SOURCE CHARACTERISTICS OF CANNED CUTTINGS FROM THE 30/10-2 WELL, OFFSHORE NORWAY

by

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SUMMARY AND CONCLUSIONS

Canned cuttings from the 30/10-2 well were analyzed routinely for hydrocarbon source characteristics. This service work was requested in the March 29, 1974 letter No. 1014 by K. P. Pipes (ref. 6231/6244). Charges for the work have been billed to our Job No. 6550.

The analytical data for 30/10-2 can be interpreted as follows (applicable to shales, siltstones and carbonates):

Approximate Interval (feet)	Maturity	Richness	Indigenous Hydrocarbons Expected (If Reservoired)
3800-6000	Immature	Fair	Dry Gas
6000-6600	Immature	Poor	Lean
6600-7000	Immature	Fair	Gas
7000-7300	Transitional	Fair	Gas
7300-7600	Transitional	Good	Gas
7600-8500	Mature (?)	Good	Gas; Minor Oil
8500-9000	Mature	Fair	Gas; Minor Oil

The results are also summarized graphically in Fig. 1.

The samples are rated as immature down at least to 7600 ft, and possibly nearly to 10,000 ft. The cuttings gas and gasoline profiles suggest the former; kerogen alterations suggest the latter.

Shale samples from the interval 7300-8500 ft are rated as good potential hydrocarbon sources and might have generated the Frigg oil and gas. However, this interval is predominantly sandy and the good source shales may not in the aggregate make up sufficient section to have generated all the gas and oil at Frigg. The predominant source of the Frigg hydrocarbons in that case is likely to be the older Cretaceous and Jurassic strata. In either case, the source appears to be beds older than the reservoir interval.

PROCEDURES

Compositions and concentrations of hydrocarbon gases in the air spaces above the cuttings in the sample cans were determined by gas chromatography. Similar data were obtained on gases released from a standard mixture of cuttings and tap water after two minutes of agitation in a Waring blender. Combined results on the air space gas plus the cuttings gas were calculated for each sample. The data were plotted graphically to show vertical variations in total gas (C_1-C_4) and wet gas (C_2-C_4), and a graphical plot was also made of the percent wet gas in total gas (Figure 1). Detailed results of the analyses are listed in Table I.

Chips of uniform lithologies were picked by hand from the heterogenous mixtures of chips in the original samples. These are described in Table II. Our standard analytical procedures were used for determining the C_4-C_7 content and the total organic content of the "picked" chips. These results are given in Table III and they are plotted graphically in Fig. 1. Visual kerogen characteristics of 13 of these samples were also determined (Table II and Fig. 1).

DISCUSSION

Interpretations of source characteristics of various intervals were given on page 1 and these are also shown in Fig. 1. The data leading to these interpretations are presented in Tables I-III. Some of the general guidelines used for interpreting the various types of geochemical data are given in the Appendix.

There is a possible discrepancy in the data. Kerogen alterations suggest that almost the entire section is immature, down to about 9000 ft. The first alteration value as high as "2" is in the sample from 8800 ft. However, gasoline concentrations increased notably at about 7600 ft and the percent C_2-C_4 in total hydrocarbon gas also increased sharply at the same level. (See Fig. 1.) On the basis of the gas and gasoline the beds were called mature(?) beginning at 7600 ft. However, it is possible that the gas migrated upward from deeper beds and these strata are still immature. (The higher gasoline content of the 7600-ft sample also might be due to the muddy coatings on the chips. There might have been sufficient oil in the drilling mud to produce this higher content.)

The shale samples with the relatively high total organic matter and high gasoline contents from the interval 7400-8000 ft may be cavings, but they could have come from shale breaks in the "boxcar sand" interval. In any case they appear to be good potential sources of oil and gas, though possibly still a bit immature.

It is not clear from this profile exactly where the Frigg gas originated, but it is reasonably certain that it came from beds older than the reservoir. None of the cuttings gas yields were very high, but the cans were not very well sealed, so conceivably the gas concentrations were originally greater but have been reduced by leakage. The shales below 7300 ft are rich enough to have sourced considerable gas, but the limited evidence we have at EPR suggests that this is predominantly a sand interval. If so, there may not be enough of the richer shales in the section to account for the gas. However, the deeper Cretaceous and Jurassic shales are known to be adequate sources and possibly are the origin of much of the Frigg hydrocarbons.

RELATED REPORT

EPR.80ES.73 "Hydrocarbon Source Evaluation of Canned Cuttings from the Esso 30-10-1 Well, Norway", by R. E. Metter et al, Sept. 1973.

APPENDIX

BASES FOR INTERPRETING DATA

Total Organic Matter

The concentration of organic matter in a rock gives a rough indication of the amount of materials that might produce hydrocarbons. However, this measure alone does not indicate whether the organic material is oil prone, gas prone or mixed oil and gas prone. Rocks containing less than about 0.5 percent total organic matter are generally rated as poor sources, but this is modified by lithology. Some carbonate sequences possibly include hydrocarbon sources that contain less than 0.5% total organic matter.

Sections that are notable for their production of dry gas (mainly methane) have commonly been found to be characterized by source rocks containing greater than about 1.1 percent total organic matter. However, a measure of the liquid hydrocarbons in these richer rocks is also necessary to determine whether they should be rated as oil prone or gas prone.

Visual Kerogen

Kerogen data give two types of information. The color alteration (carbonization) is believed to indicate the amount of thermal diagenesis that the organic matter has undergone. The types of materials comprising the kerogen may indicate the source character of the rocks.

Kerogen color alterations are rated on a 1 to 5 index scale, from unaltered to almost completely carbonized, respectively. A rating of 4 suggests that subsurface temperatures have been high enough to destroy most of the producible liquid hydrocarbons. Producible hydrocarbons found in sections in which the kerogen alteration is rated as 4 or greater are likely to be mainly dry gas. Immobile pyrobitumens may also be found in the associated reservoir beds. The rating of 5 is reserved for highly altered strata, where there is petrographic evidence of metamorphism. A 5 rating implies a barren source section. Alteration ratings of 1 to 2- suggest that thermal diagenesis of the kerogen has barely begun, and reservoired hydrocarbons, if present, are likely to be gases, possibly associated with heavy, asphaltic oils. Ratings of 2+ to 3 suggest that maturation of the material has progressed to the point that gas, liquid hydrocarbons, or mixed oil and gas may be produced, depending on the nature of the original source materials. A rating of 2 may be associated with either immature or moderately mature sediments.

Types of kerogen materials that are commonly recognized include amorphous, finely disseminated, algal, herbaceous, woody and coaly. The source significance of these types is not established, but there have been suggestions in several areas, such as the offshore of southern Australia, that gas production is associated with woody and coaly kerogen, whereas rocks containing amorphous, finely disseminated and algal materials are sources of hydrocarbon liquids. A type of material referred to as "nonfilamentous algae" has more recently been distinguished, and tentatively this material is regarded as more gas prone. These observations are still speculative.

Cuttings Gas

Cuttings gas data give indications of the vertical variability in the source character of a section of interest. The ratio of wet gas (C_2-C_4) to total gas (C_1-C_4) may distinguish methane-prone from oil- and "wet" gas-prone sections. The critical value of this ratio varies from basin to basin. In Western Canada C_2-C_4 concentrations of about 45 percent or greater in the total gas are considered to be diagnostic of sections that are likely to produce oil or perhaps gas with appreciable amounts of hydrocarbon liquids. In the Permian section of West Texas the significant ratio appears to be closer to 20 percent or greater of wet gas in total gas.

The significant values for total amounts of hydrocarbon gas yielded by the cuttings also appear to vary from basin to basin, and possibly must be established separately for each area of interest. Zones with the greatest yields of gas are considered to be of most interest as sources. Samples from coal-bearing zones commonly give up large concentrations of gas, but we are not certain that coals produce commercial amounts of oil.

Oil in the drilling mud makes it nearly impossible to establish practical quantitative criteria that can be used in comparing different wells. The oil will tend to reduce the amount of cuttings gas released during agitation in the blender, and it will affect the composition of the hydrocarbon gas that is obtained for analysis. However, even with oil in the mud, significant vertical patterns in hydrocarbon gas concentrations and compositions can be established in each well. The patterns from different wells can be compared to establish regional trends or areal configurations of different organic facies within a section of interest.

Light Gasoline (C_4-C_7) Hydrocarbons

Light gasolines apparently do not appear in source beds in concentrations above one or two parts per million until a fair degree of maturation occurs. Therefore, gasoline concentrations give one criterion of the degree of thermal maturation that the organic matter has attained.

In addition, ratios of specific gasoline compounds may indicate the possible source character of the rocks. In particular, the ratio of cyclohexane to methylcyclopentane (CH/MCP) has been found to be useful in the U. S. Gulf Coast and the Alaskan areas for distinguishing "non oily" from "oily" facies. To date commercial oil has not been found associated with strata having a CH/MCP ratio of less than 0.25. However, dry gas has been found in strata characterized by ratio values greater than 0.25 as well as in sections having ratio values less than 0.25.

The CH/MCP ratio may also be useful in helping distinguish different organic facies that may be present within a section, even though all ratio values may be greater than 0.25. Zones with similar ratio values can sometimes be distinguished and such zones may differ from one another in their source ratings. Definition of such zones may be quite useful in correlating reservoired oils with specific source intervals.

Other ratios of gasoline compounds have proven useful in crude oil correlations and correlations of oils with source rocks. Some of these are included in Table III of this report.

TABLE IA

C_1-C_4 HYDROCARBON ANALYSES - AIR SPACE AT TOP OF CANS

SAMPLE NUMBER	R	DEPTH	GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS)							GAS COMPOSITION (PERCENT)										NOTES
			METHANE (C_1)	ETHANE (C_2)	PROPANE (C_3)	ISO-BUTANE (iC_4)	NORMAL BUTANE (nC_4)	WET (C_2-C_4)	TOTAL (C_1-C_4)	TOTAL GAS						WET GAS				
										C_2-C_4	C_1	C_2	C_3	iC_4	nC_4	C_2	C_3	iC_4	nC_4	
61844G	4	3800	84.70	0.07	0.22	0.01	0.07	0.37	85.07	0.4349	100.	0.	0.	0.	0.	19.	59.	3.	19.	
61844I	4	4000	104.00	0.09	0.41	0.01	0.18	0.69	104.69	0.6591	100.	0.	0.	0.	0.	13.	60.	1.	26.	
61844K	4	4200	659.42	1.05	2.43	0.42	2.19	6.09	665.51	0.9150	100.	0.	0.	0.	0.	17.	40.	7.	36.	
61844L	4	4400	3087.58	20.17	12.72	1.74	1.47	36.10	3123.68	1.1557	99.	1.	0.	0.	0.	56.	35.	5.	4.	
61844N	4	4600	9107.93	28.90	6.69	2.36	1.69	39.63	9147.56	0.4333	100.	0.	0.	0.	0.	73.	17.	6.	4.	
61844P	4	4800	3876.82	0.30	2.64	3.61	1.19	7.74	3884.56	0.1992	100.	0.	0.	0.	0.	4.	34.	47.	15.	
61844R	4	5000	7571.93	15.28	15.55	9.04	2.85	42.71	7614.64	0.5609	100.	0.	0.	0.	0.	36.	36.	21.	7.	
61844T	4	5200	6476.36	99.31	17.56	5.98	1.71	124.55	6600.91	1.8869	98.	2.	0.	0.	0.	80.	14.	5.	1.	
61845B	4	5400	10896.19	51.95	26.11	8.47	2.92	89.45	10985.63	0.8142	100.	0.	0.	0.	0.	59.	29.	9.	3.	
61893A	4	5500	8865.54	292.53	40.15	12.11	4.69	349.47	9215.01	3.7924	97.	3.	0.	0.	0.	85.	11.	3.	1.	
61893B	4	5600	6438.60	224.00	29.07	9.72	3.53	266.31	6704.91	3.9719	97.	3.	0.	0.	0.	84.	11.	4.	1.	
61893C	4	5700	10363.08	436.80	54.13	18.94	7.71	517.57	10880.65	4.7568	96.	4.	0.	0.	0.	85.	10.	4.	1.	
61893D	4	5800	8296.23	346.35	43.38	14.49	5.04	409.25	8705.48	4.7011	96.	4.	0.	0.	0.	84.	11.	4.	1.	
61893E	4	5900	127.20	26.47	4.15	1.88	0.84	33.34	160.54	20.7674	79.	16.	3.	1.	1.	79.	12.	6.	3.	
61893F	4	6000	4595.37	280.76	29.36	9.29	3.46	322.86	4918.23	6.5646	93.	6.	1.	0.	0.	87.	9.	3.	1.	
61893G	4	6100	3173.43	313.96	32.10	10.59	3.99	360.64	3534.07	10.2047	90.	9.	1.	0.	0.	87.	9.	3.	1.	
61893H	4	6200	5353.89	401.36	33.62	11.09	4.41	450.47	5804.36	7.7609	92.	7.	1.	0.	0.	90.	7.	2.	1.	
61893I	4	6300	618.75	18.47	8.04	4.09	2.06	32.66	651.41	5.0137	95.	3.	1.	1.	0.	56.	25.	13.	6.	
61893J	4	6400	4465.78	449.54	33.26	16.14	6.19	505.12	4970.90	10.1616	90.	9.	1.	0.	0.	89.	7.	3.	1.	
61893K	4	6500	2815.21	625.37	51.78	43.46	15.50	736.11	3551.32	20.7278	80.	18.	1.	1.	0.	85.	7.	6.	2.	
61893L	4	6600	7669.32	1567.55	89.75	66.08	22.44	1745.81	9415.13	18.5426	81.	17.	1.	1.	0.	90.	5.	4.	1.	
61893M	4	6640	20312.68	2474.56	131.88	85.13	30.70	2722.27	23034.95	11.8180	88.	11.	1.	0.	0.	91.	5.	3.	1.	
61893N	4	6800	440.89	409.90	40.32	37.99	13.59	501.80	942.69	53.2306	48.	43.	4.	4.	1.	81.	8.	8.	3.	
61893O	4	6900	2498.35	758.08	57.89	53.47	19.65	889.09	3387.44	26.2466	73.	22.	2.	2.	1.	85.	7.	6.	2.	
61893P	4	7000	328.59	194.40	23.66	21.49	8.05	247.60	576.19	42.9719	57.	34.	4.	4.	1.	78.	10.	9.	3.	
61893Q	4	7054	487.15	312.83	71.28	55.67	30.27	470.05	957.20	49.1067	51.	33.	7.	6.	3.	67.	15.	12.	6.	
61893R	4	7100	1412.11	992.00	503.42	333.51	271.87	2100.80	3512.91	59.8023	41.	28.	14.	9.	8.	47.	24.	16.	13.	
61893S	4	7200	2811.77	1401.98	453.45	192.26	158.90	2206.58	5018.35	43.9702	56.	28.	9.	4.	3.	63.	21.	9.	7.	
61893T	4	7300	1840.58	1160.62	403.13	137.44	173.93	1875.12	3715.70	50.4648	49.	31.	11.	4.	5.	63.	21.	7.	9.	
61893U	4	7400	699.08	544.71	713.88	485.44	591.62	2335.65	3034.73	76.9640	23.	18.	24.	16.	19.	23.	31.	21.	25.	
61893V	4	7500	1662.81	1046.11	366.73	235.98	206.56	1855.38	3518.19	52.7368	47.	30.	10.	7.	6.	56.	20.	13.	11.	
61903A	4	7600	971.77	904.53	300.29	163.00	135.31	1503.13	2474.90	60.7350	39.	37.	12.	7.	5.	60.	20.	11.	9.	
61903B	4	7700	1332.45	1044.48	284.39	170.18	121.15	1620.20	2952.65	54.8727	45.	35.	10.	6.	4.	64.	18.	11.	7.	
61903C	4	7800	587.22	503.17	171.31	135.89	110.35	920.72	1507.94	61.0581	40.	33.	11.	9.	7.	54.	19.	15.	12.	
61903D	4	7900	96.31	75.34	21.13	13.94	10.32	120.73	217.04	55.6257	44.	35.	10.	6.	5.	61.	18.	12.	9.	
61903E	4	8000	1645.69	1015.53	348.52	250.74	224.82	1839.61	3485.30	52.7820	48.	29.	10.	7.	6.	55.	19.	14.	12.	
61903F	4	8100	1503.14	934.97	557.26	281.26	380.64	2154.13	3657.27	58.8999	41.	26.	15.	8.	10.	43.	26.	13.	18.	
61903G	4	8200	376.43	286.72	227.11	123.14	191.50	828.47	1204.90	68.7584	31.	24.	19.	10.	16.	35.	27.	15.	23.	
61903H	4	8300	116.14	115.35	108.90	55.01	106.49	385.75	501.89	76.8594	23.	23.	22.	11.	21.	30.	28.	14.	28.	
61903I	4	8400	164.69	169.60	298.08	102.56	211.93	782.17	946.86	82.6067	17.	18.	32.	11.	22.	22.	38.	13.	27.	
61903J	4	8500	82.58	84.22	204.64	76.58	166.30	531.74	614.32	86.5575	13.	14.	34.	12.	27.	16.	39.	14.	31.	
61903K	4	8600	23690.61	16383.98	1121.80	300.58	579.37	18385.72	42076.33	43.6961	56.	39.	3.	1.	1.	89.	6.	2.	3.	
61903L	4	8700	13.84	4.74	39.72	23.39	64.33	132.18	146.02	90.5218	9.	3.	27.	16.	45.	4.	30.	18.	48.	
61903M	4	8800	149.66	364.47	592.33	135.57	303.11	1395.48	1545.14	90.3141	10.	24.	37.	9.	20.	26.	42.	10.	22.	
61903N	4	8900	265.42	401.90	515.63	107.89	256.26	1281.68	1547.10	82.8440	17.	26.	33.	7.	17.	31.	41.	8.	20.	
61903O	4	9000	70.69	102.12	153.26	35.82	81.42	372.62	443.31	84.0540	16.	23.	35.	8.	18.	27.	41.	10.	22.	
61903P	4	9037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	*C*

B = CUTTINGS NOT ANALYZED   *C* = AIR SPACE GAS NOT RUN   *BC* = NO ANALYSES RUN

TABLE IB

C_1-C_4 HYDROCARBON ANALYSES - CUTTINGS ONLY

SAMPLE NUMBER	R	DEPTH	GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS) METHANE (C_1)	ETHANE (C_2)	PROPANE (C_3)	ISO-BUTANE (iC_4)	NORMAL BUTANE (nC_4)	WET (C_2-C_4)	TOTAL (C_1-C_4)	GAS COMPOSITION (PERCENT) TOTAL GAS C_2-C_4	C_1	C_2	C_3	iC_4	nC_4	WET GAS C_2	C_3	iC_4	nC_4	NOTES
61844G	4	3800	494.59	0.45	0.21	0.05	0.45	1.16	495.75	0.2339	100.	0.	0.	0.	0.	39.	18.	4.	39.	
61844I	4	4000	2825.62	1.56	1.54	0.10	1.22	4.42	2830.04	0.1562	100.	0.	0.	0.	0.	35.	35.	2.	28.	
61844K	4	4200	1736.58	1.85	4.74	0.78	8.52	15.89	1752.47	0.9067	100.	0.	0.	0.	0.	12.	30.	5.	53.	
61844L	4	4400	2922.34	2.63	5.25	1.52	3.96	13.36	2935.70	0.4551	100.	0.	0.	0.	0.	20.	39.	11.	30.	
61844N	4	4600	2770.96	18.90	5.50	2.50	1.60	28.50	2799.46	1.0180	99.	1.	0.	0.	0.	66.	19.	9.	6.	
61844P	4	4800	2993.82	39.00	6.92	11.13	2.47	59.52	3053.34	1.9493	99.	1.	0.	0.	0.	65.	12.	19.	4.	
61844R	4	5000	3557.26	105.36	21.18	18.41	7.85	152.80	3710.06	4.1185	96.	3.	1.	0.	0.	69.	14.	12.	5.	
61844T	4	5200	3784.32	155.04	36.64	18.57	7.52	217.77	4002.09	5.4414	95.	4.	1.	0.	0.	71.	17.	9.	3.	
61845B	4	5400	4141.72	60.00	41.36	17.60	9.29	128.25	4269.96	3.0034	98.	1.	1.	0.	0.	47.	32.	14.	7.	
61893A	4	5500	143.49	4.01	1.03	0.29	0.28	5.61	149.10	3.7626	96.	3.	1.	0.	0.	72.	18.	5.	5.	
61893B	4	5600	2707.89	95.76	32.23	15.38	7.99	151.36	2859.25	5.2937	95.	3.	1.	1.	0.	64.	21.	10.	5.	
61893C	4	5700	603.39	26.40	4.47	1.65	0.60	33.12	636.51	5.2033	95.	4.	1.	0.	0.	80.	13.	5.	2.	
61893D	4	5800	842.01	12.63	4.45	1.51	0.88	19.47	861.48	2.2600	98.	1.	1.	0.	0.	64.	23.	8.	5.	
61893E	4	5900	271.74	13.50	2.06	0.51	0.33	16.40	288.14	5.6915	94.	5.	1.	0.	0.	82.	13.	3.	2.	
61893F	4	6000	1709.25	111.60	13.72	4.52	2.75	132.59	1841.84	7.1988	93.	6.	1.	0.	0.	85.	10.	3.	2.	
61893G	4	6100	269.63	12.78	1.68	0.46	0.31	15.23	284.86	5.3463	95.	4.	1.	0.	0.	84.	11.	3.	2.	
61893H	4	6200	263.85	13.20	1.36	0.49	0.22	15.27	279.12	5.4707	95.	5.	0.	0.	0.	87.	9.	3.	1.	
61893I	4	6300	300.64	21.42	2.45	1.68	0.49	26.04	326.68	7.9710	91.	7.	1.	1.	0.	83.	9.	6.	2.	
61893J	4	6400	336.38	34.80	3.67	2.28	0.75	41.50	377.88	10.9822	89.	9.	1.	1.	0.	84.	9.	5.	2.	
61893K	4	6500	633.87	58.44	4.53	1.88	0.87	65.72	699.59	9.3940	91.	8.	1.	0.	0.	89.	7.	3.	1.	
61893L	4	6600	235.21	39.84	3.49	2.64	0.74	46.71	281.92	16.5684	84.	14.	1.	1.	0.	85.	7.	6.	2.	
61893M	4	6640	274.89	13.71	1.50	2.17	1.94	19.32	294.21	6.5667	92.	5.	1.	1.	1.	71.	8.	11.	10.	
61893N	4	6800	285.40	14.70	2.33	2.51	0.77	20.31	305.71	6.6433	93.	5.	1.	1.	0.	73.	11.	12.	4.	
61893O	4	6900	236.52	16.05	1.55	1.46	0.44	19.50	256.02	7.6165	92.	6.	1.	1.	0.	83.	8.	7.	2.	
61893P	4	7000	232.05	12.00	2.33	1.89	0.83	17.05	249.10	6.8446	93.	5.	1.	1.	0.	70.	14.	11.	5.	
61893Q	4	7054	132.71	1.27	0.35	0.44	0.33	2.39	135.10	1.7690	99.	1.	0.	0.	0.	53.	15.	18.	14.	
61893R	4	7100	1524.24	134.40	249.89	305.83	350.46	1040.58	2564.82	40.5712	59.	5.	10.	12.	14.	13.	24.	29.	34.	
61893S	4	7200	2081.38	1324.80	943.92	368.61	585.52	3222.85	5304.23	60.7600	39.	25.	18.	7.	11.	42.	29.	11.	18.	
61893T	4	7300	351.10	136.32	55.02	28.17	25.00	244.51	595.61	41.0520	59.	23.	9.	5.	4.	55.	23.	12.	10.	
61893U	4	7400	273.84	0.52	1.01	0.71	1.33	3.57	277.41	1.2867	100.	0.	0.	0.	0.	15.	28.	20.	37.	
61893V	4	7500	257.54	11.70	5.94	5.37	3.95	26.96	284.50	9.4762	91.	4.	2.	2.	1.	43.	22.	20.	15.	
61903A	4	7600	265.43	42.00	18.23	13.00	11.68	84.91	350.34	24.2364	76.	12.	5.	4.	3.	50.	21.	15.	14.	
61903B	4	7700	245.72	34.08	12.73	9.13	6.90	62.84	308.56	20.3654	80.	11.	4.	3.	2.	54.	20.	15.	11.	
61903C	4	7800	182.65	17.40	8.01	7.58	5.60	38.59	221.24	17.4426	82.	8.	4.	3.	3.	44.	21.	20.	15.	
61903D	4	7900	243.35	9.51	4.54	3.95	3.48	21.48	264.83	8.1108	92.	4.	2.	1.	1.	45.	21.	18.	16.	
61903E	4	8000	293.28	37.98	18.44	15.62	14.05	86.09	379.37	22.6928	77.	10.	5.	4.	4.	45.	21.	18.	16.	
61903F	4	8100	311.68	15.15	10.40	6.75	9.96	42.26	353.94	11.9398	88.	4.	3.	2.	3.	35.	25.	16.	24.	
61903G	4	8200	748.45	24.00	22.67	12.72	23.67	83.06	831.51	9.9890	89.	3.	3.	2.	3.	30.	27.	15.	28.	
61903H	4	8300	231.79	6.00	11.77	7.94	14.65	40.36	272.15	14.8300	86.	2.	4.	3.	5.	15.	29.	20.	36.	
61903I	4	8400	1166.83	149.76	813.76	394.72	1278.65	2636.89	3803.72	69.3240	31.	4.	21.	10.	34.	6.	31.	15.	48.	
61903J	4	8500	227.32	7.05	23.29	10.31	19.05	59.70	287.02	20.7998	79.	2.	8.	4.	7.	12.	39.	17.	32.	
61903K	4	8600	174.76	20.40	39.31	11.46	23.01	94.18	268.94	35.0189	64.	8.	15.	4.	9.	22.	42.	12.	24.	
61903L	4	8700	178.18	0.26	0.85	0.39	1.66	3.16	181.34	1.7426	99.	0.	0.	0.	1.	8.	27.	12.	53.	
61903M	4	8800	111.69	1.60	3.56	0.80	2.18	8.14	119.83	6.7929	93.	1.	3.	1.	2.	20.	43.	10.	27.	
61903N	4	8900	189.74	5.02	15.87	4.90	9.29	35.08	224.82	15.6036	85.	2.	7.	2.	4.	14.	46.	14.	26.	
61903O	4	9000	259.12	5.64	12.85	3.39	7.52	29.40	288.52	10.1898	90.	2.	4.	1.	3.	19.	43.	12.	26.	
61903P	4	9037	337.43	30.48	51.36	14.82	27.52	124.18	461.61	26.9014	73.	7.	11.	3.	6.	25.	41.	12.	22.	*C*

B = CUTTINGS NOT ANALYZED *C* = AIR SPACE GAS NOT RUN *BC* = NO ANALYSES RUN

TABLE IC

C_1-C_4 HYDROCARBON ANALYSES - CUTTINGS AND AIR SPACE

SAMPLE NUMBER	R	DEPTH	GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS)							GAS COMPOSITION (PERCENT)										NOTES
			METHANE (C_1)	ETHANE (C_2)	PROPANE (C_3)	ISO-BUTANE (iC_4)	NORMAL BUTANE (nC_4)	WET (C_2-C_4)	TOTAL (C_1-C_4)	TOTAL GAS C_2-C_4	TOTAL GAS C_1	TOTAL GAS C_2	TOTAL GAS C_3	TOTAL GAS iC_4	TOTAL GAS nC_4	WET GAS C_2	WET GAS C_3	WET GAS iC_4	WET GAS nC_4	
61844G	4	3800	579.29	0.52	0.43	0.06	0.52	1.53	580.82	0.2634	100.	0.	0.	0.	0.	34.	28.	4.	34.	
61844I	4	4000	2929.62	1.65	1.95	0.11	1.40	5.11	2934.73	0.1741	100.	0.	0.	0.	0.	32.	39.	2.	27.	
61844K	4	4200	2396.00	2.90	7.17	1.20	10.71	21.98	2417.98	0.9090	100.	0.	0.	0.	0.	13.	33.	5.	49.	
61844L	4	4400	6009.92	22.80	17.97	3.26	5.43	49.46	6059.38	0.8162	100.	0.	0.	0.	0.	46.	36.	7.	11.	
61844N	4	4600	11878.89	47.80	12.19	4.86	3.29	68.13	11947.02	0.5703	100.	0.	0.	0.	0.	70.	18.	7.	5.	
61844P	4	4800	6870.64	39.30	9.56	14.74	3.66	67.26	6937.90	0.9694	99.	1.	0.	0.	0.	59.	14.	22.	5.	
61844R	4	5000	11129.19	120.64	36.73	27.45	10.70	195.51	11324.70	1.7264	99.	1.	0.	0.	0.	62.	19.	14.	5.	
61844T	4	5200	10260.68	254.35	54.20	24.55	9.23	342.32	10603.00	3.2285	97.	2.	1.	0.	0.	74.	16.	7.	3.	
61845B	4	5400	15037.91	111.95	67.47	26.07	12.21	217.69	15255.60	1.4270	99.	1.	0.	0.	0.	51.	31.	12.	6.	
61893A	4	5500	9009.03	296.54	41.18	12.40	4.97	355.08	9364.11	3.7920	97.	3.	0.	0.	0.	84.	12.	3.	1.	
61893B	4	5600	9146.48	319.76	61.30	25.10	11.52	417.67	9564.16	4.3671	96.	3.	1.	0.	0.	76.	15.	6.	3.	
61893C	4	5700	10966.46	463.20	58.60	20.59	8.31	550.69	11517.16	4.7815	95.	4.	1.	0.	0.	83.	11.	4.	2.	
61893D	4	5800	9138.23	358.98	47.83	16.00	5.92	428.72	9566.96	4.4813	96.	4.	0.	0.	0.	84.	11.	4.	1.	
61893E	4	5900	398.94	39.97	6.21	2.39	1.17	49.74	448.68	11.0857	89.	9.	1.	1.	0.	81.	12.	5.	2.	
61893F	4	6000	6304.62	392.36	43.08	13.81	6.21	455.45	6760.07	6.7374	93.	6.	1.	0.	0.	87.	9.	3.	1.	
61893G	4	6100	3443.06	326.74	33.78	11.05	4.30	375.87	3818.93	9.8423	90.	9.	1.	0.	0.	87.	9.	3.	1.	
61893H	4	6200	5617.73	414.56	34.98	11.58	4.63	465.74	6083.48	7.6559	92.	7.	1.	0.	0.	89.	8.	2.	1.	
61893I	4	6300	919.39	39.89	10.49	5.77	2.55	58.70	978.09	6.0014	94.	4.	1.	1.	0.	68.	18.	10.	4.	
61893J	4	6400	4802.16	484.34	36.93	18.42	6.94	546.62	5348.78	10.2195	90.	9.	1.	0.	0.	89.	7.	3.	1.	
61893K	4	6500	3449.08	683.81	56.31	45.34	16.37	801.83	4250.91	18.8625	82.	16.	1.	1.	0.	85.	7.	6.	2.	
61893L	4	6600	7904.52	1607.39	93.24	68.72	23.18	1792.52	9697.05	18.4852	81.	17.	1.	1.	0.	90.	5.	4.	1.	
61893M	4	6640	20587.57	2488.27	133.38	87.30	32.64	2741.59	23329.15	11.7518	88.	11.	1.	0.	0.	91.	5.	3.	1.	
61893N	4	6800	726.29	424.60	42.65	40.50	14.36	522.11	1248.40	41.8223	59.	34.	3.	3.	1.	81.	8.	8.	3.	
61893O	4	6900	2734.87	774.13	59.44	54.93	20.09	908.59	3643.46	24.9375	74.	21.	2.	2.	1.	85.	7.	6.	2.	
61893P	4	7000	560.64	206.40	25.99	23.38	8.88	264.65	825.29	32.0675	68.	25.	3.	3.	1.	78.	10.	9.	3.	
61893Q	4	7054	619.86	314.10	71.63	56.11	30.60	472.44	1092.30	43.2518	56.	29.	7.	5.	3.	67.	15.	12.	6.	
61893R	4	7100	2936.35	1126.40	753.31	639.34	622.33	3141.38	6077.73	51.6867	48.	19.	12.	11.	10.	36.	24.	20.	20.	
61893S	4	7200	4894.15	2726.78	1397.37	560.87	744.42	5429.43	10322.58	52.5976	47.	26.	14.	5.	7.	50.	26.	10.	14.	
61893T	4	7300	2191.68	1296.94	458.15	165.61	198.93	2119.63	4311.31	49.1644	50.	30.	11.	4.	5.	61.	22.	8.	9.	
61893U	4	7400	972.92	545.23	714.89	486.15	592.95	2339.22	3312.14	70.6256	29.	16.	22.	15.	18.	23.	31.	21.	25.	
61893V	4	7500	1920.35	1057.81	372.67	241.35	210.51	1882.34	3802.69	49.5002	50.	28.	10.	6.	6.	56.	20.	13.	11.	
61903A	4	7600	1237.20	946.53	318.52	176.00	146.99	1588.04	2825.24	56.2090	44.	34.	11.	6.	5.	60.	20.	11.	9.	
61903B	4	7700	1579.17	1078.56	297.12	179.31	128.05	1683.04	3261.21	51.6078	48.	33.	9.	5.	4.	63.	18.	11.	8.	
61903C	4	7800	769.87	520.57	179.32	143.47	115.95	959.31	1729.18	55.4777	45.	30.	10.	8.	7.	54.	19.	15.	12.	
61903D	4	7900	339.66	84.85	25.67	17.89	13.80	142.21	481.87	29.5121	70.	18.	5.	4.	3.	59.	18.	13.	10.	
61903E	4	8000	1938.97	1053.51	366.96	266.36	238.87	1925.70	3864.67	49.8283	51.	27.	9.	7.	6.	55.	19.	14.	12.	
61903F	4	8100	1814.82	950.12	567.66	288.01	390.60	2196.39	4011.21	54.7563	45.	24.	14.	7.	10.	43.	26.	13.	18.	
61903G	4	8200	1124.88	310.72	249.78	135.86	215.17	911.53	2036.41	44.7616	55.	15.	12.	7.	11.	34.	27.	15.	24.	
61903H	4	8300	346.93	121.35	120.67	62.95	121.14	426.11	774.04	55.0500	45.	16.	16.	8.	16.	28.	28.	15.	29.	
61903I	4	8400	1332.52	319.36	1111.84	497.28	1490.58	3419.06	4750.58	71.9714	28.	7.	23.	10.	31.	9.	33.	15.	43.	
61903J	4	8500	309.90	91.27	227.93	86.89	185.35	591.44	901.34	65.6178	34.	10.	25.	10.	21.	15.	39.	15.	31.	
61903K	4	8600	23865.37	16404.38	1161.11	312.04	602.38	18479.90	42345.27	43.6410	56.	39.	3.	1.	1.	89.	6.	2.	3.	
61903L	4	8700	192.02	5.00	40.57	23.78	65.99	135.34	327.36	41.3428	59.	2.	12.	7.	20.	4.	30.	18.	48.	
61903M	4	8800	261.35	366.07	595.89	136.37	305.29	1403.62	1664.97	84.3030	16.	22.	36.	8.	18.	26.	42.	10.	22.	
61903N	4	8900	455.16	406.92	531.50	112.79	265.55	1316.76	1771.92	74.3126	26.	23.	30.	6.	15.	31.	40.	9.	20.	
61903O	4	9000	329.81	107.76	166.11	39.21	88.94	402.02	731.83	54.9334	45.	15.	23.	5.	12.	27.	41.	10.	22.	
61903P	4	9037	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	*C

B = CUTTINGS NOT ANALYZED *C* = AIR SPACE GAS NOT RUN *BC* = NO ANALYSES RUN

TABLE II

Descriptions of "Picked" Cuttings and of Visual Kerogen, 30/10-2 Samples

(Kerogen by J. L. Morgan)

Depth (ft)	EPR No.	Gross Lithology	GSA Color Code	Kerogen Alteration	Types of Kerogen* Predominant	Secondary	Other	Remarks
3800	61844-G	Siltstone and fine-grained sandstone, olive gray to light gray, some micaeous, some calc.	5Y4/1-N7					
4200	-K	Siltstone, lt. olive gray, poorly sorted, soft, sl. calc.	5Y6/1	1+	W	H	C	
4600	-N	Claystone, med. olive gray	5Y5/1					
4800	-P	Claystone, as above	5Y5/1	1+	W	M	H,C	Mod. pyrite
5200	-T	Shale, olive gray, sl. silty	5Y4/1					
5400	61845-B	Shale, med. olive gray, tr. pyrite	5Y5/1	1+	W	H	C	Mod. pyrite; minor "2+" microfossils
5700	61893-C	Claystone and shale, med. olive gray to greenish gray, tr. pyrite, disaggregates in acid	5Y5/1	1+	W	H	C	Minor "2+" microfoss.
6000	-F	As above, olive gray	5Y4/1					
6300	-I	Shale, dk. greenish gray, tr. pyrite, disaggregates in acid	5GY4/1	1+	H,M	C	W	Abdnt. pyrite; minor "2+" microfoss.
6500	-K	Shale, med. greenish gray	5GY5/1	1+	H,M	C	W	Abdnt. pyrite; minor "2+" microfoss.
6640	-M	Shale, med. olive gray, splintery fracture	5Y5/1	2-	A,W	H	C	Abdnt. pyrite
6900	-O	Shale, med. greenish gray	5GY5/1					
7100	-R	Shale, med. gray to med. greenish gray, rough texture	N5-5GY5/1	1+	A,H	C	W	Abdnt. pyrite; abdnt. spores & pollen
7400	-U	Shale, med. gray, thin laths	N5					
7600	61903-A	Shale, med. dk. gray, thin laths, some micaeous, muddy coatings	N4	1+	A,H	W	C	Abdnt. pyrite; abdnt. spores & pollen
7800	-C	Shale, dark to med. dk. gray, as above	N3-N4					
8000	-E	Shale, as above	N4	1+	H	A,W	C	Mod. pyrite; abdnt. spores & pollen
8300	-H	Shale, as above but with greenish cast	N4					
8500	-J	Shale, med. dk. gray, prismatic laths, splintery	N4	1+	Al,H	C	W	Mod. pyrite; minor "2" microfossils
8700	-L	Shale, med. dk. gray	N4					
8800	-M	Shale with minor siltstone, med. dk. gray to med. gray	N4-N5	2	C	Al?	W	Abdnt. pyrite
9000	-O	Chalk, lt. pinkish gray, and micritic limestone	5YR8/1	2+	C	W	H,M	Considerable "contamination"

* A - Amorphous
Al - Algal
H - Herbaceous
W - Woody
C - Coaly
M - Microplankton

TABLE III

Total Organic Matter and Light Gasolines (C_4 - C_7), 30/10-2 "Picked" Cuttings

(Analyses by H. M. Fry, J. Roy)

Depth (feet)	EPR No.	Total Organic Matter (%)	Total C_4-C_7 (ppm)	Correlation Ratios (See Table III-A) C_1/D_2	A/D_2	C_1/D_2	CH/MCP*
3800	61844-G	1.00	0.	-	-	-	-
4200	-K	1.04	0.	-	-	-	-
4600	-N	.72	0.	-	-	-	-
4800	-P	.81	0.	-	-	-	-
5200	-T	.88	0.	-	-	-	-
5400	61845-B	.85	0.	-	-	-	-
5700	61893-C	.59	.31	.65	21.48	8.30	.20
6000	-F	.59	.39	.76	28.08	11.77	.14
6300	-I	.32	.48	5.96	6.91	40.71	4.96
6500	-K	.31	.91	6.40	6.29	48.43	4.99
6640	-M	.83	.29	3.36	51.24	72.43	2.13
6900	-O	.59	1.01	2.52	16.25	72.02	2.89
7100	-R	.76	.82	.49	2.17	7.31	.65
7400	-U	1.59	7.70	1.57	2.68	19.16	1.54
7600	61903-A	1.83 (muddy)	24.8	.77	2.25	23.60	1.50
7800	-C	1.96	17.0	1.47	1.33	9.91	1.47
8000	-E	1.54	18.0	1.39	3.48	20.50	1.50
8300	-H	1.26	9.77	1.65	5.92	11.32	1.69
8500	-J	1.04	5.98	2.60	6.18	7.22	2.00
8700	-L	.88	7.14	3.76	6.46	7.69	2.96
8800	-M	.74	2.85	8.22	4.68	9.40	5.45
9000	-O	.67	0.	-	-	-	-

* CH - cyclohexane
MCP - methylcyclopentane

TABLE III-A

DEFINITION OF SIGNIFICANT GASOLINE RATIOS

Light Gasoline Compounds Determined by Gas Chromatography

1. Pentane
2. Hexane
3. Heptane
4. Iso-Pentane
5. 2-Methylpentane
6. 3-Methylpentane
7. 2,3-Dimethylbutane
8. 2,2-Dimethylbutane
9. 3-Methylhexane
10. 2-Methylhexane + 1,1-Dimethylcyclopentane
11. 2,3-Dimethylpentane
12. 2,4-Dimethylpentane
13. 2,2-Dimethylpentane
14. 2,2,3-Trimethylbutane
15. 2,2,4-Trimethylpentane
16. Cyclopentane
17. Methylcyclopentane
18. 1-c-3-Dimethylcyclopentane
19. 1-t-3-Dimethylcyclopentane
20. 1-c-2-Dimethylcyclopentane
21. 1-t-2-Dimethylcyclopentane + 3-Ethylpentane*
22. Cyclohexane + 3,3-Dimethylpentane*
23. Methylcyclohexane
24. Benzene
25. Toluene

Significant Groupings of Molecular Data

A. Hexane + Heptane

B. Pentane + iso-Pentane + 2-Methylpentane + 3-Methylpentane

C. Naphthenes

C_1 2-Methylhexane + 1 , 1-Dimethylcyclopentane* + Cyclohexane + 3,3-Dimethylpentane* + Methylcyclohexane

C_2 Methylcyclopentane + 1-c-3-Dimethylcyclopentane + 1-t-3-Dimethylcyclopentane + 1-c-2-Dimethylcyclopentane + (1-t-2-Dimethylcyclopentane + 3-Ethylpentane)*

D. Aromatics Plus 3-Methylhexane

D_1 Benzene + Toluene

D_2 3-Methylhexane

*Analyzed together by gas chromatography.

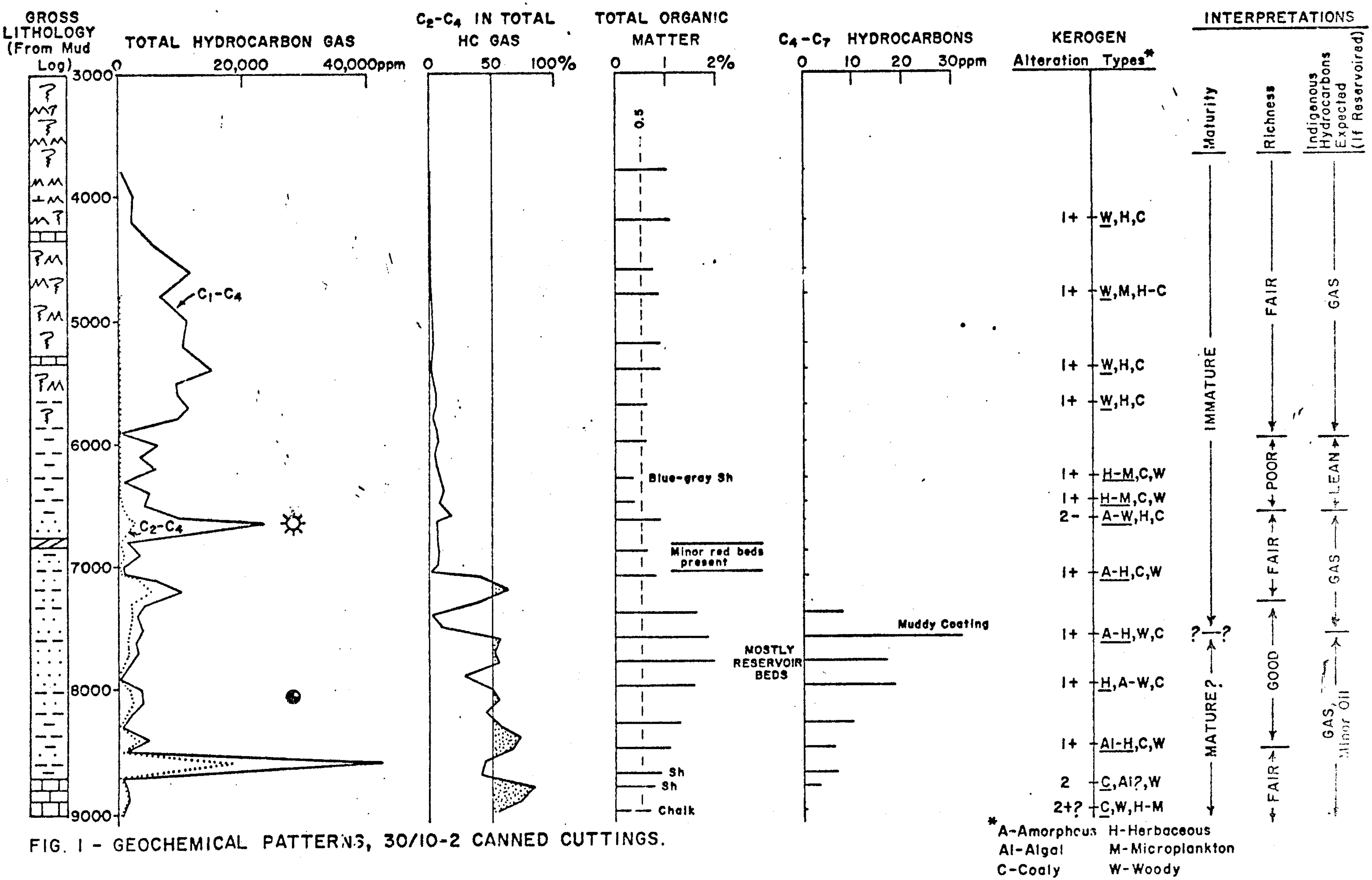

FIG. I - GEOCHEMICAL PATTERNS, 30/10-2 CANNED CUTTINGS.