enhanced considerably had most of the shale samples contained greater than 35,000 ppm of methane gas.

2. Zone B Sediments (3850± feet to 5300± feet)

The samples from Zone B (3850± feet to 5300± feet) are made up predominately of igneous rocks and some pieces of shale (cavings?) which have no oil source character because of their advanced maturity caused by proximity to igneous activity. The poor oil source character is defined by the poor organic carbon

contents (0.06% to 0.16%, mean 0.10%; Table II; Figure 1), the very low C_{15+} solvent extractable bitumen contents (61 ppm and 100 ppm) and by the lack of any meaningful amount of in place kerogens.

It should be pointed out that low to fair amounts of C_5-C_7 gasoline-range hydrocarbons (0 ppm to 479 ppm, mean 216 ppm respectively; Table I-C; Figure 1) are found in Zone B section. It is interpreted that the quantities of C_5-C_7 and C_2-C_4 gases are too low to warrant "wet" gas or condensate prospectiveness in this section. The prospectiveness of this section, as well as Zone A section, would be enhanced if encountered distant to the igneous activity in the local area of the KCM No. 1 Cochise - State A Well.

Sam, I feel that these results, although discouraging for Hidalgo County, are optimistically encouraging from a "dry" methane gas standpoint. If you would like to discuss the results of this study further, please contact me.

Yours very truly,

Paul J. Cernock

Paul J. Cernock
Chief Geologist
GEOCHEM LABORATORIES, INC.

PJC:bt
Enclosures

TABLE I-A

C1-C7 HYDROCARBON ANALYSES OF AIR SPACE

GeoChem Sample Number	Well Interval*	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC4
553-001	2400	623.7	47.7	9.8	0.6	0.0	0.0	681.8	58.1	8.5	-
553-002	2500	460.6	64.9	10.6	0.0	0.0	0.0	536.1	75.5	14.1	-
553-003	2600	607.1	83.7	21.2	0.0	0.0	0.0	712.0	104.9	14.7	-
553-004	2700	581.5	105.7	17.4	0.0	0.0	0.0	704.6	123.1	17.5	-
553-005	2800	272.2	12.3	0.0	0.0	0.0	0.0	284.5	12.3	4.3	-
553-006	2900	1367.6	73.8	9.7	0.0	0.0	0.0	1451.1	83.5	5.8	-
553-007	3000	1822.1	103.7	13.2	0.0	0.0	0.0	1939.0	116.9	6.0	-
553-008	3100	2716.1	73.5	6.4	0.0	0.0	0.0	2796.0	79.9	2.9	-
553-009	3200	34806.9	90.7	30.4	0.0	0.0	0.0	34928.0	121.1	0.3	-
553-010	3300	540.8	77.1	12.3	0.0	0.0	0.0	630.2	89.4	14.2	-
553-011	3500	332.7	51.1	10.7	0.0	0.0	0.0	394.5	61.8	15.7	-
553-012	3700	635.8	96.8	44.9	0.0	0.0	0.0	777.5	141.7	18.2	-
553-013	3900	890.4	92.2	122.7	0.0	0.0	0.0	1105.3	214.9	19.4	-
553-014	4200	230.4	5.3	5.9	14.8	0.0	339.2	256.4	26.0	10.1	-
553-015	4500	246.9	110.4	70.3	25.5	21.4	479.3	474.5	227.6	48.0	1.19
553-016	5000	927.1	265.2	148.9	122.5	0.0	242.3	1463.7	536.6	36.7	-
553-017	5300	196.1	27.5	14.5	94.7	0.0	18.6	332.8	136.7	41.1	-

*In Feet
ppm valves expressed as volumes of gas per million volumes of sediment.

TABLE I-B

C1-C7 HYDROCARBON ANALYSES OF CUTTINGS GAS

GeoChem Sample Number	Well Interval*	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC4
553-001	2400	147.6	2.5	1.4	0.0	0.0	0.0	151.5	3.9	2.6	-
553-002	2500	302.3	5.5	1.8	0.0	0.0	0.0	309.6	7.3	2.4	-
553-003	2600	649.8	5.9	1.2	0.0	0.0	0.0	656.9	7.1	1.1	-
553-004	2700	561.9	5.3	1.0	0.0	0.0	0.0	568.2	6.3	1.1	-
553-005	2800	527.9	7.4	0.0	0.0	0.0	0.0	535.3	7.4	1.4	-
553-006	2900	549.1	4.8	0.0	0.0	0.0	0.0	553.9	4.8	0.9	-
553-007	3000	837.2	6.5	0.9	0.0	0.0	0.0	844.6	7.4	0.9	-
553-008	3100	432.5	4.0	0.0	0.0	0.0	0.0	436.5	4.0	0.9	-
553-009	3200	553.0	3.9	1.6	0.0	0.0	0.0	558.5	5.5	1.0	-
553-010	3300	487.4	4.0	0.0	0.0	0.0	0.0	491.4	4.0	0.8	-
553-011	3500	355.6	2.2	0.0	0.0	0.0	0.0	357.8	2.2	0.6	-
553-012	3700	300.0	1.9	1.3	0.0	0.0	0.0	303.2	3.2	1.1	-
553-013	3900	205.0	1.9	1.0	0.0	0.0	0.0	207.9	2.9	1.4	-
553-014	4200	80.4	0.0	0.0	0.0	0.0	0.0	80.4	0.0	0.0	-
553-015	4500	253.3	2.7	0.9	0.0	0.0	0.0	256.9	3.6	1.4	-
553-016	5000	138.1	2.1	1.8	0.9	0.0	0.0	142.9	4.8	3.4	-
553-017	5300	97.3	0.0	0.0	2.6	0.0	0.0	99.9	2.6	2.6	-

*In Feet
ppm valves expressed as volumes of gas per million volumes of sediment.

TABLE I-C

C1-C7 HYDROCARBON ANALYSES OF AIR SPACE AND CUTTINGS GAS

GeoChem Sample Number	Well Interval*	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC4
553-001	2400	771.3	50.2	11.2	0.6	0.0	0.0	833.3	62.0	7.4	-
553-002	2500	762.9	70.4	12.4	0.0	0.0	0.0	845.7	82.8	9.8	-
553-003	2600	1256.9	89.6	22.4	0.0	0.0	0.0	1368.9	112.0	8.2	-
553-004	2700	1143.4	111.0	18.4	0.0	0.0	0.0	1272.8	129.4	10.2	-
553-005	2800	800.1	19.7	0.0	0.0	0.0	0.0	819.8	19.7	2.4	-
553-006	2900	1916.7	78.6	9.7	0.0	0.0	0.0	2005.0	88.3	4.4	-
553-007	3000	2659.3	110.2	14.1	0.0	0.0	0.0	2783.6	124.3	4.5	-
553-008	3100	3148.6	77.5	6.4	0.0	0.0	0.0	3232.5	83.9	2.6	-
553-009	3200	35359.9	94.6	32.0	0.0	0.0	0.0	35486.5	126.6	0.4	-
553-010	3300	1028.2	81.1	12.3	0.0	0.0	0.0	1121.6	93.4	8.3	-
553-011	3500	688.3	53.3	10.7	0.0	0.0	0.0	752.3	64.0	8.5	-
553-012	3700	935.8	98.7	46.2	0.0	0.0	0.0	1080.7	144.9	13.4	-
553-013	3900	1095.4	94.1	123.7	0.0	0.0	0.0	1313.2	217.8	16.6	-
553-014	4200	310.8	5.3	5.9	14.8	0.0	339.2	336.8	26.0	7.7	-
553-015	4500	500.2	113.1	71.2	25.5	21.4	479.3	731.4	231.2	31.6	1.19
553-016	5000	1065.2	267.3	150.7	123.4	0.0	242.3	1606.6	541.4	33.7	-
553-017	5300	293.4	27.5	14.5	97.3	0.0	18.6	432.7	139.3	32.2	-

*In Feet
ppm valves expressed as volumes of gas per million volumes of sediment.

Table II

Organic Carbon Analyses and Gross Lithological Description

GeoChem Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
553-001	2400'			0.29*
-A		90% Igneous, mainly silicates		
-B		10% Shale, carbonaceous, slightly calcareous, nonsilty, blocky, moderately hard, grayish black Trace of fractures filled with calcite	N2	
553-002	2500'			0.43*
-A		70% Igneous		
-B		30% Shale, same as 553-001B		
553-003	2600'			0.46*
-A		70% Igneous		
-B		30% Shale, same as 553-001B		
553-004	2700'			0.61*
-A		60% Igneous		
-B		40% Shale, same as 553-001B		
553-005	2800'			0.98*; 0.99*R
-A		70% Shale, same as 553-001B		
-B		30% Igneous		
553-006	2900'			0.91*
-A		80% Shale, same as 553-001B		
-B		20% Igneous		
553-007	3000'			0.81*
-A		80% Shale, same as 553-001B		
-B		20% Igneous		
553-008	3100'			0.65*
-A		70% Shale, same as 553-001B		
-B		30% Igneous		
553-009	3200'			0.63*
-A		70% Shale, same as 553-001B		
-B		30% Igneous		
553-010	3300'			0.42*; 0.47*R
-A		60% Shale, same as 553-001B		
-B		40% Igneous		

* Organic carbon value of gross sample used for C_{15}^{+} extraction.

Table II

Organic Carbon Analyses and Gross Lithological Description

GeoChem Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
553-011	3500'			0.37*
-A		60% Shale, same as 553-001B		
-B		40% Igneous		
553-012	3700'			0.40*
-A		80% Shale, slightly calcareous, nonsilty, blocky, moderately hard, dark gray	N3	
-B		20% Igneous		
553-013	3900'			0.13*
-A		100% Igneous, mainly silicates Trace of shale		
553-014	4200'			0.06*
-A		100% Igneous		
553-015	4500'			0.05*; 0.06*R
-A		100% Igneous		
553-016	5000'			0.16*
-A		100% Igneous		
553-017	5300'			0.11*
-A		100% Igneous		

* Organic carbon value of gross sample used for C_{15+} extraction.

Table III

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography

A. Weights of Extracts and Chromatographic Fractions

GeoChem Sample Number	Well Interval*	Weight of Rock Extd. (grams)	Total Extract (grams)	Precipitated Asphaltenes (grams)	N-C5 Soluble (grams)	Sulfur (grams)	Paraffins-Naphthenes (grams)	Aromatics (grams)	Eluted NSO'S (grams)	Noneluted NSO'S (grams)
553-002	2500	100.0	0.0129	0.0105	0.0024	N.D.	N.D.	N.D.	N.D.	N.D.
553-004	2700	90.0	0.0151	0.0117	0.0034	N.D.	N.D.	N.D.	N.D.	N.D.
553-005	2800	100.0	0.0104	0.0078	0.0026	N.D.	N.D.	N.D.	N.D.	N.D.
553-006	2900	100.0	0.0070	0.0054	0.0016	N.D.	N.D.	N.D.	N.D.	N.D.
553-007	3000	100.0	0.0114	0.0075	0.0039	N.D.	N.D.	N.D.	N.D.	N.D.
553-009	3200	100.0	0.0193	0.0118	0.0075	0.0015	0.0019	0.0018	0.0005	0.0018
553-011	3500	95.0	0.0096	0.0056	0.0040	N.D.	N.D.	N.D.	N.D.	N.D.
553-012	3700	70.0	0.0076	0.0049	0.0027	N.D.	N.D.	N.D.	N.D.	N.D.
553-014	4200	100.0	0.0061	0.0041	0.0020	N.D.	N.D.	N.D.	N.D.	N.D.
553-016	5000	70.0	0.0070	0.0043	0.0027	N.D.	N.D.	N.D.	N.D.	N.D.

* In Feet

Table III (Continued)

B. Concentration of Extracted Materials in Rock

GeoChem Sample Number	Well	Interval*	Total Extract (ppm)	Hydrocarbons: Paraffin-Naphthene (ppm)	Hydrocarbons: Aromatic (ppm)	Hydrocarbons: Total (ppm)	Hydrocarbons: Sulfur (ppm)	Nonhydrocarbons: Precipitd. Asphaltene (ppm)	Nonhydrocarbons: Eluted NSO'S (ppm)	Nonhydrocarbons: Noneluted NSO'S (ppm)	Nonhydrocarbons: Total (ppm)
553-002		2500	129	-	-	-	-	105	-	-	-
553-004		2700	168	-	-	-	-	130	-	-	-
553-005		2800	104	-	-	-	-	78	-	-	-
553-006		2900	70	-	-	-	-	54	-	-	-
553-007		3000	114	-	-	-	-	75	-	-	-
553-009		3200	193	19	18	37	15	118	5	18	15
553-011		3500	101	-	-	-	-	59	-	-	-
553-012		3700	109	-	-	-	-	70	-	-	-
553-014		4200	61	-	-	-	-	41	-	-	-
553-016		5000	100	-	-	-	-	61	-	-	-

* In Feet

ppm values on a Weight/Weight Basis

Table III (Continued)

C. Composition of Extracts

GeoChem Sample Number	Well	Interval*	Hydrocarbons: Paraffin-Naphthene %	Hydrocarbons: Aromatic %	Hydrocarbons: PN/Arom	Hydrocarbons: Sulfur %	Nonhydrocarbons: Eluted NSO'S %	Nonhydrocarbons: Noneluted NSO'S %	Nonhydrocarbons: Precipitd. Asphaltene %	Nonhydrocarbons: Asph/NSO	HC'S %	HC/Non HC
553-002		2500	-	-	-	-	-	-	81.4	-	-	-
553-004		2700	-	-	-	-	-	-	77.5	-	-	-
553-005		2800	-	-	-	-	-	-	75.0	-	-	-
553-006		2900	-	-	-	-	-	-	77.1	-	-	-
553-007		3000	-	-	-	-	-	-	65.8	-	-	-
553-009		3200	9.8	9.3	1.06	7.8	2.6	9.3	61.1	5.13	19.2	0.
553-011		3500	-	-	-	-	-	-	58.3	-	-	-
553-012		3700	-	-	-	-	-	-	64.5	-	-	-
553-014		4200	-	-	-	-	-	-	67.2	-	-	-
553-016		5000	-	-	-	-	-	-	61.4	-	-	-

* In Feet

Table IV-A

Saturate Hydrocarbon Analyses

Summary of Paraffin-Naphthene Distribution

GeoChem Sample Number	Well Interval*	% Paraffin	% Isoprenoid	% Naphthene	C-P Index A	C-P Index B	ip19/ip20
553-002	2500	7.1	2.0	90.8	1.17	2.27	0.58
553-004	2700	11.4	4.0	84.6	0.96	1.33	0.22
553-005	2800	9.5	3.3	87.2	0.96	1.50	0.27
553-006	2900	9.5	1.0	89.5	1.04	1.35	1.35
553-007	3000	8.3	2.4	89.4	1.06	1.52	0.60
553-009	3200	8.3	5.3	86.4	-	-	0.43
553-011	3500	29.6	43.5	27.0	1.67	-	0.11
553-012	3700	10.9	6.9	82.2	0.94	-	0.37
553-014	4200	9.6	5.6	84.8	0.95	-	0.42
553-016	5000	6.4	1.4	92.2	1.02	1.65	0.07

* In Feet

Table IV-B

Saturate Hydrocarbon Analyses

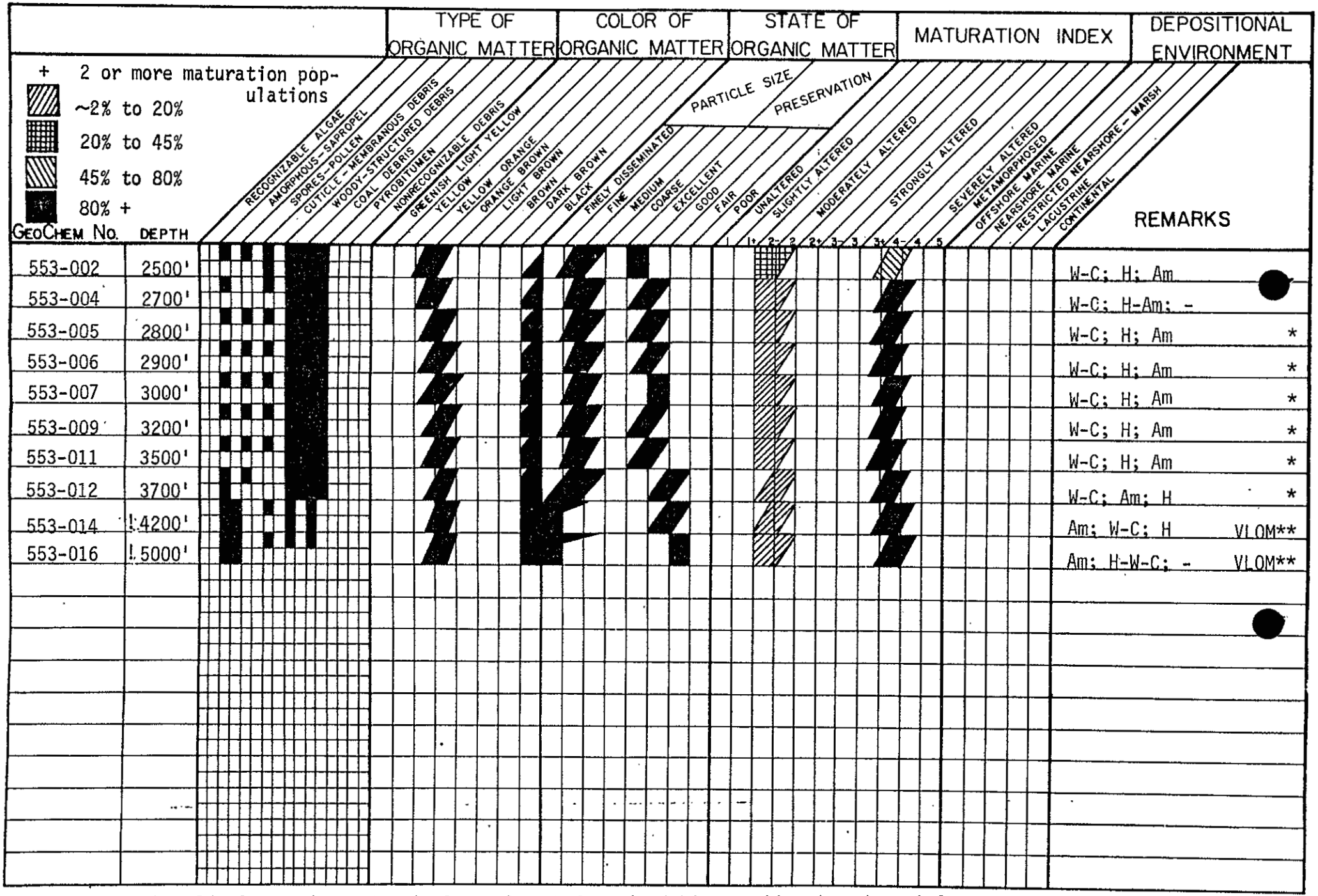
Normalized Paraffin Distribution

GeoChem Sample Number	Well Interval*	% nC15	% nC16	% nC17	% ip19	% nC18	% ip20	% nC19	% nC20	% nC21	% nC22	% nC23	% nC24	% nC25	% nC26	% nC27	% nC28	% nC29	% nC30	% nC31	% nC32	% nC33	% nC34	% nC35
553-002	2500	1.0	0.5	3.0	8.1	14.0	13.8	9.4	8.8	4.8	6.5	7.1	5.2	6.0	2.8	3.7	1.0	2.5	0.5	1.2	0.1	0.1	0.0	0.0
553-004	2700	0.1	0.2	4.6	4.7	17.2	21.4	17.0	12.0	4.9	3.6	3.5	3.5	3.1	1.9	1.0	0.4	0.4	0.1	0.2	0.1	0.0	0.0	0.0
553-005	2800	0.2	0.4	4.6	5.5	15.5	20.1	13.4	9.2	3.5	4.0	4.7	5.4	5.4	3.1	2.1	0.7	1.0	0.4	0.5	0.1	0.1	0.0	0.0
553-006	2900	0.2	0.2	0.6	5.5	6.7	4.1	5.6	7.7	5.0	7.8	12.9	14.0	12.8	7.9	4.6	1.7	1.3	0.5	0.6	0.1	0.1	0.0	0.0
553-007	3000	0.2	0.4	6.8	8.3	16.4	13.8	12.3	11.2	7.9	7.2	5.8	3.4	2.6	1.2	0.8	0.3	0.6	0.2	0.3	0.1	0.0	0.0	0.0
553-009	3200	0.2	2.2	12.3	11.7	22.0	27.5	13.8	6.1	1.3	1.1	0.9	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
553-011	3500	0.0	2.3	4.1	5.7	0.9	53.9	2.9	2.6	2.3	5.4	6.9	1.6	4.6	0.8	3.0	2.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0
553-012	3700	0.2	0.4	8.9	10.4	23.8	28.3	14.2	5.9	1.6	1.8	2.0	1.0	0.6	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
553-014	4200	0.2	0.4	9.1	11.0	20.7	25.9	12.9	7.0	2.5	2.5	3.0	2.1	1.3	0.6	0.4	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
553-016	5000	0.4	0.4	0.4	1.1	9.4	16.5	17.6	13.8	5.6	6.2	7.6	6.7	6.0	2.9	2.4	0.7	0.9	0.4	0.7	0.2	0.0	0.0	0.0

* In Feet

Table V

Visual Kerogen Assessment Worksheet



* Less than 2% of organic matter is 2- to 2

** Trace of organic matter having a 2- to 2 Index

! Organic debis considered to be uphole or contamination from mud system. VLOM- very little organic matter on slide

APPENDIX A

Brief Description of Organic Geochemical Analyses Performed in This Study

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 porapac 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 results of the C_1-C_7 air space and cuttings analyses are shown in Tables IA and IB.

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. This data is recorded in Table IC and plotted on the well profile of Figure 1.

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_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.

The organic carbon data is recorded in Table II and plotted in Figure 1.

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 benzene-methanol 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 saturate hydrocarbon (P-N), aromatic hydrocarbon (AROM) and nitrogen-sulfur-oxygen containing fraction (NSO) by adsorption chromatography on a silica gel-alumina column. Unfortunately, non-quantitative micro-chromatographic analyses had to be performed on all but one of the samples since they contained an insufficient amount of n-C_5 soluble extract suitable for quantitative liquid chromatography.

All C_{15+} compositional data is reported in Table III.

GC Analysis of C_{15+} Paraffin-Naphthene Hydrocarbons

The content and molecular composition of the heavy C_{15+} paraffin-naphthene 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 chromatographic traces are shown in Figure 2 and the compositional data obtained for the C_{15+} saturate hydrocarbon is reported in Table IV.

In this study, 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:

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

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

These C.P.I. values are recorded in Table IV.

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-termperature 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. The kerogen assessment is noted in Table V.

FIGURE 1

SUMMARY OF ORGANIC ANALYSES

C_1-C_7 HYDROCARBON

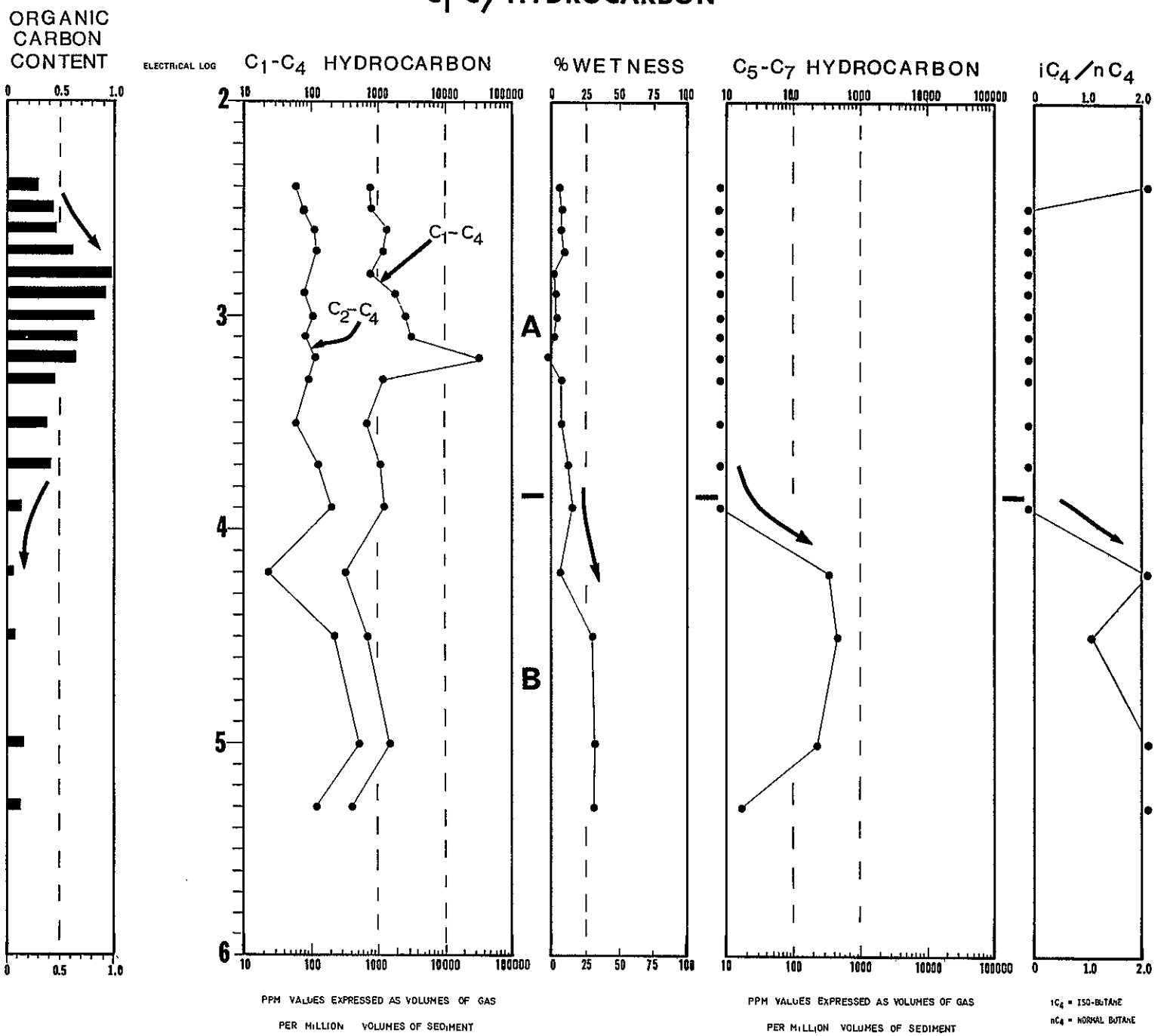
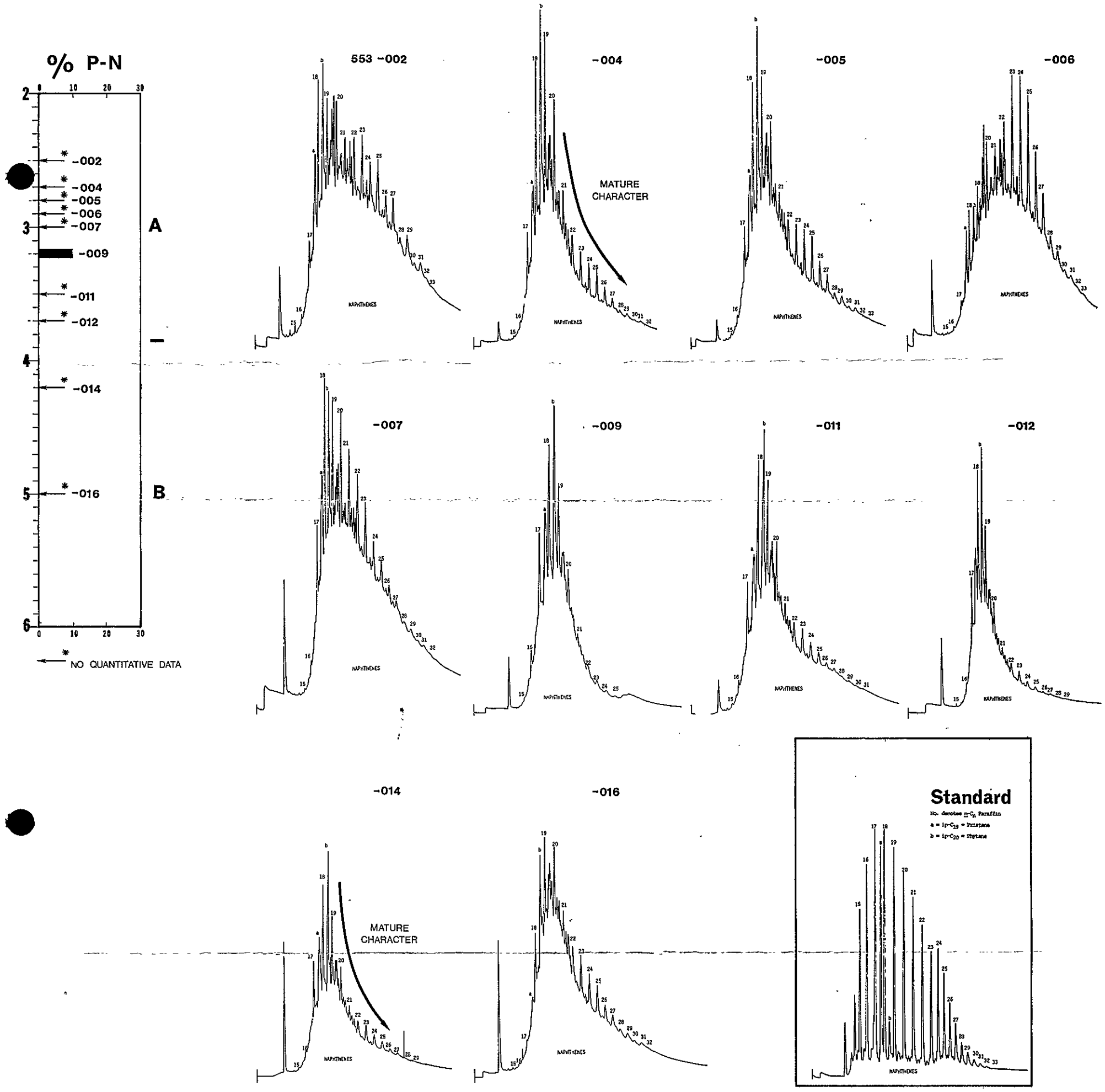


FIGURE 2


% P-N
0 10 20 30
2
3
4
5
6
-002
-004
-005
-006
-007
-009
-011
-012
-014
-016
A
B
NO QUANTITATIVE DATA
553 -002
-004
-005
-006
-007
-009
-011
-012
-014
-016
MATURE CHARACTER
NAPHTHENES
Standard
No. denotes n-C17 Paraffin
a = Ip-C18 = Pristane
b = Ip-C20 = Phytane