New Mexico Bureau of Mines and Mineral Resources
Open-File Report No. OF-263

ORGANIC GEOCHEMICAL ANALYSES OF THE GULF OIL CO. NO. 1 CHAVES-STATE U WELL (CHAVES COUNTY), MARATHON OIL CO. NO. 1 MESA VERDE RANCH WELL (OTERO COUNTY), SOUTHERN PRODUCTION CO. NO. 1 CLOUDCROFT UNIT WELL (OTERO COUNTY), AND OUTCROP SAMPLES FROM THE SACRAMENTO MOUNTAINS, NEW MEXICO

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May 25, 1984

WHITING

May 25, 1984

So. Production #1 Cloudcroft 5-17S-12E Otero Co.
Marathon #1 Mesa Verde Ranch 35-18S-14E Otero Co.
Gulf #1 Chaves State 26 10-18S-16E Chaves Co.

Samples for the study consisted of cuttings and core from the Southern Production Co. #1 Cloudcroft well and cuttings from the Marathon Oil Co. #1 Mesa Verde Ranch and Gulf Oil Co. #1 Chaves State wells. In addition, outcrop samples from Alamo, Fresnal and La Luz canyons along the Sacramento Mountains escarpment were collected. The initial sample set consisted of over 300 samples and was somewhat weighted toward rocks of Late Ordovician through Devonian and Early Pennsylvanian age. These samples were initially screened by hydrochloric acid and cut fluorescence tests to determine those likely to have significant quantities of hydrocarbons. Ultimately, 34 samples were submitted to Jacobsen Consulting of Littleton, Colorado for analysis. Conodont analysis was subcontracted to Dr. Walt Sweet of Ohio State University. The results of these studies are enclosed with this letter.

Because of the limited number of samples analyzed, statistical correlations were not possible; however, the following observations can be made when considered in context of the sample set:

1) Lower Pennsylvanian rocks of the Gobbler and Beeman formations appear to have good source potential with 5 of 9 samples having T.O.C >.5% and 2 of 9 having T.O.C. >1.0%. Due to possible contamination, pyrolysis results could not establish the nature (free or residual) of these hydrocarbons.

WHITING PETROLEUM CORPORATION
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2) Of 14 total samples analyzed from the #1 Chaves State and #1 Cloudcroft wells only one sample had a T.O.C. >.5% (sample #8 from the Gobbler formation of the #1 Cloudcroft well). By contrast, the #1 Mesa Verde Ranch well cuttings had significantly higher T.O.C.'s with 7 of 11 samples having T.O.C. >.5% and 4 of 11 samples having T.O.C. >1.0%. The same trend was qualitatively observed when examining the cut fluorescence during the initial screening.

3) The thermal maturity of Pennsylvanian and Permian potential source rocks was estimated by kerogen color alteration in palynomorphs of the #1 Mesa Verde Ranch well. T.A.I. values from the Beeman and Gobbler formations were slightly less than 3 (i.e. late oil to early wet gas phase). No palynomorphs were observed in samples from Permian rocks.

4) Samples from Alamo Canyon in the Sacramento Mountains escarpment were used to obtain sufficient quantities of rock for conodont extraction and analysis. C.A.I. values for these rocks (age Late Ordivician through Mississippian) are between 3 and 4. This corresponds to a thermal maturity within the dry gas generative range. A decrease in thermal maturity with age was also noted but remains unexplained.

5) Interpretation of hydrocarbons generated during pyrolysis revealed the possible presence of contaminants in certain samples from the #1 Mesa Verde Ranch well. A review of the mud constituents used at depths corresponding to those of potentially contaminated samples revealed no petroleum based additives used in the mud.

I hope these results may be of use to your company should you decide to further evaluate the area.

Sincerely,

Mark R Williams

MRW:tsw
Enclosure

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May 13, 1984

ORGANIC CARBON, MATURITY AND AGE ANALYSIS OF ROCKS FROM THE SACRAMENTO MOUNTAINS AREA, OTERO COUNTY, NEW MEXICO

REQUEST: Total Organic Carbon (T.O.C.) for 28 samples; Rock-Eval pyrolysis for 6 samples; age and thermal maturation for 7 samples using conodonts and/or palynomorphs; thermal maturation for 4 samples using palynomorphs.

SAMPLES: Thirty-four (34) samples were provided from six localities from the Sacramento Mountains area, Otero County, New Mexico. These include outcrop, well cuttings and core samples as listed below:

Outcrop samples.

For conodonts:

La Luz Canyon	b 2.5	84012-1
Alamo Canyon	d 3.2	84012-2 (and acritarchs)
	f 2.7	84012-3
	g 3.1	84012-4
	i 3.2	84012-5

For T.O.C. and Rock-Eval pyrolysis:

Fresnal Canyon	a 1.3	84012-33

Well cuttings and core samples.

For T.O.C.:

Southern Production Co. Cloudcroft #1
35-17S-12E

2400'	84012-6
2450'	84012-7
3130'	84012-8
3150'	84012-9
3450'	84012-10
3470'	84012-11
3500'	84012-12
4154'	84012-13
4400'	84012-14

Marathon Oil Co. Mesa Verde Ranch #1
35-18S-14E

1448'	84012-15
2011'	84012-16
5395'	84012-17

	5600'	84012-18
	5806'	84012-19
	5900'	84012-20
	6031'	84012-21
	6118'	84012-22
Gulf Oil Co. Chaves State #1	1896'	84012-23
	2287'	84012-24
	2670'	84012-25
	2685'	84012-26
	2825'	84012-27

For T.O.C., Rock-Eval pyrolysis, and T.A.I.:

Marathon Oil Co. Mesa Verde Ranch #1		
	1482'	84012-28
	3530'	84012-29
	3810'	84012-30
	4519'	84012-31
Southern Production Co. Cloudcroft #1		
	3565'	84012-32

For acritarchs:

Southern Production Co. Cloudcroft #1		
	3894'	84012-34

RESULTS AND DISCUSSION:

Total Organic Carbon (T.O.C.) values are listed in Table 1. Table 2 gives results of Rock-Eval pyrolysis for 6 samples; the pyrograms are also included. Interpretations for T.O.C. and Rock-Eval pyrolysis for the 6 samples analysed are given below, followed by notes on T.O.C., thermal maturation and age determinations.

84012-28. The T.O.C. (0.30%) is extremely low (=poor). No T_{max} was found although three S_2 peaks show the complexity of the sample. The very high S_3 suggests a heavily weathered (oxidized) sample.

84012-29. The T.O.C. (0.51%) is barely fair. The large shoulder on the S_2 peak may reflect some generated hydrocarbon or contamination which has lowered the T_{max} (438°). There are many ways to interpret this sample depending upon whether mud-contaminants or show were recorded, or whether deisel, gilsonite, or LCM was added to the well. Without additional data we cannot interpret further on this sample.

84012-30. The T.O.C. (0.73%) would normally be considered fair if not for the clearly spurious nature of the S_2 peak. The T_{max} (305°) is "immature" and is a response to some contaminant.

84012-31. The T.O.C. is low (=poor) at 0.36%. The T_{max} of the dominant of the three or four S_2 peaks is 445°C. The multiple peaks indicate multiple substances generating hydrocarbons during pyrolysis and support the idea of a contaminated sample, whether contamination be a) additives to drilling mud (deisel, thixotropic constituents, mud-thinners, etc.), b) particulates (Lost-Circulation Material like walnut hulls, cedar shavings, etc. - although not obvious in the rock sample), c) uphole cave, or d) migrated hydrocarbons (dead oil or live). The T_{max} shows a minimum thermal maturity certainly lower than realistic for the one component it represents. The large "shoulder" on the left of S_2 peak supports this.

84012-32. This sample is characterized by a very low T.O.C. (0.09%). This is virtually barren of organic matter making pyrolysis results suspect. The four-peaked S_2 curve demonstrates this and makes evaluation of these data of no value. Any contaminant from drilling mud, deisel or even pipe dope could be wholly or partially responsible for the almost unmeasurable S_1 (0.02) and S_2 (0.10) values.

84012-33. This sample has a relatively high T.O.C. (1.15%, generally considered a "good" amount). However, the pyrolysis suggests dry gas generative regime (T_{max}=507°C). The pyrogram shows only a single S_2 peak supporting the notion of an uncontaminated sample. The amount of S_1 and S_2 are low (0.09 and 0.17) suggesting some caution in interpretation, however the P.I.=0.36 also supports a somewhat advanced thermal maturity. The very low Hydrogen Index either supports the high maturity for this sample or the very low quality of the kerogen for hydrocarbon generation. Unfortunately with neither kerogen analysis, T.A.I. or vitrinite reflectance corroboration of these conclusions they remain somewhat tentative.

Quantity of Organic Matter.

Total Organic Carbon (T.O.C.) values show five of the 28 samples with values exceeding 1%. These samples with the appropriate quality, thermal maturation and volumes of similar lithology demonstrate "good" hydrocarbon source potential.

Thermal Maturation.

Thermal maturation may be determined from palynomorph wall color and conodont color, as well as vitrinite reflectance and Rock-Eval pyrolysis.

Palynomorph wall color varies from pale yellow to yellowish orange in the immature phase, to orange brown in the oil generative phase, to red-brown in the wet gas phase, through dark brown and dark brownish black in the dry gas phase, to opaque black where only traces of dry gas and CO_2 may occur. Using this visual method the thermal maturity or Thermal Alteration Index (T.A.I.) was estimated.

Sample 84012-28 is barren of palynomorphs therefore no accurate T.A.I. can be obtained. Most of the kerogen is opaque black, although this may be the result of oxidation rather than high thermal maturity, an idea that is corroborated by the pyrolysis results.

84012-29,-30 and -31 include palynomorphs of dark reddish brown color (T.A.I. slightly less than 3, equivalent to a vitrinite reflectance in the R_o =1.3-1.5% range), i.e. in the wet gas generative regime.

Conodont Alteration Index (C.A.I.) data are included below. They range from C.A.I. about 3 (equivalent to a vitrinite reflectance of about R_o =1.4-1.95%, i.e. mainly dry gas, may include some wet gas in the less mature range) to 4 (R_o about 1.95-3.6, i.e. dry gas regime). Some anomalies in the C.A.I. values may reflect actual thermal differences in the rocks, however there are fine resolution difficulties in C.A.I. interpretation for this range (see conodont data).

Acritarchs.

Acritarchs (marine microphytoplankton) are useful for dating Paleozoic rocks. Two samples, 84012-2 and 84012-34, were processed for acritarchs but unfortunately are barren. Organic content for these samples is low.

Conodonts.

84012-1. The residue contained no conodonts or other identifiable organic material.

84012-2. Ten specimens of conodonts were recovered, including Belodina confluens (1 specimen) and Panderodus feulneri (9 specimens). These are Middle to Late Ordovician conodonts and quite typical of the western-Midcontinent biofacies. In New Mexico the association is common to the Montoya Group, which is entirely Late Ordovician in age.

C.A.I. = about 3.

84012-3. This sample yielded a single specimen of a large trichonodelliform conodont element of a type not known in the Ordovician, but otherwise not immediately diagnostic of age.

C.A.I. = about 3.

84012-4. Twelve conodonts were recovered from this sample and included Polygnathus sp. cf. P.parawebbi (juveniles, 2 specimens), Polygnathus sp. cf. P.varcus (2 specimens, platforms rather longer than typical) and 8 fragmentary ramiform elements of indeterminate assignment. This is probably a late Middle Devonian association. It is difficult to be completely confident of identifications in such a small collection, but the general types of polygnathids are of Middle Devonian aspect.

C.A.I. = 3.5 - 4.

84012-5. This sample yielded 4 conodont elements which are 2 fragments of a very large ramiform element, and 2 specimens of a Gnathodus, which appears to be transitional in morphology between G. semiglaber and G. pseudosemiglaber, possibly because the specimens are very small and not too well preserved. The age is Mississippian (anchoralis-latus Zone, probably).

C.A.I. = 4.

Note on C.A.I. values. The gradually ascending C.A.I. values need some qualification, as anyone who has tried to distinguish them in the 3 - 4.5 range will understand. It is best to have a fairly diverse collection of small, intermediate and large-sized specimens to work with; it is not always easy to be precise when comparing big, massive forms with very small, probably juvenile ones. In the above sampler, bigger specimens tend to give higher C.A.I. values than smaller ones because they are thicker walled and thus have enclosed in them more organic material to coalify. In a diverse collection this is obvious; in small collections, like the ones above, it is difficult to be precise. All the specimens in the above samples were compared with ones in a "standard set" that come closest to them in size and morphology.

TABLE 1. RESULTS OF TOTAL ORGANIC CARBON

SAMPLE NUMBER	TOTAL ORGANIC CARBON (wt.% of rock)
84012-6	0.15
84012-7	0.32
84012-8	0.60
84012-9	0.45
84012-10	0.15
84012-11	0.16
84012-12	0.44/0.43
84012-13	0.12
84012-14	0.13
84012-15	0.30
84012-16	1.08
84012-17	1.74
84012-18	0.30
84012-19	0.51
84012-20	1.02/1.00
84012-21	1.28
84012-22	0.20
84012-23	0.14
84012-24	0.07
84012-25	0.12
84012-26	0.11
84012-27	0.40
84012-28	0.29/0.30
84012-29	0.51
84012-30	0.73
84012-31	0.36
84012-32	0.09
84012-33	1.15

TABLE 2. RESULTS OF ROCK-EVAL PYROLYSIS

Sample No.	T_{max} °C	S_1 (mg/g)	S_2 (mg/g)	S_3 (mg/g)	PI	S_2/S_3	T.O.C. (wt.%)	Hydrogen Index	Oxygen Index
84012-28		0.18	0.24	5.78	0.43	00.04	00.30	79.9	1926.7
84012-29	438	0.31	1.10	0.66	0.22	01.67	00.51	216.0	129.5
84012-30	305	0.56	1.87	0.41	0.23	04.53	00.73	256.6	056.7
84012-31	445	0.15	0.36	0.26	0.30	01.41	00.36	100.1	071.0
84012-32	430	0.02	0.10	0.36	0.20	00.27	00.09	109.4	404.4
84012-33	507	0.09	0.17	1.11	0.36	00.15	01.15	014.7	096.6

T.O.C. = Total Organic Carbon, wt.%
S_1 = Free hydrocarbons, mg HC/g of rock
S_2 = Residual hydrocarbon potential, mg HC/g of rock
S_3 = CO_2 produced from kerogen pyrolysis, mg CO_2/g of rock
Hydrogen Index = mg HC/g organic carbon
Oxygen Index = mg CO_2/g organic carbon
PI = $S_1/S_1 + S_2$
T_{max} = Temperature Index, degrees C

GEOCOM ROCK EVAL II

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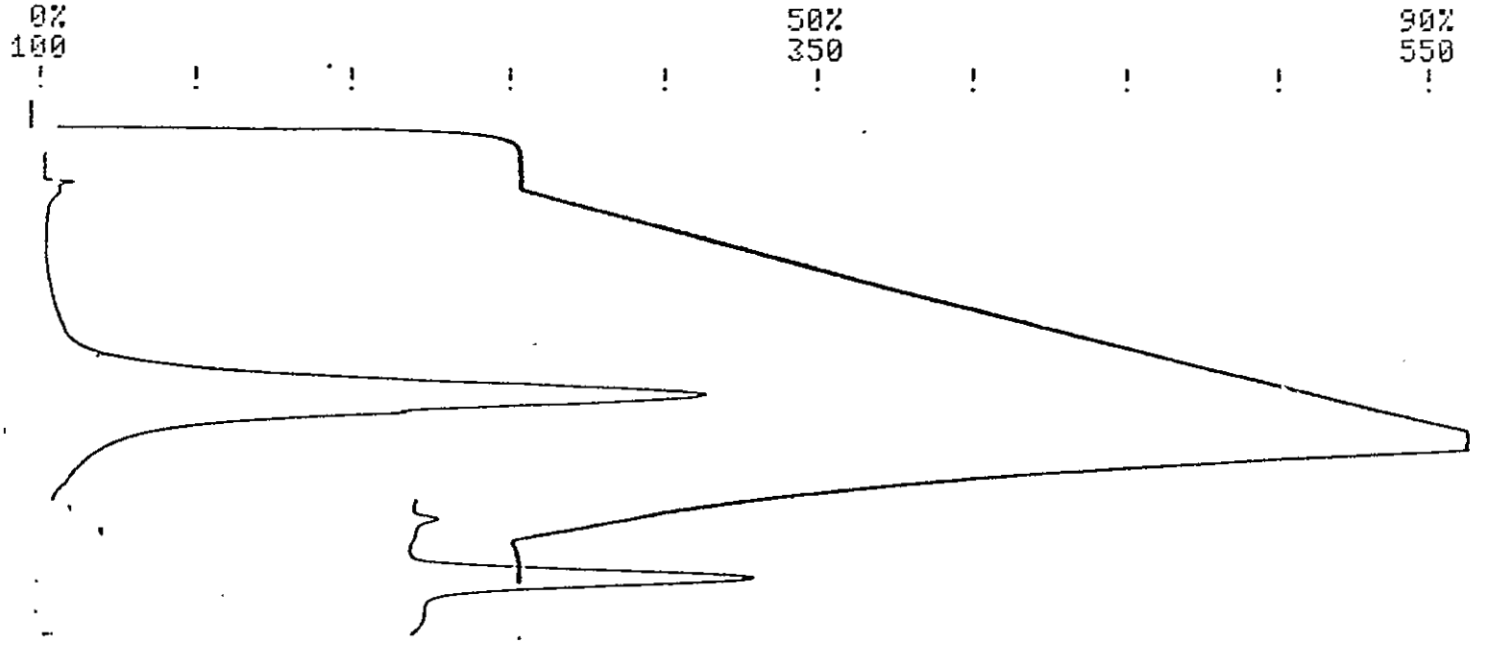
TCD ATTENUATION= 32



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WT = 100.0
TMAX = 442 DEGREES C
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S2= +4.460E+00 SUM= +3.903E+04
S3= +6.230E-01 SUM= +8.748E+03
STANDARD

GEOCOM ROCK EVAL II

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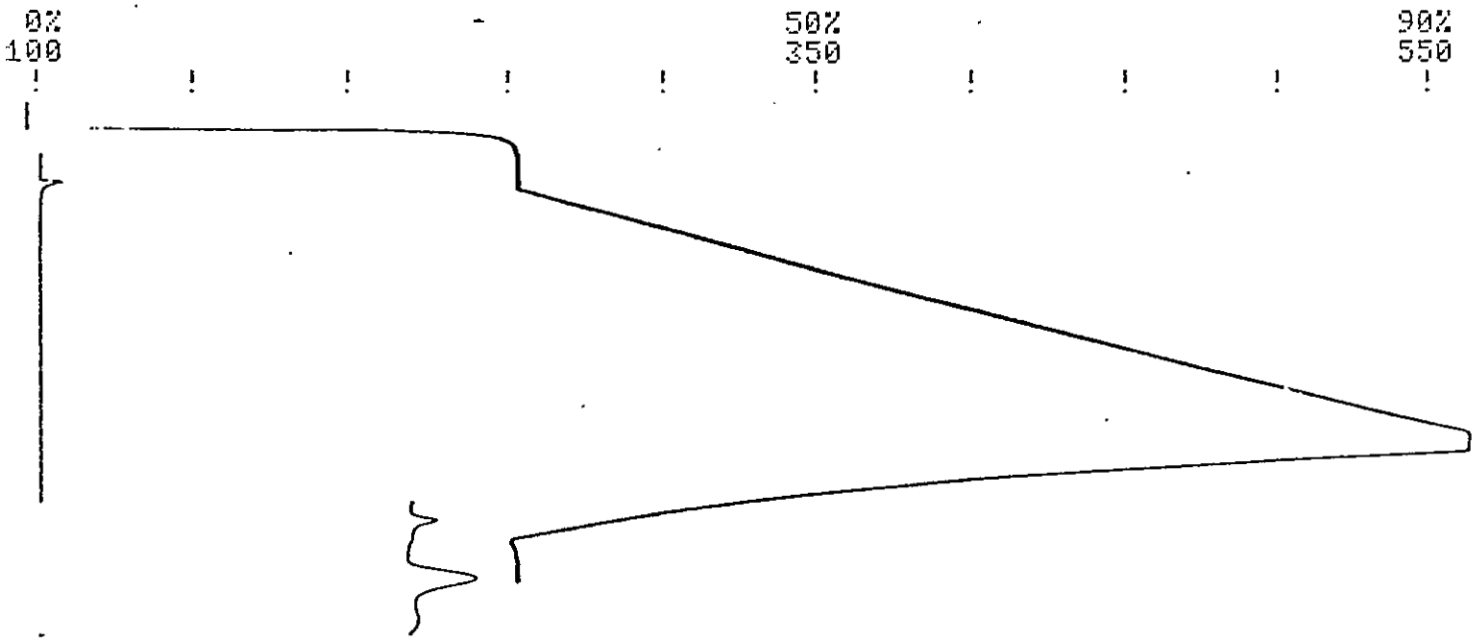

GEOCOM ROCK EVAL II

PPR 9, 1984
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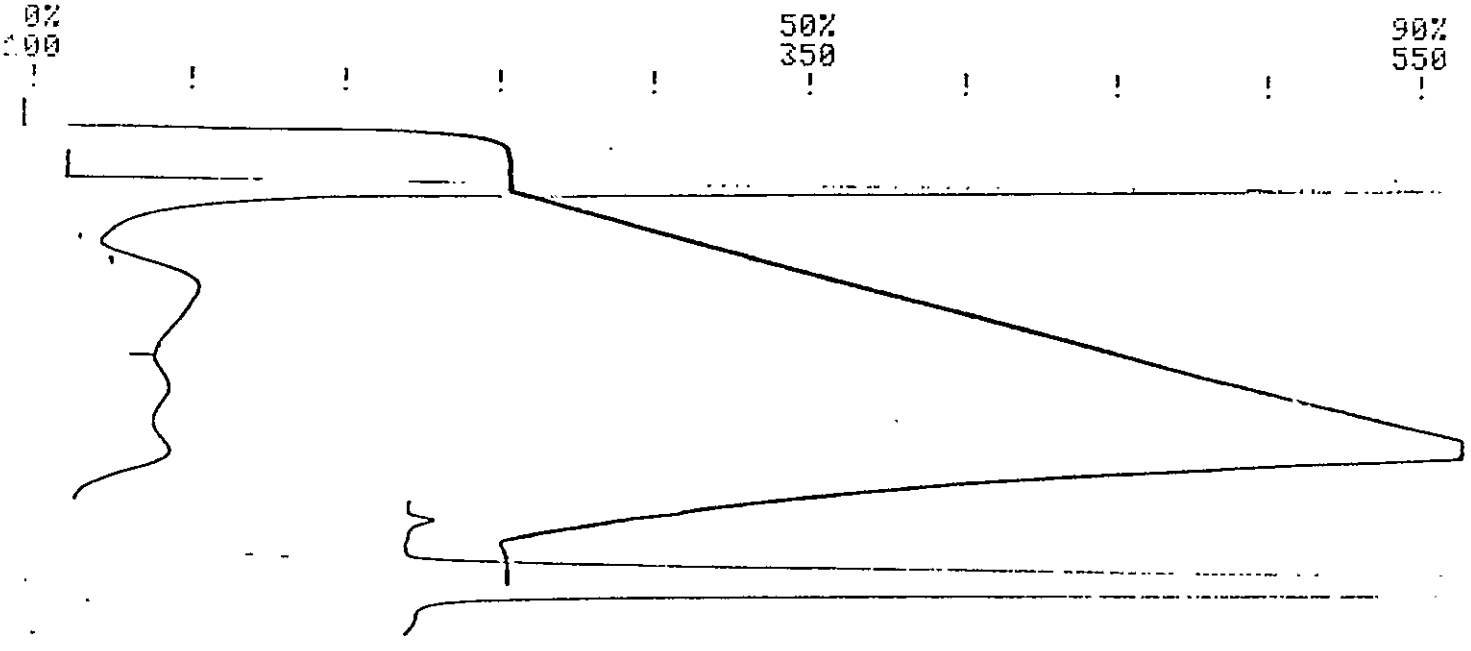

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WT = 99.9
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S2= +2.397E-01 SUM= +2.096E+03
S3= +5.777E+00 SUM= +6.541E+04
UNKNOWN

GEOCOM ROCK EVAL II

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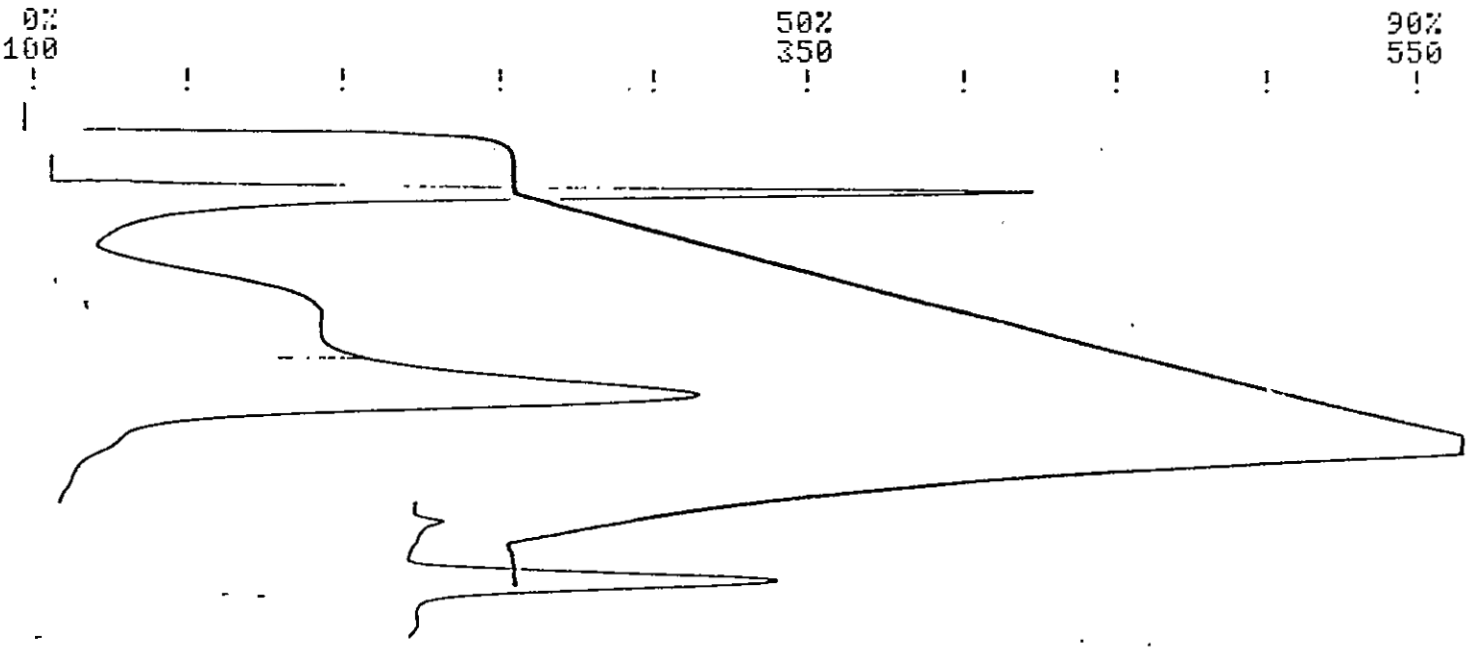

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WT = 99.3
TMAX = 438 DEGREES C
S1= +3.103E-01 SUM= +2.697E+03
S2= +1.101E+00 SUM= +9.572E+03
S3= +6.605E-01 SUM= +9.110E+03
UNKNOWN

GEOCOM ROCK EVAL II

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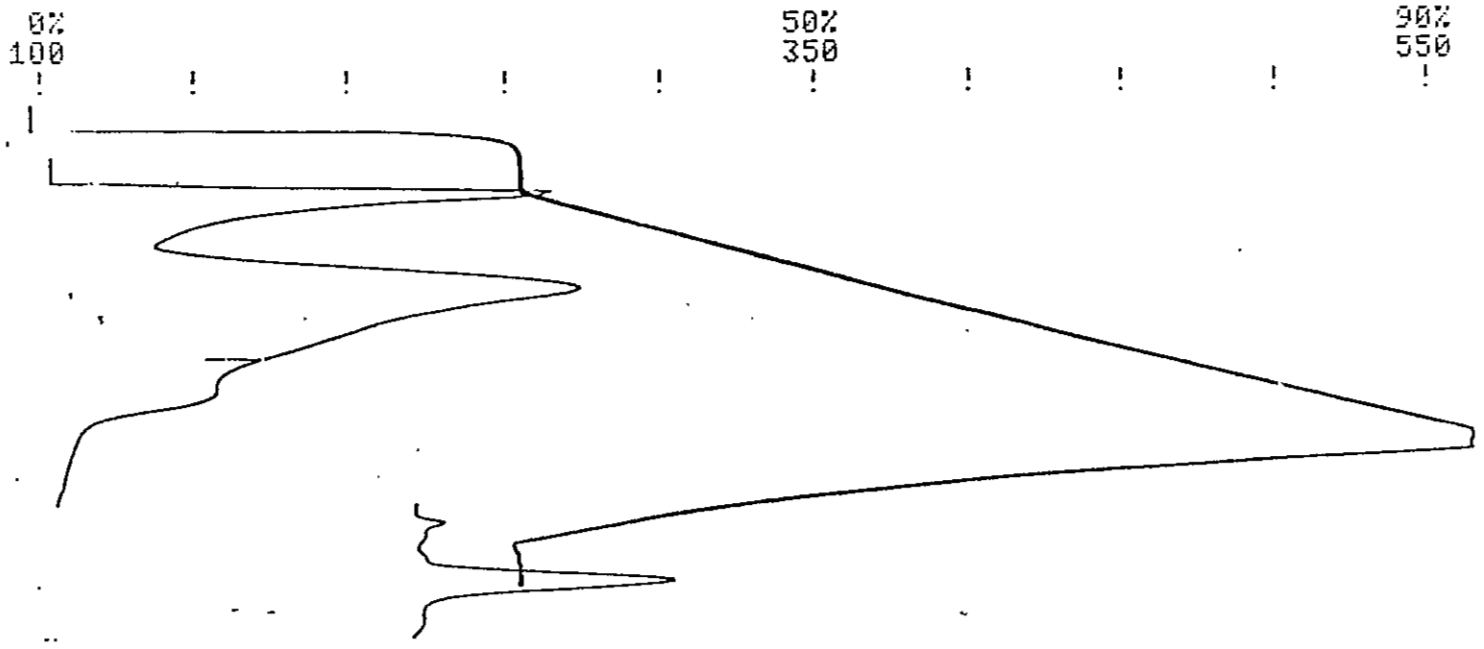

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WT = 99.6
TMAX = 305 DEGREES C
S1= +5.566E-01 SUM= +4.852E+03
S2= +1.873E+00 SUM= +1.632E+04
S3= +4.136E-01 SUM= +6.425E+03
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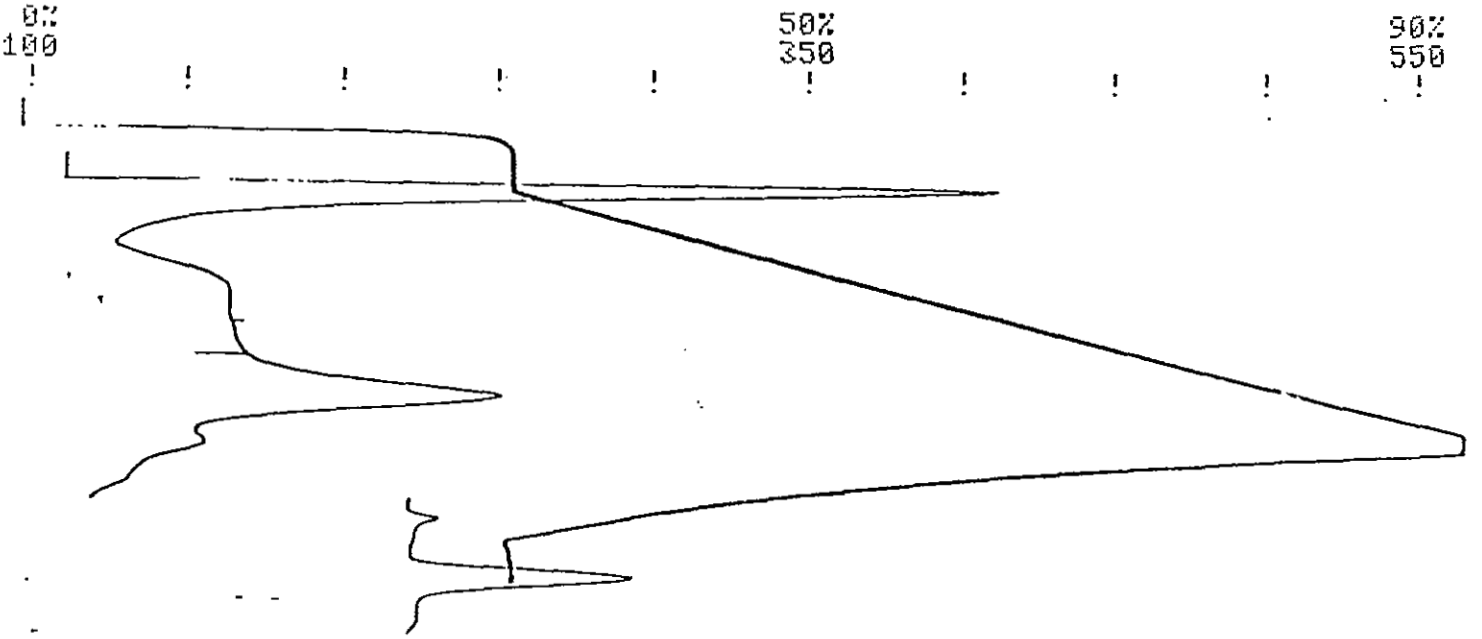

TOC = 0.36
PT = 123.0
TMAX = 445 DEGREES C
S1= +1.518E-01 SUM= +1.635E+03
S2= +3.603E-01 SUM= +3.879E+03
S3= +2.555E-01 SUM= +5.350E+03
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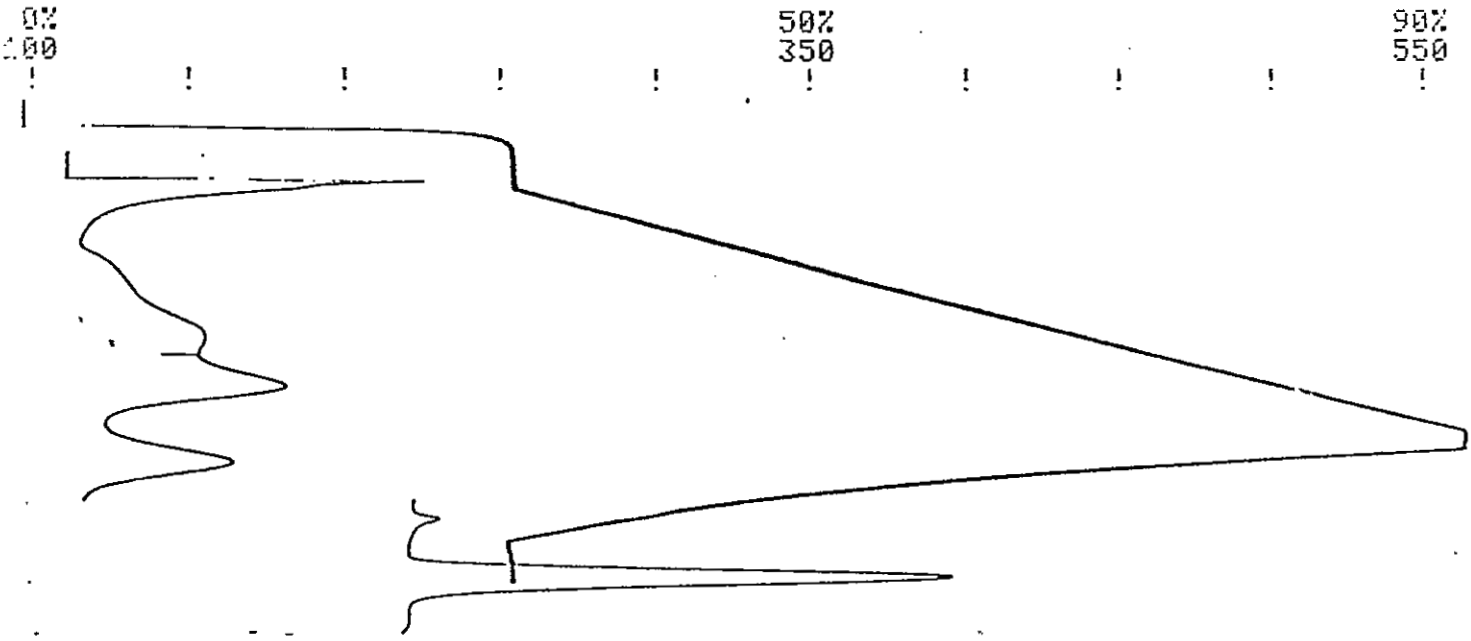

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S2= +9.847E-02 SUM= +2.383E+03
S3= +3.639E-01 SUM= +1.296E+04
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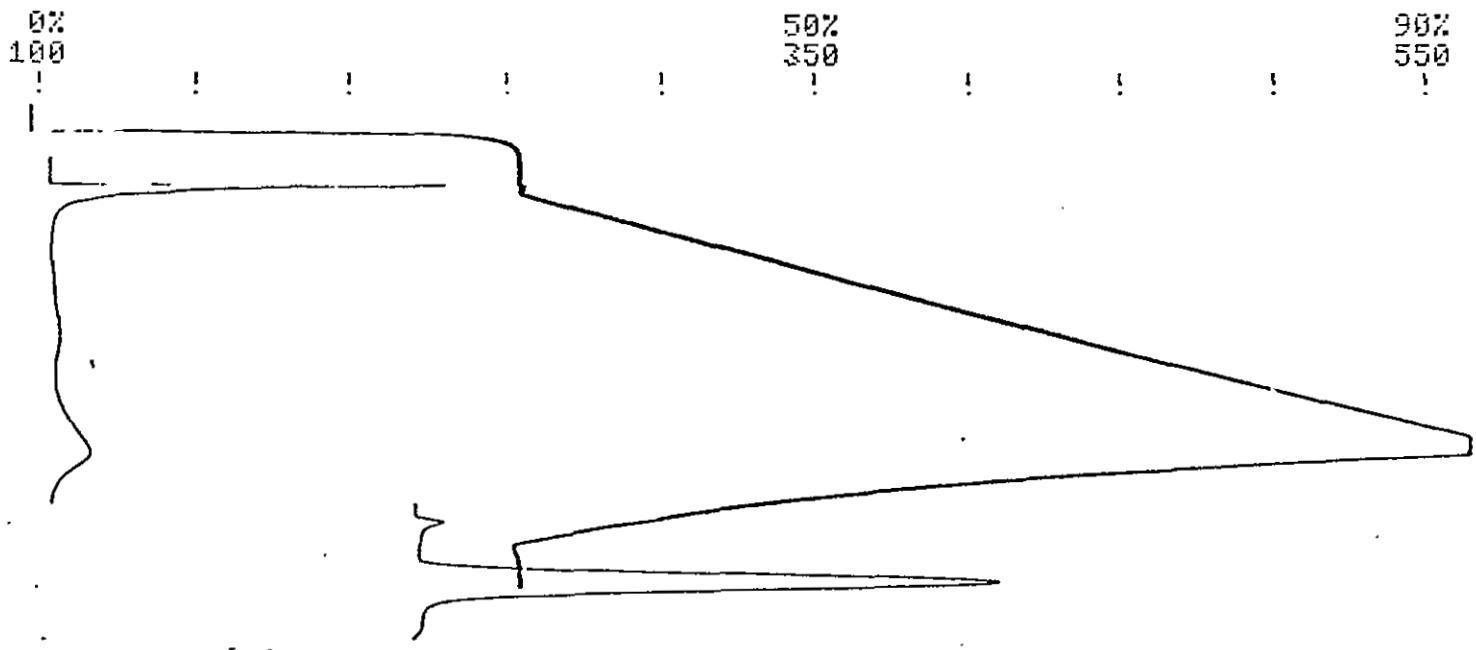
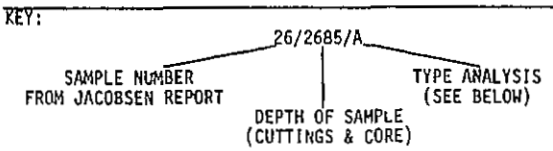


TOC = 1.15
WT = 99.8
TMAX = 507 DEGREES C
S1= +9.399E-02 SUM= +8.210E+02
S2= +1.692E-01 SUM= +1.478E+03
S3= +1.110E+00 SUM= +1.408E+04
UNKNOWN

ORGANIC CARBON AND MATURITY ANALYSIS OF ROCKS FROM
THE SACRAMENTO MOUNTAINS REGION OF OTERO COUNTY, NEW MEXICO

	OUTCROP SAMPLES			CUTTINGS & CORE		
FORMATION	LA LUZ CAN.	FRESNAL CAN.	ALAMO CAN.	SOUTHERN PRODUCTION CO. #1 CLOUDCROFT	MARATHON OIL CO. #1 MESA VERDE RANCH	GULF OIL COMPANY #1 CHAVES STATE
YESO					15/1448/E 28/1482/C, D 16/2010/E	
ABO				6/2400/E		23/1896/E
HOLDER						
BEEMAN	1/-/A				29/3530/C, D	
GOBBLER		33/-/D		7/2450/E 8/3130/E 9/3150/E	30/3810/C, D 31/4518/C, D 17/5395/E	24/2286/E
MISSISSIPPIAN UNDIFFERENTIATED			5/-/A	10/3450/E	18/5600/E	
DEVONIAN UNDIFFERENTIATED			4/-/A	11/3470/E	19/5806/E 20/5900/E	25/2670/E 26/2685/E
FUSSELMAN			3/-/A	12/3500/E 32/3565/D*	21/6031/E	
VALMONT			2/-/A, B		22/6118/E	27/2825/E
MONTOYA						
EL PASO				34/3894/B* 13/4154/E 14/4400/E		
BLISS						

KEY:



A - Thermal Maturity by Conodont Analysis

B - Thermal Maturity by Acritarch Analysis

C - Thermal Maturity by Kerogen Color Alteration

D - Total Organic Carbon by Pyrolysis

E - Total Organic Carbon by Chemical Analysis

* Indicate Core Sample