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GeoChem Laboratories (U.K.) Limited

GEOCHEMICAL SERVICE REPORT

Prepared for

NORSK HYDRO

PARTIAL GEOCHEMICAL EVALUATION OF
NORSK HYDRO'S 33/5-2 WELL

BA 82-6024-1

April 1982

CHESTER STREET · CHESTER CH4 8RD · ENGLAND

Source Rock

PARTIAL GEOCHEMICAL EVALUATION OF NORSK HYDRO'S 33/5-2 WELL

SUMMARY

The shales and silty shales which dominate the section between 2000 metres and T.D. in 33/5-2 generally display relatively little variation in organic richness. Detailed analyses were not authorised for these sediments, but they are probably only poor to fair source rocks which are just mature below 4050± metres. They could not yield economically significant hydrocarbon accumulations.

Oil prone organic matter would be marginally mature below 3150± metres and mature (not oil window) below 4050± metres.

However, interbeds of brownish grey are present within the interval 3905-4060± metres and extend, as minor interbeds, down to 4140± metres and even down to 4340± metres. These sediments have very good organic carbon contents but the character of their organic matter is variable. As a result, they are potentially very good source rocks for (light) oil above 3950± metres, good source rocks for gas and condensate at 3950-4060± metres, but only poor to fair source rocks below this depth. Clearly, the shallowest of these shales are both the richest and the most oil-prone on-structure and they are just mature enough for the initiation of significant hydrocarbon generation.

Indeed, there is a strong show of medium gravity crude at 3905-4060± metres (with a diffusion halo up to 3840± metres) and a show of a second crude at (4090)4200-4270± metres. Weak shows of liquid hydrocarbons which were not characterised occur down to 4430± metres and especially at 4370-4400± metres.

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INTRODUCTION

This report presents a geochemical evaluation of the section between 2000 metres and 4520 metres in Norsk Hydro's 33/5-2 well, drilled offshore Norway.

The analytical format was specified by Norsk Hydro and was designed to:-

a) investigate the hydrocarbon source potential of the sediments
b) detected and characterise shows of migrated hydrocarbons.

This project was authorised by S.I. Leivestad, Norsk Hydro A.S., Oslo.

A. ANALYTICAL

Ninety two (92) canned ditch cutting samples were received from 33/5-2. Those from 2000-3600 metres were collected on an interval of fifty (50) metres whilst below this depth, a fifteen (15) metre interval was employed (composites below 4445 metres). A mud sample from an unspecified depth but possibly from the interval 4215-4430± metres was also included in the study. These samples were assigned the Geochem job number 584.

No significant contamination was observed during the preparation steps, but significant proportions of lost circulation material were commonly present in the samples from below 4325 metres.

Geochem were instructed to screen the samples (using alternate samples at 3650-3890 metres) with the light hydrocarbon (C_1-C_7) and organic carbon analyses and to perform a specified number of vitrinite reflectance determinations. These results were submitted to Norsk Hydro and Mr. Leivestad specified the samples for further analysis. It was not always possible to hand-pick individual lithologies for separate extraction.

A total of ninety three light hydrocarbon analyses, one hundred and eighty organic carbon analyses, thirty eight vitrinite reflectance determinations, eleven kerogen analyses, eleven extractions with chromatography, eleven high resolution paraffin-naphthene analyses, eleven pyrolysis analyses and eleven pyrolysis-GC analyses were performed in this study. The data are presented in tables 1 through 8 and graphically in figures 1 through 7. A brief description of the analytical techniques employed in this study is included in the back of this report.

B. GENERAL INFORMATION

Ten (10) copies of this report have been forwarded to S.I. Leivestad, Manager Operations Geology at Norsk Hydro A.S. The kerogen slides prepared for this study were included with the reports. A copy of the data has been retained by Geochem for future consultation with authorised Norsk Hydro personnel.

The remaining sample material will be handled as directed.

All of the results relating to this study are proprietary to Norsk Hydro A.S.

RESULTS AND INTERPRETATION

Each of the parameters relevant to the geochemical evaluation of these sediments will be considered in turn and then combined to form the "Conclusions".

No well logs were available for this study, but a gross breakdown by age was provided by Norsk Hydro.

A. ZONATION

This zonation is based upon a synthesis of the light hydrocarbon (C_1-C_7) and organic carbon results. Seven (7) zones are recognised and appear to correlate, very approximately, with the age of the sediments.

Zone A^1 2000 metres to 3525± metres, is believed to be Upper Cretaceous inage. It is dominated by medium grey and medium light grey shaly mudstones above 3325± metres and by dark grey shaly siltstones below this depth. There is a minor shaly coal at 3100± metres.

The C_1-C_4 gaseous hydrocarbons range from (163)286 ppm up to 1168(2588) ppm and are generally marginally wet at (7.1)15.0-49.7% C_{2+}. The very wet gases (87% C_{2+}) from 2150-2200± metres are associated with very low methane abundances but their low isobutane to normal butane ratios (and the slight C_5-C_7 kick at 2200 metres) do not support the concept of loss of methane through can leakage. Ignoring these samples, the butane ratios drop at 2425± metres from more than 1.0 to the general range of 0.4-0.8. The C_5-C_7 hydrocarbons are sparse above 2425± metres, but then normally lie within the limits of 122-600 ppm, but reach 1093-1335 ppm at 2550-2600 metres.

Zone A^2 3525± metres to 3665± metres is apparently, like Zone A^3, Lower Cretaceous in age. It is composed of dark grey and brownish grey siltstones with interbedded medium dark grey shales.

This interval is richer than Zone A^1, with 1750-4356 ppm and (1703)3056-3862(6041) ppm of the C_1-C_4 and C_5-C_7 hydrocarbons respectively. The richest sample is that from 3660 metres. Isobutane to normal butane ratios now approximate 0.25, but the gases are only 25-29(39)% wet.

Zone A^3 lies between 3665± metres and 3905± metres and is dominated by medium dark grey to medium grey shales. Minor interbeds of dusky greyish red shale appear below 3795± metres and there are a few minor limestones.

No fluorescence was observed.

Geochemically, there is a break at 3835± metres. Above this depth the gaseous hydrocarbons vary rather erratically from 459 ppm up to 1939(3537) ppm and are generally 34-41(46%) wet. Butane ratios of 0.3-0.5 jump to 1.0-2.8 below 3800± metres. With the exception of the uppermost sample, the C_5-C_7 hydrocarbon fraction ranges from 0 ppm up to 690 ppm and is lowest below 3790± metres. There is a significant change below 3835± metres, as the gases are now more abundant (2527-3959 ppm), wetter (48-76% C_{2+}) and have lower butane ratios (0.3). The C_5-C_7 hydrocarbons increase with depth from 748 ppm to 5205 ppm.

Zone B extends from 3905± metres down to 4060± metres and is believed to be Upper Jurassic in age. It consists of interbedded medium dark grey shales and brownish grey silty shales with minor greyish brown shales.

This unit is rich and very wet. The C_1-C_4 gases jump to 26527-46517 ppm and are 83.6-91.9% wet, whilst the C_5-C_7 fraction lies within the range of 17622-37277(48093) ppm.

Zone C 4060± metres to 4270± metres, is largely composed of medium dark grey shales which are grossly Middle Jurassic in age. Relatively minor very dark brownish grey and greyish blackish red shales are also present, whilst interbeds of sandstone occur below 4160± metres.

No fluorescence was detected in the sands.

Gas abundances of 10333-17921 ppm above 4110± metres drop to 1343-7882 ppm before increasing with depth, below 4220± metres, from 13197 ppm to 55407 pm. The gases are still 66-90% wet, although they do not exceed 70% and 79% in the richer intervals at the top and bottom of the zone. Butane ratios generally approximate 0.3. The heavier C_5-C_7 hydrocarbons normally lie within the limits of (1660)2716-8312(12704) ppm but reach 21032-39479 ppm at 4095 metres and below 4220± metres (again, increasing in abundance with depth).

Zone D 4270± metres to 4430± metres, corresponds to the top of the Lower Jurassic. It is composed of dark grey to medium dark shales and pale yellowish orangish brown mudstones above 4320± metres and of medium dark grey silty shales below this depth, passing into sands at 4420± metres. The "coals" within this interval are believed to be a lignite mud additive.

No fluorescence was detected in the sandstone.

The C_1-C_4 gases range from (542)1358 ppm up to 7746 ppm, peaking at 4370-4385± metres and are 69-92% wet. The C_5-C_7 fraction generally lies within the limits of 1599-5707 ppm but reaches 8026-10333 ppm at 4370-4400± metres.

Zone E extends from 4430± metres down to 4520 metres and comprises sands with, at 4505-4520 metres, a moderate brown siltstone. Lost circulation material tends to be fairly abundant in these samples.

No fluorescence was observed.

In contrast to Zone D, the gases are relatively sparse (112-464 ppm), drier (13.5-33.5(49.8)% C_{2+}) and tend to have higher isobutane to normal butane ratios. The C_5-C_7 hydrocarbons decrease with depth from 1635 ppm to 76 ppm and are presumably entrained in the mud.

B. AMOUNT AND TYPE OF ORGANIC MATTER

The amount of organic matter within a sediment is measured by its organic carbon content. Average shales contain approximately one percent organic carbon, and this is the standard to which these samples will be compared.

Organic matter type influences not only source richness but also the character of the hydrocarbon product (oil, gas) and the response of the organic matter to thermal maturation. Richness and oiliness decrease in the order: amorphous-algal-herbaceous-woody. Wood has a primary (but not exclusive) potential for gas whilst inertinitic (oxidised, mineral charcoal) material has only a limited hydrocarbon potential.

The shaly mudstones of Zone A^1 contain 0.29-0.60(0.82)% organic carbon. On average, the basal shaly siltstones are richer at 0.57-0.65% and maintain similar values of (0.40)0.57-0.72% organic carbon throughout Zone A^2, where they are comparable to the interbedded shales (0.49-0.65%). This pattern continues throughout Zone A^3 where the dominant shales contain (0.34)0.40-0.64% organic carbon, although the relatively minor dusky greyish red shales and limestones are significantly leaner at 0.13-0.34% and 0.12-0.24(0.40)% organic carbon respectively.

All of these sediments are of below-average richness. The minor shaly coal at 3100 metres is rich (39.80%) but is not indigenous to the section. No kerogen determinations were authorised for Zones A^1 through A^3.

In Zone B, the medium dark grey shales are of similar richness to those discussed above at 0.48-75(1.04)% organic carbon and the minor greyish brown shales are lean, containing only 0.04-0.23(0.56)% organic carbon. However in contrast, the brownish grey silty shales have very good values of (2.84)3.60-4.61(5.30)% organic carbon. Their organic matter is variable in type. Above 3950± metres they are characterised by an amorphous and algal assemblage, but with fairly significant proportions of inertinitic debris. However below this depth, although the algal, amorphous±woody fractions are significant, inertinite is the most abundant constituent.

Relatively minor interbeds of very dark brownish grey shale occur throughout Zone C and down to 4340± metres in Zone D and contain 1.45-3.33(5.27)% and 2.20-3.02% organic carbon respectively. Their organic matter is a mixed inertinitic-amorphous-woody±algal assemblage which, as in the Zone B shales below 3950± metres, includes significant reworked material. However, the dominant medium dark grey shales of Zone C are significantly leaner at (0.25)0.39-0.69(0.92)% organic carbon. Thus they resemble those of Zone B and the same is true of the relatively minor greyish blackish red shales (0.06-0.29% organic carbon).

In Zone D, the dark grey to medium dark grey shales and the pale yellowish brown mudstones above 4320± metres contain 0.83-0.90% and 0.43-0.68% organic carbon respectively, whilst the medium dark grey silty shales below this depth are slightly richer at 0.81-1.22(1.55)% organic carbon. Thus, ignoring the rich very dark brownish grey shales, Zone D is richer than Zone C and indeed, is of approximately average richness.

The moderate brown silt at the base of Zone E contains 0.65% organic carbon.

The minor "coals" within Zones D and E resemble a lignite mud additive and generally have values of 14.25-18.96% organic carbon. However, that from 4415 metres in Zone D is much richer at 40.54%.

Kerogen determinations were only authorised for the rich shales in Zones B, C and the top of Zone D.

C. LEVEL OF THERMAL MATURATION

Thermal maturity has been evaluated with the organic matter (spore) colouration and vitrinite reflectance techniques. Spore colouration determinations were only performed within the interval 3915-4340 metres but vitrinite measurements were made throughout the analysed section.

The indigenous organic matter achieves a colouration thermal index of 2 at 4050± metres. Oil prone organic matter is marginally mature (minor hydrocarbon generation) and mature (significant generation, not oil window) above and below 4050± metres, but the woody-inertintic fraction only becomes marginally mature at this depth. In view of the change in organic matter type at 3950± metres, the "rich" very dark brownish grey shales below 4050± metres should be regarded as transitional between the marginally mature and mature states.

The vitrinite reflectance data apparently only indicate a gross trend of increasing reflectivity with depth. However, it is clear that drilling-introduced lignite is common below 4170± metres and that much of the woody organic matter in Zone D is reworked. When the data points referring to these vitrinite populations are removed, a good trend line can be drawn through the data from 2000 metres, 2400 metres and below 3850± metres. This line indicates values of 0.45% Ro and of 0.53% Ro at depths of 3150± metres and of 4000± metres respectively. A reflectivity of 0.53% Ro should be equivalent to a thermal index of 2 and hence, there is an excellent correlation between the two methods.

Minor hydrocarbon generation can be anticipated from good quality organic matter below 3150± metres.

The shaly coal from 3100 metres in Zone A^1 resembles drilling introduced lignite in reflected light, although the morphology of the rock particles suggest instead, that it must be caved.

D. SOURCE RICHNESS

A preliminary interpretation of source richness based upon organic carbon abundances suggests that the dominant sediments of Zones A^1 through A^3 are potentially poor to fair (perhaps fair in Zones A^2 and A^3) source rocks. The medium dark grey shales of Zones B and C are rated as fair and poor to fair respectively, but the interbedded brownish grey shales are potentially very good source rocks. In Zone D the major medium dark grey shales and silty shales are apparently fair or fair to good source rocks.

Extractions were authorised for a selection of the richer brownish grey shales from Zones B and C. The sample from 4340 metres in Zone D was also extracted but, in this case, the bulk sample (which included finely-ground lignite) had to be employed. The shales from Zone B yielded 2701-3168(4426) ppm C_{15+} hydrocarbons, whilst 1189-1944 ppm C_{15+} hydrocarbons (with higher paraffin-naphthene to aromatic ratios) were obtained from Zone C (and D). In all of these samples, the hydrocarbons constitute between 42.6% and 70.4% of the total extract. These values suggest non-indigenous hydrocarbons and this hypothesis is confirmed by the paraffin-naphthene chromatograms, which are all too mature. Indeed, the samples from 3990-4025± metres contain a medium gravity crude oil, and it is likely that this oil is also present in the shallower samples. A different crude oil occurs at 4260 metres. Between 4065± metres and 4215± metres the chromatograms show some features indicative of source-indigenous hydrocarbons but overall, are too mature, and the isoparaffins suggest traces of the underlying crude oil below 4090± metres and particularly below 4140± metres. The normal paraffins in the chromatogram from 4340 metres indicate the presence of both contamination (gas-oil ?) and of rather immature source-indigenous hydrocarbons. This sample does of course, contain lignite.

The C_{15+} hydrocarbon abundances rate these shales as potentially very good source rocks but, in view of the widespread occurrence of non-indigenous species, these ratings must be treated with caution.

The pyrolysis analysis was run upon the same suite of brownish grey shale samples. This technique evaluates source richness under optimum maturity conditions. Pyrolysate abundances decrease with depth from approximately 6700 ppm above 3950± metres, to 3415-4188 ppm at 3990-4035± metres and to 1952-2886 ppm at 4065-4260± metres, before returning to 6827 ppm at 4340 metres. These values display a very gross relationship towards organic richness. The pyrolysate to organic carbon ratios are rather low suggesting that the total organic matter is not of good quality. Indeed, due to the high organic carbon contents of these shales, the following are the best ratings that can be applied to them:

- above 3950± metres and at 4340 metres, very good source rocks.
- 3990± metres to 4035± metres, good.
- 4065± metres to 4260± metres, poor to fair source rocks.

Chromatograms of the pyrolysate material define whether a sediment will yield oil, condensate or gas. The samples specified for analysis in this study belong to two basic groups. In the first the chromatograms extend out to approximately C_{25} and, although they exhibit a front-end dominance, are characterised by good normal alkene-alkane doublets. These samples will, when mature, yield a (light) oil. In the second group, the chromatograms "die" at about C_{20} and, although the lighter doublets are evident, the peaks of the aromatic compounds are dominant. These sediments have a potential for gas and condensate.

The organically rich brownish grey shales from above 3950± metres have a potential for (light) oil. Those from 3990-4260± metres will generally yield gas and condensate, although they are rather more condensate or light oil prone at 4065-4095± metres. Finally, the lignite-containing sample from 4340 metres is gas-prone.

E. MIGRATED HYDROCARBONS

No fluorescence was observed within this section.

The light hydrocarbon data suggest the presence of insignificantly minor traces of wet gas at 2150-2200± metres in Zone A^1 and it is possible but not certain that there could be minor shows elsewhere above 3830± metres (e.g. Zone A^2). In contrast, there is a strong show of liquid hydrocarbons in Zone B with an interesting diffusion gradient extending upwards into Zone A^3 which exhibits a progressive depletion in the gasoline-range fraction until, at 3840 metres, only wet gas (without the butanes) is present. Shows are also suggested throughout Zone C, particularly at 4095± metres and 4200-4270± metres, whilst there are weak shows in Zone D, especially at 4370-4400± metres.

C_{15+} data are only available for the organically rich brownish grey shales from Zones B and C. In conjunction with the paraffin-naphthene chromatograms, a show of medium gravity crude oil is indicated at 3990-4025± metres (see Section D) and it is likely that this oil is also present up to the top of Zone B. A different medium gravity crude (isoparaffin fingerprints) occurs at 4260 metres and traces of this oil are probably present up to 4090± metres and particularly up to 4140± metres.

The available C_{15+} data confirm the shows deduced from the light hydrocarbon results.

F. CONCLUSIONS

Seven (7) zones are recognised between 2000 metres and 4520 metres (TD) in 33/5-2, although only a partial suite of analyses were authorised, particularly above 3900± metres. Below this depth, only the richer shales were completely analysed.

Zones A^1 (2000-3525± metres), A^2 (3525-3665± metres) and A^3 (3665-3905± metres) are understood to be Upper Cretaceous (Zone A^1) and Lower Cretaceous in age. The major shales within this gross interval generally contain 0.40-0.65% organic carbon. On average, they tend to be richest in Zone A^2 within which zone, the dominant shaly siltstones have slightly enhanced values of (0.40)0.57-0.72% organic carbon. Without further analyses it is difficult to be certain about the hydrocarbon source potential of these sediments, but they are probably poor to fair and rather uninteresting source rocks which are effectively immature (assuming woody-inertinitic organic matter below 3150± metres).

Minor hydrocarbon generation would be expected from good quality organic matter below 3150± metres.

Insignificantly minor traces of wet gas are indicated at 2150-2200± metres and there could be traces elsewhere within this gross interval and especially in Zone A^2, but none of them merit the term "show".

Zone B (3905-4060± metres) is believed to be Upper Jurassic in age. The medium dark grey shales resemble those within Zones A^1 through A^3 but the interbedded brownish grey silty shales are dramatically different. They contain (2.84)3.60-4.61(5.30)% organic carbon, whilst their organic matter varies from an amorphous-algal assemblage above 3950± metres to inertinitic (with significant algal, amorphous±woody debris) below this depth. Fairly significant hydrocarbon generation has just started to occur in these silty shales. Above 3950± metres they are potentially very good source rocks for (light) oil but below this depth, although they are more abundant, are only good source rocks with a potential not for oil but for gas and condensate. If fully mature, these sediments could generate significant hydrocarbon accumulations in associated reservoirs. The interbedded medium dark grey to medium grey shales, which tend to dominate the zone above 3980± metres, have lower values of 0.48-0.75(1.04)% organic carbon and are probably (at best) only fair source rocks.

There is a strong show of medium gravity crude oil in Zone B. Diffusion has occurred upwards into Zone A^3 and there is progressive depletion of the "heavier" ends until, at 3840 metres, only wet gas (without the butanes) is present. The lateral equivalents of the Zone B silty shales constitute the likely source for these hydrocarbons.

Zone C (4060-4270± metres, grossly Middle Jurassic) is dominated by medium dark grey shales which contain (0.25)0.39-0.69(0.92)% organic carbon and are probably only poor source rocks which are just mature. The minor greyish blackish red shales (as in Zones A^3 and B) are lean, but relatively minor interbeds of very dark brownish grey shale are also present. At 1.45-3.33(5.27)% organic carbon these are not as rich as their equivalents in Zone B and their organic matter is a mixed inertinitic-amorphous-woody±algal assemblage which includes significant proportions of reworked material. As a result, they are only poor to fair source rocks with a potential for gas and condensate which are only just mature. They are also limited by volume, but this is rather academic.

Significant hydrocarbon generation can be anticipated from oil-prone organic matter below 4050± metres.

Zone D (4270-4430± metres) corresponds to the top of the Lower Jurassic. The interbeds of pale yellowish brown mudstone above 4320± metres contain 0.43-0.68% organic carbon but otherwise, the shales and silty shales of this zone have values of 0.83-1.22(1.55)% organic carbon. No detailed analyses were performed upon these sediments but they are probably potentially fair source rocks. The minor very dark brownish grey shales above 4340± metres have better values of 2.20-3.02% organic carbon. They are rated as potentially very good source rocks within which significant hydrocarbon generation has occurred, but are apparently too limited in volume to be effective. The scattered "coals" within Zones D and E are believed to be a lignite mud additive.

Zone E (4430-4520± metres) is totally dominated by sandstones and, although there is a silt in the lowermost sample, is not considered to be an effective source.

There is a show of medium gravity crude at 4200-4270± metres in Zone C, with scattered weaker shows extending up to at least 4090± metres. This oil is not the same as that in Zone B. Weak shows of liquid hydrocarbons are present in Zone D (especially at 4370-4400± metres) but, in the absence of C_{15+} data these cannot be characterised.

TABLE 1A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-001	2000-2050	203	25	33	10	8	278	75	27.0	3	1.32
584-002	2100	885	30	17	4	3	938	53	5.7	0	1.70
584-003	2150	32	32	17	6	21	109	76	70.5	0	0.30
584-004	2200	21	32	22	14	41	131	109	83.6	62	0.34
584-005	2250	27	19	13	7	17	83	56	67.8	0	0.43
584-006	2300	174	5	3	2	1	185	11	5.8	0	2.50
584-007	2350	392	12	17	13	6	440	48	10.9	15	1.96
584-008	2400	370	15	24	18	11	438	68	15.5	12	1.56
584-009	2450	308	11	21	17	18	375	67	17.9	118	0.94
584-010	2500	685	22	40	26	30	802	118	14.7	380	0.88
584-011	2550	560	27	58	36	75	756	197	26.0	234	0.48
584-012	2600	414	13	26	16	32	500	86	17.3	127	0.49
584-013	2650	264	12	24	13	28	340	77	22.5	99	0.47
584-014	2700	687	18	29	12	21	768	80	10.5	77	0.55
584-015	2750	855	21	30	13	25	944	90	9.5	94	0.53
584-016	2800	119	9	19	7	12	167	47	28.3	97	0.57
584-017	2850	108	7	22	11	17	165	57	34.5	61	0.63
584-018	2900	139	8	22	10	14	192	53	27.6	2	0.71
584-019	2950	163	14	38	4	16	234	72	30.5	231	0.24
584-020	3000	172	12	22	10	12	228	57	24.8	52	0.78
584-021	3050	172	19	36	15	17	258	86	33.4	0	0.90
584-022	3100	333	35	50	18	19	455	122	26.7	0	0.95
584-023	3150	571	61	72	30	32	765	195	25.4	143	0.94
584-024	3200	175	30	30	13	15	263	88	33.4	34	0.88
584-025	3250	165	31	34	14	15	259	93	36.1	0	0.96
584-026	3300	255	50	34	8	16	364	109	29.9	133	0.51
584-027	3350	370	61	37	5	25	498	128	25.7	117	0.22
584-028	3400	215	28	21	6	7	276	61	22.2	73	0.82
584-029	3450	409	75	47	10	19	561	152	27.1	2	0.50
584-030	3500	506	47	17	4	13	587	80	13.7	49	0.31

TABLE 1A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
584-031	3550	645	115	47	11	33	850	206	24.2	170	0.32
584-032	3600	1066	151	60	12	40	1330	264	19.8	426	0.31
584-033	3615	1866	296	128	26	90	2406	540	22.4	1016	0.29
584-034	3630	1197	222	103	21	77	1620	423	26.1	1082	0.27
584-035	3645	1237	441	256	52	213	2199	962	43.8	2915	0.25
584-036	3660	2585	484	237	62	235	3604	1018	28.3	3969	0.26
584-037	3675	139	109	21	2	10	282	142	50.5	347	0.25
584-038	3690	472	641	85	4	14	1216	745	61.2	88	0.30
584-039	3705	200	110	17	2	6	334	135	40.3	134	0.33
584-040	3720-3735	218	139	21	1	2	380	163	42.8	244	0.47
584-041	3750	1174	492	34	1	5	1706	532	31.2	162	0.27
584-042	3750-3765	221	85	5	0	1	312	91	29.0	107	0.39
584-043	3780	406	160	7	1	1	574	169	29.4	152	0.75
584-044	3795	314	136	5	0	0	455	141	31.0	85	0.35
584-045	3810	820	381	13	0	0	1215	394	32.5	0	0.00
584-046	3825	2164	1020	31	3	1	3219	1055	32.8	19	2.84
584-047	3840	198	311	0	0	0	508	311	61.1	0	0.00
584-048	3855	871	625	232	19	47	1795	923	51.5	218	0.40
584-049	3870	767	640	280	25	60	1773	1006	56.7	246	0.41
584-050	3885	1775	687	243	33	92	2830	1055	37.3	643	0.36
584-051	3900	328	233	221	46	155	984	656	66.6	571	0.30
584-052	3915	2722	3284	4179	1101	3888	15173	12452	82.1	4665	0.28
584-053	3930	3602	4637	6344	1303	5097	20982	17380	82.8	10459	0.26
584-054	3945	3535	6866	13976	2671	11155	38202	34667	90.7	23326	0.24
584-055	3960	3278	3464	4197	1357	4287	16584	13306	80.2	8801	0.32
584-056	3975	1371	1286	1470	364	1374	5865	4494	76.6	2629	0.26
584-057	3990	4375	5509	6884	3444	8638	28851	24476	84.8	20154	0.40
584-058	4005	3469	3684	4327	1765	5055	18301	14832	81.0	6200	0.35
584-059	4020	5704	6723	7870	2326	7349	29972	24268	81.0	10039	0.32
584-060	4035	2085	3896	5524	1134	4451	17090	15004	87.8	7629	0.25

TABLE 1A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-061	4050	2320	3068	4765	880	3367	14401	12080	83.9	13352	0.26
584-062	4065	3481	2952	2490	310	1066	10298	6817	66.2	3067	0.29
584-063	4080	5181	4037	3468	469	1295	14450	9269	64.1	3359	0.36
584-064	4095	2535	2298	1731	195	591	7349	4814	65.5	1668	0.33
584-065	4110	3195	2564	2130	234	783	8907	5712	64.1	2104	0.30
584-066	4125	1607	1200	1059	136	435	4436	2830	63.8	874	0.31
584-067	4140	24	14	9	1	5	53	29	54.9	14	0.32
584-068	4155	76	63	62	9	32	241	165	68.5	50	0.27
584-069	4170	1854	1042	689	104	335	4024	2169	53.9	1274	0.31
584-070	4185	14	8	5	1	2	31	16	53.2	7	0.37
584-072	4215	987	905	839	157	480	3368	2381	70.7	2047	0.33
584-073	4230	2375	1818	1978	692	1853	8717	6342	72.8	4346	0.37
584-074	4245	9538	7008	6403	1448	3591	27988	18450	65.9	15155	0.40
584-075	4260	14163	13207	12801	2799	7894	50863	36700	72.2	28066	0.35
584-076	4280	373	369	220	28	81	1070	697	65.1	1014	0.34
584-077	4295	12	15	22	5	28	83	70	84.9	575	0.19
584-078	4310	222	574	1116	175	596	2681	2460	91.7	2040	0.29
584-079	4325	987	864	837	127	370	3184	2197	69.0	1012	0.34
584-080	4340	472	387	395	61	168	1484	1011	68.2	1097	0.37
584-081	4355	562	573	973	303	748	3160	2598	82.2	1688	0.41
584-082	4370	670	650	1284	413	1020	4037	3367	83.4	3873	0.40
584-083	4385	1654	988	1085	306	709	4742	3089	65.1	2029	0.43
584-084	4400	224	192	321	101	249	1086	862	79.4	1295	0.40
584-085	4415	156	181	325	83	231	976	820	84.0	1127	0.36
584-086	4430	64	95	170	32	88	449	385	85.7	548	0.36
584-087	MUD	113	19	12	2	10	157	44	27.8	477	0.16
584-088	4445	36	16	19	2	10	83	47	57.0	315	0.24
584-089	4445-4460	116	26	14	3	10	170	53	31.5	105	0.28
584-090	4460-4475	179	27	11	3	4	224	46	20.3	489	0.77

TABLE 1A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-091	4475-4490	101	15	7	3	3	128	27	21.4	99	0.83
584-092	4490-4505	114	16	4	2	4	139	26	18.4	230	0.42
584-093	4505-4520	36	10	6	1	2	54	18	33.9	1	0.60

TABLE 1B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
584-001	2000-2050	20	5	6	4	4	39	19	49.5	0	0.85
584-002	2100	49	7	6	3	3	67	18	27.3	0	1.29
584-003	2150	1	20	18	5	99	143	142	99.0	0	0.05
584-004	2200	1	6	5	2	19	33	32	98.4	5	0.10
584-005	2250	62	9	10	6	7	94	32	33.8	0	0.85
584-006	2300	109	13	14	8	6	149	40	26.9	8	1.33
584-007	2350	80	12	10	12	6	120	39	32.7	9	2.05
584-008	2400	62	10	9	15	9	106	44	41.4	6	1.66
584-009	2450	93	15	25	38	41	213	120	56.1	135	0.92
584-010	2500	117	19	35	42	75	288	171	59.4	181	0.56
584-011	2550	106	14	8	42	77	247	140	56.9	1101	0.54
584-012	2600	161	32	69	86	192	540	379	70.2	966	0.45
584-013	2650	62	18	25	26	64	195	133	68.1	214	0.40
584-014	2700	114	19	33	27	63	256	142	55.4	178	0.43
584-015	2750	104	19	24	22	54	223	119	53.5	453	0.41
584-016	2800	54	17	25	21	45	161	107	66.2	454	0.46
584-017	2850	49	17	16	13	25	120	71	59.0	356	0.51
584-018	2900	49	13	17	16	29	124	75	60.3	391	0.57
584-019	2950	75	18	20	15	27	155	80	51.4	28	0.54
584-020	3000	80	18	19	11	21	150	70	46.4	94	0.53
584-021	3050	76	18	34	32	43	203	127	62.5	24	0.75
584-022	3100	78	18	24	30	31	180	102	56.8	31	0.96
584-023	3150	154	36	41	32	42	306	152	49.6	34	0.76
584-024	3200	35	10	11	8	10	73	39	52.7	88	0.74
584-025	3250	69	20	25	24	27	165	96	58.0	68	0.90
584-026	3300	99	16	10	4	9	138	39	28.6	7	0.48
584-027	3350	1831	155	51	12	41	2090	259	12.4	483	0.29
584-028	3400	621	52	18	11	8	709	88	12.4	351	1.43
584-029	3450	170	14	14	63	71	332	162	48.9	40	0.89
584-030	3500	444	52	20	7	25	549	105	19.1	21	0.29

TABLE 1B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-031	3550	633	101	60	19	87	900	267	29.6	1534	0.22
584-032	3600	1067	191	119	42	171	1590	523	32.9	2930	0.24
584-033	3615	539	93	60	24	100	816	277	33.9	2040	0.24
584-034	3630	667	119	67	20	88	960	294	30.6	2393	0.23
584-035	3645	708	132	74	14	71	998	290	29.0	947	0.19
584-036	3660	495	91	62	18	87	753	258	34.3	2071	0.21
584-037	3675	325	52	19	15	28	440	115	26.2	1430	0.55
584-038	3690	65	91	60	9	11	236	171	72.4	0	0.84
584-039	3705	69	37	12	1	4	124	55	44.3	386	0.31
584-040	3720-3735	61	47	17	1	8	135	74	54.8	445	0.17
584-041	3750	82	116	28	3	4	233	152	65.0	0	0.63
584-042	3750-3765	86	60	12	1	2	161	75	46.5	262	0.52
584-043	3780	82	76	15	1	20	194	112	57.8	428	0.07
584-044	3795	96	74	0	0	0	170	74	43.4	0	0.00
584-045	3810	119	94	12	1	1	228	109	47.6	0	1.04
584-046	3825	159	144	15	0	0	318	159	49.9	0	0.00
584-047	3840	103	410	57	0	0	571	468	82.0	0	0.00
584-048	3855	226	326	209	17	59	837	611	73.0	530	0.28
584-049	3870	176	292	292	26	113	899	723	80.4	583	0.23
584-050	3885	268	559	213	20	70	1130	861	76.3	1193	0.29
584-051	3900	268	365	432	91	386	1543	1274	82.6	4634	0.24
584-052	3915	379	1404	6150	1479	7643	17055	16676	97.8	12957	0.19
584-053	3930	256	679	2393	638	3495	7461	7205	96.6	8871	0.18
584-054	3945	197	428	2412	758	4102	7898	7701	97.5	9427	0.18
584-055	3960	339	1380	4264	927	5118	12028	11689	97.2	13563	0.18
584-056	3975	893	2720	7579	1907	8977	22076	21183	96.0	18543	0.21
584-057	3990	182	1454	6321	1641	8068	17666	17484	99.0	17123	0.20
584-058	4005	850	2677	7751	2082	9437	22798	21948	96.3	16100	0.22
584-059	4020	315	1074	3741	1068	518	6716	6401	95.3	15927	2.06
584-060	4035	421	793	2999	910	4315	9438	9017	95.5	12694	0.21

TABLE 1B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-061	4050	1322	1614	5202	1829	7609	17576	16254	92.5	34741	0.24
584-062	4065	60	101	156	35	153	506	446	88.2	644	0.23
584-063	4080	204	286	686	1926	370	3472	3268	94.1	825	5.21
584-064	4095	967	570	747	138	561	2984	2017	67.6	23850	0.25
584-065	4110	265	398	679	165	646	2154	1889	87.7	4686	0.26
584-066	4125	438	657	1093	252	1007	3446	3008	87.3	6637	0.25
584-067	4140	193	359	363	73	301	1290	1096	85.0	2964	0.24
584-068	4155	183	258	492	104	473	1511	1328	87.9	2667	0.22
584-069	4170	139	86	133	31	170	559	420	75.2	3333	0.18
584-070	4185	225	457	879	186	651	2398	2173	90.6	1653	0.29
584-071	4200	561	641	1184	343	1164	3893	3332	85.6	12704	0.29
584-072	4215	672	505	1163	359	1257	3955	3284	83.0	6265	0.29
584-073	4230	520	472	1281	494	1714	4481	3960	88.4	16686	0.29
584-074	4245	821	1521	2425	604	1963	7334	6513	88.8	10940	0.31
584-075	4260	223	770	1783	397	1371	4544	4321	95.1	11413	0.29
584-076	4280	65	63	101	22	93	343	278	81.1	1028	0.23
584-077	4295	54	26	66	46	268	459	405	88.1	5132	0.17
584-078	4310	23	29	126	44	234	456	433	95.0	1842	0.19
584-079	4325	171	157	357	97	355	1136	966	85.0	3123	0.27
584-080	4340	204	85	282	75	255	901	697	77.4	1055	0.30
584-081	4355	190	59	154	79	247	730	540	74.0	2389	0.32
584-082	4370	418	296	922	439	1210	3284	2866	87.3	4756	0.36
584-083	4385	424	330	782	391	1077	3004	2580	85.9	8304	0.36
584-084	4400	659	174	446	285	868	2432	1773	72.9	6730	0.33
584-085	4415	158	30	70	31	93	382	224	58.6	1586	0.34
584-086	4430	160	28	69	34	117	408	248	60.8	1051	0.29
584-087	MUD	28	7	6	3	11	55	27	48.8	1158	0.29
584-088	4445	105	12	15	17	48	198	93	46.8	798	0.35
584-089	4445-4460	100	12	10	4	5	130	30	22.8	397	0.83
584-090	4460-4475	213	14	7	2	4	239	27	11.1	95	0.54

TABLE 1B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-091	4475-4490	37	4	4	1	3	49	12	25.1	191	0.46
584-092	4490-4505	239	16	2	4	8	269	30	11.0	186	0.47
584-093	4505-4520	39	6	5	2	6	58	19	33.1	75	0.34

TABLE 1C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-001	2000-2050	223	30	39	14	12	317	94	29.8	3	1.15
584-002	2100	934	36	23	8	5	1006	72	7.1	0	1.49
584-003	2150	33	51	36	12	120	252	218	86.7	0	0.10
584-004	2200	22	38	27	16	60	163	141	86.6	67	0.26
584-005	2250	89	28	23	13	24	177	88	49.7	0	0.55
584-006	2300	283	17	17	10	7	334	51	15.2	8	1.47
584-007	2350	473	23	27	24	12	560	87	15.5	25	2.00
584-008	2400	432	25	33	33	21	544	112	20.6	18	1.61
584-009	2450	402	26	46	55	59	588	187	31.8	253	0.93
584-010	2500	801	41	75	68	104	1090	289	26.5	562	0.65
584-011	2550	666	41	66	78	152	1003	337	33.6	1335	0.51
584-012	2600	575	45	95	102	223	1040	465	44.7	1093	0.46
584-013	2650	326	30	49	39	92	535	209	39.1	313	0.42
584-014	2700	802	37	62	39	84	1024	222	21.7	255	0.46
584-015	2750	959	40	54	36	79	1168	209	17.9	547	0.45
584-016	2800	174	25	44	28	57	328	154	47.0	552	0.48
584-017	2850	158	24	38	24	43	286	128	44.8	417	0.56
584-018	2900	188	21	39	26	42	316	128	40.5	394	0.62
584-019	2950	238	32	58	19	43	389	151	38.8	259	0.43
584-020	3000	252	30	42	21	34	378	126	33.4	146	0.62
584-021	3050	248	37	70	47	59	461	213	46.2	24	0.79
584-022	3100	411	53	73	48	50	635	224	35.3	31	0.96
584-023	3150	725	98	113	62	74	1071	346	32.3	177	0.84
584-024	3200	210	39	41	21	25	336	127	37.6	122	0.82
584-025	3250	234	51	59	38	41	424	189	44.6	68	0.92
584-026	3300	354	65	45	13	25	502	148	29.5	141	0.50
584-027	3350	2200	215	89	18	66	2588	387	15.0	600	0.27
584-028	3400	836	80	38	16	14	985	149	15.1	424	1.14
584-029	3450	579	90	61	73	90	893	314	35.2	42	0.81
584-030	3500	951	99	37	11	37	1136	185	16.3	70	0.30

TABLE 1C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-031	3550	1278	216	107	30	120	1750	472	27.0	1703	0.25
584-032	3600	2133	343	179	54	212	2921	787	27.0	3356	0.26
584-033	3615	2405	388	188	51	190	3222	817	25.4	3056	0.27
584-034	3630	1864	341	170	41	165	2580	717	27.8	3475	0.25
584-035	3645	1945	572	330	66	283	3197	1252	39.2	3862	0.23
584-036	3660	3080	575	299	80	322	4356	1276	29.3	6041	0.25
584-037	3675	464	161	41	18	38	722	258	35.7	1777	0.47
584-038	3690	537	731	146	13	25	1452	916	63.0	88	0.53
584-039	3705	269	147	29	3	10	459	190	41.4	520	0.32
584-040	3720-3735	278	187	38	2	10	515	236	45.9	690	0.23
584-041	3750	1256	608	63	4	9	1939	684	35.2	162	0.44
584-042	3750-3765	307	144	17	1	3	472	165	35.0	369	0.48
584-043	3780	487	236	22	2	21	768	281	36.6	580	0.09
584-044	3795	410	210	5	0	0	625	215	34.4	85	0.35
584-045	3810	940	475	26	1	1	1443	503	34.9	0	1.04
584-046	3825	2323	1164	46	3	1	3537	1214	34.3	19	2.84
584-047	3840	300	721	57	0	0	1079	779	72.2	0	0.00
584-048	3855	1098	951	441	36	107	2632	1534	58.3	748	0.34
584-049	3870	943	932	572	51	174	2672	1729	64.7	830	0.29
584-050	3885	2043	1246	456	53	161	3959	1916	48.4	1836	0.33
584-051	3900	597	599	653	137	541	2527	1930	76.4	5205	0.25
584-052	3915	3101	4688	10329	2580	11531	32229	29128	90.4	17622	0.22
584-053	3930	3858	5316	8737	1940	8592	28444	24586	86.4	19330	0.23
584-054	3945	3732	7294	16388	3429	15257	46100	42368	91.9	32754	0.22
584-055	3960	3617	4844	8461	2284	9405	28612	24995	87.4	22365	0.24
584-056	3975	2264	4006	9049	2271	10351	27941	25677	91.9	21172	0.22
584-057	3990	4558	6963	13205	5085	16707	46517	41960	90.2	37277	0.30
584-058	4005	4318	6362	12078	3848	14493	41099	36780	89.5	22299	0.27
584-059	4020	6019	7797	11611	3394	7866	36688	30669	83.6	25967	0.43
584-060	4035	2506	4688	8523	2044	8766	26527	24021	90.6	20323	0.23

TABLE 1C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
584-061	4050	3642	4682	9967	2710	10976	31976	28334	88.6	48093	0.25
584-062	4065	3540	3053	2646	345	1219	10803	7263	67.2	3711	0.28
584-063	4080	5385	4323	4155	2395	1664	17921	12536	70.0	4185	1.44
584-064	4095	3502	2868	2478	333	1152	10333	6831	66.1	25518	0.29
584-065	4110	3461	2963	2810	399	1430	11062	7601	68.7	6790	0.28
584-066	4125	2044	1857	2152	387	1442	7882	5838	74.1	7511	0.27
584-067	4140	218	373	372	75	306	1343	1126	83.8	2979	0.24
584-068	4155	259	321	554	113	504	1752	1493	85.2	2716	0.22
584-069	4170	1993	1127	822	135	505	4583	2589	56.5	4607	0.27
584-070	4185	239	465	884	187	653	2429	2190	90.1	1660	0.29
584-071	4200	561	641	1184	343	1164	3893	3332	85.6	12704	0.29
584-072	4215	1659	1411	2002	515	1737	7324	5665	77.3	8312	0.30
584-073	4230	2895	2290	3259	1186	3567	13197	10302	78.1	21032	0.33
584-074	4245	10359	8529	8828	2051	5554	35321	24963	70.7	26095	0.37
584-075	4260	14386	13977	14584	3196	9265	55407	41021	74.0	39479	0.34
584-076	4280	438	432	321	49	174	1413	975	69.0	2042	0.28
584-077	4295	67	40	88	51	296	542	475	87.6	5707	0.17
584-078	4310	244	603	1242	219	829	3137	2893	92.2	3882	0.26
584-079	4325	1158	1020	1195	223	725	4321	3163	73.2	4136	0.31
584-080	4340	676	472	677	137	423	2385	1708	71.6	2152	0.32
584-081	4355	752	633	1127	383	995	3890	3138	80.7	4077	0.38
584-082	4370	1088	946	2206	852	2230	7321	6233	85.1	8630	0.38
584-083	4385	2077	1318	1867	697	1786	7746	5668	73.2	10333	0.39
584-084	4400	883	367	766	386	1116	3519	2636	74.9	8026	0.35
584-085	4415	314	211	395	114	324	1358	1044	76.9	2713	0.35
584-086	4430	224	123	239	66	205	857	633	73.9	1599	0.32
584-087	MUD	141	26	18	5	21	212	70	33.2	1635	0.23
584-088	4445	141	28	35	19	58	281	140	49.8	1113	0.33
584-089	4445-4460	216	38	24	7	15	299	83	27.7	502	0.45
584-090	4460-4475	391	41	18	5	8	464	72	15.6	584	0.66

TABLE 1C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
584-091	4475-4490	138	19	11	4	6	177	40	22.4	290	0.66
584-092	4490-4505	353	32	6	5	12	408	55	13.5	416	0.45
584-093	4505-4520	74	16	11	3	8	112	37	33.5	76	0.40

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-001	2000-050m	A 98% Shaly Mudstone, subfissile to blocky, soft, non calc. medium light to light grey Minor mud and lost circulation material - paint	N6-N7	0.57
584-002	2100m	A 98% Shaly Mudstone, as 584-001A Minor other mudstone Minor lost circulation material	N6-N7	0.40
584-003	2150m	A 95% Shaly Mudstone, as 584-001A B 5% Shale, blocky to subfissile, soft, sl. calc. to non calc., medium greyish brown Minor other mudstone	N6-M7 5YR4/2	0.44 0.19,0.16
584-004	2200m	A 98% Shaly Mudstone, subfissile to blocky, non calc., medium light grey Minor other mudstone	N6	0.29
584-005	2250m	A 98% Shaly Mudstone, as 584-004A Minor other mudstone	N6	0.41
584-006	2300m	A 98% Shaly Mudstone, as 584-004A, minor cavings Minor other mudstone	N6	0.45
584-007	2350m	A 98% Shaly Mudstone, as 584-004A minor cavings Minor other mudstone	N6	0.49
584-008	2400m	A 98% Shaly Mudstone, as 584-004A, minor cavings Minor other mudstone	N6	0.47
584-009	2450m	A 98% Shaly Mudstone, blocky, soft, sl. silty in part, non calc., minor cavings, medium light grey Minor other mudstone Minor lost circulation material - mud	N6	0.52,0.50
584-010	2500m	A 98% Shaly Mudstone, as 584-009A minor cavings Minor other mudstone	N6	0.49
584-011	2550m	A 98% Shaly Mudstone, as 584-009A minor cavings Minor other mudstone	N6	0.51
584-012	2600m	A 98% Shaly Mudstone, as 584-009A mod. caved Minor other mudstone Minor lost circulation material - paint	N6	0.46
584-013	2650m	A 98% Shaly Mudstone, as 584-009A, mod. caved Minor other mudstone	N6	0.48

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2

ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-014	2700m	A 98% Shaly Mudstone, platy to blocky, soft, non calc., mod. caved, medium light grey to light grey Minor other mudstone	N6-N7	0.50
584-015	2750m	A 98% Shaly Mudstone, as 584-014A mod. caved Minor other mud	N6-N7	0.44,0.40
584-016	2800m	A 98% Shaly Mudstone, as 584-014A mod. caved Minor other mud	N6-N7	0.46
584-017	2850m	A 98% Shaly Mudstone, as 584-014A mod. caved Minor other mud	N6-N7	0.34
584-018	2900m	A 98% Shaly Mudstone, as 584-014A mod. caved Minor quartz and pyrites Minor other mud	N6-N7	0.37
584-019	2950m	A 98% Shaly Mudstone, as 584-014A mod. caved Minor quartz and pyrites Minor other mud	N6-N7	0.37
584-020	3000m	A 98% Shaly Mudstone, as 584-014A Minor other mudstone	N6-N7	0.40
584-021	3050m	A 98% Shaly Mudstone, blocky, soft to mod. hard, non calc., medium grey Minor other mudstone, sand and pyrite	N5	0.42,0.38
584-022	3100m	A 95% Shaly Mudstone, as 584-021A	N5	0.46
		B 5% Shaly Coal, platy to blocky, brittle, non calc., dark grey to greyish black Minor other mud	N3-N2	39.80
584-023	3150m	A 98% Shaly Mudstone, as 584-021A mod. to abundantly caved Minor other mudstone and coal	N5	0.80
584-024	3200m	A 98% Shaly Mudstone, as 584-021A mod. caved Minor other mud	N5	0.60
584-025	3250m	A 95% Shaly Mudstone, as 584-021A, mod. caved	N5	0.45
		B 5% Mudstone, blocky, soft, non calc., moderate brown Minor other mudstone Lost circulation material - metal turnings	5YR3/4	0.26,0.28
584-026	3300m	A 98% Shaly Mudstone, as 584-021A mod. caved Minor other mudstone, coal and pyrite Minor lost circulation material	N5	0.35

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-027	3350m	A 85% Shaly Siltstone, blocky, hard, non calc., turbodrilled, dark grey	N3	0.57
		B 15% Shaly Mudstone, blocky, soft to mod. hard, non calc., mod. caved, medium grey	N5	0.69
		Minor other mudstone		
584-028	3400m	A 95% Shaly Siltstone, as 584-027A, turbodrilled	N3	0.63
		B 5% Shaly Mudstone, as 584-027B abundantly caved	N5	0.32
584-029	3450m	A 95% Shaly Siltstone, as 584-027A, turbodrilled	N3	0.64,0.66
		B 5% Shale, platy, fissile, soft to mod. hard, non calc., medium grey	N5	0.82
		Minor mudstone, mostly caved		
584-030	3500m	A 95% Shaly Siltstone, as 584-027A turbodrilled	N3	0.59
		B 5% Shale, as 584-029B, minor cavings	N5	0.40
		Minor mudstone - caved		
584-031	3550m	A 90% Shaly Siltstone, as 584-027A, turbodrilled	N3	0.68
		B 10% Shale, as 584-029B	N5	0.54
		Minor caved mudstone		
584-032	3600m	A 90% Shaly Siltstone, as 584-027A, turbodrilled	N3	0.59,0.56
		B 10% Shale, as 584-029B	N5	0.65
		Minor caved mudstone		
584-033	3615m	A 75% Siltstone, blocky, hard, v.sl.calc. to non calc., turbodrilled, brownish grey	5YR4/1	0.72
		B 25% Shale, platy to subfissile, hard, non calc., medium dark grey	N4	0.58
		Minor caved mudstone		
584-034	3630m	A 55% Siltstone, as 584-033A, turbodrilled	5YR4/1	0.65
		B 45% Shale, as 584-033B, minor cavings	N4	0.53
		Minor caved mudstone		
584-035	3645m	A 60% Siltstone, as 584-033A, turbodrilled	5YR4/1	0.38,0.41
		B 40% Shale, as 584-033B, mod. caved	N4	0.49
		Minor caved mudstone		
584-036	3660m	A 80% Siltstone, as 584-033A, turbodrilled	5YR4/1	0.67
		B 20% Shale, as 584-033B, mod. caved	N4	0.61
		Minor caved mudstone		
584-037	3675m	A 80% Shale, platy to subfissile, hard, non calc., mod. caved, medium dark grey to medium grey	N4-N5	0.59
		B 20% Siltstone, as 584-033A, turbodrilled Minor other shale	5YR4/1	0.33

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2

ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-038	3690m	A 98% Shaly Mudstone, platy to subfissile hard, non calc., mod. caved, medium dark grey to medium grey	N4-N5	0.50,0.52
		Minor caved mudstone		
584-039	3705m	A 90% Shaly Mudstone, as 584-038A, mod. to abundantly caved	N4-N5	0.58
		B 10% Dolomitic Limestone, blocky, hard, v. finely broken, pale to moderate yellowish brown	10YR6/2-10YR5/4	0.40
		Minor other mudstone		
		Lost circulation material - metal turnings		
584-040	3720-735m	A 95% Shaly Mudstone, as 584-038A, mod. caved	N4-N5	0.36
		B 5% Limestone, as 584-039B	10YR6/2-10YR5/4	
		Minor other mudstone		
		Lost circulation material - metal turnings		
584-041	3750m	A 98% Shale, platy to subfissile, mod. hard, non calc., medium dark grey to medium grey	N4-N5	0.64
		Minor other shale		
		Lost circulation material - metal turnings		
584-042	3750-765	A 90% Shale, as 584-041A, mod. caved	N4-N5	0.58
		B 10% Shale, platy to subfissile, mod. hard, non calc., medium light grey	N6	0.29,0.31
		Minor other shale		
		Lost circulation material - metal turnings		
584-043	3780m	A 98% Shale, as 584-041A, mod. caved	N4-N5	0.48
		Minor coal and other shale		
584-044	3795m	A 95% Shale, as 584-041A, mod. caved	N4-N5	0.44
		B 5% Shale, platy, mod. hard, v.sl. calc. medium dusky red	10R3/2	0.29
		Minor coal and limestone		
584-045	3810m	A 90% Shale, as 584-041A, mod. caved	N4-N5	0.47
		B 10% Shale, as 584-044B	10R3/2	0.24
		Minor other mudstone		
584-046	3825m	A 95% Shale, as 584-041A, mod. caved	N4-N5	0.42,0.42
		B 5% Shale, as 584-044B	10R3/2	0.22
		Minor other mudstone		
		Lost circulation material - metal turnings		
584-047	3840m	A 85% Shale, as 584-041A, mod to abundantly caved	N4-N5	0.64
		B 15% Shale, as 584-044B, minor cavings	10R3/2	0.13
		Minor other shale and limestone		
		Minor lost circulation material - metal turnings		

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-048	3855m	A 90% Shale, platy to subfissile, mod. hard, non calc., medium dark grey to medium grey, mod. to abundantly caved	N4-N5	0.40
		B 10% Shale, platy, mod. hard, v. sl. calc., minor cavings, medium dusky red	10R3/2	0.34
		Minor other shale and limestone		
		Minor LCM - metal turnings		
584-049	3870m	A 95% Shale, as 584-048A, mod. caved	N4-N5	0.35,0.32
		B 5% Shale, as 584-048B	10R3/2	0.21
		Minor other shale and limestone		
		LCM - metal turnings		
584-050	3885m	A 85% Shale, blocky to subfissile, occ. platy, mod. hard, non calc., mod. caved, medium dark to medium grey	N4-N5	0.55
		B 10% Shale, blocky to subfissile, mod. hard, non calc., greyish brown	5YR3/2	0.23
		C 5% Limestone, blocky, mod. hard, occ. chalky, very light grey	N8	0.12
		Minor pyrites and other shale		
		LCM - metal turnings		
584-051	3900m	A 75% Shale, as 584-050A, minor cavings	N4-N5	0.51
		B 15% Shale, as 584-050B	5YR3/2	0.24,0.20
		C 5% Limestone, as 584-050C	N8	0.24
		D 5% LCM - metal turnings		
584-052	3915m	A 55% Shale, as 584-050A, minor cavings	N4-N5	0.52
		B 25% Silty Shale, blocky to subfissile, soft to mod. hard, non calc., brownish grey to dark brownish grey	5YR4/1-3/1	4.61
		C 10% Shale, as 584-050B	5YR3/2	0.56
		D 10% LCM - metal turnings		
584-053	3930m	A 75% Shale, as 584-050A, mod. caved	N4-N5	0.67
		B 15% Silty Shale, as 584-052B	5YR4/1-3/1	3.70,3.50
		C 5% Shale, as 584-050B	5YR3/2	0.20
		D 5% LCM - metal turnings		
		Minor limestone, other shale		
584-054	3945m	A 70% Shale, platy, fissile, mod. hard, non calc., minor cavings, medium dark grey to medium grey	N4-N5	0.66
		B 20% Silty Shale, as 584-052B	5YR4/1-3/1	5.30
		C 5% Shale, as 584-050B	5YR3/2	0.15
		D 5% LCM - metal turnings		
		Minor limestone		
584-055	3960m	A 60% Shale, as 584-054A, mod. caved	N4-N5	1.04
		B 20% Silty Shale, as 584-052B	5YR4/1-3/1	4.37,4.40
		C 10% LCM - metal turnings		
		D 10% Shale, as 584-050B	5YR3/2	0.12
584-056	3975m	A 50% Shale, as 584-054A,mod. caved	N4-N5	0.75
		B 25% Silty Shale, as 584-052B	5YR4/1-3/1	4.55
		C 15% LCM - metal turnings		

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-056	3975m	D 10% Shale, blocky to subfissile, mod. hard, non calc., greyish brown	5YR3/2	0.19
584-057	3990m	A 60% Silty Shale, platy to subfissile, soft to mod. hard, non calc., dark brownish grey	5YR3/1	4.46
		B 35% Shale, platy to subfissile, mod. hard, non calc., medium dark grey	N4	0.55,0.51
		C 5% Shale, as 584-056D	5YR3/2	0.13
		Minor LCM - metal turnings		
584-058	4005m	A 50% Shale, as 584-057A	5YR3/1	4.99
		B 40% Shale, as 584-057B, minor cavings	N4	0.49
		C 10% Shale, as 584-056D, minor cavings	5YR3/2	0.04
		Minor LCM - metal turnings		
584-059	4020m	A 80% Shale, as 584-057B, mod. caved	N4	0.72
		B 10% Silty Shale, as 584-057A	5YR3/1	4.43,4.50
		C 10% Shale, as 584-056D, minor cavings	5YR3/2	0.17
		Minor LCM - metal turnings		
584-060	4035m	A 45% Shale, as 584-057B, minor cavings	N4	0.48
		B 45% Silty Shale, as 584-057A	5YR3/1	3.75
		C 10% Shale, as 584-056D, minor cavings	5YR3/2	0.15
		Minor coal		
		Minor LCM - metal turnings		
584-061	4050m	A 55% Silty Shale, as 584-057A	5YR3/1	0.73
		B 35% Shale, as 584-057B	N4	2.84,2.84
		C 10% Shale, as 584-056D	5YR3/2	0.23
		Minor coal, siltstone and pyrites		
		Minor LCM - metal turnings		
584-062	4065m	A 70% Shale, platy, mod. hard, non calc., mod. caved, medium dark grey to medium grey	N4-N5	0.25
		B 20% Shale, platy, mod. hard, non calc., brownish black	5YR2/1	2.44
		C 10% Shale, platy to subfissile, mod. hard, non calc., patchy pearly lustre, greyish red	5R4/2	0.20
		Minor sandstone, other shale and pyrites		
		LCM - metal turnings		
584-063	4080m	A 80% Shale, as 584-062A, mod. caved	N4-N5	0.55
		B 15% Shale, as 584-062C	5R4/2	0.13,0.12
		C 5% Shale, as 584-062B	5YR2/1	1.93
		Minor sandstone, siltstone		
		LCM - metal turnings		
584-064	4095m	A 75% Shale, as 584-062A, mod.caved	N4-N5	0.58
		B 20% Shale, as 584-062C, minor cavings	5R4/2	0.18
		C 5% Shale, platy to subfissile, mod. hard, non calc., patchy pearly lustre, dark brownish grey	5YR3/1	2.18
		Minor sandstone, siltstone and pyrites		
		LCM - metal turnings		

Abbreviations = **are**naceous, **arg**illaceous, **calc**areous, Cut, **dol**omitic, Fluorescence, **foram**inifera, **foss**iliferous
Lost Circulation Material, **mod**erately, **occ**asionally, **sl**ightly, **v**ery

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-065	4110m	A 80% Shale, platy, mod. hard, non calc., mod. caved, medium dark grey to medium grey	N4-N5	0.80
		B 15% Shale, platy, mod. hard, non calc., brownish black	5YR2/1	0.07,0.10
		C 5% Shale, platy to subfissile, mod. hard, non calc., patchy pearly lustre, dark brownish grey	5YR3/1	1.90
		Minor sandstone and pyrites		
		LCM - metal turnings		
584-066	4125m	A 80% Shale, as 584-065A, mod. caved	N4-N5	0.39
		B 15% Shale, as 584-065C	5YR3/1	1.45
		C 5% Shale, as 584-065B	5YR2/1	0.22
		Minor sandstone, pyrites and coal		
		LCM - metal turnings		
584-067	4140m	A 80% Shale, as 584-065A, mod. caved	N4-N5	0.60
		B 10% Shale, as 584-65C	5YR3/1	1.83,1.91
		C 10% Shale, as 584-065B	5YR2/1	
		Minor sandstone and pyrites		
		LCM - metal turnings		
584-068	4155m	A 75% Shale, platy to subfissile, mod. hard, non calc., minor cavings, dark to medium dark grey	N3-N4	0.92
		B 25% Shale, platy, soft to mod. hard, non calc., minor cavings, very dark greyish red	5R3/2	0.10
		Minor sandstone and other shale		
		Minor LCM - metal turnings		
584-069	4170m	A 55% Shale, as 584-068A, minor cavings	N3-N4	0.63
		B 35% Sandstone, blocky, v. fine grained subangular, mostly quartz, well sorted, non calc., matrix, pinkish grey	5YR8/1	
		C 10% Shale, as 584-068B, minor cavings	5R3/2	0.13
		Minor other shale		
		Minor LCM - metal turnings		
584-070	4185m	A 75% Shale, as 584-068A, mod. caved	N3-N4	0.40,0.39
		B 15% Sandstone, as 584-069B	5YR8/1	
		C 10% Shale, as 584-068B, minor cavings	5R3/2	0.12
		Minor other shale		
584-071	4200m	A 80% Shale, as 584-068A, minor cavings	N3-N4	0.69
		B 15% Shale, as 584-068B	5R3/2	0.06
		C 5% Siltstone, blocky to platy, soft to mod. hard, non calc., brownish grey	5YR4/1	3.33
		Minor sandstone and other shael		
584-072	4215m	A 70% Shale, as 584-068A, minor cavings	N3-N4	0.55
		B 20% Shale, as 584-068B	5R3/2	0.30,0.28
		C 10% Coaly Shale, blocky, mod. hard, non calc., brownish black	5YR2/1	5.27
		Minor sandstone		

Abbreviations = **are**naceous, **arg**illaceous, **calc**areous, Cut, **dol**omitic, Fluorescence, **foram**inifera, **foss**iliferous
Lost Circulation Material, **mod**erately, **occ**asionally, **sl**ightly, **v**ery

TABLE 2

ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-073	4230m	A 55% Shale, platy to subfissile, mod. hard, non calc., mod. caved, dark to medium dark grey	N3-N4	0.44
		B 25% Sandstone, blocky, v. fine grained subangular, quartz, well sorted, non calc. matrix, pinkish grey	5YR8/1	
		C 10% Shale, platy, soft to mod. hard, non calc., very dark greyish red	5R3/2	0.12
		D 10% Shale, blocky to subfissile, soft to mod. hard, non calc., patchy vitreous lustre, dark brownish grey	5YR3/1	1.86
		Minor other shale		
		LCM - brick		
584-074	4245m	A 65% Shale, as 584-073A, mod. caved	N3-N4	0.61
		B 15% Sandstone, as 584-073B	5YR8/1	
		C 10% Shale, as 584-073C	5R3/2	0.17,0.14
		D 10% Shale, as 584-073D	5YR3/1	2.53
584-075	4260m	A 70% Shale, as 584-073A, mod. caved	N3-N4	0.55
		B 15% Sandstone, as 584-073B	5YR8/1	
		C 10% Shale, as 584-073D	5YR3/1	2.87
		D 5% Shale, as 584-073C	5R3/2	0.16
584-076	4280m	A 50% Shale, as 584-073A, mod. caved	N3-N4	0.83
		B 30% Silty Mudstone, blocky, soft to mod. hard, v. sl. calc. to non calc., very pale yellowish brown	10YR7/2	0.67,0.69
		C 15% Shale, as 584-073D	5YR3/1	2.20
		D 5% Shale, as 584-073C, mod. caved	5R3/2	0.18
		Minor sandstone		
584-077	4295m	A 60% Shale, as 584-073A, mod. caved	N3-N4	0.84
		B 30% Mudstone, as 584-076B	10YR7/2	0.43
		C 10% Shale, as 584-073C	5R3/2	0.24
		Minor other shale		
		LCM - metal turnings		
584-078	4310m	A 70% Mudstone, as 584-076B	10YR7/2	0.43
		B 30% Shale, as 584-073A	N3-N4	0.91,0.88
		Minor other shale and mudstone		
		LCM - metal turnings		
584-079	4325m	A 60% Siltstone, platy to blocky, soft, non calc., medium dark grey to brownish grey	N4-5YR4/1	0.92
		B 30% LCM - metal turnings		
		C 10% Mudstone, as 584-076B	10YR7/2	0.32
584-080	4340m	A 50% Siltstone, as 584-079A, minor cavings	N4-5YR4/1	
		B 35% LCM - metal turnings - brick and grease		
		C 15% Shale, blocky to platy, soft to mod. hard, non calc., carbonaceous, brownish black	5YR2/1	3.02
584-081	4355m	A 60% Siltstone, as 584-079A, minor cavings	N4-5YR4/1	1.05

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2

ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-081	4355m	B 40% LCM - metal turning and plastic Minor other mudstone and shale		
584-082	4370m	A 80% Siltstone, platy to blocky, soft, non calc., medium dark grey to brownish grey	N4-5YR4/1	0.93
		B 20% Shale, platy to subfissile, soft to mod. hard, non calc., medium dark grey Minor other mudstone LCM - metal turnings	N4	1.10
584-083	4385m	A 80% Siltstone, as 584-082A, minor cavings	N4-5YR4/1	0.81
		B 20% Shale, as 584-082B Minor mudstone and drilling mud	N4	0.84
584-084	4400m	A 70% Siltstone, as 584-082A, minor cavings	N4-5YR4/1	1.02,0.94
		B 25% LCM - metal turnings, fibre, grease		
		C 5% Coal, blocky, brittle, non calc., greyish black	N2	14.25
584-085	4415m	A 50% Siltstone, as 584-082A	N4-5YR4/1	1.55
		B 25% Coal, as 584-084C	N2	40.54
		C 25% LCM - metal turnings and grease Minor sandstone		
584-086	4430m	A 90% Sandstone, blocky, fine to med. grained, subangular quartz, fairly well sorted, sl. calc. matrix, very light grey to pinkish grey	N8-5YR8/1	
		B 10% Siltstone, as 584-082A Minor mud and grease as LCM	N4-5YR4/1	0.83
584-087	NO DEPTH	A 99% MUD SAMPLE		
584-088	4445m	A 80% Sandstone, as 584-086A	N8-5YR8/1	
		B 20% LCM - grease and mud Minor mudstone and siltstone		
584-089	4445-460m	A 75% Sandstone, as 584-086A, sl. chloritised in part	N8-5YR8/1	
		B 15% Coal, blocky, brittle, non calc., grading to carbargillite, greyish black to brownish black	N2-5YR2/1	18.96
		C 10% LCM - grease and metal turnings Minor siltstone		
584-090	4460-475m	A 60% Sandstone, blocky, med. grained, subangular, quartz, fairly well sorted, non calc. matrix, partly chloritised, pinkish grey	5YR8/1	
		B 40% LCM - walnut shell and metal turnings Minor coal and siltstone		
584-091	4475-490m	A 65% LCM - walnut shell and metal		
		B 35% Sandstone, as 584-090A Minor shale	5YR8/1	

Abbreviations = **are**naceous, **arg**illaceous, **calc**areous, Cut, **dol**omitic, Fluorescence, **foram**inifera, **foss**iliferous
Lost Circulation Material, **mod**erately, **occ**asionally, **sl**ightly, very

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
584-092	4490-505m	A 70% LCM - walnut shell and metal		
		B 30% Sandstone, blocky, med. grained, subangular, quartz, fairly well sorted, non calc. matrix, partly chloritised, pinkish grey	5YR8/1	
		Minor shale and siltstone		
584-093	4505-520m	A 50% Siltstone, platy to blocky, soft, v. sl. calc. to non calc., mod. brown to mod. brown	5YR3/4-5YR4/4	0.65
		B 25% Sandstone, as 584-092B	5YR8/1	
		C 25% LCM - walnut shells and metal		
		Minor shale		

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 3

KEROGEN TYPE AND MATURATION

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION					THERMAL MATURATION INDEX
		TYPES 40%; 10–40%; 10%	REMARKS	REWORKED (%)	PARTICLE SIZE	PRESERV-ATION	
584-052B	3915m	Am*-Al**;I;W-H	*includes incompletely developed material. **includes material passing to Am. Significant material at 2.	-	F-C	P	2- to 2/2
584-054B	3945m	Am*-Al**;I;W-H	* **as 052B. Significant material at 2.	-	F-M/C	P	2- to 2
584-057A	3990m	I;Am*-Al**-W;H	* **as 052B. Significant material at 2.	60	F-C	P	2- to 2
584-058A	4005m	I;Al**-W;Am*-H	* **as 052B.	70	M	F	2 max.
584-060B	4035m	-;I-Al**-Am*-W;H	* **as 052B.	40	M	P-F	2- to 2/2
584-062B	4065m	-;Am*-I-Al**-W;H	* **as 052B.	30	M	P-F	2
584-064C	4095m	Am*-I;Al**-W;H	material at 2- to 2. * **as 052B.	40	M	P-F	2
584-067B	4140m	-;I-Am*-W-Al**;H	* **as 052B.	50	M	F	2
584-072C	4215m	-;I-W-Am*;Al**-H	lignite additive present? * **as 052B.	45	F-C	P	2
584-075C	4260m	-;I-Am*-W;Al**-H	* **as 052B.	55	M	P-F	2
584-080C	4340m	W;I;Am-H	resembles lignite.	-	F-C	F	1+ to 2- max.

Algal, Amorphous, Herbaceous, Inertinite, Resin, Wood

postscript = coarse, cuticle, cysts, degraded, fine, other,. structured, spore-pollen, thick-walled, unstructured

TABLE 4

VITRINITE REFLECTANCE DATA

GEOCHEM SAMPLE NUMBER	DEPTH	SAMPLE TYPE	AVERAGE REFLECTIVITY Ro (%)			NUMBER OF PARTICLES			REMARKS
			1	2	3	1	2	3	
584-001A	2000-050m	WHOLE ROCK	0.36	0.46	-	6	5	-	
584-008A	2400	KER. CON.	0.38	0.51	0.62	5	4	9	
584-011A	2550	WHOLE ROCK	0.92	-	-	4	-	-	
584-016A	2800	WHOLE ROCK	0.55	0.76	-	9	1	-	
584-022B	3100	KER. CON.	0.30	-	-	25	-	-	
584-023A	3150	KER. CON.	0.30	0.45	-	4	2	-	
584-025A	3250	WHOLE ROCK	NO DETERMINATION POSSIBLE						
584-025B	3250	WHOLE ROCK	" " "						
584-033A	3615	WHOLE ROCK	NO DETERMINATION POSSIBLE						
584-038A	3690	WHOLE ROCK	" " "						
584-039B	3705	WHOLE ROCK	" " "						
584-042A	3750-765	WHOLE ROCK	1.26	-	-	5	-	-	
584-045A	3810	WHOLE ROCK	NO DETERMINATION POSSIBLE						
584-048B	3855	WHOLE ROCK	" " "						
584-050A	3885	WHOLE ROCK	0.50	-	-	8	-	-	
584-052B	3915	KER. CON.	0.43	0.57	0.69	2	5	1	
584-054B	3945	KER. CON.	0.34	0.50	0.60	5	17	7	4th pop. 0.79(1)
584-055A	3960	WHOLE ROCK	0.95	1.58	-	1	5	-	
584-057A	3990	KER. CON.	0.52	0.63	-	25	12	-	
584-060B	4035	KER. CON.	0.52	0.64	-	9	1	-	
584-061A	4050	KER. CON.	0.34	0.53	0.68	1	18	2	
584-062B	4065	KER. CON.	0.33	0.55	0.85	2	4	3	4th pop. 1.31(2)
584-064A	4095	WHOLE ROCK	0.86	-	-	2	-	-	
584-067A	4140	WHOLE ROCK	NO DETERMINATION POSSIBLE						

TABLE 4

VITRINITE REFLECTANCE DATA

GEOCHEM SAMPLE NUMBER	DEPTH	SAMPLE TYPE	AVERAGE REFLECTIVITY Ro (%)			NUMBER OF PARTICLES			REMARKS
			1	2	3	1	2	3	
584-071A	4200	WHOLE ROCK	0.63	0.89	1.22	5	1	2	
584-072C	4215	KER. CON.	0.33	-	-	35	-	-	
584-074A	4245	WHOLE ROCK	0.59	1.01	-	1	3	-	
584-075C	4260	KER. CON.	0.32	0.59	0.95	4	1	9	
584-076A	4280	WHOLE ROCK	0.28	-	-	1	-	-	
584-079A	4325	WHOLE ROCK	0.69	0.86	1.01	1	5	2	
584-080C	4340	KER. CON.	0.32	-	-	36	-	-	
584-082A	4370	KER. CON.	0.61	0.70	-	15	10	-	
584-083A	4385	WHOLE ROCK	0.35	0.64	0.83	5	3	4	
584-083B	4385	WHOLE ROCK	0.83	1.08	1.45	11	5	7	
584-084A	4400	WHOLE ROCK	0.87	1.14	-	13	12	-	
584-085B	4415	KER. CON.	0.34	-	-	38	-	-	
584-089B	4445-460	KER. CON.	0.29	-	-	25	-	-	
584-093A	4505-520	WHOLE ROCK	NO DETERMINATION POSSIBLE						

KER. CON.- KEROGEN CONCENTRATE

TABLE 4A

VITRINITE REFLECTANCE - RAW DATA

GEOCHEM SAMPLE NUMBER	DEPTH	READINGS
584-001A	2000-050m	0.36, 0.40, 0.39, 0.36, 0.47, 0.45, 0.48, 0.32, 0.33, 0.45, 0.47.
584-008A	2400	0.61, 0.59, 0.50, 0.34, 0.52, 0.56, 0.69, 0.49, 0.51, 0.39, 0.60, 0.65, 0.60, 0.66, 0.66, 0.40, 0.39, 0.38.
584-011A	2550	0.93, 0.94, 0.88, 0.93.
584-016A	2800	0.57, 0.55, 0.76, 0.59, 0.65, 0.58, 0.49, 0.49, 0.51, 0.52.
584-022B	3100	0.24, 0.23, 0.37, 0.38, 0.33, 0.27, 0.28, 0.26, 0.29, 0.26, 0.31, 0.29, 0.30, 0.28, 0.22, 0.31, 0.26, 0.37, 0.26, 0.37, 0.35, 0.34, 0.22, 0.32, 0.29.
584-023A	3150	0.34, 0.45, 0.26, 0.31, 0.28, 0.44.
584-042A	3750-765	1.30, 1.22, 1.40, 1.14, 1.23.
584-050A	3885	0.45, 0.44, 0.48, 0.52, 0.51, 0.49, 0.56, 0.55.
584-052B	3915	0.56, 0.58, 0.69, 0.56, 0.59, 0.58, 0.41, 0.44.
584-054B	3945	0.59, 0.79, 0.38, 0.46, 0.58, 0.58, 0.48, 0.49, 0.30, 0.42, 0.49, 0.61, 0.64, 0.30, 0.47, 0.55, 0.65, 0.52, 0.58, 0.52, 0.57, 0.51, 0.52, 0.39, 0.43, 0.35, 0.45, 0.52, 0.55, 0.53.
584-055A	3960	0.95, 1.60, 1.48, 1.64, 1.46, 1.72.
584-057A	3990	0.59, 0.48, 0.61, 0.61, 0.59, 0.49, 0.56, 0.61, 0.66, 0.54, 0.70, 0.55, 0.55, 0.52, 0.52, 0.58, 0.65, 0.57, 0.53, 0.56, 0.56, 0.53, 0.62, 0.43, 0.67, 0.62, 0.50, 0.46, 0.47, 0.46, 0.60, 0.50, 0.51, 0.51, 0.54, 0.49, 0.50.
584-060B	4035	0.53, 0.46, 0.47, 0.52, 0.64, 0.58, 0.49, 0.53, 0.56, 0.54.

TABLE 4A

VITRINITE REFLECTANCE - RAW DATA

GEOCHEM SAMPLE NUMBER	DEPTH	READINGS
584-061A	4050	0.34, 0.57, 0.58, 0.48, 0.49, 0.56, 0.56, 0.54, 0.54, 0.53, 0.65, 0.52, 0.70, 0.54, 0.52, 0.51, 0.50, 0.50, 0.51, 0.52, 0.50.
584-062B	4065	0.80, 0.50, 1.26, 0.32, 0.84, 1.35, 0.90, 0.52, 0.34, 0.57, 0.62.
584-064A	4095	0.83, 0.89.
584-071A	4200	1.25, 1.19, 0.65, 0.66, 0.57, 0.62, 0.89, 0.65.
584-072C	4215	0.29, 0.30, 0.31, 0.33, 0.34, 0.31, 0.31, 0.31, 0.32, 0.34, 0.31, 0.32, 0.28, 0.31, 0.36, 0.33, 0.35, 0.38, 0.35, 0.33, 0.35, 0.35, 0.32, 0.31, 0.30, 0.36, 0.35, 0.34, 0.35, 0.34, 0.35, 0.34, 0.35, 0.35, 0.35.
584-074A	4245	0.59, 0.93, 0.99, 1.12.
584-075C	4260	0.86, 0.92, 1.06, 0.94, 0.33, 1.02, 0.99, 1.06, 0.30, 0.31, 0.82, 0.84, 0.59, 0.32.
584-079A	4325	0.89, 1.00, 0.69, 0.92, 0.87, 1.02, 0.80, 0.83.
584-080C	4340	0.36, 0.41, 0.30, 0.32, 0.34, 0.33, 0.33, 0.32, 0.31, 0.33, 0.35, 0.32, 0.33, 0.39, 0.30, 0.31, 0.32, 0.27, 0.32, 0.27, 0.29, 0.32, 0.35, 0.32, 0.40, 0.29, 0.30, 0.29, 0.31, 0.31, 0.28, 0.28, 0.29, 0.30, 0.32, 0.35.
584-082A	4370	0.59, 0.70, 0.66, 0.77, 0.63, 0.65, 0.69, 0.64, 0.60, 0.58, 0.62, 0.65, 0.52, 0.72, 0.62, 0.68, 0.67, 0.70, 0.69, 0.70, 0.71, 0.57, 0.64, 0.59, 0.62.
584-083A	4385	0.38, 0.86, 0.35, 0.40, 0.63, 0.63, 0.78, 0.34, 0.30, 0.66, 0.84, 0.82.

TABLE 4A

VITRINITE REFLECTANCE - RAW DATA

GEOCHEM SAMPLE NUMBER	DEPTH	READINGS
584-083B	4385	1.40, 1.23, 1.43, 0.80, 1.05, 1.43, 1.44, 0.87, 0.89, 1.00, 1.50, 1.47, 0.97, 0.84, 0.78, 0.76, 0.82, 0.86, 0.89, 0.74, 0.87, 1.49, 1.16.
584-084A	4400	1.06, 1.04, 0.93, 0.94, 1.27, 0.55, 1.17, 0.69, 0.79, 0.80, 0.76, 0.81, 0.93, 0.96, 0.61, 0.85, 1.27, 0.90, 1.01, 1.46, 0.92, 1.13, 1.00, 0.67, 1.05, 0.81, 1.11, 1.13, 0.86, 0.73.
584-085B	4415	0.29, 0.34, 0.23, 0.41, 0.36, 0.40, 0.29, 0.30, 0.29, 0.33, 0.34, 0.33, 0.32, 0.29, 0.38, 0.31, 0.37, 0.37, 0.37, 0.25, 0.35, 0.29, 0.39, 0.32, 0.33, 0.40, 0.33, 0.34, 0.37, 0.42, 0.25, 0.31, 0.29, 0.44, 0.36, 0.34, 0.35, 0.33.
584-089B	4445-460	0.27, 0.25, 0.27, 0.28, 0.30, 0.25, 0.26, 0.27, 0.30, 0.31, 0.30, 0.30, 0.29, 0.31, 0.29, 0.27, 0.28, 0.28, 0.30, 0.33, 0.30, 0.30, 0.31, 0.32, 0.28.

TABLE 5A

WEIGHT (GRAMMES) OF C_{15+} EXTRACTS AND CHROMATOGRAPHIC FRACTIONS

GEOCHEM SAMPLE NUMBER	INTERVAL	ROCK EXTRACTED	TOTAL EXTRACT OBTAINED	TOTAL EXTRACT		nC_5 SOLUBLE FRACTION				
				Preciptd. Asphaltenes	nC_5 soluble	Paraffin – Naphthenes	Aromatics	Eluted NSO's	Non-eluted NSO's	Sulphur
584-052B	3915	4.2700	0.02722	0.00974	0.01747	0.00447	0.00901	0.00255	0.00145	0.00001
584-054B	3945	4.4700	0.02859	0.00833	0.02026	0.00504	0.00912	0.00427	0.00183	0.00000
584-057A	3990	9.3900	0.05905	0.00863	0.04279	0.01966	0.02190	0.00585	0.00301	0.00763
584-058A	4005	11.9700	0.04953	0.00734	0.04145	0.01446	0.01787	0.00643	0.00344	0.00074
584-060B	4025	10.7200	0.05226	0.01100	0.04052	0.01497	0.01741	0.00611	0.00277	0.00074
584-062B	4065	4.4500	0.00969	0.00323	0.00641	0.00266	0.00263	0.00112	0.00005	0.00005
584-064C	4095	4.0900	0.01108	0.00248	0.00847	0.00280	0.00278	0.00225	0.00076	0.00013
584-067B	4140	5.9700	0.01548	0.00553	0.00992	0.00415	0.00382	0.00192	0.00006	0.00003
584-072C	4215	3.0700	0.01188	0.00350	0.00821	0.00286	0.00264	0.00229	0.00059	0.00017
584-075C	4260	8.3500	0.02487	0.00448	0.02030	0.00981	0.00642	0.00374	0.00042	0.00009
584-080	4340	12.7100	0.04257	0.01144	0.03104	0.00976	0.00839	0.01054	0.00243	0.00009

TABLE 5C

COMPOSITION (NORMALISED %) OF C_{15+} MATERIAL EXTRACTED FROM ROCK

GEOCHEM SAMPLE NUMBER	INTERVAL	HYDROCARBONS			NON HYDROCARBONS					HC / NON HC
		Paraffin – Naphthenes	Aromatics	P – N / AROM	Preciptd. Asphaltenes	Eluted NSO's	Non eluted NSO's	Sulphur	ASPH / NSO	
584-052B	3915	16.43	33.08	0.50	35.78	9.37	5.33	0.04	2.43	0.98
584-054B	3945	17.63	31.90	0.55	29.14	14.94	6.40	0.00	1.37	0.98
584-057A	3990	33.29	37.09	0.90	14.61	9.90	5.10	12.92	0.97	1.65
584-058A	4005	29.19	36.08	0.81	14.82	12.98	6.94	1.49	0.74	1.80
584-060B	4025	28.64	33.31	0.86	21.05	11.69	5.31	1.42	1.24	1.57
584-062B	4065	27.46	27.15	1.01	33.33	11.54	0.52	0.52	2.76	1.19
584-064C	4095	25.29	25.11	1.01	22.38	20.34	6.87	1.17	0.82	0.99
584-067B	4140	26.83	24.69	1.09	35.72	12.38	0.39	0.19	2.80	1.06
584-072C	4215	24.06	22.25	1.08	29.46	19.25	4.98	1.43	1.22	0.84
584-075C	4260	39.46	25.81	1.53	18.01	15.02	1.70	0.36	1.08	1.86
584-080	4340	22.93	19.72	1.16	26.87	24.76	5.72	0.21	0.88	0.74

TABLE 6

SIGNIFICANT RATIOS (%) OF C_{15+} FRACTIONS AND ORGANIC CARBON

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC CARBON	HYDROCARBONS / TOTAL EXTRACT	HYDROCARBONS / ORGANIC CARBON	TOTAL EXTRACT / ORGANIC CARBON
584-052B	3915	4.47	49.51	7.06	14.26
584-054B	3945	5.23	49.53	6.06	12.23
584-057A	3990	4.44	70.38	9.97	14.16
584-058A	4005	5.11	65.27	5.29	8.10
584-060B	4025	5.53	61.96	5.46	8.82
584-062B	4065	2.17	54.60	5.48	10.03
584-064C	4095	2.18	50.40	6.26	12.43
584-067B	4140	2.86	51.51	4.67	9.07
584-072C	4215	4.42	46.31	4.05	8.75
584-075C	4260	2.24	65.27	8.68	13.30
584-080	4340	12.08	42.65	1.18	2.77

TABLE 7

PYROLYSIS ANALYSIS

SAMPLE NUMBER	DEPTH	ORGANIC CARBON	PPM BITUMEN*	PPM PYROLYSATE+	PYROLYSATE / ORGANIC CARBON	BITUMEN / PYROLYSATE	PEAK PYROL TEMP (oC)
584-052B	3915	4.61	1324	6692	0.15	0.198	493
584-054B	3945	5.30	1584	6767	0.13	0.234	490
584-057A	3990	4.46	1853	3415	0.08	0.543	492
584-058A	4005	4.99	1401	4188	0.08	0.334	490
584-060B	4035	3.75	1313	3946	0.11	0.333	495
584-062B	4065	2.44	808	2886	0.12	0.280	501
584-064C	4095	2.18	279	1952	0.09	0.143	499
584-067B	4140	1.86	440	2027	0.11	0.217	504
584-072C	4215	5.27	420	2256	0.04	0.186	505
584-075C	4260	2.87	1044	2322	0.08	0.449	501
584-080C	4340	3.02	246	6827	0.23	0.036	497

*50-340°C

+350-550°C

TABLE 8

COMPOSITION (NORMALISED %) OF C_{15+} PARAFFIN – NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	-052B	-054B	-057A	-058A	-060B	-062B	-064C	-067B	-072C	-075C
DEPTH	3915m	3945m	3990m	4005m	4035m	4065m	4095m	4140m	4215m	4260m
SAMPLE TYPE										
nC_{15}	8.22	5.07	12.21	11.17	11.59	4.34	6.53	6.59	9.43	10.68
nC_{16}	11.55	11.03	11.80	11.70	11.37	9.97	9.67	9.39	12.51	10.48
nC_{17}	11.80	13.43	10.99	11.47	10.85	12.54	11.79	11.18	13.28	10.07
nC_{18}	11.72	10.94	9.14	9.73	9.12	11.09	9.83	8.96	11.74	9.32
nC_{19}	9.76	10.23	7.68	8.74	8.38	10.29	8.41	8.39	9.60	8.23
nC_{20}	8.71	9.61	7.36	7.37	7.33	8.36	7.63	7.60	8.31	7.82
nC_{21}	7.16	7.56	6.06	6.53	6.96	7.64	7.94	6.67	6.43	6.80
nC_{22}	6.59	6.94	5.74	5.55	5.91	7.07	7.08	6.52	6.17	6.19
nC_{23}	5.45	5.43	4.93	5.09	5.68	6.91	6.13	5.95	5.48	5.37
nC_{24}	4.80	4.98	4.37	4.64	5.31	6.27	5.66	5.38	4.54	4.76
nC_{25}	3.66	4.27	4.04	3.88	3.89	5.39	5.11	5.09	3.43	4.22
nC_{26}	3.34	3.20	3.72	3.65	3.37	3.62	4.25	4.66	3.26	3.40
nC_{27}	2.60	2.49	2.67	2.66	2.92	3.22	3.93	4.23	2.66	3.40
nC_{28}	1.95	1.96	2.51	2.28	2.39	1.29	2.59	3.23	1.54	2.93
nC_{29}	1.30	1.33	2.10	1.82	1.94	0.96	1.89	2.58	0.86	2.18
nC_{30}	0.57	0.71	1.62	1.37	1.20	0.40	0.79	1.43	0.34	1.56
nC_{31}	0.41	0.36	1.21	0.84	0.75	0.24	0.39	0.93	0.17	1.09
nC_{32}	0.16	0.18	0.65	0.53	0.37	0.16	0.16	0.43	0.09	0.61
nC_{33}	0.08	0.09	0.57	0.46	0.30	0.08	0.08	0.43	0.09	0.48
nC_{34}	0.08	0.09	0.40	0.30	0.22	0.08	0.08	0.29	0.09	0.27
nC_{35}	0.08	0.09	0.24	0.23	0.15	0.08	0.08	0.07	0.00	0.14
PARAFFIN	47.56	46.76	51.07	50.00	54.33	54.71	55.35	55.12	57.35	55.22
ISOPRENOID	4.26	5.03	6.03	5.17	5.00	4.18	3.92	3.40	4.13	3.72
NAPHTHENE	48.18	48.21	42.90	44.83	40.67	41.12	40.73	41.49	38.53	41.06
CPI INDEX A	0.97	0.98	0.96	0.99	1.02	1.09	1.06	1.01	0.98	1.02
CPI INDEX B	1.04	1.09	1.00	0.97	1.04	1.32	1.15	1.09	1.05	1.07
PRISTANE/PHYTANE	1.44	1.28	1.28	1.34	1.56	1.88	2.33	2.19	2.82	2.41
PRISTANE/nC_{17}	0.45	0.45	0.60	0.52	0.52	0.40	0.42	0.38	0.40	0.47

TABLE 8

COMPOSITION (NORMALISED %) OF C_{15+} PARAFFIN – NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	-080
DEPTH	4340'
SAMPLE TYPE	
nC_{15}	14.71
nC_{16}	15.42
nC_{17}	13.39
nC_{18}	10.45
nC_{19}	8.42
nC_{20}	7.30
nC_{21}	5.27
nC_{22}	4.46
nC_{23}	4.06
nC_{24}	4.06
nC_{25}	3.14
nC_{26}	3.55
nC_{27}	1.93
nC_{28}	1.12
nC_{29}	0.91
nC_{30}	0.81
nC_{31}	0.30
nC_{32}	0.30
nC_{33}	0.20
nC_{34}	0.10
nC_{35}	0.10
PARAFFIN	39.20
ISOPRENOID	3.30
NAPHTHENE	57.50
CPI INDEX A	0.92
CPI INDEX B	0.87
PRISTANE/PHYTANE	1.59
PRISTANE/nC_{17}	0.39

BRIEF DESCRIPTION OF THE ANALYSES PERFORMED BY GEOCHEM

"Screen Analyses" are described in sections A, C and D, "Sample Preparation" in section B, "Follow-up Analyses" in sections E through K and "Correlation Studies" in section L. The analyses can be run on either core or cuttings material with the proviso that samples must be canned for the C_1-C_7 analysis and should be canned (or at least wet) for the C_4-C_7 analysis. The other analyses can be run on both canned and bagged samples.

A) C_1-C_7 LIGHT HYDROCARBON ANALYSIS

The abundance and composition of the C_1-C_7 hydrocarbons in sediments reflects their source richness, maturity and the character of the hydrocarbons they can yield. Most importantly, it is extremely sensitive to the presence of migrated hydrocarbons and is an excellent method for their detection. As it provides the information on most of the critical parameters and is also economical, this analysis is excellent for screening samples to decide which of them merit further analysis.

During the time which elapses betwwen the collection of the sample at the wellsite and its analysis in the laboratory, a fraction of the total gas passes from the rock to the air space at the top of the can. For this reason, both the air space and the cuttings are analysed.

The analysis involves the gas chromatographic separation of the individual C_1-C_4 gaseous hydrocarbons (methane, ethane, propane, isobutane and normal butane) and a partial resolution of the C_5-C_7 gasoline-range hydrocarbons (for their complete resolution see Section E). The ppm abundance of the five gases and of the total C_5-C_7 hydrocarbons are calculated from their electronically integrated peak areas (<u>not</u> from peak height) by comparison with a standard.

In the report, the following data are tabulated: the abundance and composition of the air space gas, of the cuttings gas and of the combined air space and cuttings gases. The combined results are also presented graphically.

B) SAMPLE WASHING AND HAND PICKING

All of the analyses described in subsequent sections are run on washed and hand picked samples.

Cuttings are washed to remove the drilling mud, care being taken not to remove soft clays and fine sand during the washing procedure. Using the C_1-C_7 hydrocarbon data profile of the well, or the organic carbon profile (if this analysis is used for screening), electric logs (if supplied) and the appearance of the cuttings under the binocular microscope, samples are selected to represent the lithological and geochemical zones penetrated by the well. These samples are then carefully hand picked and the lithology of the uncaved material is described. It is these samples which are submitted for further analysis.

Sample material remaining after analysis is retained for six months. Unless instructions are received to the contrary, Geochem Laboratories may then destroy the samples.

Our reports incorporate a gross lithological description of <u>all</u> the samples which have been analysed and litho percentage logs. As screen analyses are recommended at narrow intervals, a complete lithological profile is obtained.

C) ORGANIC CARBON ANALYSIS

The organic carbon content of a rock is a measure of its total organic richness. Combined with the visual kerogen, C_1-C_7, C_4-C_7, pyrolysis and C_{15+} analyses, the organic carbon content is used to evaluate the potential (not necessarily actual) hydrocarbon source richness of the sediment. This analysis is an integral part of a total evaluation and it can also be used as an economical screen analysis for dry samples (when the C_1-C_7 analysis cannot be used).

Hand picked samples are dried, crushed and then acidised to remove the inorganic calcium and magnesium carbonates. The actual analysis involves combustion in a Leco carbon analyser. Blanks, standards and duplicates are run routinely for purposes of quality control at no extra cost to the client.

The data are tabulated and presented diagramatically in our reports in a manner which facilitates comparison with the gross lithology (see Section B) of the samples.

D) MINI-PYROLYSIS

An ideal screen analysis which provides a definitive measure of potential source richness upon those samples whose organic carbon contents suggest fair or good source potential. This is described in detail in section K.

E) DETAILED C_4-C_7 HYDROCARBON ANALYSIS

The abundance and composition of the C_4-C_7 gasoline-range hydrocarbons in sediments reflects their source quality, level of thermal maturation and organic facies. In addition, the data also reveal the presence of migrated hydrocarbons and can be used for crude oil-parent source rock correlation studies.

This powerful analysis, performed upon hand picked lithologies, is employed as a follow-up to confirm the potential of samples which have been selected using the initial screen analysis. It is used in conjunction with the organic carbon, visual kerogen and C_{15+} analyses.

The individual normal paraffins, isoparaffins, naphthenes and aromatics with between four and seven carbon atoms in the molecule (but also including toluene) are resolved by capillary gas chromatography and their peak areas electronically integrated.

Normalised compositions, selected ratios and the ppm abundance of the total gasoline-range fraction are tabulated in the report and also presented graphically.

F) KEROGEN TYPE AND MATURATION

Kerogen is the insoluble organic matter in rocks. Visual examination of the kerogen gives a direct measure of thermal maturity and of the composition of the organic matter (organic facies) and indicates the source quality of the sediment - which is confirmed using the organic carbon, light hydrocarbon, pyrolysis and C_{15+} analyses.

The type of hydrocarbon (oil or gas) generated by a source rock is a function of the types and level of thermal maturation of the organic matter which are present. Both of these parameters are measured directly by this method.

Kerogen is separated from the inorganic rock matrix by acid digestion and flotation methods which avoid oxidation of the organic matter. It is then mounted on a glass slide and examined at high and low magnifications with a Leitz microscope. Chemical methods measure the total kerogen population but, with this technique, individual particles can be selected for examination and spurious material identified. This is particularly valuable in reworked, contaminated and turbodrilled sediments.

The following data are generated: the types of organic matter present and their relative abundances, an estimate of the proportion of reworked material, preservation state, the thermal maturity of the non-reworked organic matter using the spore colouration technique.

Our maturation scale has been developed to digitise small but recognisable changes in organic matter colouration resulting from increasing maturity and to place particular emphasis upon the immature to mature transition. In the absence of a universal colouration scale, the most significant points on our scale have been calibrated against equivalent vitrinite reflectance values. The following maturation stages are recognised at the low end of the scale:-

a) immature; thermal index less than 2- (0.45% Ro)
b) marginally mature; indices between 2- and 2. Minor hydrocarbon generation from amorphous and herbaceous (± algal) organic matter
c) mature; indices between 2 (0.53% Ro) and 2 to 2+ (0.72% Ro), significant generation from amorphous, algal and herbaceous organic matter but wood only marginally mature
d) oil window; indices of 2 to 2+ (0.72% Ro) through to 3 (1.2% Ro). Peak hydrocarbon generation.

The condensate zone starts at a thermal index of 3 whilst indices of 3+ (2.0% Ro) and higher indicate the eometamorphic dry gas stage.

A total of fourteen types of organic matter are sought based upon the major categories of algal, amorphous, herbaceous (spore, pollen, cuticle), wood, inertinite and resin. This detail is essential for a proper understanding of hydrocarbon source potential as the different sub-groups within each category have different properties.

Upon completion of the study, the kerogen slides are sent to the client.

G) VITRINITE REFLECTANCE

Vitrinite reflectance is an alternative/confirmatory method for evaluating thermal maturation which is used in conjection with the visual kerogen analysis. The reflectivity of vitrinite macerals increases in response to thermal alteration and is used to define maturation levels and, by projection, to predict maturity at depth or the thicknesses of section removed by erosion.

Measurements are made upon kerogen separations in conjunction with polished whole rock samples. In general, this analysis is performed upon the same samples as the visual kerogen analysis, thus facilitating a direct comparison of the two sets of results.

If possible, forty to fifty measurements are taken per sample - unless the sediments are organically lean, vitrinite is sparse or only a single uniform population is present. The data are plotted in a histogram which distinguishes the indigenous vitrinite from possible reworked or caved material. Averages are calculated for each population. Comments upon exinite fluorescence and upon the character of the phytoclasts are noted on the histograms. The reports contain the tabulated data, histograms and the reflectivities plotted against depth.

The vitrinite and visual kerogen techniques provide mutually complementary information upon maturity, organic matter type and diagenesis.

H) C_{15+} EXTRACTION, DEASPHALTENING AND CHROMATOGRAPHIC SEPARATION

Sections "A" and "E" dealt with analyses covering the light end of the hydrocarbon spectrum. This section is concerned with the solvent extractable organic material in the rock with more than fourteen carbon atoms in the molecule (i.e. the heavy end). The amount and composition of this extract indicates source richness and type, the level of thermal maturation and the possible presence of migrated hydrocarbons.

These results are integrated with those derived from the pyrolysis, visual kerogen, organic carbon and light hydrocarbon analyses.

The techniques involved in this analysis employ pure solvents and have been designed to give reproducible results. Hand picked samples are ground and then solvent extracted in a soxhlet apparatus, or by blending, with dichloromethane (the solvent system can be adapted to client's specifications). After asphaltene precipitation, the total extract is separated by column chromatography or high pressure liquid chromatography into the following fractions: paraffin-naphthene hydrocarbons, aromatic hydrocarbons, eluted NSO's (nitrogen-, sulphur-, and oxygen- containing non-hydrocarbons) and non-eluted NSO's. Note that the non-hydrocarbons are split into three fractions and not reported as a gross value. These fractions can be submitted for further analyses (carbon isotopes, gas chromatography, high mass spectroscopy) including correlation studies.

For convenience and thoroughness, the data are reported in three formats: the weights of the fractions, ppm abundances and normalised percentage compositions. The data are also presented diagramatically.

J) GC ANALYSIS OF C_{15+} PARAFFIN-NAPHTHENE HYDROCARBONS

The gas chromatographic configurations of the heavy C_{15+} paraffin-naphthene hydrocarbons reflect source type, the degree of thermal maturation and the presence and character of migrated hydrocarbons or contamination.

Not only is this analysis an integral part of any source rock study but it also provides a fingerprint for correlation purposes and helps to define the geochemical/palynological environmental character of the source rocks from which crude oils were derived.

The paraffin-naphthene hydrocarbons obtained by column chromatography are separated by high resolution capillary chromatography. Excellent resolution of the individual normal paraffins, isoprenoids and significant individual isoparaffins and naphthenes is achieved. Runs are normally terminated at nC_{35}. A powerful in-house microprocessor system is being introduced to correct for the change in response factor with chain length.

The normal paraffin carbon preference indices (C.P.I.) indicate if odd (values in excess of 1) or even (values less than 1) normal paraffins are dominant. Strong odd preferences (± strong pristane peaks) are characteristic of immature land plant organic matter whilst even preferences (± strong phytane peaks) suggest a reducing environment of deposition. With increasing maturity, values approach 1.0 and oils are typically close to 1.0. The indices are calculated using the following formulae:

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

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

Chromatograms are reproduced in the report for use as visual fingerprints and in addition, the following data are tabulated: normalised normal paraffin distributions; proportions of paraffins, isoprenoids and naphthenes in the total paraffin-naphthene fraction; C.P.I_A and C.P.I_B; pristane to phytane ratio; pristane to nC_{17} ratio.

K) PYROLYSIS

The process of thermal maturation can be simulated in the laboratory by pyrolysis, which involves heating the sample under specified conditions and measuring the oil-like material which is freed/generated from the rock. With this analysis, the potential richness of immature sediments can be determined and, by coupling the pyrolysis unit to a gas chromatograph, the liberated material can be characterised. These results are correlated with those obtained from the organic carbon, kerogen and C_{15+} analyses.

Small amounts of powdered sample are heated in helium to release the thermal bitumen (up to 340^oC) and pyrolysate (340-550^oC). The thermal bitumen correlates with the solvent extractable material (see above) whilst the pyrolysate fraction does not exist in a "free" state but is generated from the kerogen, thus simulating maturation in the subsurface. Abundances (weight ppm of rock) are measured with a flame ionisation detector against a standard. Thermal bitumen includes source indigenous, contaminant and migrated hydrocarbons but the pyrolysate abundance is a measure of ultimate source richness. The capillary gas chromatogram of the pyrolysate is used to evaluate the character of the parent organic matter and whether it is oil or gas prone. Peak temperature(s) of pyrolysate evolution is recorded. Carbon dioxide can be measured if requested but is normally ignored as the separation of the organic and inorganic species has been found to be artificial and unreliable.

Pyrolysate yields provide a definitive measure of potential source richness which avoids the ambiguities of the organic carbon data and the problem of contamination. This analysis is also used to evaluate the quality and character of the organic matter and the degree to which it has realised its ultimate hydrocarbon potential. Geochem does not employ the pyrolysis technique to evaluate maturation, preferring the kerogen and vitrinite reflectance analyses which avoid the problem of reworking and hence, are more reliable.

Capillary chromatograms produced for the pyrolysate hydrocarbons range from C_1 (methane) out towards C_{35} but exhibit considerable variations. They are used to define whether a source rock will yield oil, condensate or gas. With this new technique, it is now possible to complete the evaluation of a source rock.

The data are tabulated and presented graphically. MINI-PYROLYSIS includes ppm thermal bitumen and ppm pyrolsate. PYROLYSIS also provides the above together with the temperature of peak pyrolysate evolution. The capillary chromatograms of the pyrolysate obtained by PYROLYSIS-GC are reproduced in the report. The Mini-Pyrolysis analysis is recommended as a screening technique.

L) CORRELATION STUDY ANALYSES

Oil to oil and oil to parent source rock correlation studies require high resolution analytical techniques. This requirement is satisfied by some of the analyses discussed above but others have been selected specifically for correlation work. Many of these analyses also provide information upon the character of the environment of deposition of the parent source rocks.

- detailed C_4-C_7 hydrocarbon (gasoline range) analysis. See Section E. Although these hydrocarbons can be affected by migrational/alteration processes, they commonly provide a very useful correlation parameter.
- capillary gas chromatography of the C_{15+} paraffin-naphthenes. See section J. The branched$\pm$normal paraffin distributions are used to "fingerprint" the samples.
- capillary chromatograms of whole oils and of the C_{8+} fraction of source rocks.
- capillary gas chromatography of C_{15+} aromatic hydrocarbons. Separate chromatograms of the hydrocarbons and of the sulphur-bearing species are reproduced.
- high pressure liquid chromatograms.
- mass spectrometric carbon isotope analyses of crude oil and rock extract fractions and of kerogen separations. A powerful tool for comparing hydrocarbons and correlating hydrocarbons to organic matter. With this technique the problem of source rock contamination can be avoided. The data are recorded on x-y or Galimov plots.
- mass fragmentograms (mass chromatograms) of fragment ions characteristic of selected hydrocarbon groups such as the steranes and terpanes. The fragmentograms provide a convenient and simple means of presenting detailed mass spectrometric data and are used as a sophisticated fingerprinting technique. This provides the ultimate resolution for correlating hydrocarbons and facilitates the examination of hydrocarbon classes.
- vanadium and nickel contents.

Suites of (rather than single) analyses are employed in correlation studies, the actual selection depending upon the complexity of the problem. See also section N.

M) ANALYSES FOR SPECIAL CASES

M-1) ELEMENTAL KEROGEN ANALYSIS

This analysis evaluates source quality, whether the sediments are oil or gas prone, the character of the organic matter and its level of thermal maturation. It is the chemical equivalent of the visual kerogen analysis. The pyrolysis analysis is generally preferred to this technique, both methods providing similar information.

M-2) SULPHUR ANALYSIS

The abundance of sulphur in source rocks and crude oils.

M-3) CARBONATE CONTENT

The mineral carbonate content of sediments is determined by acid treatment. These data are particularly useful when used in conjunction with organic carbon contents as a screening technique.

M-4) NORMAL PARAFFIN ANALYSIS

Following the removal of the branched paraffins and naphthenes from the total paraffin-naphthene fraction, a chromatogram of the normal paraffins is obtained. The resulting less complicated chromatogram facilitates the examination of normal paraffin distributions.

M-5) SOLID BITUMEN EVALUATION

Residual solid bitumen after crude oil is generated by three prime processes: the action of waters, gas deasphalting, thermal alteration. Thus it provides a means of determing the reservoir history of a crude and of evaluating whether adjacent traps will or will not be prospective for oil. In carbonate sections, where organic matter is sometimes sparse, this technique is also used to evaluate thermal maturation levels.

The analysis involves the determination of the solubility (in CS_2) of the solid bitumen and of the atomic hydrogen to carbon ratio of the insoluble fraction.

N) CRUDE OIL ANALYSIS

N-1) API GRAVITY

This can be performed upon large (hydrometer) and small (SG bottle, pycnometer) samples and even upon stains extracted from sediments (refractive index).

N-2) SULPHUR CONTENTS (ASTM E30-47)

N-3) POUR POINT (ASTM D97-66, IP15/67)

N-4) VISCOSITY (ASTM D445-72, IP71/75)

N-5) FRACTIONAL DISTILLATION

Graph of cumulative distillation yield against temperature. Five percent cuts taken for further analysis. Mass spectrometric studies of these fractions provide a detailed picture of the distribution of paraffins and of the various naphthene and aromatic groups within a crude, which is useful both for correlation and for refinery evaluation purposes.

FIGURE 1 $C_1 - C_7$ HYDROCARBONS WELL 33/5-2

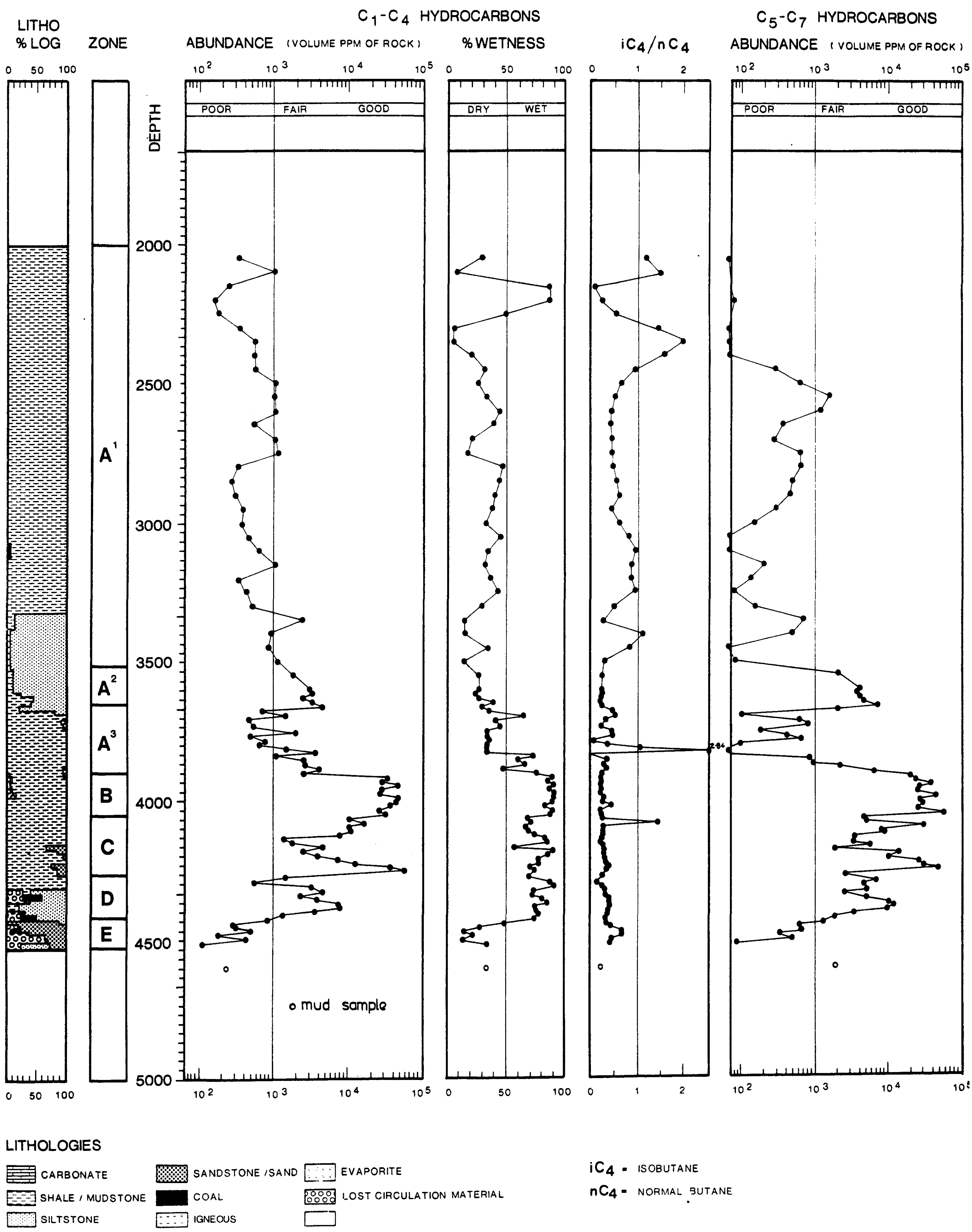
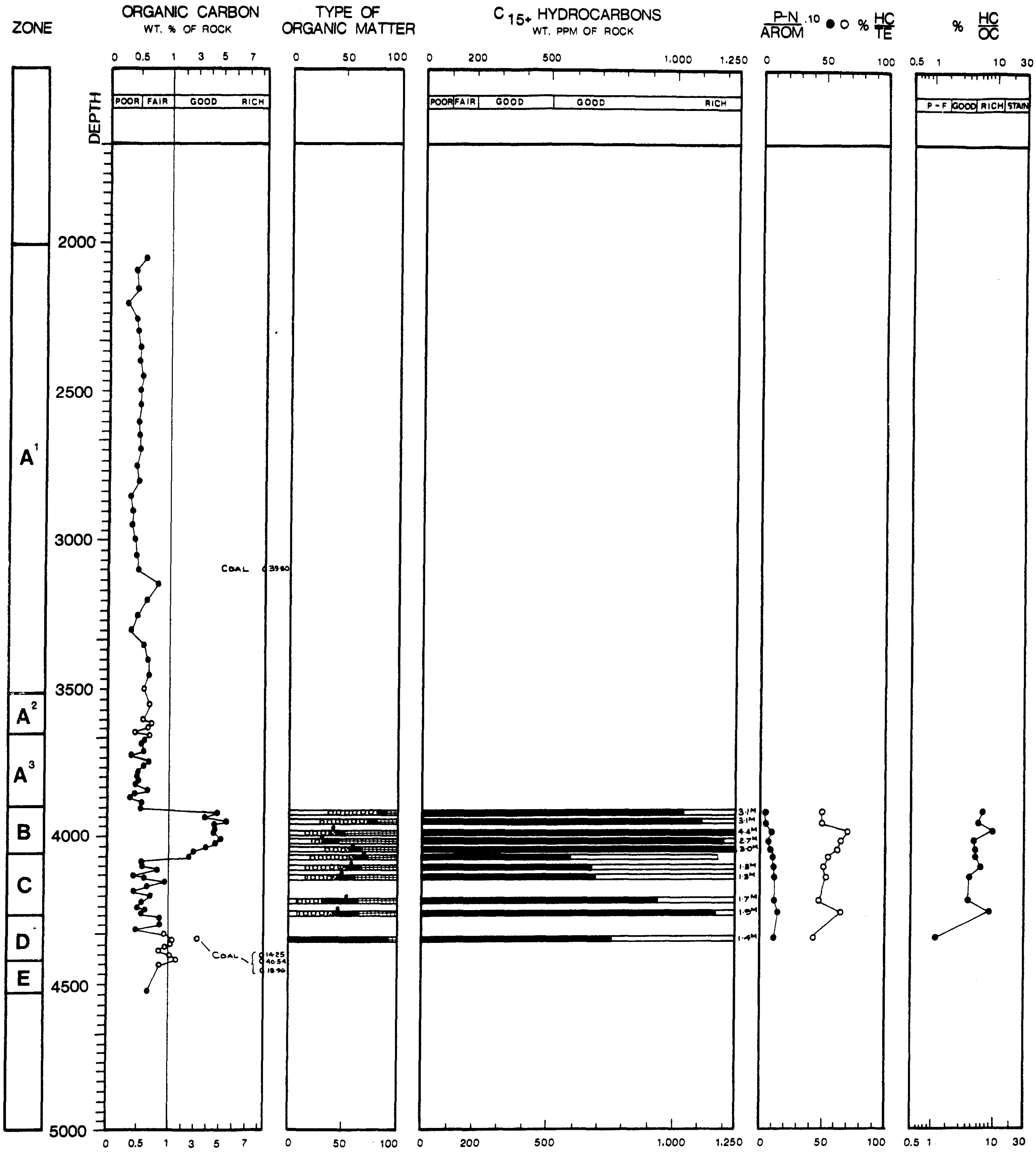


FIGURE 2 **RICHNESS** WELL 33/5-2



● SHALE
○ OTHER LITHOLOGIES

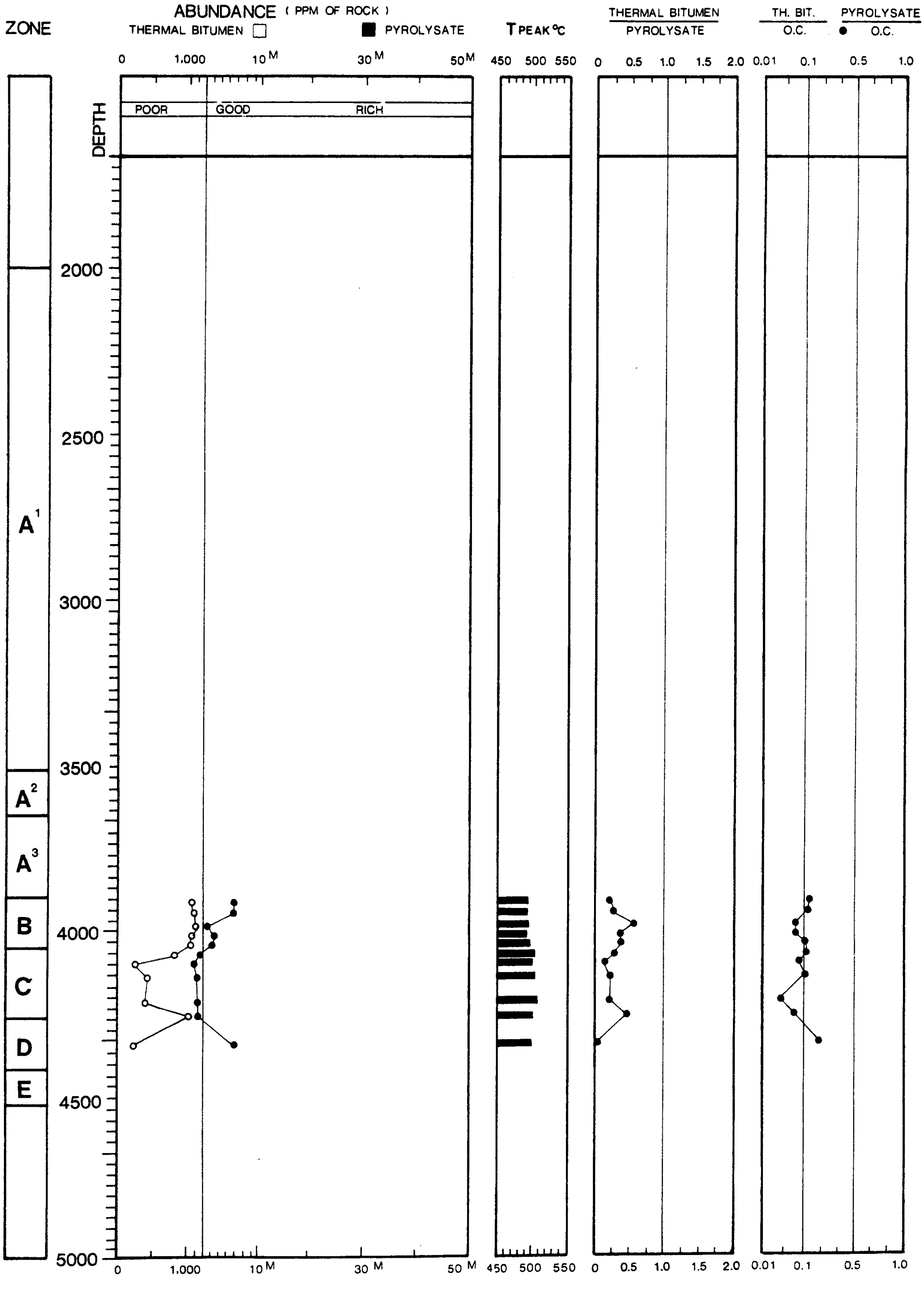
100 % REWORKED 0

ALGAL
AMORPHOUS
HERBACEOUS-SPORE, POLLEN, CUTICLE
RESIN
WOOD
INERTINITE ("COALY")

PARAFFIN-NAPHTHENES P-N
AROMATIC HYDROCARBONS AROM
FREE ELEMENTAL SULPHUR S
N_2 - S - O_2 BEARING COMPOUNDS NSO
ASPHALTENES ASP

HC = C_{15+} HYDROCARBONS
OC = ORGANIC CARBON
TE = TOTAL EXTRACT

FIGURE 3 **PYROLYSIS** WELL 33/5-2



M = 10 3

O.C. = ORGANIC CARBON

FIGURE 4a **PYROLYSIS GC** WELL 33/5-2

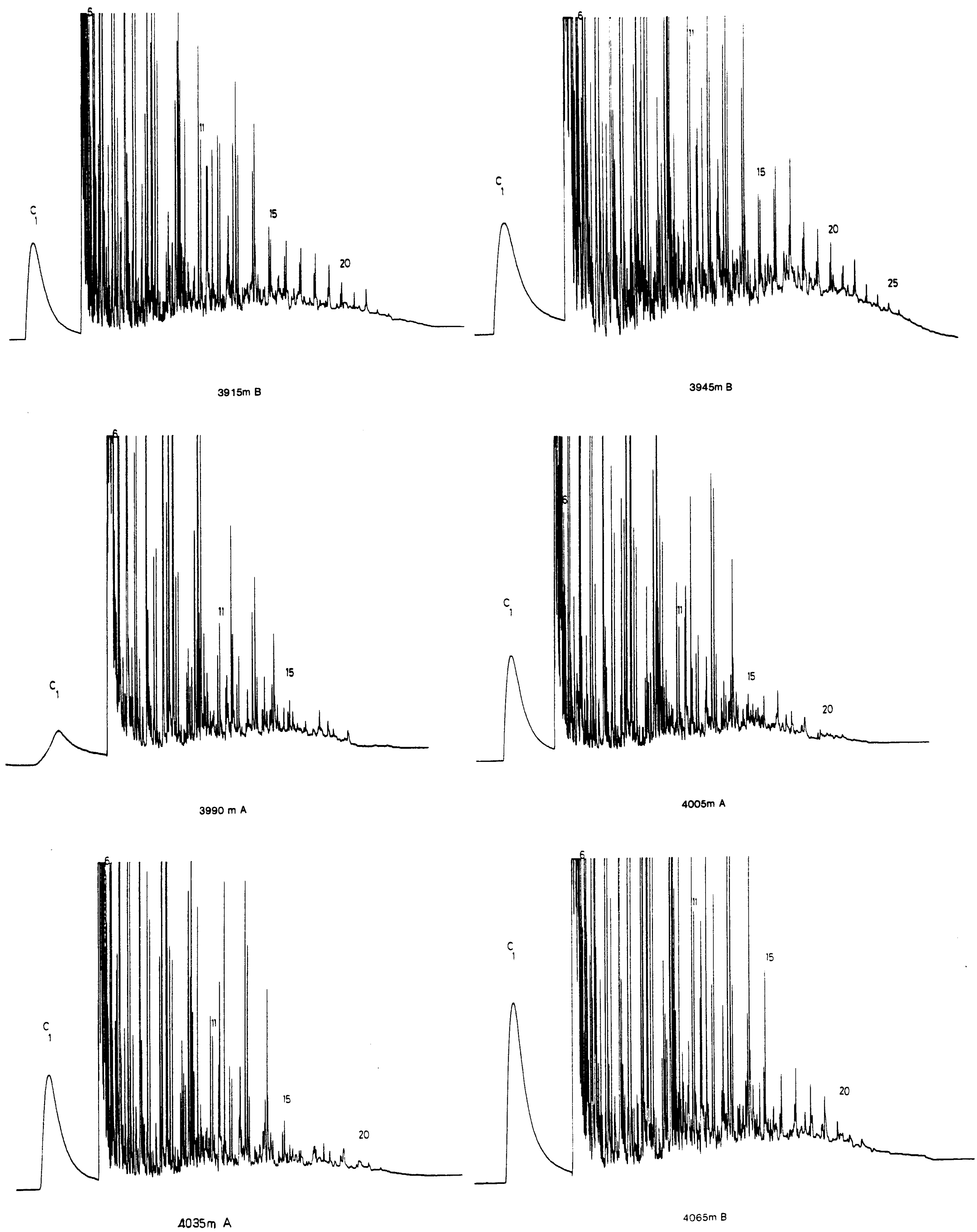
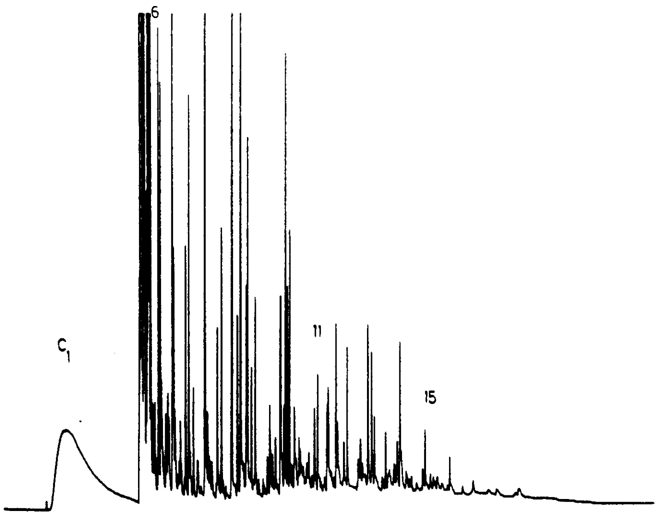
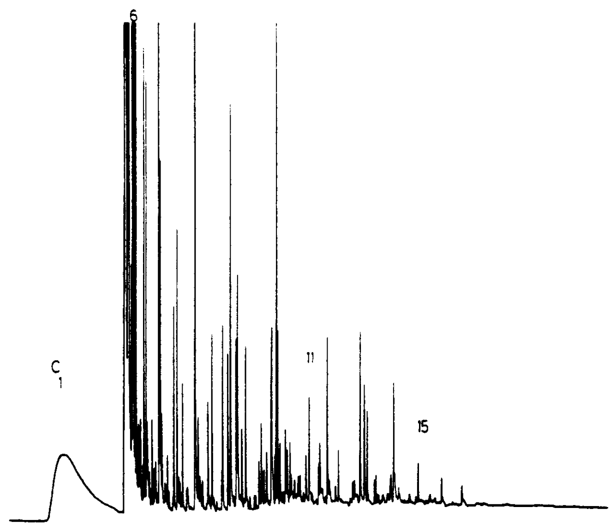


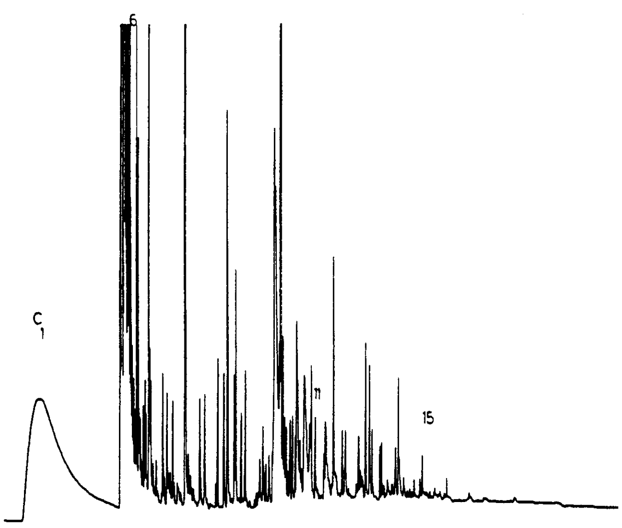
FIGURE 4b **PYROLYSIS GC** WELL 33/5-2



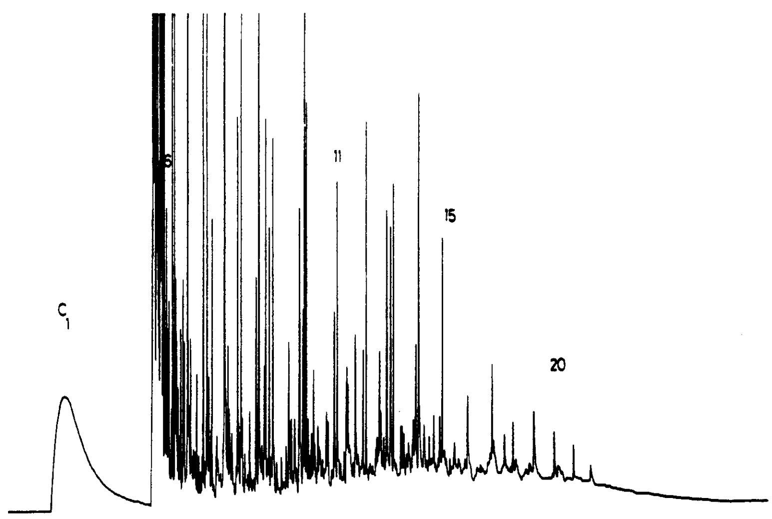
4095m C



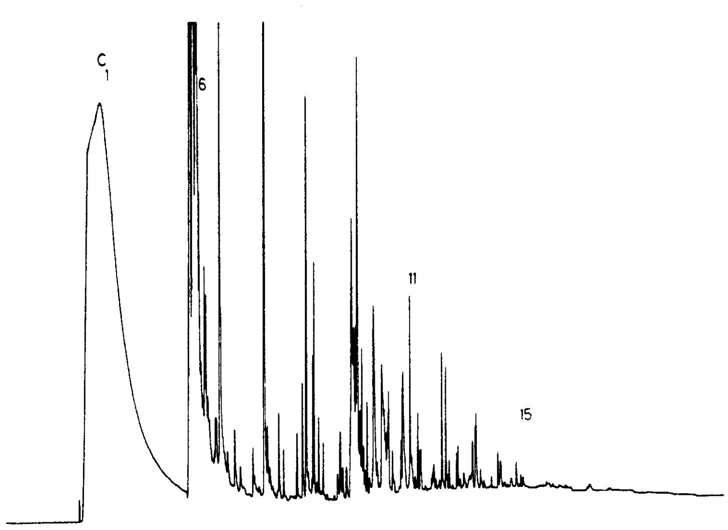
4140m B



4215m C

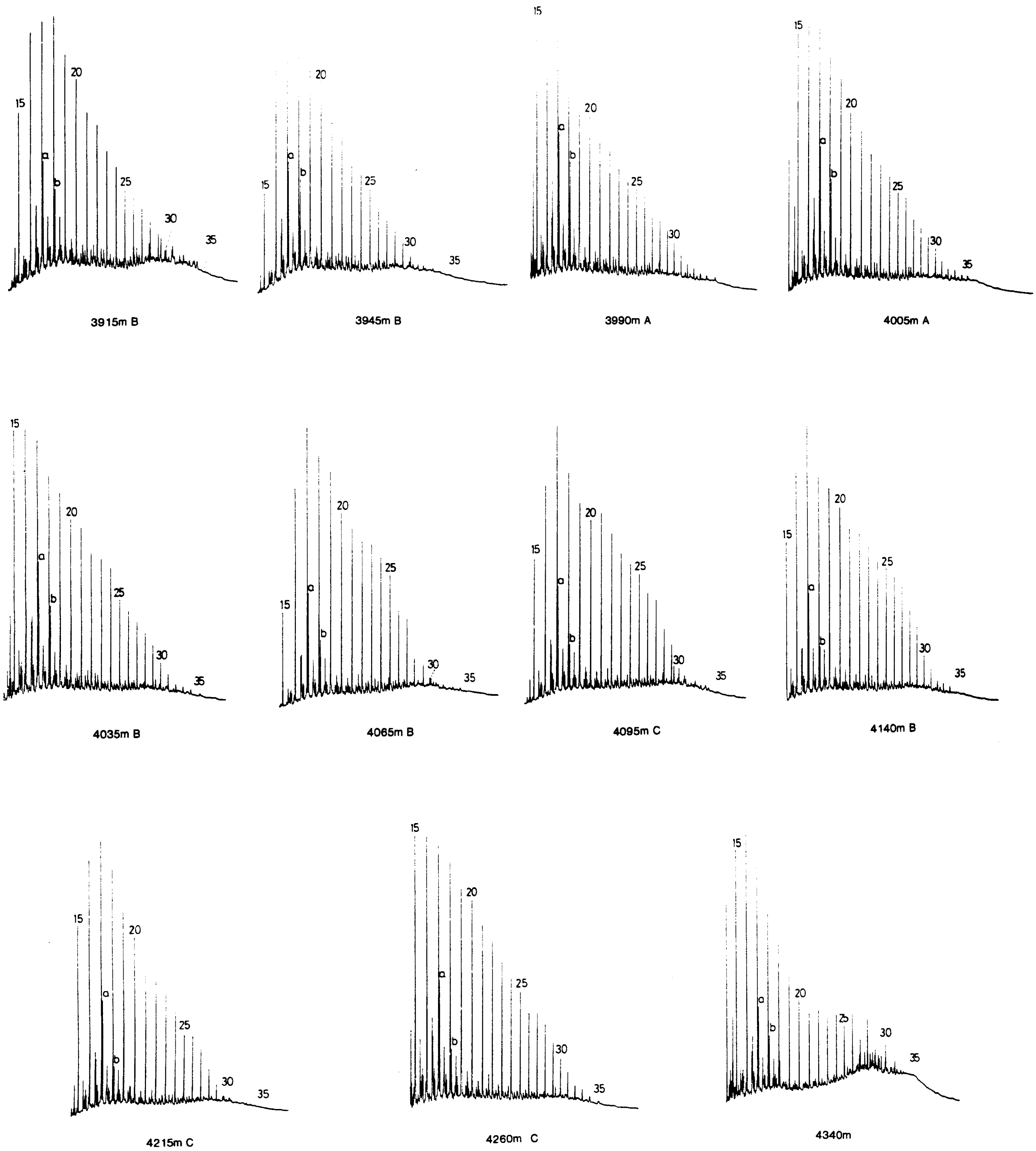


4260m C



4340m C

FIGURE 5 C_{15+} **PARAFFIN - NAPHTHENES** WELL 33/5-2



a = PRISTANE
b = PHYTANE

CARBON NUMBERS OF NORMAL PARAFFINS INDICATED (20 = nC_{20})

FIGURE 6a VITRINITE HISTOGRAMS WELL 33/5-2

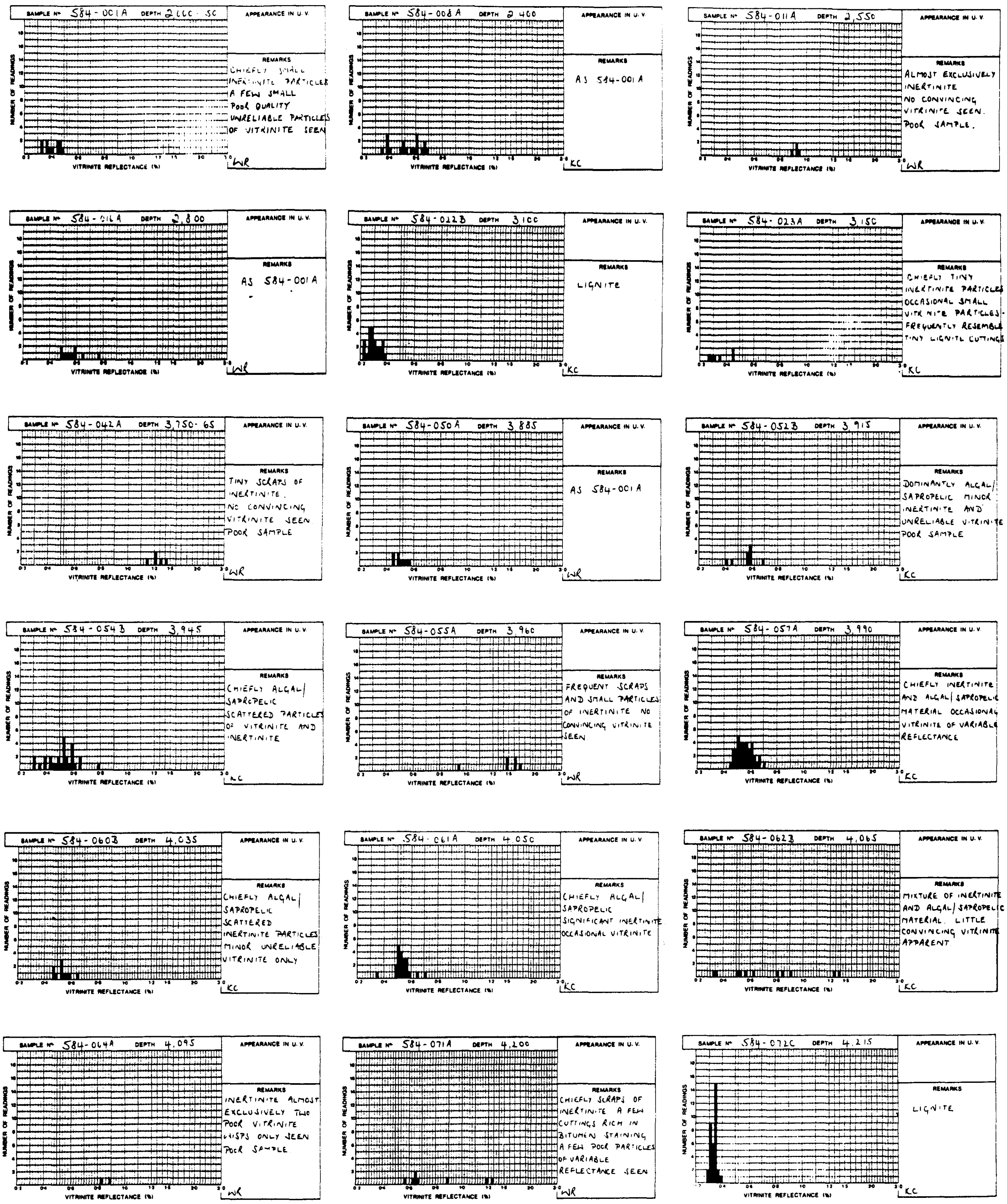


FIGURE 6b VITRINITE HISTOGRAMS WELL 33/5-2

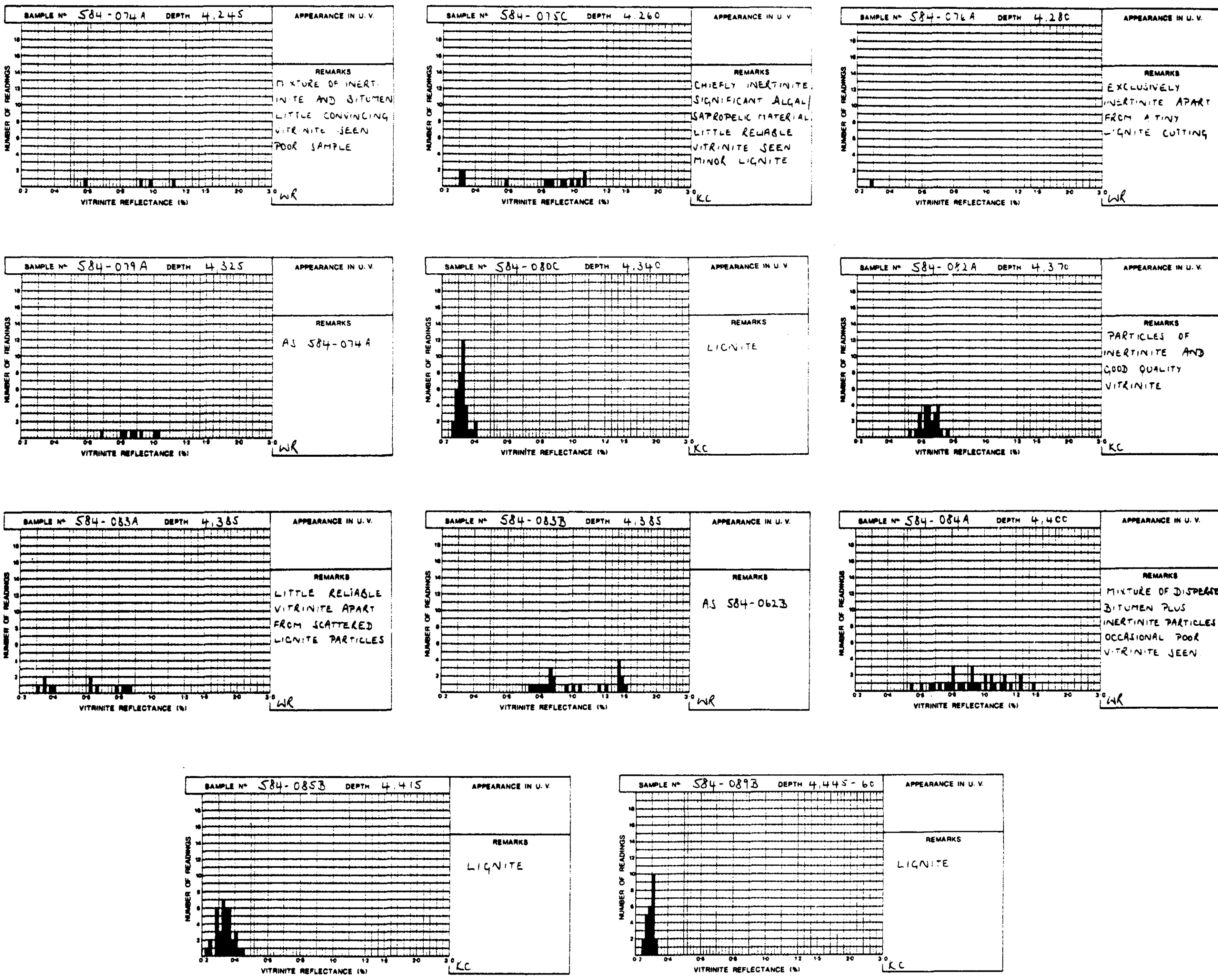


FIGURE 7 **INTERPRETATION** WELL 33/5-2