GeoChem Laboratories (U.K.) Limited

GEOCHEMICAL SERVICE REPORT

Prepared for

BP PETROLEUM DEVELOPMENT OF NORWAY A.S.

GEOCHEMICAL EVALUATION OF THE BP-NOCS 2/1-2 WELL, NORWEGIAN NORTH SEA.

PetroData

707-1815

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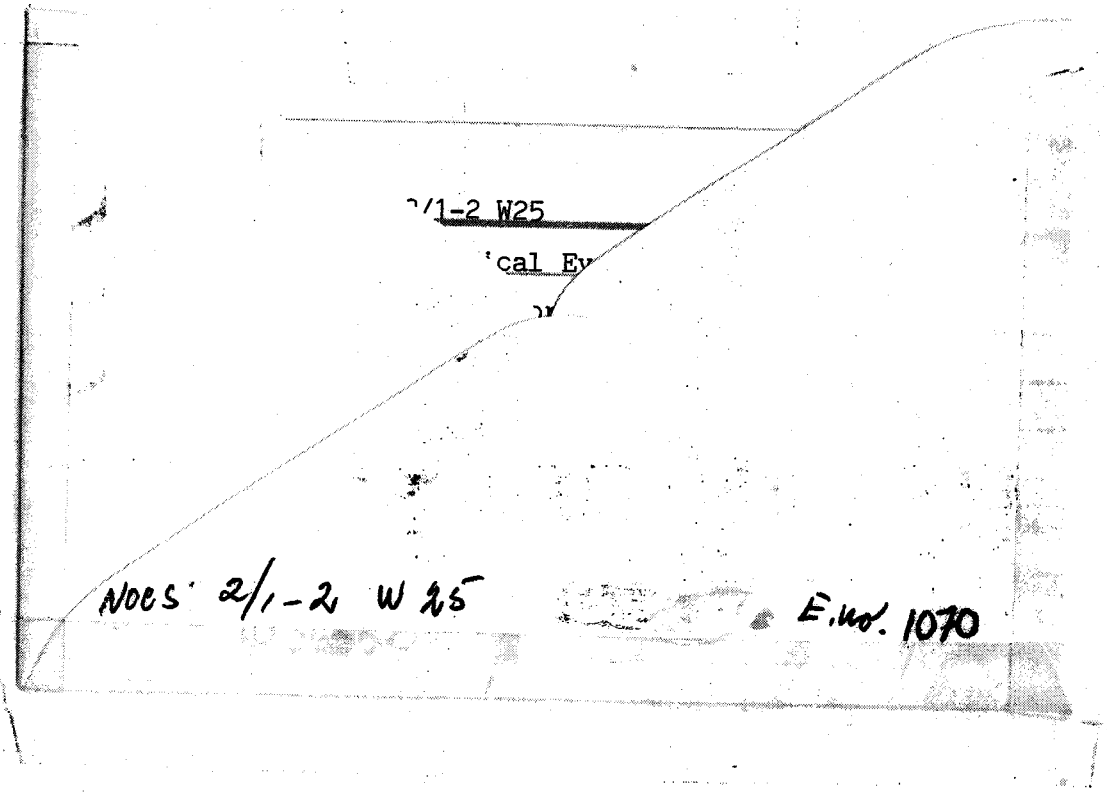
CHESTER STREET · CHESTER CH4 8RD · ENGLAND

Zone A	2248 – 2745	ORIG –	TOP CRET
B	2745 – 3140	TOP CRET –	Late A1b
C	3140 – 3301	Late A1b. –	Top Jur
D	3301 – 3320	Top Jur –	Top Sst.
E	3320 – 3550	Top Sst. –	T.D.



NOCS 2/1-2 W 25 E.no. 1070

GEOCHEMICAL EVALUATION OF THE BP-NOCS 2/1-2 WELL, NORWEGIAN NORTH SEA

SUMMARY

Five (5) geochemical zones are recognised between 2248 metres and 3550 metres.

The dominant shales within Zone A (2248-2745± metres) are potentially fair to good source rocks for oil but are immature above 2600± metres. Minor liquid hydrocarbon generation is occurring below this depth. Traces of light ends (wet gas with minor young condensate) are suggested at 2300-2360± metres, below 2525± metres and within the underlying limestones. The volumes involved are insignificant.

Zones B (2745-3140± metres), C (3140-3301± metres) and E (3320-3550± metres) are poor and effectively immature source intervals.

In contrast, Zone D (3301-3320± metres) has a potential for major oil although it is only marginally mature on-structure. Its off-structure lateral equivalents have apparently yielded the young oil detected in Zone D, whilst traces of light ends (wet gas?) are apparently present as high as 3240± metres and down to total depth (but particularly above 3380± metres) and were probably generated from the Zone D shales. The presence of a young oil in Zone D indicates oil, but not major oil, generation within the drainage area of this structure.

N J L Bailey
GEOCHEM LABORATORIES (UK) LIMITED

INTRODUCTION

This report presents a geochemical evaluation of the section between 2248 metres and 3550 metres in the BP-NOCS 2/1-2 well, drilled in the Norwegian sector of the North Sea.

The study was designed to be compatible with the previous studies performed for BP. Its primary objectives were to:

- determine the hydrocarbon source potential of the section in terms of richness, maturity and hydrocarbon type
- recognise and characterise migrated hydrocarbons

Some further analyses are being performed upon a suite of sidewall cores from the interval 2248-2742 metres and will be reported separately.

This study was authorised by Mr D South, BP Petroleum Development of Norway A.S.

A. ANALYTICAL

Thirty-four (34) canned sediment samples were received from the interval 2250-3550 metres in 2/1-2. They were normally collected on a fifty metre spacing above 3100 metres and at twenty metre intervals below this depth. In addition, twenty three sidewall cores (core chips 3322.4-3334.4 metres) were submitted for the study, principally from between 3146.5 metres and 3334.4 metres, but samples were also received from 3488.2 metres and 3537.8 metres. Subsequently, eight extra sidewall cores were received from the interval 2248-2742 metres. A mud sample (3335 metres) was included in the study. These samples were assigned the Geochem job number 235 and sequential sample numbers from -001 to -066.

Only scattered minor contamination was observed in washing the canned samples.

The samples were screened with the light hydrocarbon (C_1-C_7) and organic carbon analyses and samples for further analysis were selected on the basis of the screen results. A total of thirty-five light hydrocarbon analyses, eighty-nine organic carbon analyses, twenty-one visual kerogen analyses, fourteen vitrinite reflectance determinations, twenty-four extractions with chromatography, twenty-four paraffin-naphthene analyses and twelve pyrolysis analyses were performed.

The data are presented in tables 1 through 8 and graphically in figures 1 through 5. A brief description of the analyses is included in the back of this report.

B. GENERAL INFORMATION

Twelve (12) copies of this report have been forwarded to Mr D South, BP Petroleum Development of Norway A.S., Stavanger. A copy of the data has been retained by Geochem for future consultation with authorised BP personnel.

The kerogen slides and vitrinite reflectance worksheets are included with this report. The remaining washed and bagged sample material will be handled as directed.

All of the results and interpretations related to this study are regarded as highly confidential and are proprietary to BP Petroleum Development of Norway A.S.

RESULTS AND INTERPRETATION

Each of the parameters relevant to the evaluation of the interval between 2248 metres and 3550 metres will be discussed individually and then integrated to form the "Conclusions".

No well logs were available for this study.

A. ORGANIC GEOCHEMICAL ZONATION

Although there is lithologic variation, a meaningful zonation cannot be established above 3300± metres using the light hydrocarbon (C_1-C_7) data and hence the zonation presented below is based upon a combination of the light hydrocarbon, organic carbon and lithological data. Five (5) Zones have been picked.

Zone A — 2248 metres to 2745± metres, is dominated by medium grey to medium olive grey shales, which are interbedded with mixed shales ranging from dark greenish grey to light bluish grey and dark brownish grey. Medium dark grey and medium grey shales are dominant at 2530-2620± metres. Minor sand is present at 2700 metres, whilst siltstones were sampled (sidewall cores) at 2303 metres and 2742 metres.

No fluorescence was observed in the sand or in the siltstones.

With one exception (2450 metres, 144 ppm) the gaseous C_1-C_4 hydrocarbons range from 464 ppm up to 2989 ppm. They pass from dry to marginally wet at 2525± metres, whilst isobutane to normal butane ratios in excess of 2.2 above 2525± metres fall to values of less than 0.9 below 2575± metres. The heavier C_5-C_7 hydrocarbons show an imperfect tendency to decrease from approximately 300 ppm down to 150 ppm at 2575± metres, but then jump up to 505-716 (1210) ppm.

Thus the lowermost one hundred and fifty± metres tends to be wetter and to have somewhat enhanced C_5-C_7 abundances and lower butane ratios. The sample from 2600 metres is both the richest and wettest.

Zone B — extends from 2745± metres down to 3140± metres and is composed of limestones (chalky at the top) with minor (caved?) medium grey shales.

No fluorescence was detected in the limestones.

With the exception of the sample from 2800 metres, hydrocarbon abundances tend to decrease with depth: C_1-C_4 fraction, 950 ppm down to 200 ppm; C_5-C_7 fraction, 700 ppm to 200 ppm. The gases are transitional between marginally wet and wet.

Zone C covers the interval from 3140± metres to 3301± metres and is shaly. The shales are variable in colour, but are commonly approximately medium light grey above 3170± metres and medium dark grey below 3180± metres. The sample from 3170-3180± metres consists of a lignite mud additive with limestone and greyish brown shale.

The C_1-C_4 gases are generally sparse (33-237 ppm) throughout this interval, although they increase with depth. More significant than this rather minor increase is the drop in the isobutane to normal butane ratios below 3180± metres to low values of 0.18-0.38 and the increase in gas wetness to 53% at 3250 metres and 72% at 3275 metres. All of these trends culminate in the sample from 3300 metres, which contains almost 3000 ppm of extremely wet gas associated with over 3500 ppm of the C_5-C_7 hydrocarbons.

Zone D 3301± metres to 3320± metres, consists of dark olive grey shales.

No canned samples were collected over this interval and hence the light hydrocarbon analysis could not be run.

Zone E extends from 3320± metres down to the deepest sample at 3550 metres. Sandstones above 3340± metres are underlain by a sequence of medium dark grey and moderate brown shales with minor sands at 3400-3475± metres. The sidewall cores from 3488 metres and 3538 metres consist of moderate brown shale, suggesting that the medium dark grey shales, at least from below 3480± metres, may be caved.

Abundance values of approximately 2000 ppm C_1-C_4 hydrocarbons and 1500 ppm C_5-C_7 hydrocarbons tend to apply above 3380± metres and below 3520± metres, whilst both fractions approximate 600 ppm within the intervening (3380-3520± metres) section. The gases are wet throughout (69-86% C_{2+} in total C_1-C_4, generally over 75%) and have low butane ratios. It

is possible that the richer samples from below 3520± metres could be caved.

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 per cent 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 (oil,gas) of the hydrocarbon product and the response of the organic matter to thermal maturation. Richness and oiliness decrease in the order: amorphous-herbaceous-stem-woody. Wood has a primary (but not exclusive)potential for gas, whilst coaly (oxidised) material has only a limited hydrocarbon potential.

The medium grey to medium olive grey shales which dominate Zone A above 2530± metres and below 2620± metres are of approximately average richness, containing (0.76) 0.90-1.29 (1.53)% organic carbon. The olive grey and olive black shales (0.97-1.08%) at 2305-2315 metres and the dark yellowish brown (0.77%) shale at 2400 metres resemble the medium grey shales. Their organic matter is dominantly herbaceous in type, although woody±coaly material is also a significant constituent. Amorphous kerogen is sparse or absent. The organic matter in the medium grey to medium light grey shale at 2550 metres is similar in composition but is less abundant (0.62%), whilst the medium dark grey to dark greenish grey shale at 2600 metres is not only leaner (0.42% organic carbon; brownish black shale at 2495 metres, 0.48%) but is dominated by woody material, herbaceous debris being a significant rather than major constituent. However, the minor shales within Zone A are lean, containing only 0.13-0.21% organic carbon. This leaness is emphasised by the fact that their organic matter is almost exclusively woody and coaly in type.

The (caved?) shales within Zone B resemble the medium grey shales of Zone A in richness, with (0.50) 0.93-1.42% organic carbon. The organic matter within the limestones is almost exclusively coaly and woody.

The lignite-type mud additive at 3175 metres is extremely rich (41.0%) in woody material (with significant coaly and stem debris). With this exception, the shales of Zone C contain 0.09-0.60 (generally less than 0.45)% organic carbon. Not only are they lean, but their organic matter is almost entirely woody coaly.

In contrast, the Zone D shales are rich in oil-prone amorphou kerogen. They normally range from 4.7% up to 7.2% organic carbon, although the shales from 3314 metres (9.65%)and 3316 metres (2.76%) are richer and leaner respectively. Their organic

matter is dominantly amorphous. Fairly significant proportions of herbaceous debris are also present and there is a sizeable amount of herbaceous material which has not completely passed over to the amorphous form and is now "frozen" in a transitional state.

The shales of Zone E resemble those of Zone C. Their organic matter is very dominantly woody and coaly in type, herbaceous material being minor to significant and amorphous kerogen only minor. Furthermore, the medium dark grey shales generally contain 0.35-0.50% organic carbon (although a few samples range up to 0.8%), whilst the moderate brown shales are lean (but, 1.18% at 3538 metres).

Relatively oxidising conditions apparently prevailed at the seawater-sediment interface during Zone B, C and E times, but the Zone D shales were deposited in a reducing environment. Oxidising interludes are also indicated within Zone A.

C. LEVEL OF THERMAL MATURATION

Thermal maturity has been evaluated using the vitrinite reflectance and organic matter colouration techniques.

Vitrinite reflectance determinations were based upon cuttings and sidewall core material above 3100± metres and upon sidewall cores, below this depth, the only exception being the "carbargillite" from 3175 metres. This gave an anomalously low value of 0.28% Ro suggesting that it might be a lignite mud additive. The physical appearance of this material is quite compatible with this idea. No determinations were possible upon the limestones, or upon the lean moderate brown shales below 3480± metres.

There is only a very poor trend of reflectivity against depth. However, this is somewhat improved by eliminating the lignite and ignoring the values in excess of 0.8% at 3170 metres, 3221 metres and 3270 metres and the values greater than 0.6% above 2750 metres, all of which are believed to represent "reworked" material. In addition, the recorded measurements from 2600 metres and 2700 metres could be recalculated to give values of approximately 0.45% Ro (instead of 0.49) and 0.46% Ro (instead of 0.41).

After the data have been 'doctored' in this way, there is a suggestion of a trend from 0.4% Ro at the top of the analysed section to 0.5% Ro at 3300-3500± metres. The lower pick is subjective due to the sparcity of data points below 2700± metres and the general scatter which is still present. Nevertheless, this trend suggests maturity (but not the peak maturity of the oil window) below approximately 3500± metres.

Using the organic matter colouration technique, a maturation index of 2- is achieved at 2590± metres and, although a value of 2 is not

reached within this section, it apparently lies close to total depth.

The sediments above 2590± metres are immature and, within them, the process of thermal hydrocarbon generation has not been initiated. Below this depth the amorphous and herbaceous fractions of the total organic matter are marginally mature and have started to generate minor volumes of liquid hydrocarbons. Thus, the lowermost one hundred± metres of Zone A is just marginally mature and Zone D is also marginally mature. However, due to the character of their organic matter, Zones B, C and E are effectively immature.

A vitrinite reflectivity of 0.5% Ro should correlate with a maturation index of 2 and hence, there appears to be a reasonable correlation between the two methods.

Reworked organic matter is present throughout this well section.

D. HYDROCARBON SOURCE RICHNESS

Preliminary assessments of present and potential source richness can be obtained from the light hydrocarbon and organic carbon abundances respectively.

The light hydrocarbon data suggest that Zone A consists of potentially fair source rocks (with some poor intervals) whilst Zones B, C and below 3800± metres, E, are poor. Using the organic carbon contents, the dominant shales of Zone A are rated as potentially fair to good source rocks, whilst Zone D is rich, but the rest of the section is only poor with occasional fair intervals.

Definitive assessments include the C_{15+} hydrocarbon abundances. The medium dark grey shale from 2600 metres contains 137 ppm C_{15+} hydrocarbons and is rated as a potentially fair source rock, whilst the samples representative of the medium grey to medium olive grey shales of Zone A range from 317 ppm up to 494 ppm and are apparently potentially good or good to very good oil sources. However, it is believed that both source indigenous and non-indigenous hydrocarbons are indicated in their paraffin-naphthene chromatograms and that a fair to good rating would be more realistic. This interpretation is supported by the olive black sidewall core shale from 2352 metres which contain 237 ppm C_{15+} hydrocarbons and is rated as fair or fair to good. The Zone B limestones are poor source rocks (32-94 ppm) but the shales of Zone C vary from a poor 62 ppm up to a surprisingly good 760 ppm. The richest sample (3169.5 metres), although it is a sidewall core, has an anomalously high hydrocarbon to organic carbon ratio indicating the presence of non-indigenous hydrocarbons. The configuration of the background envelope of its paraffin-naphthene chromatogram indicates that these have been introduced from the mud system. In fact, the chromatograms indicate this problem throughout Zone C and, as a result, the measured hydrocarbon abundances do not reflect the actual source potential of the sediments. However, as even the lowest value of 62 ppm includes some contamination, it would appear that this

interval has, at best, a poor to fair source potential. The chromatogram of the sample from 3175 metres confirms that the "carbargillite" is, in fact, a lignite mud additive.

Very high C_{15+} hydrocarbon abundances apply to the Zone D shales (3573-7216 ppm) and particularly to those above 3315± metres. The values in excess of 7000 ppm which apply to the two analysed samples from above this depth are believed to include migrated hydrocarbons (see Section E) but even so, Zone D is rated as a potentially excellent oil source.

The shales of Zone E contain 158-392 ppm C_{15+} hydrocarbons and hence, are comparable to the sands. The paraffin-naphthene chromatograms of the shales and sands are also related and indicate very significant drilling-introduced contamination.

In order to determine the true source potential of these intervals for which contamination has been interpreted, selected samples were submitted for the pyrolysis analys s. This is a laboratory simulation of the maturation process which evaluates not only source richness under optimum maturation conditions but also the quality of the organic matter. The shales of Zone A yielded 2111-4826 ppm pyrolysate and are rated as potentially fair to good and good source rocks for oil. Abundances are halved in Zone C resulting in mixed poor, poor to fair and fair ratings. In contrast, the shales of Zone D gave 28000-48000 ppm pyrolysate and uniformly high pyrolysate to organic carbon ratios. These are potentially major oil source rocks. Zone E is two orders of magnitude leaner (190-240 ppm pyrolysate) and is rated as a poor source.

E. MIGRATED HYDROCARBONS

Potential reservoir facies are represented by the minor sand at the base of Zone A, the Zone B carbonates, the sands at the top of and within Zone E and the Zone A siltstones.

No fluorescence was detected within this section.

During the vitrinite reflectance study, traces of hydrocarbons were reported at 2450 metres, 2600 metres, 2800 metres and 2950 metres.

Although the light hydrocarbons are not particularly abundant (no samples from Zone D), gas wetness values and C_5-C_7 abundances are commonly anomalous for sediments at these levels of maturation. In particular, the trend below 3240± metres in Zone C and the values above 3380± metres in Zone E suggest the presence of traces of migrated liquid hydrocarbons. Minor traces are also suggested throughout the rest of Zone E, at 2525-2785± metres (and possibly at 2300-2350± metres) in Zone A and within Zone B.

Within Zones A through C and the sands of Zone E, hydrocarbons constitute (3.9)13.3-27.3% and 1.4-13.7% respectively of the total C_{15+} extract. These values are low and are not indicative

of migrated oil. The normal paraffin distributions in the C_{15+} paraffin-naphthene chromatograms of some of the cuttings samples from Zones A and B are anomalously mature, but this appears to reflect drilling-introduced contamination. However, those of the Zone A sidewall cores from 2303 metres, 2352 metres and 2742 metres indicate the possible presence of young oil or condensate. This can only occur in insignificant traces (ppm abundance, hydrocarbon to total extract ratio). The chromatograms of Zone E are non oil-like and this is generally also true of Zone C, although traces of migrated oil could be present at 3299 metres (together with contaminant and source-indigenous hydrocarbons).

The shales above 3313± metres in Zone D have high hydrocarbon to total extract ratios (0.6). These values are anomalously good for sediments at these levels of thermal maturation, whilst their paraffin-naphthene chromatograms are characterised by mature normal paraffin distributions, strong isoprenoid (especially pristane) peaks and relatively low steranes. These data are interpreted to indicate the presence of migrated fairly young oil.

Combining these different sets of data therefore:

- migrated crude oil appears to be present within Zone D. This oil is fairly young and was probably generated within the downdip lateral equivalents of the Zone D shales. It probably represents a relatively localised redistribution, but does indicate that oil generation is occurring although it cannot be taken as evidence of a generation process (within the drainage area of the structure) which is capable of yielding economic accumulations.
- traces of oil have diffused a short distance into the overlying sediments of Zone C whilst wet gas could have moved up to sixty± metres into Zone C.
- oil was not detected in the Zone E sands which underlie the rich shales of Zone D. Even allowing for the contamination only insignificantly minor traces could be present. Traces of the light ends (wet gas?) could, however, be present.
- traces of light ends (wet gas?) are also suggested throughout the rest of Zone E and, with insignificant condensate, at 2300-2360± metres and 2525-2745± metres in Zone A and in the Zone B carbonates.
- the data do not indicate the presence of <u>significant</u> volumes of hydrocarbons in any of the reservoir facies.

F. <u>CONCLUSIONS</u>

Five (5) geochemical zones are recognised between 2250 metres and 3550 metres in 2/1-2.

Zone A (2248-2745± metres) consists of mixed shale lithologies but is dominated by medium grey to medium olive grey shales which, together with most of the other shales, have average (for shale) values within the range (0.76) 0.90-1.29 (1.53)% organic carbon.

Their organic matter is largely herbaceous in type, although significant proportions of woody±coaly debris are also present, but amorphous kerogen is sparse to absent. The medium grey to medium light grey shales at 2550 metres contain similar, but less abundant (0.6%), organic matter whilst the underlying medium dark grey to dark greenish grey shales at 2600 metres are further reduced (0.4%) and their organic matter is now dominantly woody, herbaceous material being a significant but not major constituent. The shales at 2495 metres, 2550 metres and 2600 metres (but not 2584 metres) have only a fair potential for hydrocarbons but the major shales above and below this interval are potentially fair to good and good source rocks. However, the sediments above 2590± metres are immature. Below this depth, the amorphous and herbaceous fractions of the total organic matter are marginally mature and have started to generate minor volumes of liquid hydrocarbons but the woody and coaly materials are still immature. Effectively therefore, the medium grey to medium olive grey shales below 2600 metres are just marginally mature whilst the rest of Zone A is immature and unable to realise its potential. Off-structure, the lateral equivalents of all of the Zone A shales are probably marginally mature.

Zone B (2745-3140± metres) consists of limestones with minor (caved?) medium grey shales. The shales resemble those of Zone A in richness, containing (0.50) 0.93-1.42% organic carbon. The organic matter in the limestones is almost entirely coaly and woody in type and hence this interval is a poor, immature source which is of no exploration significance.

Traces of light ends (wet gas with minor young condensate) are suggested at 2300-2360± metres and 2525-2745± metres in Zone A and within Zone B. These hydrocarbons, which are of no economic significance, could have been generated from the off-structure, lateral equivalents of the Zone A shales.

Zone C (3140-3301± metres) is composed of relatively lean mixed shales. Organic carbon values vary from a very low 0.09% up to 0.60%, but generally fall below 0.45%. This leaness is compounded by the fact that the organic matter is almost exclusively woody and coaly in type. These are poor (occasionally fair) source rocks which, because of the character of their organic matter, are effectively immature, and hence, of no interest.

In contrast, the dark olive grey shales of Zone D (3301-3320± metres) are rich. They generally contain 4.7-7.2% organic carbon, although the lowermost samples from 3314 metres and 3316 metres are richer (9.65%) and somewhat "leaner" (2.76%) respectively. Not only are they rich, but their organic matter is dominantly composed of amorphous kerogen. Herbaceous debris is fairly significant and there is also a significant proportion of herbaceous material which has not been completely altered over to the amorphous form and is "frozen" in a transitional state.

These sediments are potentially excellent source rocks for major oil which, on-structure, are marginally mature and starting to generate minor volumes of oil.

In fact, a young oil has moved into this interval from the off-structure lateral equivalents of these shales. This is probably a relatively localised redistribution which indicates oil (but not major oil) generation within the drainage area of the structure. Traces of oil appear to have diffused into the overlying Zone C shales whilst minor traces of light ends (wet gas?) may be present as high as 3240± metres. Oil was not detected in the underlying sands, but there is a suggestion of light ends (wet gas?) down to total depth but particularly above 3380± metres.

Zone E (3320-3550± metres) consists of sands (down to 3340 metres) which overlie medium dark grey and moderate brown shales. At least below 3430± metres, the medium dark grey shales may be caved. The medium dark grey shales contain 0.35-0.50 (occasionally 0.7)% organic carbon, whilst the moderate brown shales are lean. Their organic matter is very dominantly woody and coaly in type, herbaceous debris being minor to significant and amorphous kerogen only a minor constituent. Although the amorphous and herbaceous material is marginally mature, these shales are effectively immature, although close to marginal maturity. They are rated as poor source rocks.

Significant oil generation from suitable types of organic matter should start at approximately total depth, although the top of the oil window, within which peak hydrocarbon generation occurs, probably lies below approximately 4500± metres.

The sediments of Zone D were deposited under reducing conditions, but relatively oxidising conditions apparently prevailed during the deposition of Zones B, C and E and at intervals within Zone A.

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	$\frac{iC_4}{nC_4}$
235-001	2250m	1796	75	90	68	25	2055	259	12.6	148	2.69
235-002	2300m	393	23	29	23	9.4	478	85	17.7	47	2.47
235-003	2350m	1879	105	133	99	30	2246	367	16.4	250	3.25
235-004	2400m	755	22	29	19.7	7.5	834	78	9.4	51	2.61
235-005	2450m	58	4.3	16.4	21	7.6	108	50	46.2	86	2.79
235-006	2500m	956	40	4.9	31	11.2	1088	131	12.1	41	2.74
235-007	2550m	251	16.1	37	25	14.8	344	93	27.0	62	1.68
235-008	2600m	1105	92	212	79	113	1601	496	31.0	291	0.69
235-009	2650m	1269	111	183	81	82	1726	457	26.5	262	0.99
235-010	2700m	497	22	31	18.7	15.0	584	87	14.9	54	1.24
235-011	2750m	278	27	54	24	29	411	134	32.6	99	0.84
235-012	2800m	814	119	162	58	76	1230	415	33.8	1428	0.76
235-013	2850m	280	40	101	39	50	511	231	45.2	346	0.79
235-014	2900m	314	47	100	40	45	548	233	42.6	221	0.89
235-015	2950m	106	12.9	29	14.0	17.8	179	73	40.9	67	0.79
235-016	3000m	9.0	1.4	2.4	1.3	16	15.7	6.7	42.6	94	0.79
235-017	3050m	461	46	72	25	27	632	170	26.9	69	0.94
235-018	3100m	222	19.3	32	14.9	13.3	301	80	26.5	32	1.12
235-019	3125m	48	9.6	25	19.3	11.4	113	65	57.7	73	1.70
235-022	3175m	7.7	0.6	2.5	1.7	1.7	14.3	6.6	46.0	25	1.00
235-024	3200m	32	5.0	0.7	0.1	0.1	37	5.9	15.8	78	1.00

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	$\frac{iC_4}{nC_4}$
235-026	3225m	66	33	7.1	0.2	0.2	107	41	38.1	140	1.00
235-028	3250m	23	13.1	13.9	1.1	4.7	56	33	58.6	33	0.23
235-030	3275m	29	23	52	7.9	28	140	111	79.2	221	0.28
235-034	3300m	66	120	515	117	453	1271	1205	94.8	900	0.26
235-047	3335m	99	13.2	15.0	2.7	12.6	143	43	30.4	153	0.21
235-048	3350m	1423	1192	1678	154	657	5104	3681	72.1	940	0.23
235-049	3375m	237	144	250	40	135	805	568	70.6	332	0.30
235-050	3400m	44	28	75	13.4	54	214	170	79.4	176	0.25
235-051	3425m	91	74	127	19.5	71	383	292	76.3	423	0.27
235-052	3450m	53	53	80	13.7	50	250	197	78.6	255	0.27
235-053	3475m	173	102	137	15.7	54	481	308	64.0	254	0.29
235-055	3500m	78	99	167	23	80	447	368	82.5	299	0.29
235-056	3525m	264	289	653	116	364	1687	1423	84.3	935	0.32
235-058	3550m	289	175	296	45	152	958	668	69.8	352	0.30

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	$\frac{iC_4}{nC_4}$
235-001	2250m	104	9.6	24	32	16.7	187	83	44.4	163	1.94
235-002	2300m	61	9.6	46	55	26	198	138	69.4	222	2.12
235-003	2350m	78	14.0	60	76	33	261	183	70.0	264	2.30
235-004	2400m	110	13.1	43	51	21	239	129	53.9	80	2.39
235-005	2450m	21	2.7	3.5	5.5	4.2	37	15.9	42.5	103	1.33
235-006	2500m	117	11.6	34	37	18.7	220	102	46.5	103	1.98
235-007	2550m	43	5.4	28	25	19.0	121	78	64.1	112	1.30
235-008	2600m	374	76	402	165	371	1389	1015	73.1	919	0.44
235-009	2650m	153	32	117	49	75	426	273	64.0	454	0.65
235-010	2700m	196	21	54	29	38	338	142	42.0	451	0.78
235-011	2750m	208	35	137	66	92	538	329	61.3	596	0.71
235-012	2800m	68	27	51	29	50	226	158	70.0	399	0.59
235-013	2850m	39	11.3	33	16.2	24	124	85	68.4	236	0.67
235-014	2900m	70	24	107	54	69	325	254	78.3	464	0.79
235-015	2950m	72	16.0	33	21	32	174	102	58.5	239	0.65
235-016	3000m	62	15.3	20	11.7	14.3	124	61	49.5	212	0.82
235-017	3050m	110	42	107	42	71	371	261	70.4	273	0.59
235-018	3100m	50	12.8	23	19.7	29	134	84	62.6	202	0.68
235-019	3125m	24	4.9	7.2	6.1	5.9	48	24	50.3	12.2	1.04
235-022	3175m	10.4	3.2	3.3	0.5	1.3	18.6	8.2	44.1	53	0.36
235-024	3200m	27	6.2	1.8	0.6	2.2	38	10.8	28.5	7.6	0.25

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	$\frac{iC_4}{nC_4}$
235-026	3225m	16.5	6.4	2.0	0.6	1.9	27	10.9	39.6	72	0.29
235-028	3250m	44	13.6	18.3	1.4	9.1	86	42	49.0	38	0.15
235-030	3275m	37	9.1	16.5	6.8	28	98	61	61.8	346	0.24
235-034	3300m	111	38	426	202	815	1593	1482	93.0	2771	0.25
235-047	3335m	23	4.2	9.5	3.3	16.7	56	34	59.7	227	0.20
235-048	3350m	89	338	971	107	414	1920	1830	95.3	1370	0.26
235-049	3375m	73	91	426	94	371	1055	983	93.1	685	0.25
235-050	3400m	45	27	68	19.5	69	227	183	80.3	393	0.28
235-051	3425m	21	11.6	105	27	113	278	257	92.5	355	0.24
235-052	3450m	47	25	39	13.6	36	160	113	70.9	271	0.38
235-053	3475m	43	36	72	16.0	51	219	176	80.2	289	0.31
235-055	3500m	53	49	143	31	85	361	308	85.4	298	0.37
235-056	3525m	31	39	191	45	183	489	458	93.7	596	0.25
235-058	3550m	110	168	411	97	306	1171	981	83.8	870	0.32

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	$\frac{iC_4}{nC_4}$
235-001	2250m	1900	85	114	100	42	2240	340	15.2	311	2.40
235-002	2300m	454	33	75	78	35	675	221	32.7	269	2.20
235-003	2350m	1957	119	193	175	63	2507	550	21.9	514	2.78
235-004	2400m	865	35	72	71	28	1071	206	19.3	131	2.48
235-005	2450m	79	7.0	19.9	26	11.8	144	65	45.2	189	2.25
235-006	2500m	1073	52	83	68	30	1305	232	17.8	144	2.27
235-007	2550m	294	21	65	50	34	464	170	36.7	174	1.48
235-008	2600m	1479	168	614	244	484	2989	1510	50.5	1210	0.50
235-009	2650m	1422	143	300	130	157	2152	730	33.9	716	0.83
235-010	2700m	693	43	85	48	53	922	229	24.8	505	0.90
235-011	2750m	486	62	191	90	121	950	464	48.8	695	0.74
235-012	2800m	882	146	213	87	126	1454	572	39.3	1827	0.69
235-013	2850m	319	51	134	55	74	633	314	49.6	582	0.75
235-014	2900m	384	71	207	94	114	870	486	55.9	685	0.82
235-015	2950m	178	29	62	35	50	354	176	49.7	306	0.70
235-016	3000m	71	16.7	22	13.0	15.9	139	68	48.9	306	0.82
235-017	3050m	571	88	179	67	98	1003	432	43.1	342	0.68
235-018	3100m	272	32	55	35	42	436	164	37.6	234	0.82
235-019	3125m	72	14.5	32	25	17.3	161	89	55.4	85	1.47
235-022	3175m	18.1	3.8	5.8	2.2	3.0	33	14.8	45.0	78	0.73
235-024	3200m	59	11.2	2.5	0.7	2.3	76	16.7	22.1	86	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	$\frac{iC_4}{nC_4}$
235-026	3225m	82	39	9.1	0.8	2.1	134	51	38.4	212	0.38
235-028	3250m	67	27	32	2.5	13.8	142	75	52.9	71	0.18
235-030	3275m	66	32	68	14.7	56	237	171	72.2	567	0.26
235-034	3300m	177	158	941	319	1268	2863	2686	93.8	3671	0.25
235-047	3335m	122	17.4	24	6.0	29	199	77	38.8	380	0.20
235-048	3350m	1512	1530	2649	261	1071	7023	5511	78.5	2310	0.24
235-049	3375m	310	235	676	134	506	1861	1551	83.3	1017	0.26
235-050	3400m	89	55	143	33	123	443	354	79.9	569	0.27
235-051	3425m	112	86	232	46	184	660	548	83.0	778	0.25
235-052	3450m	100	78	119	27	86	410	310	75.6	526	0.32
235-053	3475m	216	138	209	32	105	700	484	69.1	543	0.30
235-055	3500m	131	148	310	54	165	808	677	83.8	597	0.33
235-056	3525m	295	328	844	161	547	2175	1880	86.4	1531	0.29
235-058	3550m	479	343	707	142	458	2129	1650	77.5	1222	0.31

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH		GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-059 swc No. 30	2248m		Shale, fissile, slightly calcareous, olive grey	5Y4/1	0.76
235-001	2250m	A 98%	Shale, fissile, non calcareous, cavings, medium grey to medium olive grey Minor lost circulation material	N5-5Y5/1	1.10
235-002	2300m	A 98%	Shale, as 235-001A Cavings Minor lost circulation material	N5-5Y5/1	0.90
235-060 swc No. 29	2302m		Shale, fissile, non calcareous,olive grey	5Y3/2	0.97
235-061 swc No. 20	2302.5m		Siltstone, blocky, soft, non calcareous, no fluorescence, greenish grey Minor banding	5GY6/1	0.37
235-003	2350m	A 98%	Shale, as 235-001A cavings Minor lost circulation material	N5-5Y5/1	1.29
235-062 swc No. 28	2352m		Shale, fissile, non calcareous, olive black	5Y2/1	1.08
235-004	2400m	A 70%	Shale, as 235-001A minor cavings	N5-5Y5/1	1.53
		B 30%	Shaly mudstone, fissile to blocky, slightly calcareous, dark yellowish brown	10YR4/2	0.77
235-005	2450m	A 98%	Shale, as 235-001A minor cavings Minor shaly mudstone and lost circulation material	N5-5Y5/1	1.11
235-063 swc No.25	2495m		Shale, fissile, slightly to non calcareous, greyish brown Minor shale	5YR3/2	0.48,0.48
235-006	2500m	A 90%	Shale, as 235-001A significant cavings	N5-5Y5/1	1.01
		B 10%	Shale, fissile, non calcareous, light bluish grey Minor other shale and mudstone	5B7/1	0.20

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-007	2550m	A 60% Shale, fissile, non calcareous, medium grey to medium light grey	N5-N6	0.62
		B 30% Shale, fissile, non calcareous, greenish grey	5G6/1	0.18
		C 10% Shale, fissile, non calcareous, brownish grey	5YR4/1	0.13
235-064 swc No. 24	2553m	A Shale, fissile, calcareous greenish grey	5G6/1	0.17
		B Shaly mudstone, fissile to blocky, very calcareous, light greenish grey	5GY8/1	0.19
235-065 swc No. 23	2584m	Shale, fissile, non calcareous, medium grey	N5	1.06,1.06
235-008	2600m	A 98% Shale, fissile, non calcareous, minor cavings, medium dark grey to dark greenish grey Very minor other shale	N4-5GY4/1	0.42,0.43
235-009	2650m	A 80% Shale, fissile, non calcareous, cavings, medium grey to medium olive grey	N5-5Y5/1	1.28
		B 20% Shale, fissile, non calcareous, light bluish grey Minor other shale and limestone	5B7/1	0.21
235-010	2700m	A 95% Shale, as 235-009A	N5-5Y5/1	1.27
		B 5% Sandstone, blocky, fine grained, non calcareous, no fluorescence, light grey to very light grey to light greenish grey Minor other shale	N8-5GY8/1	
235-066 swc No. 16	2742m	Siltstone, blocky, soft, non calcareous, no fluorescence, light greenish grey Interbedded with very thin bands of shale	5GY8/1	

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-011	2750m	A 65% Chalky limestone, blocky, no fluorescence, very light grey to white	N8-N9	
		B 35% Shale, fissile, non calcareous, cavings, medium grey Minor sandstone	N5	1.42
235-012	2800m	A 70% Chalky limestone, as 235-011A, no fluorescence	N8-N9	0.12
		B 30% Shale, as 235-011B	N5	0.50
235-013	2850	A 95% Chalky limestone, as 235-011A, no fluorescence	N8-N9	
		B 5% Shale, as 235-011B Mostly cavings	N5	
235-014	2900m	A 85% Limestone, as 235-011A no fluorescence	N8-N9	
		B 15% Shale, as 235-011B	N5	1.00
235-015	2950m	A 95% Limestone, as 235-011A no fluorescence	N8-N9	0.14,0.14
		B 5% Shale, fissile, non calcareous, medium dark grey to dark greenish grey Minor other shale	N4-5GY4/1	
235-016	3000m	A 98% Chalky limestone, as 235-011A, no fluorescence Minor shale	N8-N9	
235-017	3050m	A 95% Chalky limestone, blocky, no fluorescence, very light grey to medium brownish grey	N8-5YR7/1	
		B 5% Shale, as 235-015B cavings	N4-5GY4/1	
235-018	3100m	A 95% Limestone, fissile to blocky, no fluorescence, very light grey to medium brownish grey	N8-5YR7/1	0.10
		B 5% Shale, as 235-015B cavings Minor other shale and bitumen	N4-5GY4/1	

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-019	3125m	A 90% Limestone, fissile to blocky, no fluorescence, very light grey to medium brownish grey	N8-5YR7/1	
		B 10% Shale, fissile, non calcareous, cavings, medium grey Minor other shale	N5	0.93
235-020 Core No.90	3146.5m	Shale, fissile, very calcareous, medium light grey to light grey Minor banding	N6-N7	0.43
235-021 Core No.88	3169.5m	Silty shale, fissile to blocky, calcareous, greenish grey	5GY6/1	0.14
235-022	3175m	A 50% Lignite (mud additive), blocky, fine grained, sub-rounded, non calcareous, brittle, greyish black	N2	41.01
		B 30% Limestone, as 235-019A no fluorescence	N8-5YR7/1	
		C 20% Shale, fissile, calcareous greyish brown Minor other limestone	5YR3/2	0.11,0.07
235-023 Core No. 87	3194m	Shale, fissile, slightly calcareous, medium dark grey to olive grey	N4-5Y4/1	0.26
235-024	3200m	A 85% Shale, fissile, non calcareous, medium dark grey to olive grey	N4-5Y4/1	0.31
		B 15% Shale, as 235-022C	5YR3/2	0.15
235-025 Core No.86	3221m	Shale, as 235-023	N4-5Y4/1	
235-026	3225m	A 98% Shale, fissile, non calcareous, medium dark grey Minor other shale	N4	0.29
235-027 Core No.84	3247m	Shale, fissile, non calcareous, medium dark grey	N4	0.32,0.34
235-028	3250m	A 98% Shale, as 235-026A Minor other shale	N4	0.37

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-029 Core No.120	3270m	Shale, fissile, non calcareous, dark olive grey	5Y3/1	0.53
235-030	3275m A 98%	Shale, fissile, non calcareous, medium dark grey Very minor other shale	N4	0.41
235-031 Core No.79	3294m	Shale, fissile, slightly calcareous, medium grey	N5	
235-032	3299m	Shale, fissile, slightly calcareous, greenish black	5G2/1	0.27
235-033	3299.8m	Shale, as 235-032	5G2/1	0.60
235-034	3300m A 98%	Shale, as 235-030A Very minor limestone and other shale	N4	0.55
235-035 Core No.75	3301.5m	Shale, fissile, non calcareous, dark olive grey	5Y2/2	6.64,6.66
235-036 Core No.74	3303.5m	Shale, as 235-035	5Y2/2	4.70
235-037 Core No. 73	3305.0m	Shale, as 235-035	5Y2/2	6.21
235-038 Core No. 71	3307.8m	Shale, as 235-035	5Y2/2	5.76
235-039 Core No. 69	3310.0m	Shale, as 235-035	5Y2/2	6.77,6.77
235-040 Core No. 68	3312.5m	Shale, as 235-035	5Y2/2	7.19
235-041 Core No.67	3314.0m	Shale, as 235-035	5Y2/2	9.65
235-042 Core No.65	3315.5m	Shale, as 235-035	5Y2/2	2.76
235-043 Core chip	3322.4m	Sandstone, silty, fine grained, non calcareous, no fluorescence, medium dark grey to medium grey	N4-N5	
235-044 Core chip	3327.15m	Silty sandstone, fissile to blocky, non calcareous, no fluorescence, olive grey	5Y4/1	

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH		GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-045	3331.65m		Sandstone, fine grained non calcareous, no fluorescence, light grey Minor banding	N7	
235-046	3334.44m		Sandstone, as 235-045 no fluorescence Minor banding	N7	
235-047	3335m		MUD SAMPLE		
235-048	3350m	A 98%	Shale, fissile, non calcareous, medium dark grey	N4	0.37
235-049	3375m	A 90%	Shale, as 235-048A	N4	0.42
		B 10%	Shale, fissile, calcareous, greyish brown Minor limestone and sandstone	5YR3/2	0.12,0.12
235-050	3400m	A 70%	Shale, as 235-048A	N4	0.39
		B 25%	Sandstone, fine grained angular, no fluorescence pinkish grey	5YR8/1	
		C 5%	Shale, as 235-049B	5YR3/2	
235-051	3425m	A 90%	Shale, as 235-048A	N4	0.83
		B 10%	Shale, as 235-049B Minor sandstone	5YR3/2	0.16
235-052	3450m	A 98%	Shale, as 235-048A Minor sandstone	N4	0.35
235-053	3475m	A 95%	Shale, as 235-048A	N4	0.38
		B 5%	Sandstone, blocky, non calcareous, no fluorescence, pale brown	5YR5/2	
235-054 Core No. 42	3488.2m		Shale, fissile, silty, non calcareous, moderate brown to moderate brown	5YR3/4-5YR4/4	0.10,0.11
			Evaporite, soft, soluble in water, non calcareous, white	N9	
235-055	3500m	A 98%	Shale, as 235-048A Very minor shale	N4	0.36

TABLE 2
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (% of Rock)
235-056	3525m A 98%	Shale, fissile, non calcareous, medium dark grey Minor other shale and sandstone	N4	0.48,0.51
235-057 Core No.34	3537.8m	Shale, fissile, non calcareous, moderate brown Minor Evaporite	5YR3/4	1.18
235-058	3550m A 98%	Shale, as 235-056A Minor anhydrite and other shale	N4	0.72

TABLE 3

VITRINITE REFLECTANCE DATA

GEOCHEM SAMPLE NUMBER	DEPTH	SAMPLE TYPE	AVERAGE REFLECTIVITY Ro (%)			NUMBER OF PARTICLES			REMARKS
			1	2	3	1	2	3	
235-059	2248m	S.W.C.	0.45	0.65*		19	1		* reworked
235-001	2250m	CUTTINGS	0.39	0.68*		18	2		* reworked
235-003A	2350m	CUTTINGS	0.43			20			
235-062	2352m	S.W.C.	0.44			20			
235-005A	2450m	CUTTINGS	0.47			20			hydrocarbon traces
235-065	2584m	S.W.C.	0.61*	0.95*		6	3		* reworked
235-008A	2600m	CUTTINGS	0.49			20			
235-010A	2700m	CUTTINGS	0.41			21			
235-066	2742m	S.W.C.	0.40	0.66*		5	13		* reworked
235-012A	2800m	CUTTINGS	NO DETERMINATION POSSIBLE						
235-015A	2950m	CUTTINGS	NO DETERMINATION POSSIBLE						
235-021	3169.5m	S.W.C.	1.71*			22			* reworked/oxidised bitumen
235-022A	3175m	CUTTINGS	0.28			22			lignite
235-025	3221m	S.W.C.	0.34	0.62*	0.84*	5	2	3	* reworked, lean
235-029	3270m	S.W.C.	0.43	0.83*		7	2		* reworked, lean
235-040	3312.5m	S.W.C.	0.27*	0.53		9	13		* bitumen
235-054	3488.2m	S.W.C	NO DETERMINATION POSSIBLE						
235-057	3537.8m	S.W.C.	NO DETERMINATION POSSIBLE						

TABLE 4

VISUAL KEROGEN DATA

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION				THERMAL MATURATION INDEX
		TYPES	REMARKS	PARTICLE SIZE	PRESERV-ATION	
235-059	2248m	H;W-C-S;-	largely reworked (2 and 2 to 2+)	M	F	1+ to 2-*
235-001A	2250m	H;W;S-C	fairly abundant reworked material. Scattered minor sapropelisation.	M	F-G	1+ to 2-
235-003A	2350m	H;W;S-C	minor H at 2. Reworked material present.	F-M	F-G	1+/1+ to 2-
235-062	2352m	S-W-H;-;C-Am	dominantly reworked (2, 2+)	F-M	F-G	1+ to 2-*
235-005A	2450m	H;W-C;S-Am	scattered sapropelisation. Some H at 2.	F	F-G	1+ to 2-/2-
235-007A	2550m	H;W-C;S-Am	reworked material at 2. Contamination?	F-M	F-G	1+ to 2-
235-007B	2550m	W-C;-;H-S		F	F-G	1+ to 2-
235-065	2584m	H;W;C-S-Am	reworked material present.	F	G	1+ to 2-
235-008A	2600m	W;C-H;S	reworked material present.	M	F-G	2-
235-009B	2650m	W-C;-;H-S		F-M	F	2-
235-010A	2700m	H;W-S;C-Am	some H at 1+. Scattered minor sapropelisation.	M	F-G	2-
235-012A	2800m	C-W;-;H-S		F	P-F	2-/2- to 2
235-015A	2950m	C-W;-;H-S		F	F	2- to 2
235-020	3146.5m	C-W;-;H-S		M	F	2- to 2/2
235-021	3169.5m	C-W;-;H	one fresh spore	M	F	2- to 2 (?)
235-022A	3175m	W;C-S;H		F-C	F	2- to 2
235-025	3221m	W-C;-;H		F-M	F	2- to 2
235-029	3270m	W;C;H-S	minor reworked material.	F-M	F-G	2- to 2
235-032	3299m	W;C-H;S		F-M	F	2

Algal, Amorphous, Coaly, Herbaceous, Stem, Woody.

TABLE 4

VISUAL KEROGEN DATA

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION				THERMAL MATURATION INDEX
		TYPES	REMARKS	PARTICLE SIZE	PRESERV-ATION	
235-035	3301.5m	Am;H;W-S-C	H passing to Am.	M	F-G	2- to 2
235-040	3312.5m	Am*;H;W-S-C	* includes H passing to Am.	M	F-G	2- to 2
235-051A	3425m	W-C;-;H-S	reworked material present.	M	F	2- to 2
235-054	3488.2m	W-C;H;Am*-S	* not globular	F-M	F-G	2- to 2
235-057	3537.8m	W-C;H*;Am*-S	reworked material present. * finely disseminated.	F-M	F	2- to 2(?)

Algal, Amorphous, Coaly, Herbaceous, Stem, Woody.

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
235-001A	2250m	4.52000	0.01038	0.00744	0.00294	0.00068	0.00085	0.00132	0.00009	–
235-061	2302.5m	21.09000	0.02407	0.02205	0.00202	0.00084	0.00046	0.00050	0.00022	–
235-062	2352m	27.82000	0.04439	0.03595	0.00844	0.00388	0.00270	0.00160	0.00024	–
235-005	2450m	5.78000	0.01068	0.00774	0.00294	0.00095	0.00088	0.00111	–	–
235-008A	2600m	13.05000	0.01127	0.00824	0.00303	0.00093	0.00086	0.00116	0.00008	–
235-010A	2700m	4.05000	0.01147	0.00788	0.00354	0.00108	0.00092	0.00132	0.00022	–
235-066	2742m	26.02000	0.02946	0.02654	0.00292	0.00120	0.00090	0.00076	0.00005	–
235-013A	2850m	11.55000	0.00813	0.00594	0.00219	0.00072	0.00036	0.00100	0.00011	–
235-016	3000m	49.99000	0.00844	0.00564	0.00280	0.00104	0.00057	0.00095	0.00024	–
235-020	3146.5m	10.46000	0.07281	0.06908	0.00373	0.00202	0.00085	0.00086	–	–
235-021	3169.5m	2.83000	0.01009	0.00720	0.00289	0.00155	0.00060	0.00088	0.00006	–
235-022A	3175m	18.86000	0.08779	0.02884	0.05895	0.01711	0.02004	0.02179	–	–
235-025	3221m	9.17000	0.01360	0.00994	0.00366	0.00221	0.00071	0.00074	–	–
235-029	3270m	4.73000	0.01021	0.00769	0.00252	0.00131	0.00060	0.00610	–	–
235-032	3299m	12.84000	0.01834	0.01334	0.00500	0.00229	0.00177	0.00094	–	–
235-035	3301.5m	5.04000	0.06001	0.01800	0.04201	0.02159	0.01478	0.00564	–	–
235-040	3312.5m	3.81000	0.04786	0.01802	0.02984	0.01700	0.01000	0.00274	0.00002	–
235-042	3315.5m	9.22000	0.05035	0.01371	0.03664	0.02286	0.01008	0.00370	–	–
235-043	3322.4m	10.56000	0.02274	0.01858	0.00416	0.00165	0.00146	0.00105	–	–
235-045	3331.65m	7.34000	0.14600	0.14300	0.00300	0.00131	0.00073	0.00086	0.00010	–
235-047	3335m	26.58000	0.06192	0.02244	0.03948	0.03103	0.00388	0.00457	–	–
235-051	3425m	9.43000	0.00858	0.00622	0.00236	0.00095	0.00054	0.00056	0.00031	–
235-054	3488.2m	9.88000	0.01178	0.00848	0.00330	0.00186	0.00074	0.00070	–	–
235-057	3537.8m	6.00000	0.00443	0.00075	0.00368	0.00164	0.00071	0.00091	0.00017	–

TABLE 5B

CONCENTRATION (PPM) OF EXTRACTED C_{15+} MATERIAL IN ROCK

GEOCHEM SAMPLE NUMBER	INTERVAL	TOTAL EXTRACT	HYDROCARBONS			NON HYDROCARBONS				
			Paraffin – Naphthenes	Aromatics	TOTAL	Preciptd. Asphaltenes	Eluted NSO's	Non-eluted NSO's	Sulphur	TOTAL
235-001A	2250m	2296	150	188	338	1646	292	20	–	1958
235-061	2302.5m	1141	40	22	62	1046	24	10	–	1080
235-062	2352m	1596	139	97	237	1292	58	9	–	1359
235-005	2450m	1848	164	152	317	1339	192	–	–	1531
235-008A	2600m	864	71	66	137	631	89	6	–	726
235-010A	2700m	2820	267	227	494	1946	326	54	–	2326
235-066	2742m	1132	46	35	81	1020	29	2	–	1051
235-013A	2850m	704	62	31	94	514	87	10	–	610
235-016	3000m	169	21	11	32	113	19	5	–	137
235-020	3146.5m	6961	193	81	274	6604	82	–	–	6686
235-021	3169.5m	3565	548	212	760	2544	311	21	–	2876
235-022A	3175m	4655	907	1063	1970	1529	1155	–	–	2685
235-025	3221m	1483	241	77	318	1084	81	–	–	1165
235-029	3270m	2159	277	127	404	1626	1290	–	–	2915
235-032	3299m	1428	178	138	316	1039	73	–	–	1112
235-035	3301.5m	11907	4284	2932	7216	3571	1119	–	–	4690
235-040	3312.5m	12562	4462	2646	7108	4730	719	5	–	5454
235-042	3315.5m	5461	2480	1093	3573	1487	401	–	–	1888
235-043	3322.4m	2153	156	138	295	1759	99	–	–	1859
235-045	3331.65m	19891	178	99	278	19482	117	14	–	19613
235-047	3335m	2330	1167	146	1314	844	172	–	–	1016
235-051	3425m	910	101	57	158	660	59	33	–	752
235-054	3488.2m	1192	188	75	263	858	71	–	–	929
235-057	3537.8m	739	273	118	392	126	152	28	–	306

TABLE 5C

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

GEOCHEM SAMPLE NUMBER	INTERVAL	HYDROCARBONS			NON HYDROCARBONS					
		Paraffin – Naphthenes	Aromatics	P – N / AROM	Preciptd. Asphaltenes	Eluted NSO's	Non eluted NSO's	Sulphur	ASPH / NSO	HC / NON HC
235-001A	2250m	6.55	8.19	0.80	71.68	12.72	0.87	–	5.28	0.17
235-061	2302.5m	3.49	1.91	1.83	91.61	2.00	0.91	–	30.62	0.06
235-062	2352m	8.74	6.08	1.44	80.99	3.65	0.54	–	19.33	0.17
235-005A	2450m	8.90	8.24	1.08	72.47	10.39	–	–	6.97	0.21
235-008A	2600m	8.25	7.63	1.08	73.11	10.29	0.71	–	6.65	0.19
235-010A	2700m	9.46	8.06	1.17	69.00	11.56	1.93	–	5.12	0.21
235-066	2742m	4.08	3.06	1.33	90.09	2.59	0.18	–	32.53	0.08
235-013A	2850m	8.86	4.43	2.00	73.06	12.30	1.35	–	5.35	0.15
235-016	3000m	12.32	6.75	1.82	66.82	11.26	2.54	–	4.74	0.24
235-020	3146.5m	2.77	1.17	2.38	94.88	1.18	–	–	80.33	0.04
235-021	3169.5m	15.36	5.95	2.58	71.36	8.72	0.59	–	7.66	0.26
235-022A	3175m	19.49	22.83	0.85	32.85	24.82	–	–	1.32	0.73
235-025	3221m	16.25	5.22	3.11	73.09	5.44	–	–	13.43	0.27
235-029	3270m	12.83	5.88	2.18	75.32	59.75	–	–	1.26	0.14
235-032	3299m	12.49	9.65	1.29	72.74	5.13	–	–	14.19	0.28
235-035	3301.5m	35.98	24.63	1.46	30.00	9.40	–	–	3.19	1.54
235-040	3312.5m	35.52	21.06	1.69	37.65	5.73	0.04	–	6.53	1.30
235-042	3315.5m	45.41	20.02	2.27	27.23	7.35	–	–	3.71	1.89
235-043	3322.4m	7.26	6.42	1.13	81.71	4.62	–	–	17.70	0.16
235-045	3331.65m	0.90	0.50	1.79	97.95	0.59	0.07	–	148.96	0.01
235-047	3335m	50.12	6.27	7.99	36.24	7.37	–	–	4.92	1.29
235-051	3425m	11.07	6.29	1.76	72.49	6.53	3.61	–	7.15	0.21
235-054	3488.2m	15.79	6.28	2.51	71.99	5.94	–	–	12.11	0.28
235-057	3537.8m	36.99	16.01	2.31	17.00	20.52	3.83	–	0.70	1.28

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
235-001A	2250m	1.00	14.74	3.38	22.96
235-061	2302.5m	0.35	5.43	1.77	32.60
235-062	2352m	1.11	14.85	2.14	14.38
235-005	2450m	0.61	17.13	5.19	30.29
235-008A	2600m	0.45	15.88	3.05	19.19
235-010A	2700m	0.94	17.51	5.25	30.00
235-066	2742m	0.36	7.16	2.25	31.44
235-013A	2850m	0.18	13.35	5.22	39.11
235-016	3000m	0.14	18.93	2.28	12.07
235-020	3146.5m	0.35	3.94	7.84	198.88
235-021	3169.5m	0.33	21.31	23.02	108.04
235-022A	3175m	26.54	42.32	0.74	1.75
235-025	3221m	0.38	21.47	8.38	39.03
235-029	3270m	0.50	18.71	8.08	43.17
235-032	3299m	0.42	22.14	7.53	34.01
235-035	3301.5m	6.26	60.60	11.53	19.02
235-040	3312.5m	6.04	56.58	11.77	20.80
235-042	3315.5m	2.78	65.43	12.85	19.64
235-043	3322.4m	0.69	13.70	4.28	31.20
235-045	3331.65m	0.25	1.40	11.21	795.64
235-047	3335m	0.93	56.39	14.13	25.05

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
235-051	3425m	0.47	17.36	3.36	19.36
235-054	3488.2m	0.18	22.06	14.61	66.22
235-057	3537.8m	2.80	53.04	1.40	2.64

TABLE 7

PYROLYSIS ANALYSIS

SAMPLE NUMBER	DEPTH	ORGANIC CARBON	PPM BITUMEN*	PPM PYROLYSATE+	PYROLYSATE / ORGANIC CARBON	BITUMEN / PYROLYSATE
235-001A	2250m	1.10	175	3034	0.2760	0.058
235-062	2352m	1.08	84	2111	0.1952	0.040
235-065	2584m	1.06	183	4826	0.4555	0.038
235-010A	2700m	1.27	480	2748	0.2167	0.175
235-020	3146.5m	0.43	438	1786	0.4169	0.245
235-029	3270m	0.53	240	1178	0.2218	0.204
235-032A	3299m	0.27	518	715	0.2646	0.724
235-035	3301.5m	6.64	4568	35612	0.5365	0.128
235-040	3312.5m	7.19	3374	47912	0.6666	0.070
235-042	3315.5m	2.76	1497	26350	0.9524	0.057
235-051A	3425m	0.83	60	240	0.0290	0.250
235-057	3537.8m	1.18	51	190	0.0162	0.268

* 300°C

+ 500°C

TABLE 8

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

GEOCHEM SAMPLE NUMBER	001	061	062	005	008A	010A	066	013A
DEPTH	2250m	2302.5m	2352m	2450m	2600m	2700m	2742m	2850m
SAMPLE TYPE								
nC_{15}	1.0	1.0	0.9	1.8	0.5	1.6	0.8	1.6
nC_{16}	2.0	1.9	4.7	4.2	0.9	3.5	1.1	4.6
nC_{17}	4.5	6.4	13.7	10.0	1.3	7.3	6.3	11.1
nC_{18}	6.5	12.5	15.6	12.1	2.8	8.0	11.2	14.6
nC_{19}	7.6	15.2	14.0	9.3	4.0	7.9	9.9	11.8
nC_{20}	8.2	13.1	12.1	8.5	4.9	7.3	8.8	10.4
nC_{21}	11.0	10.5	9.3	9.2	6.5	9.0	8.1	9.7
nC_{22}	12.9	8.2	6.9	9.5	10.9	11.2	7.5	9.5
nC_{23}	14.1	7.0	6.7	9.2	13.1	11.5	7.8	7.7
nC_{24}	9.0	5.6	4.3	6.9	14.2	8.8	7.4	5.6
nC_{25}	6.8	5.1	4.1	5.2	12.9	6.6	6.9	4.0
nC_{26}	4.5	3.8	2.5	3.8	10.7	4.4	5.7	2.8
nC_{27}	3.6	3.1	2.8	3.3	7.8	4.2	5.5	1.9
nC_{28}	2.4	3.1	1.0	2.8	4.4	2.9	4.8	2.1
nC_{29}	2.1	1.7	0.9	2.1	2.7	2.9	3.9	1.2
nC_{30}	1.3	0.7	0.2	1.0	1.1	1.3	1.7	0.5
nC_{31}	0.7	0.5	0.1	0.3	0.9	0.7	1.7	0.4
nC_{32}	1.0	0.3	0.1	0.3	0.3	0.4	0.6	0.4
nC_{33}	0.6	0.2	–	0.3	0.2	0.2	0.2	0.2
nC_{34}	0.2	–	–	0.2	0.1	0.2	–	–
nC_{35}	0.1	–	–	0.2	–	0.2	–	–
PARAFFIN	18.8	13.5	26.0	12.9	26.9	11.4	16.7	11.4
ISOPRENOID	2.9	1.6	9.0	2.0	0.5	1.5	2.0	1.2
NAPHTHENE	79.3	84.9	65.0	85.1	72.5	87.0	80.3	87.4
CPI INDEX A	1.13	1.04	1.22	1.05	0.99	1.07	1.03	1.00
CPI INDEX B	1.10	1.05	1.52	1.08	1.13	1.22	1.16	0.99
PRISTANE/PHYTANE	2.24	0.83	2.03	1.91	0.85	2.16	0.84	0.88
PRISTANE/nC_{17}	2.38	0.81	1.68	1.03	0.73	1.35	0.85	0.44

TABLE 8

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

GEOCHEM SAMPLE NUMBER	016	020	021	022	025	029	032	035
DEPTH	3000m	3146.5m	3169.5m	3175m	3221m	3270m	3299m	3301.5m
SAMPLE TYPE								
nC_{15}	0.8	1.0	0.9		0.5	0.6	0.6	6.1
nC_{16}	2.5	3.1	2.8		2.6	2.0	4.5	8.9
nC_{17}	12.5	8.8	4.3		9.9	7.5	11.0	10.9
nC_{18}	16.9	12.9	10.2		14.4	12.4	12.5	10.6
nC_{19}	16.7	15.3	9.3		14.5	11.7	11.9	10.0
nC_{20}	16.5	15.3	9.6		14.6	11.2	10.8	9.9
nC_{21}	11.4	12.5	9.9		11.5	9.5	9.8	8.1
nC_{22}	7.9	9.8	11.5		7.4	9.1	8.5	7.9
nC_{23}	5.1	7.0	11.5		5.6	8.6	8.3	6.8
nC_{24}	3.3	4.9	9.9		4.5	7.7	6.7	6.1
nC_{25}	2.2	4.1	8.1		3.3	6.2	5.7	6.7
nC_{26}	1.4	2.0	5.6		2.9	4.1	4.0	3.4
nC_{27}	1.3	1.4	3.1		2.1	3.6	2.7	2.5
nC_{28}	0.7	1.0	1.6		1.5	2.4	1.3	1.6
nC_{29}	0.5	0.6	0.9		1.5	1.4	0.9	1.3
nC_{30}	0.1	0.2	0.3		1.4	0.8	0.3	0.7
nC_{31}	0.1	–	0.3		0.6	0.7	0.3	0.1
nC_{32}	0.1	–	–		0.2	0.1	0.3	0.2
nC_{33}	–	–	–		0.2	–	–	0.1
nC_{34}	–	–	–		–	–	–	–
nC_{35}	–	–	–		0.1	–	–	–
PARAFFIN	23.6	14.7	40.3		18.7	21.5	29.7	17.2
ISOPRENOID	3.2	3.6	3.6		2.0	1.8	2.9	3.8
NAPHTHENE	73.2	81.7	56.1		79.2	76.7	27.4	79.0
CPI INDEX A	1.10	1.09	1.02		1.08	1.03	1.09	0.99
CPI INDEX B	1.24	–	1.19		0.97	1.17	1.23	1.09
PRISTANE/PHYTANE	0.62	0.62	0.61		0.66	0.63	1.26	1.63
PRISTANE/nC_{17}	0.41	1.05	0.79		0.44	0.43	0.49	1.25

TABLE 8

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

GEOCHEM SAMPLE NUMBER	040	042	043	045	047	051	054
DEPTH	3312.5m	3315.5m	3322.4m	3331.65m	3335m	3425m	3488.2m
SAMPLE TYPE							
nC_{15}	9.5	2.2	0.6	1.1	1.3	0.7	1.2
nC_{16}	12.1	7.9	1.4	2.0	9.3	3.3	4.6
nC_{17}	12.5	12.4	6.4	6.6	16.5	7.0	11.4
nC_{18}	10.0	11.5	12.7	9.4	18.0	11.9	15.9
nC_{19}	9.7	10.8	13.6	9.2	16.0	12.4	15.6
nC_{20}	7.6	8.9	13.5	8.3	12.0	15.1	13.5
nC_{21}	6.4	7.0	13.0	10.3	7.8	14.6	9.2
nC_{22}	5.9	5.9	11.0	12.7	6.3	12.4	7.1
nC_{23}	5.3	5.1	9.0	11.2	4.3	8.4	5.6
nC_{24}	5.2	5.0	6.5	9.4	3.0	5.5	4.5
nC_{25}	4.2	4.3	4.8	6.3	2.0	5.5	3.6
nC_{26}	4.0	4.0	3.0	4.2	1.2	2.0	2.5
nC_{27}	2.9	3.5	2.0	2.9	0.7	1.3	1.6
nC_{28}	2.2	2.7	1.1	2.2	0.5	0.8	1.8
nC_{29}	1.5	2.8	0.7	1.7	0.5	0.5	0.9
nC_{30}	0.8	2.0	0.3	1.3	0.2	0.3	0.4
nC_{31}	0.6	1.5	0.1	0.6	0.2	0.2	0.3
nC_{32}	0.2	0.8	0.2	0.4	0.2	0.2	0.1
nC_{33}	0.2	0.6	0.1	0.2	–	–	–
nC_{34}	0.1	0.7	–	–	–	–	–
nC_{35}	–	0.4	–	–	–	–	–
PARAFFIN	20.3	24.4	19.2	8.6	21.1	11.7	12.0
ISOPRENOID	4.6	3.9	1.6	0.6	2.8	0.8	1.7
NAPHTHENE	75.0	71.8	79.2	90.8	76.1	87.5	86.3
CPI INDEX A	0.96	0.98	1.09	0.98	1.00	1.07	0.99
CPI INDEX B	1.01	1.09	1.19	1.04	1.18	1.14	1.00
PRISTANE/PHYTANE	1.96	1.84	0.88	0.90	0.98	0.75	0.73
PRISTANE/nC_{17}	1.21	0.83	0.63	0.50	0.39	0.43	0.53

TABLE 8

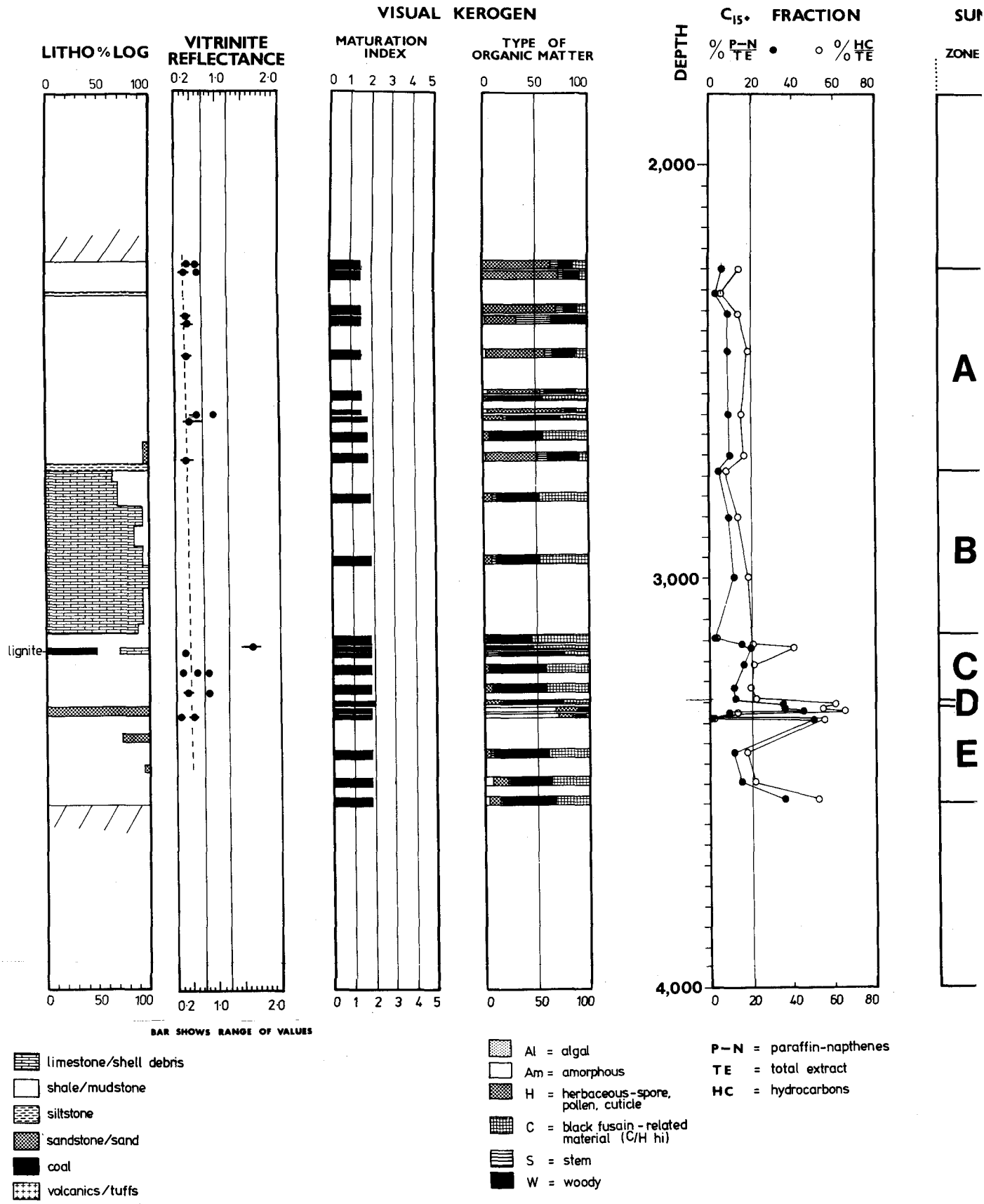
COMPOSITION (NORMALISED %) OF C_{15+} PARAFFIN – NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	057
DEPTH	3537.8m
SAMPLE TYPE	
nC_{15}	1.5
nC_{16}	6.2
nC_{17}	13.3
nC_{18}	17.2
nC_{19}	15.9
nC_{20}	13.5
nC_{21}	9.0
nC_{22}	6.7
nC_{23}	5.2
nC_{24}	3.6
nC_{25}	2.6
nC_{26}	1.7
nC_{27}	1.1
nC_{28}	1.1
nC_{29}	0.6
nC_{30}	0.4
nC_{31}	0.2
nC_{32}	0.2
nC_{33}	0.2
nC_{34}	–
nC_{35}	–
PARAFFIN	7.8
ISOPRENOID	1.3
NAPHTHENE	90.9
CPI INDEX A	1.04
CPI INDEX B	1.00
PRISTANE/PHYTANE	0.7
PRISTANE/nC_{17}	0.52

FIGURE 5

INTERPRETATION DIAGRAM

SOURCE TYPE MATURATION RATING



BRIEF DESCRIPTION OF THE ANALYSES PERFORMED BY GEOCHEM

"Screen Analyses" are described in sections A and C, "Sample Preparation" in section B and "Follow-up Analyses" in sections C through G. 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 sealed wet in a plastic bag) for the C_4 - C_7 analysis. The other analyses can also be used on outcrop 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 type, source quality, thermal maturity and the possible presence of migrated hydrocarbons. As this analysis not only provides a lot of information but is also economical, it is excellent for screening samples to decide which of them merit further analysis.

During the time which elapses between 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 D). The p.p.m. abundance of the five gases and of the total C_5 - C_7 hydrocarbons are calculated from their electronically integrated peak areas (not 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.

The remaining samples (also washed) are dried and packaged in labelled plastic bags for return to the client. Any hand picked sample remaining after analysis is also returned together with the extracted rock material.

Our reports normally incorporate a gross lithological description of all the samples which have been analysed and litho percentage logs are featured on all of the figures. 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 and C_{15+} analyses, the organic carbon content is used to evaluate the hydrocarbon source quality of the sediment. Not only is this analysis an integral part of a total evaluation, but 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, standard 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) 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 gas chromatographically and their peak areas electronically integrated.

Tabulation of the composition and p.p.m. abundance of the total gasoline-range fraction is achieved by comparison with a standard. In the report, the data are also presented graphically.

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

Sections "A" and "D" 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 (ie. the heavy end). The amount and composition of this fraction indicates source quality, source type, the level of thermal maturation and the possible presence of migrated hydrocarbons. The individual parts into which the total fraction is split, can be submitted for further analyses (carbon isotopes, gas chromatography, high mass spectroscopy) which are primarily designed to correlate crude oils to their parent source rocks (but also see section "F").

These results are integrated with those derived from the visual kerogen, organic carbon and C_4 - C_7 analyses.

The techniques involved in this analysis have been designed to give very reproducible results. Hand picked samples are ground and then solvent extracted in a soxhlet apparatus with benzene-methanol (the solvent system can be adapted to client's specifications). The total extract obtained is then separated by column chromatography into the following fractions: paraffin-naphthene hydrocarbons, aromatic hydrocarbons, eluted NSO's (nitrogen-, sulphur-, and oxygen- containing non-hydrocarbons), non-eluted NSO's and precipitated asphaltenes. Note that the non-hydrocarbons are split into three fractions instead of being reported as a gross value.

For convenience and thoroughness, these data are reported in three formats: the weights of the fractions, their p.p.m. abundance and the percentage composition of the total extract. The data are also presented diagramatically.

Upon completion of the study, the extracts and extracted rock are both returned to the client.

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

The molecular composition of the heavy C_{15+} paraffin-naphthene hydrocarbons reflects source quality, source type, the degree of thermal maturation and the presence of migrated hydrocarbons.

This analysis provides a useful cross-correlation with the visual kerogen, C_{15+} chromatography and light hydrocarbon (C_1 - C_7, C_4 - C_7) analyses.

The paraffin-naphthene hydrocarbons obtained by column chromatography are introduced into the gas chromatograph using a solid rod injection system to ensure that all of the sample, including the heaviest ends, is analysed. Excellent resolution of the individual normal paraffins and of the significant isoprenoids and other isoparaffins is achieved.

The normal paraffin carbon preference indices (C.P.I.) are calculated using the following formulae:

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

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

The 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.IA and C.P.IB; pristane to phytane ratio.

G) VISUAL KEROGEN ANALYSIS

Kerogen is the insoluble organic matter in rocks. Visual examination of the kerogen gives a direct measure of the level of thermal maturation and organic facies and indicates the source quality of the sediment. Source quality is confirmed using the analyses discussed above.

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

Kerogen is separated from the inorganic rock matrix by methods which avoid oxidation of the organic matter. It is then mounted on a glass slide and examined under a high power microscope.

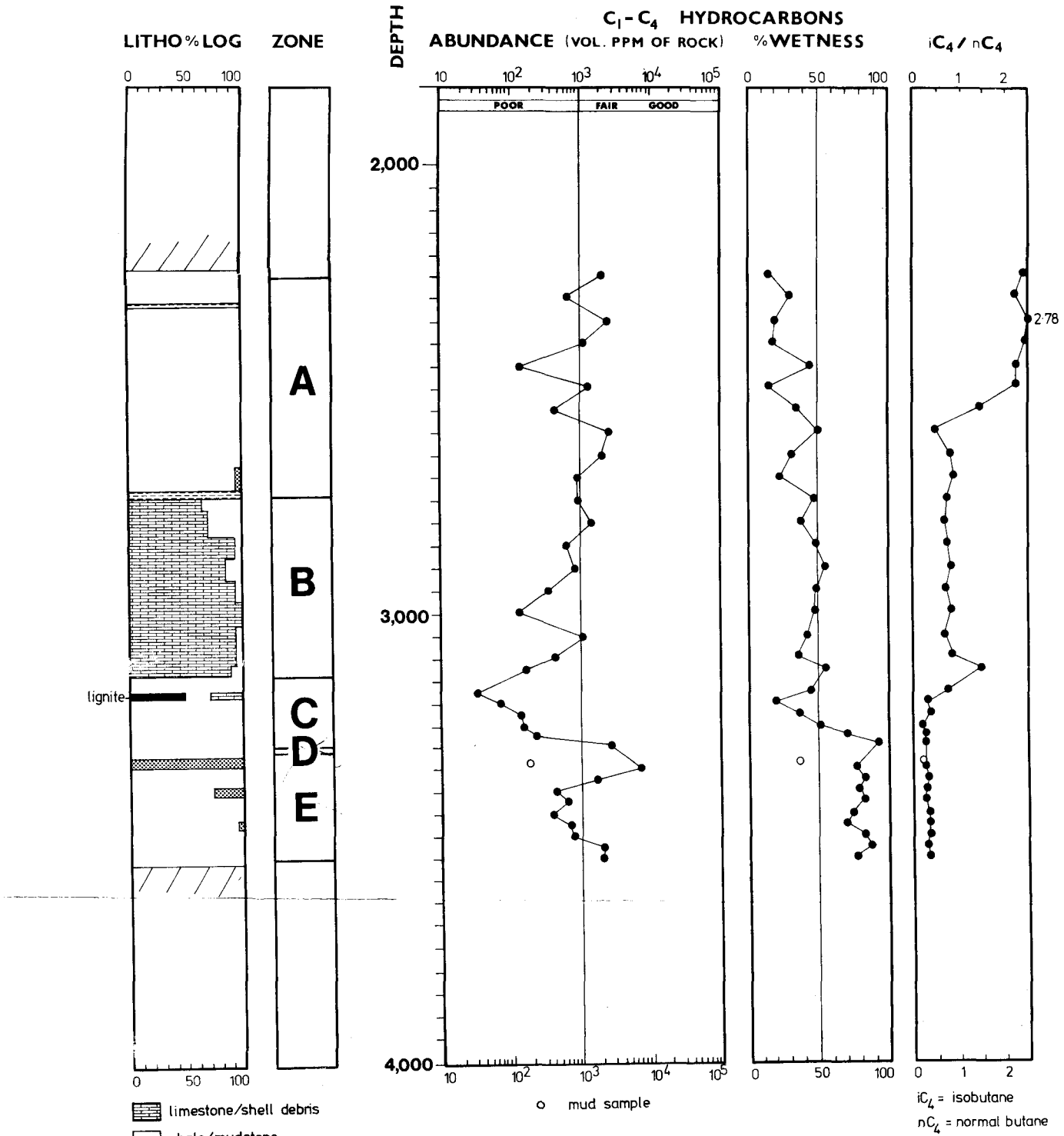
This examination gives the following data: the types (amorphous, algal, herbaceous etc.) and proportions of the organic matter present, the colour and hence level of thermal maturation of the organic matter and the state of preservation of the organic matter.

Our reports include colour transparencies of the kerogen. Upon completion of the study, the glass slides are sent to the client.

FIGURE 1

C_1-C_7 HYDROCARBONS

PRESENTATION OF ANALYTICAL DATA



PPM VALUES EXPRESSED AS VOLUMES OF GAS PER MILLION VOLUMES OF SE

FIGURE 2

C_{15+} HYDROCARBONS — RICHNESS

PRESENTATION OF ANALYTICAL DATA

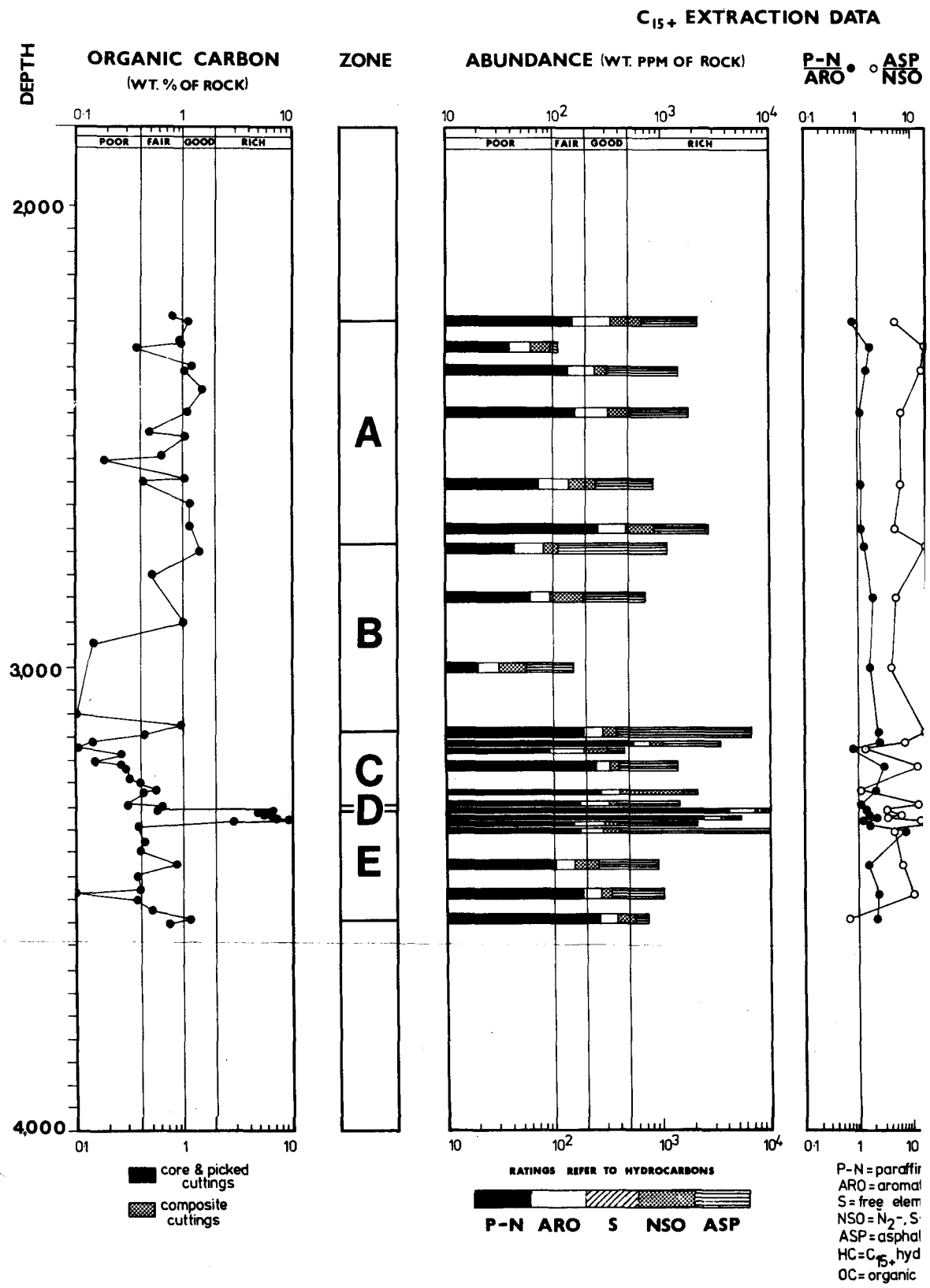
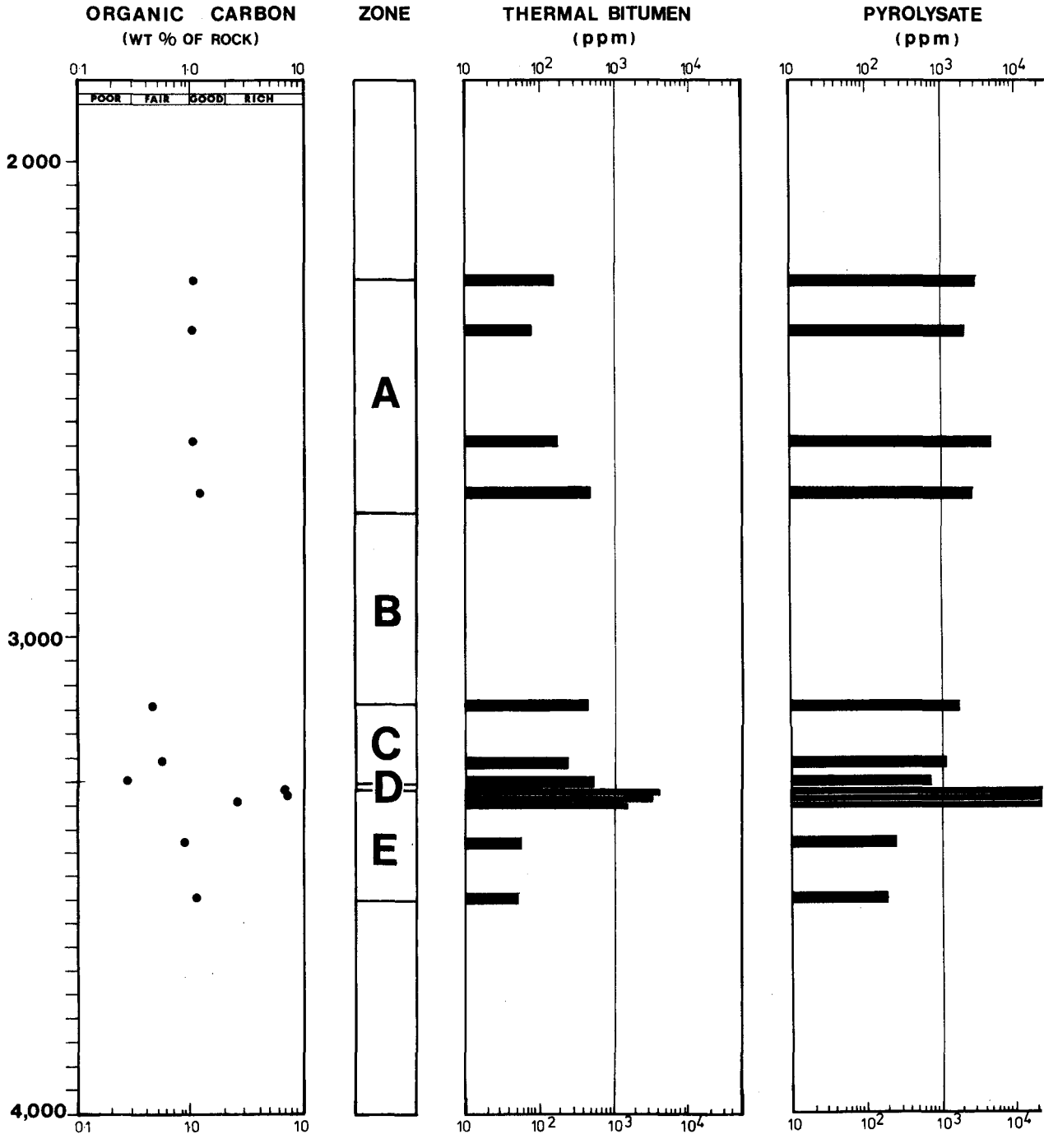
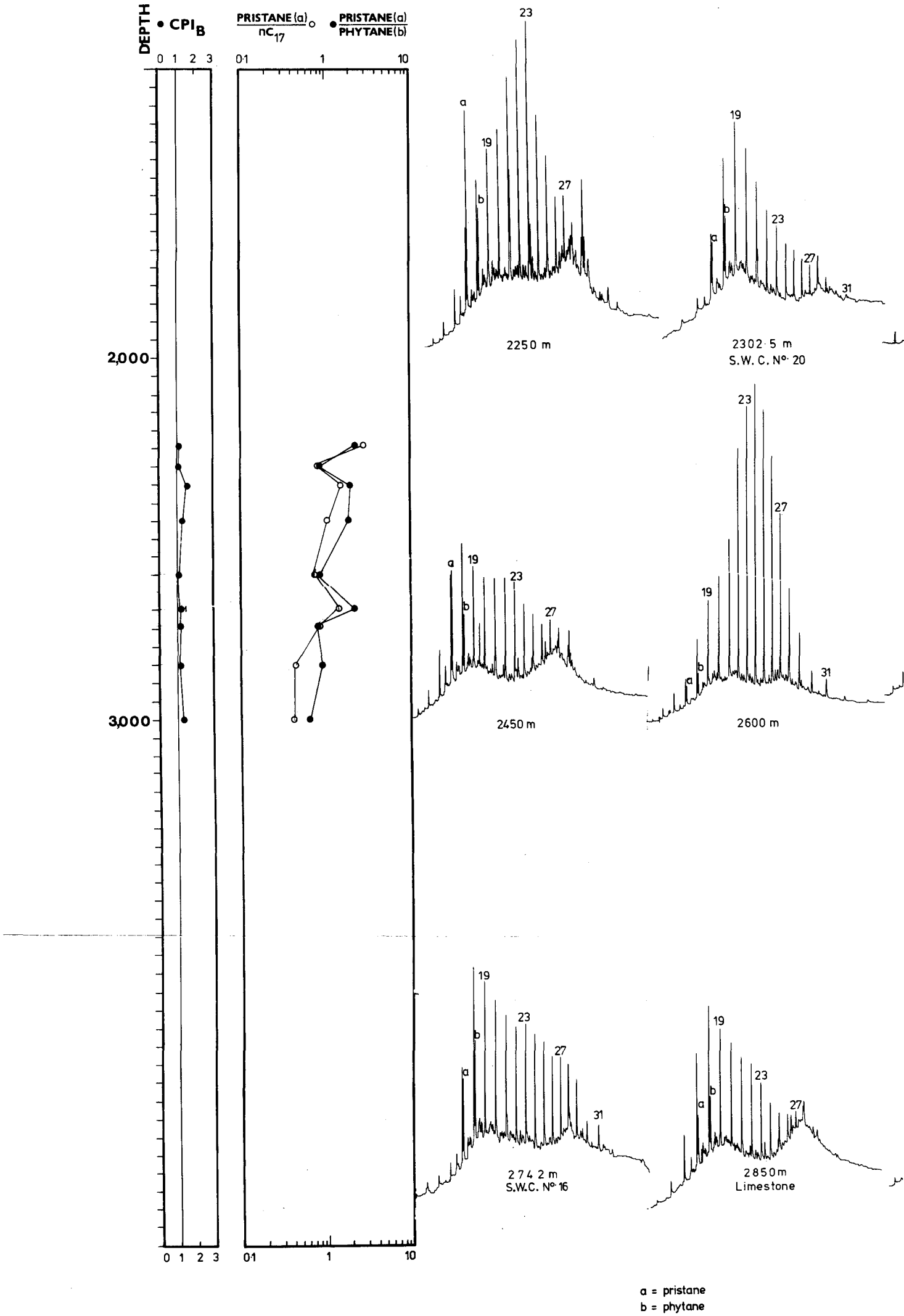
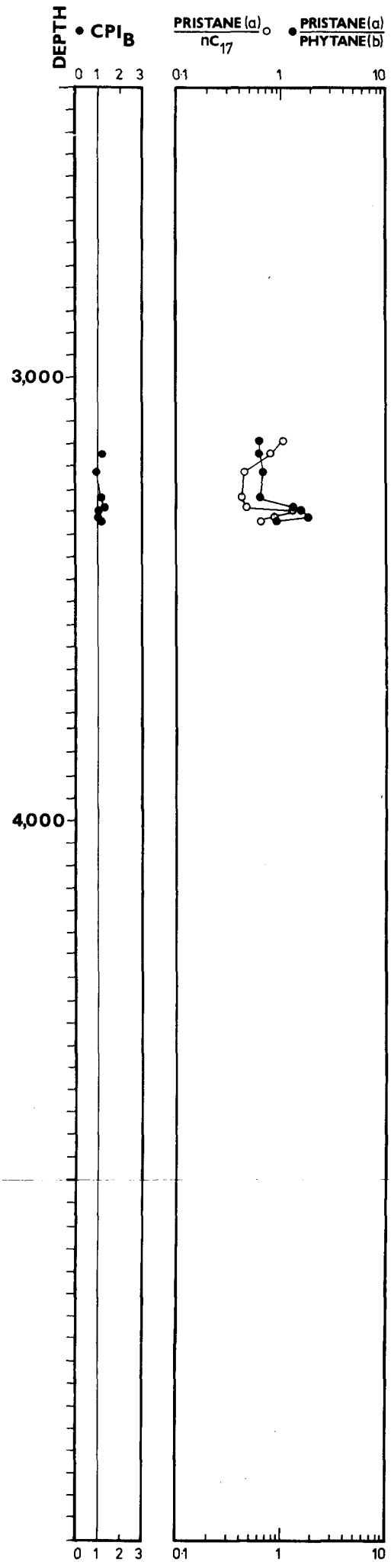


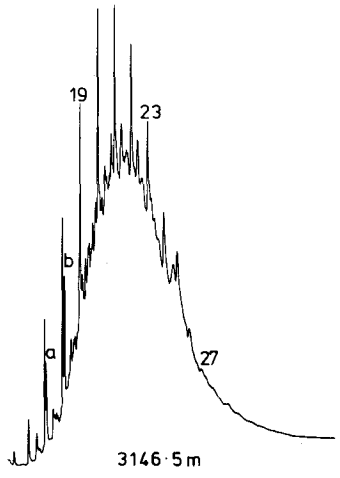
FIGURE 3

PYROLYSIS

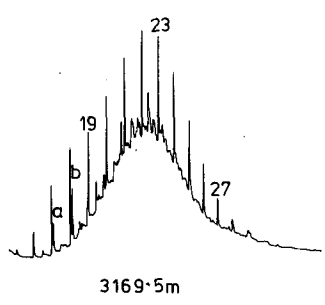



DEPTH
• CPI B
0 1 2 3
PRISTANE (a) / nC17 ○
• PRISTANE (a) / PHYTANE (b)
0·1 1 10
2,000
3,000
a
b
19
23
27
31
2250 m
2302·5 m
S.W.C. N°· 20
2450 m
2600 m
2742 m
S.W.C. N° 16
2850 m
Limestone
a = pristane
b = phytane

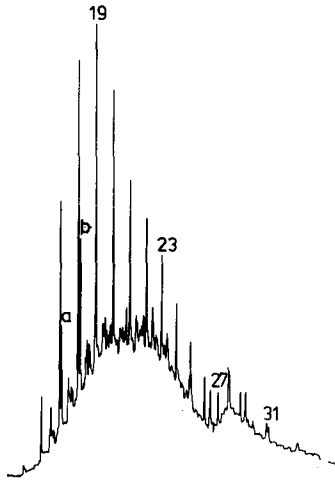




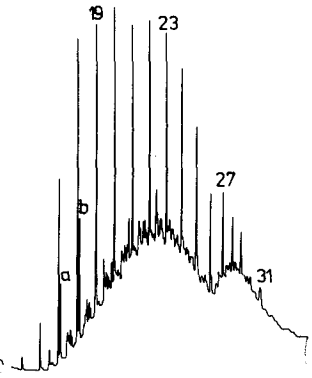
3146·5 m
Core N° 90



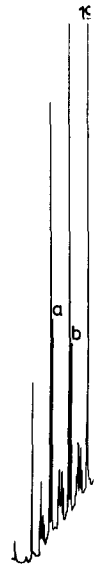
3169·5m
Core N° 88

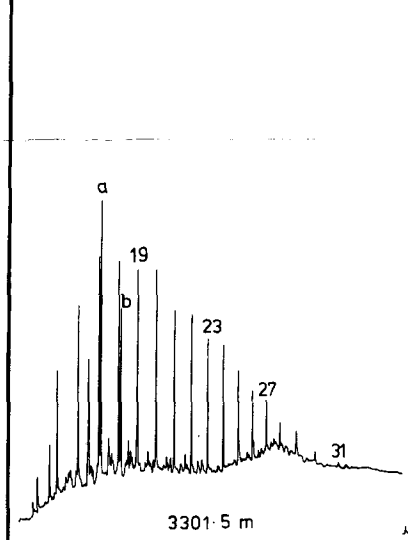


3221·0 m
Core N° 86

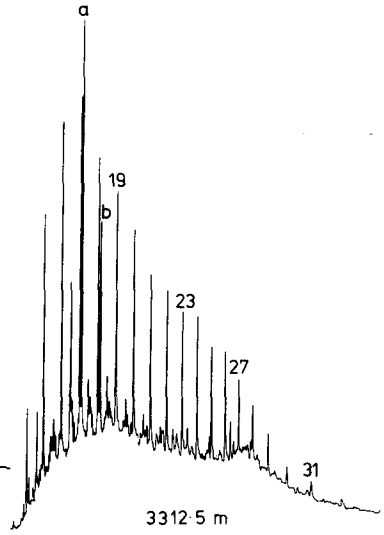


3270·0 m
Core N° 120





3301·5 m
Core N° 75



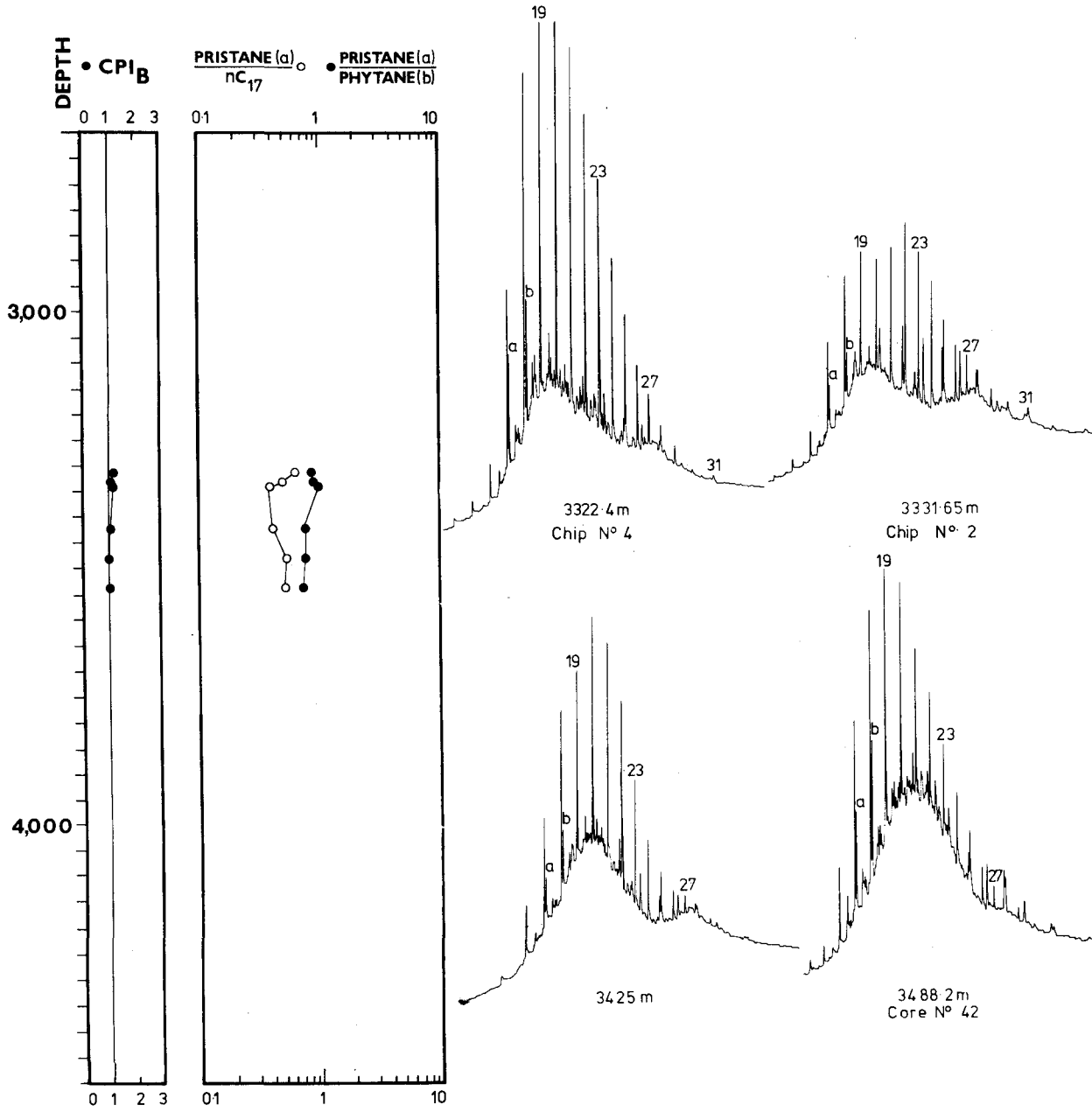
3312·5 m
Core N° 68

a = pristane
b = phytane

FIGURE 4 c

C_{15+} PARAFFIN – NAPHTHENE HYDROC

PRESENTATION OF ANALYTICAL DATA



a = pristane
b = phytane