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HYDROCARBON SOURCE ROCK EVALUATION OF J. D. HANCOCK, NO. 1 SEDBERRY, SEC. 25, T17N, R16E, SAN MIGUEL COUNTY, NEW MEXICO

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

July 1987

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION PROJECT

J. D. HANCOCK, NO.1 SEDBERRY
SEC.25, T17N, R16E, SAN MIGUEL CO., NEW MEXICO
API NO. 30-047-20003
NORTHEAST AREA
GEOCHEM JOB NO. 3550

Prepared

for

PROGRAM PARTICIPANTS

by

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CONFIDENTIAL
JULY, 1987

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

WELL NAME: J. D. HANCOCK, NO.1 SEDBERRY
API NO.: 30-047-20003
AREA: NORTHEAST
LOCATION: SAN MIGUEL COUNTY, NEW MEXICO SEC.25, T17N, R16E
GEOCHEM JOB NO.: 3550
TOTAL DEPTH: 5135 ft.
INTERVAL SAMPLED: 500-5130 ft.
TOTAL NUMBER OF SAMPLES: 14

GEOCHEM SAMPLE NUMBER	SAMPLE DEPTH	STRATIGRAPHIC INTERVAL	ANALYSES				
			LITHO	TOC	ROCK-EVAL	KEROGEN	OTHER
3550-001	500- 540	Morrison	X	X	X	X	
3550-002	780- 820	Morrison	X	X	X	X	
3550-003	1100-1150	Chinle	X	X	X	X	
3550-004	1780-1840	Chinle	X	X	X	X	
3550-005	1840-1880	Chinle	X	X	X	X	
3550-006	2300-2350	Glorieta/San Andres	X	X	X	X	
3550-007	2650-2700	Yeso	X	X	X	X	
3550-008	3200-3250	Abo	X	X	X	X	
3550-009	3510-3550	Abo	X	X	X	X	
3550-010	3890-3920	Pennsylvanian	X	X	X	X	
3550-011	3970-4020	Pennsylvanian	X	X	X	X	
3550-012	4240-4280	Pennsylvanian	X	X	X	X	
3550-013	4600-4650	Pennsylvanian	X	X	X	X	
3550-014	5080-5130	Pennsylvanian	X	X	X	X	

HANCOCK #1 SEDBERRY
JOB NUMBER 3550

SUMMARY FIGURE 1

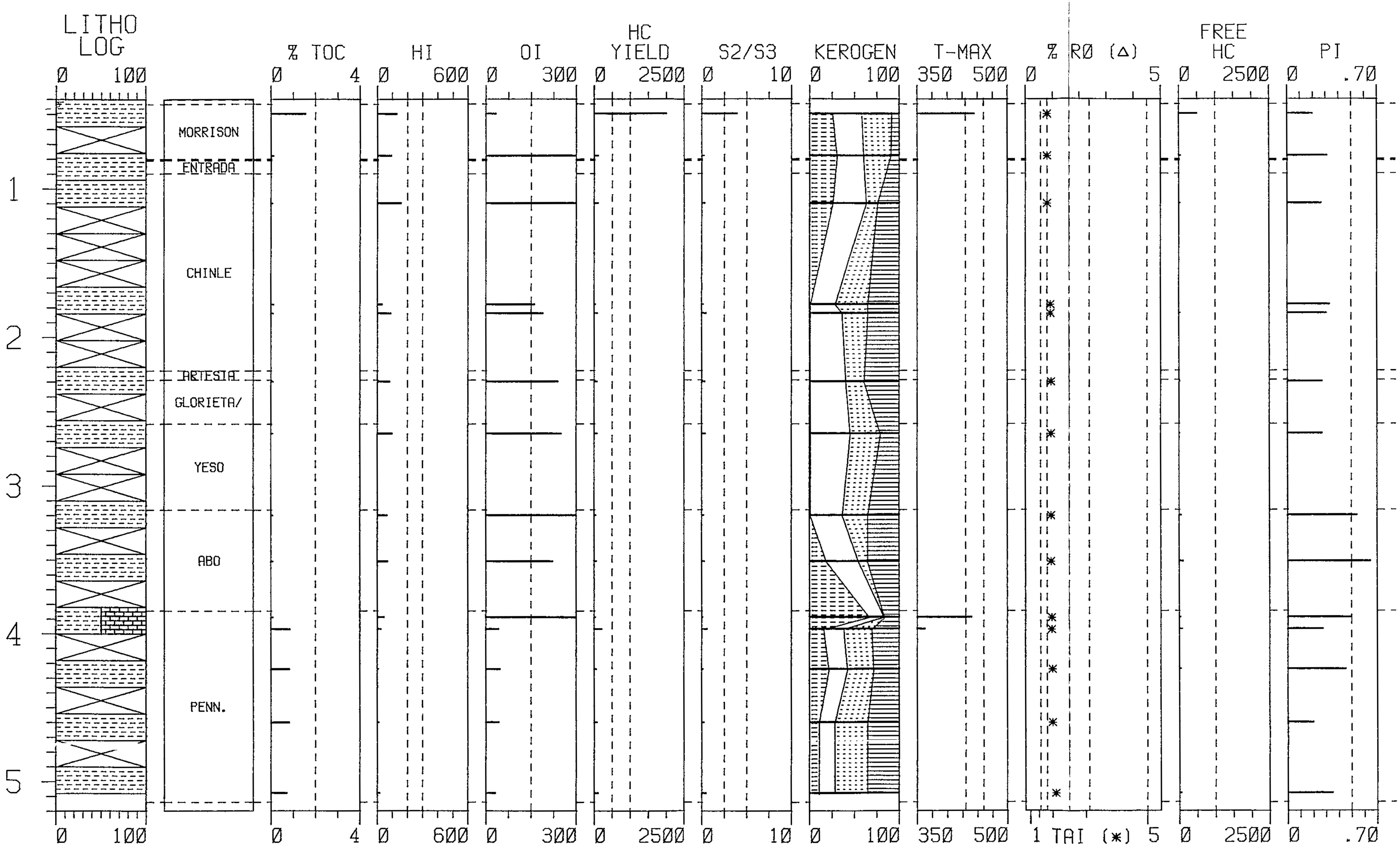

TABLE I

RESULTS OF TOTAL ORGANIC CARBON

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

J. D. HANCOCK, NO.1 SEDBERRY
SEC.25, T17N, R16E, SAN MIGUEL COUNTY, NEW MEXICO
API #30-047-20003

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	TOTAL ORGANIC CARBON (% of Rock)
3550-001	500- 540	1.56
3550-002	780- 820	0.12
3550-003	1100-1150	0.07
3550-004	1780-1840	0.13/0.12
3550-005	1840-1880	0.10
3550-006	2300-2350	0.10
3550-007	2650-2700	0.08
3550-008	3200-3250	0.08
3550-009	3510-3550	0.09
3550-010	3890-3920	0.09
3550-011	3970-4020	0.86
3550-012	4240-4280	0.83
3550-013	4600-4650	0.82
3550-014	5080-5130	0.72/0.72

TABLE II

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

J. D. HANCOCK, NO.1 SEDBERRY
SEC.25, T17N, R16E, SAN MIGUEL COUNTY, NEW MEXICO
API #30-047-20003

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3550-001	500- 540			1.56
-A		100% Shale, calcareous, medium dark gray.	N4	
3550-002	780- 820			0.12
-A		100% Shale, silty, noncalcareous, grayish red.	10R-4/2	
3550-003	1100-1150			0.07
-A		100% Shale, silty, calcareous, grayish red to dark reddish brown.	10YR-4/2 to 10R-3/4	
3550-004	1780-1840			0.13/0.12
-A		100% Shale, silty, slightly calcareous, variegated dark reddish brown to grayish green.	10R-3/4 to 10GY-5/2	
3550-005	1840-1880			0.10
-A		100% Shale, silty, calcareous, grayish red to dark reddish brown.	10YR-4/2 to 10R-3/4	
3550-006	2300-2350			0.10
-A		100% Shale, silty, non-calcareous, grayish red to dark reddish brown.	10YR-4/2 to 10R-3/4	
3550-007	2650-2700			0.08
-A		100% Shale, silty, non-calcareous, grayish red to dark reddish brown.	10YR-4/2 to 10R-3/4	

TABLE II (continued)

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

J. D. HANCOCK, NO.1 SEDBERRY
SEC.25, T17N, R16E, SAN MIGUEL COUNTY, NEW MEXICO
API #30-047-20003

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3550-008	3200-3250			0.08
-A		100% Shale, silty, non-calcareous, grayish red to dark reddish brown.	10YR-4/2 to 10R-3/4	
3550-009	3510-3550			0.09
-A		100% Shale, silty, non-calcareous, grayish red to dark reddish brown.	10YR-4/2 to 10R-3/4	
3550-010	3890-3920			0.09
-A		100% Limestone, finely crystalline, medium gray to brownish gray.	N5 to 5YR-4/1	
3550-011	3970-4020			0.86
-A		100% Shale, micaceous, slightly, calcareous, grayish black.	N2	
3550-012	4240-4280			0.83
-A		100% Shale, micaceous, slightly, calcareous, grayish black.	N2	
3550-013	4600-4650			0.82
-A		100% Shale, micaceous, slightly, calcareous, grayish black.	N2	
3550-014	5080-5130			0.72/0.72
-A		100% Shale, micaceous, slightly, calcareous, grayish black.	N2	

TABLE III

SUMMARY OF ORGANIC CARBON AND VISUAL KEROGEN DATA

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

J. D. HANCOCK, NO.1 SEDBERRY
SEC.25, T17N, R16E, SAN MIGUEL COUNTY, NEW MEXICO
API #30-047-20003

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		
3550-001	500- 540	1.56	H-W;Am;I	0	25	33	33	9	2 to 2+	2.5
3550-002	780- 820	0.12	Am-H;W;I	0	33	33	23	11	2 to 2+	2.5
3550-003	1100-1150	0.07	H;Am-I;W	0	25	38	12	25	2 to 2+	2.5
3550-004	1780-1840	0.13/0.12	W-I;H;-	0	0	28	36	36	2+ to 3-	2.7
3550-005	1840-1880	0.10	H-I;W;-	0	0	36	28	36	2+ to 3-	2.7
3550-006	2300-2350	0.10	H-I;W;-	0	0	40	20	40	2+ to 3-	2.8
3550-007	2650-2700	0.08	H;I;W	0	0	45	33	22	2+ to 3-	2.8
3550-008	3200-3250	0.08	H-I;W;-	0	0	36	28	36	2+ to 3-	2.8
3550-009	3510-3550	0.09	H-I;Am;W	0	18	36	10	36	2+ to 3-	2.8
3550-010	3890-3920	0.09	Am;-;H-I	0	66	17	0	17	2+ to 3-	2.9
3550-011	3970-4020	0.86	W-I;H;Am	0	15	23	31	31	2+ to 3-	2.9
3550-012	4240-4280	0.83	W-I;Am-H;-	0	21	21	29	29	3-	3.0
3550-013	4600-4650	0.82	W-I;H;Am	0	10	18	36	36	3-	3.0
3550-014	5080-5130	0.72/0.72	W-I;H;Am	0	10	18	36	36	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

J. D. HANCOCK, NO.1 SEDBERRY
SEC.25, T17N, R16E, SAN MIGUEL COUNTY, NEW MEXICO
API #30-047-20003

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
3550-001	500- 540	445	0.50	2.00	0.51	0.20	0.20	1.56	128	32
3550-002	780- 820	324	0.05	0.11	0.51	0.31	0.01	0.12	91	425
3550-003	1100-1150	332	0.04	0.11	0.34	0.29	0.01	0.07	157	485
3550-004	1780-1840	253	0.02	0.04	0.21	0.33	0.00	0.13	30	161
3550-005	1840-1880	275	0.04	0.09	0.19	0.33	0.01	0.10	90	190
3550-006	2300-2350	275	0.03	0.08	0.24	0.30	0.00	0.10	80	240
3550-007	2650-2700	283	0.03	0.08	0.20	0.30	0.00	0.08	100	250
3550-008	3200-3250	271	0.06	0.05	0.24	0.60	0.00	0.08	62	300
3550-009	3510-3550	272	0.11	0.06	0.20	0.69	0.01	0.09	66	222
3550-010	3890-3920	440	0.04	0.04	0.35	0.50	0.00	0.09	44	388
3550-011	3970-4020	363	0.08	0.21	0.36	0.29	0.02	0.86	24	41
3550-012	4240-4280	328	0.05	0.06	0.40	0.50	0.00	0.83	7	48
3550-013	4600-4650	326	0.02	0.08	0.36	0.20	0.00	0.82	9	43
3550-014	5080-5130	321	0.06	0.11	0.23	0.37	0.01	0.72	15	31

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

J. D. HANCOCK
NO.1 SEDBERRY
SEC.25, T17N, R16E
SAN MIGUEL COUNTY, NEW MEXICO
API #30-047-20003

GEOCHEM No.	DEPTH	SUMMARY ORGANIC MATTER TYPE
3550-001	500- 540	H-W;Am;I
3550-002	780- 820	Am-H;W;I
3550-003	1100-1150	H;Am-I;W
3550-004	1780-1840	W-I;H;-
3550-005	1840-1880	H-I;W;-
3550-006	2300-2350	H-I;W;-
3550-007	2650-2700	H;I;W
3550-008	3200-3250	H-I;W;-
3550-009	3510-3550	H-I;Am;W
3550-010	3890-3920	Am;-;H-I
3550-011	3970-4020	W-I;H;Am
3550-012	4240-4280	W-I;Am-H;-
3550-013	4600-4650	W-I;H;Am
3550-014	5080-5130	W-I;H;Am

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:

$$\text{C.P. Index A} = \frac{\frac{C_{21}+C_{23}+C_{25}+C_{27}}{C_{22}+C_{24}+C_{26}+C_{28}} + \frac{C_{21}+C_{23}+C_{25}+C_{27}}{C_{20}+C_{22}+C_{24}+C_{26}}}{2} \qquad \text{C.P. Index B} = \frac{\frac{C_{25}+C_{27}+C_{29}+C_{31}}{C_{26}+C_{28}+C_{30}+C_{32}} + \frac{C_{25}+C_{27}+C_{29}+C_{31}}{C_{24}+C_{26}+C_{28}+C_{30}}}{2}$$

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 Ziess 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.)