GEOCHEMICAL SERVICE REPORT

HYDROCARBON SOURCE ROCK EVALUATION STUDY

ORGANIC GEOCHEMICAL ANALYSES OF DRY WELL CUTTINGS

EXXON CORP. PRISOR UNIT FED. #1 WELL

SIERRA COUNTY, NEW MEXICO

Prepared

for

Beard Oil Company

Oklahoma City, Oklahoma

CONFIDENTIAL
November, 1977

1143-C BRITTMORE ROAD, HOUSTON, TEXAS 77043

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SUMMARY

Organic geochemical analyses run on a suite of dried paleo cuttings, collected from the Exxon Corp. Prisor Unit Fed. #1 Well, over the interval from 4,800± feet to 11,400± feet, indicate the following:

- Zone A (5,200± feet to 6,100± feet) contains rocks which have a moderately immature, poor oil and associated "wet" gas source character and a fair "dry" methane gas source character.

- Zone B (7,500± feet to 9,200± feet) contains rocks which have a mature, fair oil, condensate and associated "wet" gas source character.

- Zone C (9,600± feet to 10,500± feet) contains rocks which have a mature to very mature, poor condensate and associated "wet" gas source character and a fair "dry" methane gas source character.

In order of priority, exploration plays in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well are interpreted as follows (providing that reservoir traps are available):

1. The Bo, Cisco, Canyon and Upper Strawn Formations within Zone B (7,500± feet to 9,200± feet)

   This section should be considered prospective for minor to fair quantities of indigenously generated mature paraffino-naphthenic oil, condensate and associated "wet" gas.

2. The Davey, Morrow, Mississippian and Woodford Formations within Zone C (9,600± feet to 10,500± feet)

This section should be considered non-prospective for any quantities of indigenously generated oil, condensate and associated "wet" gas. However, this section should be considered prospective for fair quantities of "dry" methane gas.

3. The Lower Mesa Verde and Yeso Formations within Zone B (5,200± feet to 6,100± feet)

This section should be considered non-prospective for any quantities of indigenously generated oil and associated "wet" gas. However, this section should be considered prospective for fair quantities of "dry" methane gas.

Paul J. Cernock

Paul J. Cernock
GEOCHEM LABORATORIES, INC.

INTRODUCTION

This report summarizes the results of a source rock evaluation study carried out on a suite of dry paleo cuttings collected over the gross well interval 100± feet to 11,400± feet from the Exxon Corp. Prisor Unit Fed. #1 Well located in Sierra County, New Mexico.

The purpose of this study has been to:

- investigate the richness, type (oil, condensate or gas), and state of thermal maturity of the hydrocarbon source rocks, and their stratigraphic distribution within the sedimentary sequence penetrated by the Exxon Corp. Prisor Unit Fed. #1 Well.

- characterize geochemical zones within the stratigraphic section of this well as a basis for any subsequent crude oil - parent rock correlations which may be required in the future.

- define the exploration significance of this study with respect to future drilling in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well.

Analytical

On arrival at GeoChem's Houston laboratory, the Exxon Corp. Prisor Unit Fed. #1 Well was assigned the GeoChem Job No. 998-. Small samples (2-4± grams) were hand-picked by a geologist at intervals of approximately 150± feet throughout this well. Each of these samples was identified by the suffix -001 through -044 in order of increasing depth.

Each of the forty-four (44) samples was analyzed for total organic carbon content. On the basis of these results, plus the geological zonation and lithology of the samples, various single or composited samples were selected for more detailed geochemical analyses. Eighteen (18) different samples were selected for detailed geochemical analyses and were identified by the same suffix numbers as mentioned above, but in each case a "D" was added after the three-digit number (example, 998-004D).

The following lists the number and type of geochemical analyses carried out on the dried well cuttings which were collected from the Exxon Corp. Prisor Unit Fed. #1 Well:

Type of Analysis	Exxon Corp. Prisor Unit Fed. #1 Well
Organic carbon analyses	59
C_{15+} soxhlet extraction w/deasphaltening	16
C_{15+} quantitative liquid chromatographic separation	13
C_{15+} nonquantitative micro-liquid chromatographic separation	3
C_{15+} paraffin-naphthene (P-N) analysis	16
Kerogen isolation, slide preparation and visual assessment	18
Vitrinite reflectance	4

A brief description of the standard analytical procedures used by GeoChem in this study is presented in Appendix A.

All the analytical data obtained in this study, whether used in the ultimate interpretation or not, are documented in the appropriate Tables I-A through VII of this report. The organic carbon values from the screen analysis are presented in Table I and in Figure 1, the gross lithologic description and organic carbon values are presented in Tables I and II and in Figure 1, the kerogen organic matter type and alteration data are presented in Tables III and VI and in Figure 1, the C_{15+} extraction, deasphaltening and liquid chromatographic separation data are presented in Tables IV-A, -B and -C, the C_{15+} paraffin-naphthene (P-N) compositional data are presented in Tables V-A and -B and the vitrinite reflectance data are presented in Table VII and in Figures 3 and 4. The gas chromatographic traces, showing the molecular distribution of the C_{15+} paraffin-naphthene (P-N) hydrocarbons, are reproduced in Figure 2. Table I-A, which summarizes the hydrocarbon source character of the rocks examined in this particular well, is placed immediately after the text in this report.

An additional set of all Figures is appended in a pocket at the rear of this report in order to aid the reader in cross-referencing the text with the well-profile data illustrated.

General Information

Nine (9) copies of this report have been forwarded to Mr. David Martino, Beard Oil Company, Oklahoma City, Oklahoma, who authorized and coordinated this study. GeoChem retains one (1) report copy for reference purposes in discussions with authorized Beard Oil Company personnel on specific details of this study.

All remaining used and unused well cuttings, the C_{15+} hydrocarbon and non hydrocarbon chromat fractions, vitrinite reflectance plugs and other data will be forwarded under separate cover to Mr. David Martino, Beard Oil Company, Oklahoma City, Oklahoma, in the near future.

The data, interpretations, sample materials and all other matters pertaining to this well study have been treated in a highly confidential manner and are considered proprietary to Beard Oil Company.

RESULTS AND INTERPRETATIONS

A. Geological Zonation

The sedimentary sequence penetrated by the Exxon Corp. Prisor Unit Fed. #1 Well in Sierra County, New Mexico, has been divided into a number of discrete geological formations or groups. Specific tops which were provide to GeoChem by Beard Oil Company include the following:

Mesa Verde	4,750'
Yeso	5,492'
Tubb	6,092'
Abo	6,400'
Wolfcamp	6,802'
Bo	7,298'
Cisco	8,150'
Canyon	8,442'
Strawn	8,840'
Davey	9,767'
Morrow	10,100'
Mississippian	10,160'
Woodford	10,360'
Fusselman	10,542'
Montoya	10,594'
Ellenburger	10,886'
Bliss	11,470'
Precambrian	11,596'

B. Geochemical Zonation

The stratigraphic section, penetrated by the Exxon Corp. Prisor Unit Fed. #1 Well, over the interval from 4,800± feet to 11,400± feet, can be subdivided into three (3) hydrocarbon source generating zones which are separated by stratigraphic section defined as non-source. The subdivision of these various zones is based primarily on the organic carbon contents, organic matter (kerogen) type and predominance, and the content and composition of the C_{15+} solvent extractable bitumen and C_{15+} total hydrocarbons of the fine-grained sediments examined throughout this well profile. The geochemical parameters which define each of the interpreted source zones and non-source section are identified in Table I-A. For simplicity's sake, just the three (3) zones interpreted to be

hydrocarbon source generating, will be described in detail within this report. The three (3) geochemical zones which are of interest from a probable hydrocarbon generating standpoint are identified as follows:

Geochemical Zone	Depth Interval	Formations
Zone A	5,200±' to 6,100±'	Lower Mesa Verde, & Yeso
Zone B	7,500±' to 9,200±'	Bo, Cisco, Canyon & Upper Strawn
Zone C	9,600±' to 10,500±'	Davey, Morrow, Mississippian & Woodford

C. Thermal Maturity and Hydrocarbon Source Character of Sediments

1. Zone A Sediments (5,200± feet to 6,100± feet)

The grayish red to medium gray shales and gray dolomites and limestones within Zone A have a moderately immature, poor oil and associated "wet" gas source character and a fair "dry" methane gas source character. The entire Zone A section, overall, has generated minute amounts of moderately mature paraffino-naphthenic oil and associated "wet" gas in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well. The amounts and composition of generated hydrocarbons are such that the entire Zone A section is considered to be in an initial stage of petroleum generation. Due primarily to the moderately immature thermal regime, and the organic carbon leanness in oil-prone kerogen material within these sediments, the entire Zone A section is considered to be non-source for the generation of any producible quantities of oil and associated "wet" gas. However, since the sediments do contain poor to fair quantities of organic carbon which is made up of significant portions of gas-prone kerogen types, the Zone A section is considered to be a fair "dry" methane gas source. It is interpreted that a "dry" methane gas generating zone is present within the Zone A section from 5,200± feet to 6,100± feet, and this section should be considered to be prospective for fair quantities of "dry" methane gas, provided that reservoir traps are available in the local area of this well.

The moderately immature character of these sediments is based on the immature Maturation Index of Stage 1+ to 2- grading to a moderately

immature Maturation Index of Stage 2- to 2 for the kerogen isolated from most of the samples from 5,330± feet to 5,970± feet (Tables III and VI; Figure 1) and by the moderate percentage of paraffin-naphthene (P-N) hydrocarbon fraction making up the total C_{15+} bitumen extract (18.2% to 25.7%, mean 20.8%; Table IV-C; Figure 2).

The overall poor oil and associated "wet" gas source character assigned to the Zone A Sediments is based primarily on the overall poor to fair organic carbon contents (0.15% to 0.43%, mean 0.28%; Tables I-A, I, II and III; Figure 1), the overall poor C_{15+} solvent extractable bitumen contents (319 ppm to 542 ppm, mean 400 ppm; Tables I-A and IV-B; Figure 1), and by the overall fair C_{15+} total hydrocarbon contents (94 ppm to 149 ppm, mean 120 ppm; Tables I-A and IV-B; Figure 1). The oil and associated "wet" gas source character of the Zone A Sediments is suppressed due to the presence of more gas-prone kerogen types, i.e. herbaceous, woody and coaly type kerogen. This type of kerogen, combined with the moderately immature thermal history experienced by these sediments, limits the oil and associated "wet" gas generating capability of them. However, since the organic carbon contents are considered to be poor to fair and comprised primarily of gas-prone kerogen types, this section is interpreted to represent a fair "dry" methane gas source. Any available reservoir traps in juxtaposition to this methane gas source in the local area of the Exxon Corp. Prisor Fed. Unit #1 Well should be prospective for fair quantities of "dry" methane gas.

This Zone A section, if encountered laterally downdip, and in a thermally more advanced state, may generate fair quantities of mature, paraffino-naphthenic oil from the herbaceous type kerogen present within these samples. Ideally, the Zone A section would be most prospective if encountered in a position whereby these sediments would contain predominant amounts of the oil-prone kerogen type -- amorphous-sapropel-algal.

2. Zone B Sediments (7,500± feet to 9,200± feet)

The medium dark gray to dark gray limestones and shales within Zone B have a mature, fair oil, condensate and associated "wet" gas source character. This section, overall has generated fair amounts of mature paraffino-naphthenic oil and associated "wet" gas in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well. The amounts and composition of hydrocarbons are such that the Zone B Sediments are considered to be in a mature, progressive stage of petroleum generation. This section offers the most optimum exploration prospectiveness to the exploration geologist in the

local, as well as regional, area surrounding the Exxon Corp. Prisor Unit Fed. #1 Well for indigenously generated oil and associated "wet" gas. Essentially, the section containing the Bo, Cisco, Canyon and Upper Strawn Formations appears to be the most optimum source encountered in this well. Any available reservoir traps in juxtaposition to these sediments should be considered prospective for minor to fair quantities of indigenously generated mature oil and associated "wet" gas.

The mature character of these rocks is based on the moderately mature Maturation Index of Stage 2 to 2+ grading to a mature Maturation Index of Stage 2+ to 3- for the kerogen isolated from most of the samples from 6,400± feet to 9,130± feet (Tables I-A, III and VI; Figure 1), the mature appearance of the C_{15+} paraffin-naphthene gas chromatograms (see typical gas chromatograms of Zone B in Figure 2; samples 998-019D, -021D, -023D, -026D, and -029D), by the moderate to high percentage of paraffin-naphthene (P-N) hydrocarbons making up the C_{15+} solvent extractable bitumen (9.4% to 40.7%, mean 24.7%; Table IV-C; Figure 2), and by the high paraffin-naphthene/aromatic hydrocarbon ratios [(P-N/AROM) from 2.35 to 3.18, mean 2.89; Table IV-C; Figure 1]. A very mature appearance is suggested for these sediments on the basis of vitrinite reflectance data. The vitrinite reflectance ranges from a 1.48 to 2.68, with a mean of 1.94. This value represents a very mature thermal state for the sediments as exemplified in the geothermal diagenetic criteria diagram illustrated in Table I-A. On re-examining vitrinite reflectance plugs and the kerogen slides, GeoChem is convinced that the thermal regime suggested by the kerogen is more representative of insitu thermal conditions. The vitrinite particles examined in the plugs most probably represent reworked vitrinite material deposited with the sediments. Thus, the author feels that thermally Zone B is still within the oil, condensate and associated "wet" gas generating window.

The fair oil, condensate and associated "wet" gas source character assigned to the Zone B Sediments is based primarily on the overall poor to fair organic carbon contents (0.06% to 1.10%, mean 0.34%; Tables I-A, I, II and III; Figure 1), the overall fair C_{15+} solvent extractable bitumen contents (364 ppm to 1,305 ppm, mean 632 ppm; Tables I-A and IV-B; Figure 1), and by the overall fair to good C_{15+} hydrocarbon contents (55 ppm to 756 ppm, mean 243 ppm; Tables I-A and IV-B; Figure 1). The oil and associated "wet" gas source character of these sediments is enhanced by the fact that most of the samples do contain primary or secondary amounts of the second best oil-prone kerogen type -- herbaceous kerogens (Tables I-A, III and VI; Figure 1). The Zone B section is

similar to the upper Zone A section, but differs in the fact that it has experienced a sufficient thermal regime to generate moderate quantities of liquid petroleum from the herbaceous kerogen present within the samples. Also, the organic carbon contents of the Zone B section are slightly better than the overlying Zone A section. It is interpreted that the section consisting of the Bo, Cisco, Canyon and Upper Strawn Formations has generated minor to fair quantities of indigenously generated oil and associated "wet" gas in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well. This section should be considered prospective for minor to fair quantities of these petroleum by-products, provided that reservoir traps are available.

The reader should be cognizant of the gas chromatogram 998-024D found in Figure 2. This chromatogram may represent contamination from possible pipe dope or mud additives. The gas chromatogram could also suggest a residual hydrocarbon and may be defined as a show. Regardless of the possible contamination, the two samples overlying this (that is, those at 7,910± feet and 8,230± feet (998-021D and -023D) represent good quality, mature, paraffino-naphthenic oils. Thus, the author interprets the Zone B section to be a fair oil, condensate and associated "wet" gas source.

3. Zone C Sediments (9,600± feet to 10,500± feet)

Before defining the thermal maturity and hydrocarbon source character of the Zone C Sediments, the reader is referred to the transitional zone (from 9,200± feet to 9,600± feet) which separates Zone B from Zone C section. This transitional zone is made up of dark gray limestones and shales similar to the rocks in the overlying Zone B section and underlying Zone C section. These dark gray limestones and shales were only examined for total organic carbon contents. Thus, it is difficult to suggest that this section is either similar to Zone B or to Zone C. The author has chosen to define this zone as a transitional zone between the overlying Zone B and underlying Zone C section.

The dark gray limestones and shales within Zone C have a mature to very mature, poor condensate and associated "wet" gas source character and a fair "dry" methane gas source character. This section, overall has generated minor amounts of very mature paraffino-naphthenic oil, condensate and associated "wet" gas in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well. The amounts and composition of hydrocarbons are such that the Zone C Sediments are considered to be in an advanced stage of petroleum generation. This section has been subjected to a thermal regime such that the oil generating window has been either passed or is in the process

of being passed. That is, liquid hydrocarbons and associated "wet" gas would be themselves altered to a thermally "dry" methane gas by-product. The Zone C section is considered to be non-prospective for any quantities of indigenously generated, mature oil, condensate and associated "wet" gas. This section is, however, considered to be prospective for fair quantities of "dry" methane gas. In addition, the Zone C Sediments contain predominant amounts of the gas-prone woody type kerogens. These kerogens, even if subjected to a sufficient thermal regime, would generate primarily a "dry" methane gas.

The mature to very mature character of these rocks is based on the mature Maturation Index of Stage 3- to 3 grading to a very mature Maturation Index of Stage 3- to 3 for the kerogen isolated from most of the samples from 9,700+ feet to 10,480+ feet (Tables I-A, III and VI; Figure 1) and by the high paraffin-naphthene/aromatic hydrocarbon ratios [(P-N/AROM) from 2.33 to 3.42, mean 2.88; Table IV-C; Figure 1]. An extremely high thermal regime is suggested from the vitrinite reflectance data (see Table VII and Figures 3 and 4). The vitrinite reflectance ranges from a minimum of 1.49 to a maximum 3.79, with a mean of 2.58. These values suggest that these sediments are definitely within a dry gas thermal state. The author, after re-examining both the kerogen and vitrinite reflectance slides and plugs, is of the opinion that the vitrinite represents reworked material. Whether this is correct or not, this section still is defined as being in a thermally advanced stage, whereby no liquid hydrocarbons would be present.

The poor, mature oil, condensate and associated "wet" gas source character attributed to the Zone C Sediments is based primarily on advanced maturity of the section, and the presence of predominant amounts of the gas-prone woody type kerogen. Thus, this section is considered to be non-prospective for any quantities of indigenously generated mature oil, condensate and associated "wet" gas. The Zone C section is considered to represent a fair "dry" methane gas source on the basis of poor to fair organic carbon contents (0.15% to 0.58%, mean 0.32%; Tables I-A, I, II and III; Figure 1) and the presence of predominant amounts of the gas-prone kerogen type -- woody kerogen. The reader is referred to the geothermal diagenetic criteria graph shown in Table I-A which illustrates predominantly a "dry" thermal gas generated from woody type kerogens at a thermal maturation above a Stage 3 to 3+.

D. Exploration Significance of This Source Rock Evaluation Study

An examination of the richness, type (oil, condensate or gas) and state of thermal maturity of the hydrocarbon source rocks penetrated by the Exxon Corp. Prisor Unit Fed. #1 Well, shows that the stratigraphic interval from 4,800± feet to 11,400± feet, contains zones with varying degrees of exploration potential for indigenously sourced oil, condensate, associated "wet" gas and "dry" methane gas. In order of priority, exploration plays are interpreted as follows:

Locally

1. Zone B (7,500± feet to 9,200± feet)

The Zone B section is made up of the Bo, Cisco, Canyon and Upper Strawn Formations. The medium dark gray to dark gray limestones and shales within Zone B have a mature, fair oil, condensate and associated "wet" gas source character. Any available reservoir traps within this section should be prospective for minor to fair quantities of indigenously generated oil, condensate and associated "wet" gas in the local area of the Exxon Corp. Prisor Unit Fed. #1 Well, provided that reservoir traps are available.

2. Zone C (9,600± feet to 10,500± feet)

The Zone C section is made up of the Davey, Morrow, Mississippian and Woodford Formations. The dark gray limestones and shales within Zone C have a mature to very mature, poor condensate and associated "wet" gas source character and a fair "dry" methane gas source character. This section should be considered non-prospective for any quantities of indigenously generated oil, condensate and associated "wet" gas. However, the Zone C section should be considered prospective for fair quantities of "dry" methane gas in the local area of the Unit Fed. #1 Well, provided that reservoir traps are available.

3. Zone A (5,200± feet to 6,100± feet)

The Zone A section is made up of the Lower Mesa Verde and Yeso Formations. The grayish red to medium gray shales and gray dolomites and limestones within Zone A have a moderately immature, poor

oil and associated "wet" gas source character and a fair "dry" methane gas source character. This section should be considered non-prospective for any quantities of indigenously generated oil and associated "wet" gas. The section is considered, however, to be prospective for fair quantities of "dry" methane gas provided that reservoir traps are available in the local area of the Exxon Corp. Prisor Fed. #1 Well.

FIGURE 1

EXXON CORP. PRISOR UNIT FED. No. 1 WELL
SIERRA COUNTY, NEW MEXICO

SUMMARY OF ORGANIC ANALYSES

SOURCE CHARACTER

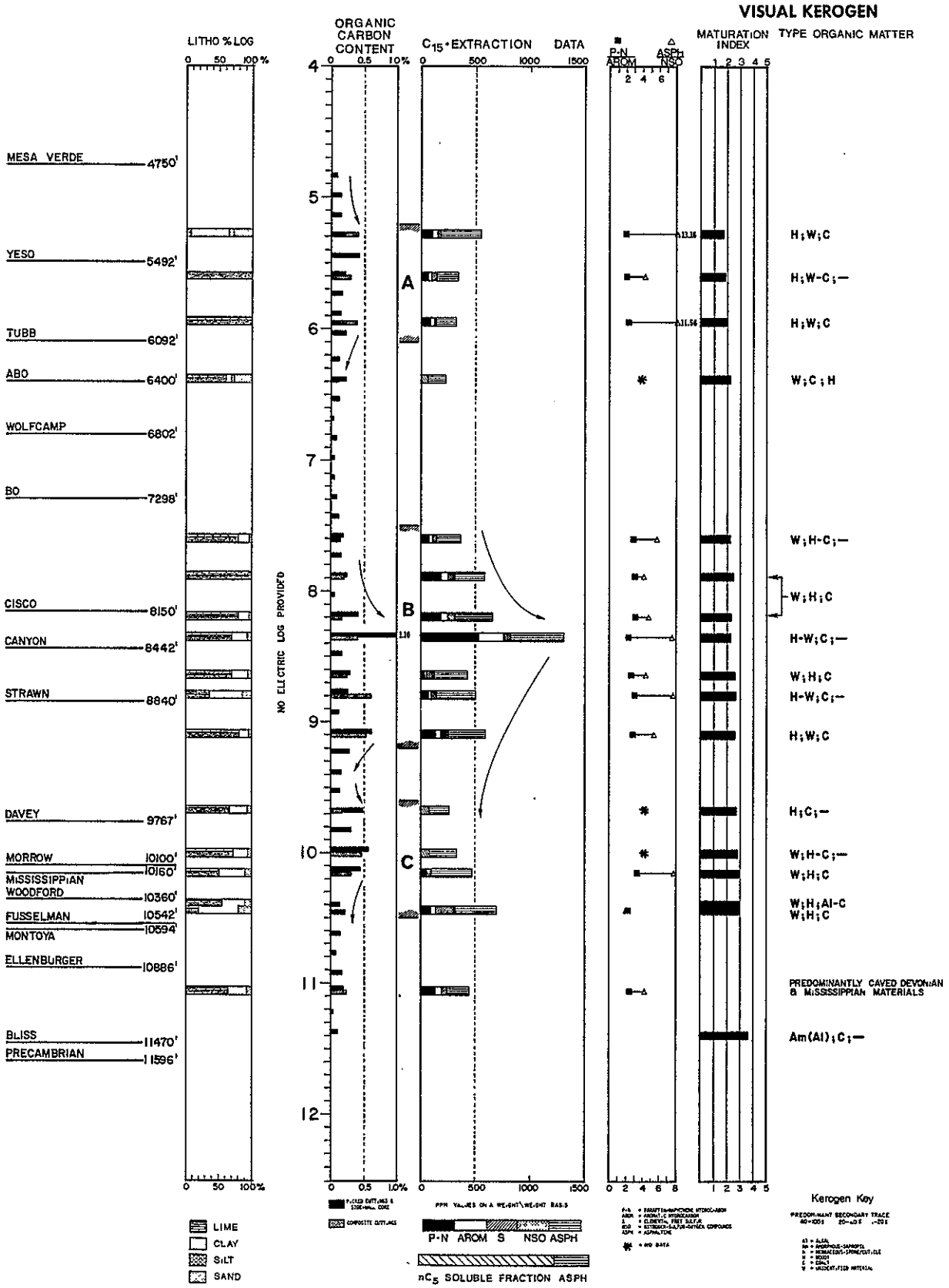


TABLE I-A

SUMMARY OF HYDROCARBON SOURCE CHARACTER

EXXON CORP. PRISCR UNIT FED. NO. 1 WELL

ORGANIC FACIES	FORMATIONS	WELL DEPTH INTERVAL (FEET)	LITHOLOGY	ORGANIC CARBON (% of rock)	VISUAL KEROGEN TYPE	VISUAL KEROGEN ALTERATION (Considered in place)	VITRINITE REFLECTANCE (% R_o) (Considered in place)	TOTAL	P-N	AROM	TOTAL HC's	HYDROCARBON SOURCE CHARACTER AT PRESENT LEVEL OF THERMAL MATURITY	PROSPECTIVENESS
	Upper Mesa Verde	4,800± to 5,200±	Grayish red and medium gray shales.	0.09 to 0.16									
				0.13 Mean								Non-source	
A	Lower Mesa Verde and Yeso	5,200± to 6,100±	Grayish red to medium gray shales and gray dolomites and limestones.	0.15 to 0.43	Herbaceous predominates			319 to 542	63 to 99	31 to 50	94 to 149	Moderately immature, poor oil and associated "wet" gas source character and a fair "dry" methane gas source character.	Non-prospective for any quantities of indigenously generated oil and associated "wet" gas.
					H:W,C	3- to 2 (Moderately immature)	N.A.						
				0.28 Mean	Secondary Woody			400 Mean	81 Mean	39 Mean	120 Mean		Prospective for fair quantities of "dry" methane gas.
	Tubb, Abo, Wolfcamp & Upper Bo	6,100± to 7,500±	Grayish red shales with minor amounts of dolomite and sandstones.	0.04 to 0.23	Woody predominates								
					W;C;H	2 to 2+ (Moderately mature)	N.A.	224	N.A.	N.A.	N.A.	Non-source	
				0.11 Mean	Secondary Coaly								
B	Bo, Cisco, Canyon & Upper Strawn	7,500± to 9,200±	Medium dark gray to dark gray limestones and shales.	0.05 to 1.10	Herbaceous and woody predominates	2 to 2+ (Moderately mature) grading to	1.48 to 2.68	384 to 1305	40 to 531	15 to 226	55 to 756	Mature, fair oil, condensate and associated "wet" gas source character.	Prospective for minor to fair quantities of indigenously generated oil and associated "wet" gas.
					H-W,-;C								
				0.34 Mean	Trace Coaly	2+ to 3- (Mature)	1.94 Mean	632 Mean	177 Mean	66 Mean	243 Mean		
	Lower Strawn	9,200± to 9,600±	Dark gray limestones and shales.	0.25 to 0.30									
				0.21 Mean								Transitional between Zones B and C	
C	Davey, Morrow, Mississippian & Woodford	9,600± to 10,800±	Dark gray limestones and shales.	0.15 to 0.56	Woody predominates		1.49 to 3.79	262 to 694	20* to 97	10* to 42	30* to 135	Mature to very mature, poor condensate and associated "wet" gas source character and a fair "dry" methane gas source character.	Non-prospective for any quantities of indigenously generated oil and associated "wet" gas.
					W,H C	3- to 3 (Mature)							
				0.32 Mean	Secondary Herbaceous		2.51 Mean	440 Mean	44* Mean	18* Mean	63* Mean		Prospective for fair quantities of "dry" methane gas.
	Fusselman, Montoya, Ellenburger, Bliss & Precambrian	10,800± to 11,400±	Dark gray limestones, dolomites and shales.	0.05 to 0.24	Amorphous-sapropel Algal predominates								
					Am(Al),C;-	3+ to 4- (Very Mature)	N.A.	447	139	56	195	Non-source	
				0.15 Mean	Secondary Coaly								

*C_{15+} nC5 soluble fraction too small for quantitative liquid chromatography. C_{15+} hydrocarbon contents estimated.

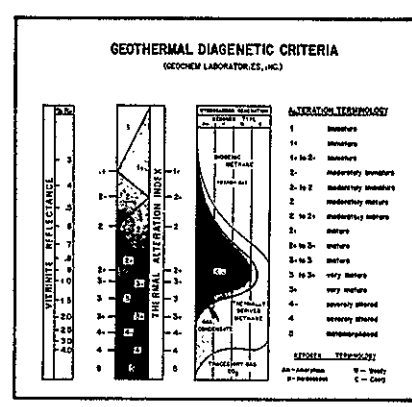
ORGANIC CARBON RICHNESS SCALE

	Carbonates	Clastics
Very poor to poor	0 to 0.25%	0 to 0.5 %
Fair to good	0.25 to 0.50%	0.5 to 1.00%
Good to very good	0.50 to 1.0 %	1.0 to 4.0 %
Excellent	> 1.00%	> 4.0 %

KEROGEN TYPE & PREDOMINANCE KEY

Predominant;	Secondary;	Trace
60-100%	20-40%	1-20%

Al = Algal
Am = Amorphous-Sapropel
H = Herbaceous-Spore/Cuticle
W = Woody
C = Coaly
U = Unidentified Material



C_{15+} TOTAL BITUMEN EXTRACT RICHNESS SCALE

0 - 250 ppm	Very Poor
250 - 500 ppm	Poor
500 - 1000 ppm	Fair
1000 - 2000 ppm	Good
2000 - 4000 ppm	Very good
Greater than 4000 ppm	Excellent

C_{15+} TOTAL HYDROCARBON RICHNESS SCALE

0 - 50 ppm	Very poor
50 - 100 ppm	Poor
100 - 200 ppm	Fair
200 - 400 ppm	Good
400 - 800 ppm	Very good
Greater than 800 ppm	Excellent

FIGURE 2

EXXON CORP. PRISOR UNIT FED. No. 1 WELL
SIERRA COUNTY, NEW MEXICO

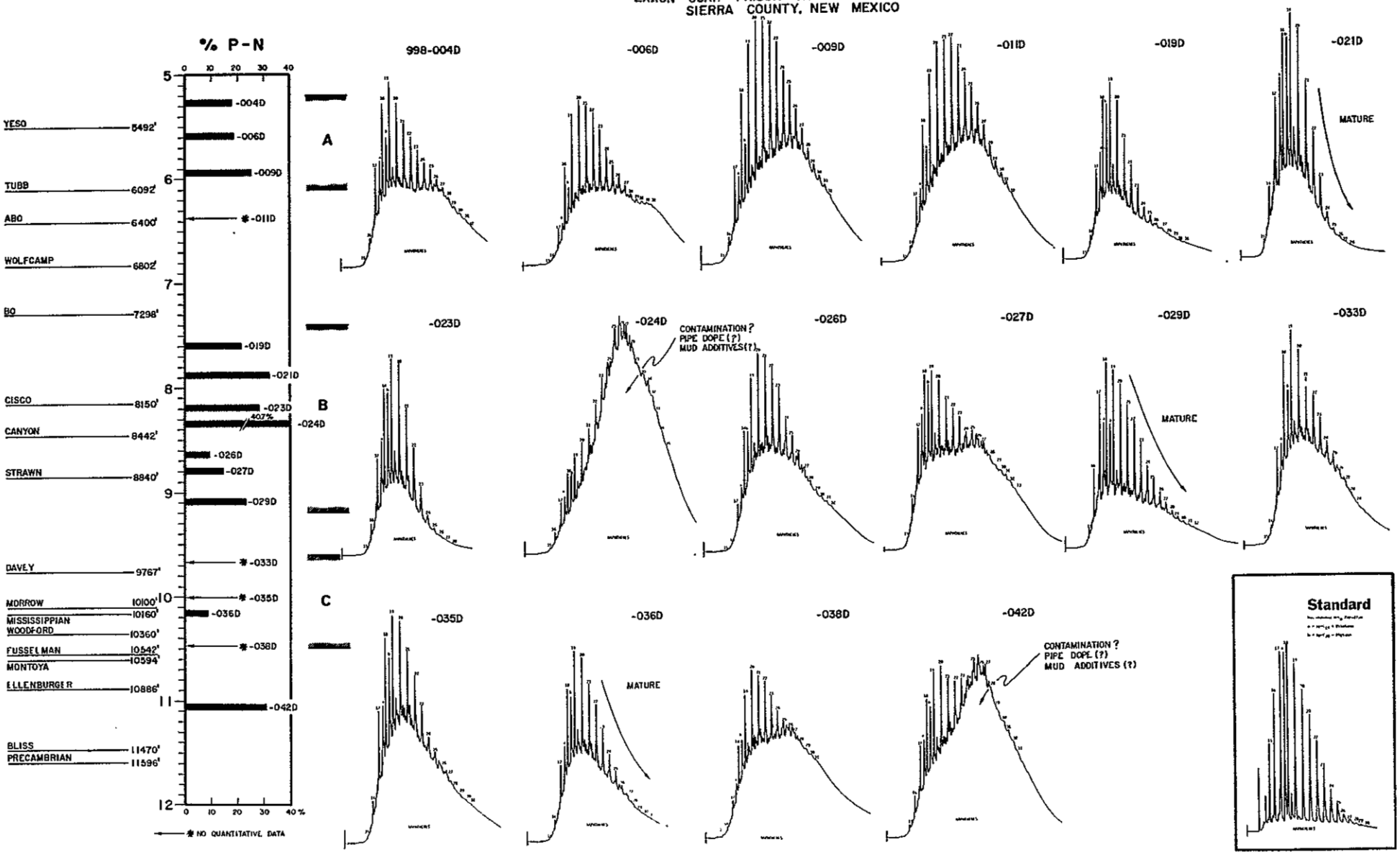
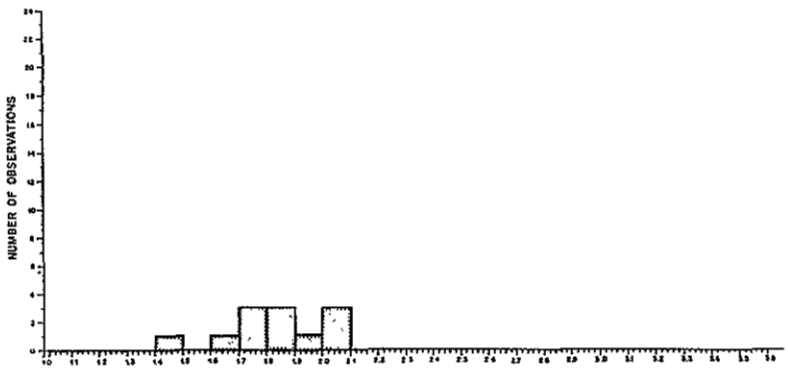


FIGURE 3

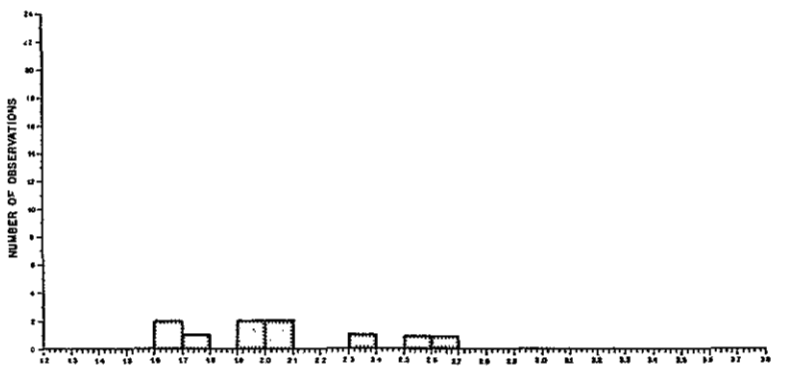
EXXON CORP. PRISOR UNIT FED. No. 1 WELL
SIERRA COUNTY, NEW MEXICO

COMPANY Beard Oil Co. GEOCHEM NO. 998-027D NUMBER OF OBSERVATIONS 12
WELL OR OUTCROP Ctgs. LOCATION New Mexico DEPTH OR SAMPLE NO. 8740'-8840'
MIN. REFLECTANCE 1.48 (%Rₒ) MAX. REFLECTANCE 2.06 (%Rₒ) AVG. REFLECTANCE 1.83 (%Rₒ)



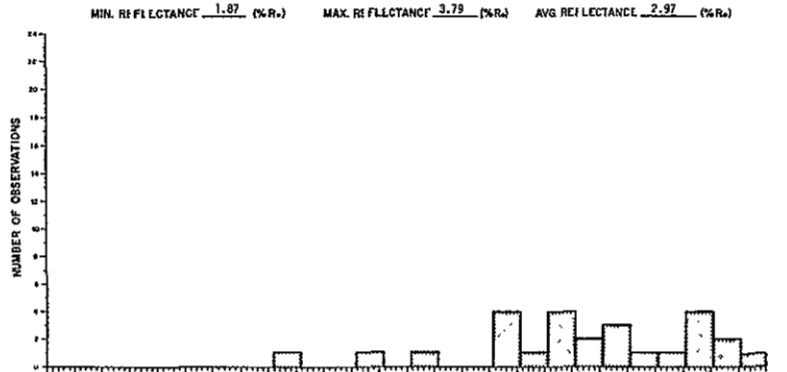
VITRINITE REFLECTANCE HISTOGRAM

COMPANY Beard Oil Co. GEOCHEM NO. 998-029D NUMBER OF OBSERVATIONS 10
WELL OR OUTCROP Ctgs. LOCATION New Mexico DEPTH OR SAMPLE NO. 9050'-9130'
MIN. REFLECTANCE 1.67 (%Rₒ) MAX. REFLECTANCE 2.68 (%Rₒ) AVG. REFLECTANCE 2.06 (%Rₒ)



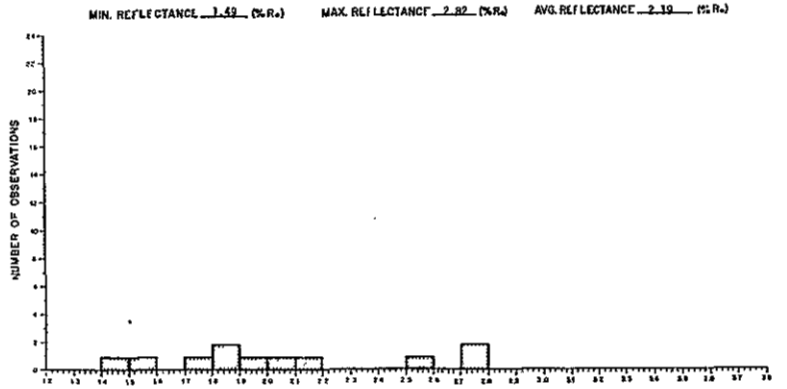
VITRINITE REFLECTANCE HISTOGRAM

COMPANY Beard Oil Co. GEOCHEM NO. 998-035D NUMBER OF OBSERVATIONS 29
WELL OR OUTCROP Ctgs. LOCATION New Mexico DEPTH OR SAMPLE NO 9950'-10,050'
MIN. REFLECTANCE 1.87 (%Rₒ) MAX. REFLECTANCE 3.79 (%Rₒ) AVG. REFLECTANCE 2.97 (%Rₒ)



VITRINITE REFLECTANCE HISTOGRAM

COMPANY Beard Oil Co. GEOCHEM NO. 998-037 NUMBER OF OBSERVATIONS 7
WELL OR OUTCROP Ctgs. LOCATION New Mexico DEPTH OR SAMPLE NO. 10360'-10400'
MIN. REFLECTANCE 1.49 (%Rₒ) MAX. REFLECTANCE 2.82 (%Rₒ) AVG. REFLECTANCE 2.19 (%Rₒ)



VITRINITE REFLECTANCE HISTOGRAM

FIGURE 4

EXXON CORP. PRISOR UNIT FED. No.1 WELL
SIERRA COUNTY, NEW MEXICO
VITRINITE REFLECTANCE

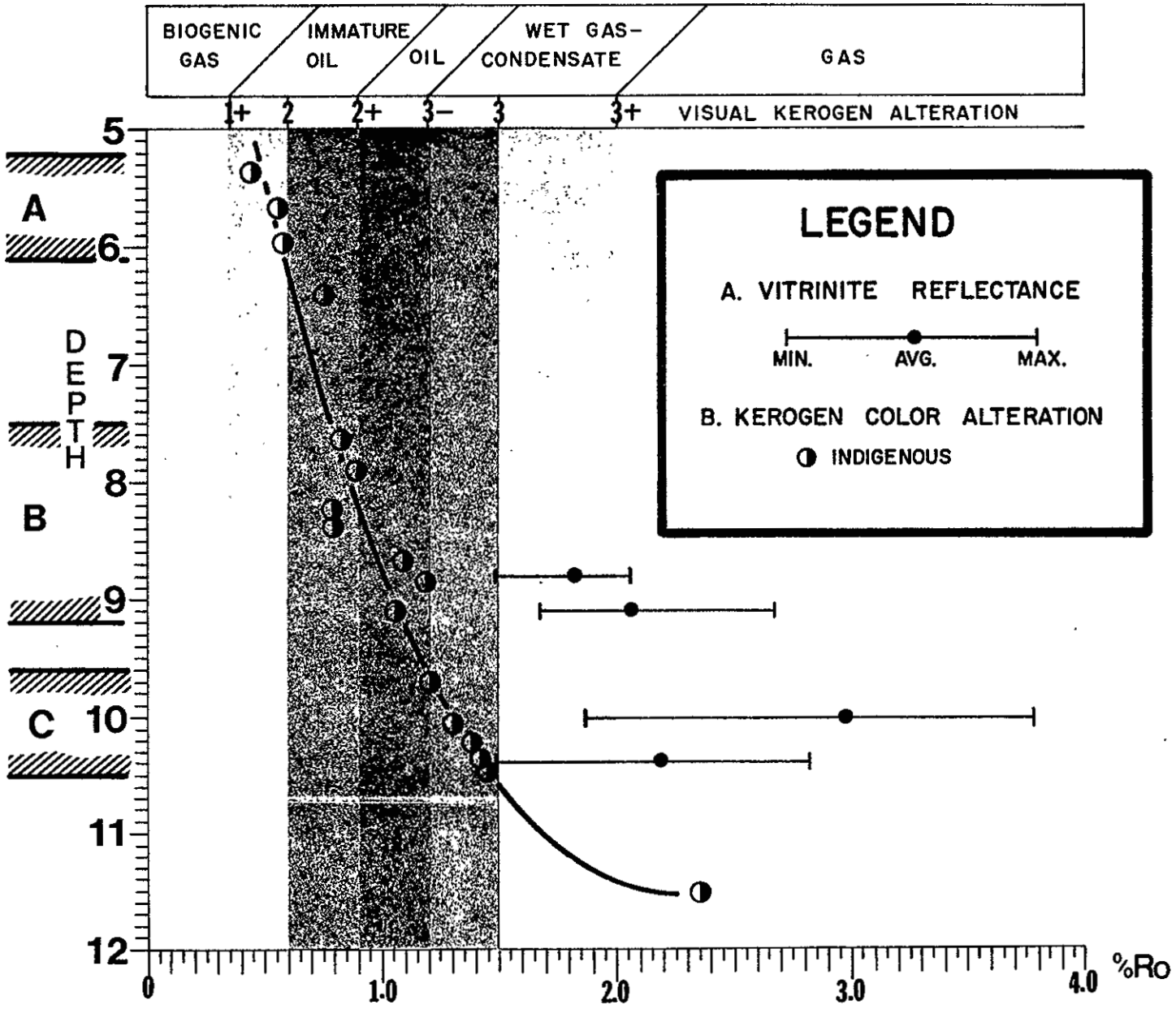


Table I

Summary of Organic Carbon Analyses of Small Picked Samples

GeoChem Sample Number	Well Depth (feet)	Percent Organic Carbon	Gross Litho Description
998-001	4,800- 4,810	0.09	80% Grayish red shale, 20% medium gray shale.
998-002	4,950- 4,960	0.15	Sandstone, grayish red shale, medium gray shale.
998-003	5,100- 5,110	0.15	50% Medium gray shale, 40% grayish red shale, 10% sandstone.
998-004	5,250- 5,260	0.21	50% Medium gray shale, 30% sandstone, 20% grayish red shale.
998-005	5,410- 5,420	0.43; 0.43R	Sandstone, medium dark gray shale.
998-006	5,550- 5,560	0.22	Limestone.
998-007	5,700- 5,710	0.17	Limestone.
998-008	5,850- 5,860	0.15	Dolomite.
998-009	6,000- 6,010	0.23	Limestone.
998-010	6,200- 6,210	0.12; 0.13R	Limestone, dolomite, medium dark gray shale.
998-011	6,350- 6,360	0.23	Medium gray shale.
998-012	6,500- 6,510	0.13	Grayish red shale.
998-013	6,650- 6,660	0.04	Grayish red shale.
998-014	6,800- 6,810	0.09	Grayish red shale.
998-015	6,950- 6,960	0.06; 0.05R	Grayish red shale.
998-016	7,100- 7,110	0.06	Grayish red shale.
998-017	7,250- 7,260	0.09	Grayish red shale.
998-018	7,400- 7,410	0.12	Medium dark gray shale and limestone.
998-019	7,550- 7,560	0.19	Limestone, dolomite.
998-020	7,700- 7,710	0.15; 0.17R	Medium dark gray limestone.
998-021	7,850- 7,860	0.25	Medium dark gray limestone.
998-022	8,000- 8,010	0.06	Limestone
998-023	8,150- 8,160	0.42	Limestone, medium dark gray shale, grayish red shale
998-024	8,310- 8,320	1.10	Shale, dolomite, limestone.
998-025	8,450- 8,460	0.21; 0.15R	Limestone, medium dark gray shale
998-026	8,600- 8,610	0.30	Medium dark gray shale and limestone.
998-027	8,740- 8,750	0.27	Dark gray shale.
998-028	8,900- 8,910	0.13	Limestone and dark gray shale.
998-029	9,050- 9,060	0.63	Limestone and dark gray shale.
998-030	9,200- 9,210	0.30; 0.29R	Limestone and dark gray shale.
998-031	9,360- 9,370	0.17	Limestone and dark gray shale.
998-032	9,500- 9,510	0.15	Limestone and dark gray shale.
998-033	9,650- 9,660	0.50	Dark gray shale and limestone.
998-034	9,800- 9,810	0.32	Limestone and dark gray shale.
998-035	9,950- 9,960	0.58	Dark gray shale and limestone.
998-036	10,100-10,110	0.46	Dark gray shale and limestone.
998-037	10,360-10,400	0.15	Dark gray shale (has been run earlier).
998-038	10,400-10,480	0.23	Dark gray shale (has been run earlier).
998-039	10,600-10,610	0.16	Siltstone, dolomite, dark gray shale.
998-040	10,750-10,760	0.09	Dolomite, dark gray shale.
998-041	10,900-10,910	0.18	Dark gray shale and dolomite
998-042	11,020-11,030	0.19; 0.22R	Dolomite, dark gray shale, limestone.
998-043	11,200-11,210	0.05	Dolomite.
998-044	11,350-11,360	0.12	Limestone, dolomite.

R = Repeat sample.

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)
998-004D	5330'			0.41
-A		70% Shale, very slightly calcareous, slightly silty, moderately hard, blocky to fissile, grayish red to medium gray.	5R 4/2 to N5	
-B		30% Sandstone, very slightly calcareous, sand is fine to medium grain, subangular to subrounded, clear to frosted, poorly sorted, well consolidated, moderately hard, no show, varied colors.		
998-006D	5680'			0.30
-A		100% Limestone grading into micrite, finely crystalline to microcrystalline, poor porosity, moderately hard, no show medium dark gray to light gray.	N4 to N7	
998-009D	5970'			0.39
-A		80% Dolomite, finely crystalline, poor porosity, hard, no show, medium dark gray to medium light gray.	N4 to N6	
-B		20% Annydrite, finely crystalline, excellent porosity, soft, no show, white.	N9	
998-011D	6400'			0.12
-A		60% Dolomite, finely crystalline, hard, poor porosity, no show, medium gray to medium dark gray.	N5 to N6	
-B		30% Sandstone, noncalcareous, silty, sand is very fine grain, subrounded, clear to frosted, moderately consolidated, excellent porosity, no show, pale red.	5R 6/2	
-C		10% Shale, noncalcareous, silty, fissile, hard, grayish black.	N2	
998-019D	7640'			0.13; 0.15R
-A		60% Limestone grading into micrite, finely crystalline to microcrystalline, poor porosity, hard, no show, medium dark gray to medium light gray.	N4 to N6	
-B		20% Dolomite, finely crystalline, hard, poor porosity, no show, medium gray to medium dark gray.	N5 to N6	
-C		20% Shale, very slightly calcareous, very slightly silty, moderately soft, good porosity, no show, grayish red. Trace shale.	10R 4/2	
998-021D	7910'			0.20
-A		100% Limestone grading into micrite, finely crystalline to microcrystalline, poor porosity, hard, no show, dark gray to medium dark gray.	N3 to N4	
998-023D	8230'			0.17
-A		80% Limestone grading into micrite, finely crystalline to microcrystalline, poor porosity, hard, no show, dark gray to medium dark gray.	N3 to N4	
-B		20% Shale, noncalcareous, silty, fissile, hard, no show, dark gray to light brownish gray.	N3 to 5YR 6/1	
998-024D	8380'			0.41
-A		60% Limestone grading into micrite, finely crystalline to microcrystalline, poor porosity, hard, no show, dark gray to medium dark gray.	N3 to N4	
-B		30% Shale, noncalcareous, silty, blocky to fissile, hard, no show, dark gray to medium dark gray.	N3 to N4	
-C		10% Dolomite, finely crystalline, poor porosity, no show, hard, white.	N9	
998-026D	8670'			0.25
-A		70% Limestone grading into micrite, finely crystalline to microcrystalline, poor porosity, hard, no show, dark gray to medium dark gray.	N3 to N4	
-B		30% Shale, noncalcareous, silty, blocky to fissile, hard, no show, dark gray to medium dark gray. Trace sparite. Trace straw.	N3 to N4	
998-027D	8840'			0.61
-A		70% Shale, slightly calcareous, silty, blocky to fissile, hard, medium dark gray.	N4	
-B		30% Limestone, finely crystalline, poor porosity, hard, no show, medium gray. Trace annydrite. Trace straw.	N5	
998-029D	9130'			0.56; 0.52R
-A		80% Limestone, finely crystalline, poor porosity, hard, no show, medium gray.	N5	
-B		20% Shale, slightly calcareous, silty, blocky to fissile, hard, medium dark gray. Trace anhydrite.	N4	
998-033D	9700'			0.17
-A		40% Limestone, finely crystalline, poor porosity, hard, no show, medium gray.	N5	
-B		30% Shale, slightly calcareous, silty, blocky to fissile, hard, medium dark gray.	N4	
-C		30% Chalk, argillaceous, soft, no show, medium light gray.	N6	
998-035D	10050'			0.47
-A		70% Limestone, finely crystalline, poor porosity, hard, no show, medium gray.	N5	
-B		30% Shale, slightly calcareous, silty, blocky to fissile, hard, medium dark gray.	N4	
998-036D	10203'			0.31
-A		50% Shale, slightly calcareous, silty, blocky to fissile, hard, medium dark gray.	N4	
-B		30% Limestone, finely crystalline, poor porosity, hard, no show, medium gray.	N5	
-C		20% Chalk, argillaceous, soft, no show, medium light gray.	N6	
998-037D	10400'			0.15
-A		50% Shale, very calcareous, silty, blocky, hard, medium dark gray.	N4	
-B		50% Limestone, micrite, argillaceous, hard, poor porosity, no show, medium gray.	N5	
998-038D	10480'			0.23
-A		100% Shale, calcareous, silty, blocky, hard, medium dark gray.	N4	
998-042D	11100'			0.24
-A		40% Limestone, finely crystalline, poor porosity, hard, no show, medium dark gray.	N4	
-B		40% Shale, very slightly calcareous, silty, blocky to fissile, hard, dark gray.	N3	
-C		20% Dolomite, finely crystalline, hard, poor porosity, no show, medium light gray.	N6	

D = Detailed description.

R = Repeat sample.

Table III

Summary of Organic Carbon and Visual Kerogen Analysis

GeoChem Sample Number	Well Depth Interval	Organic Carbon (% of Rock)	Visual Kerogen	
			Type	Alteration (1-5 Scale)
998-004D	5,200- 5,330	0.41	H;W;C	1+ to 2-
998-006D	5,500- 5,680	0.30	H;W-C;-	2- to 2
998-009D	5,900- 5,970	0.39	H;W;C	2- to 2
998-011D	6,340- 6,400	0.12	W;C;H	2 to 2+
998-019D	7,550- 7,640	0.13; 0.15R	W;H-C;-	2 to 2+
998-021D	7,850- 7,910	0.20	W;H;C	2+
998-023D	8,150- 8,230	0.17	W;H;C	2 to 2+
998-024D	8,310- 8,380	0.41	H-W;C;-	2 to 2+
998-026D	8,600- 8,670	0.25	W;H;C	2+ to 3-
998-027D	8,740- 8,840	0.61	H-W;C;-	2+ to 3-
998-029D	9,050- 9,130	0.56; 0.52R	H;W;C	2+ to 3-
998-033D	9,640- 9,700	0.17	H;C;-	3-
998-035D	9,950-10,050	0.47	W;H-C;-	3- to 3
998-036D	10,100-10,203	0.31	W;H;C	3- to 3
998-037D	10,360-10,400	0.15	W;H;Al-C	3- to 3
998-038D	10,400-10,480	0.23	W;H;C	3- to 3
998-042D	11,020-11,100	0.24	* Note *	
998-043D	11,200-11,210	0.05	Am(Al);-;C	3+ to 4-

* Note * Predominantly caved Devonian and Mississippian materials.

R = Repeat Sample

Kerogen Key

Predominant;	Secondary;	Trace
60-100%	20-40%	1-20%

Al = Algal
Am = Amorphous-Sapropel
H = Herbaceous-Spore/Cuticle
W = Woody
C = Coaly
U = Unidentified Material

Table IV

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)
998-004D	5200- 5330	90.0	0.0488	0.0329	0.0159	N.D.	0.0089	0.0045	0.0022	0.0003
998-006D	5500- 5680	95.0	0.0322	0.0189	0.0133	N.D.	0.0060	0.0029	0.0028	0.0016
998-009D	5900- 5970	100.0	0.0319	0.0185	0.0134	N.D.	0.0082	0.0036	0.0016	0.0000
998-011D	6340- 6400	75.0	0.0168	0.0121	0.0047	N.D.	N.D.	N.D.	N.D.	N.D.
998-019D	7550- 7640	100.0	0.0364	0.0220	0.0144	N.D.	0.0079	0.0027	0.0022	0.0016
998-021D	7850- 7910	95.0	0.0554	0.0256	0.0298	N.D.	0.0179	0.0058	0.0043	0.0018
998-023D	8150- 8230	95.0	0.0621	0.0320	0.0301	N.D.	0.0178	0.0056	0.0042	0.0025
998-024D	8310- 8380	85.0	0.1109	0.0412	0.0697	N.D.	0.0451	0.0192	0.0054	0.0000
998-026D	8600- 8670	100.0	0.0426	0.0303	0.0123	N.D.	0.0040	0.0015	0.0020	0.0048
998-027D	8740- 8840	80.0	0.0402	0.0287	0.0115	N.D.	0.0059	0.0019	0.0020	0.0017
998-029D	9050- 9130	100.0	0.0592	0.0343	0.0249	N.D.	0.0138	0.0048	0.0039	0.0024
998-033D	9640- 9700	100.0	0.0262	0.0183	0.0079	N.D.	N.D.	N.D.	N.D.	N.D.
998-035D	9950-10050	85.0	0.0282	0.0212	0.0070	N.D.	N.D.	N.D.	N.D.	N.D.
998-036D	10100-10203	100.0	0.0470	0.0370	0.0100	N.D.	0.0041	0.0012	0.0023	0.0024
998-038D	10400-10480	65.0	0.0451	0.0245	0.0206	N.D.	0.0063	0.0027	0.0025	0.0091
998-042D	11020-11100	95.0	0.0425	0.0195	0.0230	N.D.	0.0132	0.0053	0.0038	0.0007

Table IV (Continued)

B. Concentration of Extracted Materials in Rock

			Hydrocarbons				Nonhydrocarbons			
GeoChem Sample Number	Well Interval *	Total Extract (ppm)	Paraffin-Naphthene (ppm)	Aromatic (ppm)	Total (ppm)	Sulfur (ppm)	Preciptd. Asphaltene (ppm)	Eluted NSO'S (ppm)	Noneluted NSO'S (ppm)	Total (ppm)
998-004D	5200- 5330	542	99	50	149	-	366	24	3	393
998-006D	5500- 5680	339	63	31	94	-	199	29	17	245
998-009D	5900- 5970	319	82	36	118	-	185	16	0	201
998-011D	6340- 6400	224	-	-	-	-	161	-	-	-
998-019D	7550- 7640	364	79	27	106	-	220	22	16	258
998-021D	7850- 7910	583	188	61	249	-	269	45	19	334
998-023D	8150- 8230	654	187	59	246	-	337	44	26	407
998-024D	8310- 8380	1305	531	226	756	-	485	64	0	548
998-026D	8600- 8670	426	40	15	55	-	303	20	48	371
998-027D	8740- 8840	503	74	24	98	-	359	25	21	405
998-029D	9050- 9130	592	138	48	186	-	343	39	24	406
998-033D	9640- 9700	262	-	-	-	-	183	-	-	-
998-035D	9950-10050	332	-	-	-	-	249	-	-	-
998-036D	10100-10203	470	41	12	53	-	370	23	24	417
998-038D	10400-10480	694	97	42	138	-	377	38	140	555
998-042D	11020-11100	447	139	56	195	-	205	40	7	253

Table IV (Continued)

C. Composition of Extracts

		Hydrocarbons				Nonhydrocarbons					
GeoChem Sample Number	Well Interval*	Paraffin-Naphthene %	Aromatic %	PN/Arom	Sulfur %	Eluted NSO'S %	Noneluted NSO'S %	Precipitd. Asphaltene %	Asph/NSO	HC'S %	HC/Non HC
998-004D	5200- 5330	18.2	9.2	1.98	-	4.5	0.6	67.4	13.16	27.5	0.38
998-006D	5500- 5680	18.6	9.0	2.07	-	8.7	5.0	58.7	4.30	27.6	0.38
998-009D	5900- 5970	25.7	11.3	2.28	-	5.0	0.0	58.0	11.56	37.0	0.59
998-011D	6340- 6400	-	-	-	-	-	-	72.0	-	-	-
998-019D	7550- 7640	21.7	7.4	2.93	-	6.0	4.4	60.4	5.79	29.1	0.41
998-021D	7850- 7910	32.3	10.5	3.09	-	7.8	3.2	46.2	4.20	42.8	0.75
998-023D	8150- 8230	28.7	9.0	3.18	-	6.8	4.0	51.5	4.78	37.7	0.60
998-024D	8310- 8380	40.7	17.3	2.35	-	4.9	0.0	37.2	7.63	58.0	1.38
998-026D	8600- 8670	9.4	3.5	2.67	-	4.7	11.3	71.1	4.46	12.9	0.15
998-027D	8740- 8840	14.7	4.7	3.11	-	5.0	4.2	71.4	7.76	19.4	0.24
998-029D	9050- 9130	23.3	8.1	2.88	-	6.6	4.1	57.9	5.44	31.4	0.46
998-033D	9640- 9700	-	-	-	-	-	-	69.8	-	-	-
998-035D	9950-10050	-	-	-	-	-	-	75.2	-	-	-
998-036D	10100-10203	8.7	2.6	3.42	-	4.9	5.1	78.7	7.87	11.3	0.13
998-038D	10400-10480	14.0	6.0	2.33	-	5.5	20.2	54.3	2.11	20.0	0.25
998-042D	11020-11100	31.1	12.5	2.49	-	8.9	1.6	45.9	4.33	43.5	0.77

* In feet.

Note: ppm values are expressed on a weight/weight basis.

Table V-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
998-004D	5200- 5330	9.5	1.6	88.9	1.09	1.28	0.82
998-006D	5500- 5680	9.9	0.8	89.3	1.06	1.19	0.54
998-009D	5900- 5970	12.7	1.0	86.2	1.06	1.14	0.74
998-011D	6340- 6400	10.4	0.9	88.8	1.05	1.16	0.57
998-019D	7550- 7640	14.0	3.8	82.2	1.14	1.56	0.60
998-021D	7850- 7910	17.1	5.0	77.9	1.19	-	0.78
998-023D	8150- 8230	17.1	4.3	78.6	1.22	-	0.61
998-024D	8310- 8380	2.7	0.4	96.9	1.24	1.44	0.71
998-026D	8600- 8670	9.1	1.0	89.9	1.09	1.26	0.32
998-027D	8740- 8840	6.4	1.7	91.9	1.14	1.44	0.76
998-029D	9050- 9130	19.4	3.2	77.3	1.06	1.09	1.08
998-033D	9640- 9700	9.0	1.5	89.5	1.09	-	0.54
998-035D	9950-10050	8.4	1.9	89.7	1.13	-	0.69
998-036D	10100-10203	11.2	2.0	86.9	1.08	-	0.53
998-038D	10400-10480	5.9	0.7	93.4	1.03	-	0.42
998-042D	11020-11100	5.1	1.0	94.0	1.33	1.69	0.70

Table V-B

Saturate Hydrocarbon Analyses

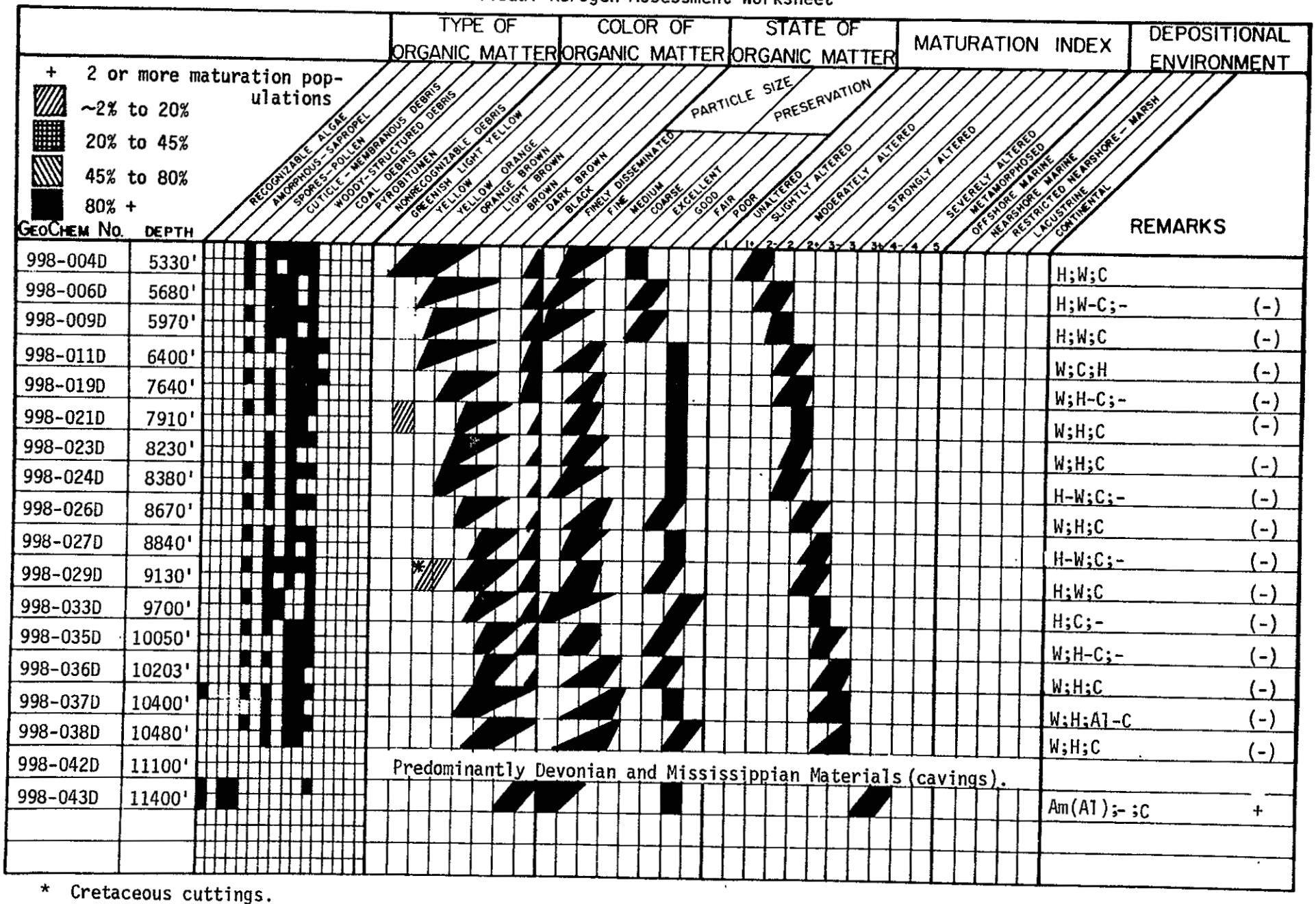
Normalized Paraffin Distribution

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
998-004D	5200- 5330	0.1	1.3	7.6	6.3	14.1	7.8	15.5	12.1	9.4	7.9	6.2	4.0	3.2	1.8	1.0	0.5	0.4	0.3	0.3	0.1	0.0	0.0	0.0
998-006D	5500- 5680	0.1	0.3	2.8	2.5	9.1	4.6	14.0	15.0	13.2	11.9	9.3	6.1	4.5	2.6	1.5	0.8	0.5	0.4	0.4	0.3	0.0	0.0	0.0
998-009D	5900- 5970	0.1	1.0	4.7	3.2	9.3	4.3	12.0	12.8	11.8	11.0	9.1	6.3	5.2	3.3	2.0	1.4	1.0	0.7	0.5	0.3	0.0	0.0	0.0
998-011D	6340- 6400	0.1	0.4	3.3	2.8	8.2	4.9	11.7	12.6	11.7	11.3	9.7	6.9	5.7	3.7	2.3	1.5	1.2	0.9	0.8	0.3	0.0	0.0	0.0
998-019D	7550- 7640	0.1	1.3	7.5	8.0	14.6	13.3	16.3	14.0	8.9	6.9	4.4	1.7	1.4	0.4	0.3	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0
998-021D	7850- 7910	0.4	3.2	8.9	9.9	13.6	12.8	15.2	14.2	9.8	6.6	3.6	1.0	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
998-023D	8150- 8230	0.1	1.8	7.2	7.6	13.6	12.4	16.6	15.8	11.4	7.7	4.1	0.8	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
998-024D	8310- 8380	0.4	2.1	6.0	5.1	10.3	7.3	10.5	10.1	7.5	7.3	7.5	3.6	5.8	3.4	4.3	3.0	0.9	0.6	2.4	1.1	0.4	0.2	0.2
998-026D	8600- 8670	0.1	0.2	2.9	2.4	9.3	7.3	13.4	14.8	13.3	12.2	9.6	5.5	3.9	2.1	1.1	0.5	0.4	0.2	0.4	0.2	0.0	0.0	0.0
998-027D	8740- 8840	0.1	2.7	8.5	8.8	13.3	11.7	13.5	11.7	7.8	7.0	5.3	2.3	2.2	1.2	1.4	0.5	0.4	0.4	0.5	0.4	0.3	0.0	0.0
998-029D	9050- 9130	0.9	4.8	10.5	7.4	13.1	6.9	12.3	10.7	9.0	7.6	6.0	3.9	2.7	1.8	1.0	0.5	0.3	0.3	0.2	0.1	0.0	0.0	0.0
998-033D	9640- 9700	0.1	1.1	7.4	5.1	16.6	9.5	17.4	13.7	9.6	7.9	5.5	2.9	2.0	0.8	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
998-035D	9950-10050	0.1	2.2	9.3	7.4	15.1	10.8	15.3	12.1	9.5	7.6	5.1	2.4	1.5	0.6	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0
998-036D	10100-10203	0.1	1.2	5.3	5.2	12.6	9.8	15.8	14.2	10.9	9.0	6.9	4.0	2.4	1.2	0.5	0.3	0.3	0.1	0.1	0.0	0.0	0.0	0.0
998-038D	10400-10480	0.2	0.3	2.2	3.1	8.0	7.4	13.8	16.1	13.7	12.5	8.9	5.6	3.1	2.1	1.4	0.3	0.5	0.5	0.3	0.0	0.0	0.0	0.0
998-042D	11020-11100	0.8	3.0	7.5	6.6	11.9	9.5	14.3	13.3	9.7	7.1	5.2	1.8	2.2	1.4	2.9	0.8	0.3	0.4	0.7	0.4	0.1	0.0	0.0

* In feet.

Table VI

Visual Kerogen Assessment Worksheet



GeoChem No.	Depth	Remarks	
998-004D	5330'	H;W;C	
998-006D	5680'	H;W-C;-	(-)
998-009D	5970'	H;W;C	(-)
998-011D	6400'	W;C;H	(-)
998-019D	7640'	W;H-C;-	(-)
998-021D	7910'	W;H;C	(-)
998-023D	8230'	W;H;C	(-)
998-024D	8380'	H-W;C;-	(-)
998-026D	8670'	W;H;C	(-)
998-027D	8840'	H-W;C;-	(-)
998-029D	9130'	H;W;C	(-)
998-033D	9700'	H;C;-	(-)
998-035D	10050'	W;H-C;-	(-)
998-036D	10203'	W;H;C	(-)
998-037D	10400'	W;H;Al-C	(-)
998-038D	10480'	W;H;C	(-)
998-042D	11100'		
998-043D	11400'	Am(Al);-;C	+

* Cretaceous cuttings.

\+ Relictamorphous (algal) and fluffy amorphous.

Table VII
Vitrinite Reflectance Summary

GeoChem Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Reflectance (% Ro)
998-011D	6340'-6400'	**	-	-	-
998-024D	8310'-8380'	**	-	-	-
998-027D	8740'-8840'	12	1.48	2.06	1.83
998-029D	9050'-9130'	10	1.67	2.68	2.06
998-035D	9950'-10050'	29	1.87	3.79	2.97
998-037	10360'-10400'	7	1.49	2.82	2.19

** Insufficient kerogen return for plug.

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 well-site 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 C_1-C_7 hydrocarbon data from the air space and cuttings gas analyses are summed to give a "resotred" 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 hydrocarbons 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 eluents.

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.