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REPORT

MOBIL EXPLORATION NORWAY INC

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GEOCHEMICAL SERVICE REPORT  
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# GEOCHEMICAL SERVICE REPORT

Prepared for  
MOBIL EXPLORATION NORWAY INC.

HYDROCARBON SOURCE CHARACTER  
of  
MOBIL'S 33/12-6 WELL, NORWEGIAN NORTH SEA

July 1976

17 CASTLE STREET · CHESTER CHI 2DS · ENGLAND

COMPANY PROPRIETARY

WELL 33/12-6

HYDROCARBON SOURCE CHARACTER OF  
MOBIL'S 33/12-6 WELL, NORWEGIAN NORTH SEA

SUMMARY

Five (5) geochemical zones are recognised within the section from 1836 metres to total depth in Mobil's 33/12-6 Well.

Zone A (1836 metres to 2706 $\pm$  metres) is, for practical purposes, immature and has a negligible hydrocarbon potential. The shales of Zone B (2706 $\pm$  metres to 3336 $\pm$  metres) are potentially rich source rocks. Buried to below 3500 $\pm$  metres and 4300 $\pm$  metres they will generate significant and major oil respectively. In this section they can yield minor hydrocarbon liquids.

Zone C (3336 $\pm$  metres to 3696 $\pm$  metres) is mature below 3500 $\pm$  metres and is a fair to good source interval for oil and gas. The potential of Zones D (3696 $\pm$  metres to 3936 $\pm$  metres) and E (3936 $\pm$  metres to total depth) is limited by their high proportion of sand: the shales of Zone D are rich and mature; the lower part of Zone E lies within the envelope of peak hydrocarbon generation but the shales are only poor to fair sources.

Traces of young condensate are believed to be present in the Zone B sands and at the top of the Zone D sands and minor amounts of waxy oil at 3876-3906 metres. Local sources are invoked. Zone E appears to be barren.



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## INTRODUCTION

This report presents the results of a geochemical study of the section below 1836 metres in Mobil's 33/12-6 Well, drilled in the Norwegian sector of the North Sea.

The study was designed to:

- evaluate the source rocks in terms of richness, type of hydrocarbon product and level of thermal maturation
- identify and characterise migrated liquid (oil, condensate) hydrocarbons within the section.

Preliminary interpretations were reported to Mobil Norway as the analyses were completed, the final interpretation being ready within three (3) weeks of the receipt of the samples.

This study was authorised by Mr C W Brown, Mobil Exploration Norway Inc.

### A. ANALYTICAL

A set of one hundred (100) wet samples, heat sealed in plastic bags, from 1836 metres to total depth in Mobil's 33/12-6 was received for analysis. Five (5) mud samples were included, the rest being thirty-metre composite ditch cuttings samples. These samples were assigned the Geochem job number 91 and sequential sample numbers from -001 to -100.

In washing the samples, significant fleck was observed from 3306 metres to 3726 metres and below 4116 metres.

Geochem Laboratories were instructed to screen the samples with the light hydrocarbon and organic carbon analyses and to perform further analyses only upon selected samples. As the samples were bagged rather than canned and some of them, although damp, did not contain free water, only the cuttings gas light hydrocarbon analysis could be run (i.e. not air space), there is a danger of anomalously low and wet gas values.

A total of one hundred cuttings gas analyses, one hundred and thirty-seven organic carbon determinations, twenty-nine visual kerogen analyses, thirty-eight extractions with chromatography and thirty-eight paraffin-naphthene analyses were performed.

The data are presented in tables 1 through 6 and graphically in figures 1 through 4. A brief description of the analyses is included in the back of the report.

B. GENERAL INFORMATION

Ten (10) copies of this report have been forwarded to Mr C W Brown, Exploration Manager, Mobil Exploration Norway Inc. The washed, bagged samples and glass kerogen slides will also be returned to Mobil. A copy of the data has been retained by Geochem for future consultation with authorised Mobil personnel.

All of the data and interpretations related to this study are regarded as highly confidential and are proprietary to Mobil Exploration Norway Inc.

## RESULTS AND INTERPRETATIONS

This discussion deals with the section from 1836 metres to total depth in Mobil's 33/12-6 Well. The parameters relevant to the evaluation of the source rocks and of migrated hydrocarbons will be considered individually and then synthesised in the "Conclusions" section.

### A. ORGANIC GEOCHEMICAL ZONATION

This zonation is based upon the abundance and composition of the light hydrocarbons (C<sub>1</sub>-C<sub>7</sub>). As the samples were bagged, only the cuttings gas analysis could be run. Five (5) Zones are recognised.

Zone A 1836 metres to 2706<sup>±</sup> metres is composed of shales which are grossly medium dark grey in colour. There is a significant sandstone development between 2646<sup>±</sup> metres and 2706<sup>±</sup> metres. No fluorescence was observed.

The lowermost sample (2676-2706 metres) is transitional between Zones A and B. With this exception the Zone is lean, only one sample exceeding 100 ppm of the gaseous (C<sub>1</sub>-C<sub>4</sub>) hydrocarbons, whilst gas wetness (%C<sub>2</sub>+ in total C<sub>1</sub>-C<sub>4</sub>) varies from 18.6% up to 41.8%, being generally above 30% except at 2046-2226<sup>±</sup> metres. The heavier C<sub>5</sub>-C<sub>7</sub> hydrocarbons generally range from 9 ppm to 60 ppm but are in excess of 100 ppm from 2436<sup>±</sup> metres to 2616<sup>±</sup> metres.

Zone B extends from 2706<sup>±</sup> metres to 3336<sup>±</sup> metres. Above 2946<sup>±</sup> metres, the sediments consist of dark grey shales. Below this depth, the samples contain significant proportions of sandstone, particularly above 3124<sup>±</sup> metres and below 3216<sup>±</sup> metres (but not in the deepest sample). Slight green fluorescence was observed in the sands at 3096-3124 metres, but not elsewhere.

This interval is richer and wetter than Zone A. The C<sub>1</sub>-C<sub>4</sub> gases are over 80% wet throughout and, with one exception, are over 85% wet: the values are particularly high (95+%) between 3006<sup>±</sup> metres and 3216<sup>±</sup> metres.

Based upon gas abundances, three sub-zones can be recognised within Zone B. Zone B<sup>1</sup> (2706<sup>±</sup> metres to 3006<sup>±</sup> metres) contains, with only one exception, between 296 ppm and 976 ppm of the C<sub>1</sub>-C<sub>4</sub> gases;

Zone B<sup>2</sup> (3006<sup>±</sup> metres to 3246<sup>±</sup> metres) is significantly richer with from 1204 ppm up to 3822 ppm; Zone B<sup>3</sup> (3246<sup>±</sup> metres to 3336<sup>±</sup> metres) is non-uniform, generally resembling Zone B<sup>1</sup> although the lowest sample is comparable to Zone B<sup>1</sup> in richness.

The C<sub>5</sub>-C<sub>7</sub> hydrocarbons generally range from 100 ppm up to 350 ppm and are most abundant in Zone B<sup>1</sup> and not in Zone B<sup>2</sup> which is the richest and wettest. Isobutane to normal butane ratios tend to be higher in Zone B<sup>2</sup> (0.28-0.87) than in Zones B<sup>1</sup> (0.24-0.63) and B<sup>3</sup> (0.51-0.55).

Zone C<sup>1</sup> covers the interval from 3336<sup>±</sup> metres down to 3516<sup>±</sup> metres and consists of dark grey shales with very minor reddish-brown shale and sandstone.

It is leaner and drier than Zone B. Only the uppermost sample exceeds 1000 ppm of the C<sub>1</sub>-C<sub>4</sub> hydrocarbons and these gases are about 50% wet in the top half of this interval and only 20% wet in the lower half. Isobutane to normal butane ratios approximate 0.3. The heavier C<sub>5</sub>-C<sub>7</sub> hydrocarbons are sparse in the dry samples but reach 200 ppm at the top of the Zone.

Zone C<sup>2</sup> 3516<sup>±</sup> metres to 3696<sup>±</sup> metres is lithologically similar to Zone C<sup>1</sup>.

Geochemically, it is slightly richer and wetter. The C<sub>1</sub>-C<sub>4</sub> gases, which are now 50% wet, increase across the Zone from 800 ppm up to 1700 ppm whilst the C<sub>5</sub>-C<sub>7</sub> hydrocarbons average approximately 600 ppm.

Zone D lies between 3696<sup>±</sup> metres and 3936<sup>±</sup> metres. Sandstones are dominant throughout, but are accompanied by significant proportions of greyish black to dark grey shale. No fluorescence was observed.

The two samples with the highest proportions of sand contain only 100 ppm and 502 ppm of the C<sub>1</sub>-C<sub>4</sub> gases, but the others range from 1143 ppm up to 5522 ppm. Except in the lowermost one hundred metres, these gases are commonly 65% wet, but reach 85.8% in the highest sample (3696-3726 metres). The C<sub>5</sub>-C<sub>7</sub> fraction varies erratically between 93 ppm and 315 ppm whilst the isobutane to normal butane ratio is commonly about 0.4.

Zone E 3936± metres to total depth, is dominated by sands down to 4086± metres. Between this depth and 4266± metres, sandstone is commonly significant but the samples, particularly below 4176± metres, consist dominantly of medium dark grey shale. Below 4266± metres the shales are largely reddish brown in colour; sands are minor to 4506± metres but abundant below this depth. No fluorescence was observed.

Within this Zone the C<sub>1</sub>- C<sub>4</sub> hydrocarbons do not exceed 400 ppm and, below 4146± metres, are always below 200 ppm. These gases are generally over 50% wet, but those samples with less than 100 ppm of the C<sub>1</sub>-C<sub>4</sub> fraction are only 25-30% wet. These variations are not reflected in the isobutane to normal butane ratio. Only one sample contains more than 200 ppm of the C<sub>5</sub>-C<sub>7</sub> hydrocarbons, whilst below 4266± metres, the values are always less than 110 ppm.

The wettest and richest samples are at 3966-3996 metres and 4086-4116 metres.

In summary:

- Zone A is lean and marginally wet
- Zone B is very wet throughout. Zone B<sup>1</sup>, which consists of shales underlain by sandstone with shale, has fair C<sub>1</sub>-C<sub>4</sub> abundance values whilst the sandstone-shale sequence of Zone B<sup>3</sup> is poor to fair. Zone B<sup>2</sup>, with only minor sandstone, is both the richest and the wettest. The poor to fair C<sub>5</sub>-C<sub>7</sub> abundances are best within Zone B<sup>1</sup>.
- the shales of Zone C have low isobutane to normal butane ratios. The C<sub>1</sub>-C<sub>4</sub> gases are of fair abundance, the best values being in Zone C<sup>2</sup>. Within Zone C<sup>1</sup> these gases pass from wet to marginally wet with depth and the C<sub>5</sub>-C<sub>7</sub> hydrocarbons become sparse whilst in Zone C<sup>2</sup> the gases and the C<sub>5</sub>-C<sub>7</sub> fraction are of fair abundance.
- Zone D is wet and has fair to good gas (but only poor to fair C<sub>5</sub>-C<sub>7</sub>) richness. The better samples have the lowest proportions of sand, although sandstones are dominant throughout. The sample at 3696-3726 metres is very wet.
- Zone E is fair to 4266± metres but poor below this depth (corresponding to the reddish-brown shales). The leaner samples are only marginally wet.
- potential reservoir lithologies are developed at 2646-2706± metres (Zone A), below 2946± metres in Zone B and particularly at 2946-3124± metres and 3216-3336± metres, throughout Zone D, above 4266± metres and below 4506± metres in Zone E. Fluorescence (slight) was only observed at 3096-3124 metres.

## 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 1.1% organic carbon and this is the standard to which these samples will be compared.

Organic matter type exerts a profound influence upon source richness, response to thermal maturation and the type (oil, gas) of hydrocarbon product. Amorphous organic matter is the most oil-prone. Herbaceous and stem kerogen can also yield major oil and gas whilst wood is more gas-prone. Coaly material has a strictly limited hydrocarbon potential.

The dominant medium dark grey shale of the uppermost sample and the minor shale of the deepest (2676-2706 metres) sample of Zone A contain 1.56% and 2.04% organic carbon respectively. With these exceptions, the shales down to 2406 $\pm$  metres contain between 0.30% and 0.88% organic carbon, but generally fall below 0.6%. From 2406 $\pm$  metres to the bottom of Zone A, values range from 0.68% up to 0.90%, only one sample falling below these limits. Thus Zone A above 2406 $\pm$  metres is poor to fair whilst the rest of the interval is fair but still of below-average richness.

With the exception of the deepest sample (which is also anomalously rich), the organic matter in the Zone A shales is dominantly woody and coaly in type, commonly with significant herbaceous debris but with negligible amorphous kerogen.

In contrast, Zone B is rich. Down to 2976 $\pm$  metres, the shales normally contain between 2.0% and 2.9% organic carbon. Below this depth, values range from 2.3% up to 6.0% being always in excess of three percent above 3186 $\pm$  metres. The minor coals within this interval are, naturally, very rich. The organic matter is also different in type: amorphous and herbaceous kerogens are dominant whilst wood is generally fairly abundant but below Zone B<sup>1</sup> may share the dominant position. Stem material is commonly significant.

Thus, Zone B is rich in organic matter which contains high proportions of amorphous and herbaceous kerogen. Much of the amorphous material has developed from the alteration of herbaceous debris.

Only one sample from Zone C<sup>1</sup> falls outside the relatively narrow range of 1.4% to 1.6% organic carbon. These shales, although not as rich as those of Zone B, are still of above-average richness. Values are grossly similar in Zone C<sup>2</sup> (1.2% to 2.2% organic carbon) although not as tight; they tend to decrease with depth.



In Zone C, woody and herbaceous kerogens are dominant but whereas amorphous and stem materials are abundant in Zone C<sup>1</sup>, they tend to be sparse in Zone C<sup>2</sup> and are replaced by coaly matter. Thus Zones C<sup>1</sup> and C<sup>2</sup> are not as rich as Zone B and contain organic matter with a lower hydrocarbon potential.

The organic matter in Zone D is similar to that of Zone C<sup>1</sup>, but throughout Zone E woody, or woody and herbaceous kerogens, are dominant and the other kerogen types are commonly sparse or absent.

In terms of organic matter contents, Zone D is very varied but is rich (2.2% to 10.7% organic carbon) throughout. The organic richness of Zone E varies as a function of lithology: the olive black shales down to 4086± metres are approximately average (1.0-1.3% organic carbon) whilst the underlying dark grey to medium dark grey shales are of below-average richness (maximum value 1.1%). Most of the shale below 4266± metres is dark reddish brown in colour and is lean (up to 0.4% organic carbon) but the dark grey shales which also occur generally contain between 1.0 and 1.5% organic carbon. At least some of these dark grey shales are caved.

Relatively reducing conditions apparently prevailed at the sediment-seawater interface during Zone B times and to a lesser degree, in Zone C<sup>1</sup> times. Throughout the rest of the section and particularly in the periods represented by the Zone A and Zone E sediments relatively oxidising conditions are suggested. Intervals in which amorphous kerogen is totally dominant are not developed in this well.

### C. LEVEL OF THERMAL MATURATION

Thermal maturation indices at the top of the section under examination are 1+ to 2-. They pass to 2- at 2150± metres and to 2 at 3500± metres. Values of 2 to 2+ are achieved at 4050± metres and of 2+ at 4300± metres. The latter transition (to 2+) is camouflaged by the presence of caved material but appears to be reasonably definite.

The sediments above 2150± metres are immature. Below this depth and down to 3500± metres, the herbaceous material of Zone A and the herbaceous and amorphous kerogen of Zones B and C<sup>1</sup> are marginally mature, becoming more mature with depth and particularly below 2600± metres. These fractions of the total organic matter are generating minor hydrocarbon liquids (heavy condensate or low gravity oil) with gas.

In Zone A, where the organic matter is dominantly woody and coaly this potential is, for practical purposes, negligible. It is also limited by the abundance of wood in Zone C<sup>1</sup>, but this is not true of Zone B.

Although not within the envelope of peak hydrocarbon generation, Zones C<sup>2</sup>, D and E down to approximately 4300± metres are mature and are producing gas and oil. The remainder of Zone E is realising its maximum potential for hydrocarbons, but the organic matter within this interval is not particularly oil prone.

Off-structure, the lateral equivalents of the Zone B shales which are buried to below 3500± metres will be mature and generating significant oil. Burial to approximately 4300± metres would enable them to yield major oil.

Allowing for the presence of non-indigenous hydrocarbons, the light hydrocarbon data and the C<sub>15</sub>+ paraffin-naphthene chromatograms give qualitative confirmation of this maturation trend.

#### D. HYDROCARBON SOURCE RICHNESS

Preliminary assessments of present and potential hydrocarbon source richness are provided by the light hydrocarbon and organic carbon abundances. In the case of the former, an adjustment must be made to correct for the fact that the samples were not canned.

The light hydrocarbon data suggest that Zone A is poor whereas Zones B and C are fair and Zone D is fair to good. Zone E is fair to 4266± metres but poor below this depth. In this study, these ratings must be treated with caution.

Organic carbon abundances suggest poor to fair and fair ratings for Zone A above and below 2406± metres respectively. Zone B is rich. Zones C<sup>1</sup> and C<sup>2</sup> are also good whilst the shale units within Zone D are rich. Although the actual volume of shale will, to some degree be limiting, migration from source to reservoir will be efficient. Zone E is fair to good above 4086± metres but then declines to fair and, below 4266± metres, to poor.

Definitive evaluations involve a consideration of the C<sub>15</sub>+ hydrocarbons. However, within most of this section, non-indigenous hydrocarbons (see Section E) augment and mask the indigenous source hydrocarbons and result in anomalously high richness ratings.

Allowing for their presence, Zone A has a poor to fair or fair source rock potential, but Zone B is good and, at a higher level of thermal maturation, would probably be very good. The shales

of Zones C<sup>1</sup> and C<sup>2</sup> are assigned a fair to good rating. Even with the contamination, Zone E is only a fair source interval; in an uncontaminated state, a poor to fair rating probably applies.

In a mature state Zone A below 2406± metres, could generate significant but not the major hydrocarbon reserves required in the North Sea. However, Zone B and also perhaps Zones C<sup>1</sup> and C<sup>2</sup> do fulfill the necessary richness requirements. Although migration from source to reservoir will be efficient within Zone D, the potential of the interval will be limited by the abundance of shales. However, the shales are so rich that, as significant units are apparently present, they must be considered a valid exploration target. Shales are of variable abundance in Zone E and furthermore are only poor to fair source rocks. The interval between 4086± metres and 4536± metres is shaly but is not rich enough to be of real exploration significance.

#### E. NON-INDIGENOUS HYDROCARBONS

Potential reservoir horizons are provided by the sandstones at 2646-2706± metres (Zone A), below 2946± metres in Zone B and particularly at 2946-3124± metres and 3216-3336± metres, throughout Zone D and in Zone E above 4266± metres and below 4506± metres. However, with the exception of the sample at 3096-3124 metres (Zone B), no fluorescence was observed in any of these units.

The light hydrocarbon data do not definitively indicate migrated hydrocarbons in Zone A but the gases associated with the Zone B sands are very wet. In Zone D, there appears to be an inverse relationship between the sand content of the samples and the light hydrocarbon gases. The sample from 3696-3726 metres is however, very wet. The data for Zone E are not indicative of the present of migrated hydrocarbons.

Five samples of drilling mud were analysed. They were initially extracted (and the results refer to) for three hours in order to extract the material which would most readily invade the formations. Additional extraction for a further sixteen hours resulted in very abundant asphaltenes, suggests lignosulphonate. The mud from 2100 metres contains fairly abundant hydrocarbons with a paraffin-naphthene to aromatic ratio of just below one. The others are very rich (up to almost 2% hydrocarbons by weight) and have high ratios. All of the muds are characterised by paraffin-naphthene chromatograms which are totally dominated by the front ends and in which both the background envelope (largely naphthenes) and the normal paraffin peaks "die" at approximately nC<sub>25</sub>. These muds apparently contain lignosulphonate whilst the higher paraffin-naphthene to aromatic ratios suggest the presence of gas-oil. Clearly, pronounced background humps or naphthenes and normal paraffins in the middle and heavy range cannot be explained in terms of mud contamination.

The Zone B sands above 3246± metres contain between 796 ppm and 3842 ppm of the C<sub>15</sub>+ hydrocarbons. These hydrocarbons constitute less than one third of the total extract and tend to have relatively low paraffin-naphthene to aromatic ratios. In view of the fact that it was not possible to effectively remove all of the shale from the samples by hand picking, these data are not particularly suggestive of non-indigenous hydrocarbons. However, the paraffin-naphthene chromatograms clearly indicate contamination from the drilling mud in addition to the shale-derived hydrocarbons. Migrated hydrocarbons, if present, are masked, but the wetness of the C<sub>1</sub>-C<sub>4</sub> gases suggests that liquid hydrocarbons could have moved into these sands. In this context it must be remembered that porosity-contained hydrocarbons will be relatively depleted due to the fact that the samples were not cased. Nevertheless, it is probable that only trace amounts are involved.

Contamination confuses the issue, but it is suggested that trace amounts of hydrocarbons, "young" condensate in character rather than oil, have moved into these sands. This would be compatible with the level of thermal maturation of the adjacent shales. It is probable that a local source is involved and that the movement could be described as a local redistribution which is of no economic significance.

Hydrocarbons are significantly less abundant (182 ppm to 675 ppm) in the sands of Zone D but constitute a much higher proportion of the total extract and have higher paraffin-naphthene to aromatic ratios. However, these hydrocarbons reflect either contamination from the drilling mud or the presence of shale. There is nothing to suggest migrated liquid hydrocarbons. This is also true of the gases with the exception of the sample from the top of the sand (3696-3726 metres) which is very wet. Thus the data suggest that hydrocarbons have moved into the top of the reservoir. It is not possible to be definitive regarding their character, but it is speculated from the light hydrocarbon data that they too, could be wet gas or young condensate in type. Again, relatively minor amounts appear to be involved.

Contamination is not evident in the sample from 3876-3906 metres towards the base of Zone D. Nevertheless, hydrocarbons constitute almost half of the total extract which suggests, particularly in comparison with the other uncontaminated samples, that non-indigenous hydrocarbons are in fact, present. Hydrocarbons are not abundant (539 ppm) but are relatively mature and appear to reflect the presence of minor amounts of paraffinic oil generated by land plant derived organic matter.

There is no evidence of migrated hydrocarbons within the sands of Zone E, but drilling mud contamination is present.

It must be emphasised that the occurrences discussed above should be regarded as minor shows and it is likely that only local sources are involved. Definitive interpretations are difficult due to the small amounts involved and the prevalence of contamination.

Hydrocarbons are relatively abundant in Zone A but constitute a too-high (at this level of maturation) proportion of the total extract. These samples were also contaminated during drilling although the background envelope of the paraffin-naphthene chromatogram indicates a difference in the overall character of the additives.

Thus, during drilling, contamination was introduced throughout the 33/12-6 section.

#### F. CONCLUSIONS

The deepest sample of Zone A resembles the underlying Zone B in both organic richness and organic matter type. With this exception, the shales of Zone A above 2406<sup>±</sup> metres have poor to fair organic contents whilst below this depth, they are of fair richness. Most of the organic matter is woody and coaly in type, although significant herbaceous debris is present.

The sediments are immature down to 2150<sup>±</sup> metres, but the herbaceous fraction in the deeper samples is marginally mature and capable of yielding minor hydrocarbon liquids. As the herbaceous material constitutes only a small part of the total organic matter, the present hydrocarbon potential of these sediments is negligible. In a mature state, they would be poor to fair or fair hydrocarbon sources, capable of generating significant but not major hydrocarbon accumulations.

Zone B is not only organically rich but the organic matter is dominantly amorphous and herbaceous, although wood is fairly abundant particularly below 3000<sup>±</sup> metres. Potentially, the Zone B shales are rich source rocks for oil with the ability to yield major volumes of hydrocarbons. On structure however, they are only marginally mature and hence are generating minor hydrocarbon liquids.

Buried to below 3500<sup>±</sup> metres and particularly to below 4300<sup>±</sup> metres, their lateral off-structure equivalents would realise their potential for major oil.

Reducing conditions apparently prevailed at the seawater-sediment interface during Zone B times.

Zones C<sup>1</sup> and C<sup>2</sup> are not as rich as Zone B but still have good organic contents. Their organic matter however, tends to be less favourable for oil: woody and herbaceous material is the most abundant whilst although amorphous kerogen is fairly abundant in Zone C<sup>1</sup> it is sparse in Zone C<sup>2</sup>. They are both rated as

potentially fair to good source rocks. Zone C<sup>1</sup> is only marginally mature, but Zone C<sup>2</sup> is mature, although not very mature. With further burial, both Zones would be of interest to the explorationist.

The source potential of Zone D is limited by the predominantly sandy character of the section, but migration from these mature shales into the adjacent reservoirs will be efficient.

Below 4300± metres, the shales of Zone E lie within the envelope of peak hydrocarbon generation where source rocks realise their maximum potential. However, they are sometimes limited in volume, of fair decreasing to poor richness and contain organic matter which is dominantly woody or woody and herbaceous in type. The shaly interval between 4086± metres and 4266± metres probably has the best potential but even so is not sufficiently rich to generate significant hydrocarbons and is of no exploration significance.

Drilling-introduced contamination is present throughout this section and complicates the recognition of migrated liquid hydrocarbons, particularly as only trace amounts are involved. No economically significant reservoir hydrocarbons were detected. However, it is suggested that trace amounts of locally sourced "young" condensate are present within the sands of Zone B and at the top (3696-3726 metres) of the Zone D sands. These appear to be local redistribution phenomena and probably do not involve long-range migration. Minor amounts of paraffinic (waxy) oil are present at 3876-3906 metres towards the base of Zone D. Zone E appears to be barren.

The shales of Zones B and C are presumably sufficiently deeply buried within the drainage area of the structure to realise their potential for major and very significant oil. The sands of Zones B and D are in communication with these rich shales and yet are believed to contain only minor locally-sourced, young condensate. This hydrocarbon product is compatible with the maturation state of the adjacent shales on-structure. Therefore, the lateral downdip equivalents of these shales did not generate oil or the oil was generated and was not able to move up into the structure or it was not trapped. The first alternative seems unlikely and, as young condensate is believed to be present, so does the third alternative.

**TABLE 1B**  
**CONCENTRATION (VOL. PPM OF ROCK) OF C<sub>1</sub> - C<sub>7</sub> HYDROCARBONS IN CUTTINGS GAS**

GEOCHEM SAMPLE NUMBER	DEPTH	C <sub>1</sub> Methane	C <sub>2</sub> Ethane	C <sub>3</sub> Propane	iC <sub>4</sub> Isobutane	nC <sub>4</sub> Butane	TOTAL C <sub>1</sub> - C <sub>4</sub>	TOTAL C <sub>2</sub> - C <sub>4</sub>	% GAS WETNESS	TOTAL C <sub>5</sub> - C <sub>7</sub>	$\frac{iC_4}{nC_4}$
91-002	1839(Mud)	12.0	2.5	1.3	0.7	0.9	17.4	5.4	31.0%	2.3	0.78
91-001	1836-866m	35	16.4	3.8	1.1	1.7	58	23	39.6%	24	0.65
91-003	1866-896m	51	22	4.7	1.5	2.5	82	31	37.4%	58	0.60
91-004	1896-926m	25	7.4	3.1	0.7	0.9	37	12.1	32.7%	12.0	0.77
91-005	1926-956m	30	7.9	6.0	2.2	3.3	49	19.4	39.6%	44	0.67
91-006	1956-986m	26	5.4	5.9	3.1	3.2	44	17.6	40.0%	44	0.97
91-007	1986-2016m	44	7.3	7.6	4.8	3.1	67	23	34.0%	21	1.55
91-008	2016-046m	32	6.9	5.6	2.8	1.8	49	17.1	34.9%	19.1	1.55
91-009	2046-076m	22	3.7	2.1	1.3	1.2	30	8.3	27.7%	24	1.08
91-010	2076-106m	22	4.9	2.5	0.7	1.1	31	9.2	29.7%	18.6	0.64
91-011	2100(Mud)	51	4.6	2.3	1.0	1.3	60	9.2	15.3%	12.0	0.77
91-012	2106-136m	34	4.3	2.2	0.6	0.7	42	7.8	18.6%	17.1	0.86
91-013	2136-166m	32	4.7	2.6	0.7	1.4	41	9.4	22.9%	13.0	0.50
91-014	2166-196m	26	4.8	2.1	0.2	0.3	33	7.4	22.4%	9.0	0.67
91-015	2196-226m	20	2.2	1.5	1.0	0.7	25	5.4	21.6%	16.6	1.43
91-016	2226-256m	24	4.6	2.9	1.8	1.9	35	11.2	32.0%	17.1	0.95
91-017	2256-286m	23	6.5	4.6	2.7	2.4	39	16.2	41.5%	15.8	1.12
91-018	2286-316m	27	5.2	4.6	1.0	1.7	39	12.5	32.0%	62	0.59
91-019	2316-346m	30	4.2	2.4	1.0	1.6	39	9.2	23.6%	29	0.62
91-020	2346-376m	23	3.3	2.1	1.3	2.1	32	8.8	27.5%	34	0.62
91-021	2376-406m	17.6	3.6	2.7	2.2	2.4	28	10.9	38.9%	24	0.92
91-022	2406-436m	31	6.3	2.8	1.1	2.4	44	12.6	28.6%	53	0.46

**TABLE 1B**  
**CONCENTRATION (VOL. PPM OF ROCK) OF C<sub>1</sub> - C<sub>7</sub> HYDROCARBONS IN CUTTINGS GAS**

GEOCHEM SAMPLE NUMBER	DEPTH	C <sub>1</sub> Methane	C <sub>2</sub> Ethane	C <sub>3</sub> Propane	iC <sub>4</sub> Isobutane	nC <sub>4</sub> Butane	TOTAL C <sub>1</sub> - C <sub>4</sub>	TOTAL C <sub>2</sub> - C <sub>4</sub>	% GAS WETNESS	TOTAL C <sub>5</sub> - C <sub>7</sub>	$\frac{iC_4}{nC_4}$
91-023	2436-466m	29	5.8	2.8	1.7	2.4	42	12.7	30.2%	125	0.71
91-024	2466-496m	22	5.1	3.4	4.4	2.9	38	15.8	41.6%	224	1.52
91-025	2496-526m	59	7.3	6.7	5.1	7.5	86	27	31.3%	122	0.68
91-026	2526-556m	40	6.7	7.0	6.4	6.0	66	26	39.5%	130	1.07
91-027	2556-586m	42	7.4	5.0	3.8	4.2	62	20	32.9%	113	0.90
91-028	2586-616m	44	7.0	4.3	2.0	3.6	61	16.9	27.8%	119	0.55
91-029	2616-631m	94	7.6	8.4	5.0	6.6	121	27	22.5%	64	0.81
91-030	2631 (Mud)	46	6.3	1.8	0.6	1.1	56	9.8	17.5%	30	0.54
91-031	2631-646m	36	6.4	4.6	2.2	3.2	52	16.4	31.5%	44	0.69
91-032	2646-676m	32	6.0	5.3	5.1	6.6	55	23	41.8%	116	0.77
91-033	2676-706m	37	6.6	15.5	14.1	19.9	93	56	60.3%	274	0.71
91-034	2706-736m	36	26	150	47	75	334	298	89.2%	346	0.63
91-035	2736-766m	55	64	294	64	122	599	544	90.8%	352	0.52
91-036	2766-796m	53	93	361	82	137	726	673	92.7%	478	0.60
91-037	2796-826m	67	48	256	61	104	536	469	87.5%	285	0.59
91-038	2826-856m	49	88	330	62	102	631	582	92.2%	225	0.61
91-039	2856-886m	67	114	481	92	152	906	839	92.6%	321	0.60
91-040	2886-916m	55	158	503	71	113	900	845	93.9%	216	0.63
91-041	2916-946m	101	206	935	115	185	1542	1441	93.4%	277	0.62
91-042	2946-976m	64	182	575	49	106	976	912	93.4%	136	0.46
91-043	2976-3006m	38	29	153	15	61	296	258	87.2%	57	0.24
91-044	3006-036m	52	528	1276	74	261	1770	1718	97.1%	179	0.28



TABLE 1B  
CONCENTRATION (VOL. PPM OF ROCK) OF C<sub>1</sub> - C<sub>7</sub> HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C <sub>1</sub> Methane	C <sub>2</sub> Ethane	C <sub>3</sub> Propane	iC <sub>4</sub> Isobutane	nC <sub>4</sub> Butane	TOTAL C <sub>1</sub> - C <sub>4</sub>	TOTAL C <sub>2</sub> - C <sub>4</sub>	% GAS WETNESS	TOTAL C <sub>5</sub> - C <sub>7</sub>	$\frac{iC_4}{nC_4}$
91-045	3036-066m	56	580	1173	67	170	2046	1990	97.3%	108	0.39
91-046	3066-096m	71	1340	1547	85	156	3199	3128	97.8%	122	0.54
91-047	3096-124m	55	525	834	56	94	1564	1509	96.5%	93	0.59
91-048	3126-156m	52	426	606	51	69	1204	1152	95.7%	101	0.74
91-049	3156-186m	49	348	702	73	93	1265	1216	96.1%	132	0.78
91-050	3186-216m	180	1602	1366	120	137	3405	3225	94.7%	167	0.87
91-051	3216-246m	270	1772	1473	132	175	3822	3552	92.9%	252	0.75
91-052	3246-276m	71	43	171	26	51	362	291	80.4%	128	0.51
91-053	3276-306m	64	86	201	26	50	427	363	85.0%	116	0.52
91-054	3306-336m	315	941	1245	116	209	2826	2511	88.8%	310	0.55
91-055	3336-366m	510	211	251	25	64	1061	551	51.9%	118	0.39
91-056	3366-396m	473	133	200	17.8	71	895	422	47.1%	200	0.25
91-057	3396-426m	236	40	132	16.6	57	482	246	50.9%	139	0.29
91-058	3426-456m	391	33	16.5	2.0	6.4	449	58	12.9%	7.4	0.31
91-059	3456-486m	493	42	34	4.3	14.7	588	95	16.1%	22	0.29
91-060	3486-516m	595	91	85	8.5	30	809	214	26.4%	142	0.28
91-061	3516-546m	397	167	256	31	74	925	528	57.1%	734	0.42
91-062	3546-576m	350	124	154	19.3	57	704	354	50.3%	657	0.34
91-063	3576-606m	707	335	468	49	136	1695	989	58.3%	677	0.36
91-064	3606-636m	595	163	168	17.5	74	1020	425	41.7%	417	0.24
91-065	3636-666m	869	258	405	49	177	1758	889	50.6%	720	0.28
91-066	3666-696m	174	39	80	13.9	47	354	180	50.8%	171	0.29

**TABLE 1B**  
**CONCENTRATION (VOL. PPM OF ROCK) OF C<sub>1</sub> - C<sub>7</sub> HYDROCARBONS IN CUTTINGS GAS**

GEOCHEM SAMPLE NUMBER	DEPTH	C <sub>1</sub> Methane	C <sub>2</sub> Ethane	C <sub>3</sub> Propane	iC <sub>4</sub> Isobutane	nC <sub>4</sub> Butane	TOTAL C <sub>1</sub> - C <sub>4</sub>	TOTAL C <sub>2</sub> - C <sub>4</sub>	% GAS WETNESS	TOTAL C <sub>5</sub> - C <sub>7</sub>	$\frac{iC_4}{nC_4}$
91-067	3696-726m	316	707	954	82	173	2232	1916	85.8%	307	0.47
91-068	3726-756m	174	92	169	20	47	502	328	65.3%	174	0.42
91-069	3756-786m	3020	1313	967	58	164	5522	2502	45.3%	192	0.35
91-070	3786-816m	711	509	644	53	138	2055	1344	65.4%	234	0.38
91-071	3816-846m	1068	897	819	58	170	3012	1944	64.5%	183	0.34
91-072	3832m (Mud)	33	13.4	28	8.1	17.3	100	67	66.8%	379	0.47
91-073	3846-876m	96	23	22	8.4	17.8	167	71	42.6%	93	0.47
91-074	3876-906m	2381	1359	659	41	95	4535	2154	47.5%	105	0.43
91-075	3906-936m	484	256	284	38	81	1143	659	57.6%	315	0.47
91-076	3936-966m	133	62	135	17.1	49	387	254	65.6%	123	0.43
91-077	3966-996m	62	50	151	17.1	39	319	257	80.6%	152	0.44
91-078	3996-026m	108	27	46	11.2	25	217	109	50.3%	85	0.45
91-079	4026-056m	93	39	87	11.7	29	260	167	64.1%	78	0.40
91-080	4056-086m	55	25	96	10.8	30	217	162	74.6%	86	0.36
91-081	4086-116m	68	79	183	19.8	46	396	328	82.8%	192	0.43
91-082	4116-146m	96	46	103	14.3	32	291	195	67.0%	161	0.45
91-085	4143m (Mud)	135	38	41	13.3	24	251	116	46.3%	296	0.55
91-083	4146-176m	69	51	34	6.6	14.3	175	106	60.5%	109	0.46
91-084	4176-206m	56	14.8	33	6.5	14.8	125	69	55.3%	104	0.44
91-086	4206-236m	41	8.7	4.7	2.1	3.6	60	19.1	31.8%	52	0.58
91-087	4236-266m	44	15.1	46	10.1	24	139	95	68.5%	188	0.42
91-088	4266-296m	46	7.4	4.6	1.2	4.3	63	17.5	27.8%	18.4	0.28
91-089	4296-326m	54	18.2	50	8.2	19.0	149	95	64.0%	82.0	0.43

**TABLE 1B**  
**CONCENTRATION (VOL. PPM OF ROCK) OF C<sub>1</sub> - C<sub>7</sub> HYDROCARBONS IN CUTTINGS GAS**

GEOCHEM SAMPLE NUMBER	DEPTH	C <sub>1</sub> Methane	C <sub>2</sub> Ethane	C <sub>3</sub> Propane	iC <sub>4</sub> Isobutane	nC <sub>4</sub> Butane	TOTAL C <sub>1</sub> - C <sub>4</sub>	TOTAL C <sub>2</sub> - C <sub>4</sub>	% GAS WETNESS	TOTAL C <sub>5</sub> - C <sub>7</sub>	$\frac{iC_4}{nC_4}$
91-090	4326-356m	34	14.1	35	6.5	13.1	103	69	66.7%	58	0.49
91-091	4356-386m	46	10.2	7.9	1.5	6.7	72	26	36.5%	16.8	0.22
91-092	4386-416m	33	18.2	66	11.7	28	157	124	78.9%	109	0.42
91-093	4416-446m	44	16.4	46	6.5	16.0	129	85	65.8%	62	0.41
91-094	4446-476m	53	16.4	45	8.1	19.0	141	88	62.8%	106	0.43
91-095	4476-506m	53	24	63	11.7	28	180	127	70.4%	106	0.42
91-096	4506-536m	36	14.6	25	3.6	8.5	88	52	58.7%	31	0.42
91-097	4536-566m	68	20	50	9.2	21	168	100	59.6%	86	0.44
91-098	4566-596m	27	5.6	2.5	0.6	1.4	37	10.1	27.3%	18.4	0.43
91-099	4596-T.D.	44	10.8	22	5.5	11.9	94	50	53.4%	83	0.46
91-100	4600 (Mud)	85	10.5	10.4	2.6	3.7	112	27	24.3%	19.1	0.70

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)
91-002	1839m	Mud Sample		
91-001	1836-66m	A 75% Shale, fissile to blocky very slightly calcareous, medium dark grey	N4	1.56
		B 24% Shale, fissile to blocky, slightly calcareous, minor cavings, light grey Minor quartz grains, sub- rounded, minor lost circulation material	N7	0.76
91-003	1866-96m	A 99% Shale, fissile to blocky non calcareous, olive grey Minor shale, greyish black Minor quartz, fine grained, subrounded and clear to frosty	5Y4/1 N2	0.50
91-004	1896-26m	99% Shale, fissile to blocky, non calcareous, dark grey Minor sandstone and caved shale, very light grey	N3 N8	0.40
91-005	1926-56m	99% Shale, thinly fissile to blocky, non calcareous, medium dark grey to dark greenish grey Minor sandstone, non calcareous, fine grained, very light grey	N4-5GY4/1 N8	0.46
91-006	1956-86m	99% Shale, thinly fissile to blocky, non calcareous, dark greenish grey Minor quartz grains, fine grained, subrounded and clear to frosty	5GY4/1	0.44
91-007	1986-2016m	99% Shale, thinly fissile to blocky, non calcareous, medium dark grey to dark greenish grey Minor quartz grains, fine grained, subrounded and clear to frosty Minor limestone	N4-5GY4/1	0.46

**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)
91-008	2016-46m	A 98% Shale, fissile, non calcareous, olive grey 2% Shale, fissile to blocky, non calcareous, minor caving, brownish grey Minor quartz grains, fine grained, subrounded Minor limestone	5Y4/1 5YR4/1	0.38, 0.40
91-009	2046-76m	A 98% Shale, fissile to blocky very slightly calcareous, medium grey B 1% Shale, fissile, non calcareous, dark grey Minor shale, fissile, non calcareous, brownish grey	N5 N3 5YR4/1	0.50
91-010	2076-106m	A 75% Shale, fissile to blocky, non calcareous, minor caving, dark grey B 22% Shale, fissile to blocky, calcareous, medium light grey 3% Limestone-chalky, very light grey Minor fine quartz grains	N3 N6 N8	0.30, 0.33 0.34
91-011	2100m	Mud Sample		
91-012	2106-136m	A 99% Shale, finely fissile, calcareous, minor cavings, medium grey Minor shale, brownish grey	N5 5YR4/1	0.32
91-013	2136-166m	A 80% Shale, finely fissile, non calcareous, minor caving dark grey B 19% Shale, fissile, calcareous minor cavings, medium grey Minor fine quartz grains, subrounded	N3 N5	0.44 0.64
91-014	2166-196m	A 99% Shale, thinly fissile, calcareous, olive grey Minor fine quartz grains, subrounded Minor limestone	5Y4/1	0.58

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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)
91-015	2196-226m A	99% Shale, fissile to blocky, calcareous, olive grey Minor fine quartz grains, subrounded	5Y4/1	0.64
91-016	2226-256m A	99% Shale, thinly fissile, calcareous, minor cavings, olive grey Minor fine quartz grains, subrounded, clear to opaque	5Y4/1	0.68
91-017	2256-286m A	99% Shale, thinly fissile, slightly calcareous, minor cavings, medium grey Minor shale, brownish grey Minor fine quartz grains, subrounded	N5 5YR4/1	0.82
91-018	2286-316m A	95% Shale, thinly fissile, calcareous, minor cavings, medium grey 5% Shale, fissile, non calcareous, moderate brown Minor limestone	N5 5YR3/4	0.46
91-019	2316-346m A	95% Shale, fissile, non calcareous, minor cavings, medium dark grey 4% Shale, thinly fissile, calcareous, moderate brown Minor quartz grains, fine grained, subrounded	N4 5YR3/4	0.88
91-020	2346-376m A	95% Shale, thinly fissile, non calcareous, medium dark grey 4% Shale, thinly fissile, non calcareous, moderate brown Minor quartz grains, fine grained, sub-rounded	N4 5YR3/4	0.30
91-021	2376-406m A	98% Shale, fissile, non calcareous, minor cavings, medium dark grey 1% Shale, thinly fissile, calcareous, moderate brown Minor lost circulation material	N4 5YR3/4	0.52

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)
91-022	2406-436m A	98% Shale, fissile, non calcareous, minor cavings, greyish black 1% Shale, moderate brown Minor fine quartz grains, subrounded	N2  5YR3/4	0.68, 0.70
91-023	2436-466m A	95% Shale, fissile, non calcareous, minor cavings, medium dark grey 4% Shale, fissile to blocky, slightly calcareous, brownish grey Minor sandstone Minor limestone	N4  5YR4/1	0.74
91-024	2466-496m A	95% Shale, finely fissile, non calcareous, medium dark grey 4% Shale, fissile to blocky, slightly calcareous, brownish grey Minor sandstone and minor limestone	N4  5YR4/1	0.68
91-025	2496-526m A	95% Shale, thinly fissile, non calcareous, minor cavings, medium dark grey 4% Shale, fissile, non calcareous, moderate brown Minor limestone and minor sandstone	N4  5YR3/4	0.68
91-026	2526-556m A	96% Shale, fissile, non calcareous, minor cavings, medium dark grey 3% Shale, fissile, calcareous moderate brown Minor limestone and minor sandstone	N4  5YR3/4	0.86
91-027	2556-586m A	95% Shale, fissile to blocky, non calcareous, minor cavings, medium dark grey 4% Shale, fissile to blocky, slightly calcareous, moderate yellowish brown Minor shale, moderate brown Minor sandstone	N4  10YR5/4  5YR3/4	0.90

**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)
91-028	2586-616m	A 92% Shale, fissile, non calcareous, medium dark grey 5% Shale, fissile to blocky, non calcareous, dark yellowish brown 3% Lost circulation material Minor shale, moderate brown Minor sandstone	N4 10YR4/2 5YR3/4	0.80
91-029	2616-631m	A 95% Shale, fissile, non calcareous, medium dark grey 3% Shale, blocky, non calcareous, dark yellowish brown 2% Lost circulation material Minor shale, moderate brown	N4 10YR4/2 5YR3/4	0.82, 0.82
91-030	2631m	Mud Sample		
91-031	2631-646m	A 99% Shale, fissile, slightly calcareous, medium dark grey Minor shale, dark yellowish brown	N4 10R4/2	0.48
91-032	2646-676m	A 98% Sandstone, fine grained, no fluorescence B 2% Shale, fissile, slightly calcareous, medium dark grey Minor shale, greyish red	N4 10R4/2	0.86
91-033	2676-706m	A 95% Sandstone, fine grained, no fluorescence B 4% Shale, fissile, non calcareous, medium dark grey Minor shale	N4 5YR2/1	2.04
91-034	2706-736m	A 98% Shale, fissile, non calcareous, minor cavings, brownish black B 2% Shale, fissile, non calcareous, minor cavings, medium dark grey Minor sandstone, fine grained Minor limestone	5YR2/1 N4	2.38

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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)
91-035	2736-766m	A 98% Shale, fissile non calcareous, dark grey 1% Shale, fissile, non calcareous, Minor sandstone, fine grained	N3  5YR4/1	2.87, 2.90
91-036	2766-796m	A 98% Shale, fissile, non calcareous, some minor cavings, dark grey B 1% Shale, fissile, non calcareous, brownish grey Minor sandstone, fine grained Minor limestone	N3  5YR4/1	2.80
91-037	2796-826m	A 98% Shale, as 91-036A B 1% Shale, fissile, non calcareous, dusky yellowish brown C 1% Shale, fissile, calcareous medium grey	N3 10YR2/2 N5	2.64
91-038	2826-856m	A 98% Shale, as 91-036A 1% Shale, as 91-037A Minor shale, medium grey	N3 10YR2/2 N5	2.00
91-039	2856-886m	A 99% Shale, as 91-036A B Minor shale, as 91-037B C Minor shale, as 91-037C Minor quartz grains, fine grained, subrounded Minor limestone	N3	2.30
91-040	2886-916m	A 99% Shale, as 91-036A B Minor shale, blocky, calcareous, dark yellowish brown C Minor shale, as 91-037C Minor limestone Minor quartz grains, fine grained, subrounded	N3 10YR4/2	1.56
91-041	2916-946m	A 99% Shale, as 91-036A B Minor shale, fissile to blocky, non calcareous, brownish grey C Minor shale, fissile, non calcareous, dark greenish grey Minor quartz grains, fine grained, subrounded	N3 5YR4/1 5GY4/1	2.06

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)
91-042	2946-976m	A 68% Shale, fissile, non calcareous, dark grey	N3	2.68
		B 32% Quartz grains, fine grained subrounded, no fluorescence, very light grey Minor shale, fissile, non calcareous, moderate reddish brown Minor mineralisation	N8 10R4/6	
91-043	2976-006m	A 90% Sandstone quartz grains, fine grained, subrounded, clear to opaque, no fluorescence, very light grey	N8	5.18
		B 10% Shale, fissile to blocky non calcareous, medium dark grey Minor shale, dark greenish grey	N4 5G4/1	
91-044	3006-36m	A 75% Sandstone quartz grains, fine grained, subrounded, clear to opaque, no fluorescence, very light grey	N8	48.03
		B 10% Coal, vitreous, minor cavings, black	N1	
		C 10% Shale, fissile, non calcareous, dark grey Minor shale, fissile, non calcareous, dark greenish grey to medium dark grey	N3 5GY4/1-N4	
91-045	3036-66m	A 75% Shale, fissile, non calcareous, dark grey	N3	3.82
		B 15% Shale, fissile, non calcareous, brownish grey	5YR4/1	3.98
		C 10% Sandstone, quartz grains, fine grained, subrounded, clear to opaque, no fluorescence, very light grey Minor mineralization	N8	

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**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)
91-046	3066-96m	A 60% Sandstone quartz grains, fine grained, subrounded, clear to opaque, no fluorescence, very light grey	N8	
		B 38% Shale, fissile; non calcareous, dark grey	N3	6.00
		C 2% Coal, vitreous, argillaceous		8.34
91-047	3096-124m	A 50% Sandstone quartz grains, fine grained, subrounded, clear to opaque, very slight green fluorescence, very light grey	N8	
		B 44% Shale, fissile, non calcareous, medium dark grey	N4	3.12, 3.10
		C 1% Coal, vitreous, black Minor mineralisation	N1	
91-048	3126-156m	A 80% Shale, fissile, non calcareous, greyish black to dark grey	N2-N3	3.16
		B 20% Sandstone, as 91-046A but no fluorescence Minor shale, fissile, non calcareous, dark greenish grey Minor shale, fissile, non calcareous, moderate reddish brown	N8 5G4/1 10R4/6	
91-049	3156-186m	A 86% Shale, fissile, non calcareous, minor cavings, dark grey to medium dark grey	N3-N4	
		12% Sandstone, as 91-046A but no fluorescence	N8	
		2% Coal, vitreous		
91-050	3186-216m	A 90% Shale, fissile, non calcareous, medium dark grey to dark grey	N4-N3	2.60
		9% Sandstone, as 91-046A		
		1% Carbonaceous shale, fissile non calcareous, greyish black Minor mineralisation	N2	
91-051	3216-246m	A 60% Sandstone, as 91-046A	N8	
		B 39% Shale, fissile, non calcareous, dark grey	N3	3.92, 3.90

3217

*Spill  
fm*

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)
91-051	3216-246m	Minor shale, fissile, non calcareous, moderate reddish brown Minor coal, vitreous, black	10R4/6 N1	
<i>3243 Rennoch Fm</i>				
91-052	3246-276m	A 60% Sandstone, quartz grains, fine grained, subrounded, clear to opaque, no fluorescence, very light grey B 39% Shale, fissile, non calcareous, medium dark grey Minor shale, fissile, non calcareous, moderate reddish brown	N8 N4 10R4/6	2.34
91-053	3276-306m	A 45% Sandstone quartz grains, as 91-052A B 51% Shale, fissile, non calcareous, dark grey C 4% Shale, fissile, non calcareous, greyish red Minor lost circulation material Minor coal, vitreous and minor cavings	N8 N3 10R4/2	2.94
<i>3285 Drake Fm</i>				
91-054	3306-336m	A 96% Shale, fissile, non calcareous, dark grey 4% Shale, fissile to blocky, non calcareous, brownish grey Minor shale, fissile, non calcareous, moderate reddish brown Minor lost circulation material Minor quartz, fine grained, subrounded	N3 5YR4/1 10R4/6	3.54
91-055	3336-366m	A 98% Shale, fissile to blocky, non calcareous, greyish black 2% Shale, fissile, non calcareous, minor cavings, medium dark grey Minor sandstone	N2 N4	2.12

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)
91-056	3366-396m A	99% Shale, fissile to blocky, non calcareous, minor cavings, greyish black to medium dark grey Minor shale, fissile, non calcareous, moderate reddish brown Minor sandstone	N2-N4  10R4/6	1.44, 1.48
91-057	3396-426m A	96% Shale, thinly fissile, non calcareous, greyish black 4% Sandstone, quartz grains, fine grained, subrounded clear to opaque, very light grey Minor shale, fissile, non calcareous, moderate reddish brown	N2  N8  10R4/6	1.64
91-058	3426-456m A	99% Shale, finely fissile, non calcareous, dark grey Minor shale, fissile, non calcareous, moderate reddish brown Minor sandstone, fine grained slightly calcareous	N3  10R4/6	1.62
91-059	3456-486m A	99% Shale, as 91-058A some minor cavings Minor shale, as 91-058 Minor sandstone, as 91-058	N3  10R4/6	1.48
91-060	3486-516m A	99% Shale, thinly fissile, non calcareous, dark grey Minor sandstone, fine grained, slightly calcareous	N3	1.52
91-061	3516-546m A	98% Shale, finely fissile, non calcareous, minor cavings, dark grey to medium dark grey 2% Shale, finely fissile, non calcareous, medium grey Minor sandstone Minor limestone Minor lost circulation material	N3-N4  N5	2.06, 2.06

*Ceolc*  
3397  
*fm*

— 3521  
*Burton*  
*fm*

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)
91-062	3546-576m A	99% Shale, thinly fissile, non calcareous, minor cavings, dark grey to medium dark grey	N3-N4	2.20
		Minor shale, fissile, non calcareous, moderate reddish brown	10R4/6	
91-063	3576-606m A	99% Shale, as 91-062A Minor Shale, as 91-062 Minor limestone	N3-N4 10R4/6	1.66
91-064	3606-636m A	99% Shale, as 91-062A Minor shale, as 91-062	N3-N4 10R4/6	1.18
91-065	3636-666m A	99% Shale, as 91-062A Minor shale, as 91-062 Minor shale, fissile, slightly calcareous, medium grey Minor quartz grain, fine grained	N3-N4 10R4/6 N5	1.38
91-066	3666-696m A	99% Shale, as 91-062A Minor shale, as 91-062	N3-N4 10R4/6	2.00, 1.99
91-067	3696-726m A	65% Sandstone, quartz grains, slightly calcareous, sub rounded, clear to opaque, no fluorescence, very light grey	N8	
		B 35% Shale, thinly fissile, non calcareous, brownish grey	5YR4/1	2.66, 2.68
91-068	3726-756m A	90% Sandstone, fine grained, very slightly calcareous, no fluorescence, very light grey	N8	
		B 10% Shale, thinly fissile, non calcareous, greyish black	N2	2.26
91-069	3756-786m A	80% Sandstone, fine grained, non calcareous, no fluorescence, very light grey	N8	
		B 20% Shale, thinly fissile, non calcareous, greyish black	N2	10.69

3566  
Amundsen  
Fm.

3721  
Staff  
Fm.

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)
91-070	3786-816m	A 85% Sandstone, fine grained non calcareous, no fluorescence, very light grey	N8	3.30
		B 15% Shale, thinly fissile, non calcareous, greyish black	N2	
91-071	3816-846m	A 80% Sandstone, fine grained, non calcareous, no fluorescence, very light grey	N8	4.88
		B 20% Shale, thinly fissile, non calcareous, dark grey	N3	
91-073	3846-876m	A 95% Sandstone, fine grained, non calcareous, no fluorescence, very light grey	N8	2.17
		B 5% Shale, thinly fissile, non calcareous, dark grey	N3	
91-074	3876-906m	A 65% Sandstone, fine grained, non calcareous, no fluorescence, very light grey	N8	8.33, 8.33
		B 35% Shale, thinly fissile, non calcareous, brownish black	5YR2/1	
91-075	3906-936m	A 80% Shale, thinly fissile, non calcareous, greyish black	N2	2.21
		B 20% Sandstone, fine grained, non calcareous, no fluorescence, very light grey	N8	
91-076	3936-966m	A 80% Sandstone, fine grained, non calcareous, no fluorescence, very light grey	N8	1.06
		B 20% Shale, thinly fissile, non calcareous, brownish black	5YR2/1	
91-077	3966-999m	A 80% Sandstone, subangular, fine grained, non calcareous, no fluorescence, very light grey	N8	1.13
		B 20% Shale, thinly fissile, non calcareous, brownish black Minor lost circulation material	5YR2/1	

**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)
91-078	3996-026m	A 95% Sandstone, subangular, fine grained, non calcareous, no fluorescence, very light grey	N8	
4031 <del>HEGAE</del> Gr		B 5% Shale, thinly fissile, non calcareous, brownish black Minor lost circulation material and caved material	5YR2/1	2.89, 2.90
91-079	4026-056m	A 80% Shale, thinly fissile, non calcareous, brownish grey	5YR4/1	0.62
	B 20% Sandstone, subangular, fine grained, non calcareous, no fluorescence, very light grey Minor lost circulation material and minor shale, medium bluish grey	N8    5B5/1		
91-080	4056-086m	A 90% Sandstone, subangular, fine grained, non calcareous no fluorescence, very light grey	N8	
	B 10% Shale, thinly fissile, non calcareous, dark grey Minor lost circulation material	N3	0.68	
91-081	4086-116m	A 60% Shale, thinly fissile, non calcareous, brownish black	5YR2/1	1.38
	B 40% Sandstone, subangular, fine grained, non calcareous, no fluorescence, very light grey Minor lost circulation material	N8		
91-082	4116-146m	A 70% Shale, fissile to blocky non calcareous, minor cavings, medium dark grey	N4	0.60, 0.62
	B 28% Sandstone, quartz grains fine grained, non calcareous subrounded, clear to opaque, very light grey	N8		



**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)	
91-085	4143m	Mud Sample			
91-083	4146-176m	A 70% Shale, fissile to blocky, non calcareous, dark grey	N3	0.84,0.82	
		B 29% Sandstone, quartz grains fine grained, non calcareous subrounded, clear to opaque, very light grey	N8		
		Minor shale, fissile, non calcareous, dark greenish grey	5GY4/1		
		Minor shale, fissile, non calcareous, dark grey	N3		
91-084	4176-206m	A 78% Shale, fissile, to blocky slightly calcareous, greyish black	N2	0.32,0.32	
		B 20% Shale, fissile, non calcareous, dusky red	10R3/2		0.08
		2% Sandstone, quartz grains fine grained, non calcareous, subrounded, clear to opaque, very light grey,	N8		
91-086	4206-236m	A 70% Shale, fissile, non calcareous, dark grey	N3	0.64,0.64	
		15% Shale, fissile, slightly calcareous, brownish grey	5YR4/1		0.14
		5% Shale, fissile, non calcareous, dark greenish grey	5GY4/1		
		10% Sandstone, quartz grains, subrounded, very slightly calcareous, clear to opaque			
91-087	4236-266m	A 70% Shale, fissile, non calcareous, medium dark grey	N4	1.06	
		B 28% Shale, fissile, non calcareous, brownish grey	5YR4/1		
		1% Sandstone, as 91-086 Minor limestone			
91-088	4266-296m	A 70% Shale, fissile, non calcareous, dark reddish brown	10R3/4	0.14	
		B 29% Shale, fissile, non calcareous, dark grey Minor sandstone, as 91-086 Minor lost circulation material	N3		2.32

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)
91-089	4296-326m	A 69% Shale, fissile, slightly calcareous, dark reddish brown 3% Shale, fissile, non calcareous, dark greenish grey Minor limestone	10R3/4 5G4/1	0.04
91-090	4326-356m	A 98% Shale, fissile, very slightly calcareous, dark reddish brown 2% Shale fissile, non calcareous, dark greenish grey Minor sandstone, quartz grains, fine grained, non calcareous, subrounded, clear to opaque, very light grey	10R3/4 5GY4/1 N8	0.26
91-091	4356-386m	A 50% Shale, fissile, non calcareous, dark reddish brown B 47% Shale, fissile, non calcareous, dark grey 2% Sandstone, as 91-090	10R3/4 N3 N8	0.20 1.20
91-092	4386-416m	A 83% Shale, fissile to blocky very slight calcareous, minor cavings 5% Sandstone, as 91-091 B 12% Shale, fissile, non calcareous, medium dark grey and olive grey Minor limestone	10R3/4 N8 N4+5G4/1	0.42, 0.42
91-093	4416-446m	A 80% Shale, fissile to blocky non calcareous, dark reddish brown 17% Shale, fissile to blocky, non calcareous, dark grey 2% Sandstone, as 91-090	10R3/4 N3 N8	0.10
91-094	4446-476m	A 87% Shale, fissile, non calcareous, minor cavings, dark reddish brown 1% Sandstone, as 91-090 11% Shale, fissile, non calcareous, medium dark grey Minor limestone, minor lost circulation material	10R3/4 N8 N4	0.28

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)
91-095	4476-506m	A 50% Shale, fissile, non calcareous, dark reddish brown	10R3/4	0.12
		B 49% Shale, fissile, non calcareous, dark greenish grey	5GY4/1	
		1% Sandstone, quartz grains, fine grained, non calcareous, subrounded, clear to opaque, very light grey	N8	
91-096	4506-536m	A 64% Shale, fissile to blocky slightly calcareous, dark reddish brown	10R3/4	1.46, 1.46
		15% Sandstone, as 91-095	N8	
		20% Shale, fissile, non calcareous, dark grey Minor limestone Minor shale, greenish grey	N3 5G6/1	
91-097	4536-566m	A 60% Sandstone, as 91-095 pink staining	N8	1.48
		B 36% Shale, fissile to blocky non calcareous, greenish black	5G2/1	
		2% Shale, fissile, non calcareous, dark reddish brown 1% Lost circulation material Minor limestone	10R3/4	
91-098	4566-596m	A 75% Sandstone, as 91-095	N8	0.24
		B 12% Shale, fissile to blocky, non calcareous, dark reddish brown	10R3/4	
		12% Shale, fissile, non calcareous, greenish black Minor lost circulation material Minor limestone	5G2/1	
91-099	4596-T.D.	A 95% Sandstone, as 91-095	N8	
		3% Shale, fissile to blocky slightly calcareous, dark reddish brown	10R3/4	
		1% Shale, fissile, non calcareous, dark grey	N3	

TABLE 3  
VISUAL KEROGEN DATA

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION			THERMAL MATURATION INDEX
		TYPES	REMARKS	PARTICLE SIZE	
91-003	1866-96m	W-C;-;H	Mineral matter		1+ to 2-
91-010	2076-106m	C-W;H;-	Mineral matter. Some reworked material		1+ to 2-
91-018	2286-316m	C-W;H;-	Some H at 1+ to 2-		2-
91-025	2496-526m	C-W;-;H			2-
91-033	2676-706m	Am;-;H-W			2- to 2
91-035	2736-766m	Am-H*;W-S;-	* passing to Am		2- to 2
91-037	2796-826m	Am-H*;W;-	* passing to Am		2- to 2
91-039	2856-886m	Am-H*;W-S;-	* passing to Am		2- to 2
91-041	2916-946m	H*-Am;W-S;-	* passing to Am		2- to 2
91-045	3036-066m	H*-W;Am;S	* passing to Am. Fresher H also present		2- to 2
91-047	3096-124m	Am-H-C-W;S;-	Some H at 2-		2- to 2
91-053	3276-306m	Am-H-W;S;-	Almost 2		2- to 2
91-055	3336-366m	W;H*-Am;S	* passing to Am		2- to 2
91-060	3486-516m	H-W;Am*-S-C;-	Abundant H at 2-. *developing from H		2- to 2
91-061	3516-546m	W-H;C-S;Am*	* developing from H		2
91-066	3666-696m	C-W-H;-;S	Am starting to develop from H		2
91-075	3906-936m	W-H;C-Am*;S	* developing from H. Almost 2 to 2+ but fresher H also present		2
91-079	4026-056m	W;C-H;S	almost 2 to 2+. Abundant caved H present.		2

TABLE 3  
VISUAL KEROGEN DATA

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION			THERMAL MATURATION INDEX
		TYPES	REMARKS	PARTICLE SIZE	
91-081	4086-116m	W-H;S-Am*;-	* developing from H		2 to 2+
91-084A	4176-206m	W-H;-;S			2 to 2+
91-084B	4176-206m	W-H;-;-	organic matter sparse. Some H at 2+		2 to 2+
91-087A	4236-266m	W-H;-;-	Some H at 2+ but fresher H also present		2 to 2+
91-087B	4236-266m	W;C-H;-	Fresher H also present		2 to 2+
91-090A	4326-356m	W;C;H	organic matter sparse		2+
91-092A	4386-416m	W-C;H;-	organic matter sparse		2+
91-092B	4386-416m	W-H;-;S	Some H at 2 to 2+		2+
91-095A	4476-506m	W-H;C-S;-	Caved material present		2+
91-095B	4476-506m	H-W;S;Am	Abundant cavings		2+ (?)
91-097B	4536-566m	W;H-S;Am	Dominantly caved		2+

**TABLE 4A**  
**WEIGHT (GRAMMES) OF C<sub>15</sub>+ EXTRACTS AND CHROMATOGRAPHIC FRACTIONS**

GEOCHEM SAMPLE NUMBER	INTERVAL	ROCK EXTRACTED	TOTAL EXTRACT OBTAINED	TOTAL EXTRACT		nC <sub>5</sub> SOLUBLE FRACTION				
				Precipd. Asphaltenes	nC <sub>5</sub> soluble	Paraffin – Naphthenes	Aromatics	Eluted NSO's	Non-eluted NSO's	Sulphur
91-003	1866-096m	78.6933	0.0406	0.0172	0.0234	0.0151	0.0040	0.0043	-	-
91-012	2106-136m	59.2459	0.0228	0.0110	0.0118	0.0057	0.0023	0.0038	-	-
91-018	2286-316m	85.7571	0.0519	0.0196	0.0323	0.0158	0.0099	0.0066	-	-
91-025	2496-526m	81.8840	0.0467	0.0134	0.0333	0.0164	0.0084	0.0083	-	-
91-032	2646-676m	15.0862	0.0170	0.0066	0.0104	0.0051	0.0023	0.0030	-	-
91-035	2736-766m	72.9395	0.0703	0.0350	0.0353	0.0125	0.0171	0.0057	-	-
91-037	2796-826m	58.0622	0.0931	0.0573	0.0358	0.0143	0.0128	0.0088	-	-
91-041	2916-946m	43.1932	0.0397	0.0264	0.0133	0.0055	0.0042	0.0034	-	-
91-043	2976-006m	22.4799	0.0683	0.0376	0.0307	0.0062	0.0117	0.0128	-	-
91-046	3066-096m	3.9932	0.0509	0.0272	0.0237	0.0085	0.0068	0.0085	-	-
91-047	3096-124m	12.0406	0.0852	0.0407	0.0445	0.0098	0.0168	0.0178	-	-
91-051	3216-246m	30.7834	0.1647	0.0862	0.0785	0.0194	0.0300	0.0291	-	-
91-052	3246-276m	25.1775	0.0195	0.0133	0.0062	0.0020	0.0017	0.0023	0.0002	-
91-055	3336-366m	72.3980	0.0636	0.0326	0.0310	0.0221	0.0022	0.0067	-	-
91-060	3486-516m	91.1002	0.0639	0.0262	0.0377	0.0178	0.0092	0.0107	-	-
91-066	3666-696m	57.8564	0.0419	0.0207	0.0212	0.0092	0.0057	0.0063	-	-
91-068	3726-756m	86.1501	0.0403	0.0190	0.0213	0.0099	0.0091	0.0023	-	-
91-069	3756-786m	96.8263	0.1603	0.0836	0.0767	0.0480	0.0170	0.0112	-	-
91-071	3816-846m	75.9442	0.0640	0.0286	0.0354	0.0193	0.0049	0.0112	-	-
91-073	3846-876m	104.9189	0.0409	0.0180	0.0229	0.0111	0.0080	0.0034	0.0004	-
91-074	3876-906m	87.1344	0.0991	0.0451	0.0540	0.0226	0.0243	0.0071	-	-
91-076	3936-966m	67.6635	0.0387	0.0331	0.0056	0.0027	0.0014	0.0015	-	-

TABLE 4A  
WEIGHT (GRAMMES) OF C<sub>15</sub>+ EXTRACTS AND CHROMATOGRAPHIC FRACTIONS

GEOCHEM SAMPLE NUMBER	INTERVAL	ROCK EXTRACTED	TOTAL EXTRACT OBTAINED	TOTAL EXTRACT		nC <sub>5</sub> SOLUBLE FRACTION				
				Precipitd. Asphaltenes	nC <sub>5</sub> soluble	Paraffin - Naphthenes	Aromatics	Eluted NSO's	Non-eluted NSO's	Sulphur
91-077	3966-996m	81.1875	0.0222	0.0159	0.0063	0.0022	0.0016	0.0025	-	-
91-078	3996-026m	82.9096	0.0302	0.0181	0.0121	0.0068	0.0023	0.0030	-	-
91-080	4056-086m	120.0099	0.0249	0.0166	0.0083	0.0040	0.0035	0.0008	-	-
91-081	4086-116m	85.5537	0.0344	0.0202	0.0142	0.0058	0.0049	0.0029	0.0006	-
91-084	4176-206m	76.7714	0.0264	0.0137	0.0127	0.0082	0.0016	0.0033	-	-
91-087	4236-266m	61.8891	0.0304	0.0151	0.0153	0.0086	0.0034	0.0033	-	-
91-090	4326-356m	72.4768	0.0231	0.0116	0.0115	0.0048	0.0036	0.0027	0.0004	-
91-092	4386-416m	62.0851	0.0347	0.0202	0.0145	0.0056	0.0056	0.0032	-	-
91-095	4476-506m	61.8937	0.0385	0.0222	0.0163	0.0080	0.0054	0.0029	-	-
91-097	4536-566m	10.9730	0.0116	0.0065	0.0051	0.0022	0.0016	0.0013	-	-
91-099	4596-T.D.	77.8426	0.0324	0.0178	0.0146	0.0071	0.0032	0.0038	-	-
<u>Mud Samples</u>										
91-011	2100m	85.3639	0.0774	0.0265	0.0509	0.0176	0.0182	0.0151	-	-
91-030	2631m	109.4443	0.8913	0.0568	0.8345	0.6753	0.1115	0.0478	-	-
91-072	3832m	118.9786	0.5190	0.0401	0.4789	0.3886	0.0463	0.0439	-	-
91-085	4143m	78.4297	1.9190	0.1239	1.7951	1.3846	0.1088	0.3016	-	-
91-100	4600m	55.5081	0.2806	0.0362	0.2444	0.1764	0.0570	0.0112	-	-

TABLE 4B  
CONCENTRATION (PPM) OF EXTRACTED C<sub>15+</sub> MATERIAL IN ROCK

GEOCHEM SAMPLE NUMBER	INTERVAL	TOTAL EXTRACT	HYDROCARBONS			NON HYDROCARBONS				
			Paraffin - Naphthenes	Aromatics	TOTAL	Precipitd. Asphaltenes	Eluted NSO's	Non-eluted NSO's	Sulphur	TOTAL
91-003	1866-096m	515	192	51	243	219	54	-	-	273
91-012	2106-136m	385	96	39	135	186	64	-	-	250
91-018	2286-316m	606	184	116	300	229	77	-	-	306
91-025	2496-526m	570	201	103	304	163	103	-	-	266
91-032	2646-676m	1127	338	152	490	437	199	-	-	636
91-035	2736-766m	480	172	234	406	480	78	-	-	558
91-037	2796-826m	1603	246	220	466	986	152	-	-	1138
91-041	2916-946m	533	127	97	224	611	79	-	-	690
91-043	2976-006m	3038	276	520	796	1673	568	-	-	2241
91-046	3066-096m	12747	2128	1714	3842	6812	2128	-	-	8940
91-047	3096-124m	7076	816	1399	2215	3380	1477	-	-	4857
91-051	3216-246m	5350	630	975	1605	2800	946	-	-	3746
91-052	3246-276m	775	79	68	147	529	91	8	-	628
91-055	3336-366m	878	305	31	336	450	93	-	-	543
91-060	3486-516m	701	196	101	297	287	117	-	-	404
91-066	3666-696m	724	159	99	258	358	108	-	-	466
91-068	3726-756m	468	116	106	222	221	26	-	-	247
91-069	3756-786m	1656	499	176	675	863	116	-	-	979
91-071	3816-846m	842	254	65	319	377	147	-	-	524
91-073	3846-876m	390	106	76	182	172	32	4	-	208
91-074	3876-906m	1137	260	279	539	517	81	-	-	593
91-076	3936-966m	572	39	21	60	489	22	-	-	511



TABLE 4B  
CONCENTRATION (PPM) OF EXTRACTED C<sub>15</sub>+ 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
91-077	3966-996m	274	27	20	47	196	31	-	-	227
91-078	3996-026m	364	82	28	110	219	36	-	-	255
91-080	4056-086m	207	33	29	62	138	7	-	-	145
91-081	4086-116m	402	68	57	125	236	34	7	-	277
91-084	4176-206m	344	107	21	128	179	43	-	-	222
91-087	4236-266m	491	140	55	195	244	53	-	-	297
91-090	4326-356m	319	66	50	116	160	37	6	-	203
91-092	4386-416m	559	91	91	182	325	52	-	-	377
91-095	4476-506m	622	129	88	217	359	47	-	-	406
91-097	4536-566m	1056	200	146	346	592	118	-	-	710
91-099	4596-T.D.	416	91	41	132	229	49	-	-	278
<u>Mud Samples</u>										
91-011	2100m	907	206	212	418	311	177	-	-	488
91-030	2631m	8144	6170	1019	7189	519	437	-	-	956
91-072	3832m	4362	3266	389	3655	337	369	-	-	706
91-085	4143m	24468	17654	1387	19041	1580	3846	-	-	5426
91-100	4600m	5055	2177	1027	4204	652	201	-	-	853

TABLE 4C  
COMPOSITION (NORMALISED %) OF C<sub>15+</sub> MATERIAL EXTRACTED FROM ROCK

GEOCHEM SAMPLE NUMBER	INTERVAL	HYDROCARBONS			NON HYDROCARBONS					HC NON HC
		Paraffin – Naphthenes	Aromatics	$\frac{P-N}{AROM}$	Preciptd. Asphaltenes	Eluted NSO's	Non eluted NSO's	Sulphur	$\frac{ASPH}{NSO}$	
91-003	1866-096m	37.21	9.88	3.76	42.44	10.47	-	-	4.06	0.89
91-012	2106-136m	24.94	10.13	2.46	48.31	16.62	-	-	2.91	0.54
91-018	2286-316m	30.36	19.14	1.59	37.79	12.71	-	-	2.97	0.98
91-025	2496-526m	35.26	18.07	1.95	28.60	18.07	-	-	1.58	1.14
91-032	2646-676m	30.02	13.50	2.22	38.81	17.67	-	-	2.20	0.77
91-035	2736-766m	17.84	24.27	0.74	49.79	8.09	-	-	6.15	0.73
91-037	2796-826m	15.33	13.72	1.12	61.47	9.48	-	-	6.49	0.41
91-041	2916-946m	13.89	10.61	1.31	66.85	8.64	-	-	7.73	0.32
91-043	2976-006m	9.09	17.12	0.53	55.08	18.70	-	-	2.95	0.36
91-046	3066-096m	16.65	13.41	1.24	53.29	16.65	-	-	3.20	0.43
91-047	3096-124m	11.54	19.78	0.58	47.79	20.89	-	-	2.29	0.47
91-051	3216-246m	11.77	18.22	0.65	52.33	17.68	-	-	2.96	0.43
91-052	3246-276m	10.19	8.77	1.16	68.26	11.74	1.03	-	5.81	0.23
91-055	3336-366m	34.69	3.53	9.84	51.19	10.58	-	-	4.84	0.62
91-060	3486-516m	27.96	14.41	1.94	40.94	16.69	-	-	2.45	0.74
91-066	3666-696m	21.96	13.67	1.61	49.45	14.92	-	-	3.31	0.55
91-068	3726-756m	24.73	22.60	1.09	47.12	5.54	-	-	8.50	0.90
91-069	3756-786m	30.17	10.64	2.83	52.18	7.01	-	-	7.44	0.69
91-071	3816-846m	30.13	7.71	3.91	44.72	17.44	-	-	2.56	0.61
91-073	3846-876m	27.18	19.49	1.39	44.10	8.21	1.03	-	5.38	0.88
91-074	3876-906m	22.87	24.54	0.93	45.47	7.12	-	-	6.38	0.90
91-076	3936-966m	6.83	3.68	1.86	85.64	3.85	-	-	22.23	0.12

**TABLE 4C**  
**COMPOSITION (NORMALISED %) OF C<sub>15+</sub> MATERIAL EXTRACTED FROM ROCK**

GEOCHEM SAMPLE NUMBER	INTERVAL	HYDROCARBONS			NON HYDROCARBONS					HC NON HC
		Paraffin – Naphthenes	Aromatics	P – N AROM	Precipd. Asphaltenes	Eluted NSO's	Non eluted NSO's	Sulphur	ASPH NSO	
91-077	3966-996m	9.85	7.30	1.35	71.53	11.31	-	-	6.32	0.21
91-078	3996-026m	22.47	7.67	2.93	60.00	9.86	-	-	6.08	0.43
91-080	4056-086m	15.94	14.01	1.14	66.67	3.38	-	-	19.71	0.43
91-081	4086-116m	16.92	14.18	1.19	58.71	8.46	1.74	-	6.94	0.45
91-084	4176-206m	30.57	6.00	5.10	51.14	12.29	-	-	4.16	0.58
91-087	4236-266m	28.46	11.18	2.55	49.59	10.77	-	-	4.60	0.66
91-090	4326-356m	20.69	15.67	1.32	50.16	11.60	1.88	-	4.32	0.57
91-092	4386-416m	16.28	16.28	1.00	58.14	9.30	-	-	6.25	0.48
91-095	4476-506m	20.71	14.13	1.47	57.62	7.54	-	-	7.64	0.53
91-097	4536-566m	18.94	13.83	1.37	56.06	11.17	-	-	5.02	0.49
91-099	4596-T.D.	22.20	10.00	2.22	55.85	11.95	-	-	4.67	0.47
<u>Mud Samples</u>										
91-011	2100m	22.73	23.40	0.97	34.34	19.54	-	-	1.76	0.86
91-030	2631m	75.75	12.51	6.05	6.37	5.37	-	-	1.19	7.52
91-072	3832m	74.89	8.92	8.40	7.73	8.46	-	-	0.91	5.18
91-085	4143m	72.15	5.67	12.73	6.46	15.72	-	-	0.41	3.51
91-100	4600m	62.82	20.31	3.09	12.89	3.97	-	-	3.24	4.93

TABLE 5  
SIGNIFICANT RATIOS (%) OF C<sub>15+</sub> FRACTIONS AND ORGANIC CARBON

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC CARBON	<u>HYDROCARBONS</u> TOTAL EXTRACT	<u>HYDROCARBONS</u> ORGANIC CARBON	<u>TOTAL EXTRACT</u> ORGANIC CARBON
91-003	1866-896m	0.70	47.18	3.47	7.36
91-012	2106-136m	0.58	35.06	2.33	6.64
91-018	2286-316m	0.84	49.50	3.57	7.21
91-025	2496-526m	1.02	53.33	2.98	5.59
91-032	2646-676m	0.91	43.48	5.38	12.38
91-035	2736-766m	1.92	42.12	2.11	5.02
91-037	2796-826m	2.36	29.07	1.07	8.35
91-041	2916-946m	2.56	24.37	0.88	3.59
91-043	2976-3006m	2.56	26.20	3.10	11.87
91-046	3066-3096m	16.76	30.14	2.29	7.61
91-047	3096-124m	7.14	31.30	3.10	9.91
91-051	3216-246m	6.08	30.00	2.64	8.80
91-052	3246-276m	1.33	18.97	1.11	5.83
91-055	3336-366m	1.52	38.27	2.21	5.78
91-060	3486-516m	1.20	42.37	2.48	5.84
91-066	3666-696m	1.16	35.64	2.22	6.24
91-068	3726-756m	0.56	47.44	3.96	8.36
91-069	3756-786m	3.10	40.76	2.18	5.34
91-071	3816-846m	1.14	37.89	2.80	7.39
91-073	3846-876m	0.70	46.67	2.60	5.57
91-074	3876-906m	2.68	47.41	2.01	4.24

TABLE 5  
SIGNIFICANT RATIOS (%) OF C<sub>15+</sub> FRACTIONS AND ORGANIC CARBON

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC CARBON	<u>HYDROCARBONS</u> TOTAL EXTRACT	<u>HYDROCARBONS</u> ORGANIC CARBON	<u>TOTAL EXTRACT</u> ORGANIC CARBON
91-076	3936-966m	0.43	10.49	1.40	13.30
91-077	3966-996m	0.70	17.15	0.67	3.91
91-078	3996-026m	1.10	30.22	1.00	3.31
91-080	4056-086m	0.30	29.95	2.07	6.90
91-081	4086-116m	0.60	31.09	2.08	6.70
91-084	4176-206m	0.56	37.21	2.29	6.14
91-087	4236-266m	0.56	39.71	3.48	8.77
91-090	4326-356m	0.58	36.36	2.00	5.50
91-092	4386-416m	0.32	32.59	5.69	17.47
91-095	4476-506m	0.48	34.89	4.52	12.96
91-097	4536-566m	0.56	32.77	6.18	18.86
91-099	4596-T.D.	0.79	31.73	1.67	5.27
<u>Mud Samples</u>					
91-011	2100m	-	46.13	-	-
91-030	2631m	-	88.26	-	-
91-072	3832m	-	83.81	-	-
91-085	4143m	-	77.82	-	-
91-100	4600m	-	83.13	-	-

**TABLE 6**  
**COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN – NAPHTHENE HYDROCARBONS**

GEOCHEM SAMPLE NUMBER	91-003	91-012	91-018	91-025	91-032
DEPTH	1866-96m	2106-136m	2286-316m	2496-526m	2646-676m
SAMPLE TYPE	6122	6909	7500	8189	8681
nC <sub>15</sub>	15.9	19.7	17.8	15.3	12.7
nC <sub>16</sub>	16.3	21.3	17.9	17.0	18.8
nC <sub>17</sub>	16.0	18.6	16.1	17.0	18.9
nC <sub>18</sub>	13.3	12.5	13.7	13.7	13.9
nC <sub>19</sub>	9.4	6.5	8.8	9.8	8.4
nC <sub>20</sub>	8.1	5.4	7.6	8.2	7.2
nC <sub>21</sub>	6.5	3.8	5.3	6.3	5.3
nC <sub>22</sub>	5.3	3.9	4.4	4.7	4.9
nC <sub>23</sub>	3.6	2.6	2.9	3.0	3.6
nC <sub>24</sub>	1.8	1.5	1.5	1.6	1.9
nC <sub>25</sub>	1.1	1.2	1.1	0.9	1.4
nC <sub>26</sub>	0.6	0.4	0.5	0.5	0.6
nC <sub>27</sub>	1.0	0.6	0.6	0.6	0.6
nC <sub>28</sub>	0.1	0.3	0.2	0.3	0.2
nC <sub>29</sub>	0.1	0.4	0.6	0.3	0.2
nC <sub>30</sub>	0.1	0.4	0.2	0.5	0.2
nC <sub>31</sub>	0.1	0.3	0.1	0.2	0.3
nC <sub>32</sub>	0.1	0.1	0.1	0.2	0.3
nC <sub>33</sub>	0.1	0.1	0.1	0.1	0.2
nC <sub>34</sub>	0.1	0.1	0.1	0.1	0.2
nC <sub>35</sub>	0.1	0.1	0.1	0.1	0.2
PARAFFIN	15.8	13.3	18.5	14.7	12.2
ISOPRENOID	2.3	1.7	2.5	1.9	1.8
NAPHTHENE	81.9	85.0	79.0	83.4	86.0
CPI INDEX A	1.17	1.04	1.11	1.12	1.09
CPI INDEX B	1.72	1.52	1.70	1.01	1.39
PRISTANE/PHYTANE	0.73	0.95	0.77	0.88	1.09
PRISTANE/nC <sub>17</sub>	0.38	0.33	0.36	0.35	0.39

TABLE 6  
COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN - NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	91-035	91-037	91-041	91-043	91-046
DEPTH	2736-766m	2796-826m	2916-946m	2976-006m	3066-96m
SAMPLE TYPE	897C	9173	9567	9764	10.059
nC <sub>15</sub>	1.4	0.9	12.0	23.5	26.0
nC <sub>16</sub>	3.7	6.3	14.1	20.8	23.9
nC <sub>17</sub>	6.5	13.3	12.0	16.8	19.2
nC <sub>18</sub>	6.6	11.8	10.4	9.2	9.7
nC <sub>19</sub>	7.1	8.3	7.5	3.8	4.2
nC <sub>20</sub>	6.3	7.4	6.0	3.0	2.7
nC <sub>21</sub>	5.6	6.7	4.8	2.7	1.9
nC <sub>22</sub>	5.4	6.9	4.5	2.7	2.0
nC <sub>23</sub>	7.5	6.4	5.1	3.0	2.2
nC <sub>24</sub>	4.7	5.0	3.6	1.9	1.3
nC <sub>25</sub>	8.3	5.2	4.5	2.7	1.8
nC <sub>26</sub>	4.7	3.6	2.9	1.6	1.0
nC <sub>27</sub>	7.8	4.4	4.2	2.2	1.1
nC <sub>28</sub>	4.2	2.7	1.8	1.1	0.7
nC <sub>29</sub>	6.6	3.9	3.0	2.2	0.8
nC <sub>30</sub>	2.4	2.1	1.0	0.5	0.3
nC <sub>31</sub>	4.4	2.1	1.4	1.1	0.5
nC <sub>32</sub>	1.7	1.0	0.4	0.3	0.2
nC <sub>33</sub>	2.8	1.3	0.7	0.5	0.2
nC <sub>34</sub>	0.8	0.4	0.1	0.2	0.2
nC <sub>35</sub>	1.6	0.2	0.1	0.2	0.2
PARAFFIN	16.7	16.5	19.4	15.3	19.4
ISOPRENOID	2.2	1.9	3.6	2.1	3.7
NAPHTHENE	81.1	81.6	76.9	82.6	76.9
CPI INDEX A	1.46	1.12	1.27	1.30	1.20
CPI INDEX B	1.89	1.41	1.78	1.97	1.59
PRISTANE/PHYTANE	1.64	1.14	2.06	2.92	2.65
PRISTANE/nC <sub>17</sub>	1.25	0.47	1.05	0.61	0.71

**TABLE 6**  
**COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN - NAPHTHENE HYDROCARBONS**

GEOCHEM SAMPLE NUMBER	91-047	91-051	91-052	91-055	91-060
DEPTH	3096-124m	3216-246m	3246-276m	3336-366m	3486-516m
SAMPLE TYPE	10.157	10.551	10.649	10.985	11.157
nC <sub>15</sub>	16.9	19.5	23.5	6.3	5.7
nC <sub>16</sub>	14.6	16.8	23.1	14.0	14.4
nC <sub>17</sub>	11.9	14.1	19.5	15.5	17.1
nC <sub>18</sub>	7.3	9.2	10.9	12.7	14.2
nC <sub>19</sub>	4.2	5.8	4.8	8.8	10.3
nC <sub>20</sub>	3.5	4.6	3.4	7.2	8.8
nC <sub>21</sub>	4.2	3.7	2.6	5.6	5.9
nC <sub>22</sub>	4.2	3.3	2.4	5.0	5.1
nC <sub>23</sub>	6.2	3.4	1.8	5.2	4.3
nC <sub>24</sub>	4.0	2.4	1.4	3.7	2.9
nC <sub>25</sub>	6.5	3.5	1.6	4.2	2.8
nC <sub>26</sub>	3.5	2.4	1.0	2.4	1.7
nC <sub>27</sub>	5.0	3.1	1.2	3.1	2.0
nC <sub>28</sub>	1.5	1.6	0.4	1.2	0.9
nC <sub>29</sub>	3.3	2.8	0.9	2.1	1.4
nC <sub>30</sub>	0.6	0.9	0.4	0.9	0.6
nC <sub>31</sub>	1.3	1.4	0.6	0.9	0.6
nC <sub>32</sub>	0.2	0.4	0.2	0.3	0.3
nC <sub>33</sub>	0.6	0.5	0.2	0.5	0.3
nC <sub>34</sub>	0.2	0.1	0.2	0.1	0.2
nC <sub>35</sub>	0.2	0.1	0.2	0.1	0.2
PARAFFIN	19.1	16.7	18.4	17.9	18.6
ISOPRENOID	3.6	2.6	1.8	2.9	3.1
NAPHTHENE	77.3	80.7	79.8	79.2	78.3
CPI INDEX A	1.55	1.25	1.13	1.23	1.12
CPI INDEX B	2.23	1.76	1.71	1.71	1.53
PRISTANE/PHYTANE	1.61	2.31	1.78	1.43	1.25
PRISTANE/nC <sub>17</sub>	0.98	0.78	0.33	0.61	0.55



TABLE 6  
COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN - NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	91-066	91-068	91-069	91-071	91-073
DEPTH	3666-696m	3726-756m	3756-786m	3816-846m	3846-876m
SAMPLE TYPE	12.027	12.224	12.323	12.520	12.618
nC <sub>15</sub>	12.1	16.9	12.7	5.8	5.7
nC <sub>16</sub>	13.6	17.0	11.1	15.4	14.4
nC <sub>17</sub>	13.1	15.0	10.1	18.2	16.6
nC <sub>18</sub>	10.8	9.8	8.0	12.4	12.1
nC <sub>19</sub>	8.2	6.0	6.6	7.4	7.8
nC <sub>20</sub>	6.8	5.1	6.3	6.0	6.1
nC <sub>21</sub>	5.8	4.4	6.5	5.1	5.6
nC <sub>22</sub>	5.3	4.2	6.4	5.3	5.3
nC <sub>23</sub>	5.0	4.0	6.5	5.0	4.9
nC <sub>24</sub>	3.5	3.0	5.2	3.7	3.5
nC <sub>25</sub>	3.7	3.6	5.8	3.9	3.6
nC <sub>26</sub>	2.5	2.2	3.9	2.5	2.3
nC <sub>27</sub>	2.7	2.7	3.3	2.6	3.1
nC <sub>28</sub>	1.4	1.2	2.1	1.8	1.7
nC <sub>29</sub>	2.2	2.1	2.1	1.8	2.5
nC <sub>30</sub>	0.9	0.8	1.1	0.8	1.6
nC <sub>31</sub>	1.1	1.0	1.1	1.0	1.3
nC <sub>32</sub>	0.3	0.5	0.4	0.4	0.8
nC <sub>33</sub>	0.8	0.4	0.4	0.4	0.8
nC <sub>34</sub>	0.3	0.1	0.1	0.1	0.1
nC <sub>35</sub>	0.2	0.1	0.1	0.1	0.1
PARAFFIN	19.3	15.6	22.8	17.3	17.6
ISOPRENOID	2.5	1.8	2.6	2.3	2.5
NAPHTHENE	78.2	82.6	74.6	80.4	79.9
CPI INDEX A	1.15	1.20	1.14	1.10	1.17
CPI INDEX B	1.54	1.66	1.32	1.38	1.40
PRISTANE/PHYTANE	1.28	1.62	3.88	1.58	1.92
PRISTANE/nC <sub>17</sub>	0.56	0.46	0.90	0.45	0.57

**TABLE 6**  
**COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN – NAPHTHENE HYDROCARBONS**

GEOCHEM SAMPLE NUMBER	91-074	91-076	91-077	91-078	91-080
DEPTH	3876-906m	3936-966m	3966-996m	3996-026m	4056-056m
SAMPLE TYPE	<i>12716</i>	<i>12913</i>	<i>13012</i>	<i>13118</i>	<i>13307</i>
nC <sub>15</sub>	3.5	10.2	3.1	13.8	11.9
nC <sub>16</sub>	9.2	17.2	4.8	17.4	17.2
nC <sub>17</sub>	10.6	17.1	3.7	17.9	18.0
nC <sub>18</sub>	9.7	11.7	1.9	12.6	12.8
nC <sub>19</sub>	8.4	7.5	1.4	8.6	8.5
nC <sub>20</sub>	7.8	6.0	2.0	6.5	6.7
nC <sub>21</sub>	7.4	4.7	3.5	4.6	5.1
nC <sub>22</sub>	7.5	4.2	4.9	3.7	4.2
nC <sub>23</sub>	7.0	4.1	6.5	2.9	3.6
nC <sub>24</sub>	5.8	2.9	7.2	1.8	2.3
nC <sub>25</sub>	5.7	3.4	9.5	2.0	2.6
nC <sub>26</sub>	4.1	2.3	7.5	1.3	1.3
nC <sub>27</sub>	3.9	2.5	10.9	1.8	2.0
nC <sub>28</sub>	2.3	1.5	6.2	0.8	0.7
nC <sub>29</sub>	2.6	1.8	8.3	1.8	1.4
nC <sub>30</sub>	1.5	0.8	4.2	0.3	0.5
nC <sub>31</sub>	1.3	0.9	5.4	0.8	0.6
nC <sub>32</sub>	0.7	0.3	2.6	0.2	0.1
nC <sub>33</sub>	0.4	0.6	3.7	0.5	0.3
nC <sub>34</sub>	0.4	0.1	1.1	0.1	0.1
nC <sub>35</sub>	0.2	0.2	1.5	0.3	0.2
PARAFFIN	32.8	20.3	20.0	18.9	17.5
ISOPRENOID	3.3	2.4	0.3	1.5	2.7
NAPHTHENE	63.9	77.3	79.7	79.6	79.8
CPI INDEX A	1.09	1.15	1.30	1.17	1.24
CPI INDEX B	1.28	1.46	1.51	1.99	1.96
PRISTANE/PHYTANE	2.49	1.40	1.40	1.35	1.58
PRISTANE/nC <sub>17</sub>	0.68	0.41	0.21	0.42	0.53

TABLE 6  
COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN - NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	91-081	91-084	91-087	91-090	91-092
DEPTH	4086-116m	4176-206m	4236-266m	4326-356m	4386-416m
SAMPLE TYPE	13405	13701	13897	14198	14390
nC <sub>15</sub>	8.5	18.8	2.9	12.4	0.9
nC <sub>16</sub>	14.4	19.0	12.5	18.0	7.7
nC <sub>17</sub>	16.3	14.9	16.5	17.7	14.9
nC <sub>18</sub>	11.9	10.5	14.1	14.0	15.0
nC <sub>19</sub>	9.9	6.3	9.8	8.9	11.4
nC <sub>20</sub>	7.7	5.5	8.0	6.8	9.6
nC <sub>21</sub>	5.0	4.4	6.4	5.0	7.5
nC <sub>22</sub>	4.1	4.4	5.8	4.0	6.7
nC <sub>23</sub>	4.2	4.1	5.2	3.5	5.7
nC <sub>24</sub>	2.8	2.6	3.8	2.2	4.0
nC <sub>25</sub>	3.3	2.6	3.6	2.0	3.9
nC <sub>26</sub>	2.1	1.5	1.9	1.2	2.4
nC <sub>27</sub>	2.6	1.5	2.5	1.4	2.8
nC <sub>28</sub>	1.5	0.7	1.3	0.7	1.5
nC <sub>29</sub>	1.9	1.1	2.0	0.9	2.1
nC <sub>30</sub>	0.9	0.6	1.2	0.3	0.9
nC <sub>31</sub>	1.1	0.6	0.9	0.5	1.1
nC <sub>32</sub>	0.4	0.4	0.6	0.1	0.5
nC <sub>33</sub>	0.8	0.4	0.6	0.2	0.6
nC <sub>34</sub>	0.2	0.2	0.1	0.1	0.1
nC <sub>35</sub>	0.3	0.2	0.1	0.1	0.2
PARAFFIN	21.6	13.5	14.0	26.3	24.1
ISOPRENOID	3.7	1.7	2.4	4.1	4.1
NAPHTHENE	74.7	84.8	83.6	69.6	71.8
CPI INDEX A	1.17	1.14	1.15	1.16	1.12
CPI INDEX B	1.52	1.44	1.45	1.59	1.50
PRISTANE/PHYTANE	1.20	1.19	1.00	1.31	0.96
PRISTANE/nC <sub>17</sub>	0.58	0.46	0.51	0.50	0.56

TABLE 6  
COMPOSITION (NORMALISED %) OF C<sub>15</sub>+ PARAFFIN - NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	91-095	91-097	91-099	91-011	91-030	91-072
DEPTH	4476-506m	4536-536m	4596-T.D.	2100m	2631m	3832m
SAMPLE TYPE	14685	14882	15079	Mud	Mud	Mud
nC <sub>15</sub>	1.7	6.8	6.8	19.0	23.5	23.0
nC <sub>16</sub>	7.8	16.9	18.7	18.1	21.5	21.6
nC <sub>17</sub>	12.9	21.0	20.2	16.6	16.3	17.3
nC <sub>18</sub>	12.2	16.0	16.7	13.5	13.1	13.4
nC <sub>19</sub>	9.0	9.8	11.2	9.0	9.1	8.9
nC <sub>20</sub>	7.8	7.5	8.1	6.8	6.6	6.3
nC <sub>21</sub>	6.3	5.5	5.3	4.7	4.4	4.0
nC <sub>22</sub>	6.0	4.6	4.0	3.7	2.9	2.7
nC <sub>23</sub>	6.3	3.4	2.9	2.7	1.6	1.6
nC <sub>24</sub>	5.7	2.1	1.5	1.8	6.3	0.8
nC <sub>25</sub>	5.6	1.6	1.3	1.2	0.3	0.3
nC <sub>26</sub>	4.4	1.0	0.7	0.7	0.1	0.1
nC <sub>27</sub>	4.2	1.0	0.7	1.6	-	-
nC <sub>28</sub>	2.5	0.5	0.4	0.5	-	-
nC <sub>29</sub>	2.6	0.8	0.6	0.1	-	-
nC <sub>30</sub>	1.4	0.5	0.2	0.1	-	-
nC <sub>31</sub>	1.5	0.4	0.2	-	-	-
nC <sub>32</sub>	0.8	0.3	0.2	-	-	-
nC <sub>33</sub>	0.7	0.3	-	-	-	-
nC <sub>34</sub>	0.3	0.1	-	-	-	-
nC <sub>35</sub>	0.4	0.1	-	-	-	-
PARAFFIN	23.9	21.2	30.6	22.4	26.5	26.9
ISOPRENOID	2.8	3.5	6.1	3.5	3.9	4.3
NAPHTHENE	73.3	75.3	63.3	74.1	69.6	68.8
CPI INDEX A	1.09	1.08	1.09	1.15	-	-
CPI INDEX B	1.26	1.29	1.39	-	-	-
PRISTANE/PHYTANE	1.00	1.11	1.27	1.09	1.18	1.25
PRISTANE/nC <sub>17</sub>	0.45	0.42	0.55	0.49	0.50	0.52

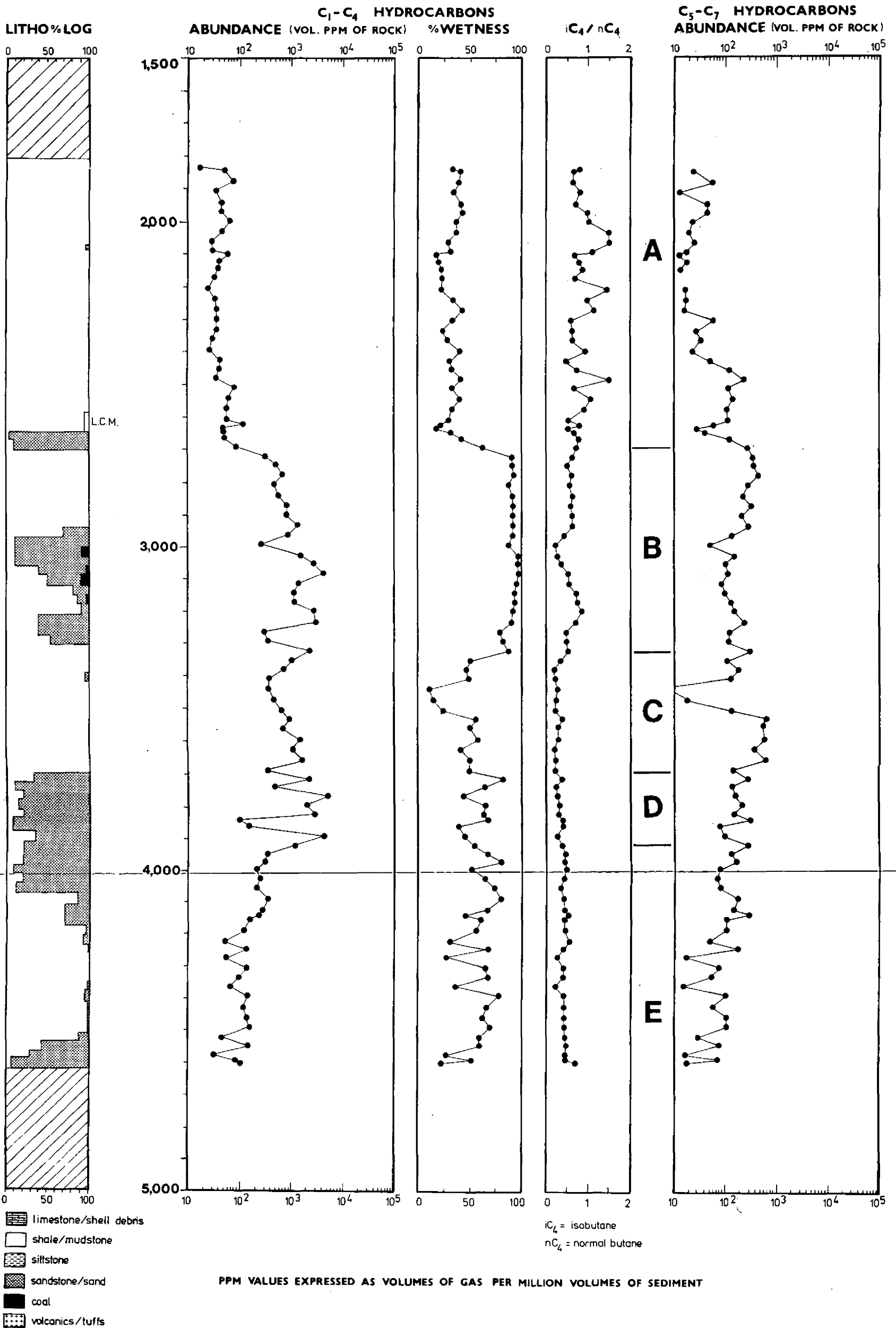
**TABLE 6**  
**COMPOSITION (NORMALISED %) OF C<sub>15+</sub> PARAFFIN – NAPHTHENE HYDROCARBONS**

GEOCHEM SAMPLE NUMBER	91-085	91-100
DEPTH	4143m	4600m
SAMPLE TYPE	Mud	Mud
nC <sub>15</sub>	23.2	26.8
nC <sub>16</sub>	21.4	24.0
nC <sub>17</sub>	17.5	17.0
nC <sub>18</sub>	13.2	12.7
nC <sub>19</sub>	8.7	7.8
nC <sub>20</sub>	6.5	5.0
nC <sub>21</sub>	4.0	2.9
nC <sub>22</sub>	2.7	1.9
nC <sub>23</sub>	1.6	1.1
nC <sub>24</sub>	0.8	0.5
nC <sub>25</sub>	0.3	0.1
nC <sub>26</sub>	0.1	0.1
nC <sub>27</sub>	-	-
nC <sub>28</sub>	-	-
nC <sub>29</sub>	-	-
nC <sub>30</sub>	-	-
nC <sub>31</sub>	-	-
nC <sub>32</sub>	-	-
nC <sub>33</sub>	-	-
nC <sub>34</sub>	-	-
nC <sub>35</sub>	-	-
PARAFFIN	26.5	22.3
ISOPRENOID	4.2	3.5
NAPHTHENE	69.3	74.2
CPI INDEX A	-	-
CPI INDEX B	-	-
PRISTANE/PHYTANE	1.26	1.34
PRISTANE/nC <sub>17</sub>	0.52	0.52

# FIGURE I

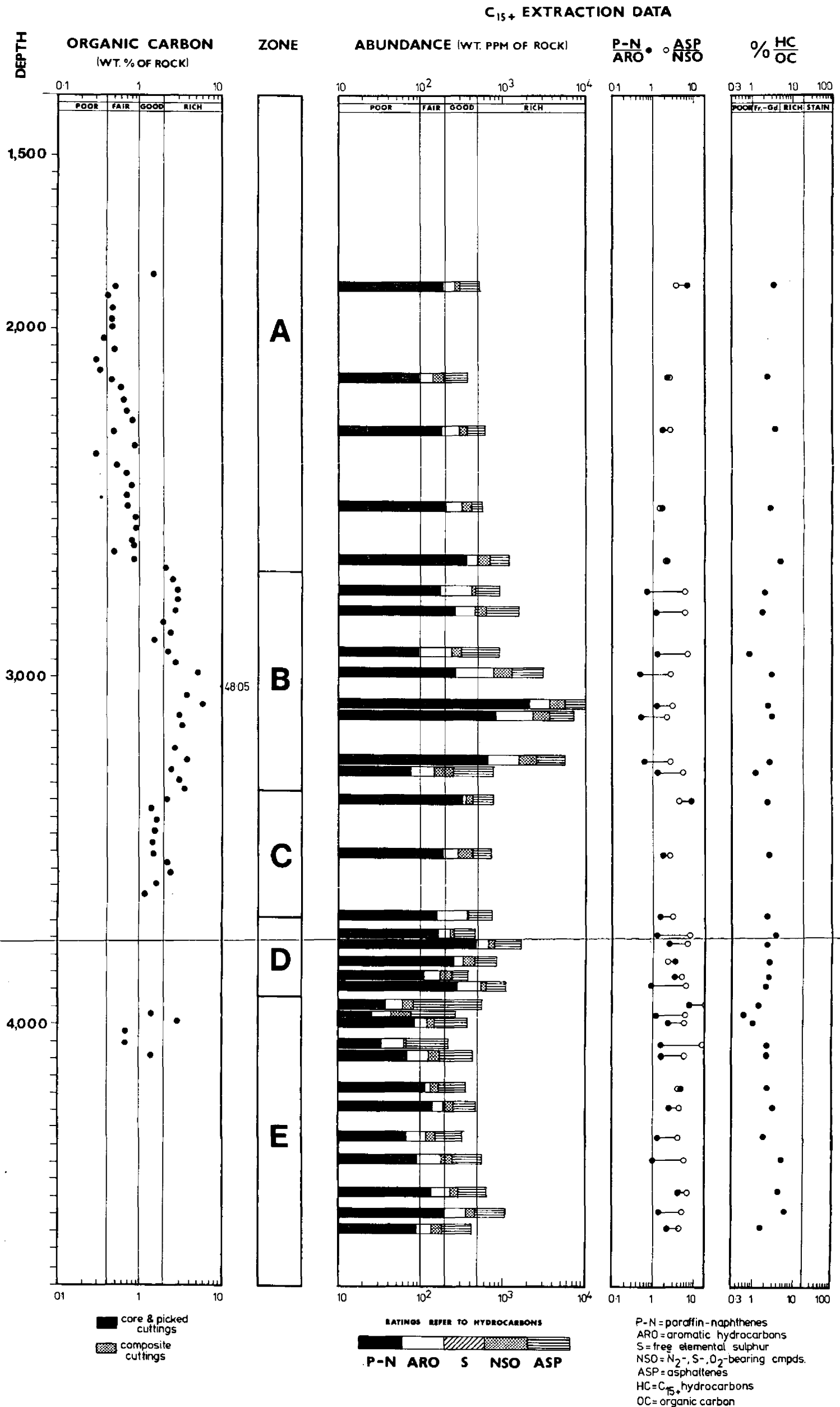
## C<sub>1</sub>-C<sub>7</sub> HYDROCARBONS

### PRESENTATION OF ANALYTICAL DATA



# FIGURE 2 C<sub>15+</sub> HYDROCARBONS — RICHNESS

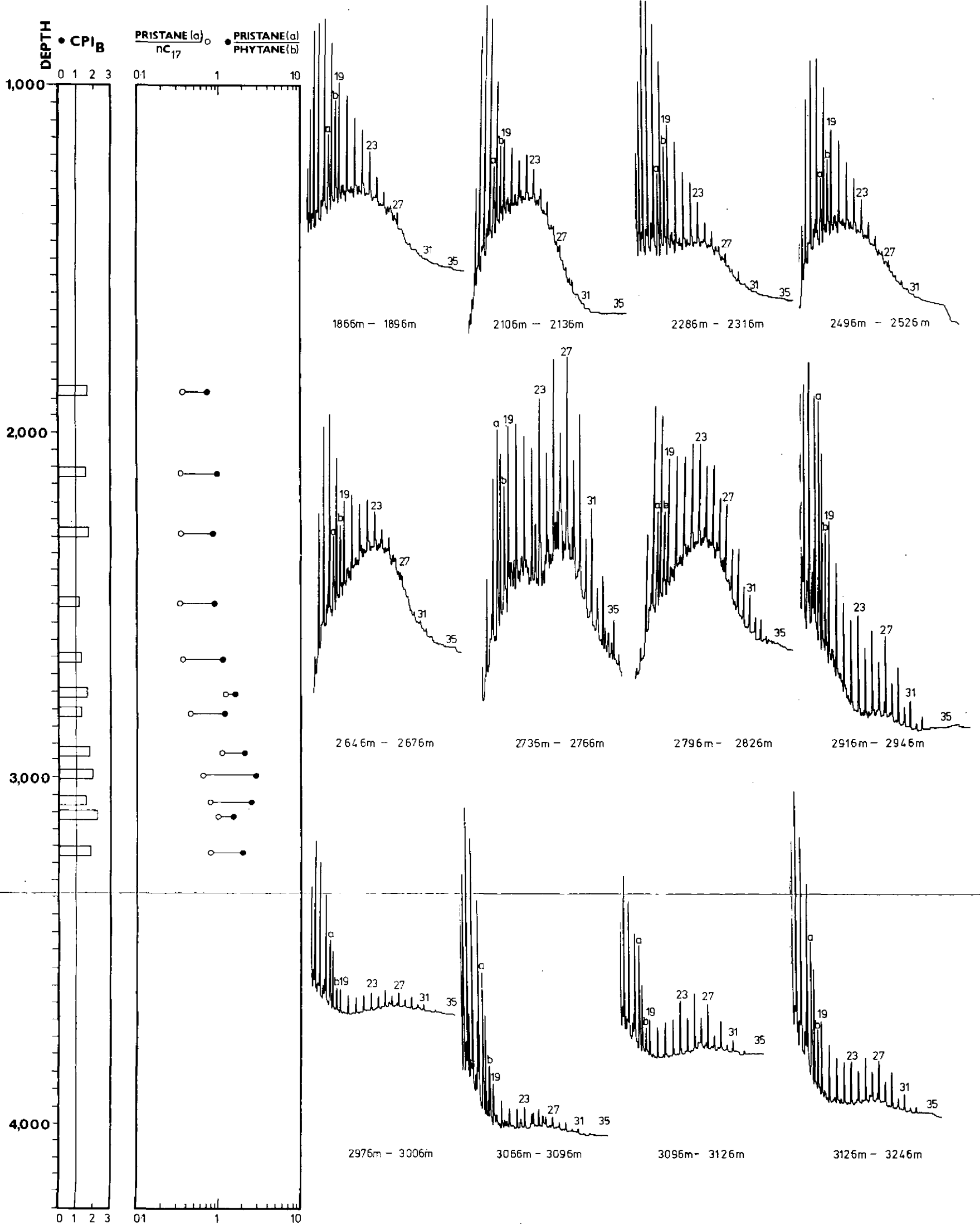
## PRESENTATION OF ANALYTICAL DATA



# FIGURE 3a

## C<sub>15+</sub> PARAFFIN - NAPHTHENE HYDROCARBONS

### PRESENTATION OF ANALYTICAL DATA



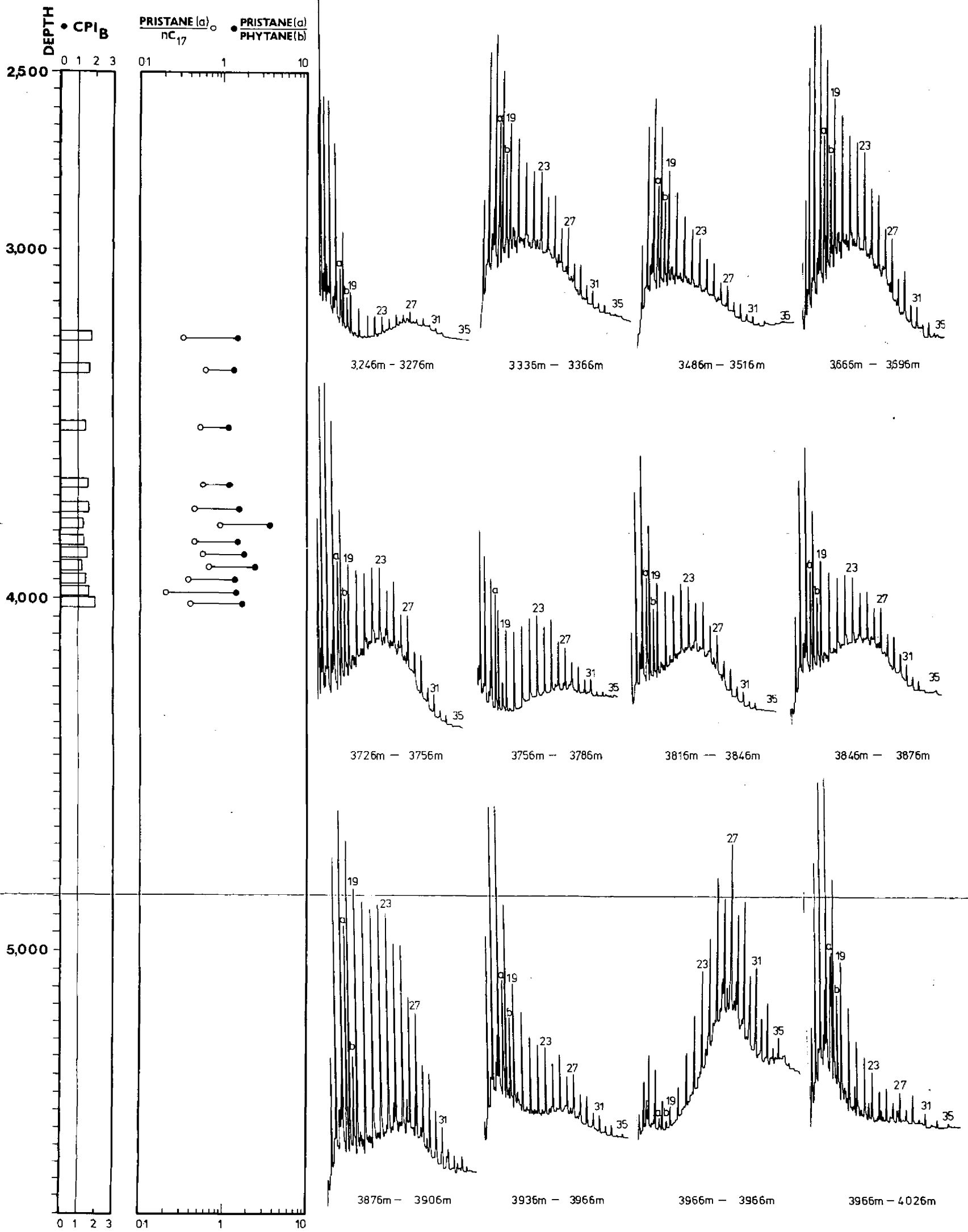
a = pristane  
 b = phytane  
 carbon numbers of normal paraffins indicated (19 = nC<sub>19</sub>)



# FIGURE 3 b

## C<sub>15</sub>+ PARAFFIN - NAPHTHENE HYDROCARBONS

### PRESENTATION OF ANALYTICAL DATA



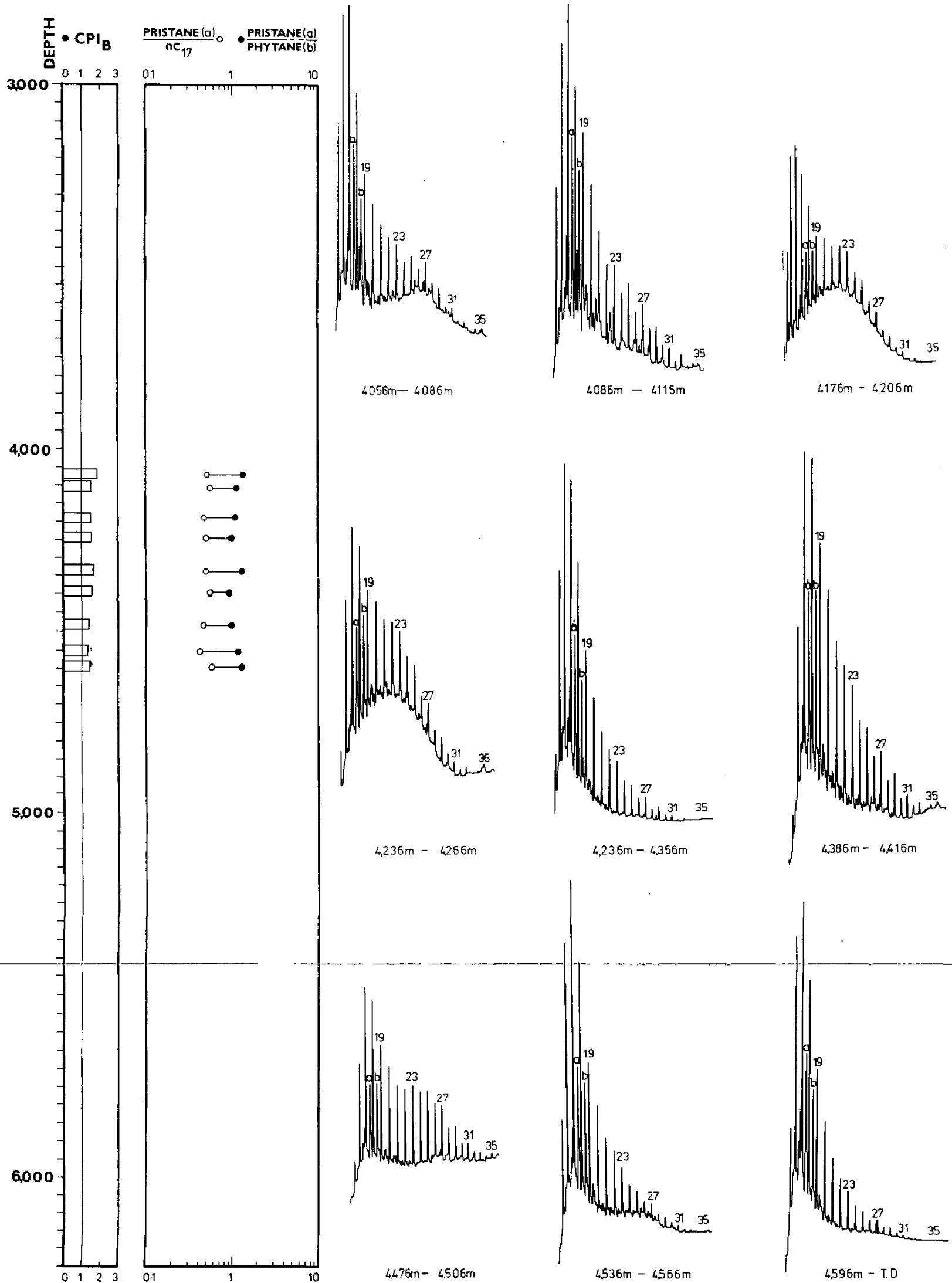
a = pristane  
b = phytane

carbon numbers of normal paraffins indicated (19 = nC<sub>19</sub>)

FIGURE 3c

# C<sub>15</sub> PARAFFIN - NAPHTHENE HYDROCARBONS

## PRESENTATION OF ANALYTICAL DATA

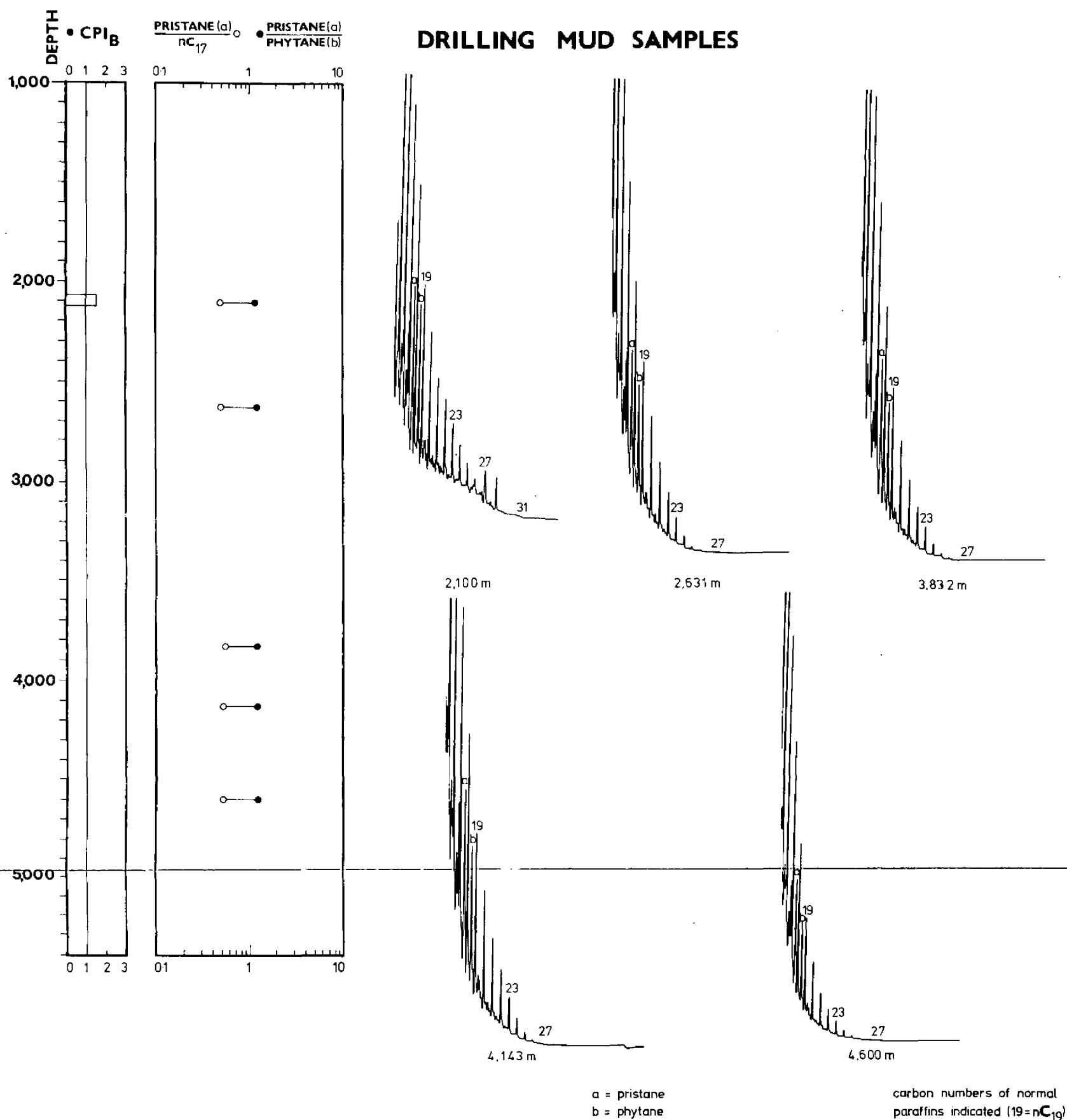


a = pristane  
b = phytane

carbon numbers of normal paraffins indicated (19 = nC<sub>19</sub>)

# FIGURE 3d C<sub>15+</sub> PARAFFIN - NAPHTHENE HYDROCARBONS

## PRESENTATION OF ANALYTICAL DATA

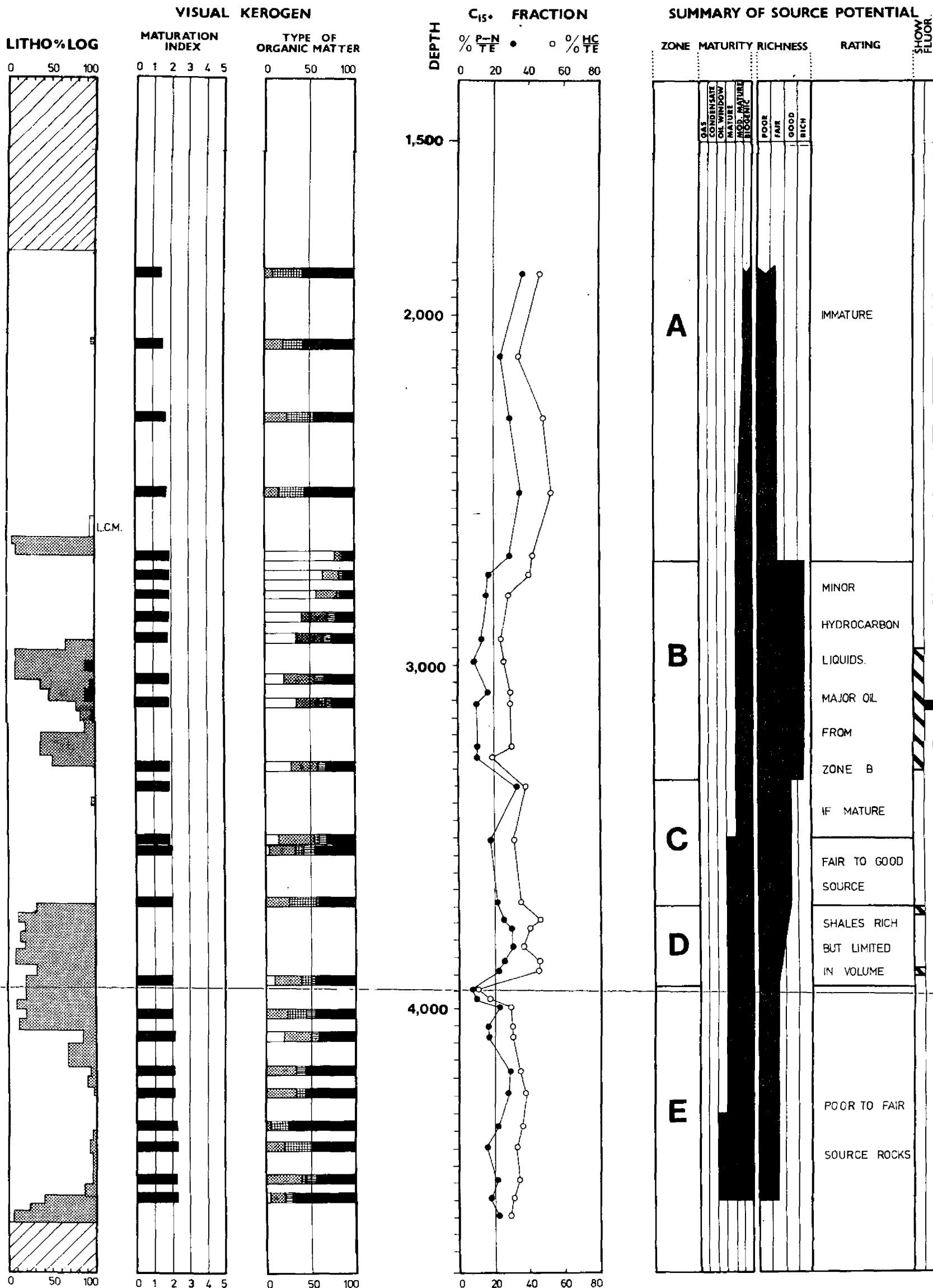


# FIGURE 4 INTERPRETATION DIAGRAM

## SOURCE TYPE

## MATURATION

## RATING



- limestone/shell debris
- shale/mudstone
- siltstone
- sandstone/sand
- coal
- volcanics/tuffs

- Al = algal
- Am = amorphous
- H = herbaceous-spore, pollen, cuticle
- C = black fusain-related material (C/H hi)
- S = stem
- W = woody

- P-N = paraffin-naphthenes
- TE = total extract
- HC = hydrocarbons

INTERPRETATION BASED UPON BOTH THIS DIAGRAM & THE PREVIOUS FIGURES  
"SHOW" BASED UPON GEOCHEMICAL DATA

## 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<sub>1</sub> - C<sub>7</sub> analysis and should be canned (or sealed wet in a plastic bag) for the C<sub>4</sub> - C<sub>7</sub> analysis. The other analyses can also be used on outcrop samples.

### A) C<sub>1</sub> - C<sub>7</sub> LIGHT HYDROCARBON ANALYSIS

The abundance and composition of the C<sub>1</sub> - C<sub>7</sub> 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<sub>1</sub> - C<sub>4</sub> gaseous hydrocarbons (methane, ethane, propane, isobutane and normal butane) and a partial resolution of the C<sub>5</sub> - C<sub>7</sub> gasoline-range hydrocarbons (for their complete resolution see Section D). The p.p.m. abundance of the five gases and of the total C<sub>5</sub> - C<sub>7</sub> 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<sub>1</sub> - C<sub>7</sub> 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<sub>1</sub> - C<sub>7</sub>, C<sub>4</sub> - C<sub>7</sub> and C<sub>15+</sub> 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<sub>1</sub> - C<sub>7</sub> 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 diagrammatically in our reports in a manner which facilitates comparison with the gross lithology (see section B) of the samples.

#### D) DETAILED C<sub>4</sub> - C<sub>7</sub> HYDROCARBON ANALYSIS

The abundance and composition of the C<sub>4</sub> - C<sub>7</sub> 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<sub>15+</sub> 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<sub>15+</sub> 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<sub>4</sub> - C<sub>7</sub> 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 diagrammatically.

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

F) GC ANALYSIS OF C<sub>15+</sub> PARAFFIN-NAPHTHENE HYDROCARBONS

The molecular composition of the heavy C<sub>15+</sub> 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<sub>15+</sub> chromatography and light hydrocarbon (C<sub>1</sub> - C<sub>7</sub>, C<sub>4</sub> - C<sub>7</sub>) 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:

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

2

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

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.