MUD RECAP FOR WELL 35/3-1.

CASING INTERVAL		TOTAL	30"	20"	13 3/8"	9 5/8"	OPEN HOLE	
MATERIAL	UNIT WEIGHT	QUANTITY	QUANTITY	QUANTITY	QUANTITY	QUANTITY	QUANTITY	REMARKS
BARITE	M.TON	1137	33	103	113	468	420	Well abandoned
SALT GEL	50 kg	940	400	540				at 4475 meters
MILBEN	50 kg	988	420	568				due to abnor-
FLOSAL	50 lbs	16	8		8			mally high
CAUSTIC	25 kg	1150	10	75	323	635	107	formation
UNICAL	50 lbs	3041		53	1239	1308	441	pressure.
MILGEL	50 kg	1866			714	999	153	Mud wt.17.1 ppg
GYPSUM	40 kg	640			640			
DRISPAC (REG.)	50 lbs	122			42	80		
EML	55 Gal	108			41	54	13	
CMC (LOVIS)	50 lb	145			88	57		
MD	55 Gal	49			14	33	2	
SODA ASH	50 kg	15				15		
DRISPAC (SUPERLO)	50 lbs	293				241	52	
LD-7	5 Gal	25				5	20	
LIGCON	50 lbs	420				100	320	
MIL-TEMP	50 lbs	47				21	26	

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RESEARCH CENTRE

SUNBURY-ON-THAMES

MIDDLESEX

EXPLORATION AND PRODUCTION DIVISION

Report EPR/R7033
March 1977

GEOCHEMISTRY BRANCH

PETROLEUM GEOCHEMISTRY OF NOCS WELL 35/3-1

by

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Contents

Summary

Petroleum geochemical studies were carried out on wet cuttings and sidewall cores from the deep test well NOCS 35/3-1, which was suspended at ~4500m in the early Bajocian.

Light hydrocarbon studies on canned wet cuttings revealed the unusual presence of significant quantities of olefins, probably derived from sea water and mud additives. Light hydrocarbon variations also revealed significant quantities of methane, of probable biogenic origin, in shallow sediments as well as large quantities of hydrocarbons below ~4100m. Autochthonous vitrinite reflectance measurements indicated an oil generation threshold of ~ 3200m, with peak liquid hydrocarbon generation occurring at ~ 4800m and a probable oil floor at ~ 6400m.

Mature source rocks were present in both the Cretaceous and Jurassic, with the Bajocian having the highest average organic carbon content of ~ 1.9% wt. However, most of the Kerogens below the generation threshold appeared to have a gas or gas/condensate hydrocarbon potential. Taking into account the degree of organic diagenesis and the likely source potential of the various sediments, it seems possible that if any deeper prospects existed in this well they would probably be gas or gas/condensate. Very light oil with an extremely high gas/oil ratio may also just be a possibility.

(A) INTRODUCTION

The exploration well NOCS 35/3-1 (proposed location 61° 50' 40" N; 03° 43' 43" E) was drilled by the Saga/BP/Statoil Group as a deep test of a Jurassic prospect in this region of the Norwegian Continental Shelf. The well also proposed to test a possible early Upper Cretaceous reservoir sand. Although it was originally intended to drill to a depth of 5250m, the well was suspended at ~ 4500m in the Early Bajocian.

During the drilling operations, a large number of canned wet cuttings samples and a range of sidewall cores were collected for geochemical analyses. These samples were subsequently forwarded to Sunbury for determination of organic diagenesis and source rock potential parameters. Sample quality was generally much improved on that obtained previously from Well 36/1-2, and the availability of canned samples enabled an investigation of light hydrocarbon compositions, and their variations with depth, to be undertaken.

Many of the sidewall core samples were also used for dating purposes by Palynology Branch, EPD, Sunbury, and the results of these studies (1) have been incorporated into this report, together with the visual Kerogen studies undertaken to supplement the organic geochemical analyses.

The sidewall core and wet cuttings samples from 35/3-1 appeared to be relatively free of the gas oil contamination which had previously considerably limited geochemical analyses on material from 36/1-2, and had given rise to some misleading hydrocarbon indications in the latter well (2). It was considered worthwhile, therefore, undertaking a relatively full range of organic diagenesis/source rock determinations, including compositional analyses of solvent extracts, on the material from 35/3-1.

(B) SAMPLES AND TECHNIQUES

Prior to opening each can of wet cuttings, the headspace gas was sampled and analysed for a wide range of saturated and unsaturated light hydrocarbons by a capillary column gas chromatographic procedure (3). Following this analyses, the cans were opened and the cuttings washed free of drilling mud and dried in a vacuum oven at 40°C. The amount of cuttings recovered from each can was weighed in order to provide a comparative basis (v.p.m./100gm) for the various gas analyses.

Selected dried cuttings were picked to provide material for vitrinite reflectance measurements by examination of polished mounts. Small portions from the interior of various sidewall cores were also taken for the same determinations. Larger amounts of cuttings were then picked to remove obvious contamination and cavings in order to provide samples of uniform lithology for solvent extraction by methylene chloride. Various sidewall cores from the deeper part of this well were also carefully cleaned of any surface contamination and used for the same extractions.

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Solvent extracts (TSE) were recovered and separated by liquid chromatography over silica gel to obtain saturate alkane concentrates (SAC). The latter were then analysed by capillary column gas chromatography to determine n-alkane distributions and CPI values. In a small number of instances, it was necessary to use a gas chromatography - mass spectrometry procedure (4) to obtain the n-alkane distributions due to interference by cyclic alkanes in the SAC fraction.

The solvent extracted samples were decarbonated and organic carbon (TOC) and C_R/C_T ratios determined on the Kerogen concentrates. Kerogen characterisation was also undertaken on selected sidewall cores by microscopic examination of organic concentrates produced by the standard acid concentration procedures used in palynology.

(C) RESULTS AND DISCUSSION

(i) Light Hydrocarbon Analyses

The availability of canned wet cuttings samples provided an opportunity of studying the variation of light hydrocarbon compositions (C_1 - C_6^+) with depth. This technique is widely used in petroleum geochemistry to provide indications of maturity, reservoired hydrocarbons and source rock type. However, many problems exist with the method, including the following :

(a) light hydrocarbons tend to migrate much more readily than heavier hydrocarbons and, hence, the presence of high concentrations of mature, light hydrocarbons at a particular depth is not necessarily confirmation of maturity of the surrounding sediments.

(b) variations in the collection of samples during drilling operations, and changes in the retention of light hydrocarbons by alteration of mud properties.

(c) build-up of light hydrocarbons in the drilling mud and lack of adequate monitoring of the mud returning to the hole.

(d) general lack of applicability of regional variations in the concentration of these components.

Despite these major drawbacks, the method has some uses in supplementing other geochemical parameters in providing general, qualitative indications of reservoired gases and approaches to maturity within a sedimentary sequence.

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Results for the cuttings and mud samples from 35/3-1 are given in Tables 1 - 3 and Figures 1 and 2. Table 1 gives the component analyses of cuttings headspace gas determined by the capillary column technique noted previously (3). The significant observations from these analyses are :

(a) a high concentration of methane in shallow sediments.

(b) the detection of hydrocarbons up to C_7 in samples from below 3760m, and of components up to C_9 below 4250m.

(c) the relatively high concentrations of hydrocarbons below 4100m.

(d) the detection of olefinic hydrocarbons, sometimes in concentrations comparable to that of the equivalent saturated hydrocarbons.

The occurrence and concentrations of olefins in these samples was particularly noteworthy as these components are rarely observed in routine light hydrocarbon analyses of wet cuttings from wells. It should be noted, however, that many of the analytical methods normally used would not be capable of detecting or determining these hydrocarbons with any accuracy. It was significant that in many of the deeper samples e.g. in the range 3250 - 3800m, the olefin concentration was often comparable with, and in some cases greater than, the saturated hydrocarbons.

Light olefins, in significant concentrations, are virtually unknown in Ancient sediments, although they have been detected in Recent sediments and seawater. In the latter case, their occurrence is thought to be due to photolysis of dissolved organic matter, and components up to propylene (C_3) have been detected (5). This observation may be of some significance if sea water was used extensively in the mud system, although the reported levels of olefins are apparently quite low and closer to those observed in the shallower part of this well i.e. in the interval 990 - 1300m.

As already noted, both the relative amounts of olefins and their occurrences in this well were rather unusual. Trace amounts were present in the shallow intervals but then, with the exception of the sample from 2500m, they disappeared until around 2750m. Significant concentrations were not reached until 3250m, and these remained at relatively high levels until 3810m when they again dropped to trace levels. Relatively high concentrations reappeared at around 4300m and remained at these levels down to TD.

These variations in appearance and disappearance of the olefins suggested that the mud properties may be having an influence on these components. The low levels in the shallow sediments could have originated from sea water, as suggested above, but the relatively much higher concentrations in the deeper sediments were more likely derived from mud

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additives. Possible examples of the latter which may contain these hydrocarbons include some lignites, lignosulphonates, Desco and Soltex. It is probably significant, therefore, that these materials were proposed as mud additives as the well drilled through the deeper sections (6).

It is possible that the trace levels of olefins encountered in this well could have been derived either from sea water or, possibly, from a mud additive. The much higher levels of these hydrocarbons encountered in the deeper sections of this well were more likely derived from a mud additive containing appreciable amounts of olefins. It is recommended, therefore, that these suggestions concerning mud additives as a possible source of these unusual hydrocarbons be investigated by a careful re-examination of the mud programme actually used in 35/3-1.

Table 2 provides an interesting check on the mud by comparing the light hydrocarbon analyses of mud and wet cuttings from virtually the same depths. It was assumed that the mud samples were taken after passage over the shale shaker and prior to re-injection into the well via the mud pumps and, hence, were fairly representative of the drilling fluid in circulation. Analyses are quoted as relative concentrations (vpm) of evolved gases in the headspaces of the various samples and are not strictly comparable to those given in Table 1. The significant observations from these analyses were :

(a) high olefin concentrations were detected in the mud from 3500m and low levels in the mud from 4000m. These variations corresponded to those intervals where similar variations were observed in the cuttings samples.

(b) in some instances, the mud and cuttings samples were comparable in hydrocarbon concentrations but, in the deeper sections of the well the mud appeared to have higher concentrations of light hydrocarbons than the cuttings. This apparent build up of hydrocarbons in the circulating mud must throw considerable doubt on the validity of light hydrocarbon determinations for geochemical evaluations, and suggested that much more careful checking of these analyses should be undertaken.

As a check on the constancy of the compositions of the headspace gases from the various mud samples, a comparison of the mud samples as received, and after heating for 4.5 hrs at 50°C, was also carried out. The results are shown in Table 3 and, for 3 of the samples, indicated comparable amounts and compositions before and after heating. No gas was detected after heating the sample from 550m due, almost certainly, to the very small volume of headspace which existed initially. Leaks were considered responsible for the marked drop in concentrations on heating the samples from 1500m and 4000m. These results suggested that no increase in hydrocarbon evolution from any mud additives occurred on heating the mud samples.

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The variation of methane concentrations with depth is illustrated in Figure 1. Very high concentrations occurred at shallow depths, and this gas was probably biogenic in origin. It would clearly be of interest to see if this methane could be detected by re-examination of the high resolution shallow seismic data for the area. It would also be of value, if samples were still available, to determine the stable carbon isotopic composition ($\delta\,^{13}C_{PDB-1}$) of the methane to confirm whether or not it was indeed biogenic in origin.

High concentrations of methane were also observed below $\sim$ 4100m but these were, almost certainly, thermal in origin and due to increasing maturity of the dominantly gas-prone Kerogens (see Sections (iii) and (iv)) which occurred at these depths. Autochthonous vitrinite reflectance values (see Section (ii)) at $\sim$ 4100m were around 0.7, which was effectively the generation threshold for most gas-prone Kerogens. However, as noted previously, considerable care should be taken in assessing generation thresholds from gas concentrations alone, as upward migration of these components occurs quite frequently. Migration may also be responsible for the various minor peaks shown in Figure 1 above the generation threshold. These concentrations probably corresponded to slightly more porous reservoir intervals occurring at the particular depths.

Variations with depth of the heavier saturate hydrocarbons (C_2 - C_5) are shown in Figure 2. These distributions correlated extremely well with each other, and the various peaks above the generation threshold again probably corresponded to more porous intervals. Similarly, much of the gas in the interval 2500 - 4000m probably originated at greater depths. The high concentrations of C_4 and C_5 hydrocarbons in the deeper gases suggested that the Kerogens present were probably mainly of the gas/condensate type rather than the dominantly dry gas prone variety.

(ii) Vitrinite Reflectance Measurements

Results of these determinations are given in Table 4 and Figure 3. 60 out of the 100 samples actually examined gave satisfactory results, and only the latter are included in Table 4. The remaining 40 samples were badly affected by cavings and, in many instances, no determinations were possible. It was fortunate that so many sidewall cores from >3000m subsequently became available, as most of the unsatisfactory material originated from the deeper part of this well. However, prior to the arrival of these sidewall cores, much time and effort had been spent on trying to obtain meaningful results from badly contaminated cuttings samples.

As shown in Table 4, a satisfactory number of determinations was usually possible for establishing the mean autochthonous vitrinite reflectance values. Allochthonous reflectances could conveniently be subdivided into a number of separate groups, a feature frequently observed in sedimentary sequences and which is, almost certainly, related to the

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provenance of the sediments. The amounts of allochthonous components indicated that considerable reworked organic matter was present in the Late Aptian, and that the Jurassic probably also contained a reasonable amount of this material.

A least mean squares fit of Log Reflectivity v Depth is shown in Figure 3. The availability of many sidewall core samples from > 3000m enabled considerable confidence to be placed in the results from below this depth. The greater variability in the results above 3000m was considered due to cavings as well as the much greater scatter which is normally associated with lower reflectivity material. A major factor in this variability was, almost certainly, the greater effect of lithology on reflectivity in immature sediments.

Figure 3 indicated that an oil generation threshold, equivalent to an autochthonous reflectance value of 0.55, occurred at a depth of ~3200m. The low palaeothermal history of this well was confirmed by extrapolation of the results which suggested an oil floor (R_o = 1.3) at ~ 6400m and a probable peak of oil generation at ~4800m (R_o = 0.85). It should be noted, however, that an oil generation threshold only applies if liquid-prone Kerogens are present at this particular depth but, if gas-prone or gas/condensate-prone Kerogens are dominant, these normally require a greater degree of organic diagenesis (DoD) for significant additional hydrocarbon generation. Many gas-prone Kerogens do not, apparently, begin to evolve appreciable amounts of hydrocarbons before a DoD equivalent to a reflectance value of ~ 0.7 and, as noted previously in Section (i), the latter value corresponds quite closely to depths in 35/3-1 where large increases in light hydrocarbons were detected. Other geochemical evidence (see Sections (iii) and (iv)) also indicated that Kerogens in the deeper part of this well were more gas than oil prone.

In view of suggestions to possibly deepen this well, it is worthwhile considering likely hydrocarbon prospects below the current TD as indicated by extrapolation of vitrinite reflectance values. These speculations assume that no marked unconformities associated with a different palaeothermal history exist below the present TD. Although an oil floor of ~ 6400m was indicated, the peak of liquid hydrocarbon generation was ~ 4800m and, hence, below the latter depth an increasing tendency exists for any liquid hydrocarbons (i.e. oil) to become more condensate-like. If this hydrocarbon liquid peak generation depth is considered in conjunction with the presence of dominantly gas-prone Kerogens down to TD (~ 4500m) in this well, it seems very likely that if any deeper hydrocarbon accumulations exist, they would more likely be gas or, at best, gas/condensate prospects. Very light oil associated with extremely high gas/oil ratios may also just be possible.

(iii) Basic Source Rock Data

Results of these determinations are shown in Table 5 and Figures 4 - 13. Table 5 indicates that, in some instances, it was possible to obtain these basic measurements on sidewall cores even though the amounts of sample involved were extremely low.

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C_R/C_T values generally displayed much lower values above the oil generation threshold than below it. No regular variation with depth was evident, but this would be anticipated in view of the presence of reworked organic material and the effect of Kerogen type, particularly humic material on these determinations. Many of the lower values in deeper sediments e.g. from 3955m, 3993m and 4219.5m, were associated with high TSE/TOC and SAC/TOC values and, hence, oil proneness of the sediments. These very low C_R/C_T values were not due to retention of soluble material in the Kerogen concentrates and appeared genuine. Despite the maturity of the sediments, they suggested that the particular samples still had a high oil potential.

Total organic carbon contents of the Tertiary sediments were not very attractive, apart from the sample from 1350m. The average content of $\sim$ 0.6% wt TOC represented only moderate amounts of Kerogen but, although the sediments were immature, they contained one or two quite high TSE/TOC and SAC/TOC ratios. The latter may be the result of traces of hydrocarbon contamination or, more likely, the concentration of organic material by diagenetic processes.

With the exception of the sample from 2650m, TOC variations in the Cretaceous were not very marked, with an average value of $\sim$ 0.85% wt. Concentrations tended to be higher, and more attractive, in the Late Albian and the Aptian. The very high content of organic carbon in the sample from 2650m was associated with microscopic evidence for the presence of corroded particles of ?bitumen and inertinite. This sample also had a relatively high C_R/C_T value and low TSE/TOC and SAC/TOC values and, hence, may well contain appreciable quantities of reworked organic matter.

The Jurassic displayed some very good TOC values, particularly in the Bajocian, with an average TOC content of $\sim$ 1.9% wt. The early Oxfordian was not well sampled, and the apparently attractive value for the cuttings from 4200m may well have been influenced by cavings. This sample also had much lower TSE/TOC and SAC/TOC values than sidewall core material from similar depths.

With the exception of the sample from 1150m, TSE/TOC and SAC/TOC values were generally low down to a depth of $\sim$ 3900m i.e. below the oil generation threshold. Some surprisingly high SAC's were, however, observed over this range and these suggested that some hydrocarbon contamination may have been present in the extracts from these samples. Below the oil generation threshold i.e. $\sim$ 3200m, the low SAC/TOC and SAC/TOC values were probably indicative of gas-prone Kerogens and the high values of oil-prone Kerogens. As high values of these ratios were interspersed with quite low values, this was much more suggestive of an overall gas/condensate situation rather than good oil potential. The Jurassic, in particular, appeared to contain rather mixed Kerogens, although much more extensive sampling should have been undertaken in order to establish these indications.

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As indicated previously, some of the higher SAC/TOC ratios in the shallow intervals may be the result of hydrocarbon contamination. The n-alkane distributions of these extracts, especially those from 1050m and 1150m (Figure 4), tended to support this suggestion. As concentrations of immature organic matter by diagenetic processes do not usually possess high SAC contents, this also supported the suggestion that some hydrocarbon contamination was present in the shallow samples.

The detailed distributions of n-alkanes and their CPI values is shown in Figures 4 - 13. The possibility of some hydrocarbon contamination in the samples from 1050m and 1150m has already been noted and, as shown in Figure 8, the same situation may apply to samples from 2470m and 2550m which had CPI values of 1.07 and 1.10 respectively. Below $\sim$ 2800m, CPI values and n-alkane distributions became much more mature in character although, even at 3150m (Figure 9), the CPI value would still be considered immature.

Considerable difficulty was experienced in determining n-alkanes in samples from the range 3024m - 4069m, and a number of these distributions had to be determined by a C-GC-MS technique (4). The capillary column chromatographic traces of the SAC fractions from this interval were rather complex and considered indicative of some biodegradation of the hydrocarbons having occurred. It would be interesting, therefore, to see whether this suggestion could be confirmed by examination of the palaeogeography of the region and its influence upon the hydrodynamic situation within the basin. Of particular interest would be any alteration in the sub-surface water regime which could be attributed to influx of less saline surface waters containing traces of oxygen and micro-organisms.

The variation of CPI values with depth (Figures 4 - 13) suggested that maturity was attained rather shallower than the depth indicated by vitrinite reflectance results i.e. $\sim$ 3200m. The indications from CPI values were not, however, supported by TSE/TOC and SAC/TOC values but, considering all of these parameters together, mature sediments were clearly present below $\sim$ 3900m. As the type of Kerogen present (i.e. whether gas or oil prone) will influence the TSE/TOC and SAC/TOC values, these parameters alone do not clearly define the depth of the generation threshold, except in a dominantly oil-prone source rock. Many of the deeper samples still retained a slight odd over even carbon number preference in their n-alkane distributions and this was probably indicative of gas rather than oil potential, a suggestion supported by low TSE/TOC and SAC/TOC values in these samples.

Thus, despite some problems associated with either, or both, contamination and/or diagenetic influences, source rock data and hydrocarbon compositions of the solvent extracts confirmed the indications from other parameters that a fairly low DoD existed in 35/3-1, and that the mature source rocks in the Cretaceous and Jurassic were dominantly gas or gas/condensate prone.

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(iv) Visual Kerogen Studies

Results of these examinations are summarised in Table 6. Samples were restricted entirely to sidewall core material from depths $\geqslant$ 2970m which was also used for palynological dating (1).

Colour maturation changes suggested that the oil generation threshold was within the range 3935m - 3983m, which was considerably lower than the depth indicated by vitrinite reflectance results i.e. $\sim$ 3200m (See Section (ii) and Figure 3). However, as the visual Kerogen technique is still essentially qualitative and rather subjective in nature, and as the vitrinite reflectance results over the lower part of 35/3-1 were based mainly upon sidewall core samples, the latter were considered a more accurate indication of DoD in this well. Compositional variations also tended to support the vitrinite reflectance indications of maturity levels in 35/3-1 rather than those derived from the visual Kerogen techniques.

The generation threshold suggested in Table 6 was, in fact, very close to the estimated gas generation threshold of this well i.e. $\sim$ 4100m. It was likely, therefore, that in this instance maturity of gas/condensate type Kerogens, rather than dominantly oil prone material, was being observed by these visual methods. The latter also appeared to indicate a much more rapid change of maturity with depth than that shown by the reflectance trend (Figure 3), possibly due to problems arising from confusion with the large amounts of reworked material present in the lower part of this well (e.g. see Table 4).

Although the visual Kerogen results did not appear to indicate the oil-proneness of a limited number of the Kerogens present, they supported the suggestion that the lower section of this well was dominantly gas or gas/condensate prone. The apparent lower generation threshold than that indicated by reflectance results was probably due to the dominant presence of gas-prone Kerogens, and the more rapid change of maturity with depth was probably influenced by reworked components.

(D) CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

(1) Light hydrocarbon analyses of wet cuttings samples from this well revealed the most unusual occurrence of significant quantities of olefins. Although trace levels of these hydrocarbons might have been derived from sea water, the higher concentrations more likely originated from organic mud additives.

(2) Light hydrocarbon analyses also indicated a considerable build up of these components in the circulating drilling mud. If this process occurs quite generally, then it casts considerable doubts on the validity of the technique as a reliable geochemical parameter.

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(3) The very high levels of light hydrocarbons below ~ 4100m in this well suggested that a gas generation threshold existed around this depth. The latter was supported by autochthonous vitrinite reflectance determinations.

(4) Methane variations with depth showed a high concentration of this gas in shallow sediments. The virtual absence of other components suggested that this gas was probably biogenic in origin.

(5) Light hydrocarbon variations with depth and their relation to other maturity parameters suggested that upward migration of these components had probably occurred in this well.

(6) The presence of significant quantities of heavier hydrocarbons in the deeper section of this well i.e. > 4100m, suggested that the Kerogens present were mainly of the gas/condensate type rather than the dry gas variety.

(7) Autochthonous vitrinite reflectance variations indicated an oil generation threshold (R_o = 0.55) in this well at ~ 3200m. Peak oil generation would probably occur at ~ 4800m, and the oil floor at ~ 6400m.

(8) Organic richness of the various potential source rocks showed some very attractive organic carbon contents (~ 1.9% wt average) in the Jurassic (Bajocian) with lower amounts in the Late Albian and Aptian. The Cretaceous as a whole tended to have a fairly uniform content of ~ 0.85% wt TOC. The average value for the Tertiary samples examined was ~ 0.6% wt.

(9) Amounts and compositions of soluble extracts indicated that some trace amounts of contamination were probably present in many of the samples examined, particularly those from the shallower intervals. The variability of the TSE/TOC and SAC/TOC ratios below the oil generation threshold indicated that many of the Kerogens were gas prone, and that the overall petroleum potential of the mature Cretaceous and Jurassic was much more likely to be gas/condensate rather than oil.

(10) Visual Kerogen results supported the suggestion that the lower sections of this well were dominantly gas or gas/condensate prone. The apparent lower generation threshold indicated by the visual method was probably due to the presence of these gas-prone Kerogens, and the more rapid change of maturity with depth was probably influenced by reworked components.

(11) As the Jurassic down to TD contained mainly gas prone Kerogens and, as the peak of any liquid hydrocarbon generation was ~ 4800m, any deeper prospects in 35/3-1 would probably be gas or gas/condensate. Light oil with a very high gas/oil ratio may also just be possible.

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RECOMMENDATIONS

(1) If samples of shallow gas are still available from this well, stable carbon isotope determinations ($\delta\ ^{13}C_{PDB-1}$) should be undertaken on the methane to confirm whether or not it is of biogenic origin.

(2) A careful examination should be carried out on both the mud additives and variations in the mud programme of this well to see if these factors can be related to the anomalous olefin occurrences.

(3) In the present study, unnecessary time and effort was spent on the examination of very poor quality cuttings samples when sidewall core material from the same depths was subsequently made available for geochemical investigations. Planning of geochemical work would be greatly improved if sample availability was made fully known at the outset, and it is recommended that this procedure be followed in any future investigations.

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TABLE 1

NORWAY : WELL 35/3-1

LIGHT HYDROCARBON ANALYSES OF CANNED CUTTINGS SAMPLES

Values Quoted are v.p.m. of Evolved Gas per One Hundred Grams of Cuttings.

Sample	C_1	C_2 SAT	C_2 OLEF	C_3 SAT	C_3 OLEF	iC_4	nC_4	C_4 OLEF	iC_5	nC_5	C_5 OLEF	C_6	C_7	C_8	C_9	Total
990m	18624	132	< 0.5	96	2.9	3.6	7.2	< 1	1.4	1.4		2.9				18871
1050m	4766	6.8	< 0.5	5.4	0.7	< 0.7		< 0.5	0.7			0.7				4781
1100m	2462	2.4	< 0.5	2.4	0.8	< 0.7		< 0.5	0.5			< 0.5				2469
1200m	4519	2	< 0.5	1.6	< 0.5	< 0.4		< 0.5	0.4			< 0.5				4523
1250m	3386		< 0.5	0.8	< 0.5	< 0.5		< 0.5	< 0.5			< 0.5				3386
1300m	4138		< 0.5	2.9	< 0.5	< 1.4		< 0.5	1.4			1.4				4145
1350m	1238															1238
1400m	717		1.4	0.5		0.5	0.5		0.5	0.5						721
1550m	78															78
1600m	57															57
1650m	554	3.4		2.3		0.6	0.6		0.3	0.3						562
1700m	2219	10.6		5.1		3.0	1.5		1.0	0.5		1.0				2241
1750m	1494	10.5		5.7		1.4	1.4		1.0	1.0		1.0				1513
1800m	361	3.7		1.8		0.9	0.9		0.9	0.5						370
1850m	315	3.2		1.6		1.0	1.0		0.6	0.6		0.6				324
1900m	320	3.8		2.6		1.6	1.3		1.1	0.9		0.9				332
1950m	670	7.1		4.3		2.1	2.1		1.4	1.1		1.1				689
2000m	911	8.9		5.3		2.8	2.8		1.9	1.4		1.4				935
2050m	960	12.4		7.9		4.3	4.1		3.1	1.9		1.9				995
2100m	478	6.2		4.4		2.8	2.6		2.3	1.3		1.5				499
2150m	454	9.4		8.4		5.7	4.9		4.9	2.2		1.9				491
2200m	962	17.8		12.6		8.0	5.7		6.9	2.3		4.6				1020
2250m	595	13.8		12.8		8.5	7.8		6.7	2.5		3.5				651

Table continued :-

TABLE 1 (continued)

Sample	C_1	C_2 SAT	C_2 OLEF	C_3 SAT	C_3 OLEF	iC_4	nC_4	C_4 OLEF	iC_5	nC_5	C_5 OLEF	C_6	C_7	C_8	C_9	Total
2300		232				7.2				6.8		4.5				251
2350		430		6.4		4.6	5.0		5.0	2.3						454
2400		58				1.9				0.9		0.9				62
2450m		221		4.7		5.5				3.5		1.6				236
2500m	357	12.6	19	12.6		9	7.2	8	5.4	3.6		5.4				435
2550m	119	3.2		4.8		4.8	1.6			1.6						135
2600m	3287	156		196		157	78		48	26		26				3974
2650m	1089	82		95		59	29		15	7.3		7.3				1384
2700m		1327		90		88	49		34	15		20				1623
2740m	1273	37		44		30	16		10	3.2						1413
2750m	1166	71	< 0.5	115	0.9	103	48	1.8	39	13	0.9	15				1573
2800m	98	8	< 0.5	12	< 0.5	9	5	0.6	4.3	1.6	< 0.5	0.3				138
2850m	468	57	< 0.5	74	0.5	46	24	0.5	19	7.0	< 0.5	3.2				2267
2900m	518	32	< 0.5	53	1.8	40	19	1.8	14	11	< 0.5	5.3				695
2950m	1057	67	< 0.5	89	< 0.5	70	28	2.2	17	6.5	< 0.5	2.2				1339
3000m	467	54	< 0.5	61	< 0.5	34	16	< 0.5	12	4.5	< 0.5	1.5				651
3050m	645	74	< 0.5	102	1.7	47	24	3.4	16	5.2	< 0.5	3.4				921
3100m	550	50	< 2.5	75	< 2.5	40	20	< 2.5	15	5.0	< 2.5	5.0				760
3200m	1865	393	< 0.7	483	1.4	152	71	< 0.7	28	10	< 0.7	5.0				3229
3250m	1285	90	172	134	41	51	30	95	16	6.6	2.0	4.0				1846
3300m	1218	137	138	94	91	24	27	42	11	8.0	19	8.0				1818
3350m	390	45	57	27	36	7.1	9.1	19	4.3	2.8	7.1	3.6				608
3450m	317	35	26.5	36	21	7.3	7.9	12	2.6	3.3	5.3	3.3				477
3500m	1292	125	173	109	98	18	25	54	8.2	8.2	4.7	8.2				1966
3550m	6838	402	653	542	282	113	131	140	47	42	71	31				9293
3600m	931	92	166	82	71	15.3	22	33	9.7	7.9	20	12				1462
3650m	854	55	137	52	59	7.9	15	38	7.0	6.0	11	11				1242

Table continued :-

TABLE 1 (continued)

Sample	C_1	C_2 SAT	C_2 OLEF	C_3 SAT	C_3 OLEF	iC_4	nC_4	C_4 OLEF	iC_5	nC_5	C_5 OLEF	C_6	C_7	C_8	C_9	Total
3700m	1385	94	117	49	51	7	9	20	3.0	4.0	7	4.0				1750
3760m	617	104		36	17	5	6	8	2.3	2.0	1.4	2.8				802
3810m	1640	142	< 0.5	54	15	6	8	2.8	2.5	1.9	3.5	3.8	2.2			1880
3860m	2137	521	< 0.5	136	< 0.5	12	16	< 0.5	6.0	3.5	< 0.5	5.8	8.0			2845
3900m	366	114	< 0.5	20	< 0.5	1	1	< 0.5	0.5	0.5	< 0.5	0.5	< 0.5			504
3940m	1026	345	< 0.6	78	< 0.6	6.9	7.7	< 0.6	2.6	1.3	1.3	2.6	3.8			1479
4000m	1266	211	< 0.5	60	< 0.5	10	10	0.6	8.0	3.1	1.9	15	8.0			1595
4050m	3894	480	< 0.5	88	< 0.5	11	13	0.5	8.0	3.8	1.0	13	5.7			4516
4100m	1210	639	< 0.5	173	< 0.5	8	11	< 0.5	2.4	1.2	< 0.5	3.6	1.2			2049
4150m	13,263	3863	< 0.5	2352	0.8	389	712	8	290	229	9.5	443	319			21878
4200m	13,430	2741	< 0.5	1931	< 0.5	175	422	1.6	136	132	2.1	217	63			18724
4250m	20,185	4058	< 0.5	2281	< 0.5	252	764	1.8	229	312	477		265	77	12	28914
4300m	5,576	1982	33	1494	1.7	181	520	1.7	150	182	290		178	28	44	10659
4350m	15,219	4528	190	3197	16	362	1108	12	287	364	469		217	58	34	26062
4400m	11,761	4789	208	3466	33	400	1285	34	389	467	957		457	111	105	24462
4450m	15,395	4616	134	2897	32	321	750	23	216	186	323		162	52	20	25125
4470m	23,358	6937	150	3689	22	402	910	13	250	236	344		182	50	12	36558

TABLE 2

NORWAY : WELL 35/3-1

LIGHT HYDROCARBON ANALYSES OF CANNED CIRCULATING DRILLING MUD AND WET CUTTINGS FROM SIMILAR DEPTHS

Values Quoted are v.p.m. of Evolved Gas in Head Space

SAMPLE	C_1	C_2 SAT	C_2 OLEF	C_3 SAT	C_3 OLEF	iC_4	nC_4	C_4 OLEF	iC_5	nC_5	C_5 OLEF	C_6	C_7	C_8	C_9	TOTAL
Depth of origin (m)					M U D S											
550			130,000			5	10	< 0.5	4	4	9		< 0.5	< 0.5	< 0.5	130032
1500	15743		< 0.5	43	< 0.5	22	22	< 0.5	22	11	14		10	< 0.5	< 0.5	15887
2500	83	2	< 0.5	2	< 0.5	3	2	< 0.5	1	1	< 0.5		< 0.5	< 0.5	< 0.5	94
3000	566		6	9	2	7	3	1	3	1	< 0.5	1	-	-	-	599
3500	5007	327	455	266	210	43	60	92	21	20	30	31	8	-	-	6570
4000	9525	633	13	262	2	50	52	2	36	15	45		18	3	< 0.5	10656
Depth of origin (m)					C U T T I N G S											
1500	17906															17906
2500	397	14	21	14		10	8	9	6	4		6	-	-	-	459
3000	313	36	< 0.5	41	< 0.5	23	11	< 0.5	8	3	< 0.5	1	-	-	-	436
3500	1731	168	232	146	131	24	33	73	11	11	63	11	-	-	-	2634
4000	2051	342	< 0.5	98	< 0.5	16	17	1	13	5	3	25	13	-	-	2584

TABLE 3

LIGHT HYDROCARBON ANALYSES OF CANNED CIRCULATING DRILLING MUD BEFORE AND AFTER HEATING*

Values Quoted are v.p.m. of Evolved Gas in Head Space

SAMPLE	C_1	C_2 SAT	C_2 OLEF	C_3 SAT	C_3 OLEF	iC_4	nC_4	C_4 OLEF	iC_5	nC_5	C_5 OLEF	C_6	C_7	C_8	C_9	TOTAL
Depth of Origin (m)	B E F O R E H E A T I N G															
550	130,000					5	10	< 0.5	4	4	9		< 0.5	< 0.5	< 0.5	130032
1500	15743		< 0.5	43	< 0.5	22	22	< 0.5	22	11	14		10	< 0.5	< 0.5	15887
2500	83	2	< 0.5	2	< 0.5	3	2	< 0.5	1	1	< 0.5		< 0.5	< 0.5	< 0.5	94
3000	566		6	9	2	7	3	1	3	1	< 0.5	1	-	-	-	599
3500	5007	327	455	266	210	43	60	92	21	20	30	31	8	-	-	6570
4000	9525	633	13	262	2	50	52	.2	36	15	45		18	3	< 0.5	10656
Depth of Origin (m)	A F T E R H E A T I N G															
550	N O G A S L E F T															
1500	2696			9	1	4	4				5			-	-	2719
2500	52	5		1	1	2					2			-	-	63
3000	475			32	1	6	4	< 0.5	3			5	-	-	-	526
3500	4782		464	234	185	35	58	82	20	18	36	22	6	-	-	5942
4000	19	9		7	1	1	3	< 0.5	1		< 0.5	1	-	-	-	42

* 4½ hours at 50°C

TABLE 4

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH, EXPLORATION AND PRODUCTION RESEARCH DIVISION

NORWAY : WELL 35/3-1

VITRINITE REFLECTANCE MEASUREMENTS

SAMPLE	MEAN VITRINITE REFLECTANCE	
	AUTOCHTHONOUS	ALLOCHTHONOUS
900	$0.24_{(20)}$	
1000	$0.23_{(20)}$	0.46(1)
1050	$0.25_{(21)}$	
1100	$0.28_{(22)}$	
1150	$0.33_{(15)}$	
1200	$0.35_{(18)}$	$0.56_{(2)}$
1250	$0.32_{(20)}$	
1300	$0.40_{(18)}$	$0.65_{(2)}$
1350	$0.35_{(20)}$	
1400	$0.34_{(20)}$	
1450	$0.37_{(4)}$	$0.74_{(12)}$
1500	$0.38_{(5)}$	$0.72_{(15)}$
1550	$0.37_{(25)}$	
1700	$0.41_{(7)}$	
1800	$0.36_{(20)}$	
1850	$0.49_{(8)}$	
2050	$0.37_{(15)}$	$0.59_{(3)}$
2350	$0.43_{(20)}$	
2400	$0.45_{(10)}$	
2450	$0.46_{(2)}$	
2740	$0.51_{(19)}$	
2750	$0.57_{(6)}$	
2850	$0.53_{(6)}$	
2900	$0.56_{(15)}$	
2950	$0.60_{(9)}$	
2996*	$0.53_{(7)}$	$1.16_{(10)}$
2997*	$0.57_{(18)}$	
3000	$0.52_{(6)}$	
3024*	$0.53_{(21)}$	
3250	$0.53_{(20)}$	

Figures in parenthesis are the number of separate determinations.

TABLE 4

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH, EXPLORATION AND PRODUCTION RESEARCH DIVISION

NORWAY : WELL 35/3-1

VITRINITE REFLECTANCE MEASUREMENTS

SAMPLE	MEAN VITRINITE REFLECTANCE					
	AUTOCHTHONOUS	ALLOCHTHONOUS				
3350*	0.60 (11)	0.80 (9)				
3375*	0.57 (20)					
3400*	0.63 (1)		1.41 (19)			
3600	0.57 (22)					
3650	0.59 (1)					
3700	0.59 (1)					
3750*	0.60 (13)					
3835*	0.62 (1)					
3860*	0.64 (4)					
3834*		1.03 (9)				
3900*	0.66 (2)	1.20 (16)		1.68 (18)	2.02 (1)	
3915*	0.65 (20)					
3935*		1.15 (20	1.34 (4)		2.48 (2)	
3955*			1.45 (7)			
3983*			1.48 (19)			
3993*	0.66 (4)	1.05 (1)				
400.5*			1.44 (13)			
4018*			1.48 (10)			
4042*		0.98 (19)	1.54 (2)			
4069*			1.44 (9)		2.14 (2)	
4080*			1.53 (6)			
4085*			1.36 (18)			
4099*			1.50 (22)			
4119*		0.95 (19)				
4140*			1.37 (11)			
4157*	0.69 (22)					
4170*		0.86 (15)				
4200*		0.82 (20)				
4221*	0.68 (20)					
4456.5*	0.72 (10)					

*swc

Figures in parenthesis are the number of separate determinations.

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH, EXPLORATION AND PRODUCTION RESEARCH DIVISION

TABLE 5

NORWAY : WELL 35/3-1

BASIC SOURCE ROCK DATA

SAMPLE	AGE	DEPTH m ft	SAMPLE* TYPE/ MAIN LITHOLOGY	KEROGEN CARBONISATION CR/CT	CARBONATE % WT (HCl SOLUBLES)	TOTAL ORGANIC CARBON (TOC)% WT	TOTAL SOLUBLE EXTRACT (TSE)% WT	TSE TOC INDEX ‰	SAC TOC INDEX ‰	TSE		SOURCE ROCK POTENTIAL
										SATURATE ALKANE CONTENT (SAC)% WT	PRISTANE/ PHYTANE RATIO pr/ph	
	OLIG	990	cttgs	0.26	41	0.73	0.0123	17	25	15		
		1050	cttgs	0.12	27	0.22	0.0110	50	15	30		
	EOC	1150	cttgs	0.17	27	0.53	0.0535	101	33	33		
		1250	cttgs	0.18	9	0.39	0.00429	11	1	9		
	PAL	1350	cttgs	0.51	7	1.37	0.0149	11	0.7	6		
		1450	cttgs	0.077	9	0.28	0.00249	9	1.3	14		
		1550	cttgs	0.18	22	0.66	0.00407	7	0.7	10		
	UPPER CRETACEOUS	1650	cttgs	0.10	8	0.45	0.00276	6	0.8	13		
		1750	cttgs	0.27	20	0.49	0.00569	12	1.4	12		
		1850	cttgs	0.31	14	0.55	0.00426	8	0.9	11		
		1950	cttgs	0.19	11	0.44	0.00528	12	1.7	14		
		2050	cttgs	0.35	13	0.47	0.00435	9	1.6	18		
		2150	cttgs	0.26	5	0.44	0.00407	9	0.9	10		
		2250	cttgs	0.44	6	0.67	0.00677	10	0.8	8		
		2350	cttgs	0.43	10	0.62	0.00613	10	0.5	5		
		2450	cttgs	0.39	12	0.52	0.00345	7	0.6	9		
		2550	cttgs	0.42	30	0.45	0.0261	58	18	31		
		2650	cttgs	0.62	21	4.09	0.103	25	0.8	7		
		2740	cttgs	0.35	21	0.41	0.0103	25	4	17		
		2750	cttgs		21	0.37	0.00914	25	8	30		
		2850	cttgs	0.47	8	0.83	0.0183	22	5	23		
		2950	cttgs	0.46	27	0.54	0.238	44	12	27		

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH, EXPLORATION AND PRODUCTION RESEARCH DIVISION

TABLE 5 (continued)

NORWAY : WELL 35/3-1

BASIC SOURCE ROCK DATA

SAMPLE	AGE	DEPTH m / ft	SAMPLE* TYPE/ MAIN LITHOLOGY	KEROGEN CARBONISATION CR/CT	CARBONATE % WT (HCl SOLUBLES)	TOTAL ORGANIC CARBON (TOC)% WT	TOTAL SOLUBLE EXTRACT (TSE)% WT	TSE / TOC INDEX ‰	SAC / TOC INDEX ‰	TSE		SOURCE ROCK POTENTIAL
										SATURATE ALKANE CONTENT (SAC)% WT	PRISTANE/ PHYTANE RATIO pr/ph	
	LATE ALBIAN	3024	swc	0.38	26	0.55	0.0178	33	16	49		
		3150	cttgs	0.43	14	0.70	0.0174	25	8	31		
		3250	cttgs	0.48	20	0.67	0.0190	29	7	23		
		3350	cttgs	0.47	23	0.65	0.0193	30	11	38		
		3450	cttgs	0.57	49	0.78	0.0219	28	10	36		
		3550	cttgs	0.67	42	0.92	0.0302	33	10	29		
		3650	cttgs	0.53	44	0.51	0.0183	36	15	43		
		3750	swc	0.73	28	1.32	0.0417	31	9	28		
		3810	cttgs	0.73	29	1.09	0.0234	22	5	21		
		3874.5	swc	0.75	8	1.63	0.0373	23	6	25		
		3900	cttgs	0.69	12	1.13	0.0357	31	16	51		
	LATE APTIAN	3955	swc	0.34	7	0.07	0.0105	142	51	36		
		3993	swc	0.19	6	0.16	0.0440	273	180	66		
		4025	swc	0.77	7	1.63	0.0374	23	10	45		
		4069	swc	0.72	22	0.74	0.0241	32	8	26		
		4110	swc	0.74	7	1.44	0.0266	18	4	24		
	EARLY OXF	4160.5	swc	0.52	18	0.37	0.208	566	198	35		
		4200	cttgs	0.69	39	2.53	0.095	37	8	22		
	MID BAJ.	4219.5	swc	0.37	19	0.32	0.085	268	94	35		
		4224.5	swc	0.51	12	0.44	0.109	251	65	26		
		4221	swc	0.54	21	2.45	0.162	66	13	20		
		4281	swc	0.64	5	3.41	0.212	62	16	26		
	EARLY BAJ.	4305	swc	0.80	50	3.08	0.260	84	15	18		
		4370	swc	0.66	20	2.21	0.131	59	14	24		
		4456.5	swc	0.54	23	1.21	0.177	147	35	24		

BRITISH PETROLEUM RESEARCH CENTRE

EXPLORATION AND PRODUCTION DIVISION

VISUAL KEROGEN DESCRIPTIONS.

TABLE 6

NORWAY : WELL 35/3-1

Samples: Depth in metres	Type	Miospores: Trace/Rare 1-2	Common 3	Frequent 4	Abundant 5	Phyto-plankton excluding Tasmanitids 1-2	3	4	5	Tasmanitids 1	2	3	Contamination	Vascular plant debris: Cuticles 1-2	3	4-5	Brown "wood" (lignite) 1-2	3	4-5	Black "wood" (vitrain fusain) 1-2	3	4-5	Finely disseminated 1-2	3	4-5	Sapropelised 1-2	3	4-5	Amorphous (algal) 1-2	3	4	5	Preservation: good	fair	poor	Colour/Maturation 1	2	3 (Threshold ?)	4	5	6	7	Source potential	Depositional environment: Marine undifferentiated	Open marine	Near-shore marine	Restricted marine	Non-marine	Unknown
2970	SWC	•					•							•							•		•										•				•						–		•				
3400	SWC	•					•							•								•	•										•					•					–		•				
3750	SWC	•					•							•							•		•										•					•					–		•				
3860	SWC		•					•														•	•										•					•					–		•				
3900	SWC		•					•														•	•										•					•					–		•				
3935	SWC	•					•							•			•					•	•										•					•					–		•				
3983	SWC	•					•															•		•										•					•				–		•				
4000.5	SWC		•				•															•		•										•					•				–		•				
4025	SWC		•				•							•								•	•											•					•				–		•				
4042	SWC	•					•															•	•											•					•				–		•				
4080	SWC	•					•															•	•											•					•				–		•				
4110	SWC	•					•										•					•		•										•						•			–		•				
4140	SWC	•						•						•				•				•		•										•						•			–		•				
4151	SWC																			•												•											–						
4157	SWC			•			•							•				•			•			•				•							•					•			–				•?		
4160.5	SWC												•																														–						•
4170	SWC			•										•				•				•	•			•									•					•			Gas ?					•	
4180	SWC				•									•				•				•		•			•								•					•			Gas ?					•	
4207	SWC				•												•					•		•			•								•					•			Gas ?				•		
4214	SWC			•										•			•					•		•			•								•					•			Gas ?				•		
4217	SWC				•									•			•					•	•					•							•					•			Gas ?				•		
4221	SWC				•												•					•		•				•							•					•			Gas ?				•		
4224.5	SWC												•																														–						•
4225	SWC												•																														–						•
4241	SWC			•													•					•		•			•								•					•			Gas ?				•		

BRITISH PETROLEUM RESEARCH CENTRE

EXPLORATION AND PRODUCTION DIVISION

TABLE 6

NORWAY : WELL 35/3-1

VISUAL KEROGEN DESCRIPTIONS.

SAMPLES		MIOSPORES				PHYTO-PLANKTON EXCLUDING TASMANITIDS					TASMANITIDS			Reworking	VASCULAR PLANT DEBRIS				CUTICLES				BROWN "WOOD" (LIGNITE)					BLACK "WOOD" (VITRAIN FUSAIN)					FINELY DISSEMINATED				SAPROPELISED					AMORPHOUS (ALGAL)					PRESERVATION			COLOUR/MATURATION							SOURCE POTENTIAL	DEPOSITIONAL ENVIRONMENT						
Depth in metres	Type	Trace	Common	Frequent	Abundant	1-2	3	4	5		1	2	3		1-2	3	4-5		1-2	3	4-5		1-2	3	4-5			1-2	3	4-5			1-2	3	4-5			1-2	3	4-5			1-2	3	4	5		good	fair	poor	1	2	3	4	5	6	7		Marine undifferentiated	Open marine	Near-shore marine	Restricted marine	Non-marine	Unknown
		1-2	3	4	5																																																									
4265	swc		o			o									o				o						o		o			o	o				o											o			o									o		
4281	swc			o		o																			o		o			o		o			o											o			o									o		
4305	swc			o		o														o					o		o			o		o			o											o			o									o		
4370	swc		o			o																			o		o			o			o			o											o			o									o		
4456.5	swc			o		o									o				o						o		o			o	o				o											o			o									o		
4465.5	swc				o	o									o				o						o		o			o	o				o											o			o									o		

NORWAY : 35/3-1

LIGHT HYDROCARBON ANALYSES OF CANNED CUTTINGS SAMPLES

P 6711

METHANE

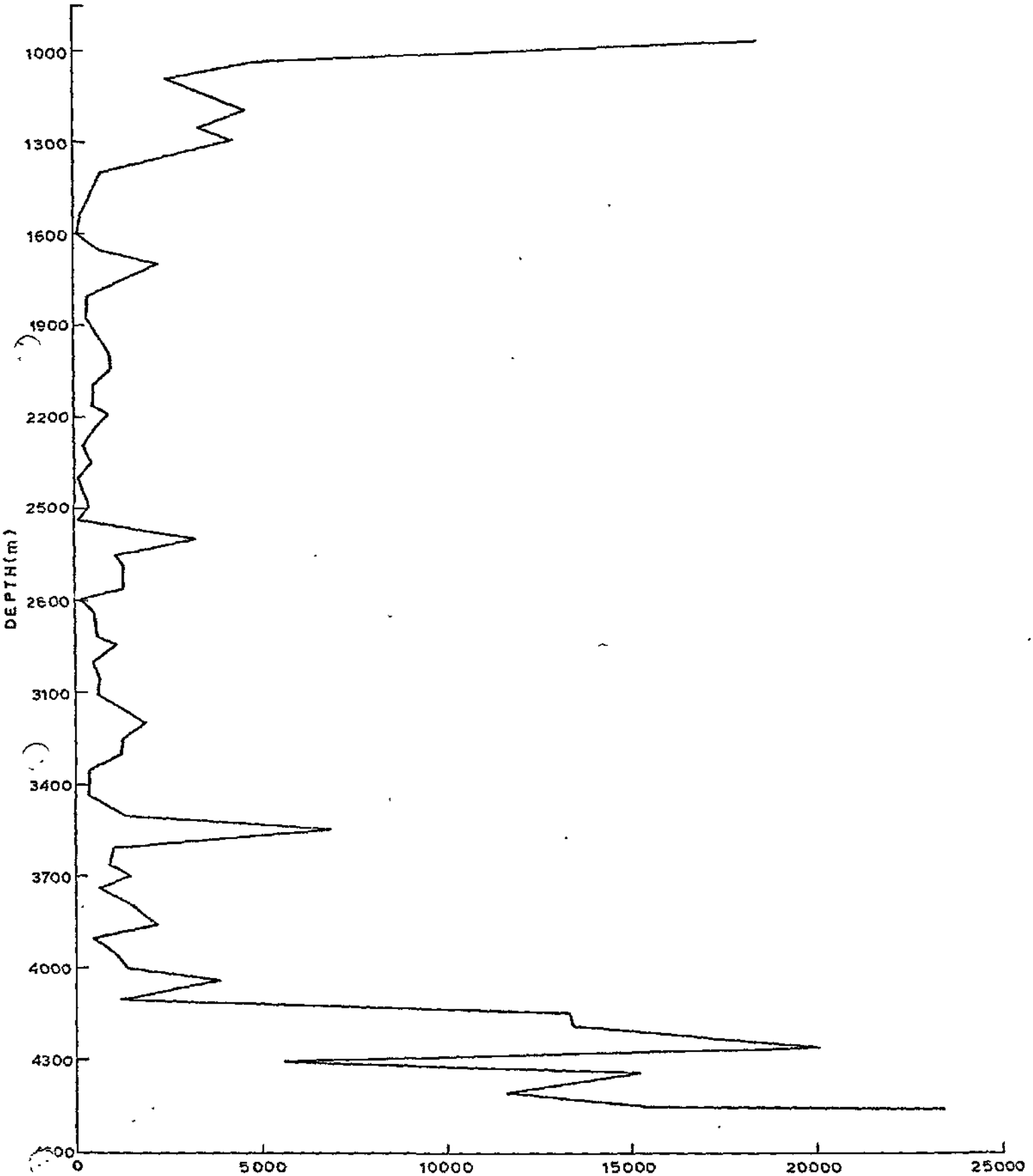
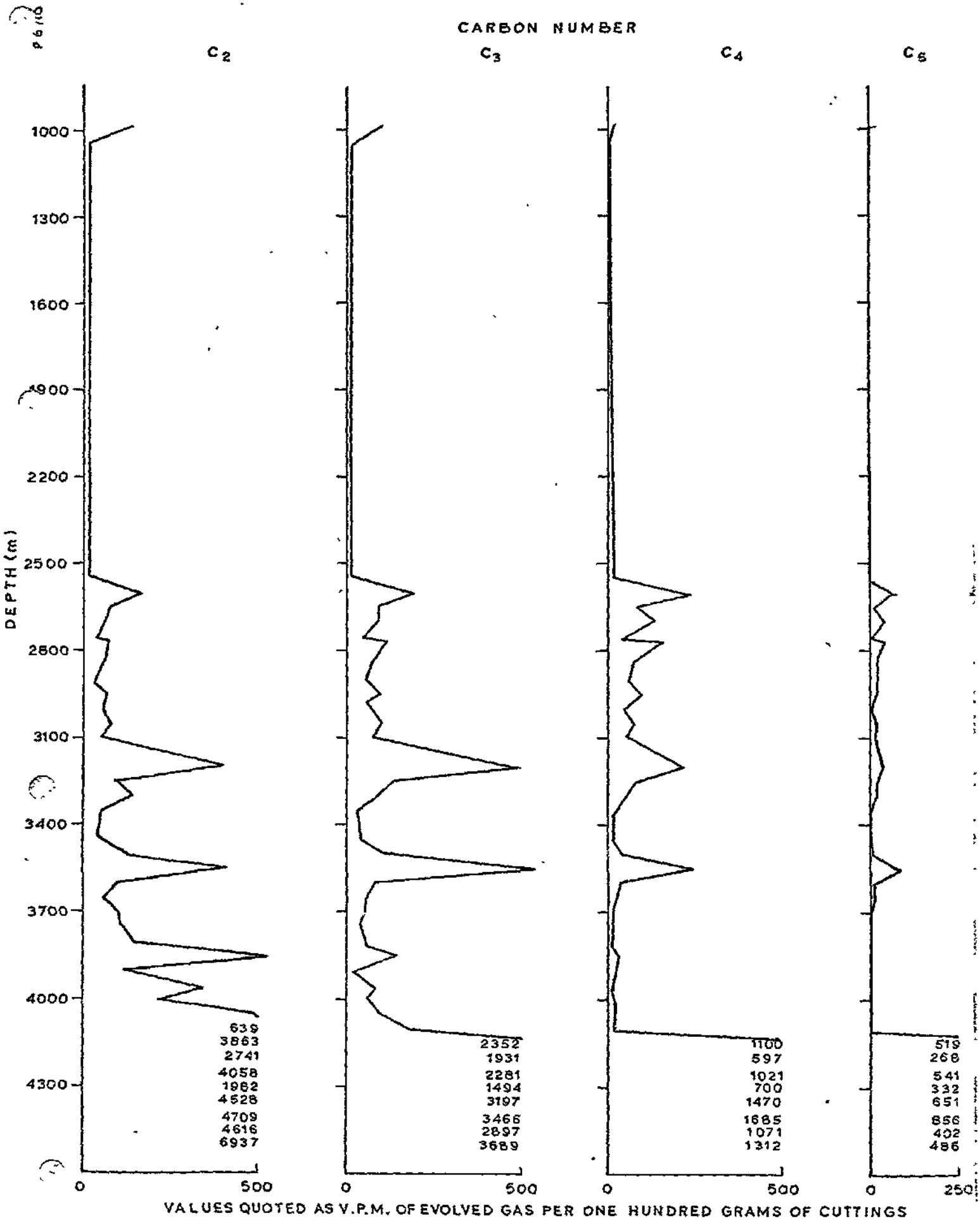


FIG. 1

NORWAY: 35/3-1

LIGHT HYDROCARBON ANALYSES OF CANNED CUTTINGS SAMPLES.

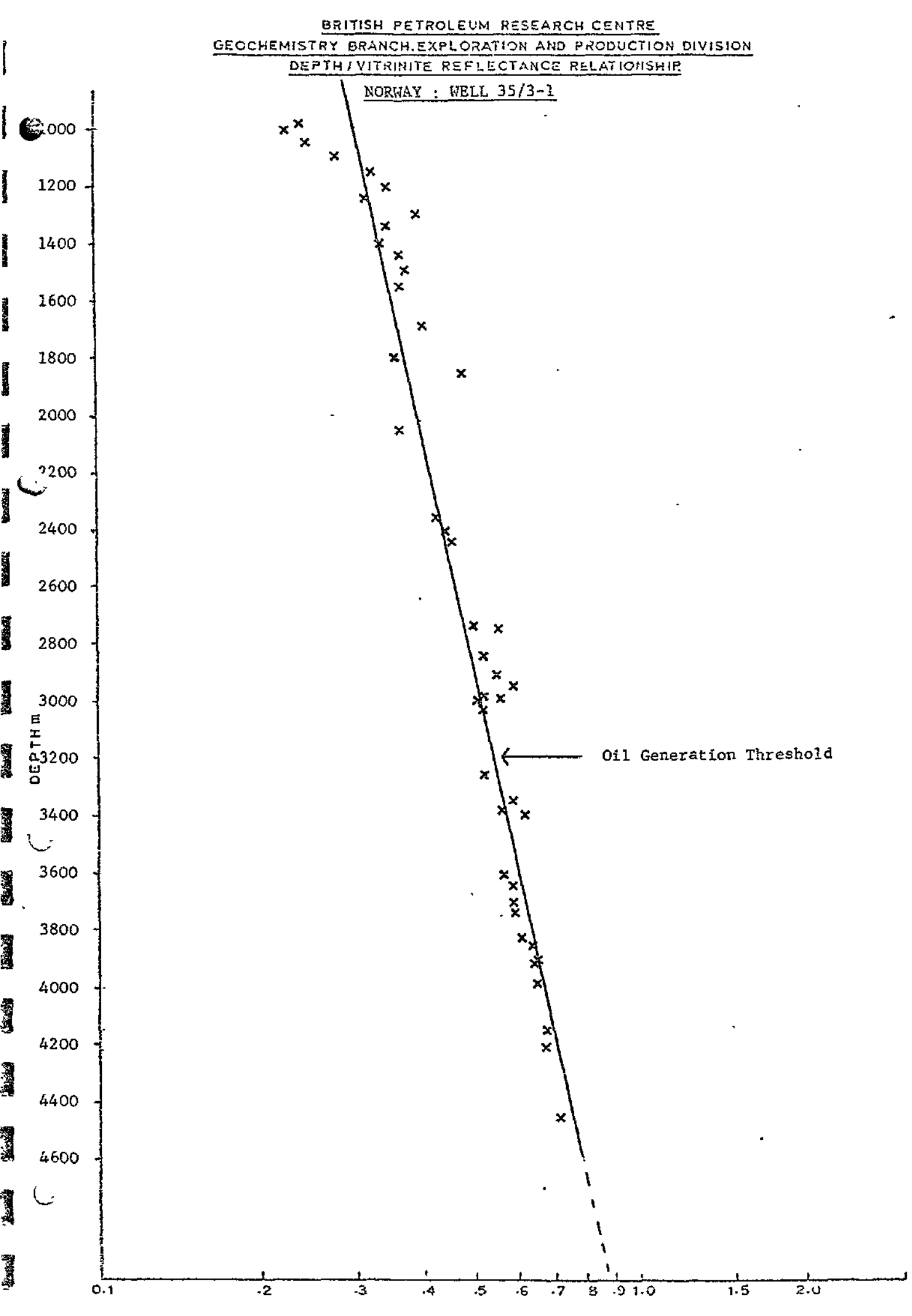


BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH, EXPLORATION AND PRODUCTION DIVISION

DEPTH / VITRINITE REFLECTANCE RELATIONSHIP

NORWAY : WELL 35/3-1



BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH. EXPLORATION AND PRODUCTION DIVISION.

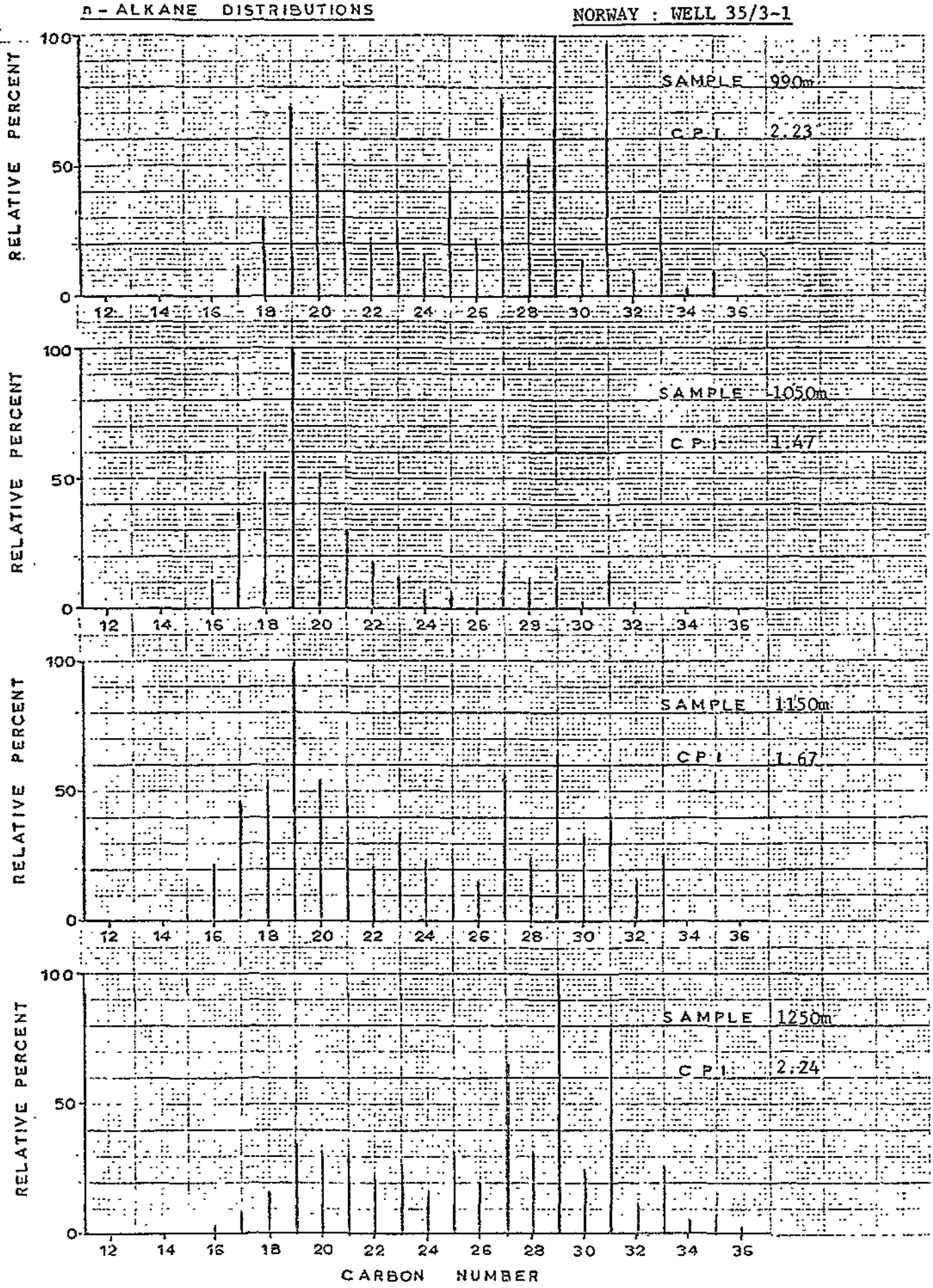


FIG. 4

BRITISH PETROLEUM RESEARCH CENTRE

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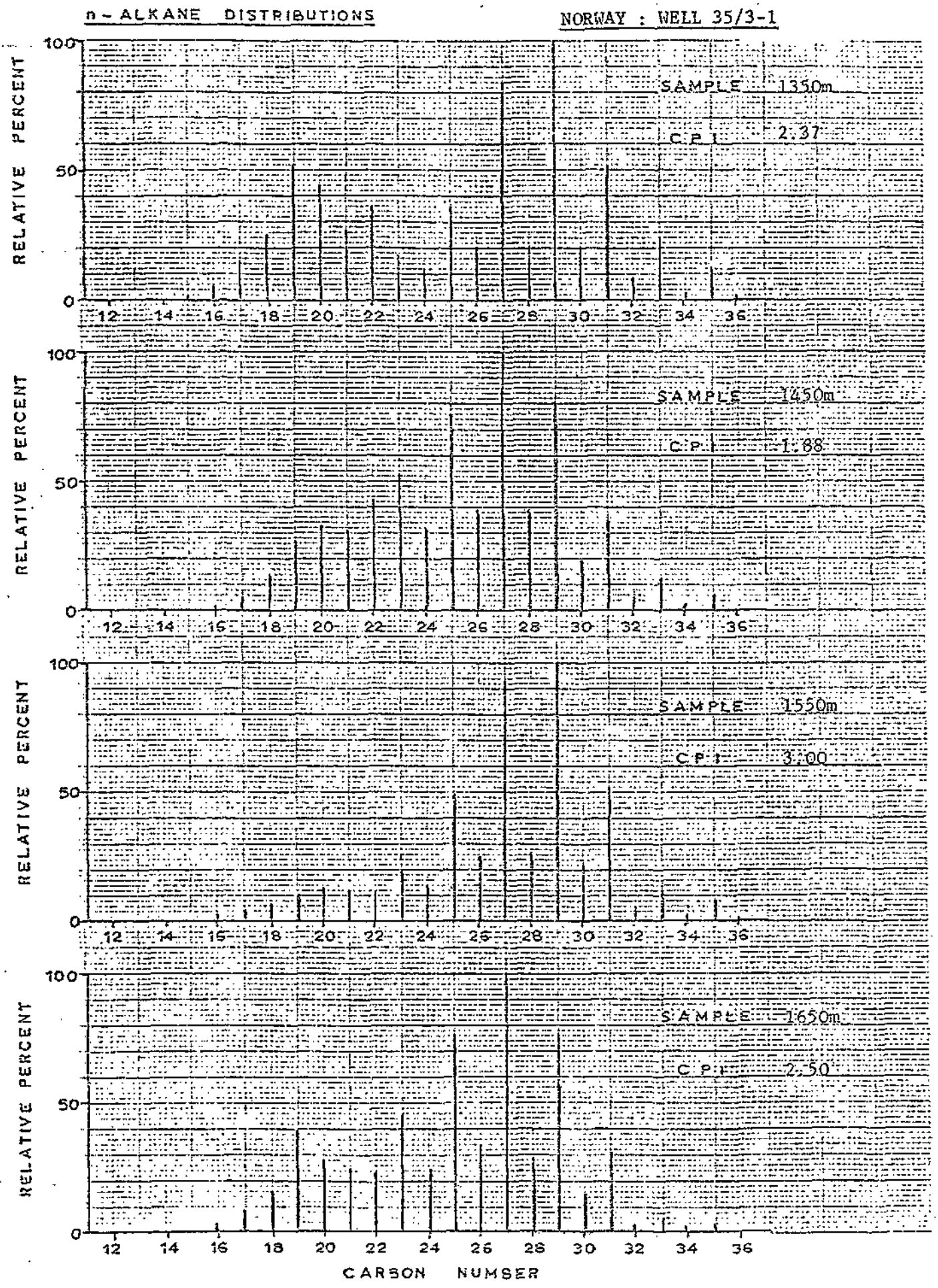

FIG. 5

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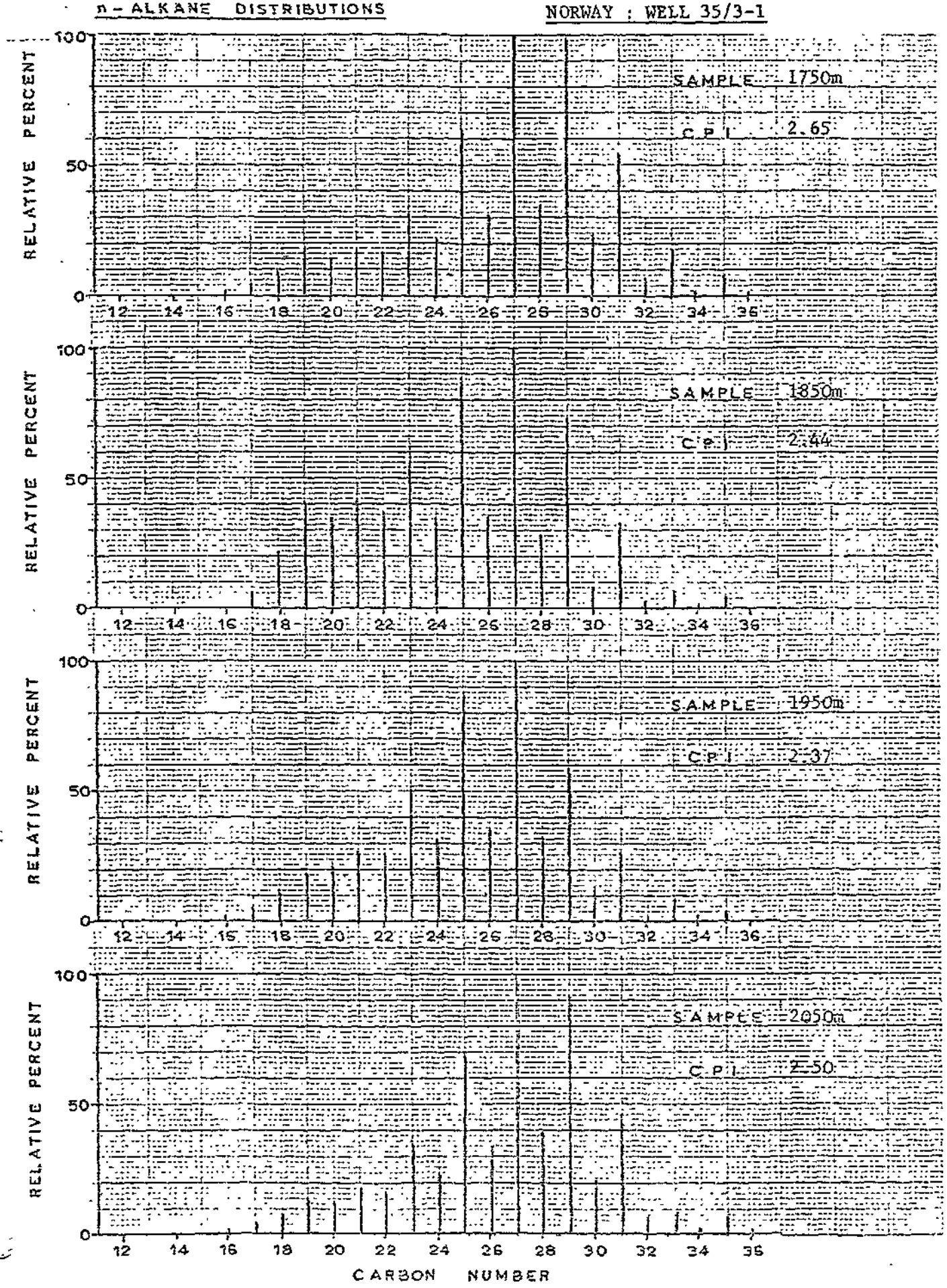

FIG. 6

BRITISH PETROLEUM RESEARCH CENTRE

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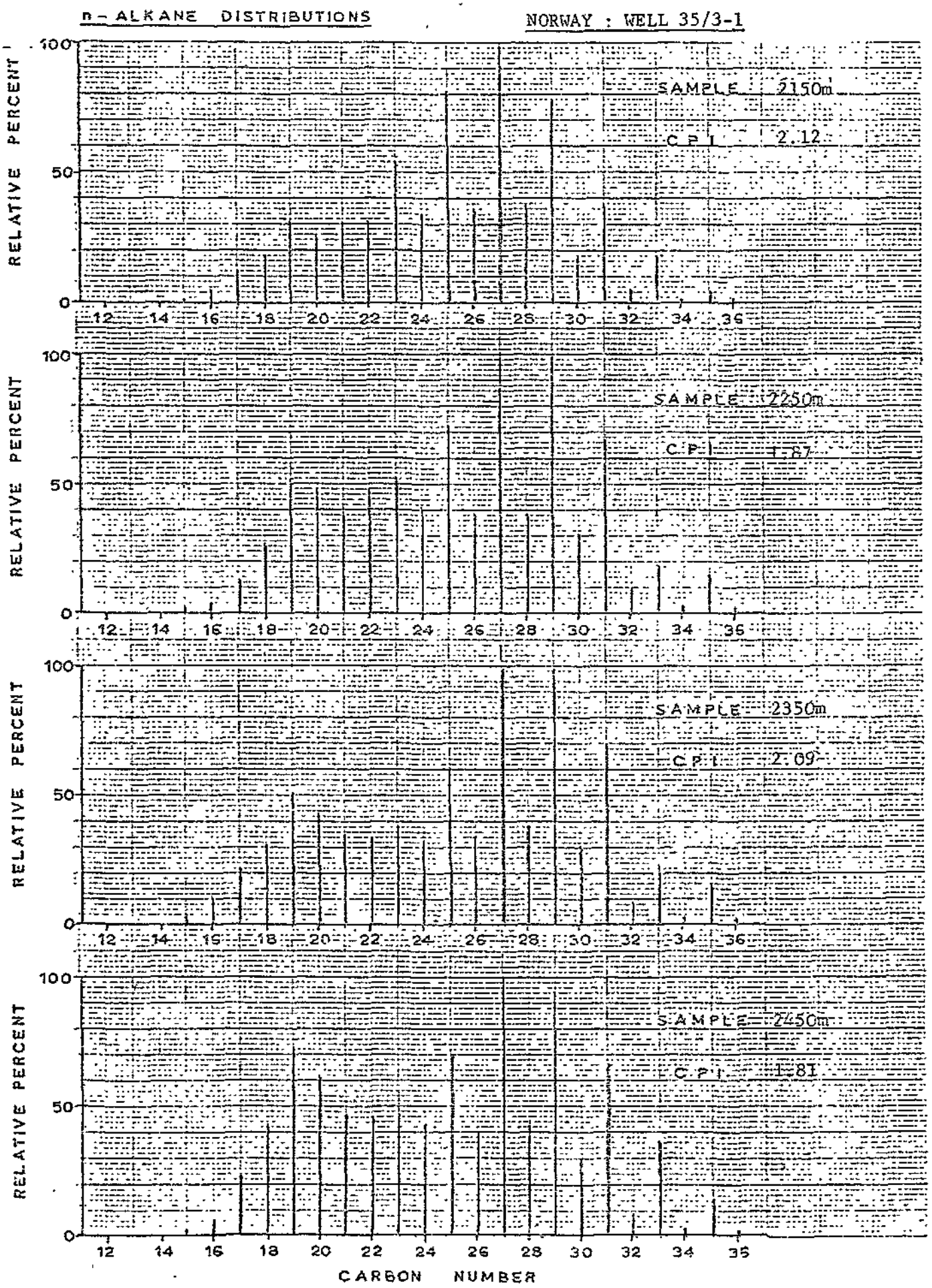

FIG. 7

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH. EXPLORATION AND PRODUCTION DIVISION.

n - ALKANE DISTRIBUTIONS

NORWAY : WELL 35/3-1

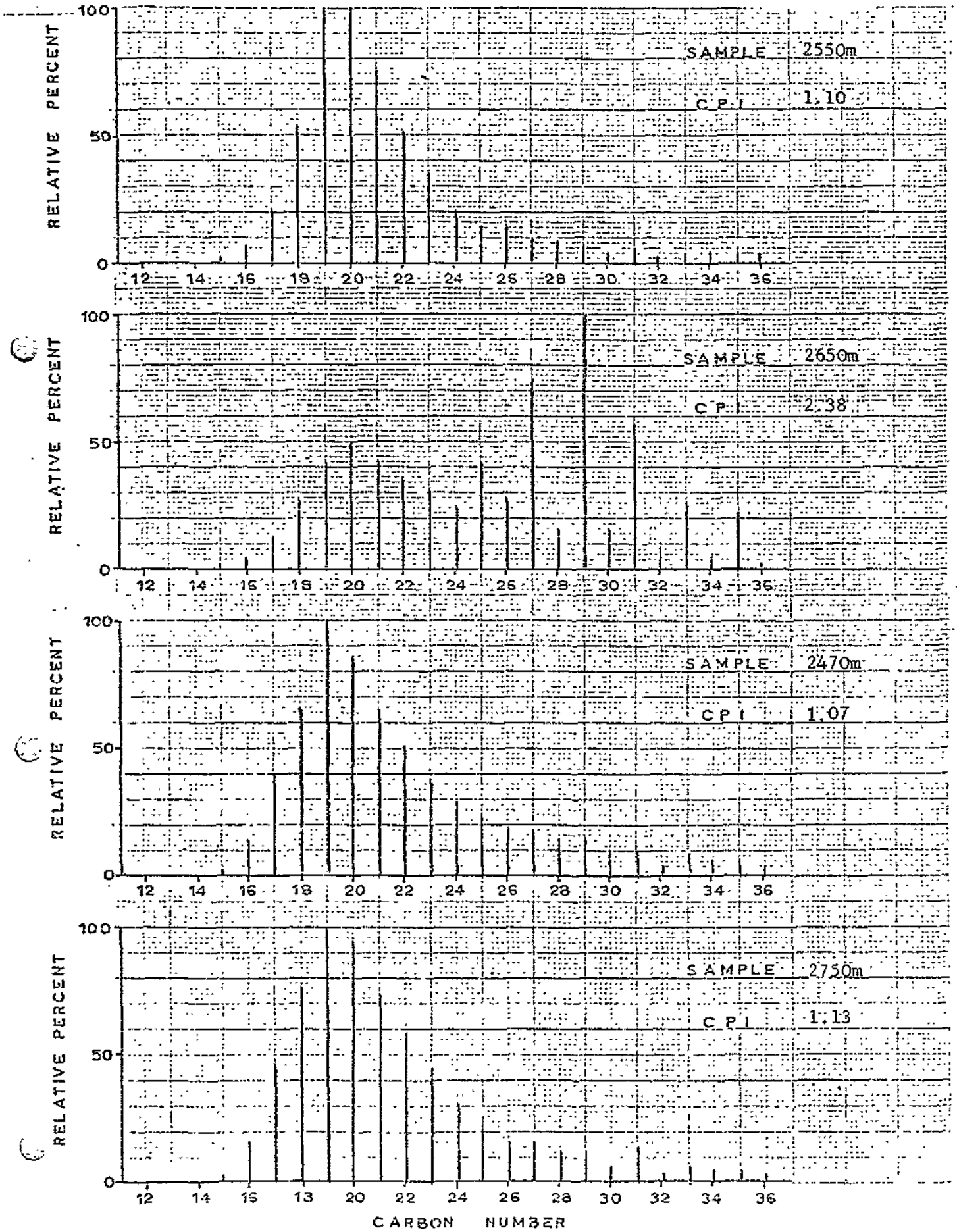

FIG. 8

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH. EXPLORATION AND PRODUCTION DIVISION.

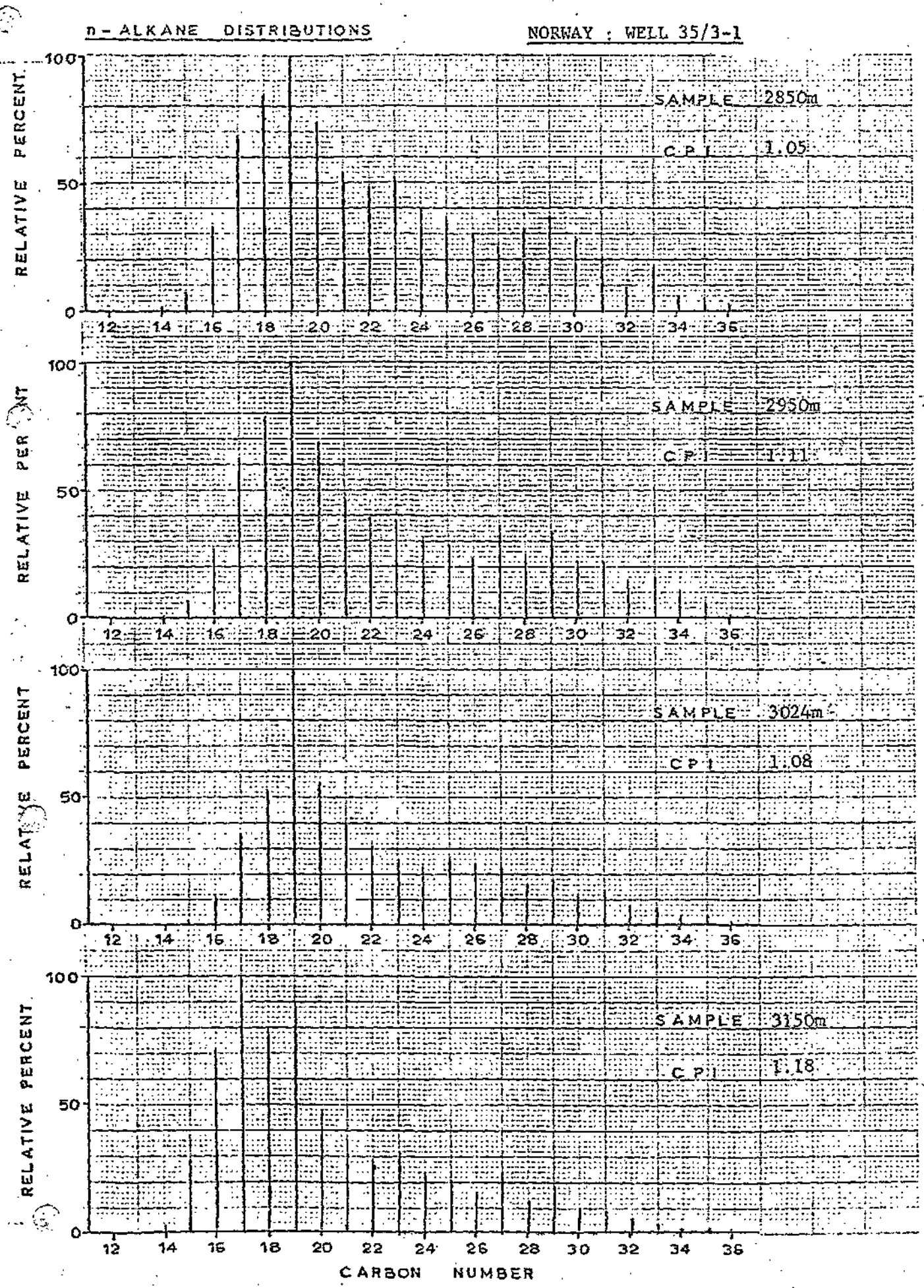

FIG. 9

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH. EXPLORATION AND PRODUCTION DIVISION.

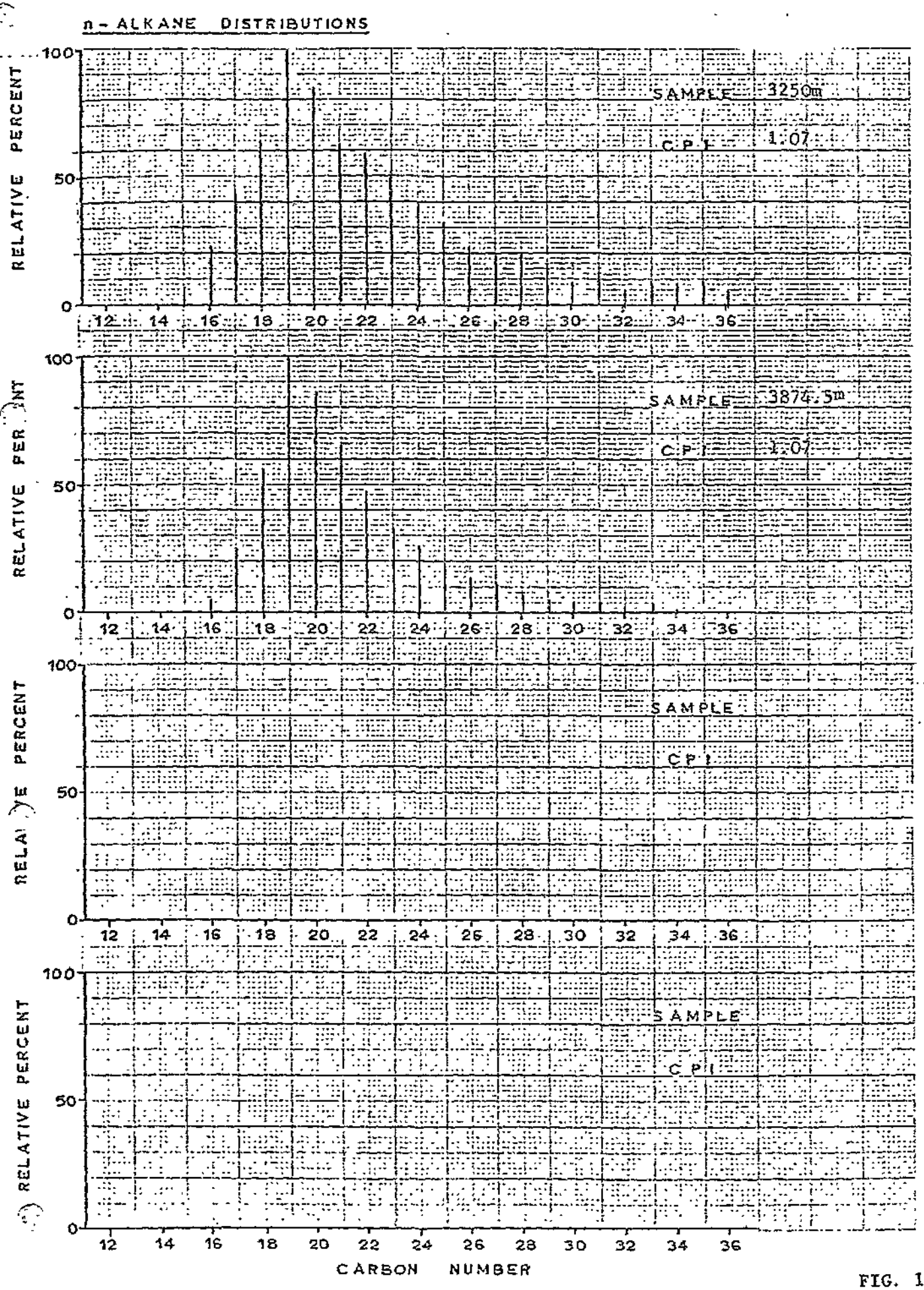

FIG. 10

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH. EXPLORATION AND PRODUCTION DIVISION.

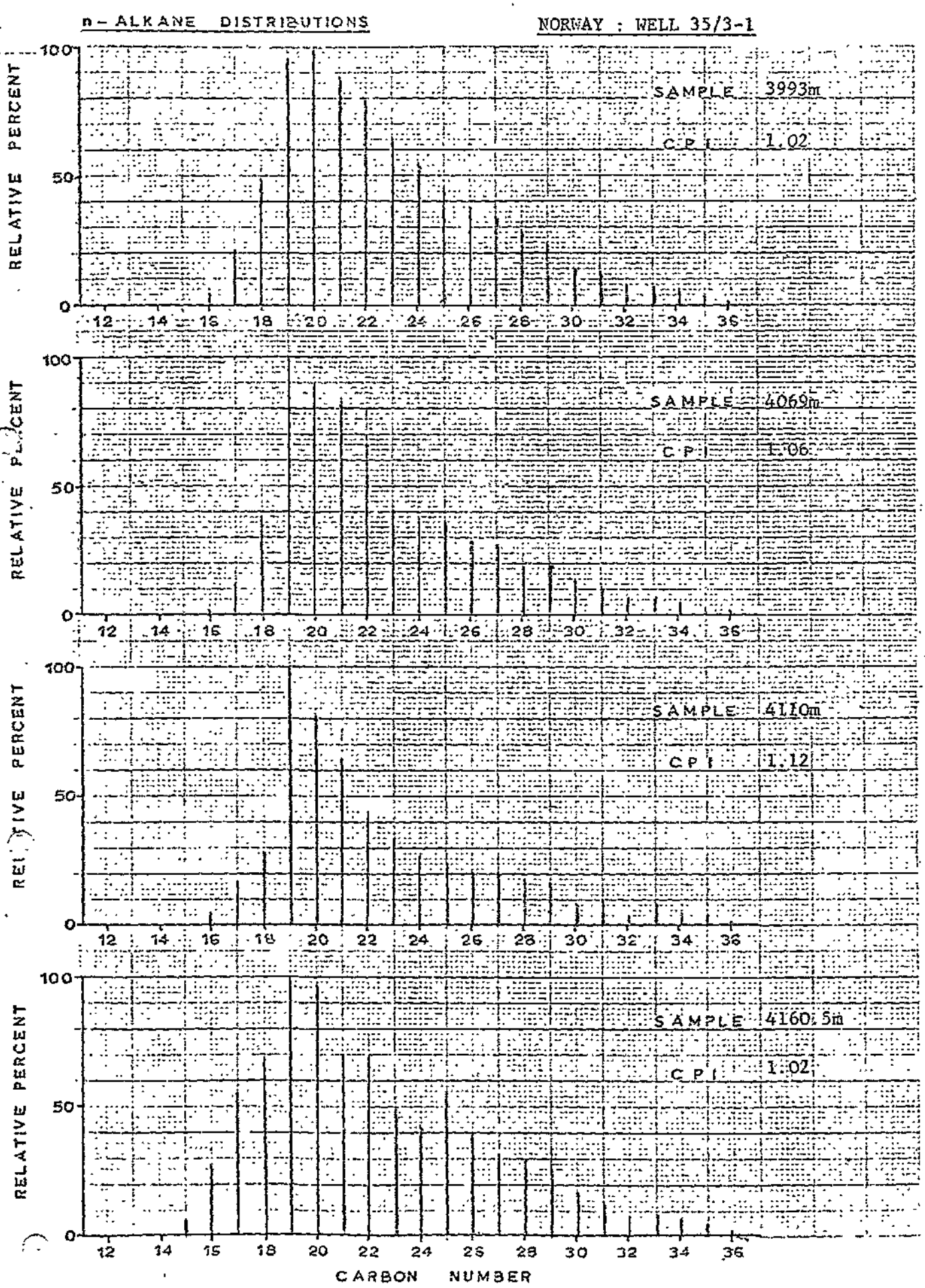

FIG. 11

BRITISH PETROLEUM RESEARCH CENTRE

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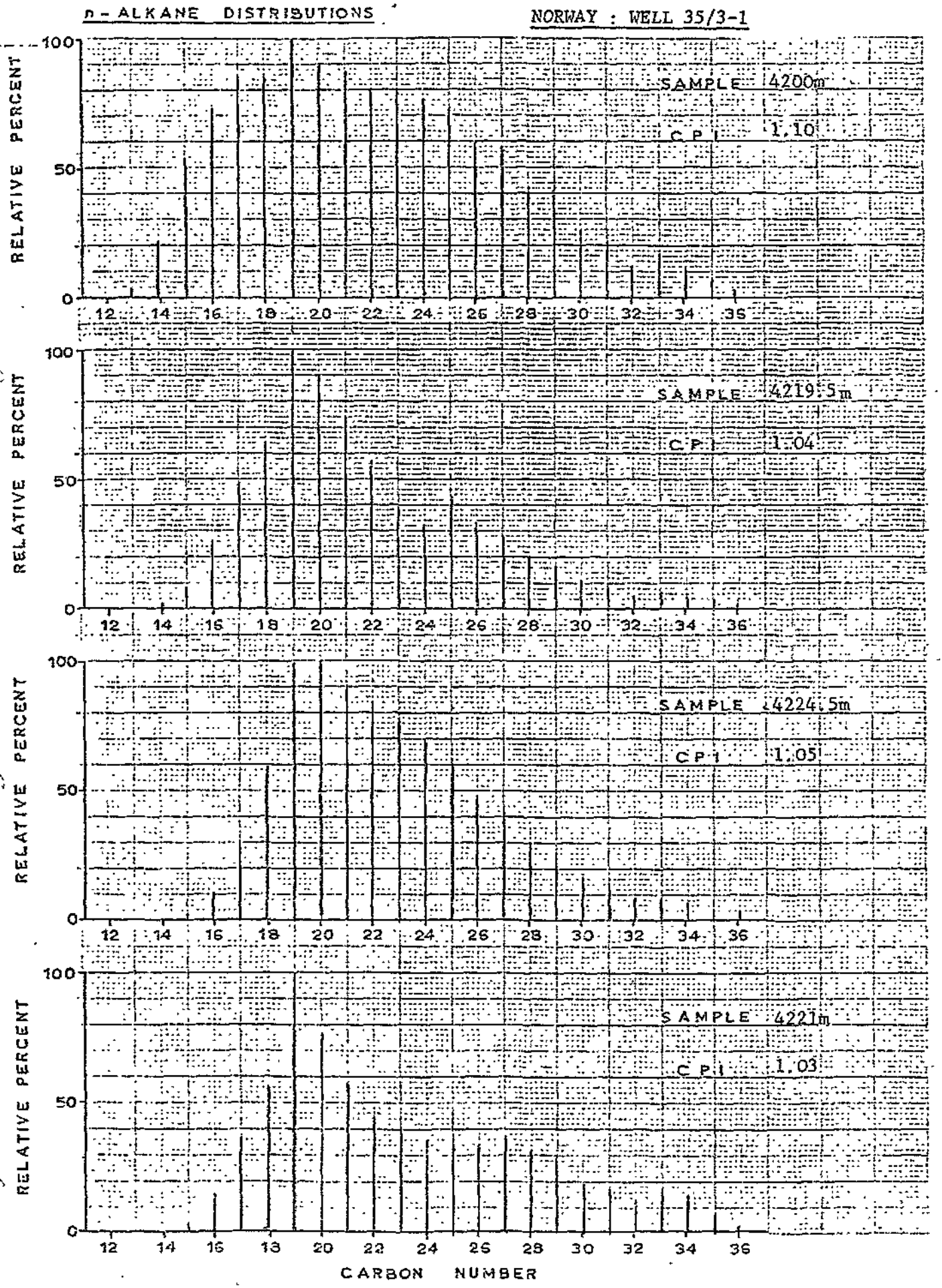

FIG. 12

BRITISH PETROLEUM RESEARCH CENTRE

GEOCHEMISTRY BRANCH, EXPLORATION AND PRODUCTION DIVISION.

n-ALKANE DISTRIBUTIONS

NORWAY : WELL 35/3-1

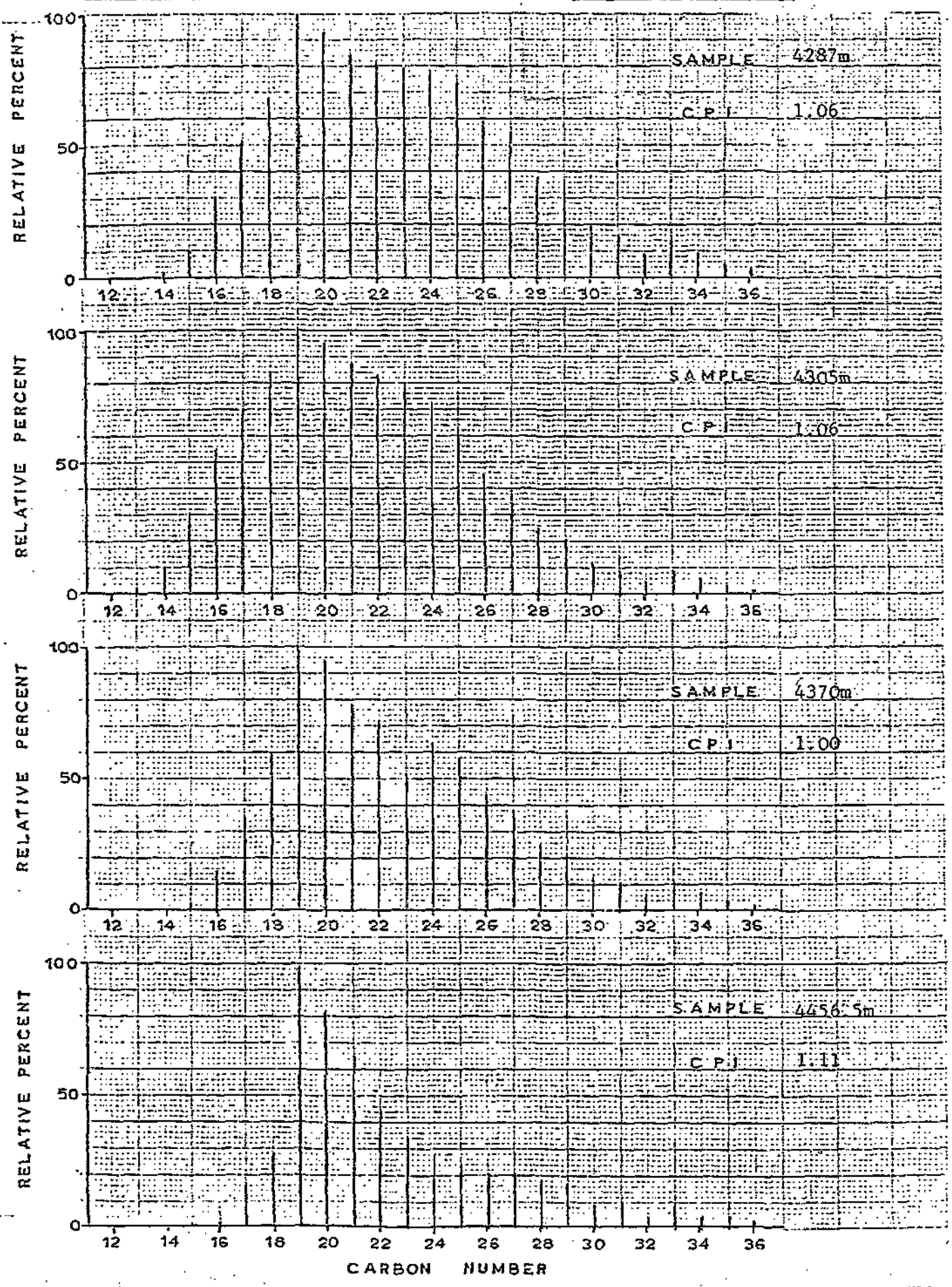

FIG. 13