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HYDROCARBON SOURCE ROCK EVALUATION OF
CONTINENTAL OIL COMPANY NO. 1 MAXWELL LAND GRANT,
SEC. 11, T28N, R22E, COLFAX COUNTY, NEW MEXICO

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

June 1987

NEW MEXICO HYDROCARBON SOURCE
ROCK EVALUATION PROJECT

CONTINENTAL OIL COMPANY, NO.1 MAXWELL LAND GRANT
SEC. 11, T28N, R22E, COLFAX COUNTY, NEW MEXICO
API NO. 30-007-05015
NORTHEAST AREA
GEOCHEM JOB NO. 3532

Prepared

for

PROGRAM PARTICIPANTS

by

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CONFIDENTIAL
JUNE, 1987

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

WELL NAME: CONTINENTAL OIL COMPANY, NO.1 MAXWELL LAND GFANT
 API NO.: 30-007-05015
 AREA: NORTHEAST
 LOCATION: COLFAX COUNTY, NEW MEXICO SEC. 11, T28N, R22E
 GEOCHEM JOB NO.: 3532
 TOTAL DEPTH: 2947 ft.
 INTERVAL SAMPLED: 370-2560 ft.
 TOTAL NUMBER OF SAMPLES: 9

GEOCHEM SAMPLE NUMBER	SAMPLE DEPTH	STRATIGRAPHIC INTERVAL	ANALYSES				
			LITHO	TOC	ROCK-EVAL	KEROGEN	OTHER
3532-001	370-410	Pierre	X	X	X	X	
3532-002	800-830	Pierre	X	X	X	X	
3532-003	1200-1240	Pierre	X	X	X	X	
3532-004	1500-1540	Carlile	X	X	X	X	
3532-005	1620-1660	Graneros	X	X	X	X	
3532-006	1950-1990	Morrison	X	X	X	X	
3532-007	2270-2300	Todilto	X	X			
3532-008	2490-2520	Chinle	X	X			
3532-009	2520-2560	Chinle	X	X			

TABLE I

RESULTS OF TOTAL ORGANIC CARBON

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

CONTINENTAL OIL CO., NO.1 MAXWELL LAND GRANT
SEC.11, T28N, R22E, COLFAX COUNTY, NEW MEXICO
API #30-007-05015

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	TOTAL ORGANIC CARBON (% of Rock)
3532-001	370-410	1.67
3532-002	800-830	2.03
3532-003	1200-1240	1.24
3532-004	1500-1540	1.61
3532-005	1620-1660	1.28
3532-006	1950-1990	1.49
3532-007	2270-2300	0.15
3532-008	2490-2520	0.11
3532-009	2520-2560	0.08/0.07

TABLE II

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

CONTINENTAL OIL CO., NO.1 MAXWELL LAND GRANT
 SEC.11 T28N, R22E, COLFAX COUNTY, NEW MEXICO
 API #30-007-05015

GEOCHEM SAMPLE NUMBER	DEPTH INTERVAL (feet)	LITHO DESCRIPTION	GSA NO.	ORGANIC CARBON (wt.%)
3532-001 -A	370-410	100% Shale, calcareous, dark gray.	N3	1.64
3532-002 -A	800-830	100% Shale, calcareous, dark gray.	N3	2.03
3532-003 -A	1200-1240	100% Shale, calcareous, dark gray.	N3	1.24
3532-004 -A	1500-1540	100% Shale, dark gray.	N3	1.61
3532-005 -A	1620-1660	100% Shale, very calcareous, dark gray.	N3	1.28
3532-006 -A	1950-1990	100% Shale, very calcareous, dark gray.	N3	1.49
3532-007 -A	2270-2300	100% Limestone, crystalline, greenish gray.	5GY-6/1	0.15
3532-008 -A	2490-2520	100% Limestone, crystalline, light brownish gray to greenish gray.	5YR-6/1 to 5GY-6/1	0.11
3532-009 -A	2520-2560	100% Mudstone, micaceous, grayish red.	5R-4/2	0.08/0.07

TABLE III

SUMMARY OF ORGANIC CARBON AND VISUAL KEROGEN DATA

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

CONTINENTAL OIL COMPANY, NO.3 MAXWELL LAND GRANT
SEC.11, T28N, R22E, COLFAX COUNTY, NEW MEXICO
API #30-007-05015

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		
3532-001	370-410	1.59/1.71	H;W-I;Am	0	16	38	23	23	2- to <u>2</u>	2.1
3532-002	800-830	1.67	Am-H*; -;W	0	44	44	12	0	2	2.2
3532-003	1200-1240	2.03	H;Am;W-I	0	27	33	20	20	<u>2</u> to 2+	2.3
3532-004	1500-1540	1.24	H;I;W(Am)	0	15	36	21	28	<u>2</u> to 2+	2.3
3532-005	1620-1660	1.61	Am;H-W;I	0	36	27	27	10	<u>2</u> to 2+	2.3
3532-006	1950-1990	1.28	H-I;Am;W	0	23	31	15	31	<u>2</u> to 2+	2.3
3532-007	2270-2300	0.15	NOT ANALYZED							
3532-008	2490-2520	0.11	NOT ANALYZED							
3532-009	2520-2560	0.08/0.07	NOT ANALYZED							

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

CONTINENTAL OIL CO., NO.1 MAXWELL LAND GRANT
SEC.11, T28N, R22E, COLFAX COUNTY, NEW MEXICO
API #30-007-05015

GEOCHEM SAMPLE NUMBER	CLIENT IDENTIFICATION	TMAX (c)	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	PI	PC*	T.O.C. (wt.%)	HYDROGEN INDEX	OXYGEN INDEX
3532-001	370-410	441	0.53	2.40	0.85	0.18	0.24	1.67	143	50
3532-002	800-830	445	0.89	1.62	1.27	0.36	0.20	2.03	79	62
3532-003	1200-1240	443	0.43	1.60	0.74	0.21	0.16	1.24	129	59
3532-004	1500-1540	441	0.58	2.41	0.90	0.19	0.24	1.61	149	55
3532-005	1620-1660	442	0.55	2.55	1.21	0.18	0.25	1.28	199	94
3532-006	1950-1990	443	0.60	2.15	0.88	0.22	0.22	1.49	144	59
3532-007	NOT ANALYZED									
3532-008	NOT ANALYZED									
3532-009	NOT ANALYZED									

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



















CONTINENTAL OIL CO., NO. 1 MAXWELL LAND GRANT SEC. 11-28N-22E COLFAX CO., NEW MEXICO API #30-007-05015 T.D. 2947 ft.		INDIGENOUS POPULATION (INTERPRETED)					GENERAL CHARACTERISTICS					CAVED AND/OR REWORKED POPULATION(S)					SUMMARY ORGANIC MATTER TYPE		
		TYPE OF ORGANIC MATTER		MATURATION INDEX			COLOR OF ORGANIC MATTER		STATE OF ORGANIC MATTER			%		TYPE OF ORGANIC MATTER		MATURATION INDEX			
		1	2	1	2	3	1	2	1	2	3	1	2	1	2	3		4	5
GEOCHEM No.	DEPTH	1	2	3	4	5	REMARKS	1	2	3	4	5	1	2	3	4	5	REMARKS	
3532-001	370-410																		H;W-I;Am
3532-002	800-830																		Am-H*;--;W
3532-003	1200-1240																		H;Am;W-I
3532-004	1500-1540																		H;I;W(Am)
3532-005	1620-1660																		Am;H-W;I
3532-006	1950-1990																		H-I;Am;W
3532-007	n.a.																		
3532-008	n.a.																		
3532-009	n.a.																		

n.a. = NOT ANALYZED





LEGEND FOR SUMMARY DIAGRAM

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

LITHOLOGIES

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

KEROGEN TYPES

	AMORPHOUS
	HERBACEOUS
	WOODY
	INERTINITE

APPENDIX A

Brief Description of Organic Geochemical analyses Carried Out by GeoChem

C₁-C₇ Hydrocarbon

The C₁-C₇ hydrocarbon content and composition of sediments reflects source type, source quality and thermal maturity.

The C₁-C₇ 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 C₁-C₇ 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 C₁-C₇ 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 C₁ (methane), C₂ (ethane), C₃ (propane), iC₄ (isobutane), nC₄ (normal butane), and C₅, C₆, C₇ hydrocarbon components.

This particular analysis gives a complete separation of the C₁-C₄ gas-range hydrocarbons and a partial separation of the C₅-C₇ gasoline-range hydrocarbons. (A detailed C₄-C₇ 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 C₁-C₇ 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 C₁, C₂, C₃, etc. determined by gc analysis of a standard gas sample, and the gc peak response.

The C₁-C₇ 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 C₁-C₇ hydrocarbon data from the air space and cuttings gas analyses are summed to give a "restored" C₁-C₇ 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 C₁-C₇ 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 C₄-C₇ hydrocarbon analyses. This sample set is used not only for the C₄-C₇ 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 C₁₅₊ soxhlet extraction and/or eventual return to the client. Sample material from this study will be retained at GeoChem until advised of disposition.

Detailed C₄-C₇ Hydrocarbon

The C₄-C₇ 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 C₄-C₇ 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 C₁-C₇ 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 C₁-C₄, C₄-C₇ and C₁₅₊ 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.

C₁₅₊ Soxhlet Extraction, Deasphalting 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. C¹³/C¹² 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 C₁₅₊ paraffin-naphthene (P-N) hydrocarbon, C₁₅₊ aromatic hydrocarbon (AROM) and C₁₅₊ 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 C₁₅₊ Paraffin-Naphthene (P-N) Hydrocarbons

The content and molecular composition of the heavy C₁₅₊ 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:

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

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

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 reservoir 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 bleaches 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 (%R₀) 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 (1) a crude oil or (2) the solvent extractable rock bitumen, is passed through an alumina silica gel micro column and the C₁₀₊ 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.

GEOHERMAL DIAGENETIC CRITERIA

(GEOCHEM LABORATORIES, INC.)

