UNIONOIL NORGE A/S
MUD RECORD

WELL: 8/4-1
R[illegible] "NORJARL"
TOTAL DEPTH: 2631.46M

SPUD DATE: 21st June 1977
MUD TYPE: LIME DRISPAC
LIGNOSULPHONATE

COMPLETION DATE: 25th June 197
FROM: 124.66 TO: 1756.89M
FROM: 1756.89 TO: 2631.46M

DATE	DEPTH	WEIGHT	VISC.	W.L.	PH	SALT	OIL	SAND	SOLIDS	REMARKS
6-22	125	Sea	Water	w/ Hi	vis s	/vgs				Set 30" csg
6-23	159	"	"	w/ Hi	vis s	/vgs				Drilling 26" hole
6-24	159	"	"	"	"	"				Drilling 17½" hole
6-25	433	9.1	63	75.0						" 17½" "
6-26	433	9.1	63	75.0						Reaming to 26" hole
6-27	433	9.1	63	75.0						" " "
6-28	433	Sea	Water							" " "
6-[illegible]	433	Sea	Water							" " "
6-30	433	Sea	Water							" " "
7-1	433	Sea	Water	and u	se Hi,	vis	slug			Set 20" csg.
7-2	694	8.9	65	30.0	12.5	28000		1%	4	Drilling 12-1/4" hole
7-3	1354	10.0	47	21.0	12.5	26400		1%	4	" " "
7-4	1388	10.5	47	26.0	12.0	26400		1%	12	" " "
7-5	1388	10.5	57	25.0	12.0	26400		1%	13	Opening hole to 17½"
7-6	1388	11.5	52	17.0	12.5	26400		1%	17	" " " "
7-7	1388	11.5	52	17.0	12.5	26400		1%	17	Ran 13-3/8" csg.
7-8	1403	11.4	62	21.0	12.0	26400		Nil	17	Drilling 12-1/4" hole
7-9	1671	11.6	59	13.0	12.0	16500		Nil	18	" " "
7-[illegible]	1795	11.7	51	7.0	11.0	16500		Nil	16	" " "
7-11	1909	11.6	49	6.2	11.0	23100		Nil	20	" " "
7-12	1991	11.6	43	5.8	11.0	28050		Nil	19	" " "
7-13	2083	11.6	44	5.0	11.0	23100		Nil	16	" " "
7-14	2151	11.6	56	5.0	11.0	23100		Nil	20	" " "
7-15	2250	11.6	46	3.8	10.5	21450		Nil	15	" " "
7-16	2344	11.9	48	4.2	11.0	18150		Nil	19	" " "
7-17	2437	12.0	50	3.8	11.0	19800		Nil	18	" " "
7-18	2503	12.5	58	3.5	11.0	29700		Nil	20	" " "
7-19	2568	12.5	53	3.6	10.3	16500		Nil	22	" " "
7-20	2602	12.5	53	4.2	11.0	16500		TR	23	" " "
7-21	2632	12.5	75	5.6	11.0	34650		TR	25	" " "
7-22	2632	12.5	75	5.6	11.0	34650		TR	25	Logging with Schlumberger
7-23	2632									
			T.D.							

AROMATICS AS A MATURITY PARAMETER (PHASE II) WELL UNIONOIL NORGE 8/4-1

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CONTENTS

1.0 INTRODUCTION

A joint research project on "Aromatics as a Maturity Parameter" is being performed by the Continental Shelf Institute, IKU (Trondheim, Norway) and the Institute for Petroleum and Organic Geochemistry, KFA/ICH-5 (Jülich, Fed. Rep. of Germany).

During phase I of the project, KFA/ICH-5 presented newly developed methods of aromatics analysis (Radke, 1981; Willsch, 1981). A sample series from the Bramsche Massif area was analysed for aromatics to demonstrate how aromatics-derived parameters can be used for assessment of maturity levels (Radke and Willsch, 1981). The Methylphenanthrene Index (MPI) has proved useful as a maturity parameter (Radke et al., 1982 a,b; Radke and Welte, 1983). Subsequently IKU performed artificial maturation experiments on samples of different kerogen types. Pyrolyzates were analysed for aromatics at the IKU laboratory using the analytical methods developed by Radke et al. (1980), Radke (1981), and Willsch (1981). Some possible maturity parameters were suggested by Hall et al. (1982).

The current phase II of the project involves the detailed organic-geochemical analysis of about ten North Sea wells. Application of aromatics-derived maturity parameters is the main objective of the present study. However, for a comparison of aromatic parameters against conventional parameters the latter had, of course, to be determined also. In addition, factors that may have influenced the aromatic parameters had to be considered, such as organic matter type and generation and redistribution of hydrocarbons. Thus, microscopical analyses have been undertaken by IKU. In addition, screening followed by detailed analysis of selected samples has been performed on the whole wells to obtain the necessary data. The present report contains the results for well Unionoil Norge 8/4-1, one out of two wells of the North Sea series investigated by KFA/ICH-5.

2.0 SAMPLES AND ANALYTICAL METHODS

Organic geochemical analysis involved screening of 123 cuttings samples including organic carbon determination, C_{15+} -IRUS determination and Rock-Eval pyrolysis (Espitalié et al., 1977). From this sample series KFA/ICH-5 selected 20 samples for vitrinite reflectance measurements and visual kerogen description based on the results of the screening analyses. Aliquots of the original cuttings were sent to IKU for these microscopic analyses (see APPENDIX for data presentation). Twenty-one composite samples were then prepared by combining the residual material from the above 20 samples with adjacent cuttings samples. Lithological descriptions of the composite samples are presented in Table 1. Detailed organic geochemical investigation of the samples includes organic carbon determination, extraction, MPLC separation, gas chromatography of saturated and aromatic hydrocarbon fractions, and HPLC separation of total aromatic fractions into subfractions.

Procedures used for screening represent well-established routine analytical techniques and hence are not described here. Methods used in the detailed analyses were the following.

The finely ground rock samples were extracted with re-distilled dichloromethane-methanol (99:1; v/v) for 2 min using a modified "flow-blending" method (Radke et al., 1978). Squalane and anthracene were used as the internal standards which were added to the rock powder prior to extraction. Elemental sulfur was removed during extraction by addition of copper powder.

The hexane-soluble portions of the extracts were separated by medium pressure liquid chromatography and saturated and aromatic hydrocarbon fractions were collected (Radke et al., 1980). The aromatic fractions of 7 extracts were further separated according to the number of aromatic rings and to molecular structure into four subfractions each (AF1-AF4) by semi-preparative high performance liquid chromatography

(Radke, 1981). Conditions: stainless steel column, 250 mm length, 8 mm i.d., 3-6 μm irregular particles, Alumina Type N, Woelm, heated to 350°C under reduced pressure (1 mbar) for 2 hr and then partly deactivated by addition of 2.5 % w/w water; flow rate 16 ml/min; stepwise gradient (% dichloromethane in n-hexane): AF1 (0 %),AF2 (8 %), AF3 (16 %), AF4 (40 %).

Total aromatics or aromatic subfractions were dissolved in xylene to which 1,1'-binaphthyl had been added as the internal standard and analysed using a Hewlett-Packard 5731A gas chromatograph equipped with Gerstel inlet and outlet splitters, flame ionization detector (FID) and Tracor flame photometric detector (FPD; 394 nm filter), which was modified to minimize dead volume. Conditions: fused silica capillary column, 50 m length, 0.22 mm i.d., coated with CP Sil 8 silicone gum; temperature programmed from 100°C (hold for 2 min) to 280°C, heating rate 3°C/min; carrier gas helium.

The experimental conditions for the gas chromatographic analysis of the saturated hydrocarbon fractions were the following: glass capillary, 23 m length, 0.3 mm i.d., coated with SE-54 silicone gum, temperature programmed from 80°C (hold for 2 min) to 254°C, heating rate 3°C/min; carrier gas helium.

3.0 RICHNESS OF ORGANIC MATTER

The ability of a potential source rock to generate and release hydrocarbons depends on its organic matter content which is commonly evaluated by organic carbon determination. The total organic carbon (TOC) contents of 123 rock samples (in weight % of rock) are shown in Fig. 1 and listed in Table 3. (Table 2 lists the abbreviations used in the various figures and tables for the formations in this well). In addition, 21 TOC measurements were made on composite samples which had been mixed for extraction purposes (Table 5). The following intervals can be distinguished in terms of richness of organic matter:

160-540 m, Poor; 0.2-0.8 % TOC; Pleistocene to Late Miocene.

560-740 m; Fair to good, increasing with depth; 0.6-1.8 % TOC, Middle Miocene.

760-1390 m; Excellent; 1.9-4.9 % TOC; Early Miocene to Early Eocene.

1410-1600 m; Fair, decreasing with depth; 0.8-1.4 % TOC, Early Eocene to middle of Paleocene.

1610-2100 m; Good; 0.4-1.1 % TOC, mainly a chalk interval; Paleocene to Coniacian.

2120-2340 m; Fair, increasing with depth; 0.8-1.3 % TOC, Turonian to Hauterivian.

2361-2400 m; Excellent; 4.6-6.2 % TOC; Late to Middle Jurassic.

2420-2631 m; Fair to Good; 0.6-1.9 % TOC; Middle Jurassic to Zechstein.

In summary, the best potential source rock intervals in this well based on total organic matter contents are from 760 to 1390 m and from 2361 to 2400 m.

4.0 CHARACTERIZATION OF KEROGEN TYPE BY ROCK EVAL PYROLYSIS

A total of 123 samples of well 8/4-1 were measured by Rock Eval pyrolysis (Table 3, Fig. 1). The hydrogen and oxygen index values obtained by this procedure basically correspond to the H/C and O/C atomic ratios from elemental analysis of kerogen (Espitalié et al., 1977). Unfortunately, when these samples were analyzed it was not possible to obtain oxygen index data. However, the hydrogen index is the more important of these two parameters and kerogen quality is usually discussed principally in terms of hydrogen index anyway.

The best interval in this well is between 2361 m and 2400 m in the Late-to-Middle Jurassic section. The hydrogen index values range from 325 to 400 mg HC/g TOC, classifying the kerogen as an oil-prone type II. The second best interval in this well is primarily the Middle Miocene at 560 to 740 m. With hydrogen index values ranging from 130 to 230 mg HC/g TOC, this interval contains type III kerogen that is gas and condensate prone. The hydrogen index values throughout the rest of the well are typically below 100 mg HC/g TOC and, thus, the kerogen in these intervals is mainly gas-prone type III.

Rock Eval data have been used to derive information about the maturity of the kerogen (Chapter 5) and about hydrocarbon generation and redistribution (Chapter 6).

5.0 LEVEL OF MATURITY

Rock Eval Pyrolysis

Rock Eval pyrolysis provides a means of maturity evaluation. The temperature measured at maximum hydrocarbon generation during pyrolysis, T_{max}, normally increases with increasing maturity or depth for a given kerogen type. No clear trend of increasing T_{max} with depth exists in this well (Fig. 1); in fact, in the 150 m to 600 m and 1450 m to 1900 m depth intervals, there appears to be a reversed trend. In addition, the higher quality kerogens with elevated hydrogen indices have somewhat lower T_{max} values than the lower quality kerogen with a more or less comparable maturity. This has been observed in our laboratory for a large number of samples having vitrinite reflectance values below 1 % (Gormly, unpublished data). The effect of this is to mask any smooth increasing trend with depth of the T_{max} values when different types of kerogen are interspersed in a section where the maturity is not exceptionally high.

The maturity data in this well, based on T_{max} values, indicate that the kerogen is approaching or is slightly into the liquid window. With the exception of strangely high values for T_{max} in the Pleistocene and Pliocene most T_{max} values in this well are below 430°C, and many are below 420°C.

Microscopy

Vitrinite reflectance data (see Appendix) indicate a low maturity level for the 300 m to 1450 m depth interval. Though bitumen staining may have affected the R_m values it appears, that the samples are all immature. The assumed low maturity level is confirmed by the green or green/yellow fluorescence in UV light, as observed for spores or spore fragments in some samples from this depth interval.

Primary vitrinite seems to be very rare in the 1600 m to 2580 m depth interval. Reflectance, that has been determined for the sporadic vitrinite particles, range from 0.39 to 0.90 % R_m, hence does not allow for an assessment of maturity in this depth interval.

6.0 GENERATION AND REDISTRIBUTION OF HYDROCARBONS

Rock Eval Pyrolysis

The transformation ratio or production index (S_1/S_1+S_2), as obtained from Rock Eval pyrolysis, can be used to get an idea of the level of hydrocarbons generated and hydrocarbon redistribution. In many wells there is a continuous increase of this ratio with increasing depth (maturity) as long as the organic matter is not overly mature.

Abnormally high values in immature sections are usually considered to indicate elevated hydrocarbon concentrations due to migration. Plotting the transformation ratio as a function of depth is useful in identifying zones of possibe enrichment (Fig. 1). The transformation ratio is slightly elevated from 160-600 m (Middle Miocene) and then is reasonably low and constant down the section until 1400 m (Early Eocene). From that point downward it increases in a regular fashion until about 1760 m (Early Maastrichtian) where it exceeds 0.3. From there until 2340 m (Hauterivian) the value is fairly constant. From 2420 m until 2631 m it is slightly lower but also reasonably constant. For the low level of maturity these elevated values indicate impregnation. The Late Jurassic section from 2361 m to 2400 m has reduced production index values, most probably due to the elevated values of S_2 as seen in the hydrogen index. The S_1 values, normalized to TOC, for these samples in this Late Jurassic interval are comparable with those in the shallower part of the well. This indicates that the entire section from 1760 m to the bottom is impregnated by migrated hydrocarbons.

IRUS Screening Technique

The IRUS (infra-red ultra-sonic) method provides a rapid screening technique for estimating the amount of mainly heavier hydrocarbons in a rock sample. This method involves an ultra-sonic extraction of a ground rock sample in carbon tetrachloride followed by IR spectroscopy of the solvent containing the extracted material, utilizing the CH_3 and CH_2 bands. The abundance of extract is directly evaluated from the absorbance measurement.

The IRUS data for 123 samples from well 8/4-1 are shown in Fig. 2 and listed in Table 4. In many ways the plot of IRUS hydrocarbon equivalents versus depth, resembles that of the transformation ratio (Fig. 1) described above. The IRUS hydrocarbon equivalents are slightly elevated in the younger sediments 160-600 m (Middle Miocene) and then are reasonably low and constant down to about 1400 m (Early Eocene). From there on down they increase until they reach high values of 25-30 mg/g TOC at 1900 m in the Santonian. These elevated values remain to the bottom of the well except in the Late Jurassic where they are reduced. These low values are due to their being normalized to the higher TOC values; the IRUS values normalized to rock weight in this interval of high TOC are the highest in the well (470-670 ppm).

Extraction and MPLC

A total of 21 cuttings samples were analyzed for yield and gross composition of C_{15+} -soluble organic matter. The data are listed in Table 5. Depth-plots of the C_{15+} -soluble organic matter yields and the carbon-normalized yields of C_{15+} -soluble organic matter and C_{15+}-hydrocarbons are presented in Fig. 3. A plot of the relative abundance of C_{15+} -hydrocarbons in total extract versus depth is given in Fig. 4. The following is a discussion of the variations of these data with depth and stratigraphic age.

Pliocene to Middle Miocene (samples from 310-710 m)

The carbon-normalized yields of C_{15+} -soluble organic matter which are moderate at the top of the interval increase gradually from 63.5 mg/g C_{org} at 310 m to 84.4 mg/g C_{org} at 570 m. The C_{15+} -hydrocarbons show a similar, yet more pronounced, increase in their carbon-normalized yields from 25.8 mg/g C_{org} to

43.5 mg/g C_{org} over the same depth interval. This difference in gradients of yield increase between C_{15+} -soluble organic matter and C_{15+} -hydrocarbons corresponds to an increase in the relative abundace of C_{15+} -hydrocarbons in total extract from 40.6 % at 310 m to 51.5 % at 570 m. The slight enrichment in C_{15+}-hydrocarbons, which is not related to lithology variations, reaches its maximum at 570 m. At 710 m the relative abundance of C_{15+} -hydrocarbons in the total extract is still somewhat elevated. However, a major redistribution of C_{15+} -hydrocarbons is unlikely due to the reasonably low carbon-normalized yield of 19.2 mg/g C_{org}. Nevertheless, redistribution phenomena apparently have blurred the original generation pattern.

<u>Early Miocene to Early Eocene (samples from 810 - 1360 m)</u>
The carbon-normalized yields of C_{15+} -soluble organic matter which are reasonably low at the top of the interval show a gradual decrease from 33.0 mg/g C_{org} at 810 m to 20.2 mg/g C_{org} at 1360 m. The C_{15+} -hydrocarbons show a similar, yet more pronounced, decrease in their carbon-normalized yields from 12.8 mg/g C_{org} to very low values, such as 5.2 mg/g C_{org}, over the same depth interval. This slight difference in gradients of yield decrease between C_{15+} -soluble organic matter and C_{15+} -hydrocarbons corresponds to a decrease in the relative abundance of C_{15+} -hydrocarbons in total extract from 38.7 % at 810 m to 25.7 % at 1360 m. Thus, a minor redistribution of C_{15+} -hydrocarbons cannot be ruled out for the upper section. The low yields are indicative of low maturity and poor kerogen quality.

<u>Paleocene to Santonian (samples from 1455-1870 m)</u>
The carbon-normalized yields of C_{15+} -soluble organic matter and C_{15+} -hydrocarbons which are reasonably low at the top of the interval increase somewhat towards the middle of the interval. Yields increase drastically at the bottom of the interval where they reach rather high values of 74.2 mg/g C_{org} and 45.8 mg/g C_{org} for C_{15+} -soluble organic matter and C_{15+} -hydrocarbons, respectively. With respect to yield and gross composition of the organic matter the samples from

1605 m and 1705 m depth are very similar to the sample at 710 m. Again, the somewhat elevated relative abundance of C_{15+} -hydrocarbons in total extract may be taken as an indication for a minor redistribution of hydrocarbons. Redistribution of C_{15+} -hydrocarbons is more obvious in the chalk interval at 1870 m where the relative abundance of C_{15+} -hydrocarbons has its maximum of 61.8 %.

Coniacian to Zechstein (samples from 2010-2582 m)
The carbon-normalized yields of C_{15+} -soluble organic matter and C_{15+} -hydrocarbons being generally high are indicative of an impregnated zone. With one exception yields range from 116.8 to 171.0 mg/g C_{org} and 60.5 to 81.9 mg/g C_{org} for C_{15+} -soluble organic matter and C_{15+} -hydrocarbons, respectively. Considerably lower carbon-normalized yields, such as 48.0 mg/g C_{org} C_{15+} -soluble organic matter and 27.9 mg/g C_{org} C_{15+} -hydrocarbons, are observed at 2370 m. The abrupt changes in carbon-normalized yields of C_{15+} -soluble organic matter and C_{15+} -hydrocarbons within rather narrow depth intervals, as seen at 1870-2010 m and 2358-2444 m, do not correlate with changes in kerogen quality, hence are indicative of a major redistribution of C_{15+} -soluble organic matter or caving effects.

Obviously, the original generation pattern has been changed in such a way that the evaluation of source rock potential is almost impossible.

Gas Chromatography of C_{15+} -Saturated Hydrocarbon Fraction

The saturated hydrocarbon fractions of 20 rock samples covering the depth interval 310-2582 m were analyzed by capillary gas chromatography to study their detailed composition. The gas chromatograms are shown in Fig. 5 a-t. From these measurements normalized n-alkane distributions (sum of peak areas = 100 %) were calculated and plotted in Fig. 6 a-t. Furthermore, carbon preference indices and isoprenoid hydrocarbon concentration ratios were determined. These are summarized in Table 6. The following observations were made. All samples between 310 m and 1870 m (Pliocene to Santonian) contain a similar type of organic matter. The predominance of short-chain n-alkanes (C_{15} to C_{17}) over their long-chain homologs (C_{25} to C_{31} range) in most of the samples suggests an admixture of migrated hydrocarbons with a front biased n-alkane distribution. The contribution of autochthonous hydrocarbons derived from terrestrial higher-plant waxes appears to be very minor (except, e.g., in the Pliocene-age sample from 310 m and in the Early Eocene-age sample from 1360 m). All samples in the depth interval 310 m to 1705 m show a strong predominance of odd-numbered n-alkanes (C_{25}-C_{31} range) over their even-numbered homologs (CPI_{29} between 3.5 and 1.9, see Table 6) and are therefore considered to be indicative of a low maturity level. The composition of the saturated hydrocarbon fractions changes significantly between 1870 m and 2010 m depth. The seven samples of Coniacian to Zechstein-age, however, are fairly similar to each other, both in the general appearance of the chromatograms and the parameters listed in Table 6. The n-alkane envelope curves have their maximum at C_{16}/C_{17}, and an almost linear decrease in concentration up to n-C_{29} can be observed. The similarity within these samples of different geologic age may be due to impregnation by migrated hydrocarbons. The hydrocarbons in these samples are most probably derived from a mature source (CPI close to unity).

Absolute hydrocarbon concentrations for the n-alkanes C_{15} through C_{36} as well as for pristane and phytane are summarized in Tables 7 and 8, both in rock-weight based (ng/g of rock) and carbon-normalized units (µg/g C_{org}). In addition, they are plotted as bar diagrams in Fig. 7 a-t and Fig. 8 a-t, respectively. Based on the carbon-normalized values, the four samples of Pliocene to Middle Miocene age (310-710 m) appear to be slightly enriched in migrated hydrocarbons. The sum of the C_{15} to C_{36} n-alkanes (1500-3000 µg/g C_{org}) is higher than expected for the corresponding maturity level. The values for the Early Miocene to Early Eocene samples (810-1360 m) are typical of autochthonous hydrocarbon quantities. From 1870 m downwards (Santonian to Zechstein) the samples are enriched in migrated hydrocarbons to a variable extent. Particularly the Coniacian-age sample (2010 m) with nearly 14000 µg/g C_{org} n-alkanes is strongly enriched. The values for the samples from 1605 m and 1705 m depth indicate no or only a slight enrichment.

Gas Chromatography of C_{11+} -Aromatic Hydrocarbon Fraction

The evaluation of 30 gas chromatographic peaks representing alkyl homologs of naphthalene and phenanthrene, as confirmed by GC-MS analysis (Radke et al., 1982b), is covered by our routine PAH determinations (Fig. 9 a-u, Fig. 10 a-g, Fig. 11 a-g). Carbon-normalized concentrations and relative abundances of naphthalenes and phenanthrenes are listed in Tables 9, 10 and are presented in normalized diagram form in Fig. 12 a-l.

In the upper well section, at 310-1130 m, the concentrations of methylnaphthalene and methylphenanthrene homologs are below detection limit, i.e. less than 0.1 µg/g C_{org}. This has to be taken as evidence for very immature organic material, as it appears to be unlikely that the whole depth interval is totally depleted in these aromatic hydrocarbons. Naphthalenes and phenanthrenes first appear at 1260 m, but their carbon-normalized yields are very low. From there to 1455 m depth carbon-normalized yields of naphthalenes show a distinct increase, then decrease with depth down to 2136 m where the naphthalenes could no longer be detected. No detectable quantities of methylphenanthrene homologs were found at 1360-1870 m depth. Obviously, phenanthrene is present at this depth interval. The carbon-normalized phenanthrene yields, however, have most likely been overestimated due to interference from overlapping peaks. As, again, extensive depletion of the samples under consideration is unlikely, it follows that generation of significant quantities of methylphenanthrene homologs has not yet occurred. The maturity, hence, is expected to be less than 0.5 % R_m at 1870 m depth.

Naphthalenes at 1260-2010 m depth as well as phenanthrenes at 1260 m depth are probably derived from a more mature source, hence represent migrated hydrocarbons. Absence of methylphenanthrenes at certain depth intervals and a shift with depth in the distribution pattern of the methylnaphthalene homologs towards predominance of trimethylnaphthalenes can be explained in terms of geochromatography. A pronounced fractionation effect is indicated in the chalk interval at 1870 m depth where the carbon-normalized yields of trimethylnaphthalenes are reasonably high, whereas mono- and dimethylnaphthalenes, and mono- and dimethylphenanthrenes are absent.

At 2010-2582 m depth carbon-normalized yields of total C_{15+} -hydrocarbons and individual PAH do not correlate, e.g. at 2010 m where carbon-normalized C_{15+} -hydrocarbon yields have their maximum, the carbon-normalized phenanthrene yield is rather low. On the other hand, at 2358 m depth carbon-normalized yields of C_{15+} -hydrocarbons and phenanthrene are consistently elevated. Thus, at 2358 m the PAH distribution is expected to be more like the original distribution of the migrated C_{15+} -hydrocarbons.

In the 300 m to 1870 m depth interval the PAH distribution is dominated by a series of components which in the gas chromatograms appear in the region of mono- to trimethylphenanthrenes (Fig. 9 a-h). The first peak (T) has been tentatively identified as o-terphenyl, a compound which is rarely found in nature. The other compounds (a-g) have not yet been identified. They probably represent mono- or diaromatics as they appear in the aromatics subfraction AF1 (Fig. 10 a-g). The distribution of these compounds shows little variation throughout the whole sample series (Fig. 9 a-u, Fig. 10 a-g), e.g. component f is always the relatively most abundant. Likewise, there are no indications for a depth trend for any of these compounds. Thus, it cannot be ruled out that they are in fact contaminants.

7.0 CONCLUSIONS DERIVED FROM ORGANIC GEOCHEMICAL ANALYSIS OF WELL UNIONOIL NORGE 8/4-1

The organic material is immature throughout the whole well. Most of the samples analyzed contain a type III kerogen which has not yet reached a maturity level where generation of significant quantities of heavier hydrocarbons has to be assumed. Thus, elevated carbon-normalized C_{15+} -hydrocarbon yields, as seen in the 160-600 m and 1700-2580 m depth intervals, are indicative of an impregnation. The hydrocarbons that had migrated in were probably received from a more mature source. Only between 2361 m and 2400 m in the Late-to-Middle Jurassic section samples contain a better type II kerogen, from which significant quantities of C_{15+} -hydrocarbons may have been generated even at the present rather low maturity level. However, as these samples are impregnated, the level of autochthonous C_{15+} -hydrocarbons cannot be assessed.

Generation of significant quantities of C_{11+} -aromatic hydrocarbons has not occurred in the present well. Where elevated concentrations of naphthalenes and phenanthrenes are observed they represent migrated rather than autochthonous material which in the course of its assumed upward movement probably has undergone fractionation. The fractionation effect seems to decrease with depth.

8.0 MATURITY PARAMETERS BASED ON POLYCYCLIC AROMATIC HYDROCARBONS

Maturity parameters that have been developed by KFA are based on methylnaphthalene and methylphenanthrene homologs which were present only in part of the samples analyzed. In the 310-1870 m depth interval detectable quantities of the methylphenanthrene homologs were observed only for sample 1260 m. On the other hand, in seven samples analyzed from the 1360-2136 m depth interval PAH distributions were incomplete. Thus, the full set of maturity parameters could be calculated only for sample 1260 m and for the four samples analyzed from the 2205-2444 m depth interval (Table 11).

In a well where no major redistribution of C_{15+} -hydrocarbons had occurred, the methylphenanthrene ratios MPR 1-9 showed systematic changes with maturity (Radke et al., 1982 a). Since these ratios seem to respond also to changes in organic matter type, they cannot rate as maturity parameters in a strict sense. Nevertheless, maturity may be deduced grossly from these ratios.

For aromatics from a type III kerogen the values of MPR 1 and MPR 9 consistently increase from 0.5 at the onset of intense C_{15+} -hydrocarbon generation (0.67 % R_m), reach unity at 0.9 % R_m, then decline with further maturation progress. This means that for type III kerogen the thermal evolution of the MP-ratios 1 and 9 runs parallel with the C_{15+} -hydrocarbon generation curve which generally reaches its maximum at about the same maturation level. On the other hand, MPR 2 values show a similar trend, yet reach unity generally at a higher maturation level corresponding to the base of the liquid window (1.35 % R_m).

In the present well low MPR 1-9 values of less than 0.4, as observed for sample 1260 m (Fig. 13), are indicative of a rather low maturity level of less than 0.65 % R_m, which is in agreement with microscopic data (see Appendix). However, at 1260 m the PAH distribution is most likely representative of migrated rather than in-situ C_{15+}-hydrocarbons, thus will not necessarily reflect the maturity of the kerogen at this depth. The same holds true for the lower section of the well, where PAH distributions have also been influenced by redistribution phenomena. Exceptionally high MPR 1-9 values in excess of 1.0, as seen for sample 2136 m, have to be taken as evidence for a redistribution of C_{15+} -hydrocarbons. MPR 1-9 values of about 0.5, as seen for samples 2358 and 2370 m, would in a situation where no major redistribution of C_{15+} -hydrocarbons had occurred indicate onset maturity, thus correspond to 0.6-0.7 % R_m. Due to the occurrence of migrated C_{15+} -hydrocarbons, maturity evaluation based on PAH will remain rather vague in the present well. Again, it is only in a situation where migrated C_{15+} -hydrocarbons are absent that the methylphenanthrene indices MPI 1 and MPI 2 will provide a reliable means of maturity evaluation (Radke et al., 1982a). The vitrinite reflectance equivalent R_c which is calculated from the MPI 1 of a C_{15+} -extract will then relate to the vitrinite reflectance (R_m) of the corresponding source rock, provided its maturity is greater than 0.65 % R_m and less than 2.1 % R_m (Radke and Welte, 1983).

In the present well R_c values range from 0.78 to 1.06 % (Table 11). They do not show a clear depth trend. From the above discussion of MP-ratios it follows that the R_c values will reflect the maturity of migrated rather than in-situ C_{15+} -hydrocarbons. Sample 2358 m exhibits the highest carbon-normalized phenanthrene yield of the samples analyzed, thus has most likely received the highest input from migrated PAH. Consequently, its R_c value of 0.85 % can rate as a good indicator for the maturity of the migrated C_{15+} -hydrocarbons. Elevated R_c values of the other samples can be attributed to fractionation effects having affected the original PAH distribution. Indeed, the highest R_c value of 1.06 % is observed at 2136 m depth where a strong PAH fractionation is indicated by a loss of methylnaphthalene homologs (Fig. 12 h).

The isomer distributions of ethyl PAH as well as mono-, di-, and trimethyl PAH all show similar thermal evolution trends (Radke et al., 1982 a, b). Thermocatalytic alkyl-shift reactions resulting in a reduction of steric strain have been considered as a possible chemical basis of this phenomenon. Though a definite calibration of individual PAH isomer ratios versus R_m has not been performed the ratios presented in Table 11 can be used in the assessment of relative maturities.

The results which have been obtained from R_c determinations are generally confirmed by the individual PAH isomer ratios. Again, there is no clear trend of increasing maturity with depth. The elevated ethylnaphthalene ratio (ENR) observed at 2205 m depth indicates a high sensitivity of this ratio to redistribution phenomena.

9.0 SUMMARY - AROMATICS AS A MATURITY PARAMETER

Vitrinite reflectance data indicate a low maturity of 0.3-0.4 % R_m in the upper well section. Methylnaphthalenes and methylphenanthrenes are not detectable at the 310-1130 m depth interval. Thus, microscopic data cannot be compared with PAH maturity parameters at this depth.

In the middle well section, at 1260-1870 m depth, samples seem to be still immature. Microscopic data appear not to be very reliable at this depth. The MPI and various PAH isomer ratios indicate reasonably high maturity corresponding to 0.8 % R_m. However, this value is likely to give the maturity of migrated rather than in-situ PAH. Redistribution of PAH is indicated by irregular distribution patterns where part of the compounds is missing.

In the lower well section, at 2010-2582 m, microscopy data do not allow for an assessment of maturity. There are traces of higher reflecting vitrinites pointing to a rather high maturity of 0.9 % R_m. PAH maturity parameters would confirm this high maturation level, if PAH were in-situ. Though this is unlikely, it cannot be ruled out that maturity is that high at the bottom of the well.

10.0 ACKNOWLEDGEMENT

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11.0 REFERENCES

Espitalié, J., Laporte, J.L., Madec, M., Marquis, P., Leplat, P., Paulet, J. and Boutefeu, A. (1977)
Méthode rapide de caractérisation des roches-mères, de leur potentiel pétrolier et de leur degré d'évolution. Rev. Inst. Français du Pétrole 32, 23-42.

Hall, P.B., Mills, N., Solli, H., Lind, K. and Os Vigran, J. (1982)
Report on aromatics as a maturity parameter. Artificial Maturation.

Radke, M., Sittardt, H.G. and Welte, D.H. (1978)
Removal of soluble organic matter from rock samples with a flow-through extraction cell. Anal. Chem. 50, 663-665.

Radke, M., Willsch, H. and Welte, D.H. (1980)
Preparative hydrocarbon group type determination by automated medium pressure liquid chromatography. Anal. Chem. 52, 406-411.

Radke, M. (1981)
Class separation of aromatic compounds in rock extracts and crude oils by semi-preparative HPLC.
KFA Internal Report No. 500581.

Radke, M. and Willsch, H. (1981)
Maturity parameters based on aromatic hydrocarbons from the Bramsche Massif area, NW-Germany. KFA Internal Report No. 502681

Radke, M., Welte, D.H. and Willsch, H. (1982a)
Geochemical study on a well in the Western Canada Basin: relation of the aromatic distribution pattern to maturity of organic matter. Geochim. Cosmochim. Acta 46, 1-10.

Radke, M., Willsch, H., Leythaeuser, D. and Teichmüller, M. (1982b)
Aromatic components of coal: relation of distribution pattern

to rank. Geochim. Cosmochim. Acta 46, 1831-1848.

Radke, M., and Welte, D.H. (1983)
The Methylphenanthrene Index (MPI): a maturity parameter based on aromatic hydrocarbons. In: Advances in Organic Geochemistry 1981 (M. Bjorøy et al., editors), John Wiley & Sons, Chichester, in press.

Willsch, H. (1981)
Glass capillary gas chromatography of aromatic hydrocarbons. KFA Internal Report No. 500481.

LIST OF TABLES

Abbreviation	Compound
MN	Methylnaphthalene
EN	Ethylnaphthalene
DN	Dimethylnaphthalene
TN	Trimethylnaphthalene

Table 10: Carbon-normalized concentrations (µg/g C_{org}; first row) and normalized abundance (wt %; second row) of phenanthrene and its methylhomologs

Abbreviation	Compound
PHE	Phenanthrene
MPHE	Methylphenanthrene
DMP	Dimethylphenanthrene

Table 11: Maturity parameters based on aromatic hydrocarbons for rock samples (from well 8/4-1).

Calculation of maturity parameters:

Methylnaphthalene Ratio	$MNR = \frac{2\text{-MN}}{1\text{-MN}}$
Ethylnaphthalene Ratio	$ENR = \frac{2\text{-EN}}{1\text{-EN}}$
Dimethylnaphthalene Ratio	$DNR = \frac{2,6\text{-DMN}+2,7\text{-DMN}}{1,5\text{-DMN}}$
Trimethylnaphthalene Ratio	$TNR = \frac{\text{TMN A}+\text{TMN B}}{\text{TMN C}+\text{TMN D}}$
Methylphenanthrene Ratio	$MPR = \frac{2\text{-MP}}{1\text{-MP}}$
Dimethylphenantrene Ratio	$DPR = \frac{\text{DMP 3}+\text{DMP 4}}{\text{DMP 5}+\text{DMP 6}}$
Methylphenanthrene Index 1	$MPI\ 1 = \frac{1.5\ (2\text{-MP}+3\text{-MP})}{P+1\text{-MP}+9\text{-MP}}$
Methylphenanthrene Index 2	$MPI\ 2 = \frac{3\ (2\text{-MP})}{P+1\text{-MP}+9\text{-MP}}$
Calculated Vitrinite Reflectance	$R_c = 0.60\ MPI\ 1 + 0.40$ (for $0.65 \leq R_m \leq 1.35$)

LIST OF FIGURES

Figure 7 a-t: Absolute concentrations (ng/g of rock) of n-alkanes, pristane and phytane for rock samples from well 8/4-1.

Figure 8 a-t: Absolute, carbon-normalized concentrations (µg/g C_{org}) of n-alkanes, pristane and phytane for rock samples from well 8/4-1.

Figure 9 a-u: Capillary gas chromatograms of total aromatic fractions (C_{11+}) for rock samples from well 8/4-1. P = phenanthrene, A = anthracene (internal standard 1), T = o-terphenyl, a-g = not identified. S = 1,1'-binaphthyl (internal standard 2).

Figure 10 a-g: Capillary gas chromatograms of aromatic subfractions AF1 containing mono- and diaromatics (see legend of Fig. 9 for abbreviations) for rock samples from well 8/4-1. Note: o-Terphenyl appears in AF1 though it contains three benzenoid rings.

Figure 11 a-g: Capillary gas chromatograms of aromatic subfractions AF2 containing tri- and peri-fused tetraaromatics (see legend of Fig. 9 for abbreviations) for rock samples from well 8/4-1 obtained from simultaneous flame ionization detection (FID) and sulfur-selective flame photometric detection (FPD).
MP = methylphenanthrenes, DMP = dimethylphenanthrenes, D = dibenzothiophene, MD = methyldibenzothiophene.

Figure 12 a-l: Carbon-normalized concentrations (µg/g C_{org}) of methylnaphthalenes (MN), ethylnaphthalenes (EN), dimethylnaphthalenes (DMN), trimethyl- and other C_3 -naphthalenes (TMN), phenanthrene (P), methylphenanthrenes (MP), first group of dimethylphenanthrenes (DMP-A), second group of dimethylphenanthrenes (DMP-B) for rock samples from well 8/4-1.

Figure 13: Methylphenanthrene/phenanthrene ratios (MPR 1-9) vs. depth for rock samples from well 8/4-1.

Table 1 (continued)

Well: Union Oil Norge - 8/4-1

LITHOLOGIC DESCRIPTION

Internal Sample No. /	Depth Interval (m) /	Description:
E 16116/	300 - 310 m:	grey-green calcareous clay to claystone (with drilling mud?), slightly sandy, slightly micaceous, occasional loose quartz grains
E 16117/	440 - 450 m:	greenish grey moderately calcareous clay to claystone, occasional shell fragments and loose quartz grains, tr. sand
E 16118/	540 - 570 m:	- as above -
E 16119/	700 - 710 m:	dark greenish grey clay to claystone, some fossils and shell fragments, tr pyrite
E 16120/	820 m:	dark brown slightly calcareous clay to claystone, fossiliferous, shell fragments, pyritic, glauconite (?)

Table 1 (continued)

Internal Sample No. / Depth Interval (m)	Description:
E 16121/ 940 - 950 m:	dark brown clay to claystone, micaceous, pyritic, slightly sandy, some fossils
E 16122/ 1100 - 1130 m:	brown clay to claystone, slightly calcareous, micaceous, some fossils
E 16123/ 1250 - 1260 m:	- as above -
E 16124/ 1350 - 1360 m:	dark brown silty, calcareous clay to claystone, micaceous
E 16125/ 1450 - 1455 m:	brown to light grey silty, calcareous clay to claystone
E 16126/ 1600 - 1605 m:	greenish grey, silty, slightly calcareous clay to claystone, tr pyrite
E 16127/ 1700 - 1705 m:	grey to white chalk (cavings ?) and greenish grey, silty claystone
E 16128/ 1860 - 1870 m:	white, occ. brown chalk

Table 1

Internal Sample No. / Depth Interval (m)	Description:
E 16129/ 2000 - 2010 m:	grey-green chalk, slightly argillaceous
E 16810/ 2130 - 2136 m:	grey-green and red-brown silty clay (to claystone) calcarecus in part
E 16130/ 2196 - 2205 m:	light brown marl, brecciated inhomogeneous
E 16811/ 2352 - 2358 m:	grey-green, sandy to silty calcareous claystone, tr. pyrite
E 16131/ 2361 - 2370 m:	grey-green silty, calcareous claystone
E 16132/ 2440 - 2444 m:	sandy, argillaceous limestone/dolomite, some coal particles
E 16133/ 2580 - 2582 m:	red to brown, calcareous sandstone (fine - medium)

Table 2: Abbreviations for the formations used throughout this report.

PLE	-	Pleistocene Recent
PLI	-	Pliocene
LMI	-	Late Miocene
MMI	-	Middle Miocene
EMI	-	Early Miocene
OLI	-	Oligocene
MLE	-	Eocene
EEO	-	Early Eocene
PAL	-	Paleocene
LMA	-	Late Maastrichtian
MMA	-	Maastrichtian
EMA	-	Early Maastrichtian
CAM	-	Campanian
SAN	-	Santonian
CON	-	Coniacian
TUR	-	Turonian
EEA	-	Early Aptian-Albian
HAB	-	Barremian, Hauterivian-Barremian, Hauterivian
LJU	-	Late Jurassic
MLJ	-	Middle-Late Jurassic
MJU	-	Middle Jurassic
TRI	-	Trias
ZEC	-	Zechstein

Table 3 (continued)

ROCK- EVAL DATA
FROM UNION OIL 8/4-1

SAMPLE	FORMATION	DEPTH (M)	TOC (%)	S1 MG/G ROCK	S1 MG/G TOC	GP MG/G ROCK	GP MG/G TOC	HYDROG. INDEX MG/G TOC	OXYGEN INDEX MG/G TOC	S1 / S1+S2	T-MAX GRAD C
E15159	PLE	160.00	0.22	0.02	9	0.08	36	27	****	0.25	446
E15161	"	180.00	0.28	0.03	10	0.17	60	49	****	0.18	0
E15163	"	200.00	0.38	0.04	10	0.36	94	84	****	0.11	441
E15165	"	220.00	0.37	0.06	16	0.42	113	97	****	0.14	443
E15167	"	240.00	0.42	0.04	9	0.39	92	83	****	0.10	438
E15169	"	260.00	0.55	0.01	1	0.17	30	29	****	0.06	437
E15171	"	280.00	0.40	0.05	12	0.32	79	67	****	0.16	438
E15173	PLI	300.00	0.55	0.04	7	0.26	47	39	****	0.15	430
E15175	"	320.00	0.54	0.03	5	0.26	48	42	****	0.12	440
E15177	"	340.00	0.49	0.07	14	0.44	89	75	****	0.16	434
E15179	"	360.00	0.55	0.06	10	0.36	65	54	****	0.17	437
E15181	"	380.00	0.50	0.05	10	0.42	84	74	****	0.12	433
E15183	"	400.00	0.57	0.07	12	0.49	85	73	****	0.14	432
E15185	LMI	420.00	0.48	0.08	16	0.51	106	89	****	0.16	431
E15187	"	440.00	0.50	0.06	11	0.40	79	67	****	0.15	432
E15189	"	460.00	0.54	0.06	11	0.37	68	57	****	0.16	427
E15191	"	480.00	0.76	0.09	11	0.68	89	77	****	0.13	427
E15193	"	500.00	0.79	0.10	12	0.74	93	81	****	0.14	428
E15195	"	520.00	0.66	0.11	16	0.64	96	80	****	0.17	424
E15197	"	540.00	0.65	0.10	15	0.76	116	101	****	0.13	422
E15199	MMI	560.00	0.61	0.10	16	0.88	144	127	****	0.11	421
E15201	"	580.00	0.72	0.15	20	1.68	233	212	****	0.09	421
E15203	"	600.00	0.89	0.10	11	1.53	171	160	****	0.07	419
E15205	"	620.00	0.92	0.20	21	1.79	194	172	****	0.11	428
E15207	"	640.00	1.07	0.15	14	1.75	163	149	****	0.09	425
E15209	"	660.00	1.06	0.16	15	2.14	201	186	****	0.07	425
E15211	"	680.00	1.28	0.15	11	2.71	211	199	****	0.06	424
E15213	"	700.00	1.43	0.19	13	3.34	233	220	****	0.06	430
E15215	"	720.00	1.62	0.23	14	3.97	245	230	****	0.06	431
E15217	"	740.00	1.75	0.25	14	3.50	200	185	****	0.07	433
E15219	EMI	760.00	2.84	0.33	11	3.32	116	105	****	0.10	434

Table 3 (continued)

ROCK- EVAL DATA
FROM UNION OIL 8/4-1

SAMPLE	FORMATION	DEPTH (M)	TOC (%)	S1 MG/G ROCK	S1 MG/G TOC	GP MG/G ROCK	GP MG/G TOC	HYDROG. INDEX MG/G TOC	OXYGEN INDEX MG/G TOC	S1 / S1+S2	T-MAX GRAD C
E15221	EMI	780.00	2.60	0.23	8	3.07	118	109	****	0.07	43[illegible]
E15223	OLI	800.00	2.96	0.33	11	4.37	147	136	****	0.08	428
E15225	"	820.00	3.46	0.27	7	4.31	124	116	****	0.06	424
E15227	"	840.00	4.05	0.25	6	4.24	104	98	****	0.06	428
E15229	"	860.00	4.14	0.71	17	6.57	158	141	****	0.11	422
E15231	"	880.00	2.74	0.23	8	2.49	90	82	****	0.09	429
E15233	"	900.00	2.44	0.20	8	2.80	114	106	****	0.07	429
E15235	"	920.00	3.40	0.26	7	2.74	80	72	****	0.09	427
E15237	"	940.00	2.39	0.14	5	2.03	84	79	****	0.07	424
E15239	"	960.00	2.53	0.17	6	2.09	82	75	****	0.08	428
E15241	"	980.00	2.83	0.17	6	2.28	80	74	****	0.07	432
E15243	"	1000.00	3.85	0.20	5	2.36	61	56	****	0.08	428
E15245	"	1020.00	1.94	0.11	5	1.50	77	71	****	0.07	427
E15247	"	1040.00	2.17	0.15	6	1.68	77	70	****	0.09	432
E15249	"	1060.00	4.89	0.12	2	1.76	35	33	****	0.07	432
E15251	"	1080.00	1.69	0.13	7	1.32	78	70	****	0.10	427
E15253	"	1100.00	1.53	0.15	9	1.51	98	88	****	0.10	415
E15255	"	1130.00	2.09	0.12	5	2.41	115	109	****	0.05	430
E15257	"	1150.00	1.98	0.13	6	1.88	94	88	****	0.07	434
E15259	"	1170.00	2.22	0.13	5	2.20	99	93	****	0.06	433
E15261	"	1190.00	2.31	0.15	6	2.33	100	94	****	0.06	430
E15263	"	1210.00	2.41	0.16	6	2.31	95	89	****	0.07	426
E15265	"	1230.00	2.73	0.19	6	3.13	114	107	****	0.06	431
E15267	MLE	1250.00	3.00	0.19	6	2.97	99	92	****	0.06	430
E15269	"	1270.00	2.99	0.17	5	3.74	125	119	****	0.05	432
E15271	"	1290.00	3.30	0.22	6	3.55	107	100	****	0.06	428
E15273	"	1310.00	3.50	0.15	4	3.74	106	102	****	0.04	433
E15275	EEO	1330.00	3.82	0.11	2	3.07	80	77	****	0.04	434
E15277	"	1350.00	3.20	0.12	3	3.23	100	97	****	0.04	430
E15279	"	1370.00	2.88	0.15	5	3.27	113	108	****	0.05	430
E15281	"	1390.00	2.67	0.12	4	2.02	75	71	****	0.06	430

Table 3 (continued)

ROCK- EVAL DATA
FROM UNION OIL 8/4-1

SAMPLE	FORMATION	DEPTH (M)	TOC (%)	S1 MG/G ROCK	S1 MG/G TOC	GP MG/G ROCK	GP MG/G TOC	HYDROG. INDEX MG/G TOC	OXYGEN INDEX MG/G TOC	S1 / S1+S2	T-MAX GRAD C
E15285	EEO	1410.00	1.29	0.08	6	1.10	85	79	****	0.07	430
E15289	"	1430.00	1.35	0.06	4	0.95	70	65	****	0.06	431
E15293	"	1450.00	1.16	0.09	7	0.96	82	75	****	0.09	424
E15297	PAL	1470.00	1.09	0.09	8	0.93	85	77	****	0.10	423
E15301	"	1490.00	1.09	0.08	7	0.75	68	61	****	0.11	425
E15305	"	1515.00	1.09	0.11	10	0.78	71	61	****	0.14	427
E15309	"	1535.00	1.01	0.06	5	0.60	59	53	****	0.10	427
E15313	"	1555.00	0.78	0.05	6	0.47	60	53	****	0.11	423
E15317	"	1575.00	0.70	0.05	7	0.43	61	54	****	0.12	427
E15321	"	1600.00	0.82	0.06	7	0.51	62	54	****	0.12	434
E15325	"	1620.00	0.63	0.04	6	0.33	52	46	****	0.12	422
E15329	"	1640.00	0.61	0.07	11	0.38	62	50	****	0.18	419
E15333	"	1660.00	0.68	0.06	8	0.47	69	60	****	0.13	423
E15337	LMA	1680.00	0.54	0.04	7	0.31	57	49	****	0.13	421
E15341	MMA	1700.00	0.83	0.08	9	0.52	62	53	****	0.15	421
E15345	"	1720.00	0.56	0.07	12	0.36	64	51	****	0.19	420
E15349	"	1740.00	0.59	0.06	10	0.42	71	61	****	0.14	420
E15353	EMA	1760.00	0.66	0.13	19	0.45	68	48	****	0.29	417
E15357	"	1780.00	0.58	0.63	108	0.93	160	51	****	0.68	411
E15361	CAM	1800.00	0.69	0.13	18	0.45	65	46	****	0.29	418
E15365	"	1820.00	0.68	0.13	19	0.48	70	51	****	0.27	409
E15369	"	1840.00	0.56	0.15	26	0.53	94	67	****	0.28	411
E15373	"	1860.00	0.58	0.12	20	0.48	82	62	****	0.25	411
E15377	SAN	1880.00	0.58	0.14	24	0.48	82	58	****	0.29	411
E15381	"	1900.00	0.49	0.13	26	0.46	93	67	****	0.28	411
E15385	"	1920.00	0.40	0.18	45	0.47	117	72	****	0.38	413
E15389	"	1940.00	0.71	0.33	46	0.76	107	60	****	0.43	414
E15393	CON	1960.00	0.57	0.17	29	0.53	92	63	****	0.32	413
E15397	"	1980.00	0.50	0.28	55	0.64	127	72	****	0.44	0
E15401	"	2000.00	0.63	0.28	44	0.67	106	61	****	0.42	420
E15405	"	2020.00	0.67	0.27	40	0.83	123	83	****	0.33	413

Table 3

ROCK- EVAL DATA
FROM UNION OIL 8/4-1

PAGE: 4

SAMPLE	FORMATION	DEPTH (M)	TOC (%)	S1 MG/G ROCK	S1 MG/G TOC	GP MG/G ROCK	GP MG/G TOC	HYDROG. INDEX MG/G TOC	OXYGEN INDEX MG/G TOC	S1 / S1+S2	T-MAX GRAD C
E15409	CON	2040.00	0.59	0.33	55	0.72	122	66	****	0.46	0
E15413	"	2060.00	0.50	0.25	50	0.62	124	74	****	0.40	414
E15417	"	2080.00	0.48	0.24	49	0.61	127	77	****	0.39	413
E15421	"	2100.00	0.79	0.40	50	1.19	150	99	****	0.34	424
E15425	TUR	2120.00	1.12	0.28	24	1.03	91	66	****	0.27	421
E15431	GAA	2139.00	1.72	0.46	26	1.46	84	58	****	0.32	422
E15438	HAB	2160.00	0.83	0.35	42	0.85	102	60	****	0.41	423
E15445	"	2181.00	1.24	0.72	58	1.57	126	68	****	0.46	421
E15451	"	2199.00	1.34	0.54	40	1.51	112	72	****	0.36	422
E15457	"	2220.00	1.00	0.41	41	1.15	114	73	****	0.36	423
E15461	"	2238.00	1.09	0.53	48	1.21	111	62	****	0.44	0
E15465	"	2259.00	1.14	0.37	32	1.12	98	65	****	0.33	423
E15470	"	2280.00	1.33	0.70	52	1.80	135	82	****	0.39	417
E15476	"	2298.00	1.15	0.97	84	2.20	191	106	****	0.44	416
E15481	"	2319.00	1.25	0.95	75	2.09	167	91	****	0.45	418
E15488	"	2340.00	0.94	0.62	65	1.53	162	96	****	0.41	418
E15495	LJU	2361.00	5.30	2.36	44	23.57	444	400	****	0.10	424
E15501	"	2379.00	6.16	2.86	46	26.13	424	377	****	0.11	419
E15508	MLJ	2400.00	4.60	1.80	39	16.78	364	325	****	0.11	422
E15516	MJU	2420.00	1.69	0.68	40	3.14	185	145	****	0.22	423
E15525	"	2440.00	1.85	0.79	42	3.80	205	162	****	0.21	425
E15535	"	2460.00	1.02	0.45	44	1.67	163	119	****	0.27	424
E15544	"	2480.00	0.72	0.23	31	0.73	101	69	****	0.32	422
E15554	"	2500.00	0.63	0.16	25	0.66	104	79	****	0.24	421
E15564	TRI	2520.00	0.55	0.19	34	0.53	96	61	****	0.36	415
E15574	"	2540.00	0.85	0.27	31	0.89	104	72	****	0.30	420
E15584	"	2560.00	0.77	0.16	20	0.70	90	70	****	0.23	420
E15594	"	2580.00	0.89	0.34	38	0.86	96	58	****	0.40	418
E15602	ZEC	2600.00	1.47	0.44	29	1.81	123	93	****	0.24	428
E15609	"	2631.00	1.89	0.86	45	2.88	152	106	****	0.30	422

1	2	3	4	5
E15159	160.0	0.22	33.5	73.7
E15161	180.0	0.28	15.7	43.9
E15163	200.0	0.38	11.3	43.0
E15165	220.0	0.37	12.7	46.8
E15167	240.0	0.42	5.9	24.6
E15169	260.0	0.55	3.9	21.4
E15171	280.0	0.40	8.1	32.5
E15173	300.0	0.55	6.0	32.8
E15175	320.0	0.54	6.6	35.4
E15177	340.0	0.49	9.0	44.2
E15179	360.0	0.55	8.4	46.3
E15181	380.0	0.50	11.0	55.0
E15183	400.0	0.57	13.4	76.5
E15185	420.0	0.48	17.0	81.4
E15187	440.0	0.50	14.0	69.9
E15189	460.0	0.54	11.3	61.2
E15191	480.0	0.76	10.4	79.0
E15193	500.0	0.79	6.7	53.2
E15195	520.0	0.66	8.9	58.8
E15197	540.0	0.65	9.7	62.9
E15199	560.0	0.61	11.1	67.4
E15201	580.0	0.72	15.8	113.9
E15203	600.0	0.89	5.9	52.7
E15205	620.0	0.92	5.2	48.1
E15207	640.0	1.07	4.9	52.1
E15209	660.0	1.06	6.5	68.6
E15211	680.0	1.28	3.5	44.9
E15213	700.0	1.43	3.4	48.1

LEGEND : 1- SAMPLE-NUMBER
2- DEPTH (M)
3- ORG. CARBON (%)
4- IRUS-CONTENT (MG/G CORG.)
5- IRUS-CONTENT (PPM)

TABLE 4 : IRUS-CONTENT OF
UNION OIL 8/4-1
(CONTINUED)

1	2	3	4	5
E15215	720.0	1.62	7.1	114.3
E15217	740.0	1.75	2.8	48.8
E15219	760.0	2.84	2.2	61.8
E15221	780.0	2.60	2.3	60.3
E15223	800.0	2.96	2.1	61.8
E15225	820.0	3.46	2.2	75.2
E15227	840.0	4.05	1.1	44.8
E15229	860.0	4.14	1.5	60.2
E15231	880.0	2.74	2.5	67.8
E15233	900.0	2.44	7.8	190.6
E15235	920.0	3.40	1.8	62.9
E15237	940.0	2.39	2.1	49.6
E15239	960.0	2.53	2.0	49.9
E15241	980.0	2.83	1.3	37.2
E15243	1000.0	3.85	1.0	40.2
E15245	1020.0	1.94	2.8	53.7
E15247	1040.0	2.17	1.9	41.1
E15249	1060.0	4.89	1.6	79.8
E15251	1080.0	1.69	3.1	52.3
E15253	1100.0	1.53	1.5	23.1
E15255	1130.0	2.09	1.7	36.6
E15257	1150.0	1.98	2.1	42.2
E15259	1170.0	2.22	1.8	39.6
E15261	1190.0	2.31	2.1	48.4
E15263	1210.0	2.41	1.6	39.1
E15265	1230.0	2.73	1.5	42.3
E15267	1250.0	3.00	1.1	31.7
E15269	1270.0	2.99	1.8	52.8

LEGEND : 1- SAMPLE-NUMBER
2- DEPTH (M)
3- ORG. CARBON (%)
4- IRUS-CONTENT (MG/G CORG.)
5- IRUS-CONTENT (PPM)

TABLE 4 : IRUS-CONTENT OF
UNION OIL 8/4-1
(CONTINUED)

1	2	3	4	5
E15271	1290.0	3.30	1.5	49.2
E15273	1310.0	3.50	1.1	38.0
E15275	1330.0	3.82	1.2	46.3
E15277	1350.0	3.20	1.0	30.5
E15279	1370.0	2.88	1.0	29.5
E15281	1390.0	2.67	1.4	36.5
E15285	1410.0	1.29	4.4	56.9
E15289	1430.0	1.35	2.1	28.0
E15293	1450.0	1.16	2.2	25.6
E15297	1470.0	1.09	3.9	42.1
E15301	1490.0	1.09	4.6	50.4
E15305	1515.0	1.09	8.8	95.4
E15309	1535.0	1.01	11.4	115.0
E15313	1555.0	0.78	7.7	59.7
E15317	1575.0	0.70	8.4	58.8
E15321	1600.0	0.82	5.3	43.5
E15325	1620.0	0.63	6.3	39.6
E15329	1640.0	0.61	17.1	104.0
E15333	1660.0	0.68	19.4	132.0
E15337	1680.0	0.54	7.7	41.6
E15341	1700.0	0.83	5.1	42.7
E15345	1720.0	0.56	8.3	46.2
E15349	1740.0	0.59	8.4	49.6
E15353	1760.0	0.66	6.3	41.9
E15357	1780.0	0.58	7.1	41.3
E15361	1800.0	0.69	8.5	58.9
E15365	1820.0	0.68	7.4	50.5
E15369	1840.0	0.56	11.3	63.5

LEGEND : 1- SAMPLE-NUMBER
2- DEPTH (M)
3- ORG. CARBON (%)
4- IRUS-CONTENT (MG/G CORG.)
5- IRUS-CONTENT (PPM)

TABLE 4 : IRUS-CONTENT OF
UNION OIL 8/4-1
(CONTINUED)

1	2	3	4	5
E15373	1860.0	0.58	8.6	49.6
E15377	1880.0	0.58	12.1	70.3
E15381	1900.0	0.49	15.2	74.7
E15385	1920.0	0.40	36.0	144.0
E15389	1940.0	0.71	22.7	161.1
E15393	1960.0	0.57	20.6	117.3
E15397	1980.0	0.50	26.5	132.7
E15401	2000.0	0.63	27.0	170.0
E15405	2020.0	0.67	28.2	188.9
E15409	2040.0	0.59	35.3	208.4
E15413	2060.0	0.50	29.0	144.9
E15417	2080.0	0.48	33.9	162.9
E15421	2100.0	0.79	28.1	221.7
E15425	2120.0	1.12	20.0	224.1
E15431	2139.0	1.72	14.9	255.7
E15438	2160.0	0.83	25.1	208.3
E15445	2181.0	1.24	19.0	236.2
E15451	2199.0	1.34	16.8	225.1
E15457	2220.0	1.00	25.6	255.8
E15461	2238.0	1.09	17.6	191.9
E15465	2259.0	1.14	19.4	221.2
E15470	2280.0	1.33	25.2	335.8
E15476	2298.0	1.15	30.0	345.3
E15481	2319.0	1.25	29.7	370.7
E15488	2340.0	0.94	28.4	267.3
E15495	2361.0	5.30	8.9	471.6
E15501	2379.0	6.16	10.9	669.8
E15508	2400.0	4.66	13.3	617.9

LEGEND : 1- SAMPLE-NUMBER
2- DEPTH (M)
3- ORG. CARBON (%)
4- IRUS-CONTENT (MG/G CORG.)
5- IRUS-CONTENT (PPM)

TABLE 4 : IRUS-CONTENT OF
UNION OIL 8/4-1
(CONTINUED)

1	2	3	4	5
E15516	2420.0	1.69	15.0	253.2
E15525	2440.0	1.85	12.9	237.9
E15535	2460.0	1.02	19.8	201.5
E15544	2480.0	0.72	18.0	129.4
E15554	2500.0	0.63	22.9	144.2
E15564	2520.0	0.55	25.6	140.9
E15574	2540.0	0.85	19.6	166.5
E15584	2560.0	0.77	21.5	165.5
E15594	2580.0	0.89	27.8	247.5
E15602	2600.0	1.47	17.3	254.1
E15609	2631.0	1.89	17.6	333.4

LEGEND : 1- SAMPLE-NUMBER
2- DEPTH (M)
3- ORG. CARBON (%)
4- IRUS-CONTENT (MG/G CORG.)
5- IRUS-CONTENT (PPM)

TABLE 4 : IRUS-CONTENT OF
UNION OIL 8/4-1

1	2	3	4	5	6	7	8
310.00	0.48	305.	63.5	25.8	34.8	5.8	59.4
450.00	0.73	561.	76.8	36.8	40.6	7.3	52.1
570.00	0.63	532.	84.4	43.5	41.1	10.4	48.5
710.00	1.46	610.	41.8	19.2	36.0	9.9	54.1
810.00	3.35	1107.	33.0	12.8	25.5	13.2	61.3
820.00	3.45	1044.	30.3	11.0	28.9	7.5	63.6
950.00	2.52	583.	23.1	6.7	21.9	7.1	71.0
1130.00	2.12	520.	24.5	7.9	24.8	7.4	67.8
1260.00	3.17	672.	21.2	5.6	20.2	6.1	73.7
1360.00	3.31	670.	20.2	5.2	19.1	6.6	74.3
1455.00	1.21	408.	33.7	15.4	36.1	9.6	54.3
1605.00	0.94	387.	41.2	19.3	39.0	7.9	53.1
1705.00	0.75	355.	47.3	19.7	34.8	6.8	58.4
1870.00	0.55	408.	74.2	45.8	49.6	12.2	38.2
2010.00	0.60	1026.	171.0	81.9	43.5	4.4	52.1
2136.00	1.17	1601.	136.8	71.8	44.3	8.2	47.5
2205.00	1.42	2128.	149.9	78.8	42.3	10.3	47.4
2358.00	3.08	4109.	133.4	71.2	38.9	14.5	46.6
2370.00	5.87	2816.	48.0	27.9	38.3	19.9	41.8
2444.00	1.54	1798.	116.8	60.5	40.3	11.5	48.2
2582.00	0.82	1004.	122.4	62.6	44.5	6.6	48.9

LEGEND:
1- DEPTH (M)
2- CORG (%)
3- C15+ SOLUBLE ORGANIC MATTER (PPM)
4- C15+ SOLUBLE ORGANIC MATTER (MG/G C-ORG)
5- C15+ HYDROCARBONS (MG/G C-ORG)
6- C15+ SATURATED HYDROCARBONS (% OF NR.3)
7- C11+ AROMATIC HYDROCARBONS (% OF NR.3)
8- N,S,O- COMPOUNDS, RESIDUE (% OF NR.3)

TABLE 5 : YIELD AND GROSS COMPOSITION OF ORGANIC MATTER FOR

UNION OIL, 8/4-1

CPI (19-25) = CPI 1
CPI (25-31) = CPI 2
CPI (29) = CPI 3
CPI (27-29) = CPI 4
LHCPI (17-21/27-31)= LHCPI

PRISTANE / N-C 17 = ISO 1
PHYTANE / N-C 18 = ISO 2
PRISTANE / PHYTANE = ISO 3
PRI +PHY / 17 +18 = ISO 4

SAMPLE NUMBER		CPI 1	CPI 2	CPI 3	CPI 4	LHCPI	ISO 1	ISO 2	ISO 3	ISO 4
E16116 -1	310M	1.14	2.95	3.27	3.22	2.05	0.48	0.61	1.1	0.53
E16117 -1	450M	1.09	3.06	3.36	3.19	2.83	0.50	0.58	1.4	0.53
E16118 -1	570M	0.91	2.74	2.72	2.66	3.17	0.67	0.84	1.4	0.73
E16119 -1	710M	1.08	3.11	3.53	3.37	3.35	0.73	0.91	1.8	0.79
E16120 -1	820M	0.99	2.43	2.53	2.41	4.35	0.49	0.55	1.1	0.51
E16121 -1	950M	1.18	2.81	2.89	2.74	2.45	0.60	0.68	1.2	0.63
E16122 -1	1130M	1.06	2.42	2.86	2.49	1.97	0.74	1.0	1.4	0.83
E16123 -1	1260M	1.33	3.12	3.07	2.90	0.76	1.2	1.1	1.9	1.1
E16124 -1	1360M	1.52	*****	*****	*****	*****	1.2	1.1	2.4	1.2
E16125 -1	1455M	0.83	2.58	3.03	2.79	2.83	0.77	0.83	1.7	0.79
E16126 -1	1605M	0.79	*****	3.02	2.46	7.72	0.71	0.78	1.9	0.73
E16127 -1	1705M	0.81	1.65	1.91	1.76	7.27	0.85	0.93	1.5	0.88
E16128 -1	1870M	0.92	*****	*****	*****	*****	0.79	0.51	3.0	0.69
E16129 -1	2010M	1.02	*****	0.99	0.96	35.67	1.1	0.81	1.3	0.95
E16810 -1	2136M	1.03	*****	*****	*****	*****	0.87	0.85	1.1	0.86
E16130 -1	2205M	1.02	*****	*****	*****	*****	0.95	0.83	1.3	0.89
E16811 -1	2358M	1.03	1.23	0.93	1.04	15.66	0.81	0.75	1.4	0.79
E16131 -1	2370M	1.03	1.11	0.97	1.04	16.58	0.79	0.77	1.4	0.78
E16132 -1	2444M	1.02	1.10	0.94	0.94	19.16	0.96	0.88	1.3	0.92
E16133 -1	2582M	1.15	*****	0.95	0.98	27.06	1.0	0.87	1.3	0.96

Table 6

	CONCENTRATION NG/G ROCK				
DEPTH IN M	310	450	570	710	820
N-CX					
15	1513.5	3846.7	4664.8	7679.4	5044.2
16	2305.6	4030.5	4252.1	5429.8	4776.3
17	1833.7	2888.0	2913.6	2745.8	3695.8
18	1260.0	1728.2	1614.3	1223.2	2962.3
19	754.5	900.9	714.2	563.5	1805.6
20	674.2	859.7	579.8	404.1	2261.7
21	718.7	722.7	662.4	290.0	2532.9
22	680.9	499.9	883.6	263.1	1816.7
23	667.2	448.0	473.0	268.3	920.1
24	381.0	275.0	284.0	141.4	539.7
25	620.9	575.8	383.1	264.1	620.8
26	294.9	262.8	200.8	131.8	294.2
27	813.4	770.1	626.7	376.7	676.2
28	217.4	240.7	279.5	105.7	299.5
29	687.9	700.4	531.7	480.3	800.7
30	203.7	176.8	111.9	166.0	333.2
31	634.8	623.7	494.7	432.3	938.0
32	95.9	122.9	52.5	58.6	160.8
33	274.9	314.5	253.1	179.1	407.2
34	54.2	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	14687.4	19987.1	19975.9	21203.8	30885.8
PRISTANE	872.3	1438.4	1947.8	2004.9	1795.1
PHYTANE	763.3	997.6	1351.8	1113.6	1620.7

Table 7 (continued)

	CONCENTRATION NG/G ROCK				
DEPTH IN M	950	1130	1260	1360	1455
N-CX					
15	3041.8	3661.8	3704.9	3210.3	4499.3
16	2741.2	2640.7	2330.9	1735.9	2763.1
17	2220.5	1725.3	1139.9	976.8	1193.3
18	1584.2	881.2	647.9	445.4	657.0
19	916.8	431.0	264.7	246.1	244.0
20	618.4	362.1	195.7	231.4	252.1
21	467.0	314.5	191.8	248.9	114.2
22	320.0	314.5	174.7	201.0	110.5
23	329.6	306.7	331.0	418.3	118.5
24	199.0	182.5	183.4	230.5	88.1
25	406.3	387.5	501.9	602.5	128.1
26	200.7	254.2	255.4	247.1	90.7
27	536.6	481.0	709.7	749.7	202.4
28	215.1	188.0	266.8	321.0	67.8
29	675.4	543.1	894.9	875.4	246.2
30	252.7	192.2	317.0	0.0	94.9
31	687.0	478.2	1013.1	861.7	259.2
32	111.8	110.9	138.2	103.6	54.4
33	362.6	218.1	421.7	325.0	86.0
34	41.8	0.0	0.0	0.0	0.0
35	80.2	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	16008.4	13673.4	13683.6	12030.5	11270.0
PRISTANE	1326.1	1278.0	1330.7	1180.8	915.2
PHYTANE	1073.2	885.7	714.5	500.1	546.8

Table 7 (continued)

DEPTH IN M	CONCENTRATION NG/G ROCK				
	1605	1705	1870	2010	2136
N-CX					
15	5828.9	3245.6	4557.2	4843.5	5178.5
16	4383.2	3013.0	5640.5	9547.8	8149.6
17	2343.1	1773.8	3867.3	12233.2	10734.4
18	1130.2	1056.1	1996.8	12596.0	10427.9
19	439.2	394.5	1048.2	10797.9	9931.8
20	392.2	417.6	843.7	9794.9	8736.7
21	167.5	292.9	675.0	7484.6	7413.4
22	152.6	294.8	642.6	5238.9	5529.1
23	117.2	206.2	472.6	3441.5	3406.6
24	96.1	143.8	331.6	2368.4	2486.5
25	86.3	125.8	200.2	1520.7	1590.6
26	77.0	85.7	145.9	898.7	1159.8
27	134.2	112.3	112.5	595.2	724.7
28	55.1	53.3	45.6	351.9	337.0
29	156.9	137.5	67.1	241.2	214.2
30	48.9	91.1	0.0	134.6	0.0
31	184.4	147.2	0.0	160.6	0.0
32	0.0	45.3	0.0	0.0	0.0
33	87.0	76.7	0.0	0.0	0.0
34	0.0	23.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	15880.0	11736.2	20646.9	82249.6	76020.9
PRISTANE	1665.3	1506.6	3052.5	13310.5	9391.0
PHYTANE	883.8	986.8	1009.6	10230.7	8852.0

Table 7 (continued)

	CONCENTRATION NG/G ROCK				
DEPTH IN M	2205	2358	2370	2444	2582
N-CX					
15	9272.1	20851.4	21704.0	8991.4	4908.0
16	15343.5	25605.4	26174.4	13345.4	8655.2
17	19196.7	26644.6	26107.4	16006.7	10271.2
18	16491.5	19863.4	19151.4	13024.9	9605.5
19	13571.7	15646.6	14025.0	10347.6	8767.5
20	11586.9	13917.7	10991.4	8709.9	6816.2
21	8906.6	11008.9	9369.2	7702.0	6198.4
22	7009.6	8508.0	6913.4	6335.9	4004.9
23	5330.7	6426.3	4914.8	4416.5	3188.3
24	3811.0	4576.3	4081.0	3270.2	2181.6
25	2568.2	4047.7	2960.8	2350.6	1644.8
26	1530.7	2377.7	1956.0	1540.5	934.9
27	1238.3	2048.9	1631.2	1039.8	649.5
28	571.0	1314.9	1058.0	669.4	371.9
29	379.3	959.4	874.8	515.8	245.5
30	0.0	752.0	740.0	425.7	147.3
31	0.0	487.1	501.0	261.1	125.1
32	0.0	190.0	331.4	170.4	0.0
33	0.0	0.0	383.6	234.7	0.0
34	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	116807.7	165226.3	153868.8	99358.3	68715.7
PRISTANE	18216.3	21627.7	20564.0	15390.6	10730.4
PHYTANE	13627.2	14925.1	14804.2	11434.6	8383.4

Table 7

DEPTH IN M	CONCENTRATION MICROGRAM/GRAM C-ORG				
	310	450	570	710	820
N-CX					
15	315.3	526.9	740.4	526.0	146.2
16	480.3	552.1	674.9	371.9	138.4
17	382.0	395.6	462.5	188.1	107.1
18	262.5	236.7	256.2	83.8	85.9
19	157.2	123.4	113.4	38.6	52.3
20	140.5	117.8	92.0	27.7	65.6
21	149.7	99.0	105.2	19.9	73.4
22	141.9	68.5	140.3	18.0	52.7
23	139.0	61.4	75.1	18.4	26.7
24	79.4	37.7	45.1	9.7	15.6
25	129.4	78.9	60.8	18.1	18.0
26	61.4	36.0	31.9	9.0	8.5
27	169.5	105.5	99.5	25.8	19.6
28	45.3	33.0	44.4	7.2	8.7
29	143.3	95.9	84.4	32.9	23.2
30	42.4	24.2	17.8	11.4	9.7
31	132.2	85.4	78.5	29.6	27.2
32	20.0	16.8	8.3	4.0	4.7
33	57.3	43.1	40.2	12.3	11.8
34	11.3	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	3059.9	2738.0	3170.8	1452.3	895.2
PRISTANE	181.7	197.0	309.2	137.3	52.0
PHYTANE	159.0	136.7	214.6	76.3	47.0

Table 8 (continued)

	CONCENTRATION MICROGRAM/GRAM C-ORG				
DEPTH IN M	950	1130	1260	1360	1455
N-CX					
15	120.7	172.7	116.9	97.0	371.8
16	108.8	124.6	73.5	52.4	228.4
17	88.1	81.4	36.0	29.5	98.6
18	62.9	41.6	20.4	13.5	54.3
19	36.4	20.3	8.4	7.4	20.2
20	24.5	17.1	6.2	7.0	20.8
21	18.5	14.8	6.1	7.5	9.4
22	12.7	14.8	5.5	6.1	9.1
23	13.1	14.5	10.4	12.6	9.8
24	7.9	8.6	5.8	7.0	7.3
25	16.1	18.3	15.8	18.2	10.6
26	8.0	12.0	8.1	7.5	7.5
27	21.3	22.7	22.4	22.6	16.7
28	8.5	8.9	8.4	9.7	5.6
29	26.8	25.6	28.2	26.4	20.3
30	10.0	9.1	10.0	0.0	7.8
31	27.3	22.6	32.0	26.0	21.4
32	4.4	5.2	4.4	3.1	4.5
33	14.4	10.3	13.3	9.8	7.1
34	1.7	0.0	0.0	0.0	0.0
35	3.2	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	635.3	645.0	431.7	363.5	931.4
PRISTANE	52.6	60.3	42.0	35.7	75.6
PHYTANE	42.6	41.8	22.5	15.1	45.2

Table 8 (continued)

DEPTH IN M	CONCENTRATION MICROGRAM/GRAM C-ORG				
	1605	1705	1870	2010	2136
N-CX					
15	620.1	432.7	828.6	807.3	442.6
16	466.3	401.7	1025.5	1591.3	696.6
17	249.3	236.5	703.2	2038.9	917.5
18	120.2	140.8	363.1	2099.3	891.3
19	46.7	52.6	190.6	1799.7	848.9
20	41.7	55.7	153.4	1632.5	746.7
21	17.8	39.1	122.7	1247.4	633.6
22	16.2	39.3	116.8	873.2	472.6
23	12.5	27.5	85.9	573.6	291.2
24	10.2	19.2	60.3	394.7	212.5
25	9.2	16.8	36.4	253.5	135.9
26	8.2	11.4	26.5	149.8	99.1
27	14.3	15.0	20.5	99.2	61.9
28	5.9	7.1	8.3	58.7	28.8
29	16.7	18.3	12.2	40.2	18.3
30	5.2	12.1	0.0	22.4	0.0
31	19.6	19.6	0.0	26.8	0.0
32	0.0	6.0	0.0	0.0	0.0
33	9.3	10.2	0.0	0.0	0.0
34	0.0	3.1	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	1689.4	1564.8	3754.0	13708.3	6497.5
PRISTANE	177.2	200.9	555.0	2218.4	802.6
PHYTANE	94.0	131.6	183.6	1705.1	756.6

Table 8 (continued)

	CONCENTRATION MICROGRAM/GRAM C-ORG				
DEPTH IN M	2205	2358	2370	2444	2582
N-CX					
15	653.0	677.0	369.7	583.9	598.5
16	1080.5	831.3	445.9	866.6	1055.5
17	1351.9	865.1	444.8	1039.4	1252.6
18	1161.4	644.9	326.3	845.8	1171.4
19	955.8	508.0	238.9	671.9	1069.2
20	816.0	451.9	187.2	565.6	831.2
21	627.2	357.4	159.6	500.1	755.9
22	493.6	276.2	117.8	411.4	488.4
23	375.4	208.6	83.7	286.8	388.8
24	268.4	148.6	69.5	212.3	266.1
25	180.9	131.4	50.4	152.6	200.6
26	107.8	77.2	33.3	100.0	114.0
27	87.2	66.5	27.8	67.5	79.2
28	40.2	42.7	18.0	43.5	45.4
29	26.7	31.2	14.9	33.5	29.9
30	0.0	24.4	12.6	27.6	18.0
31	0.0	15.8	8.5	17.0	15.3
32	0.0	6.2	5.6	11.1	0.0
33	0.0	0.0	6.5	15.2	0.0
34	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0
SUMME N-CX	8225.9	5364.5	2621.3	6451.8	8380.0
PRISTANE	1282.8	702.2	350.3	999.4	1308.6
PHYTANE	959.7	484.6	252.2	742.5	1022.4

Table 8

Table 9 (continued)

NAPHTHALENE DISTRIBUTION OF SAMPLES FROM

UNION OIL 8/4-1

EOGNR	DEPTH	%CORG	2-MN	1-MN	2-EN	1-EN	2,6/ 2,7DN	1,3/ 1,7DN	1,6DN	1,4/ 2,3DN	1,5DN	1,2DN	1. TN	2. TN	3. TN	4. TN	5. TN
E16123	1260.	3.17	0.7	0.8	0.8	0.8	3.3	4.7	4.3	2.4	1.6	1.4	2.3	3.5	2.8	1.9	2.1
PERCENTAGE			14.4	17.5	16.3	16.3	70.6	100.0	90.3	49.7	32.8	29.4	48.2	74.4	59.0	41.0	44.6
E16124	1360.	3.31	0.8	1.2	1.6	1.7	8.2	12.4	12.4	8.0	4.5	4.1	6.6	10.7	8.4	5.2	7.3
			6.7	9.6	12.5	13.4	66.1	99.9	100.0	64.5	36.3	33.2	52.9	86.3	67.5	41.8	59.1
E16125	1455.	1.21	2.9	3.4	4.0	4.0	20.1	31.4	28.4	21.5	11.4	10.4	21.0	33.7	29.7	18.5	19.2
			8.7	10.0	11.9	11.9	59.6	93.1	84.4	63.9	33.9	31.0	62.3	100.0	88.1	55.0	56.9
E16126	1605.	0.94			1.4	1.6	11.8	21.0	17.3	15.2	7.1	7.3	32.6	56.5	46.3	36.1	38.4
					2.5	2.8	20.8	37.1	30.6	26.9	12.6	13.0	57.7	100.0	82.0	64.0	68.0
E16127	1705.	0.75			1.3	0.9	6.4	13.6	10.8	10.3	5.1	4.9	25.6	44.7	37.2	28.8	31.5
					2.9	2.1	14.3	30.4	24.1	23.0	11.4	10.9	57.2	100.0	83.1	64.5	70.5
E16128	1870.	0.55											25.8	41.4	32.4	32.0	36.7
													62.2	100.0	78.3	77.2	88.6
E16129	2010.	0.60											6.4	10.9	9.6	8.0	8.7
													58.8	100.0	88.2	73.6	79.4
E16810	2136.	1.17															
E16130	2205.	1.42	2.2	1.8	6.2	1.6	7.3	9.2	8.7	5.1	3.3	2.9	10.3	17.4	14.7	12.7	13.6
			12.5	10.4	35.4	9.4	42.2	53.1	50.0	29.1	18.7	16.7	59.4	100.0	84.4	72.9	78.1
E16811	2358.	3.08	89.6	88.8	39.1	30.1	122.3	147.5	158.8	73.0	54.9	56.4	95.6	160.3	126.4	103.1	87.3
			55.9	55.4	24.4	18.8	76.3	92.0	99.1	45.5	34.3	35.2	59.6	100.0	78.9	64.3	54.5
E16131	2370.	5.87	17.8	18.1	7.1	7.4	26.2	36.8	38.1	18.1	11.6	11.3	18.1	31.0	25.2	17.1	17.2
			46.6	47.5	18.7	19.5	68.9	96.6	100.0	47.5	30.5	29.7	47.5	81.4	66.1	44.9	45.1

Table 9

NAPHTHALENE DISTRIBUTION OF SAMPLES FROM

UNION OIL 8/4-1

EOGNR	DEPTH	%CORG	2-MN	1-MN	2-EN	1-EN	2,6/ 2,7DN	1,3/ 1,7DN	1,6DN	1,4/ 2,3DN	1,5DN	1,2DN	1. TN	2. TN	3. TN	4. TN	5. TN
E16132	2444.	1.54	23.5	23.9	8.6	8.6	33.8	43.1	40.1	19.9	13.9	14.3	25.2	41.8	32.6	25.9	28.5
PERCENTAGE			54.6	55.4	20.0	20.0	78.5	100.0	93.1	46.2	32.3	33.1	58.5	96.9	75.6	60.0	66.2

Table 10 (continued)

PHENANTHRENE DISTRIBUTION OF SAMPLES FROM

UNION OIL 8/4-1

EOGNR	DEPTH	%CORG	PHE	3MPHE	2MPHE	9MPHE	1MPHE	1.DMP	2.DMP	3.DMP	4.DMP	5.DMP	6.DMP	7.DMP	8.DMP	9.DMP	10DMP
E16123	1260.	3.17	0.6	0.2	0.2	0.2	0.2	0.1		0.1	0.1	0.2	0.1	0.1		0.1	0.1
PERCENTAGE			100.0	29.5	39.3	36.1	26.2	9.8	6.6	16.4	11.5	39.3	16.4	14.8	6.6	16.4	14.8
E16124	1360.	3.3[illegible]	1.5														
			100.0														
E16125	1455.	1.21	12.3														
			100.0														
E16126	1605.	0.94	20.9														
			100.0														
E16127	1705.	0.75	26.7														
			100.0														
E16128	1870.	0.55	33.3														
			100.0														
E16129	2010.	0.60	20.2	18.1	24.3	22.3	18.1	10.5	2.8	17.0	10.5	35.0	13.2	14.6	6.3	7.0	11.8
			57.5	51.6	69.4	63.5	51.6	30.1	7.9	48.5	30.1	100.0	37.7	41.7	17.8	19.8	33.7
E16810	2136.	1.17	86.4	95.5	135.5	125.2	101.9	42.6	14.2	78.7	41.3	163.2	76.1	85.2	28.4	42.6	65.8
			53.0	58.5	83.0	76.7	62.5	26.1	8.7	48.2	25.3	100.0	46.6	52.2	17.4	26.1	40.3
E16130	2205.	1.42	20.6	15.9	20.8	18.2	14.7	6.3	2.0	10.4	6.5	25.5	9.8	11.0	4.3	5.1	0.7
			80.8	62.3	81.6	71.6	57.7	24.6	7.7	40.8	25.4	100.0	38.5	43.1	16.9	20.0	2.6
E16811	2358.	3.08	114.7	47.5	61.3	56.4	47.1	14.7	5.1	24.0	13.7	56.1	22.1	23.0	8.8	10.8	12.7
			100.0	41.5	53.4	49.1	41.0	12.8	4.4	20.9	12.0	48.9	19.2	20.1	7.7	9.4	11.1
E16131	2370.	5.87	11.1	6.0	7.2	6.9	6.2	1.8	0.8	3.2	1.7	6.6	2.8	3.1	1.2	1.5	1.1
			100.0	53.6	65.2	62.4	55.8	16.6	7.2	28.7	15.5	59.7	25.4	27.6	10.5	13.8	9.9

Table 10

PHENANTHRENE DISTRIBUTION OF SAMPLES FROM

UNION OIL 8/4-1

EOGNR	DEPTH	%CORG	PHE	3MPHE	2MPHE	9MPHE	1MPHE	1.DMP	2.DMP	3.DMP	4.DMP	5.DMP	6.DMP	7.DMP	8.DMP	9.DMP	10DMP
E16132	2444.	1.54	19.7	14.2	18.3	17.2	14.3	5.9	2.0	9.7	5.8	20.3	8.5	9.3	3.8	4.4	2.8
PERCENTAGE			97.0	69.6	90.2	84.4	70.1	29.0	10.0	47.5	28.5	100.0	41.7	45.9	18.4	21.6	13.7

MATURITY- PARAMETERS BASED ON AROMATIC HYDROCARBONS FROM UNION-OIL 8/4-1

DEPTH (M)	MNR	ENR	DNR	TNR	MPR	DPR	MPI1	MPI2	RC(%)
1260.	0.82	1.00	2.15	0.67	1.50	0.50	0.64	0.73	0.78
1360.	0.70	0.93	1.82	0.62					
1455.	0.86	1.00	1.76	0.62					
1605.		0.89	1.66	0.67					
1705.		1.40	1.26	0.66					
1870.				0.78					
2010.				0.70	1.35	0.57	1.05	1.21	1.03
2136.					1.33	0.50	1.10	1.30	1.06
2205.	1.20	3.78	2.25	0.72	1.41	0.48	1.03	1.16	1.02
2358.	1.01	1.30	2.23	0.69	1.30	0.48	0.75	0.84	0.85
2370.	0.98	0.96	2.26	0.63	1.17	0.52	0.82	0.90	0.89
2444.	0.99	1.00	2.43	0.69	1.29	0.54	0.95	1.08	0.97

Table 11

Fig. 1

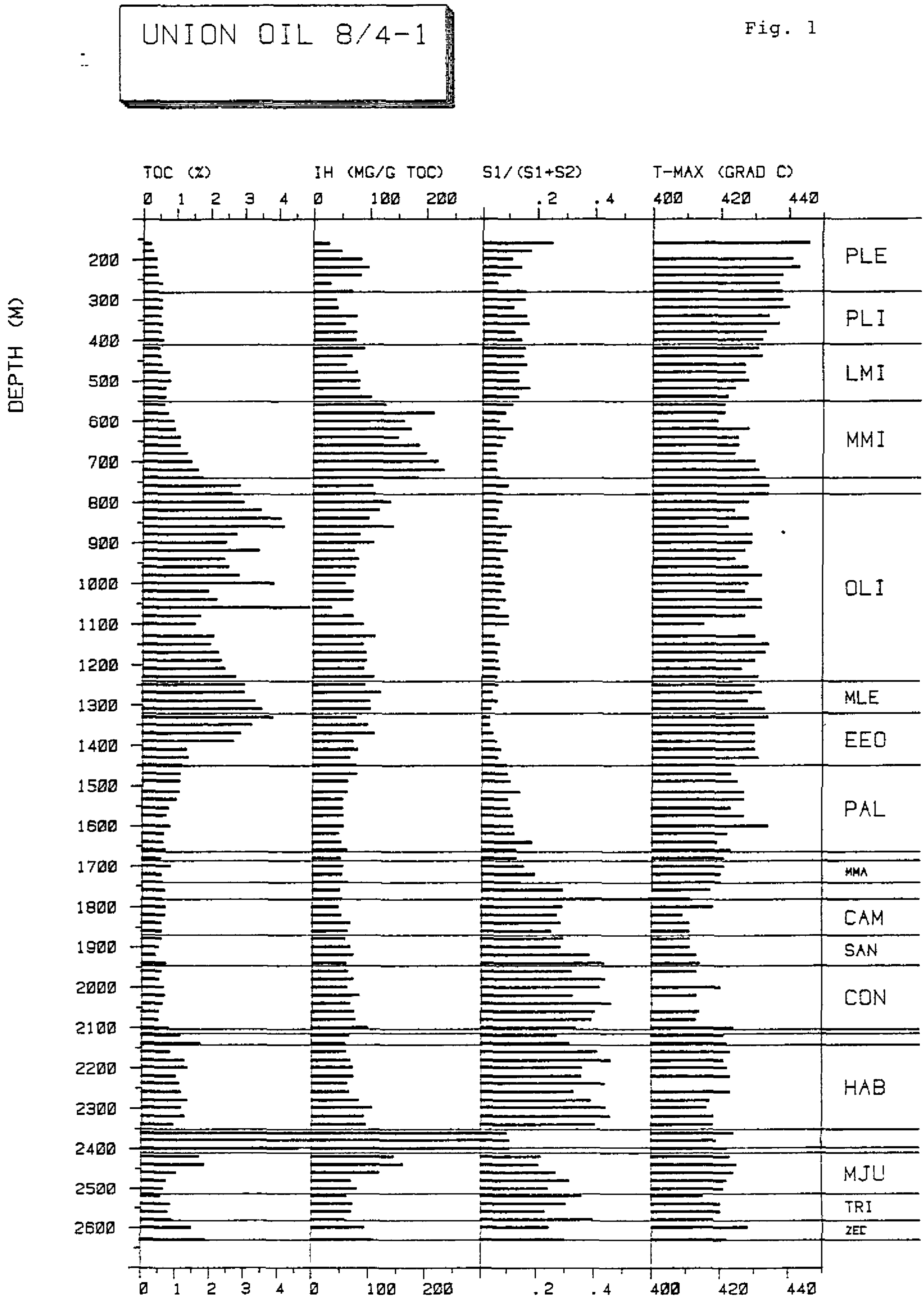
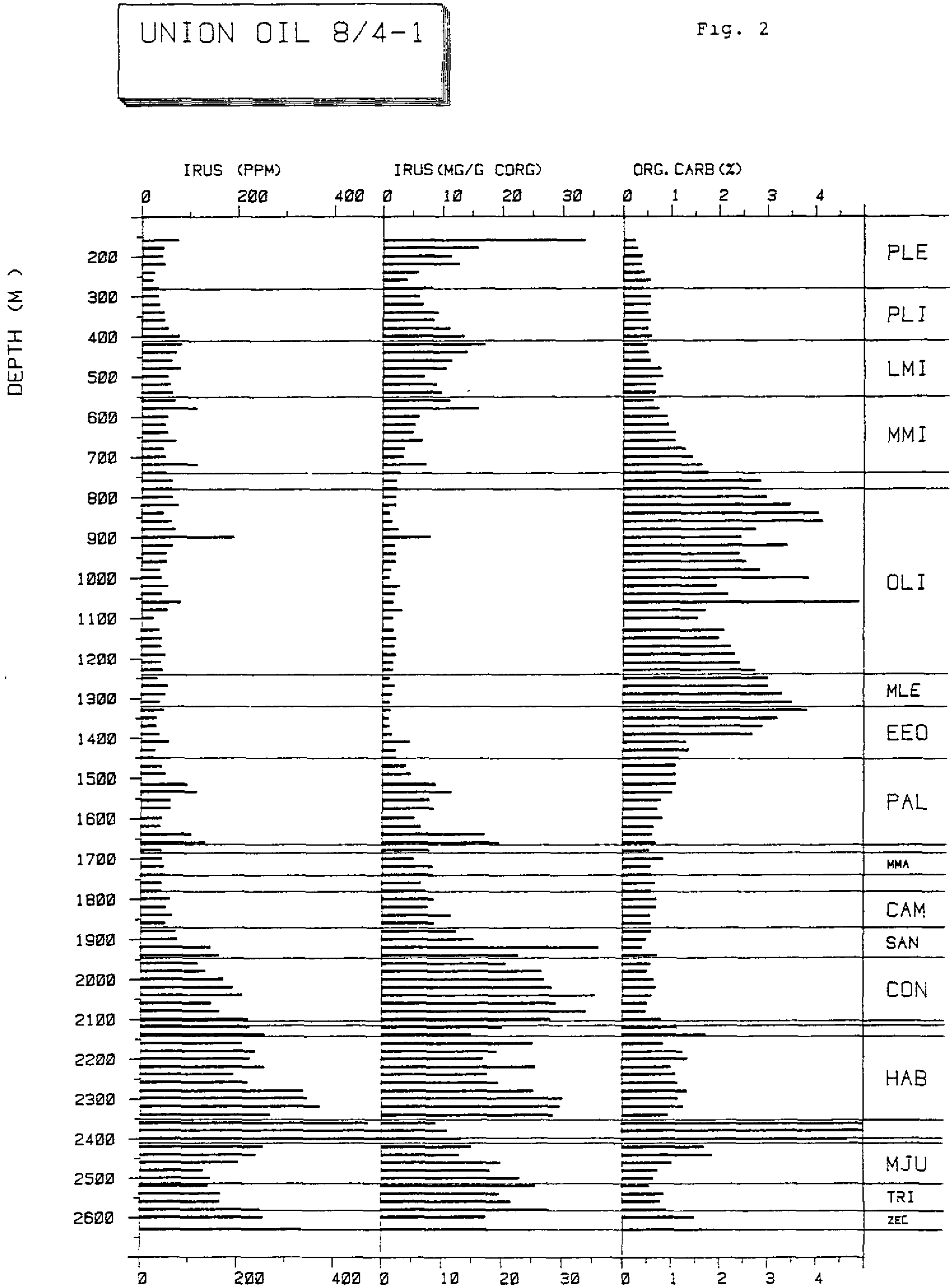
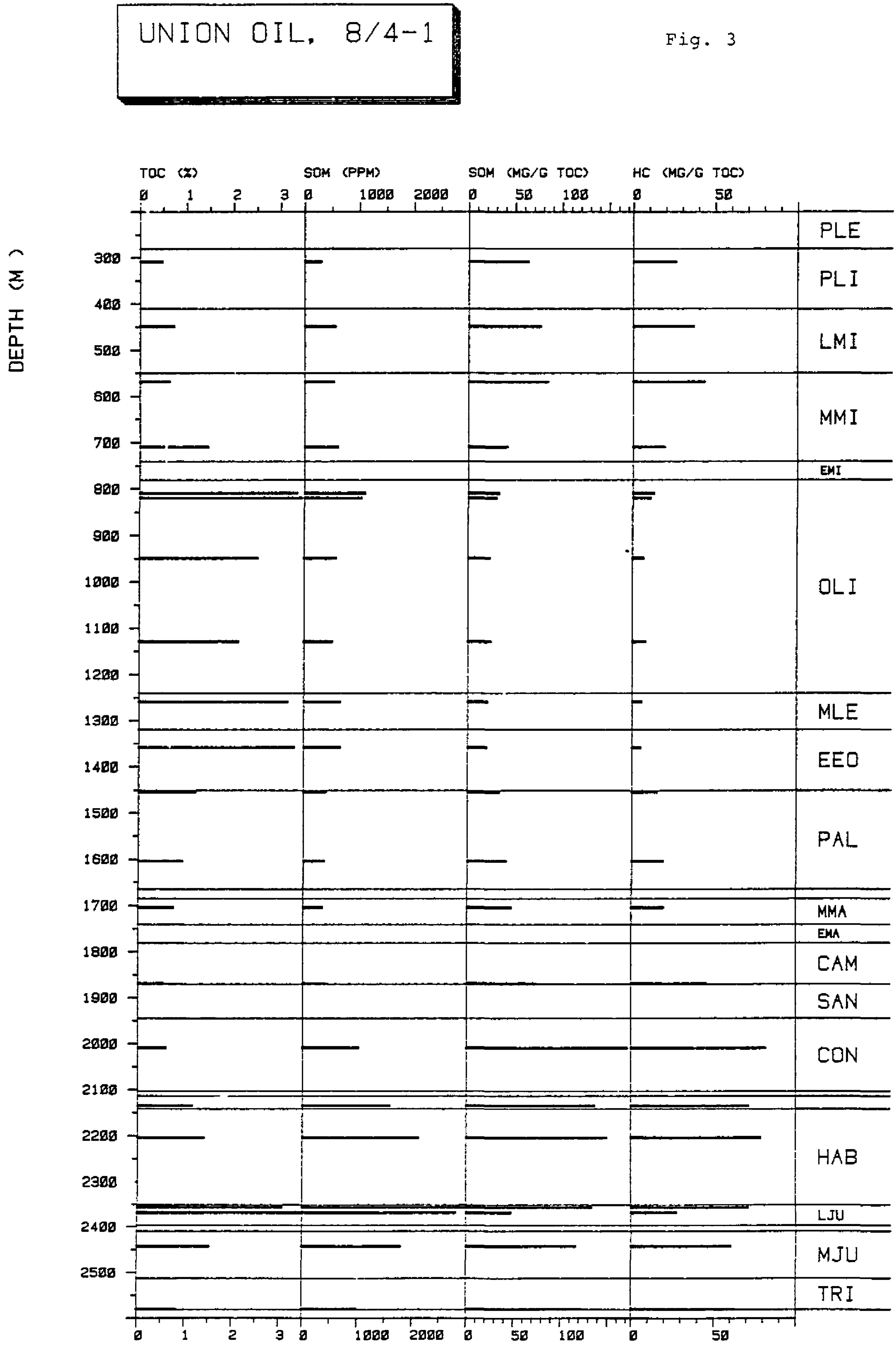
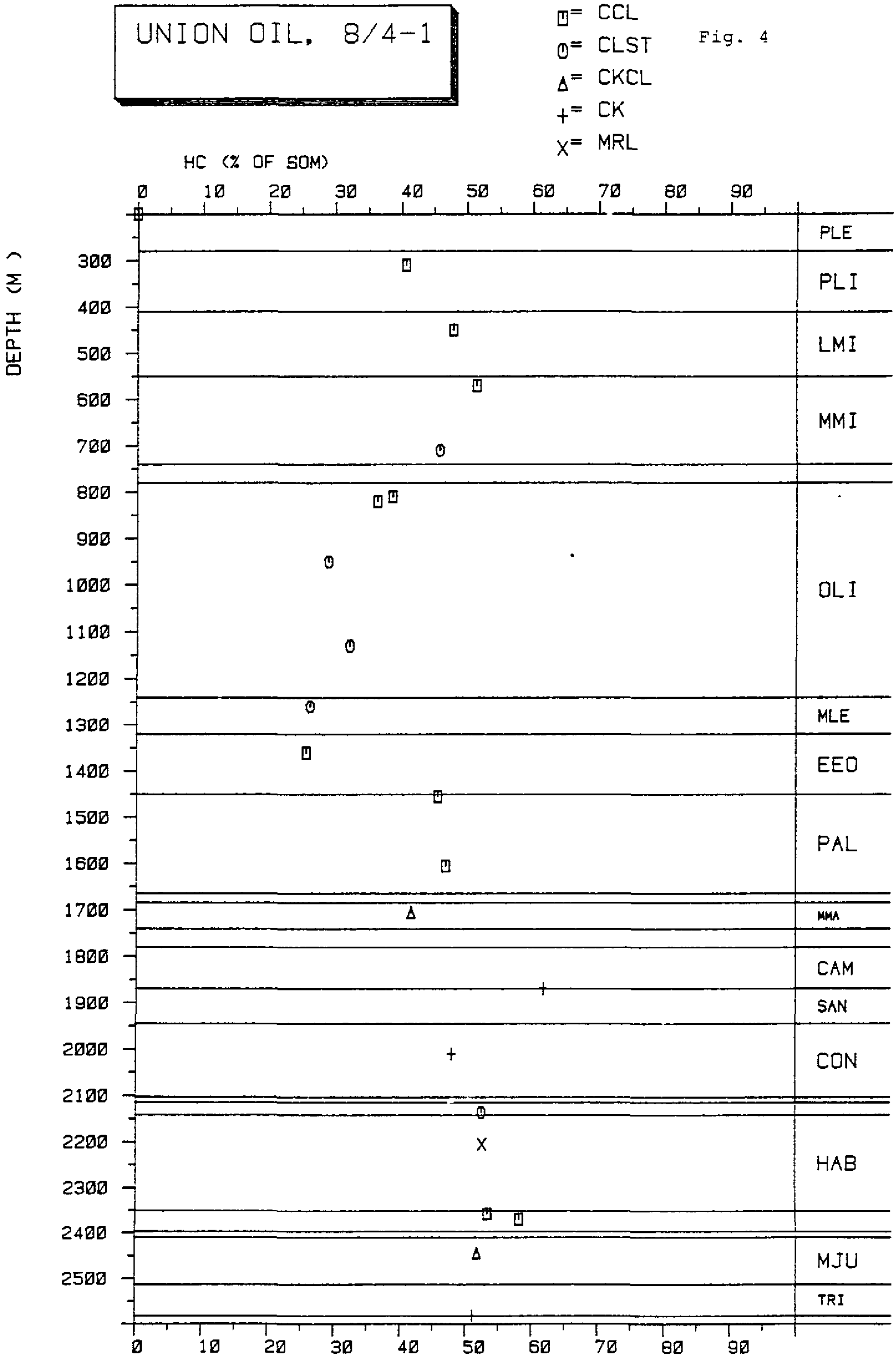

UNION OIL 8/4-1
TOC (%)
IH (MG/G TOC)
S1/(S1+S2)
T-MAX (GRAD C)
DEPTH (M)
0 1 2 3 4
0 100 200
.2 .4
400 420 440
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
PLE
PLI
LMI
MMI
OLI
MLE
EEO
PAL
MMA
CAM
SAN
CON
HAB
MJU
TRI
ZEC

Fig. 2


UNION OIL 8/4-1
IRUS (PPM)
IRUS (MG/G CORG)
ORG. CARB (%)
DEPTH (M)
PLE
PLI
LMI
MMI
OLI
MLE
EEO
PAL
MMA
CAM
SAN
CON
HAB
MJU
TRI
ZEC


UNION OIL, 8/4-1
Fig. 3
TOC (%)
SOM (PPM)
SOM (MG/G TOC)
HC (MG/G TOC)
DEPTH (M)
PLE
PLI
LMI
MMI
EMI
OLI
MLE
EEO
PAL
MMA
EMA
CAM
SAN
CON
HAB
LJU
MJU
TRI



UNION OIL, 8/4-1
Fig. 4
= CCL
= CLST
Δ= CKCL
+= CK
X= MRL
HC (% OF SOM)
DEPTH (M)
0 10 20 30 40 50 60 70 80 90
300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500
PLE
PLI
LMI
MMI
OLI
MLE
EEO
PAL
MMA
CAM
SAN
CON
HAB
MJU
TRI

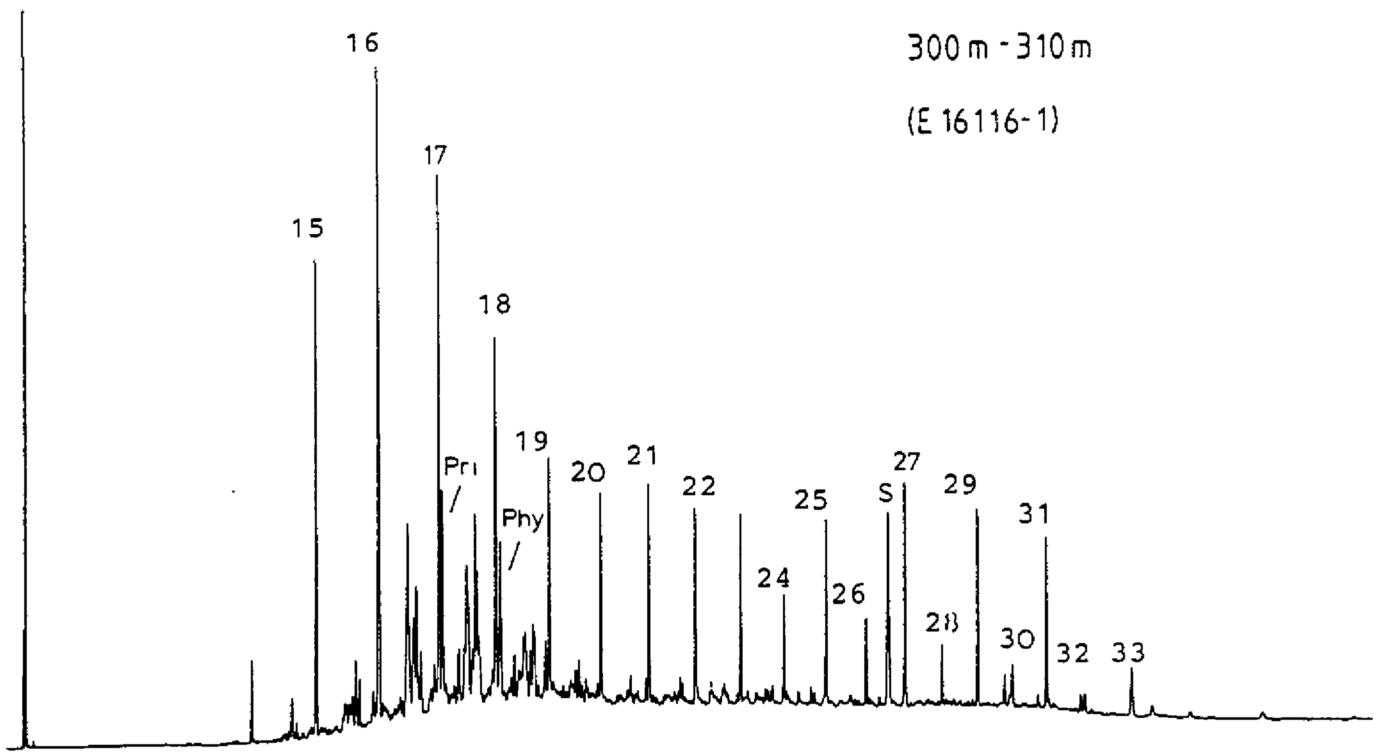

300 m - 310 m
(E 16116-1)
16
17
15
18
19
Pri
20
21
22
Phy
25
27
S
29
31
24
26
28
30
32
33

Fig. 5a

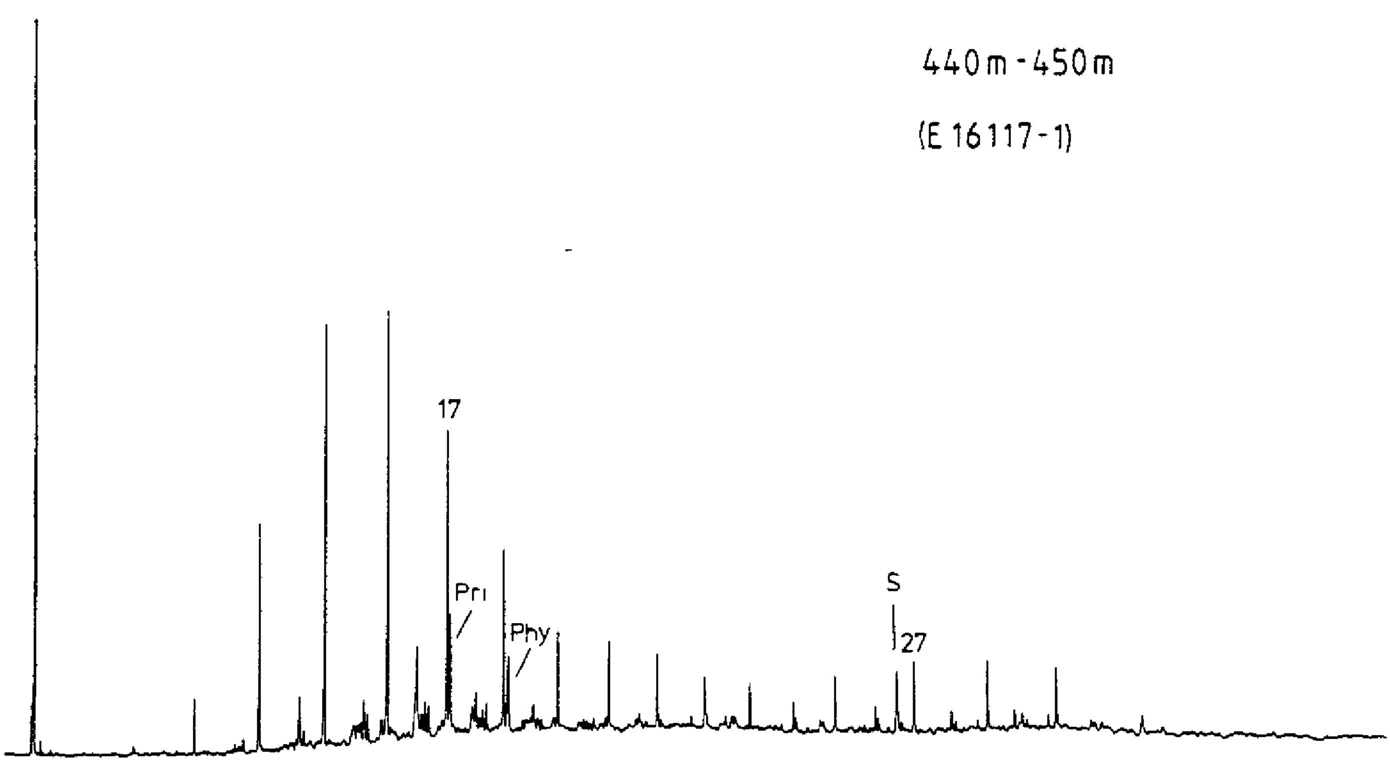

440 m - 450 m
(E 16117-1)
17
Pri
Phy
S
27

Fig. 5b

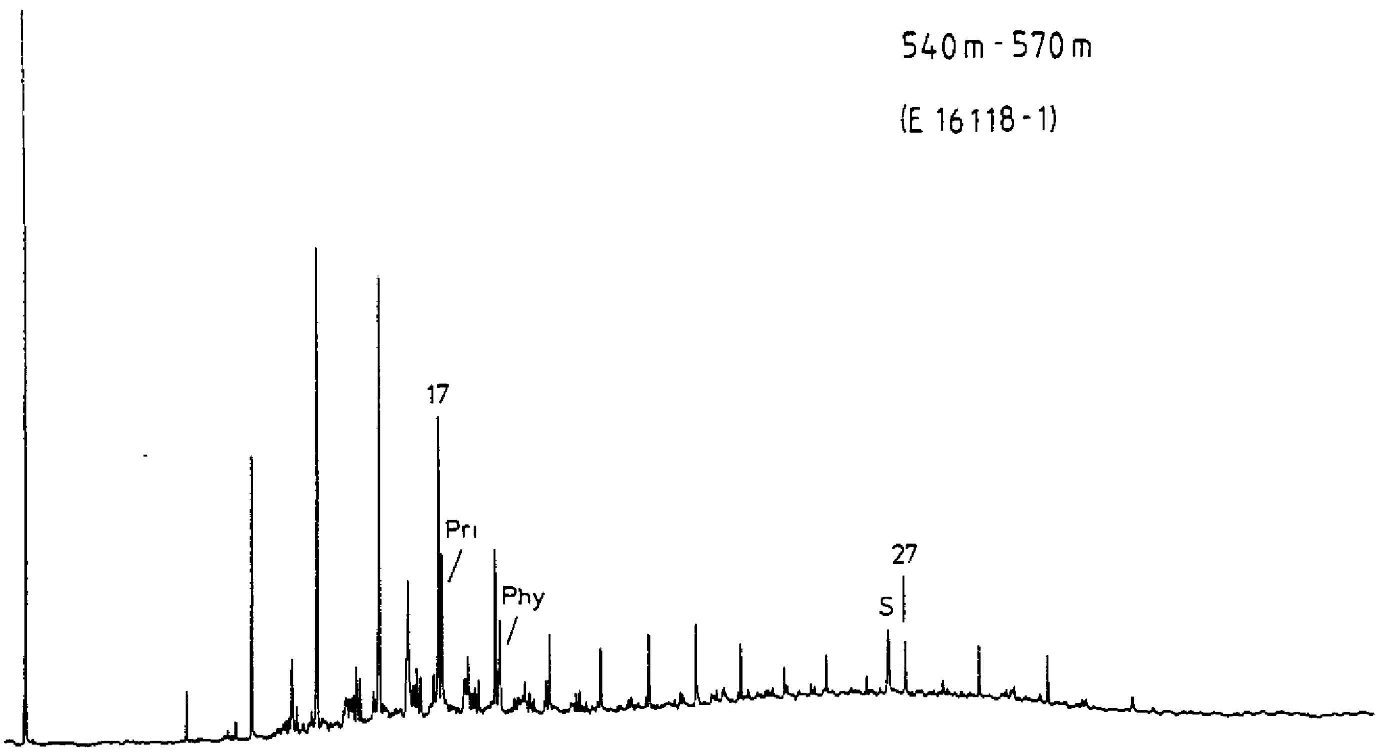

540 m - 570 m
(E 16118 - 1)
17
Pri
Phy
27
S

Fig. 5c

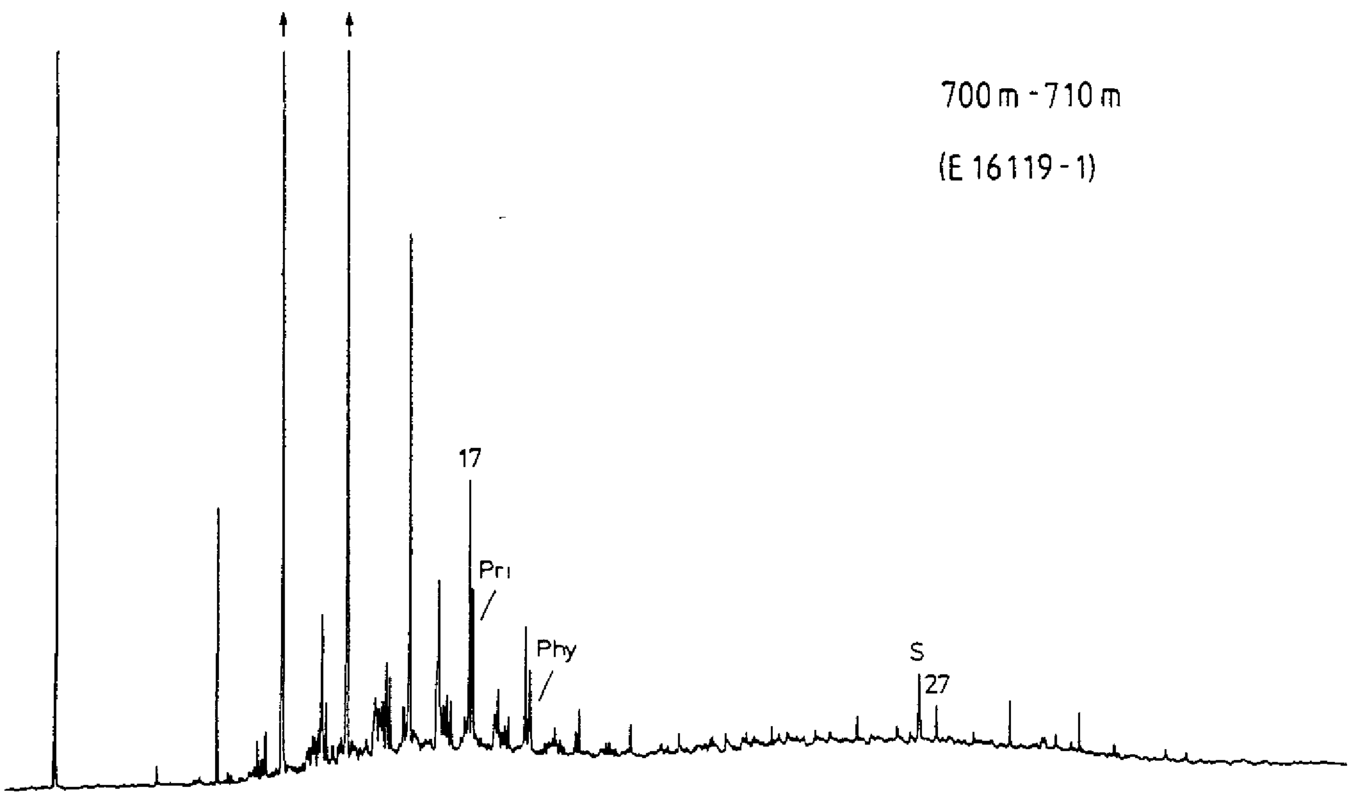

700 m - 710 m
(E 16119 - 1)
17
Pri
Phy
S
27

Fig. 5d

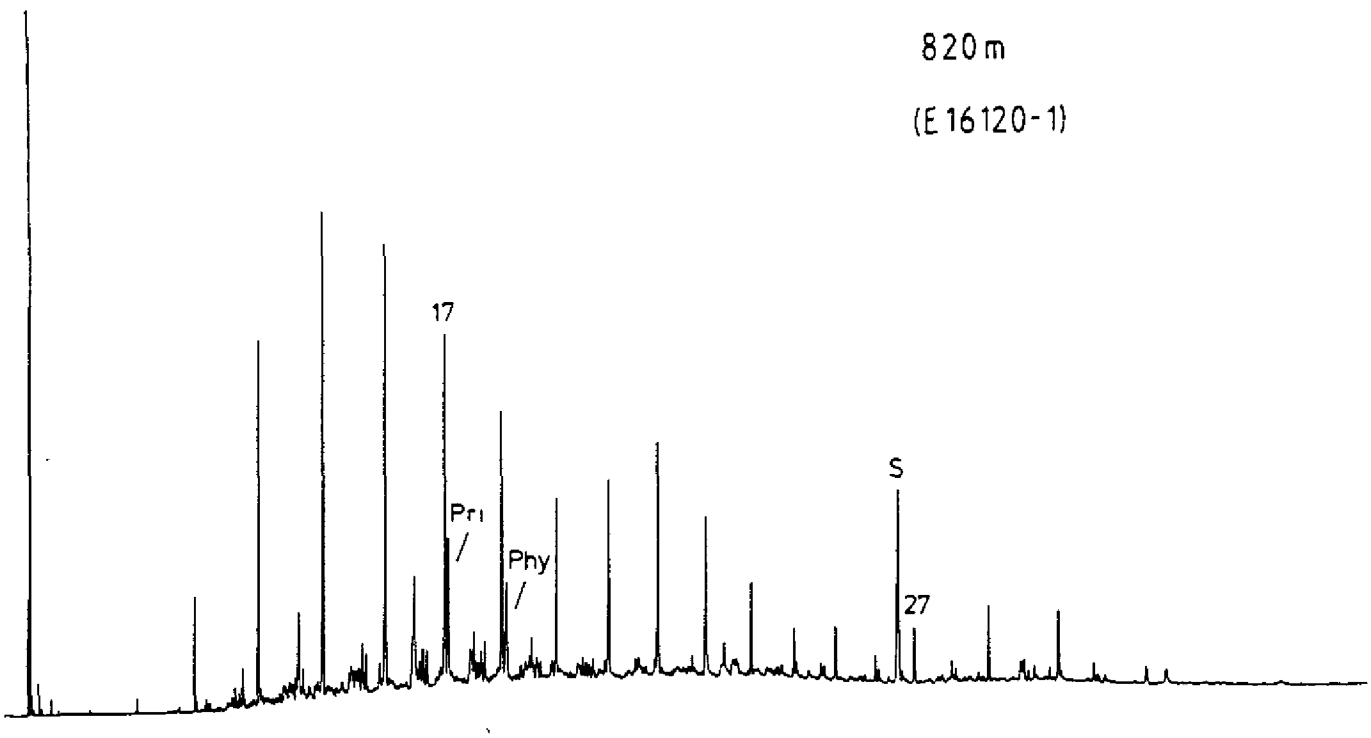


Fig. 5e

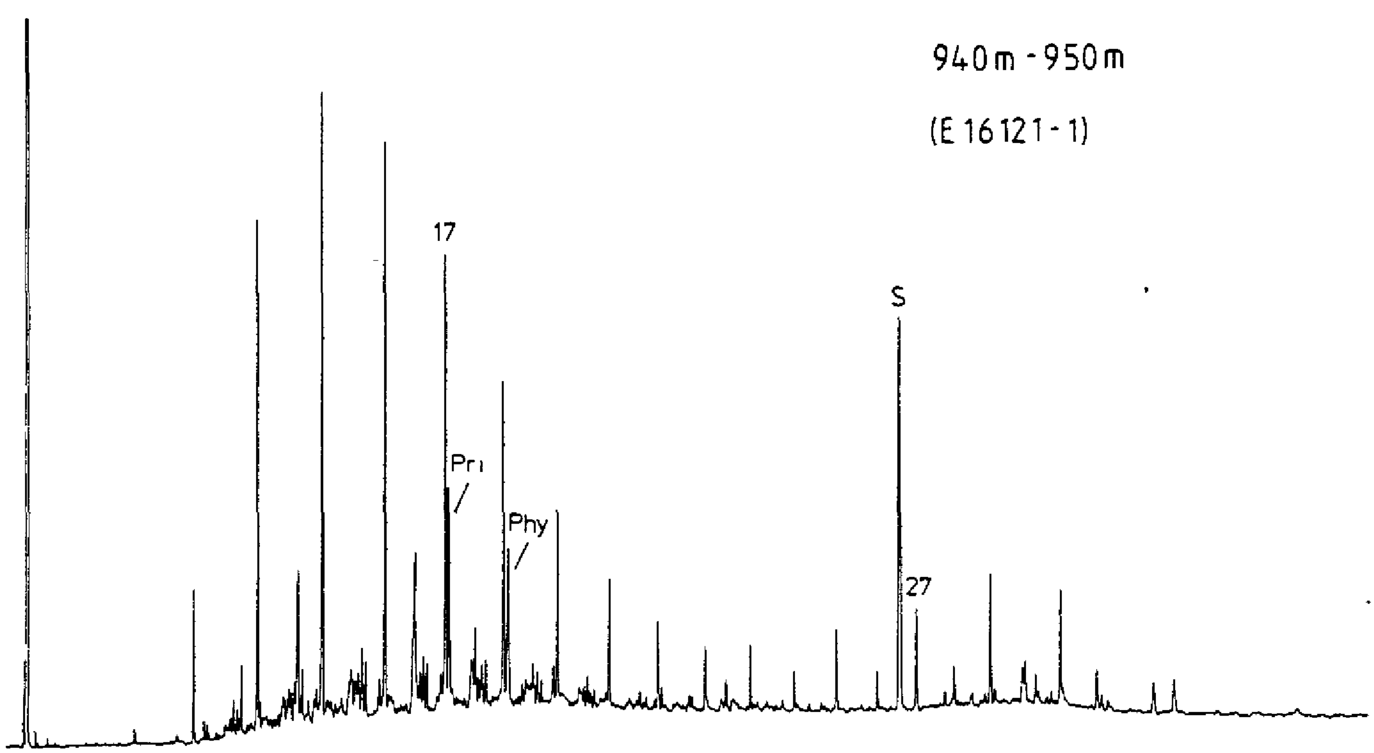


Fig. 5f

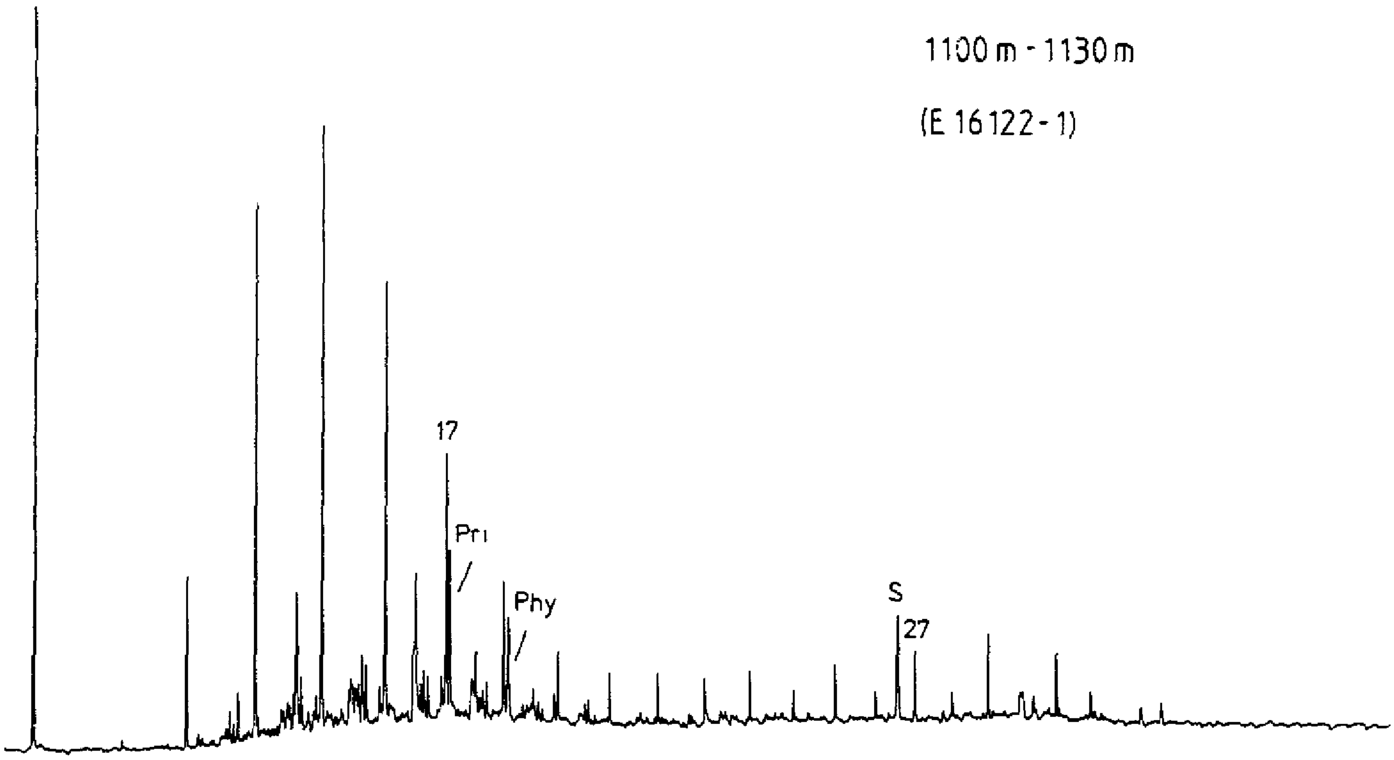

1100 m - 1130 m
(E 16122 - 1)
17
Pri
Phy
S
27

Fig. 5g

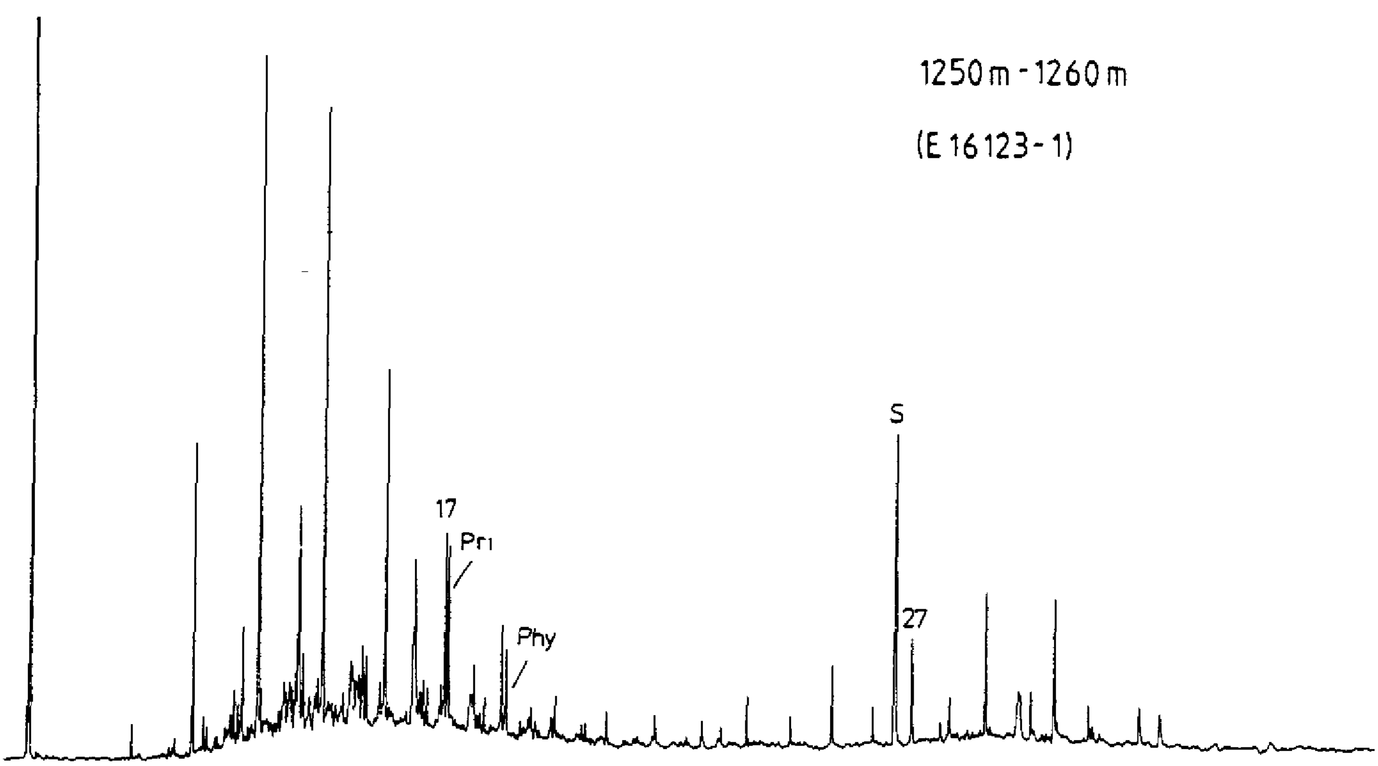

1250 m - 1260 m
(E 16123 - 1)
17
Pri
Phy
S
27

Fig. 5h

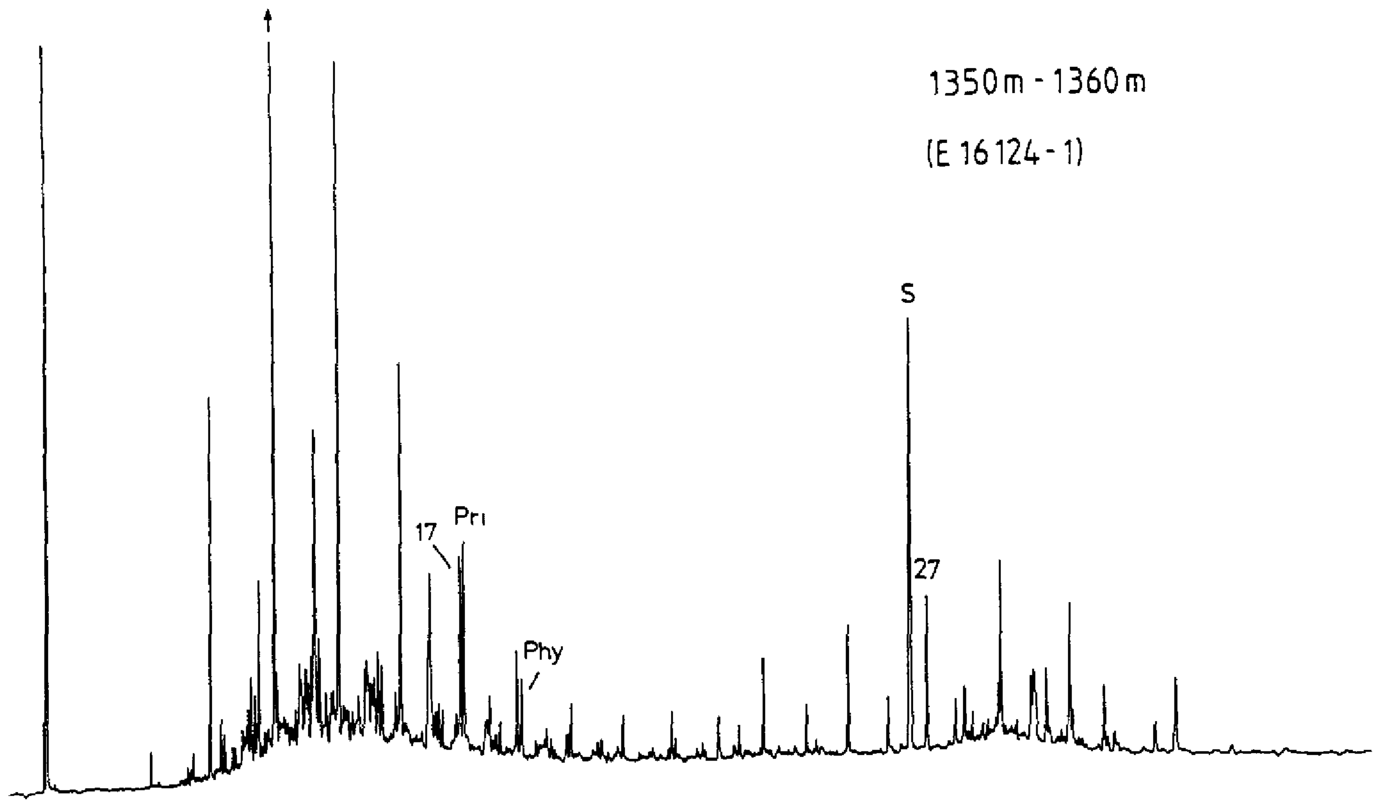

1350m - 1360m
(E 16124-1)
S
17
Pri
27
Phy

Fig. 5i

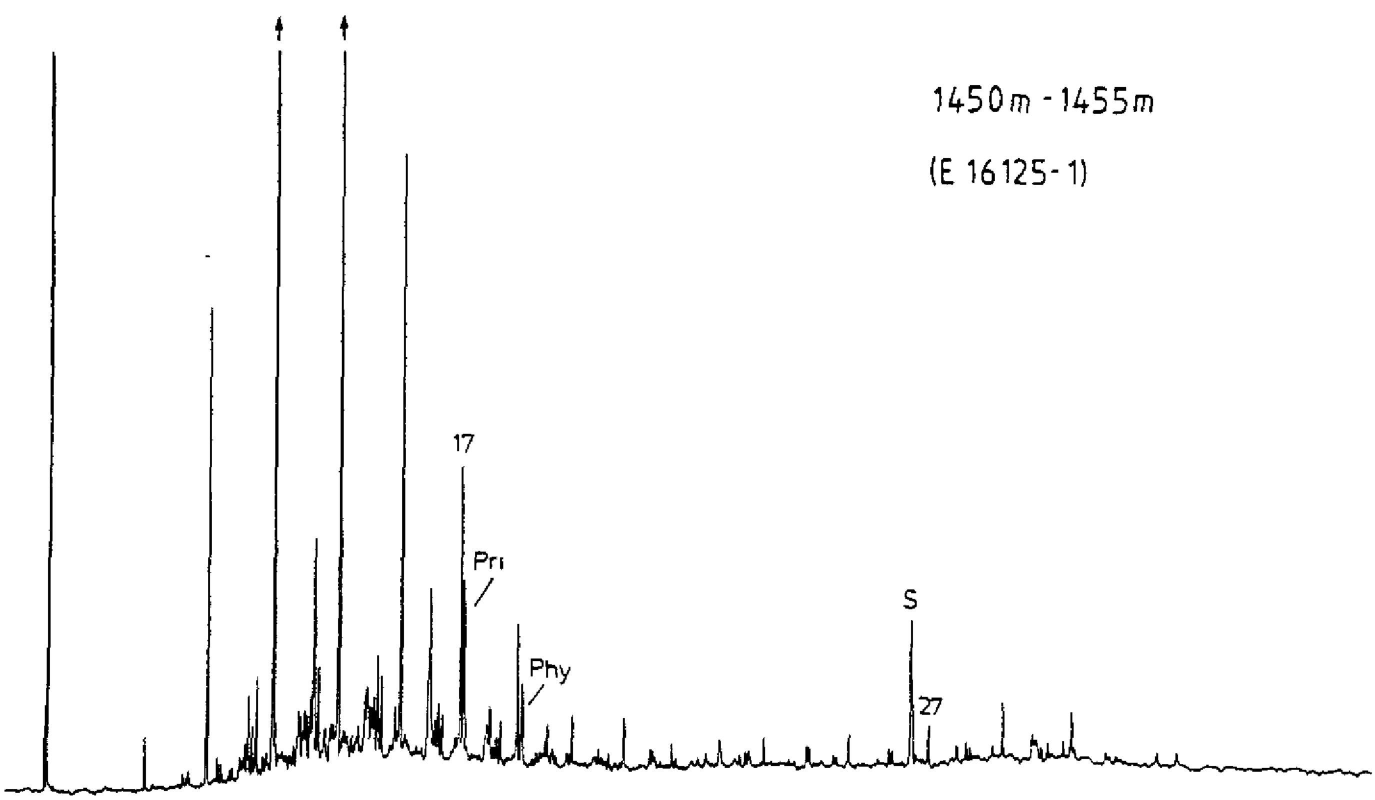

1450m - 1455m
(E 16125-1)
17
Pri
S
Phy
27

Fig. 5j

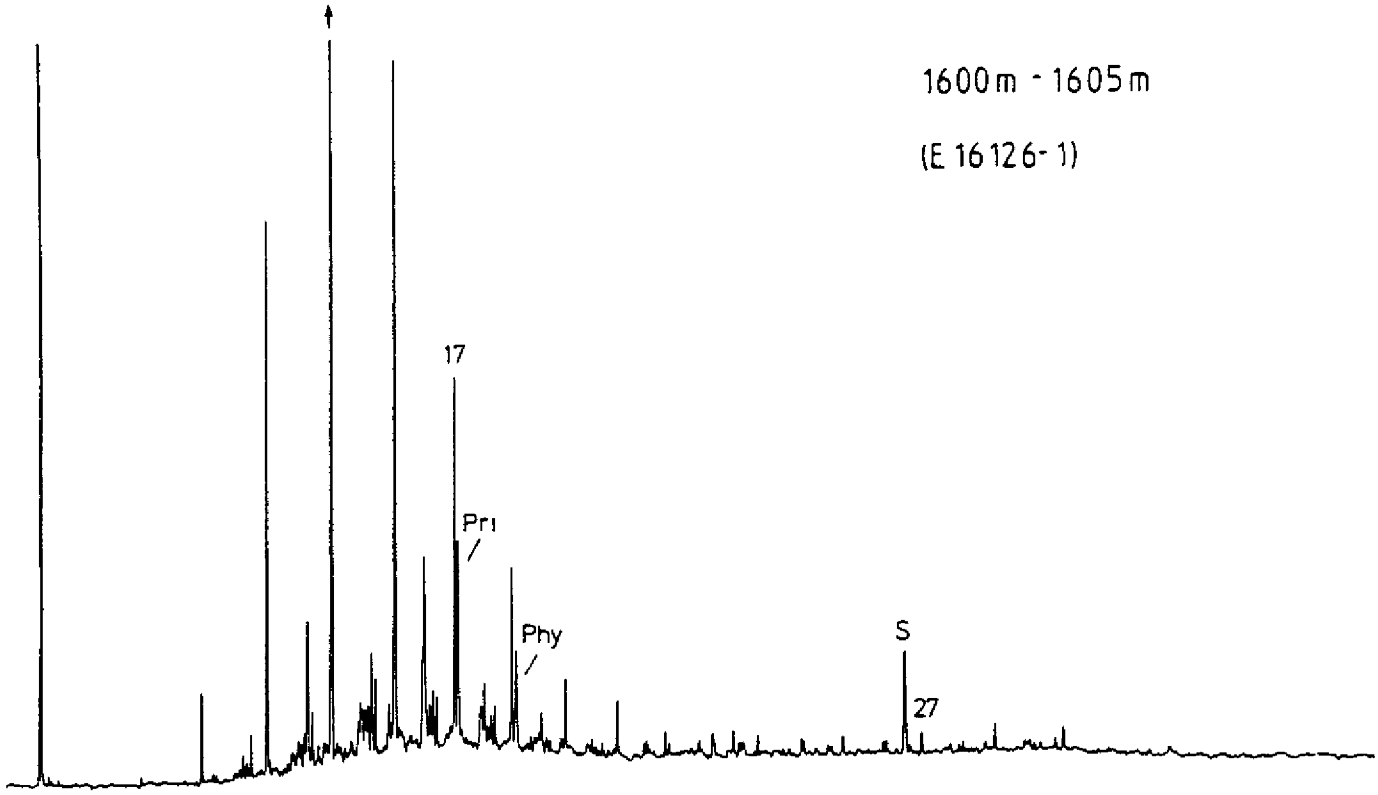

1600m - 1605m
(E 16126-1)
17
Pri
Phy
S
27

Fig. 5k

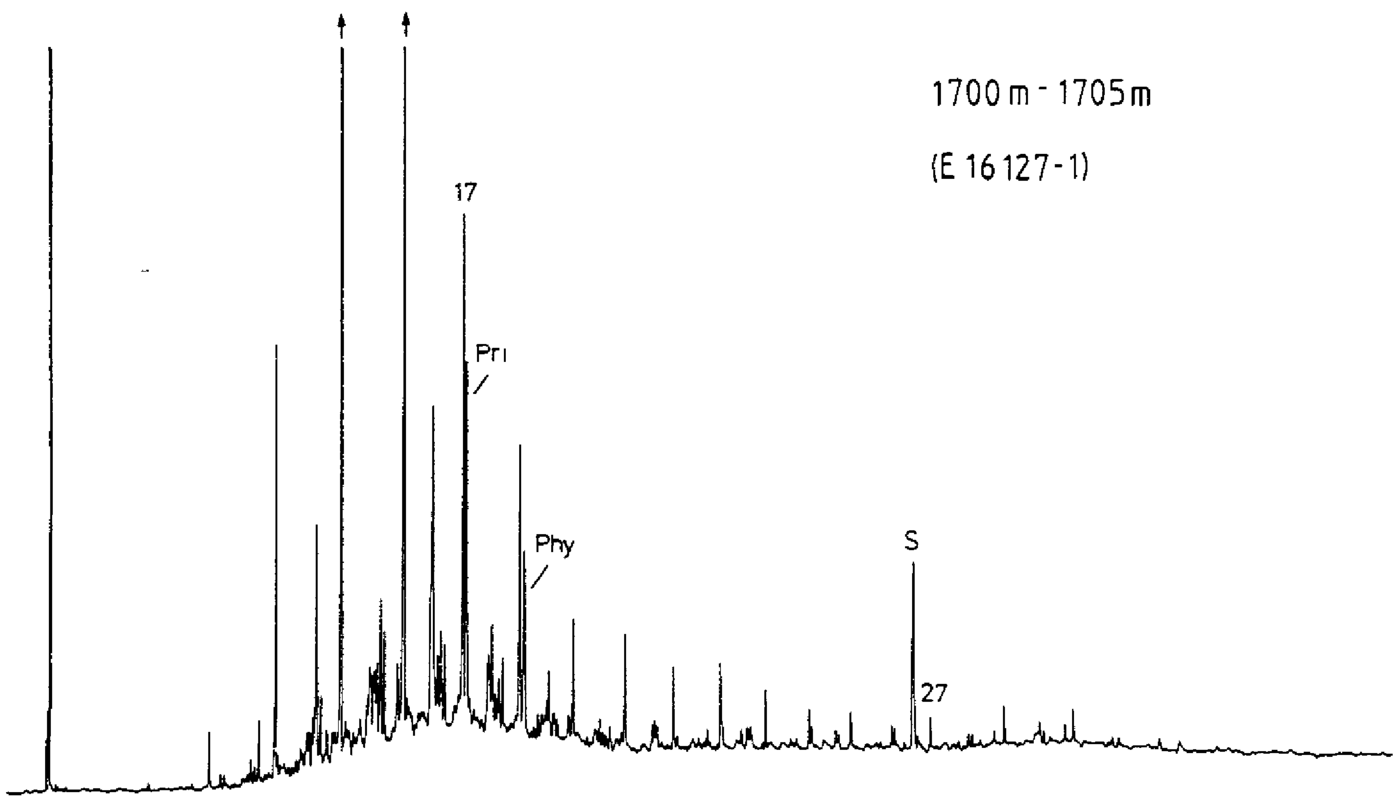

1700m - 1705m
(E 16127-1)
17
Pri
Phy
S
27

Fig. 5l

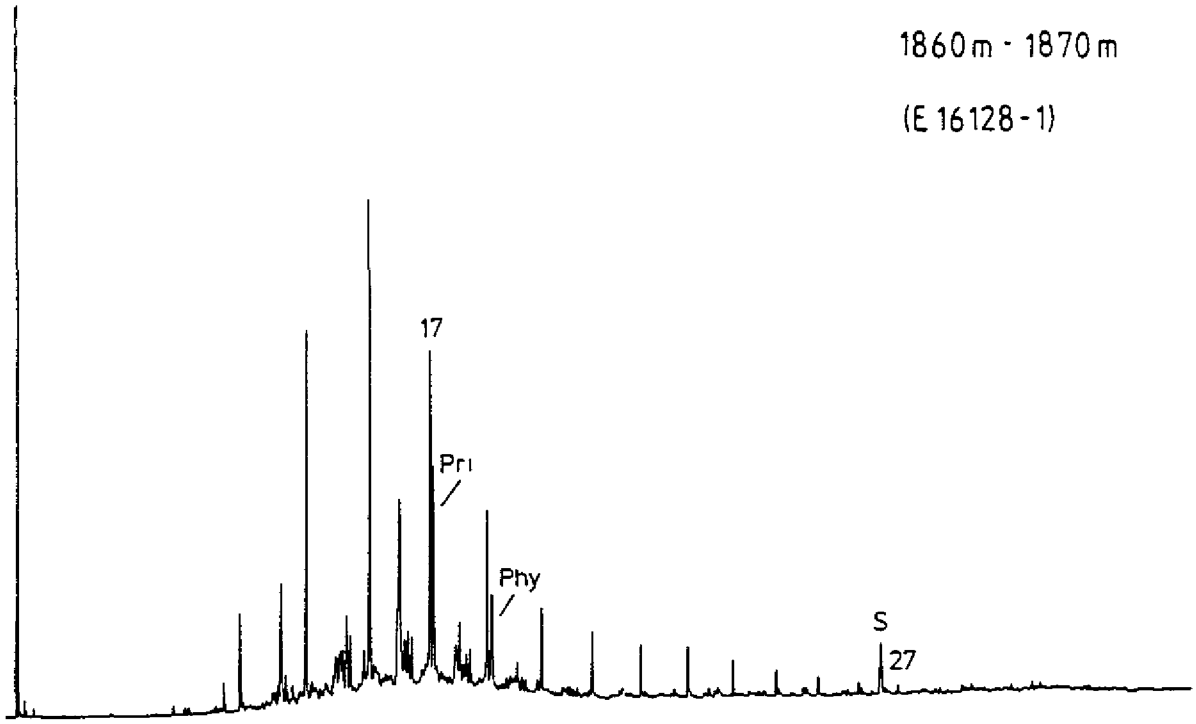

1860 m - 1870 m
(E 16128 - 1)
17
Pri
Phy
S
27

Fig. 5m

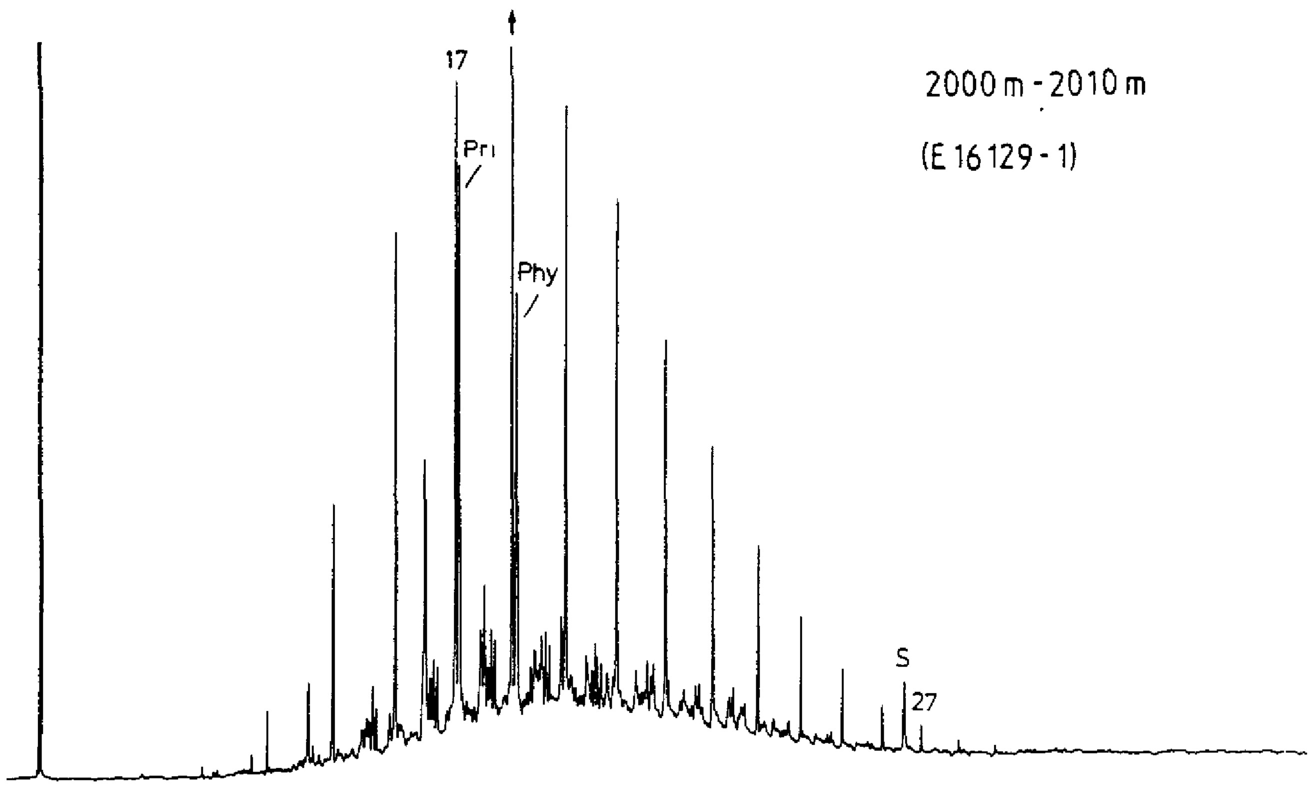

2000 m - 2010 m
(E 16129 - 1)
17
Pri
Phy
S
27

Fig. 5n

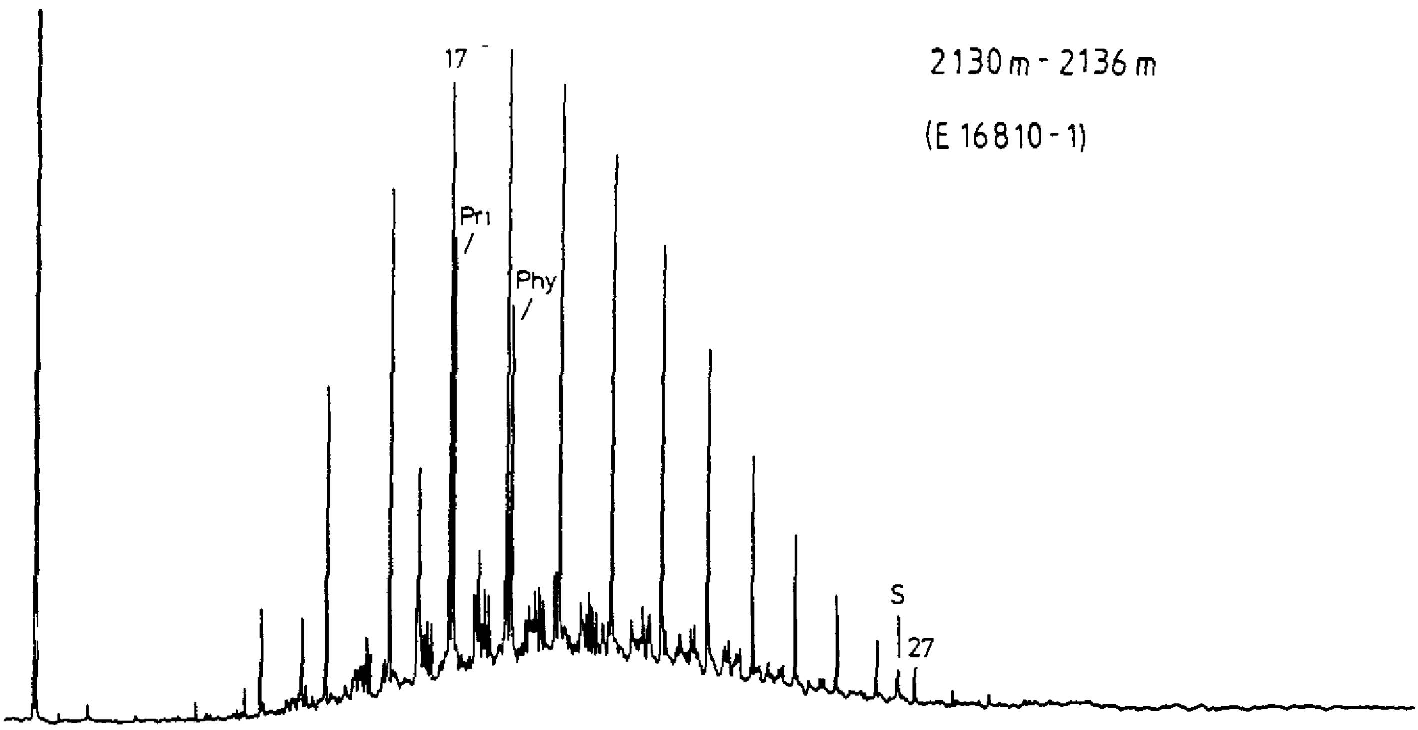

17
Pr1
Phy
S
27
2130 m - 2136 m
(E 16810 - 1)

Fig. 5o

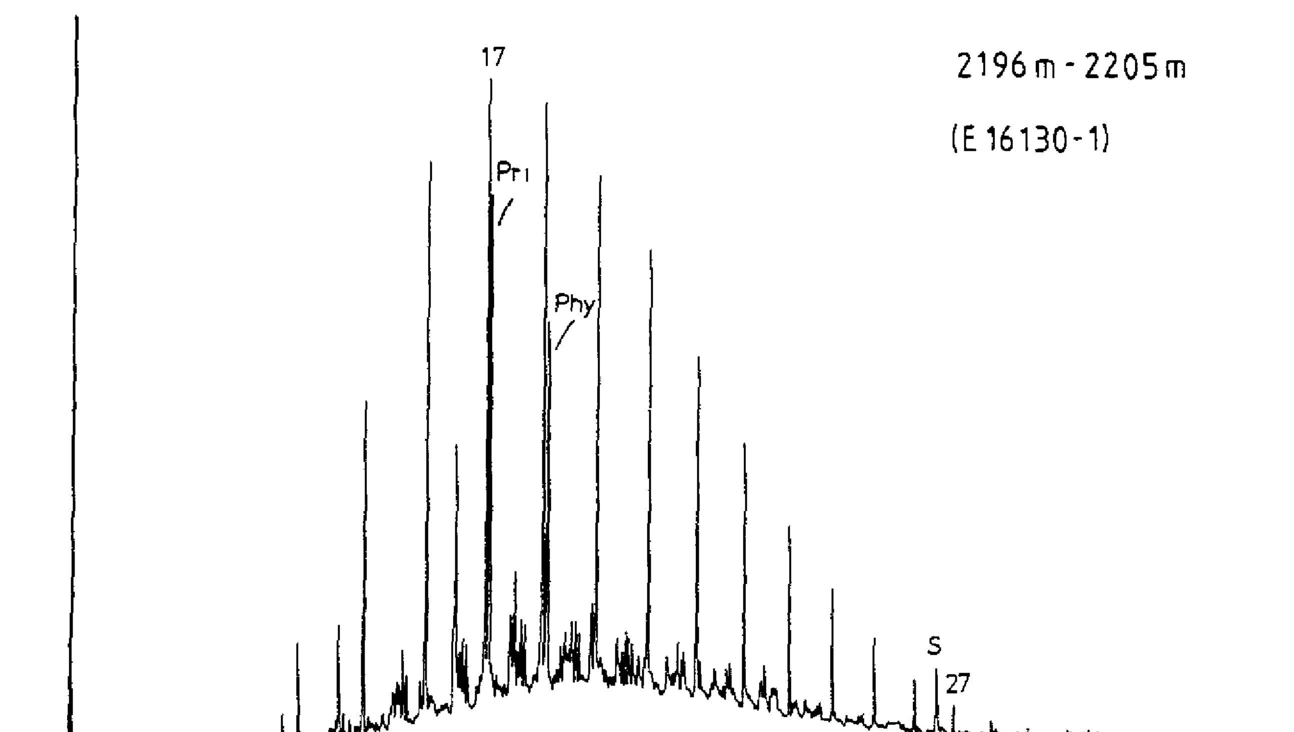

17
Pr1
Phy
S
27
2196 m - 2205 m
(E 16130 - 1)

Fig. 5p

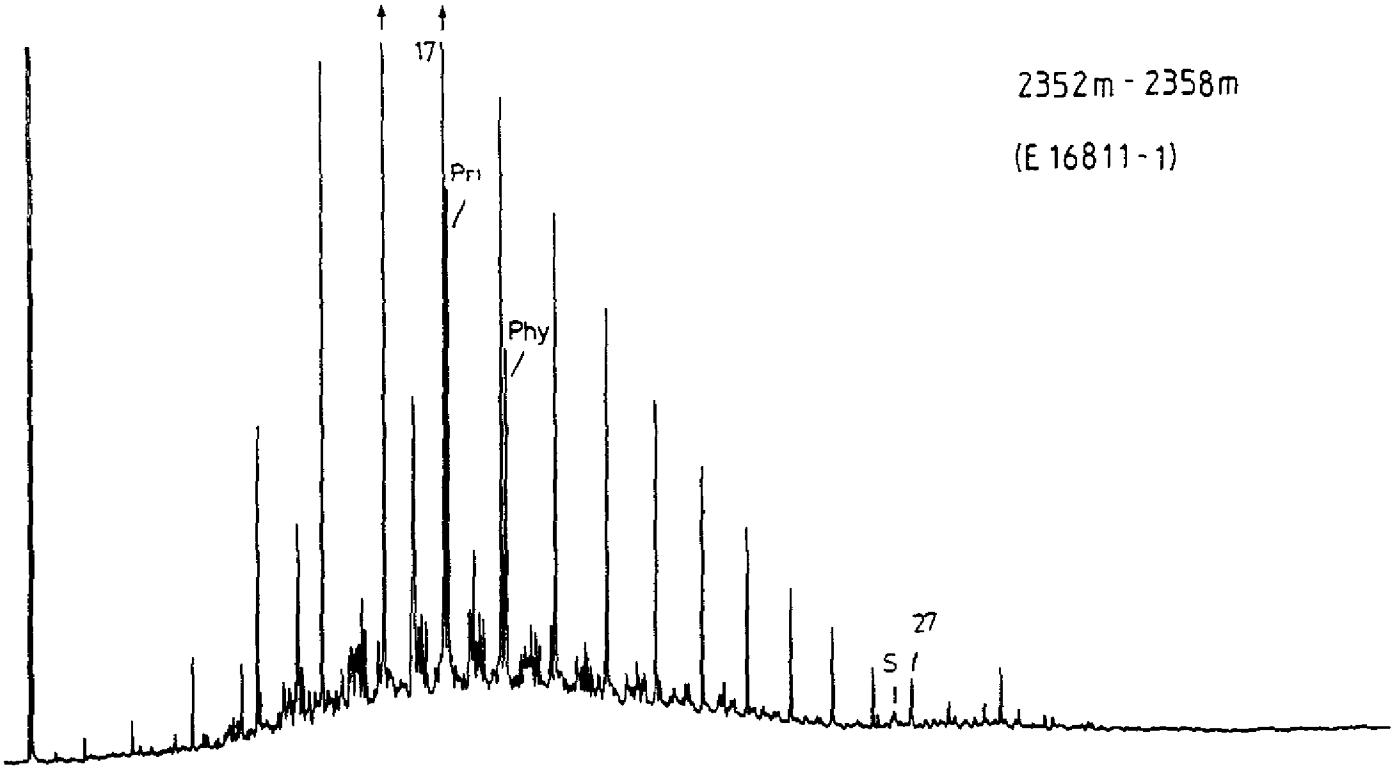

17
Pri
Phy
27
S
2352m - 2358m
(E 16811 - 1)

Fig. 5q

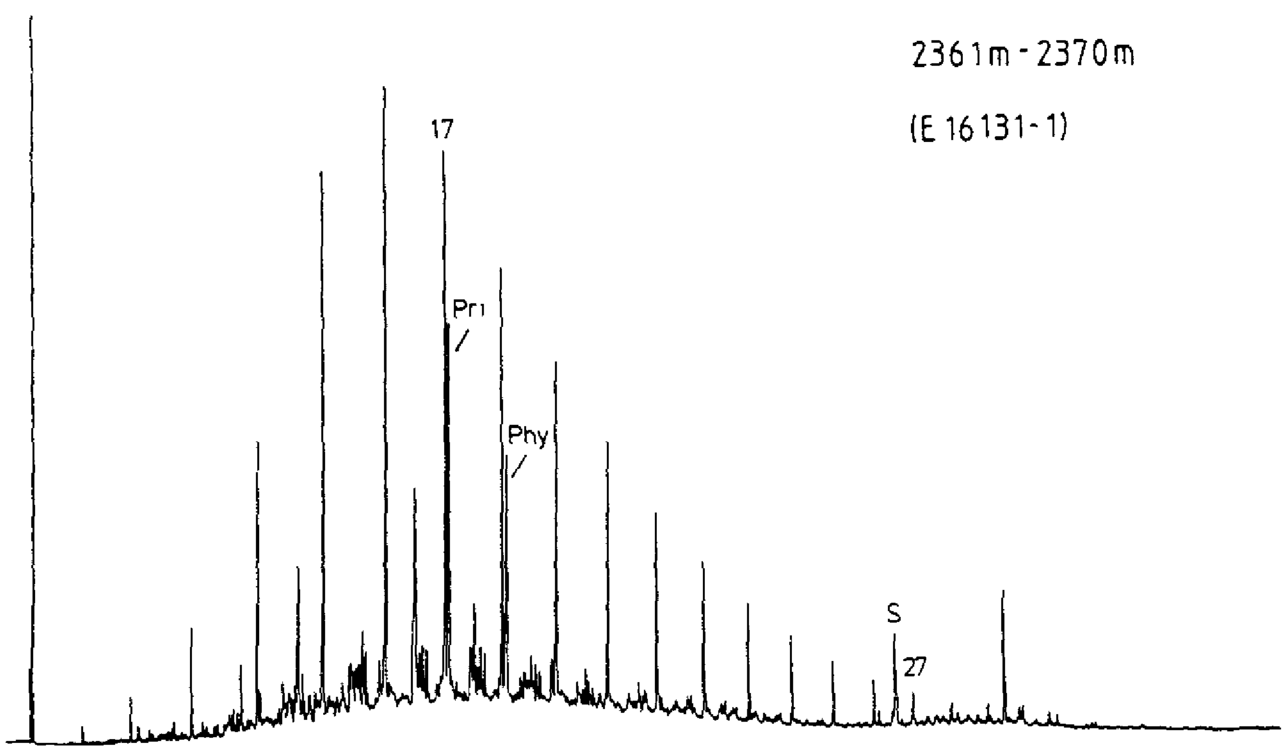

17
Pri
Phy
S
27
2361m - 2370m
(E 16131 - 1)

Fig. 5r

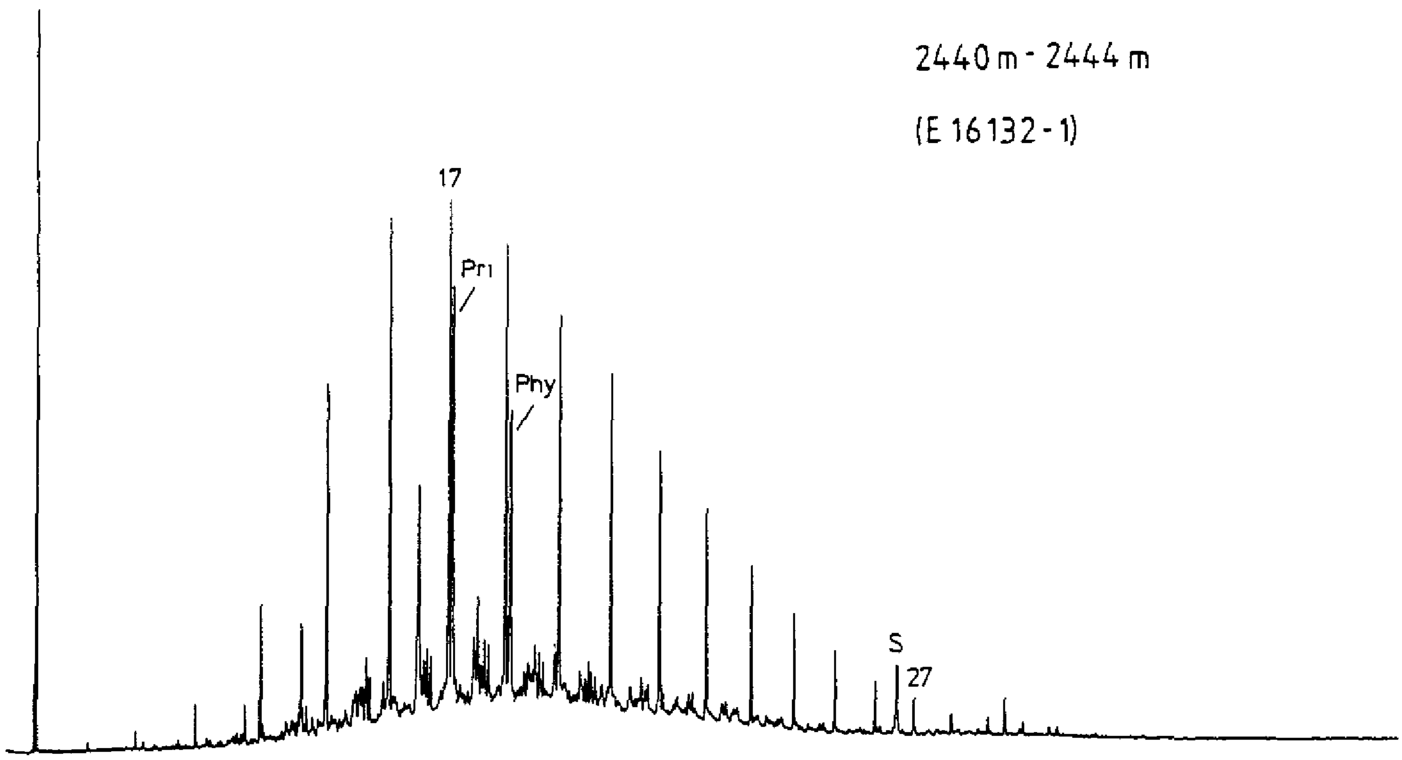

2440 m - 2444 m
(E 16132-1)
17
Pri
Phy
S
27

Fig. 5s

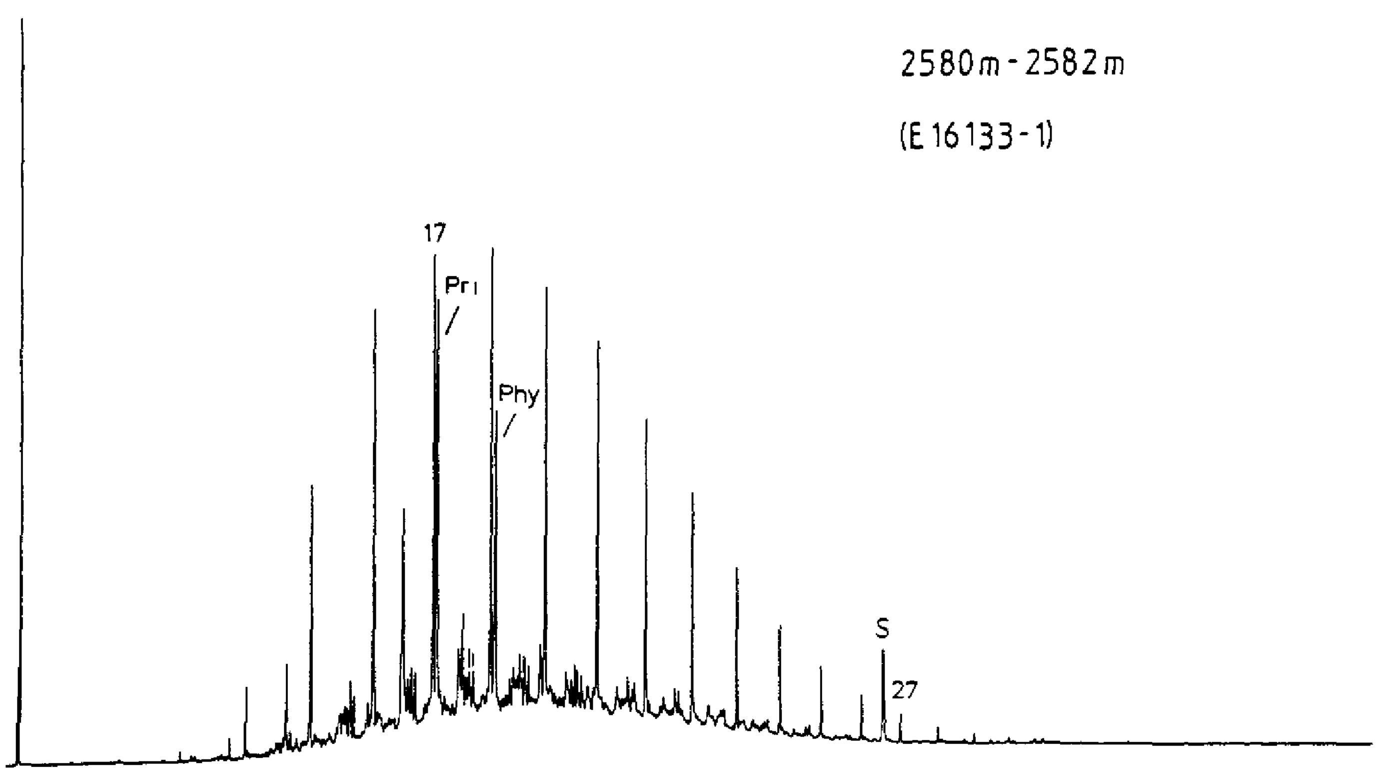

2580 m - 2582 m
(E 16133-1)
17
Pri
Phy
S
27

Fig. 5t

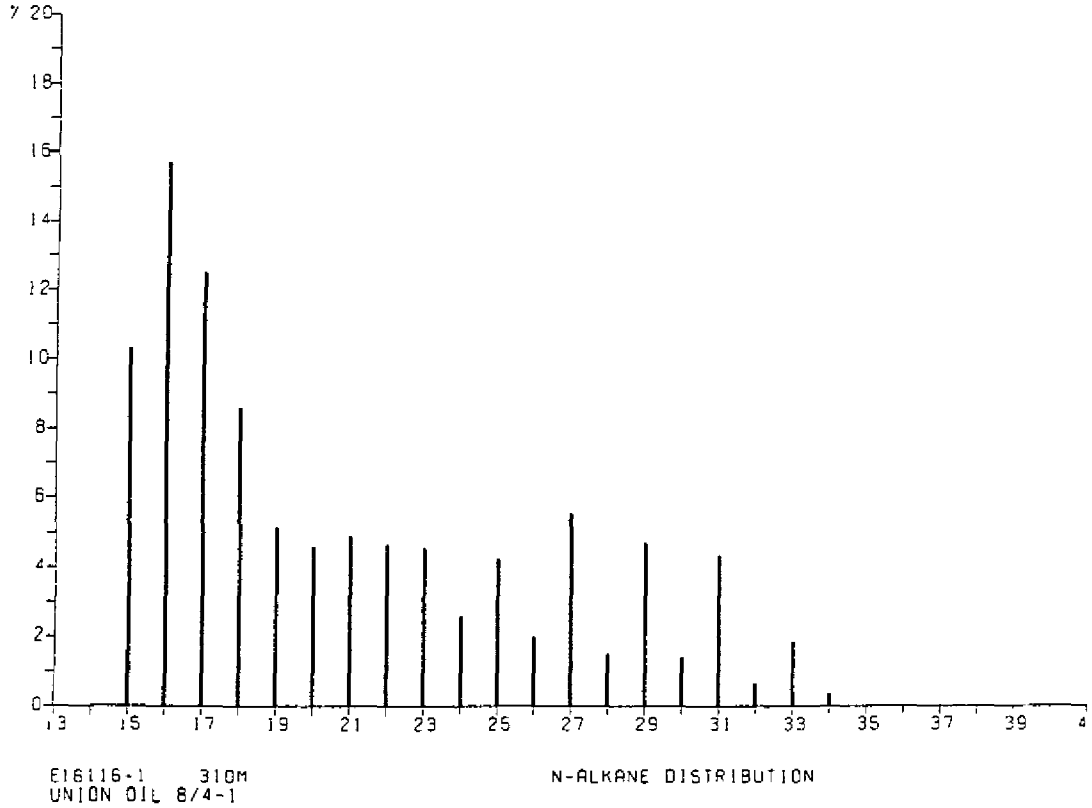

E16116-1 310M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6a

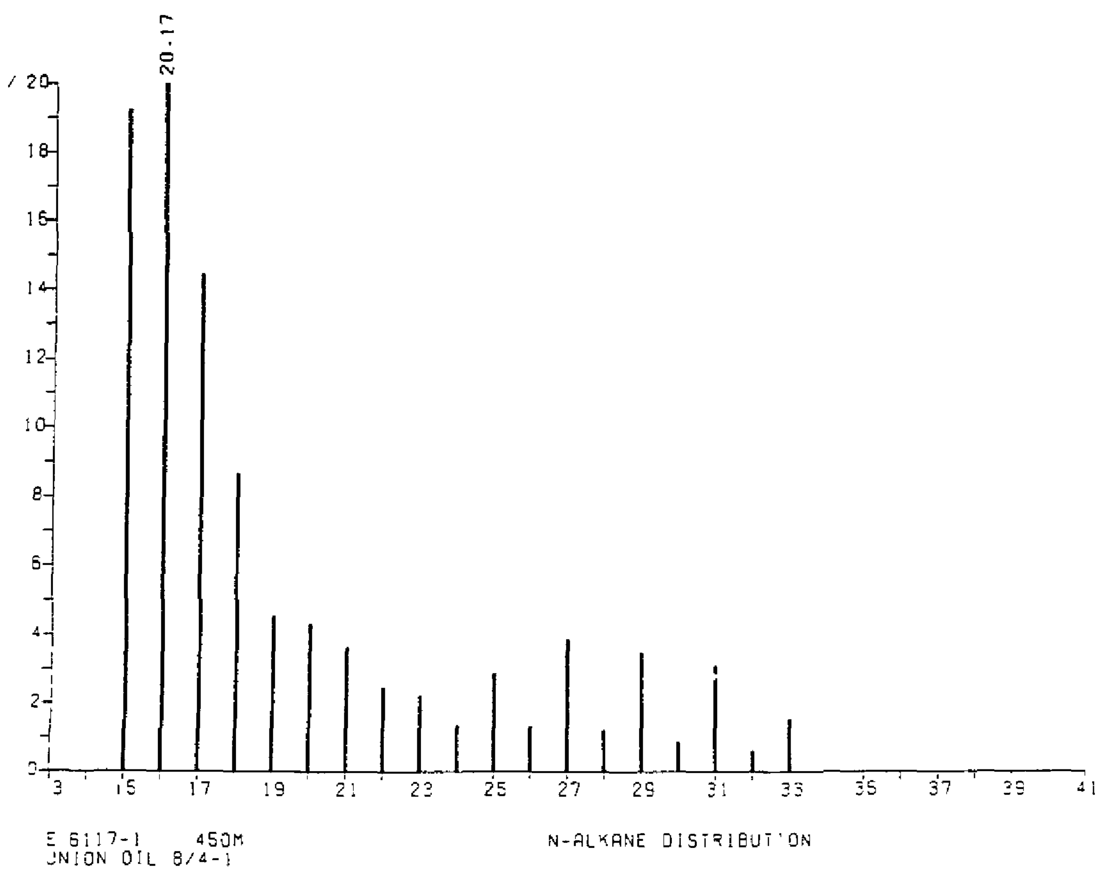

20.17
N-ALKANE DISTRIBUT'ON

Fig. 6b

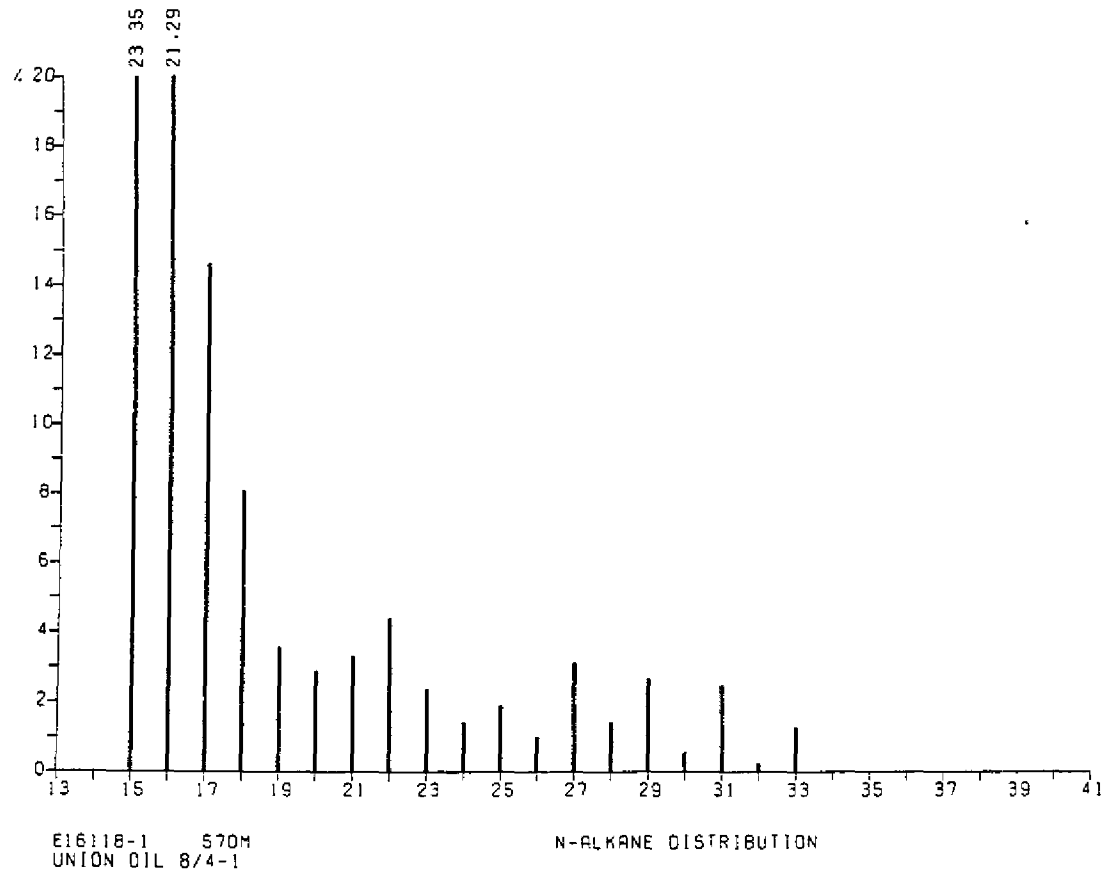
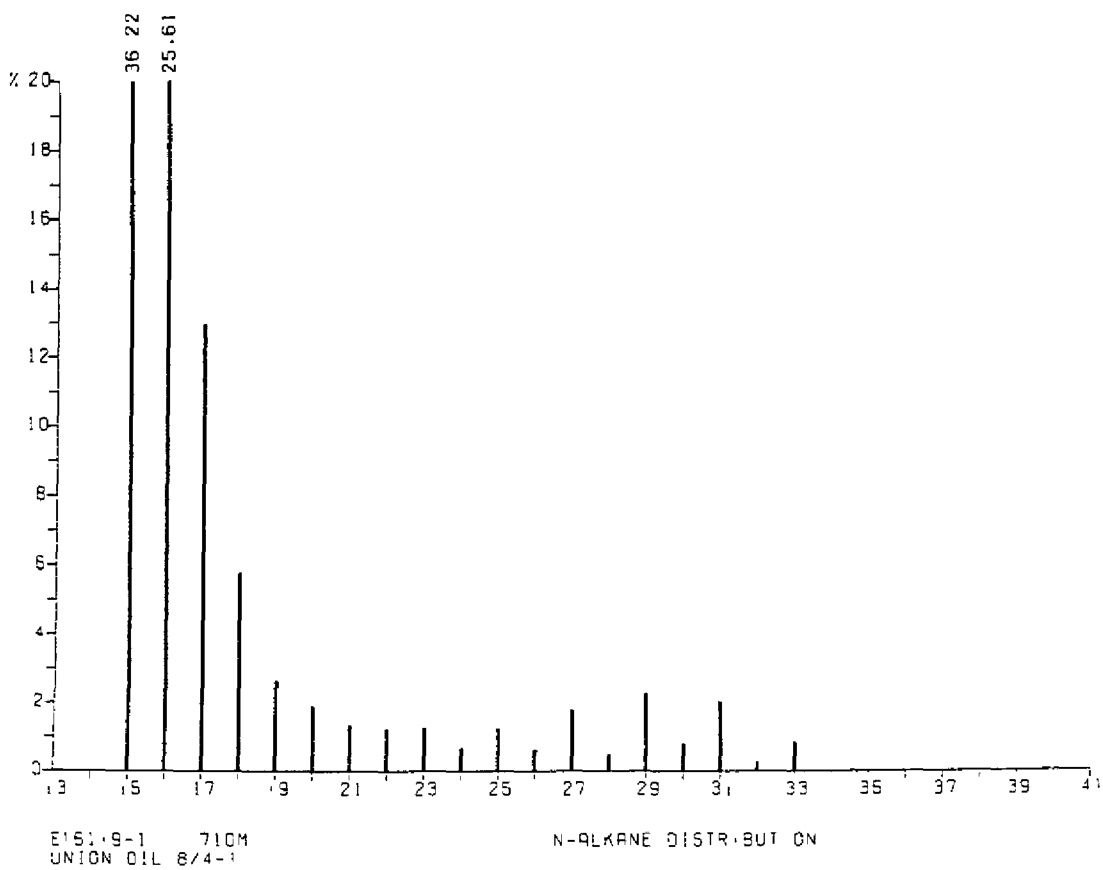

23 35
21.29
% 20
18
16
14
12
10
8
6
4
2
0
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
E16118-1 570M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6c


36 22
25.61
% 20
18
16
14
12
10
8
6
4
2
0
13
15
17
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23
25
27
29
31
33
35
37
39
41
710M
UNION OIL 8/4-1

Fig. 6d

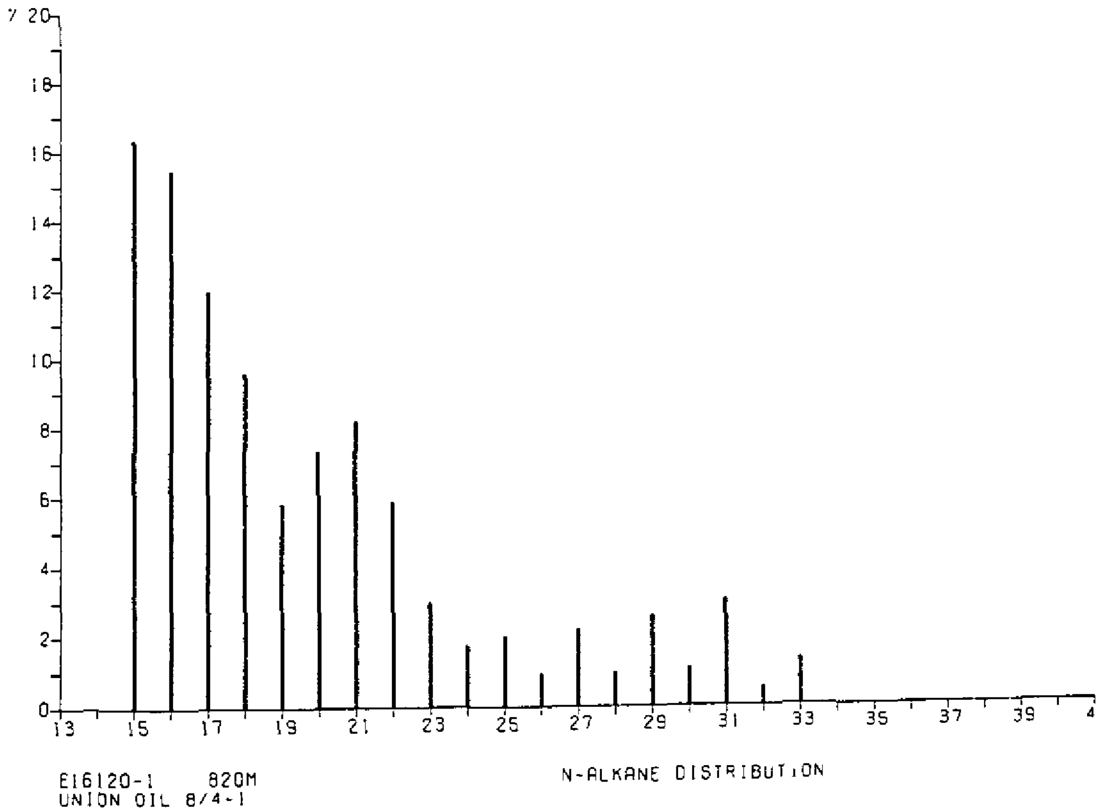

% 20
18
16
14
12
10
8
6
4
2
0
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
E16120-1 820M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6e

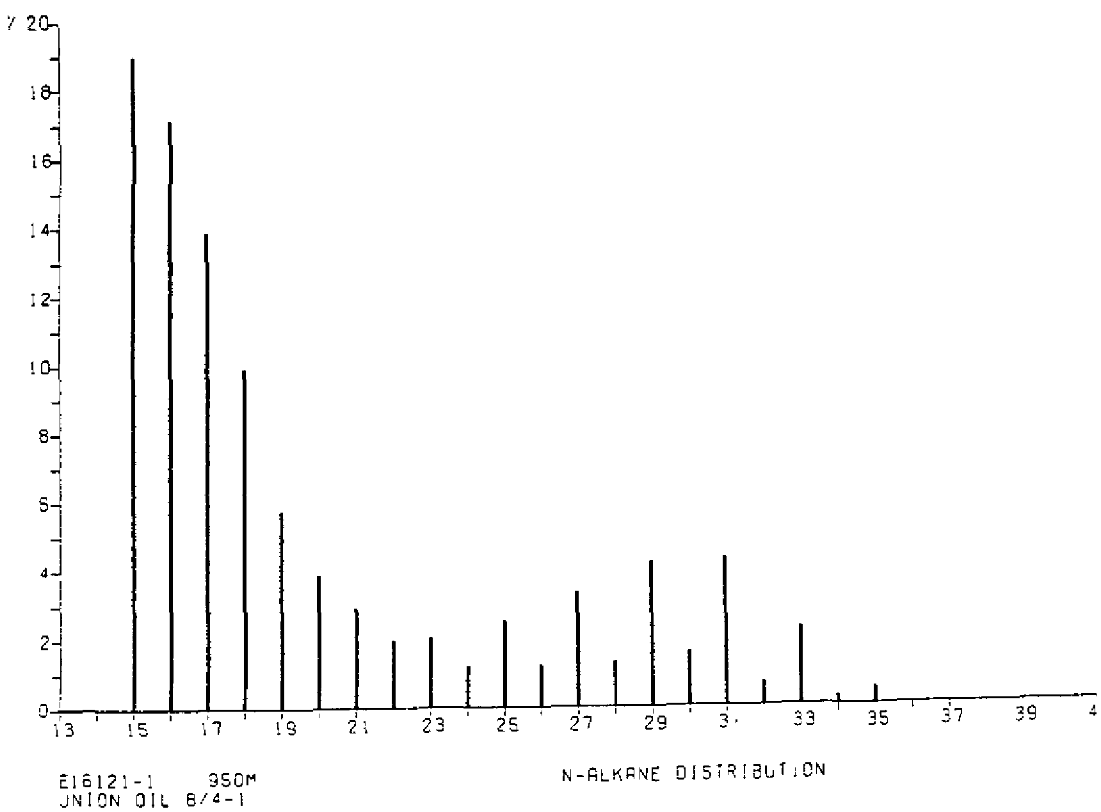

% 20
18
16
14
12
10
8
6
4
2
0
13
15
17
19
21
23
25
27
29
33
35
37
39
E16121-1 950M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6f

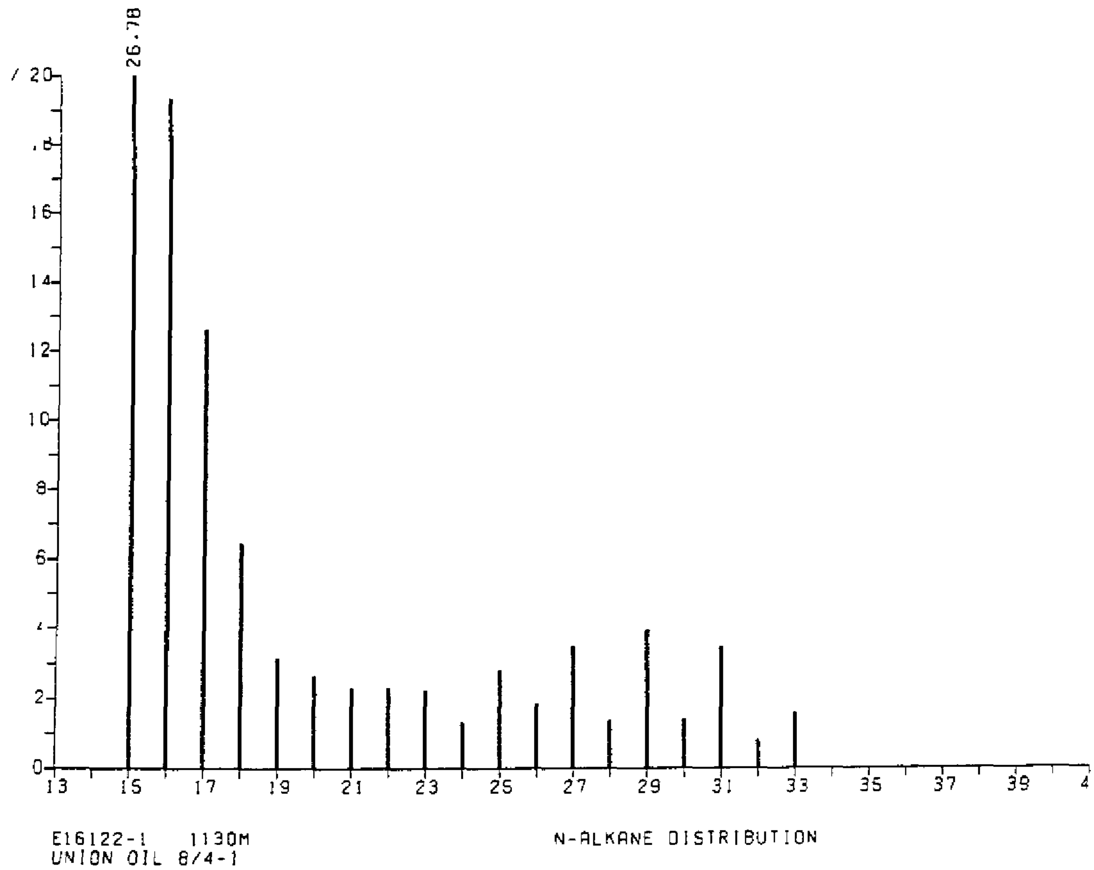

26.78
E16122-1 1130M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6g

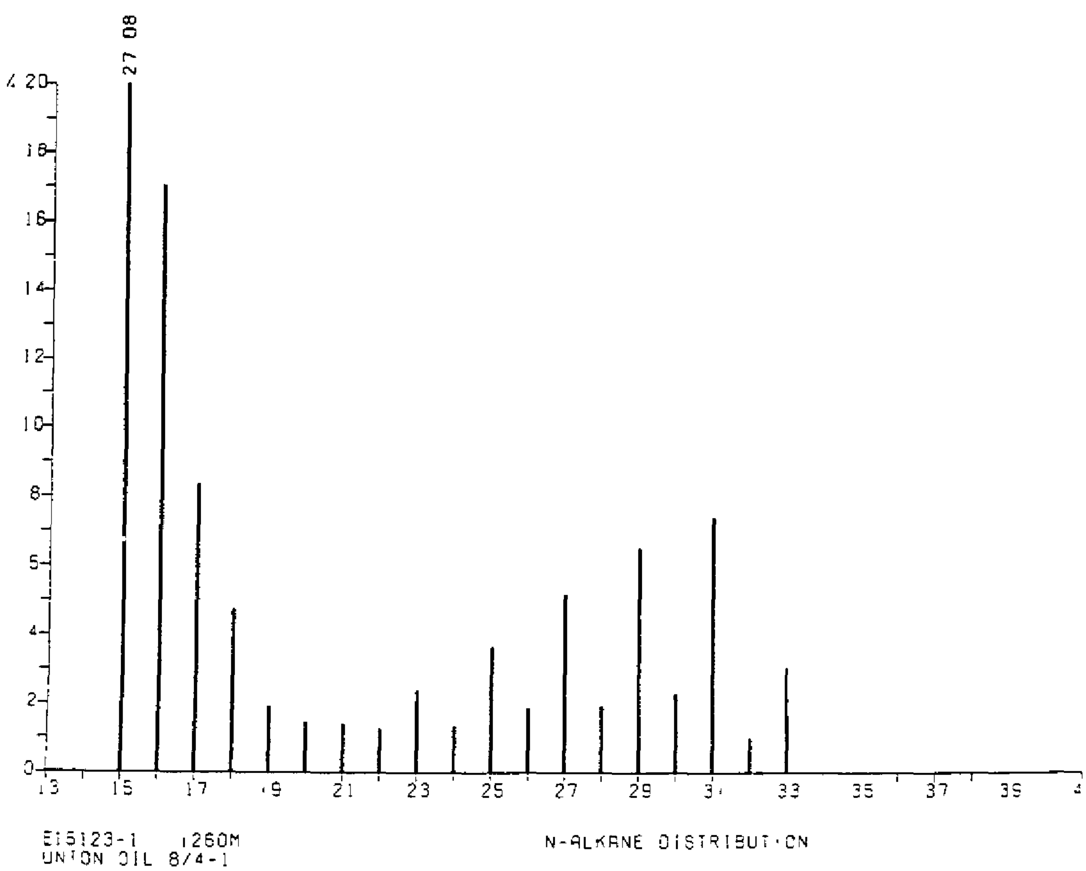
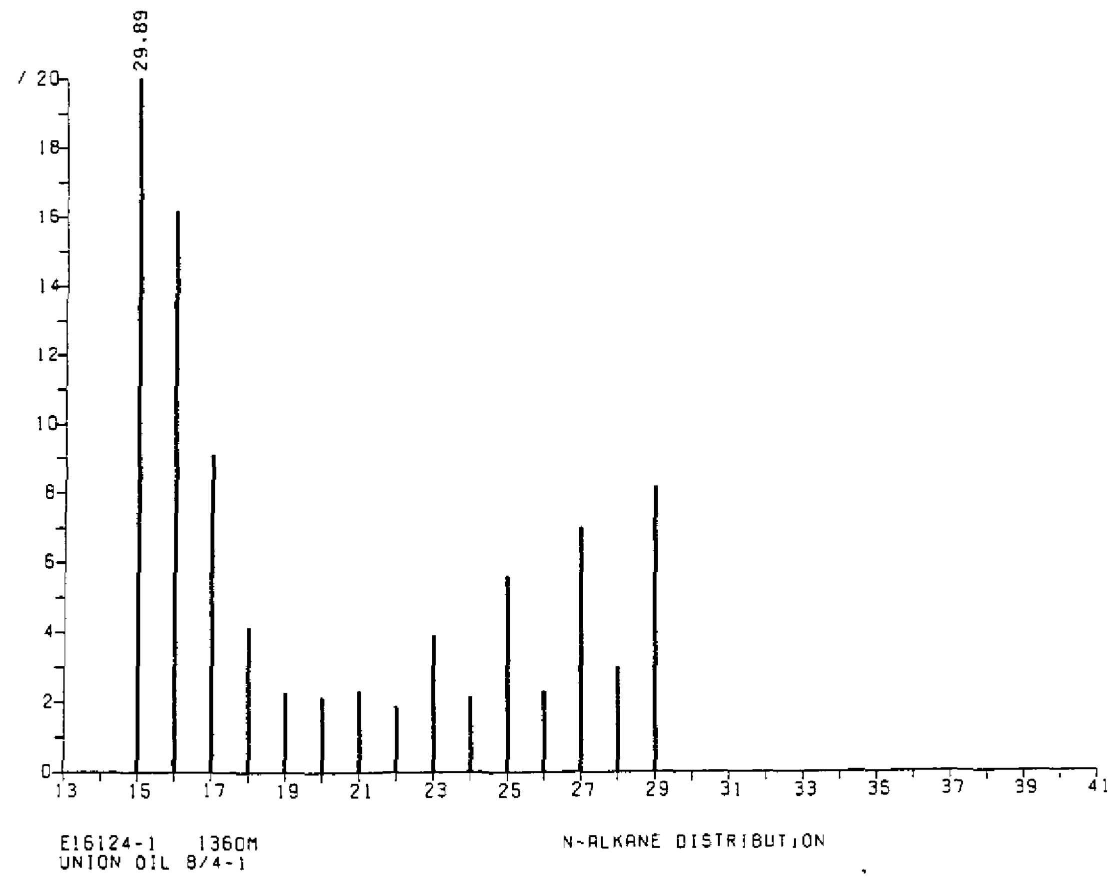

27 08
E15123-1 1260M
UNION OIL 8/4-1
N-ALKANE DISTRIBUT·ON

Fig. 6h


29.89
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UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6i

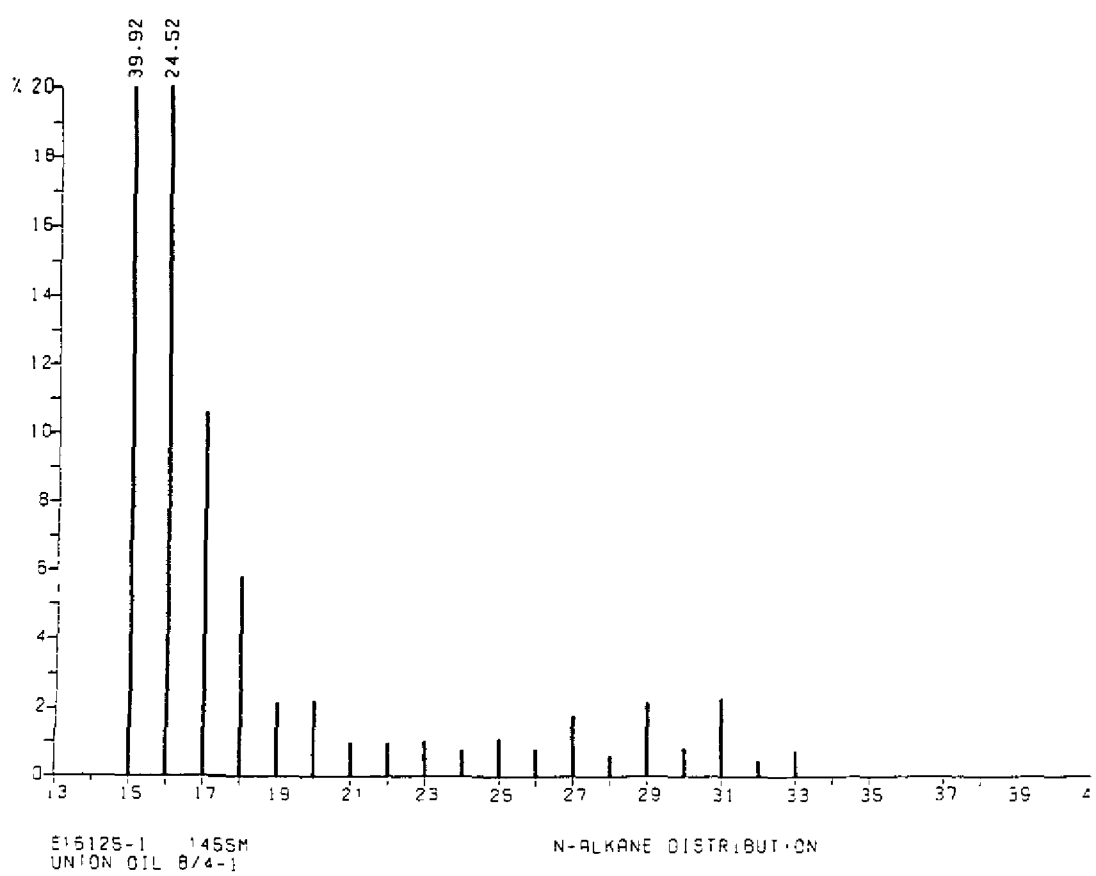
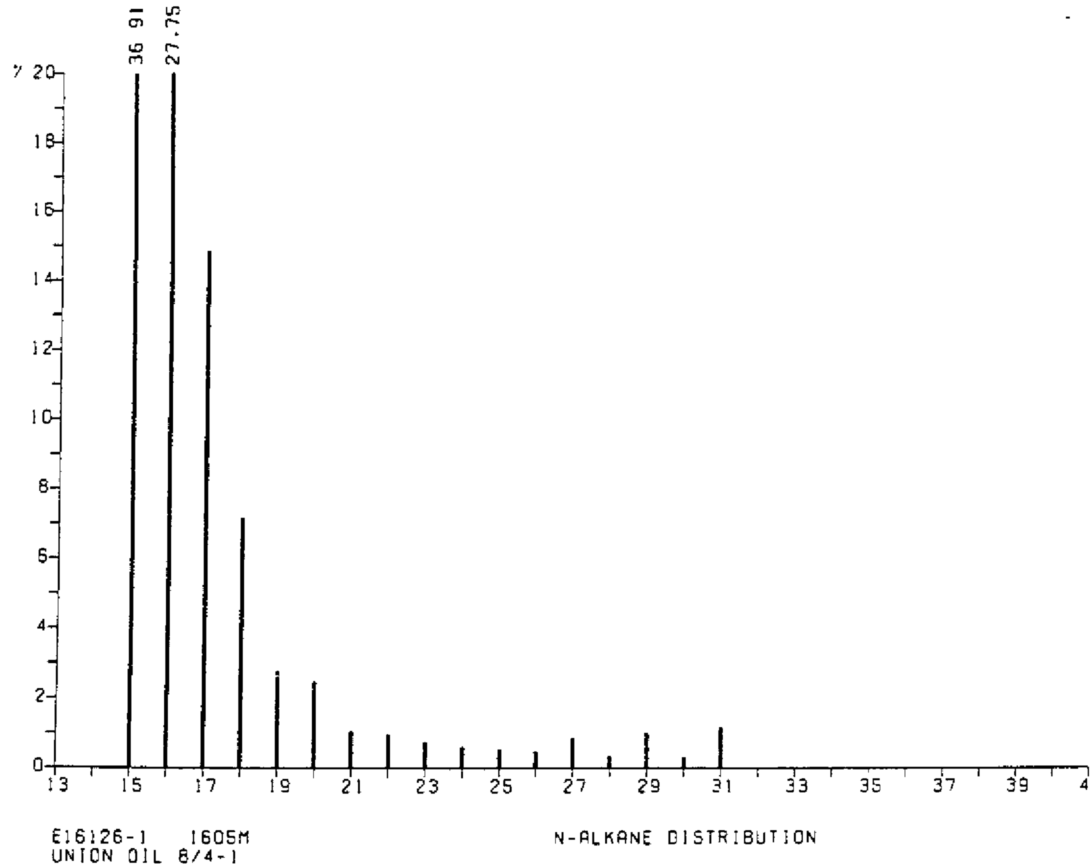

39.92
24.52
% 20
E16125-1 1455M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6j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% 20
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21
23
25
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31
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35
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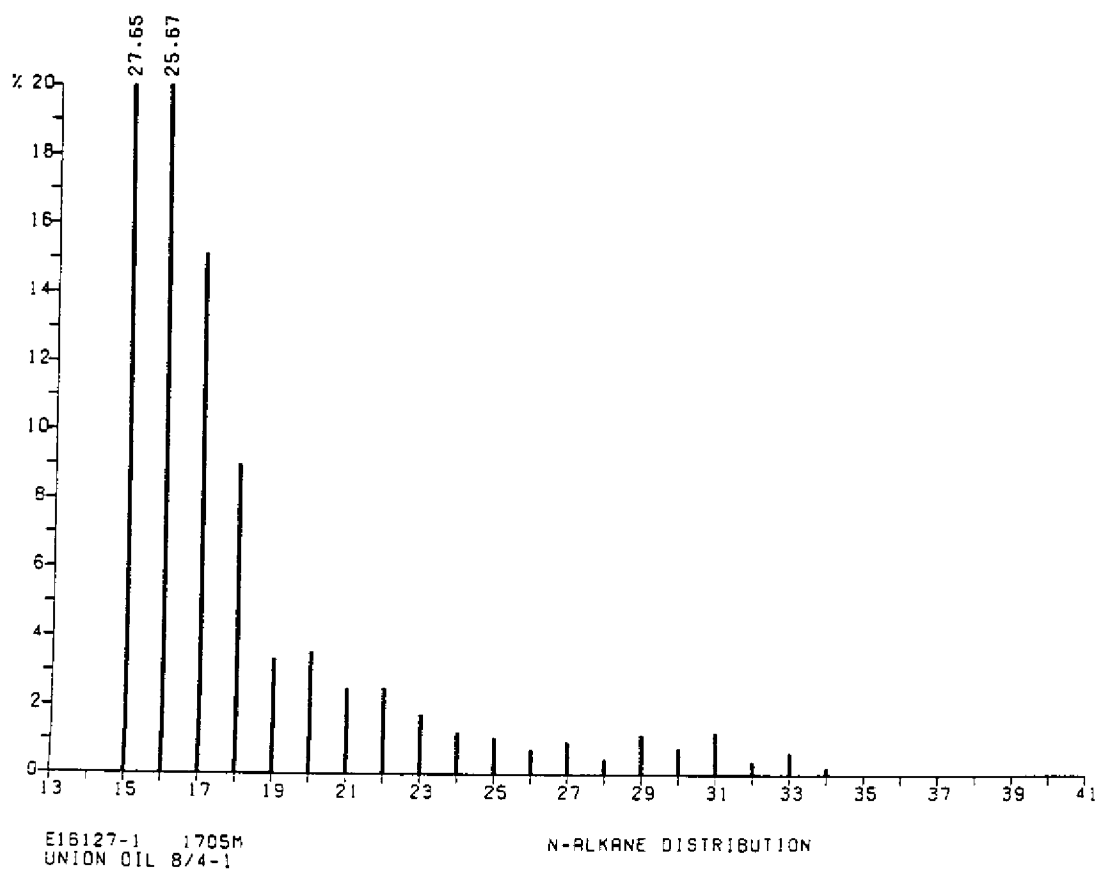
39
41
E16126-1 1605M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6k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23
25
27
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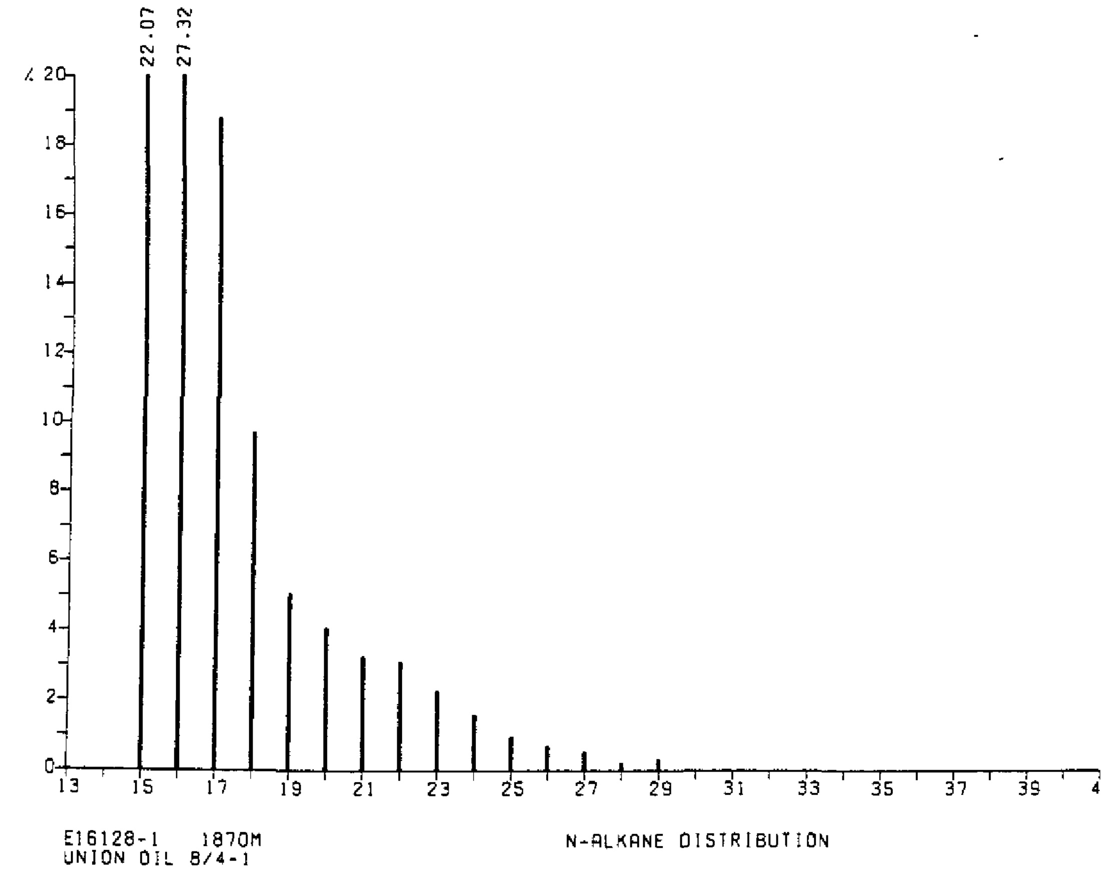
39
41
E16127-1 1705M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6l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12
10
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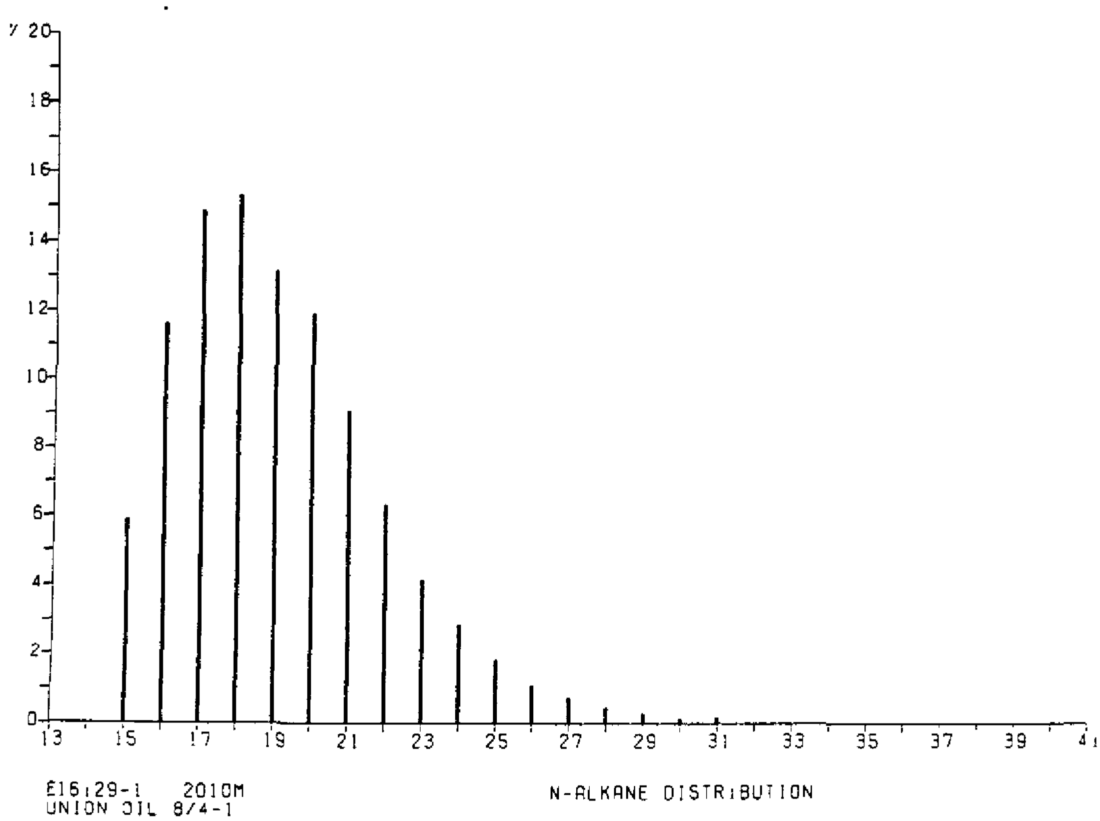
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
E16128-1 1870M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6m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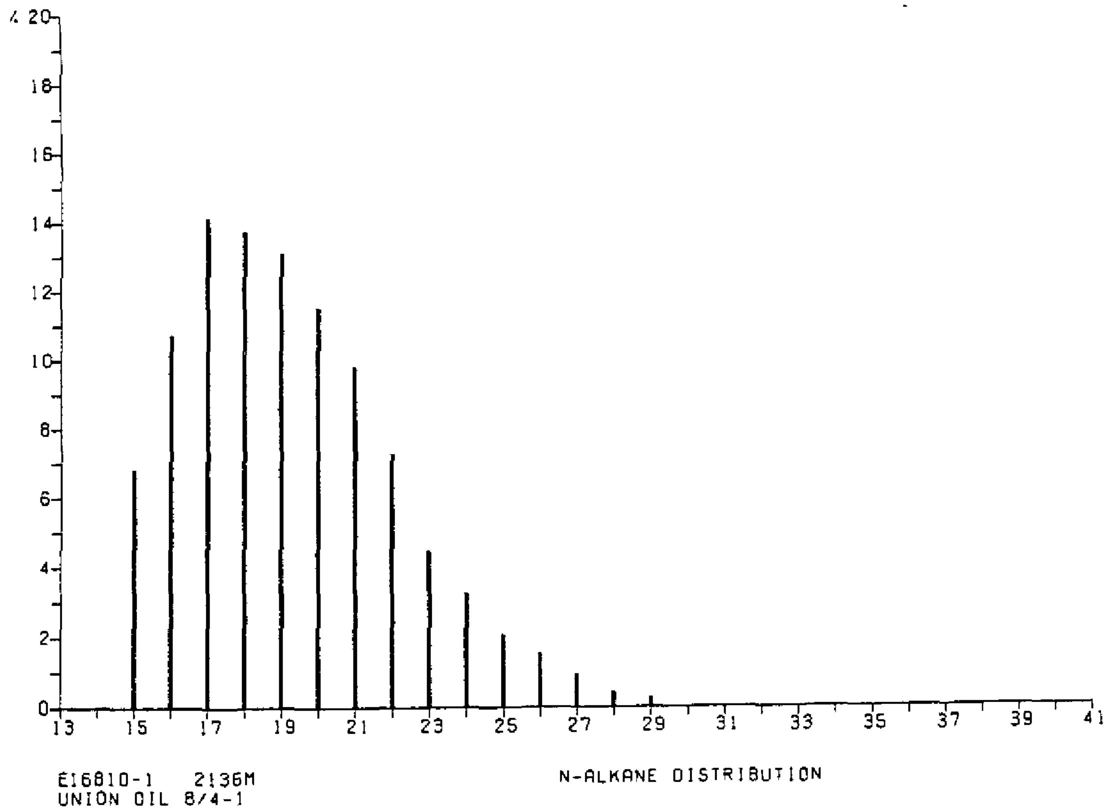
E16129-1 2010M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6n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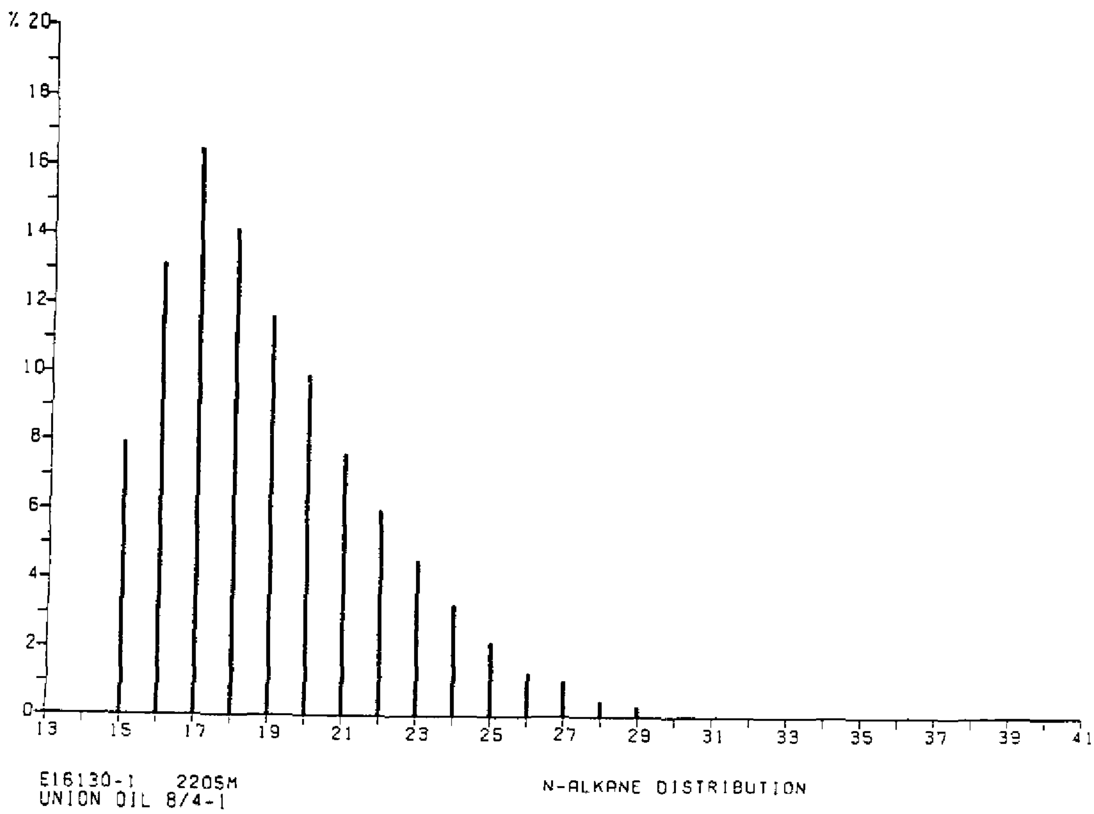
41
E16810-1 2136M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6o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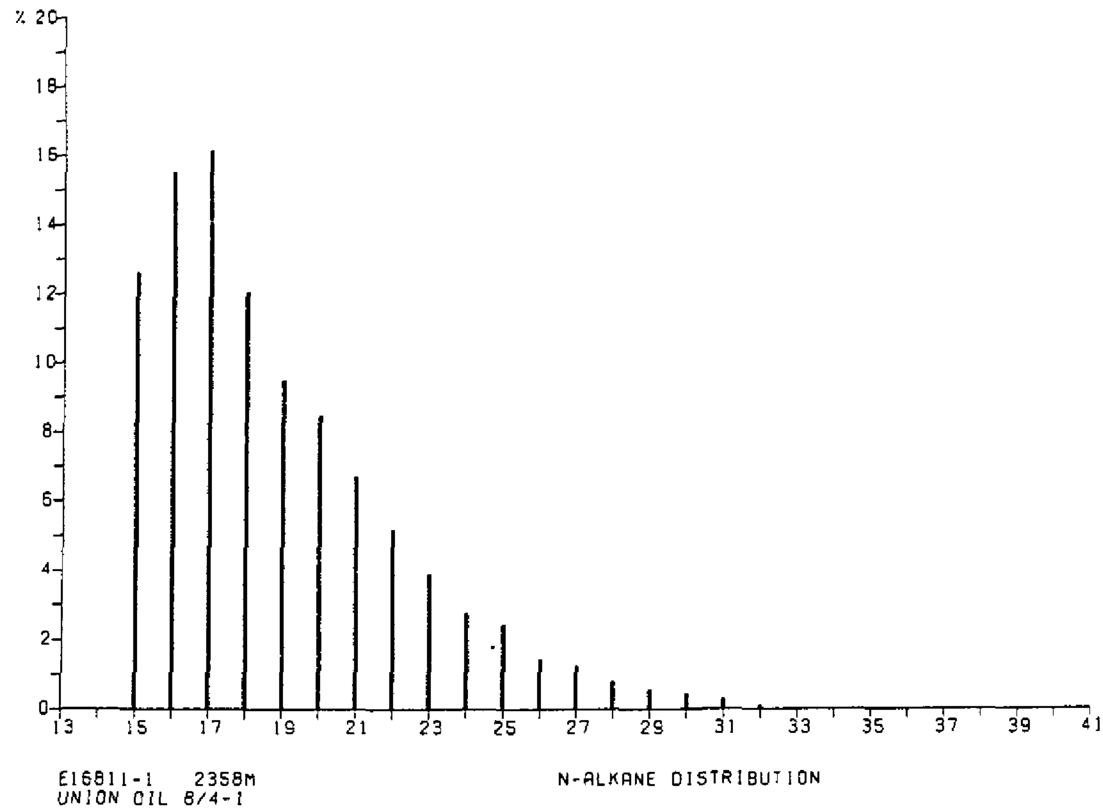
E16130-1 2205M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6p


% 20
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8
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4
2
0
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17
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31
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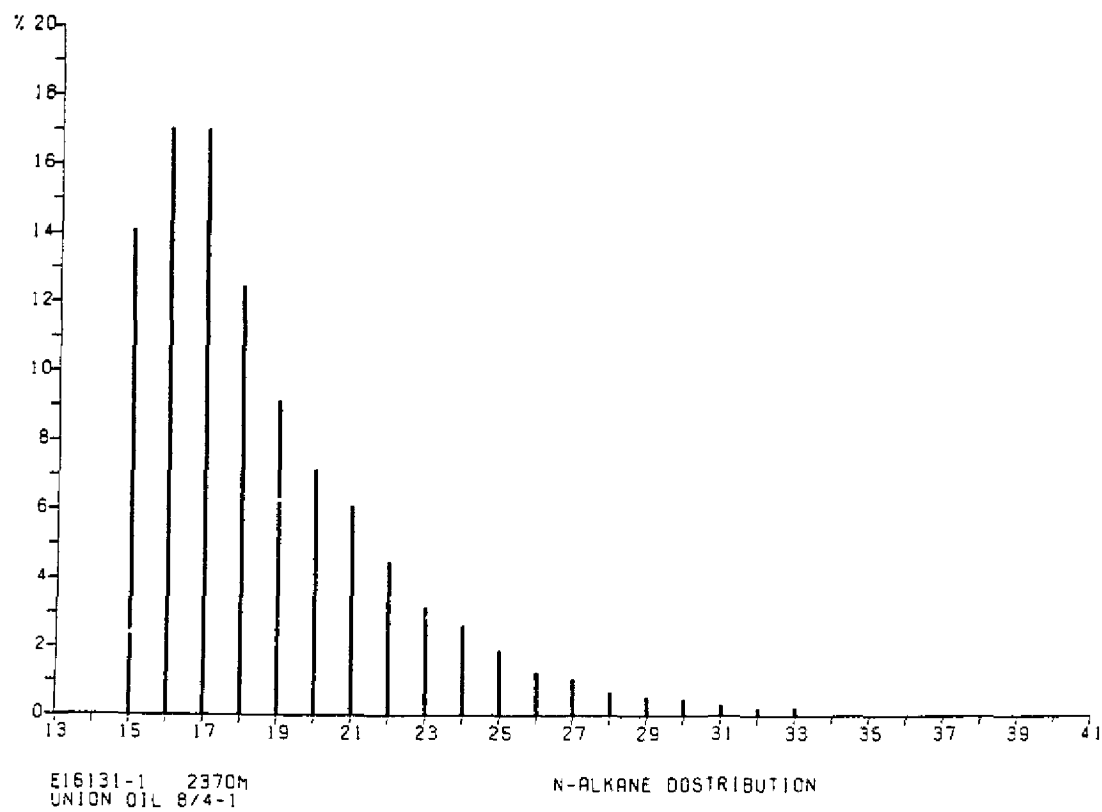
39
41
E16811-1 2358M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6q


% 20
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12
10
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2
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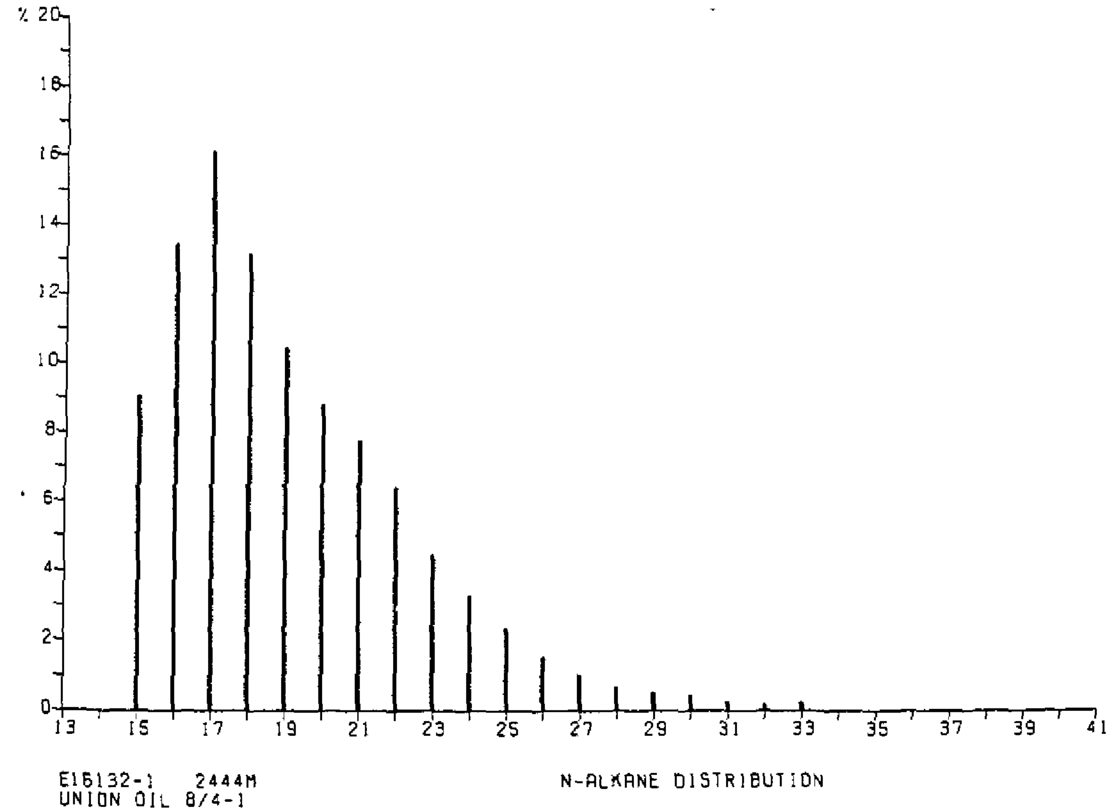
E16131-1 2370M
UNION OIL 8/4-1
N-ALKANE DOSTRIBUTION

Fig. 6r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12
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8
6
4
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13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
E16132-1 2444M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6s

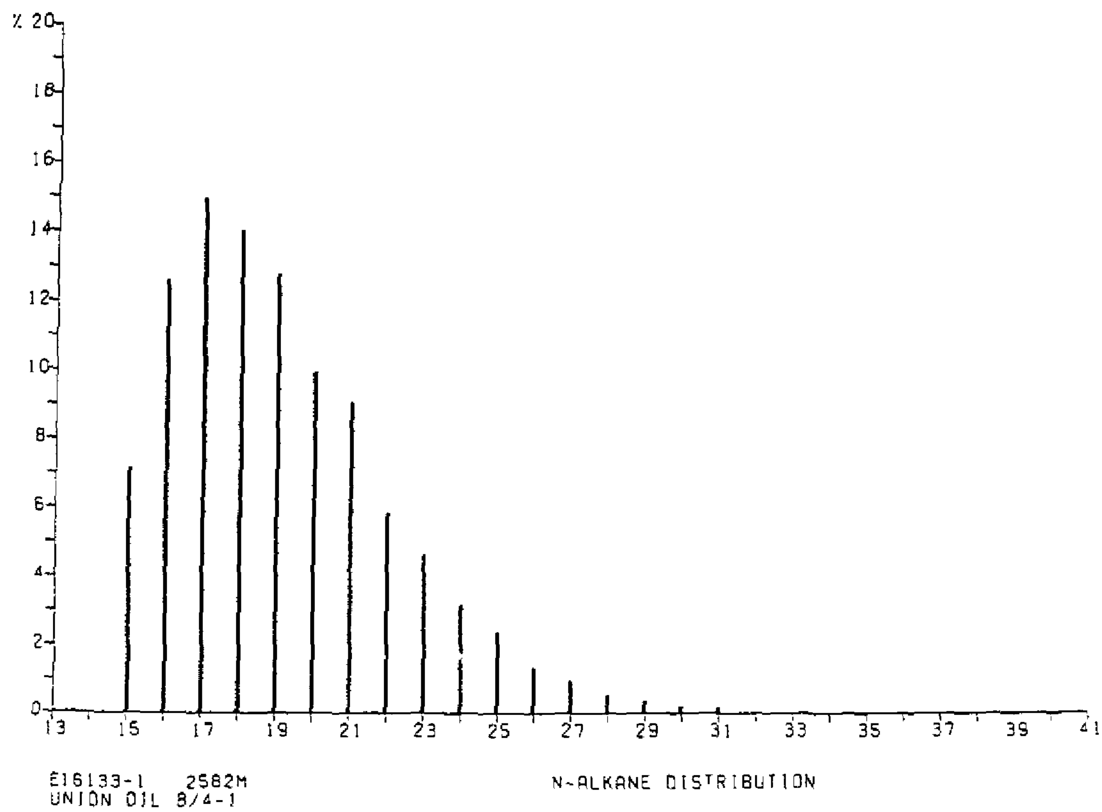

% 20
18
16
14
12
10
8
6
4
2
0
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
E16133-1 2582M
UNION OIL 8/4-1
N-ALKANE DISTRIBUTION

Fig. 6t

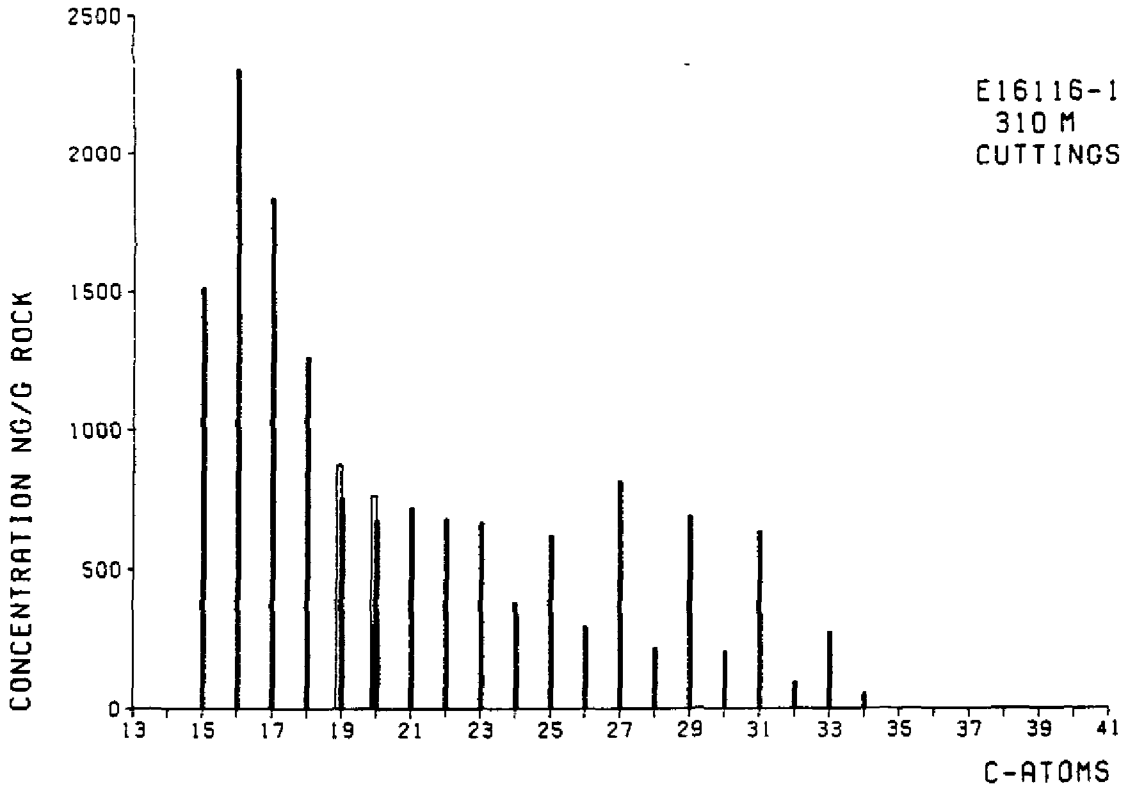
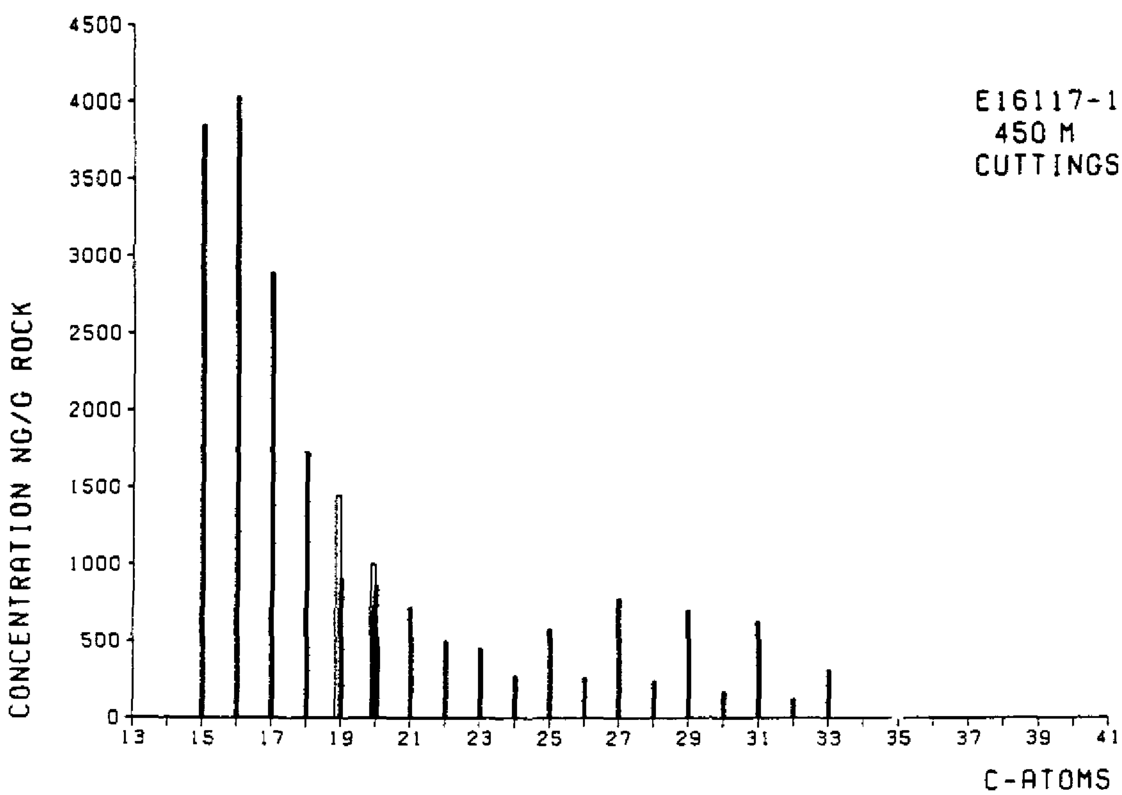

E16116-1
310 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS
0
500
1000
1500
2000
2500
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41

Fig. 7a


E16117-1
450 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS
0
500
1000
1500
2000
2500
3000
3500
4000
4500
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17
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37
39
41

Fig. 7b

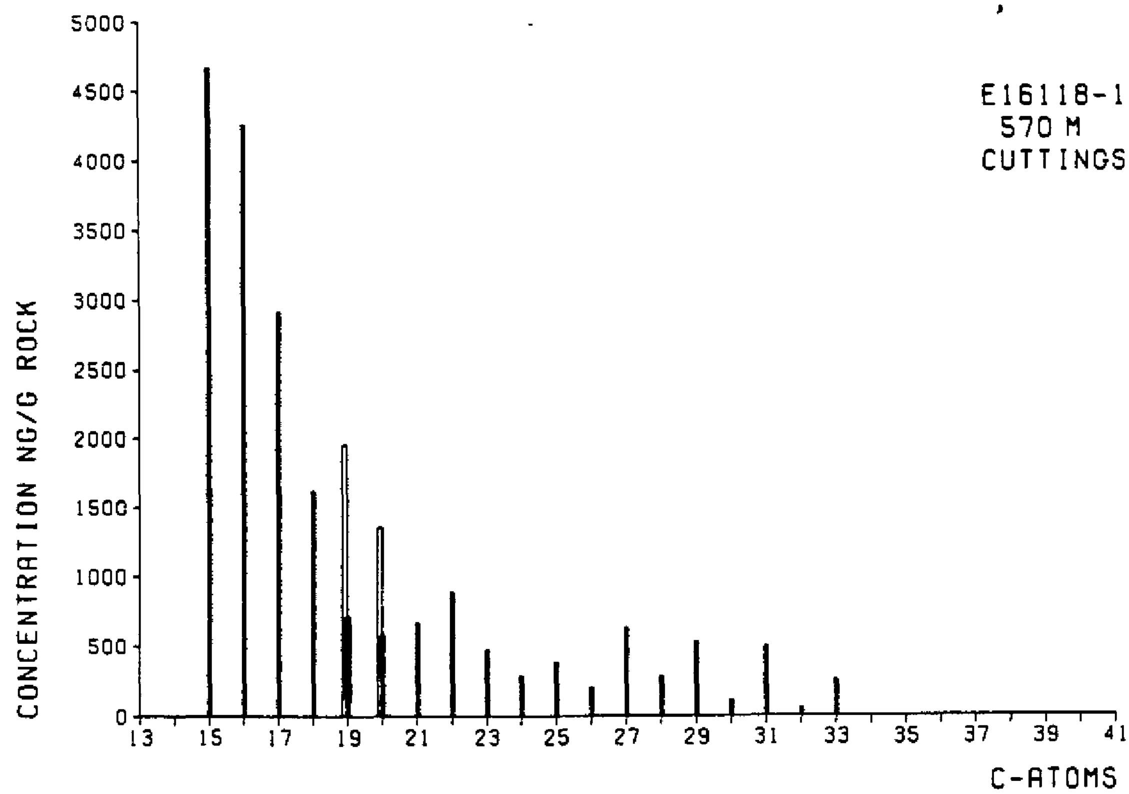

E16118-1
570 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7c

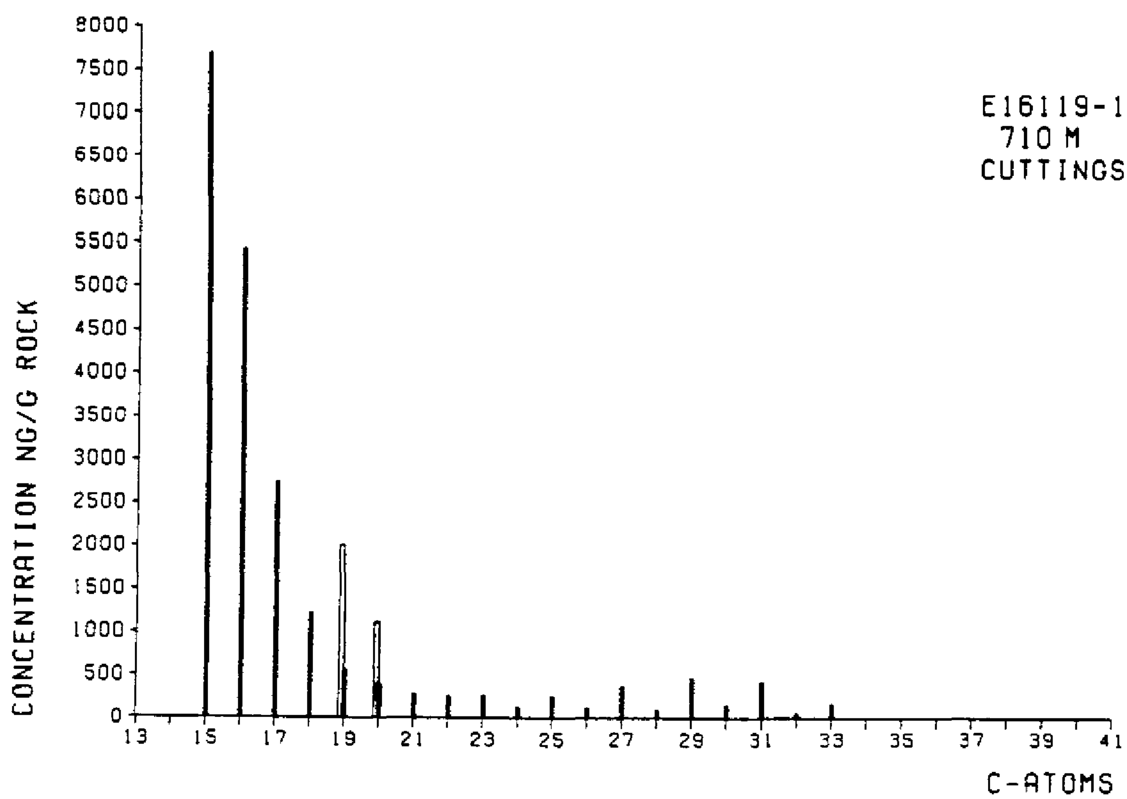

E16119-1
710 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7d

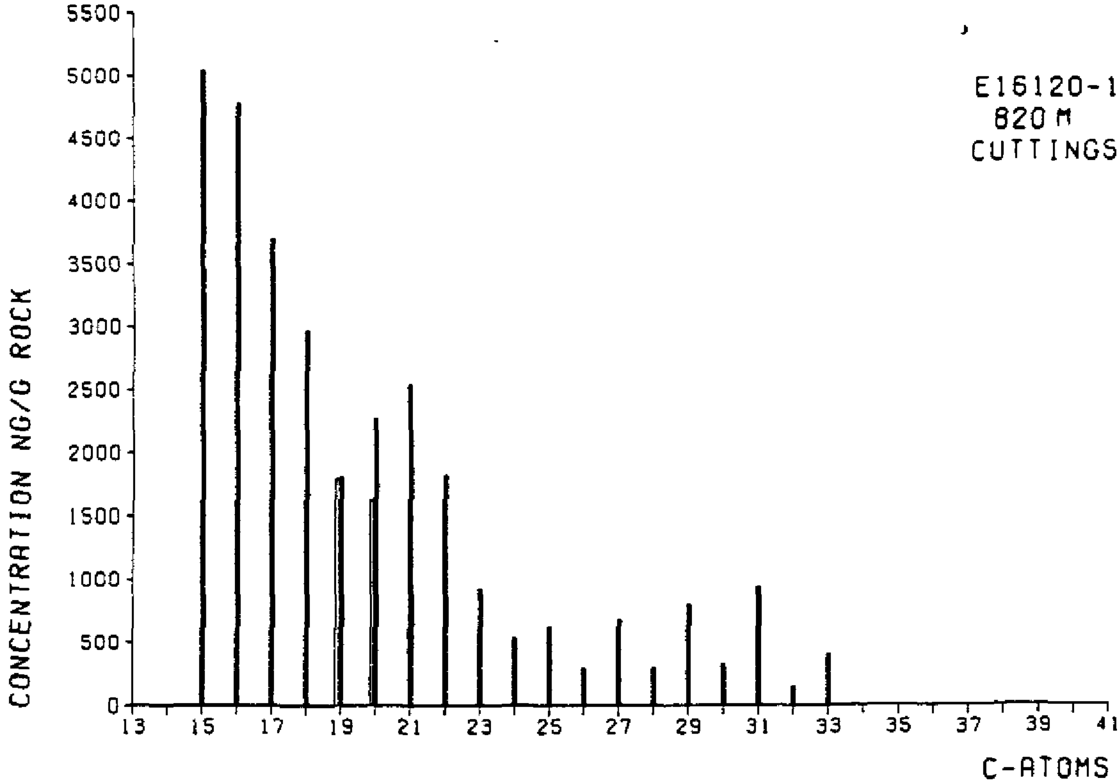
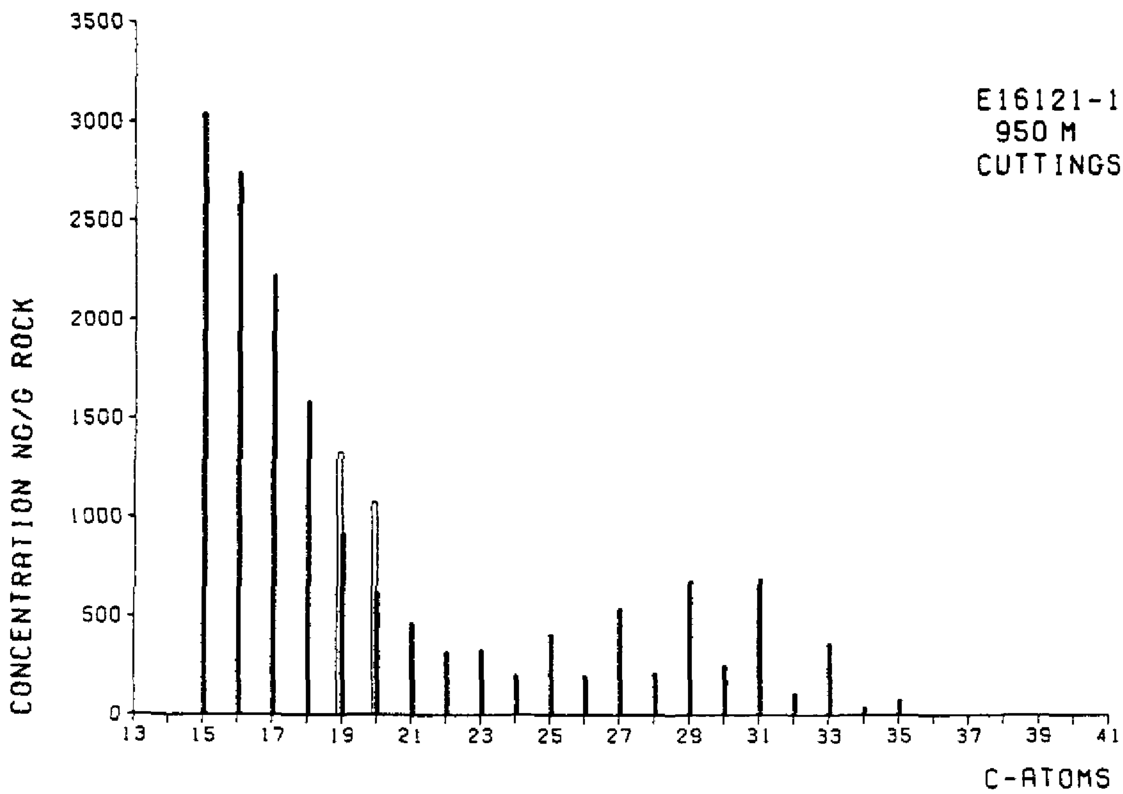

E16120-1
820 M
CUTTINGS
CONCENTRATION NG/G ROCK
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
C-ATOMS

Fig. 7e


E16121-1
950 M
CUTTINGS
CONCENTRATION NG/G ROCK
3500
3000
2500
2000
1500
1000
500
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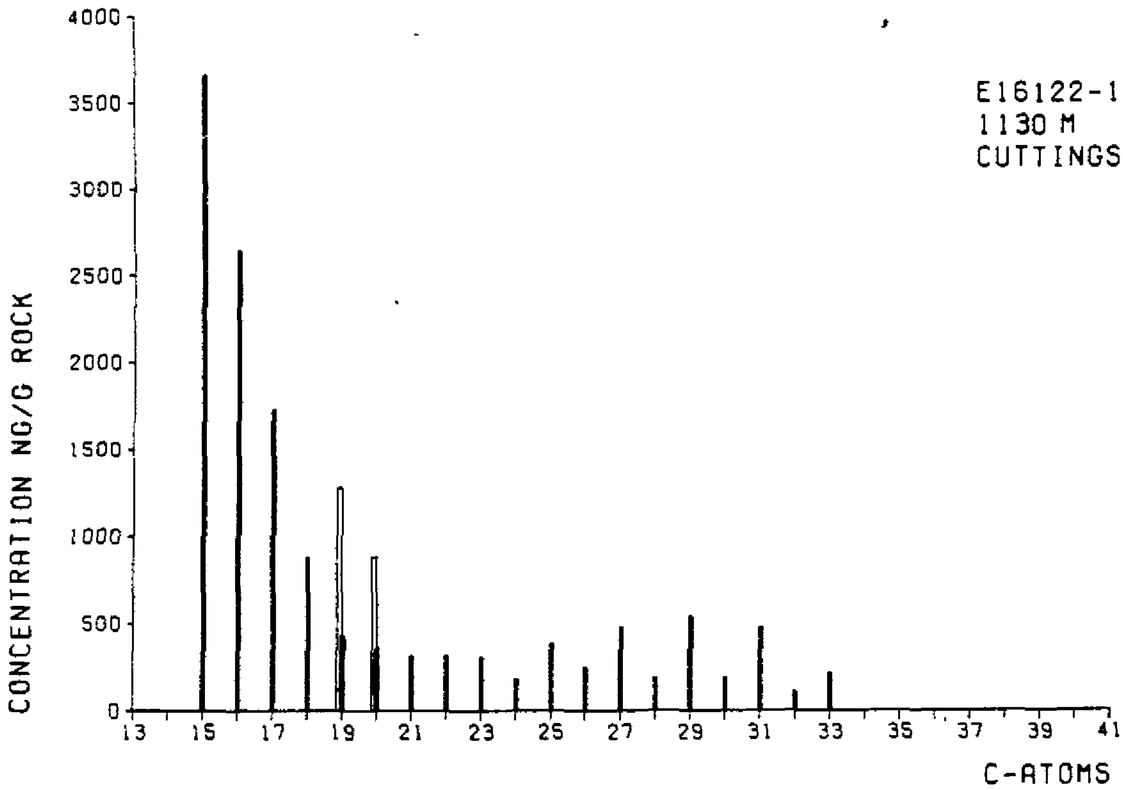
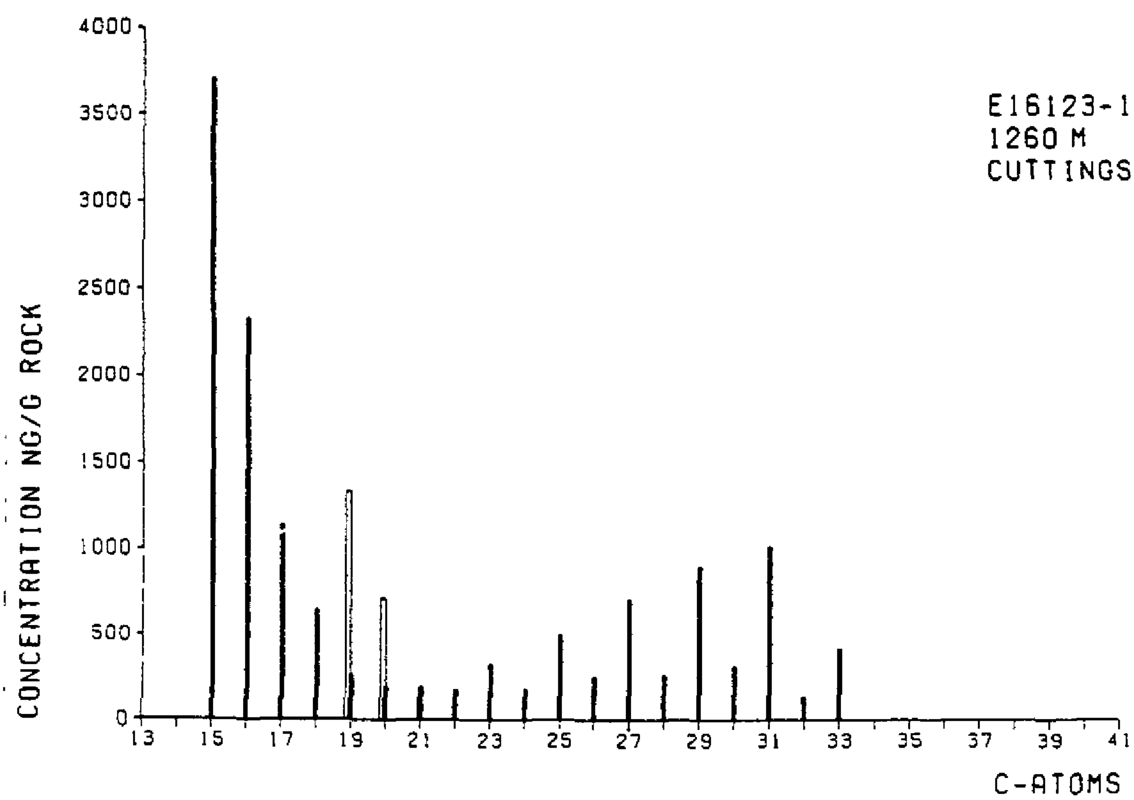
17
19
21
23
25
27
29
31
33
35
37
39
41
C-ATOMS

Fig.7f



E16122-1
1130 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7g



E16123-1
1260 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7h

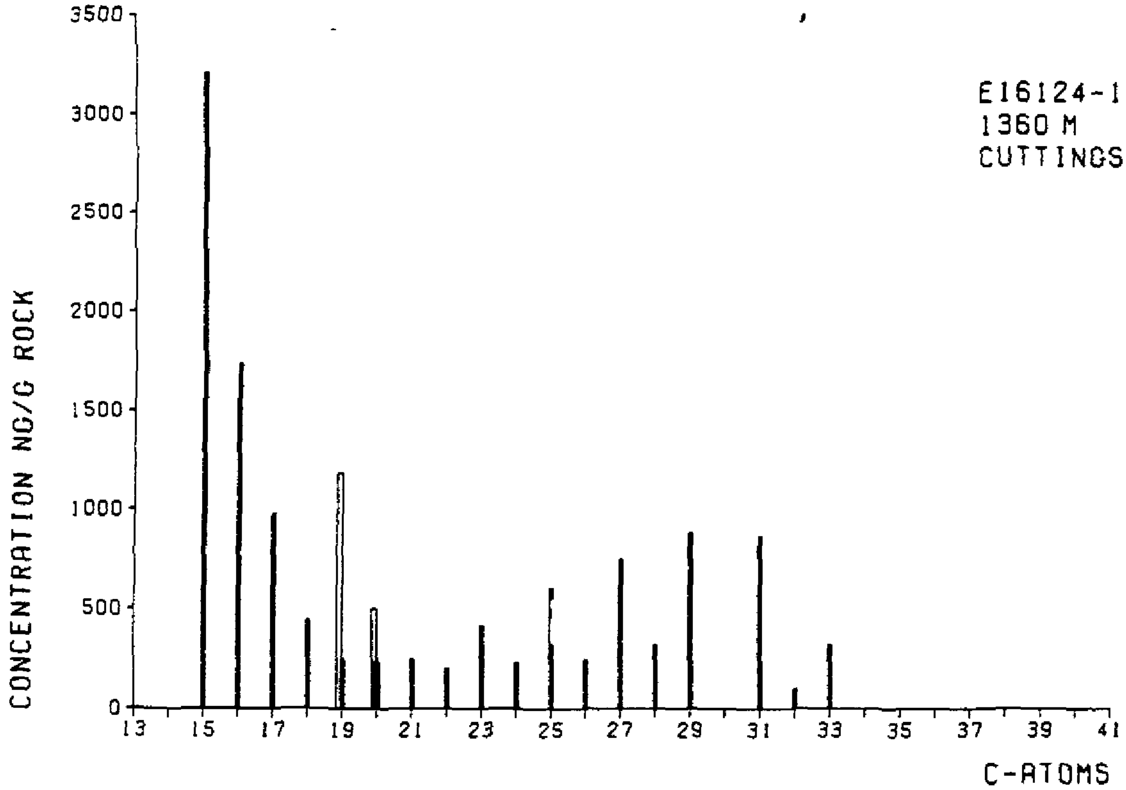

E16124-1
1360 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7i

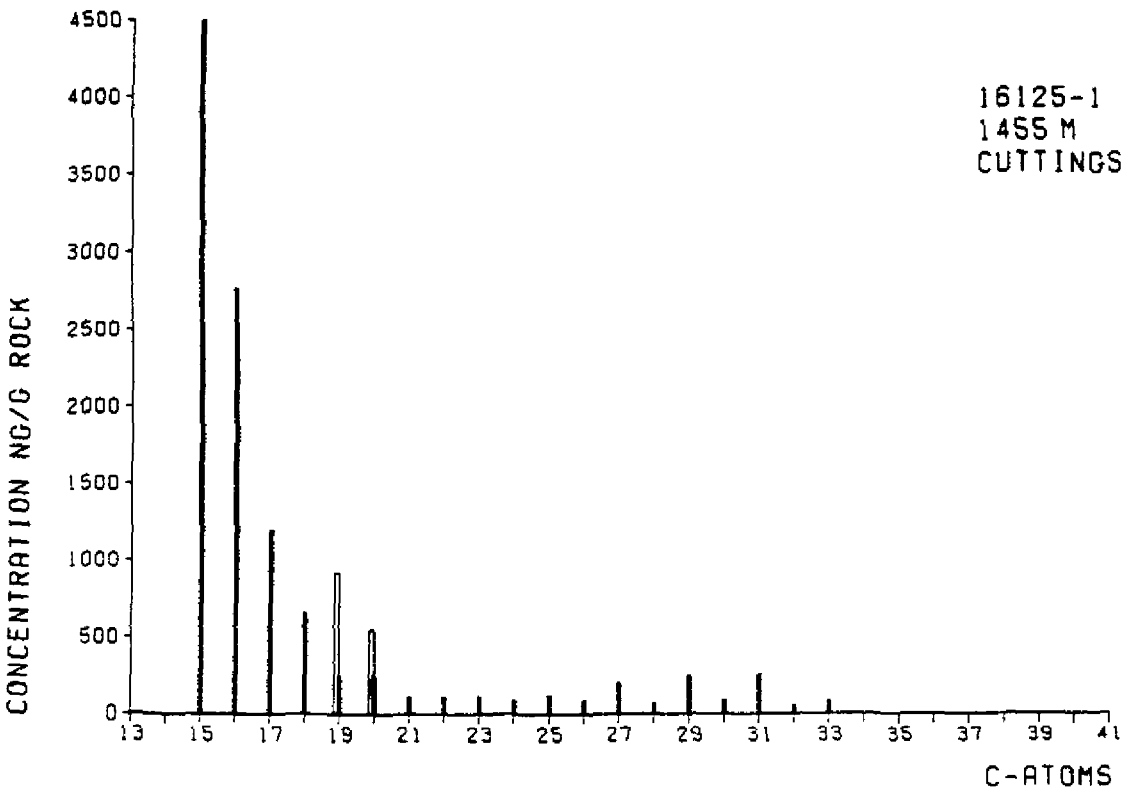
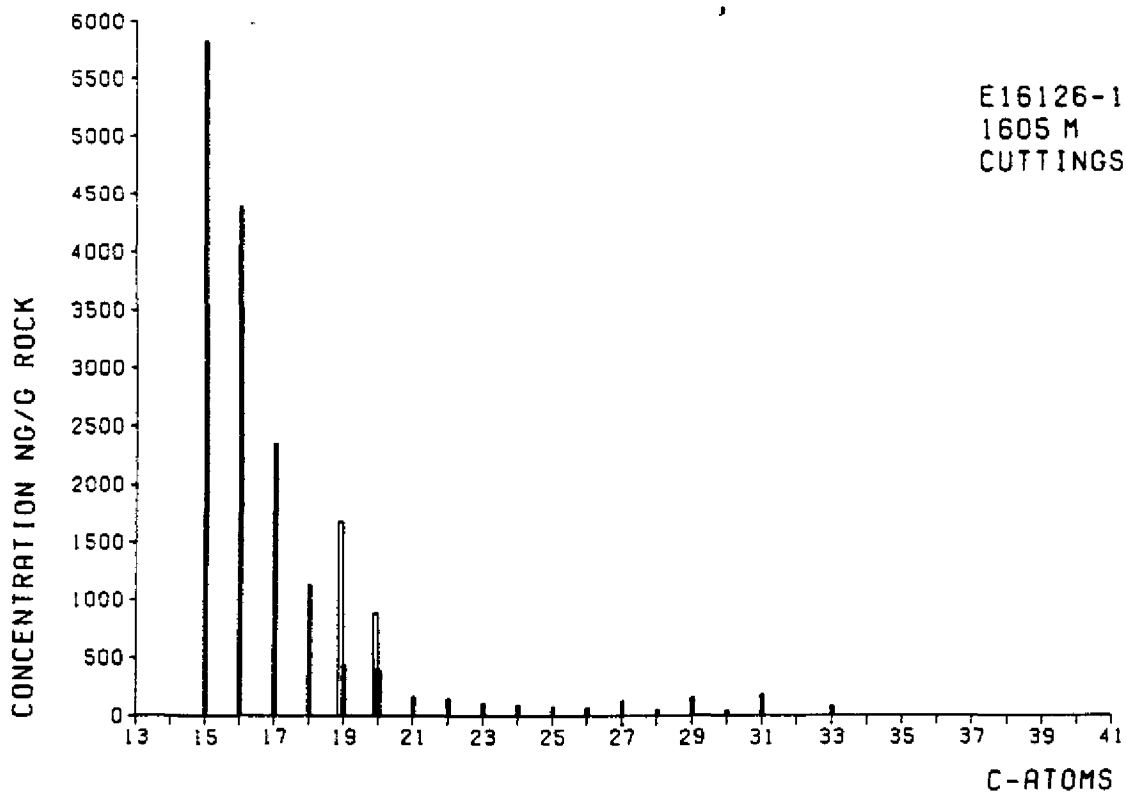
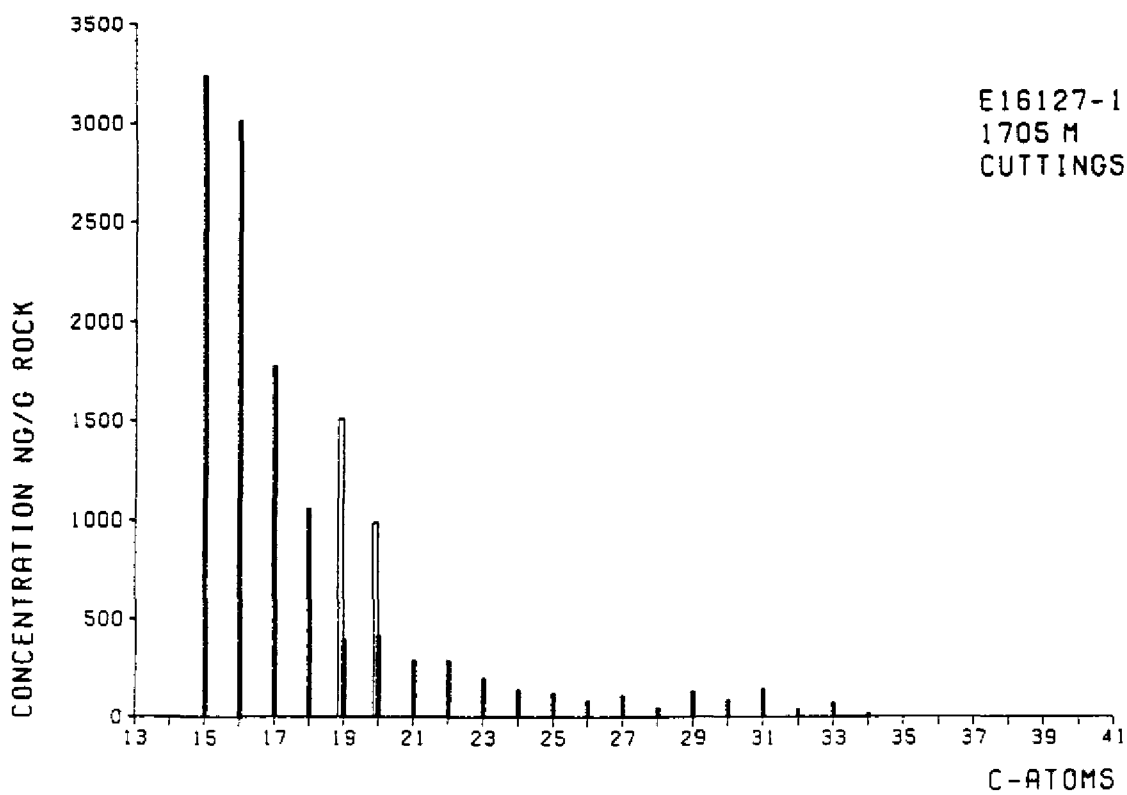

16125-1
1455 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7j



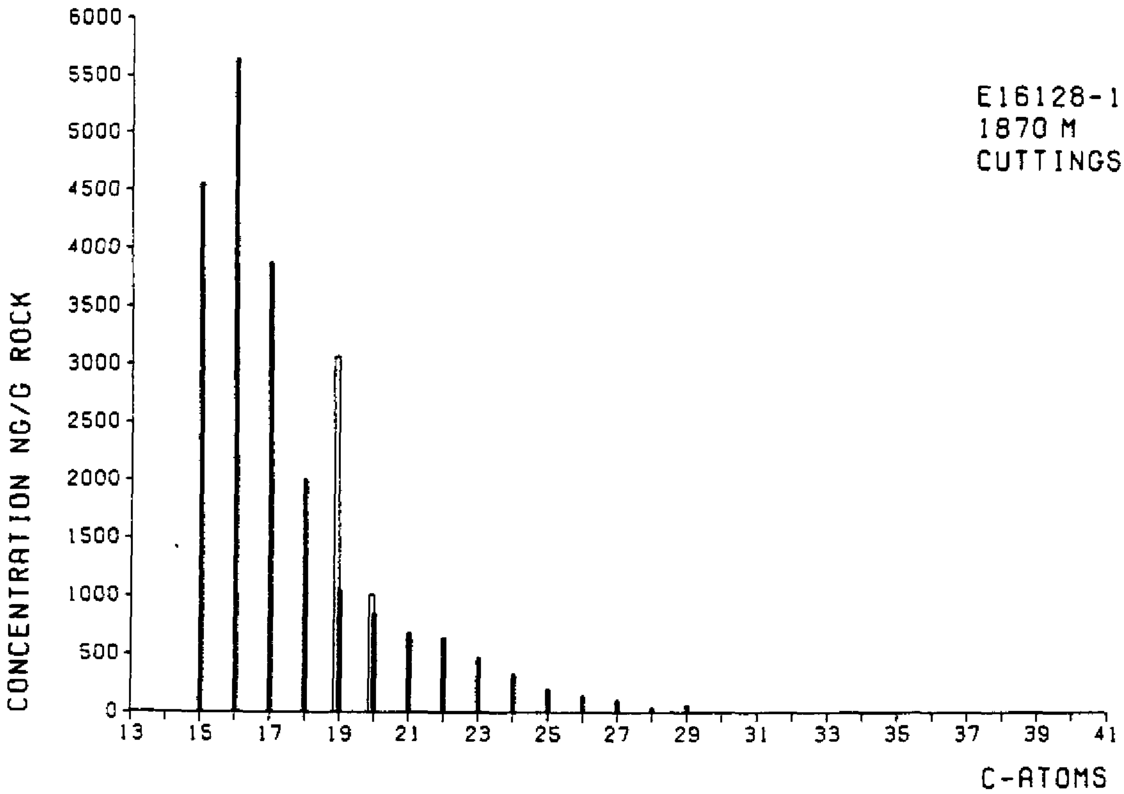
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
CONCENTRATION NG/G ROCK
E16126-1
1605 M
CUTTINGS
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
C-ATOMS

Fig. 7k



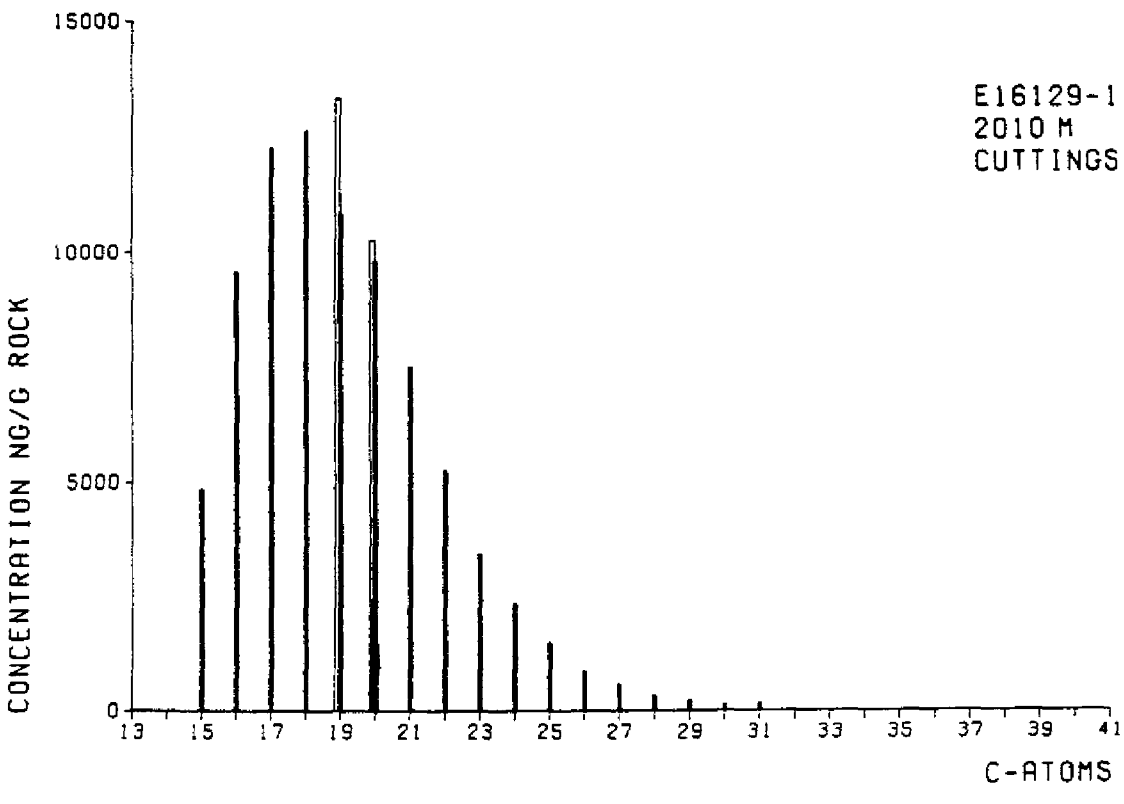
3500
3000
2500
2000
1500
1000
500
0
CONCENTRATION NG/G ROCK
E16127-1
1705 M
CUTTINGS
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
C-ATOMS

Fig. 7l



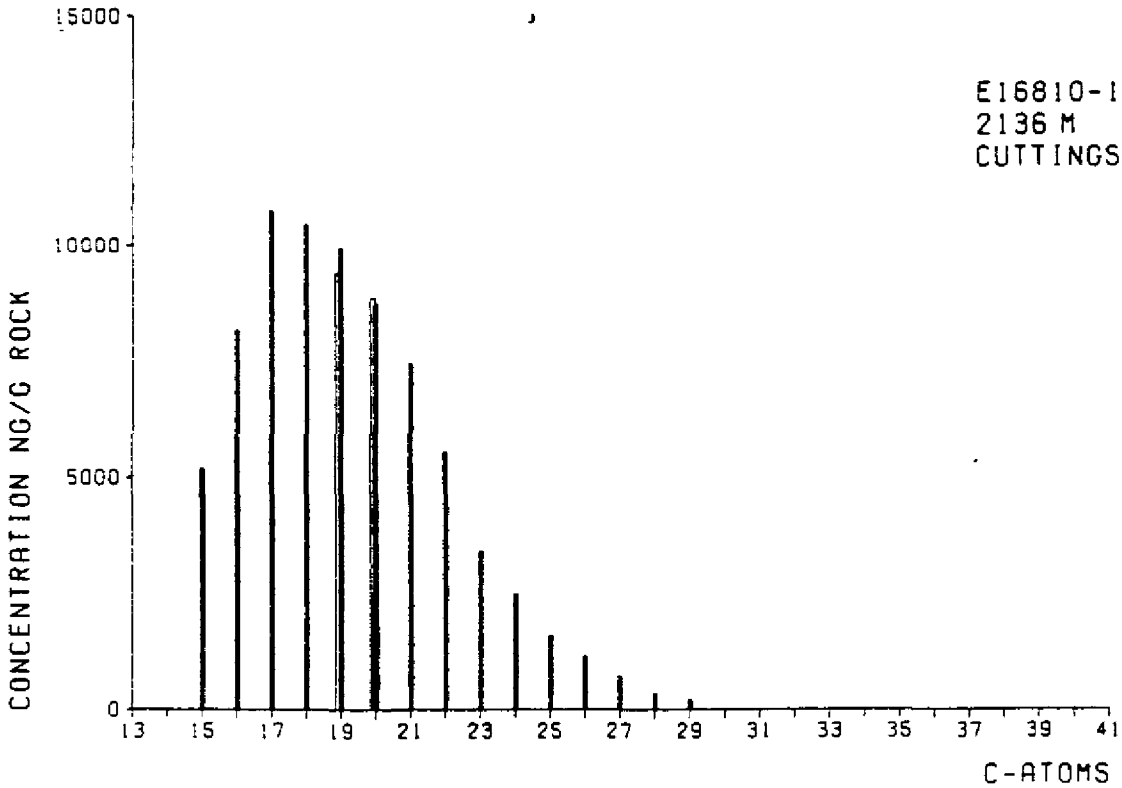
E16128-1
1870 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7m



E16129-1
2010 M
CUTTINGS
CONCENTRATION NG/G ROCK
C-ATOMS

Fig. 7n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CONCENTRATION NG/G ROCK
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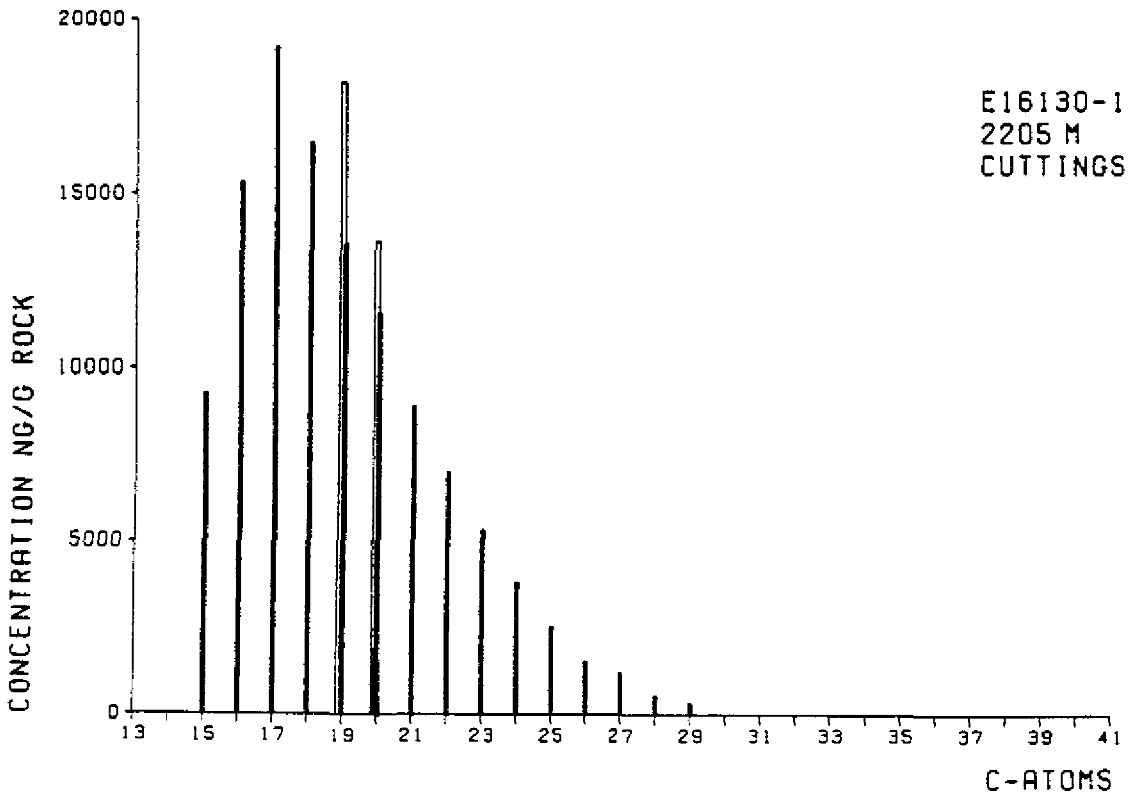
C-ATOMS
E16810-1
2136 M
CUTTINGS

Fig. 7o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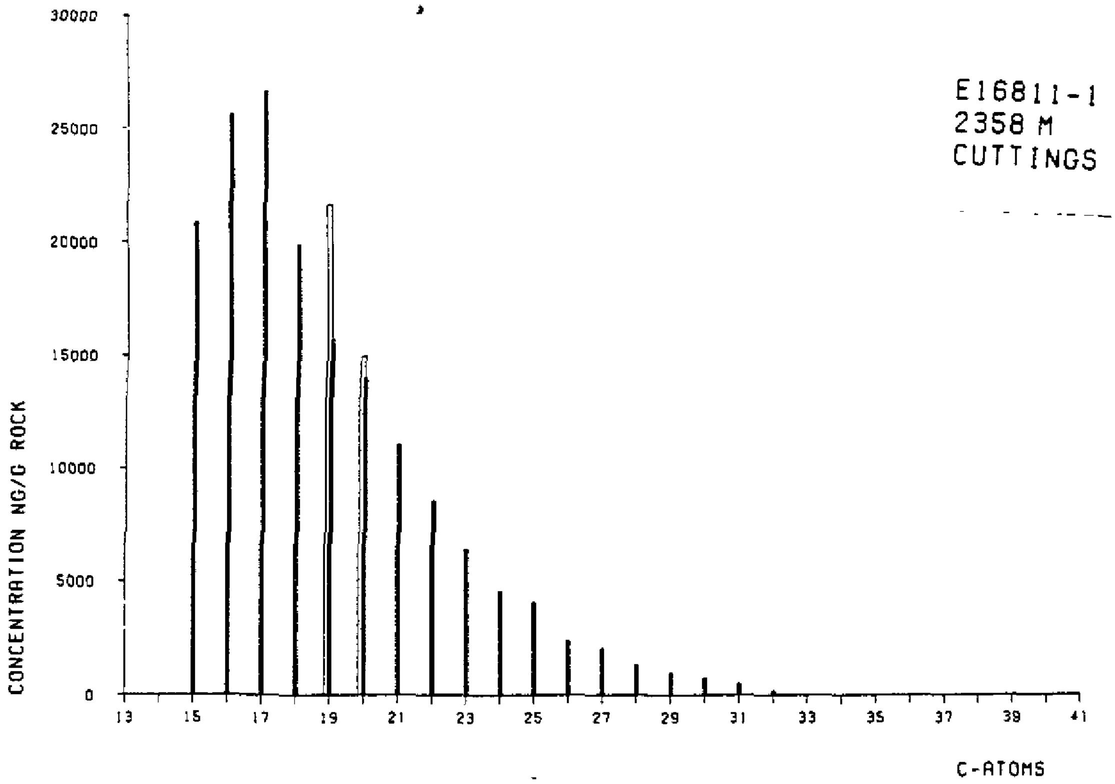
39
41
C-ATOMS
E16130-1
2205 M
CUTTINGS

Fig. 7p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CONCENTRATION NG/G ROCK
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21
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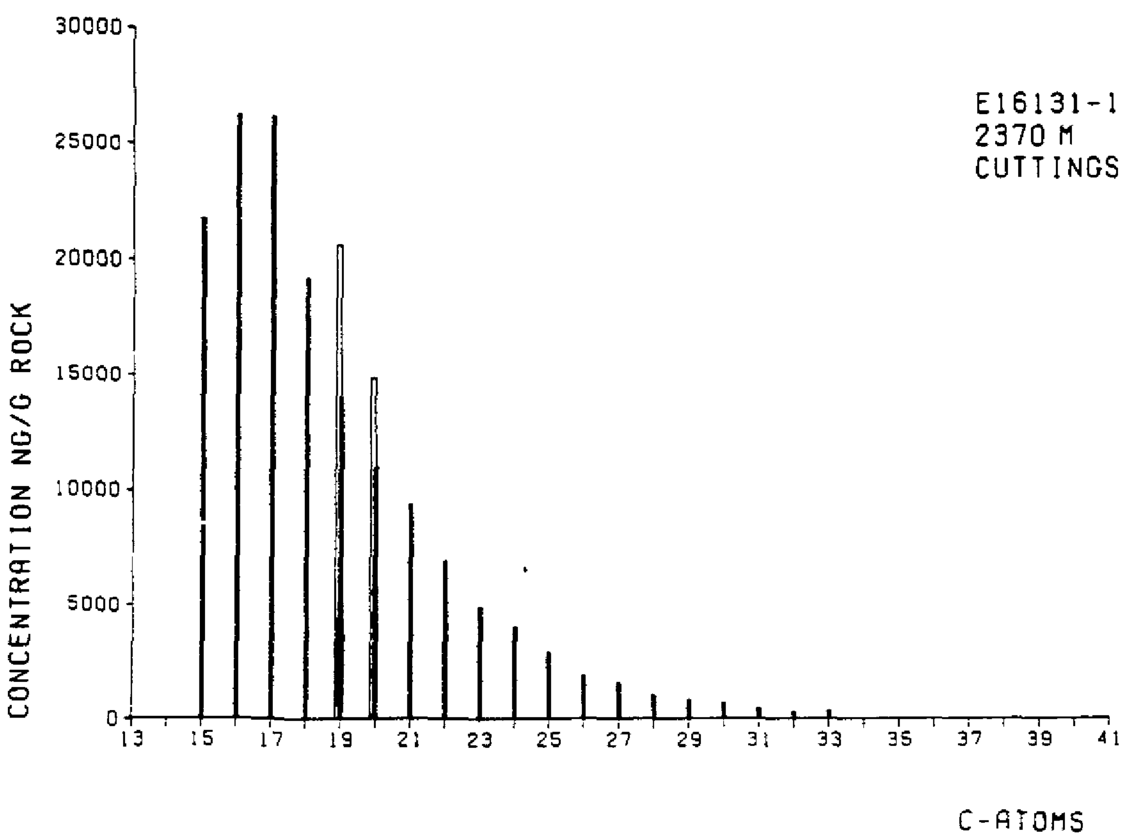
37
39
41
C-ATOMS
E16811-1
2358 M
CUTTINGS

Fig. 7q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CONCENTRATION NG/G ROCK
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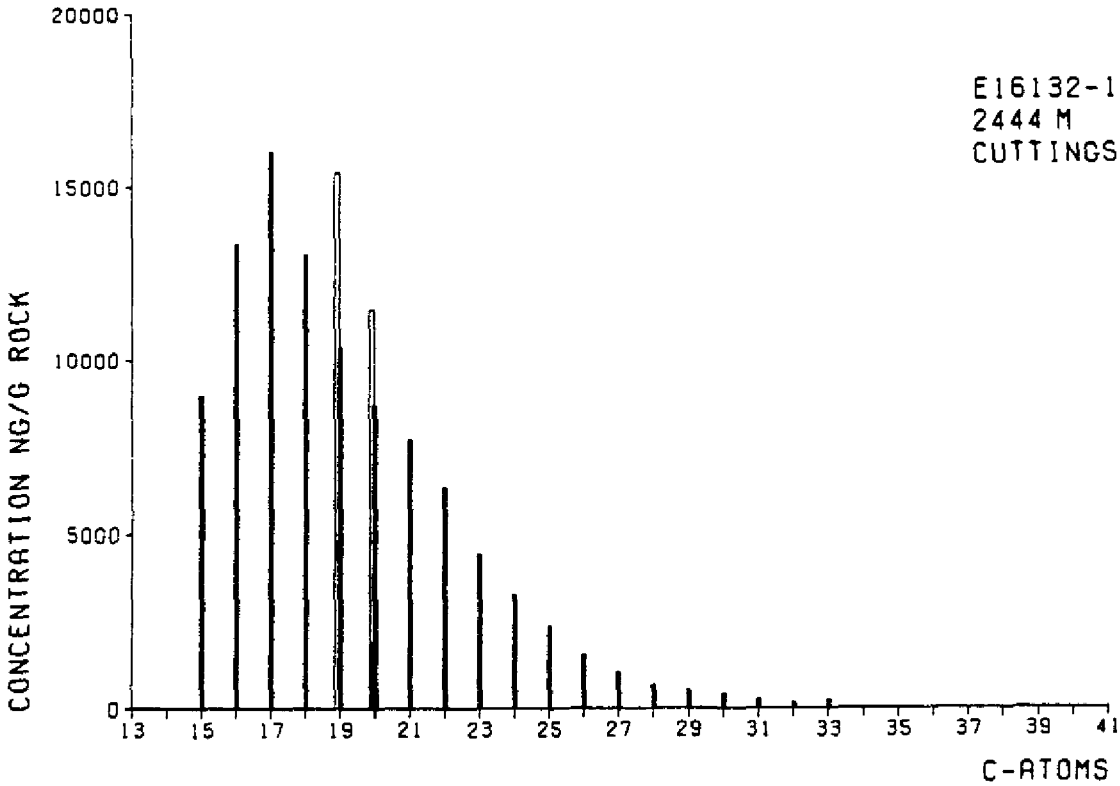
41
C-ATOMS
E16131-1
2370 M
CUTTINGS

Fig. 7r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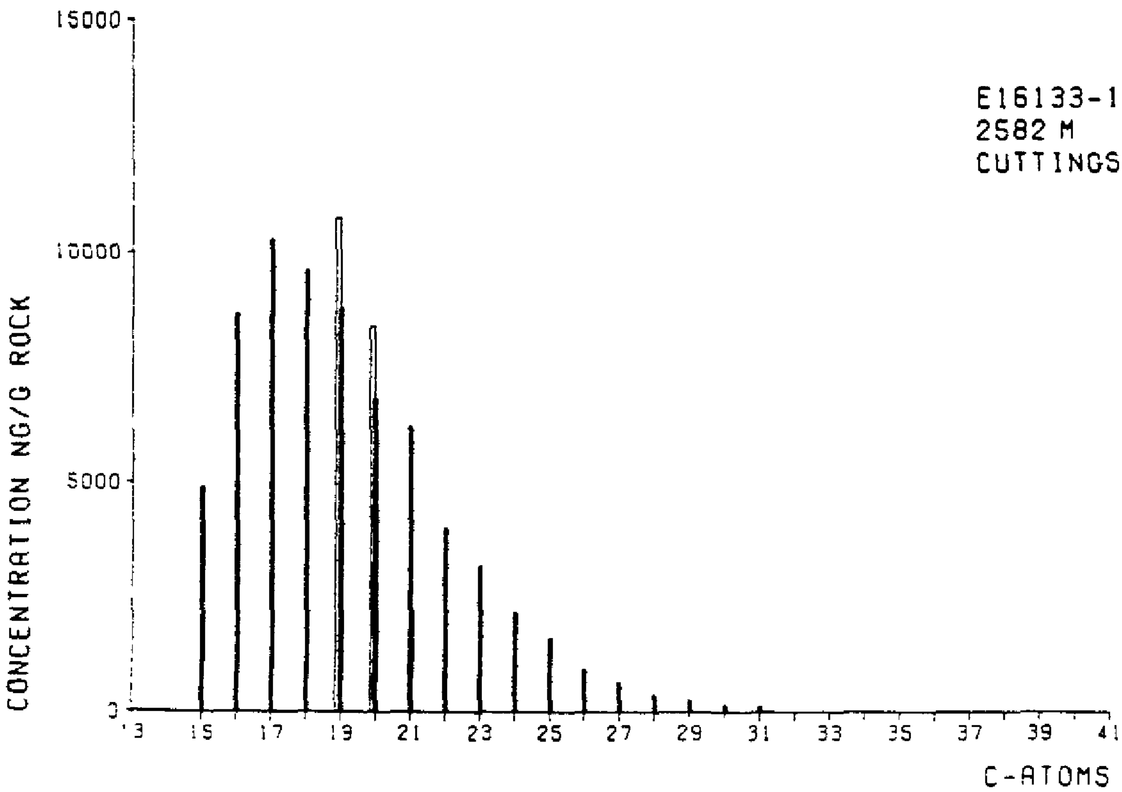
39
41
C-ATOMS
E16132-1
2444 M
CUTTINGS

Fig. 7s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CONCENTRATION NG/G ROCK
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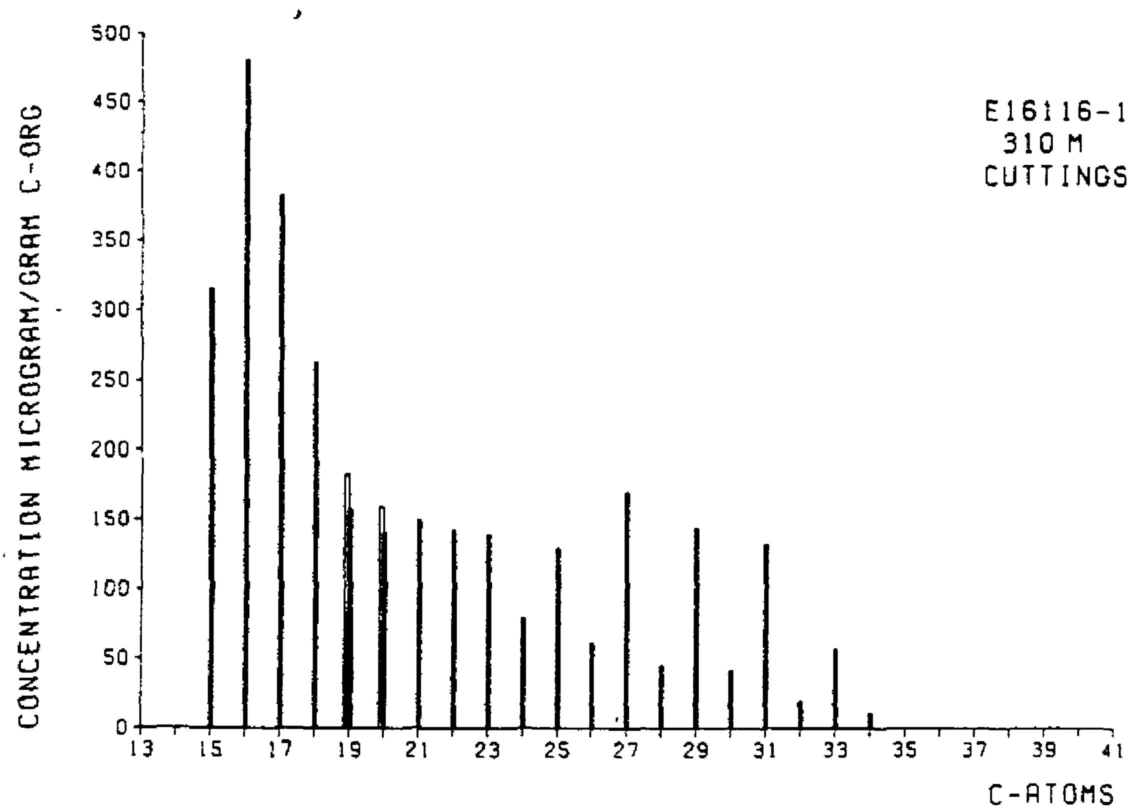
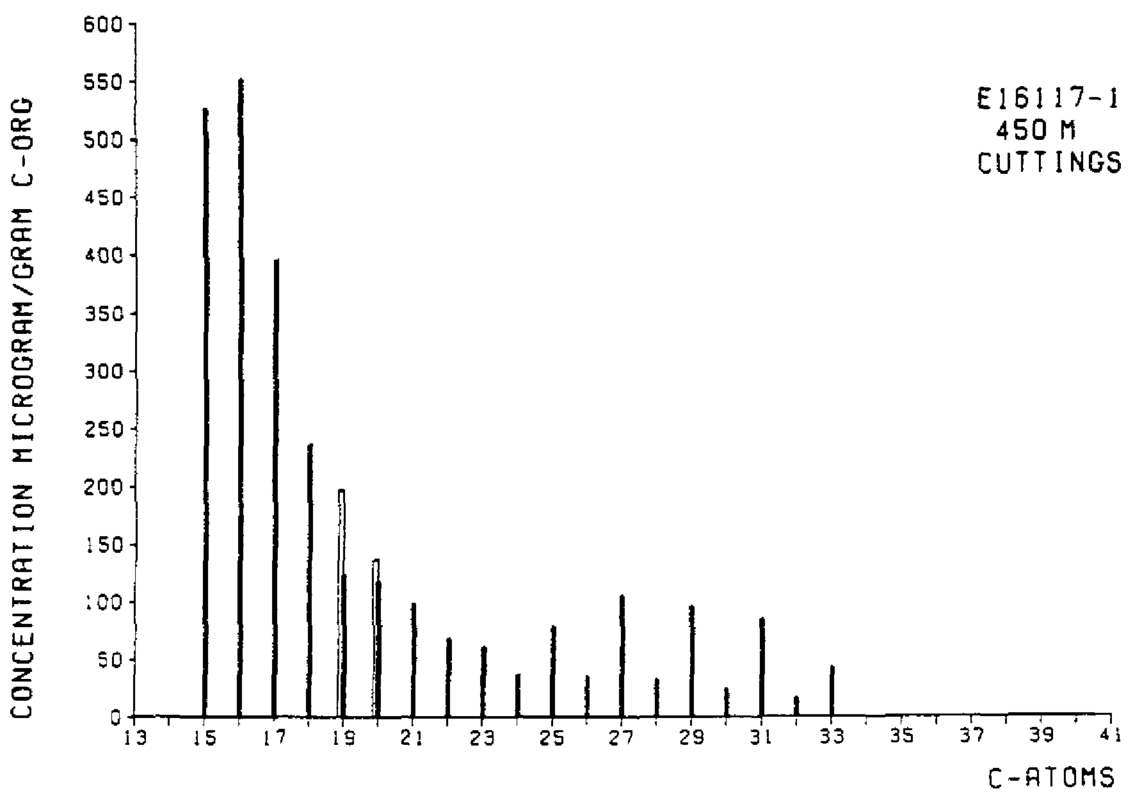
41
C-ATOMS
E16133-1
2582 M
CUTTINGS

Fig. 7t



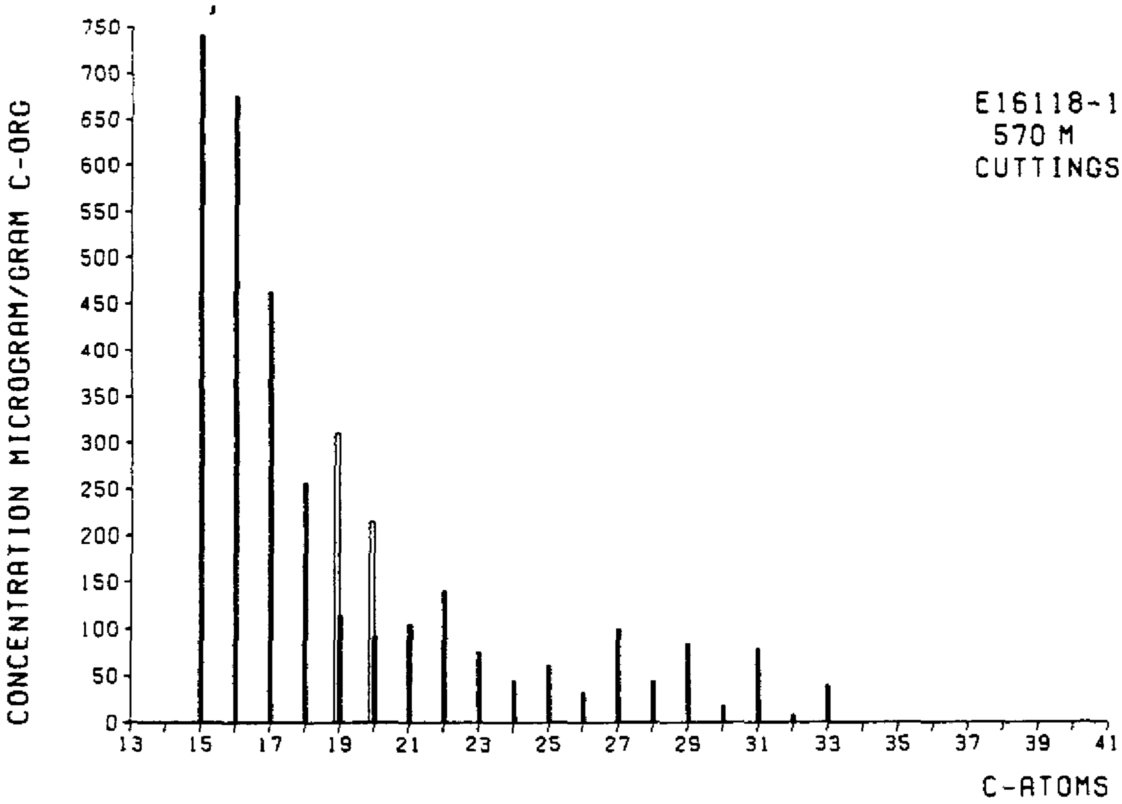
E16116-1
310 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8a



E16117-1
450 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8b



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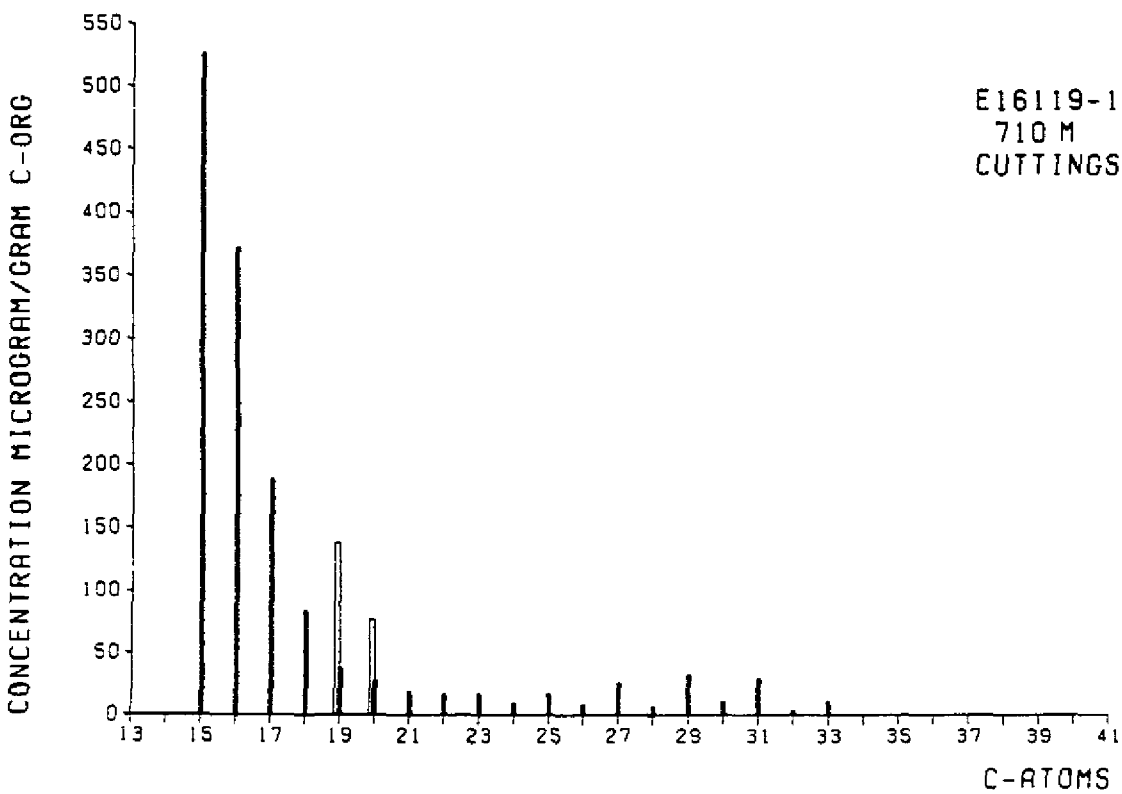
50
0
CONCENTRATION MICROGRAM/GRAM C-ORG
E16118-1
570 M
CUTTINGS
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
C-ATOMS

Fig. 8c



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50
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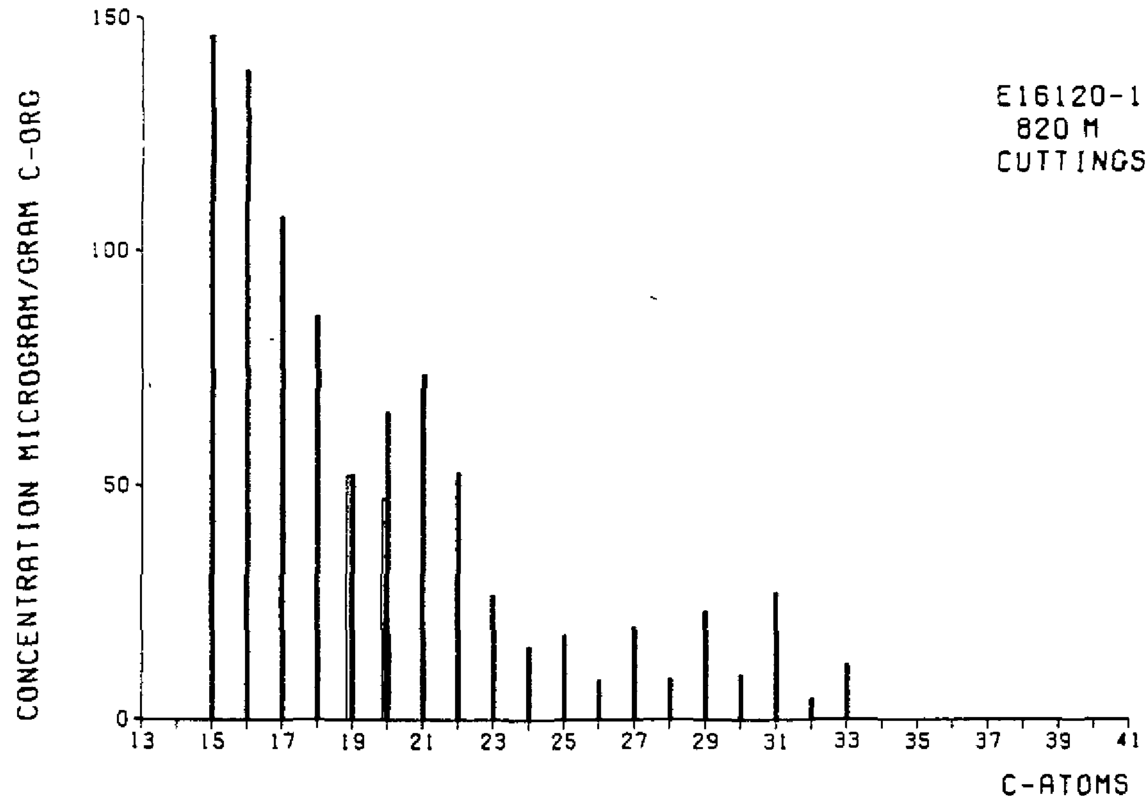
E16119-1
710 M
CUTTINGS
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
C-ATOMS

Fig. 8d



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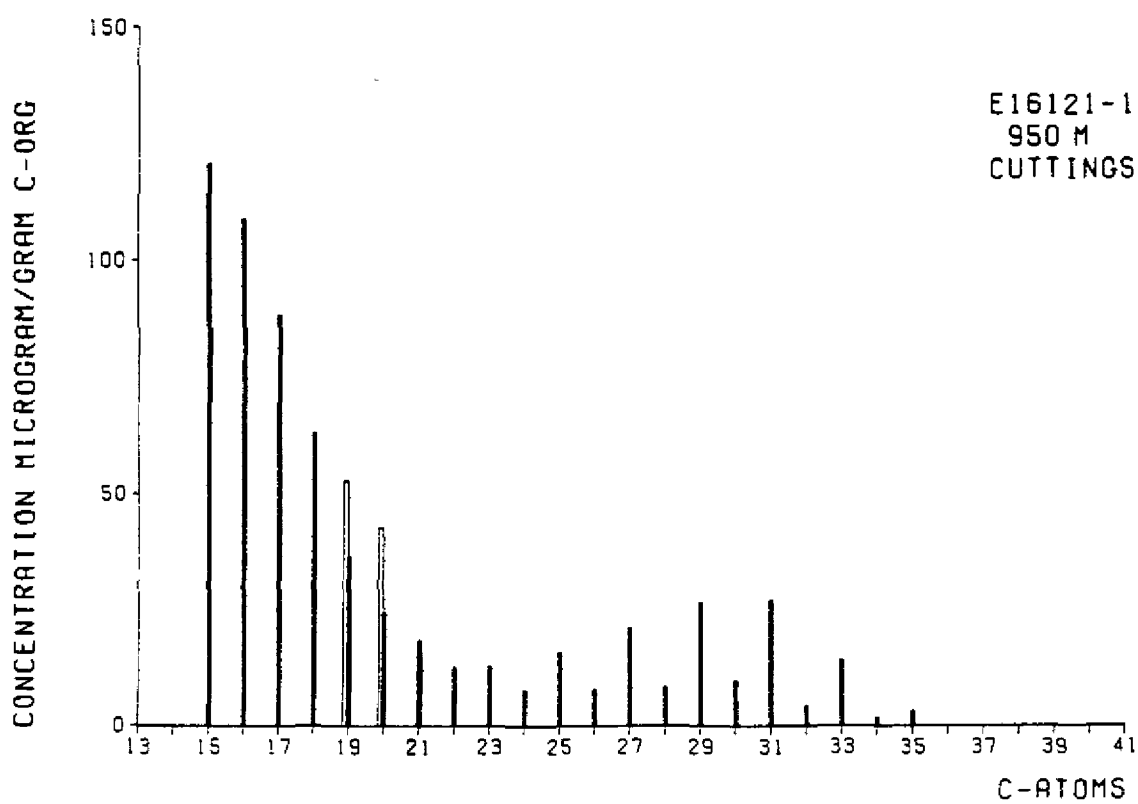
CONCENTRATION MICROGRAM/GRAM C-ORG
E16120-1
820 M
CUTTINGS
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
C-ATOMS

Fig. 8e



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100
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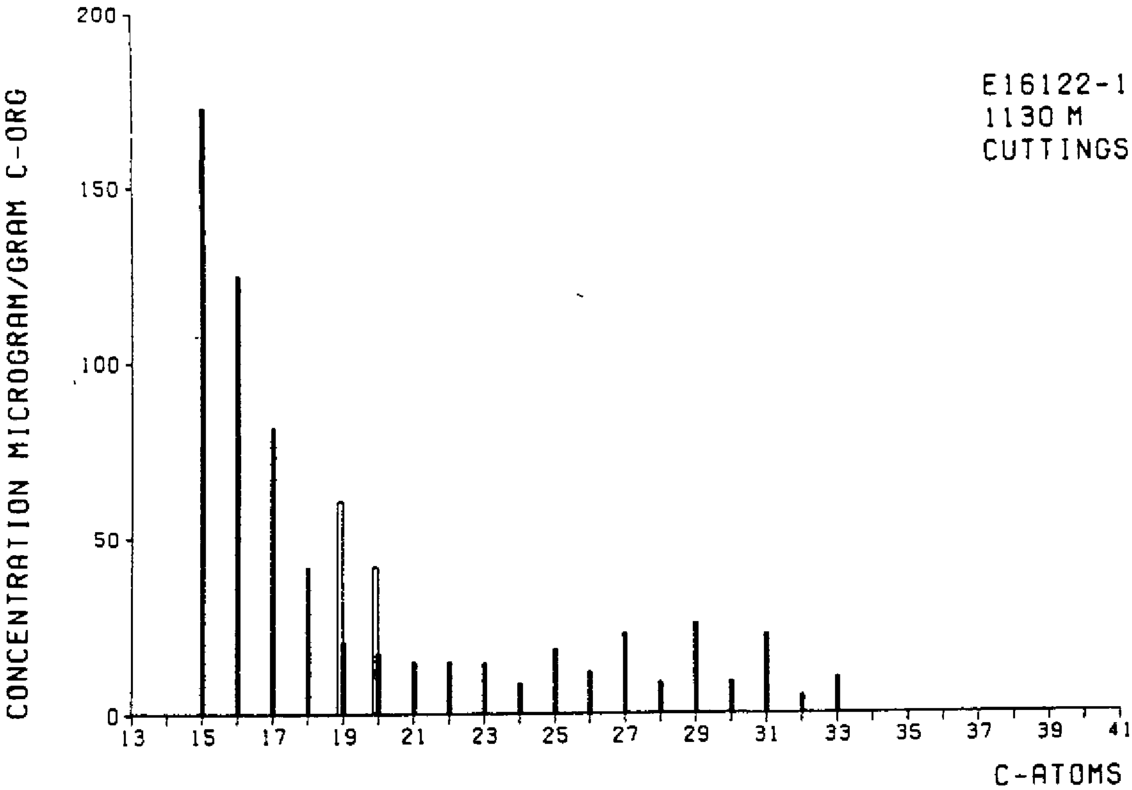
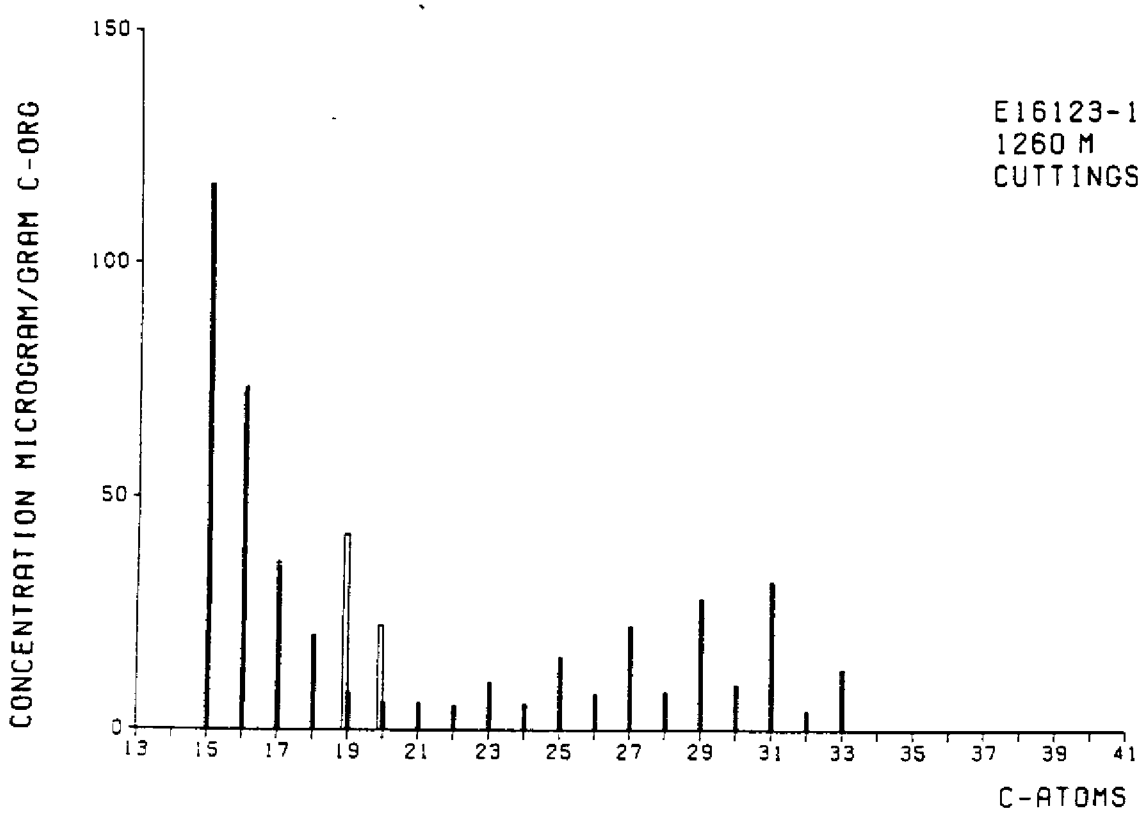
CONCENTRATION MICROGRAM/GRAM C-ORG
E16121-1
950 M
CUTTINGS
13 15 17 19 21 23 25 27 29 31 33 35 37 39 41
C-ATOMS

Fig. 8f



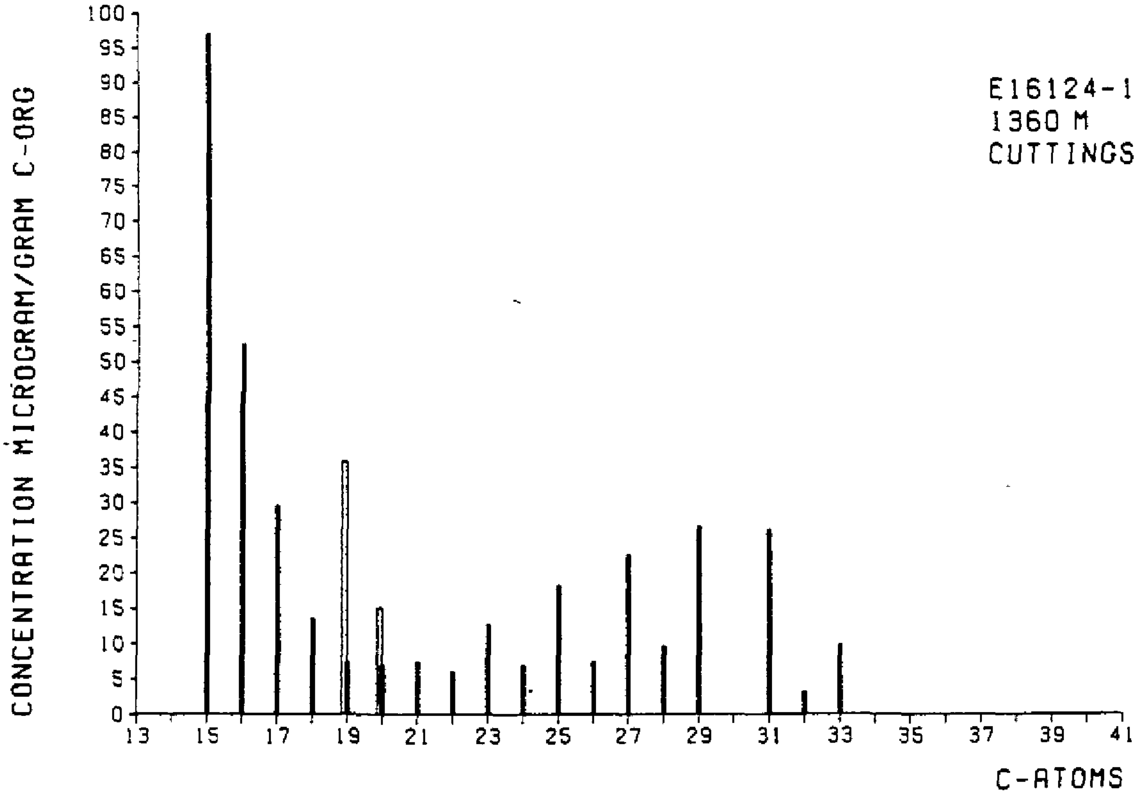
E16122-1
1130 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8g



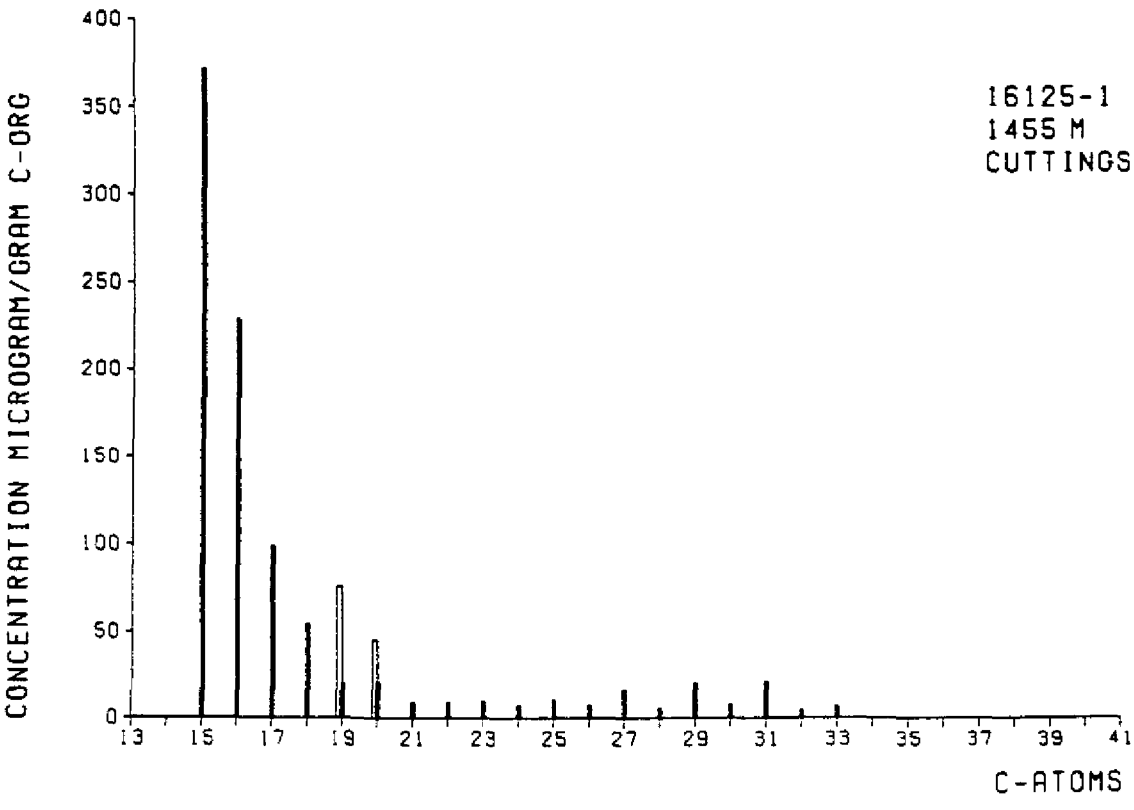
E16123-1
1260 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8h



E16124-1
1360 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8i



16125-1
1455 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8j

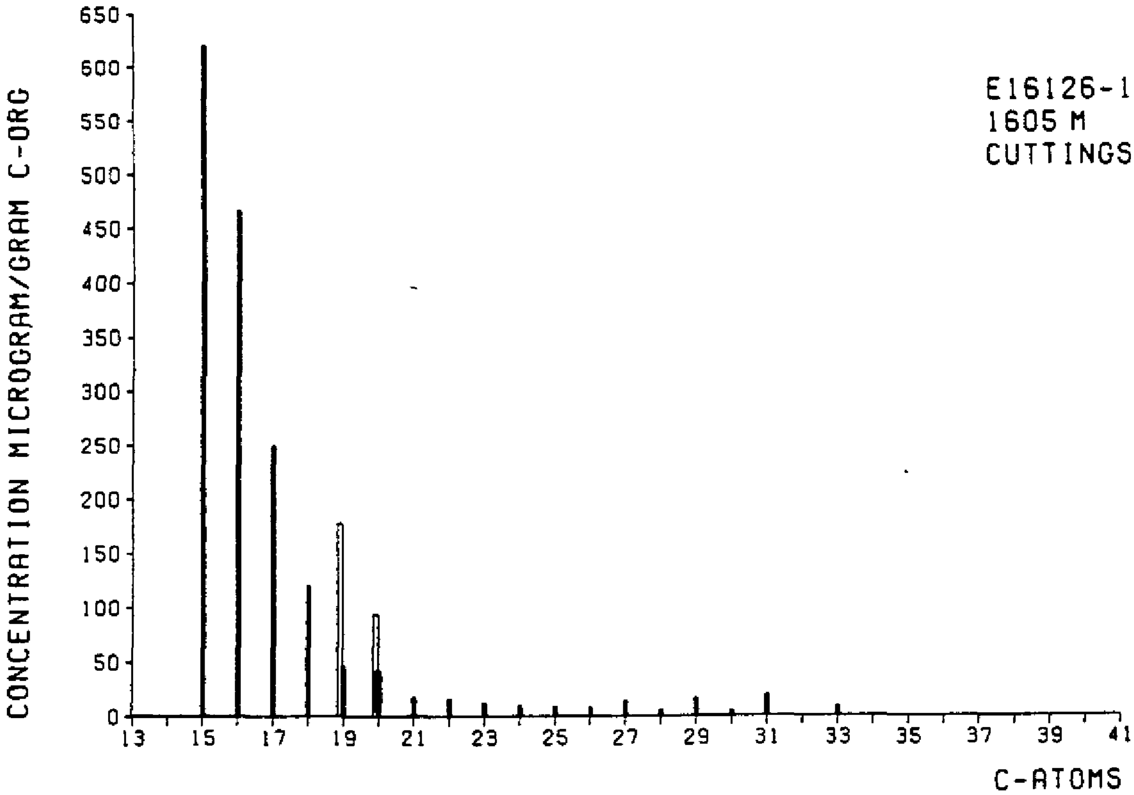

E16126-1
1605 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig 8k

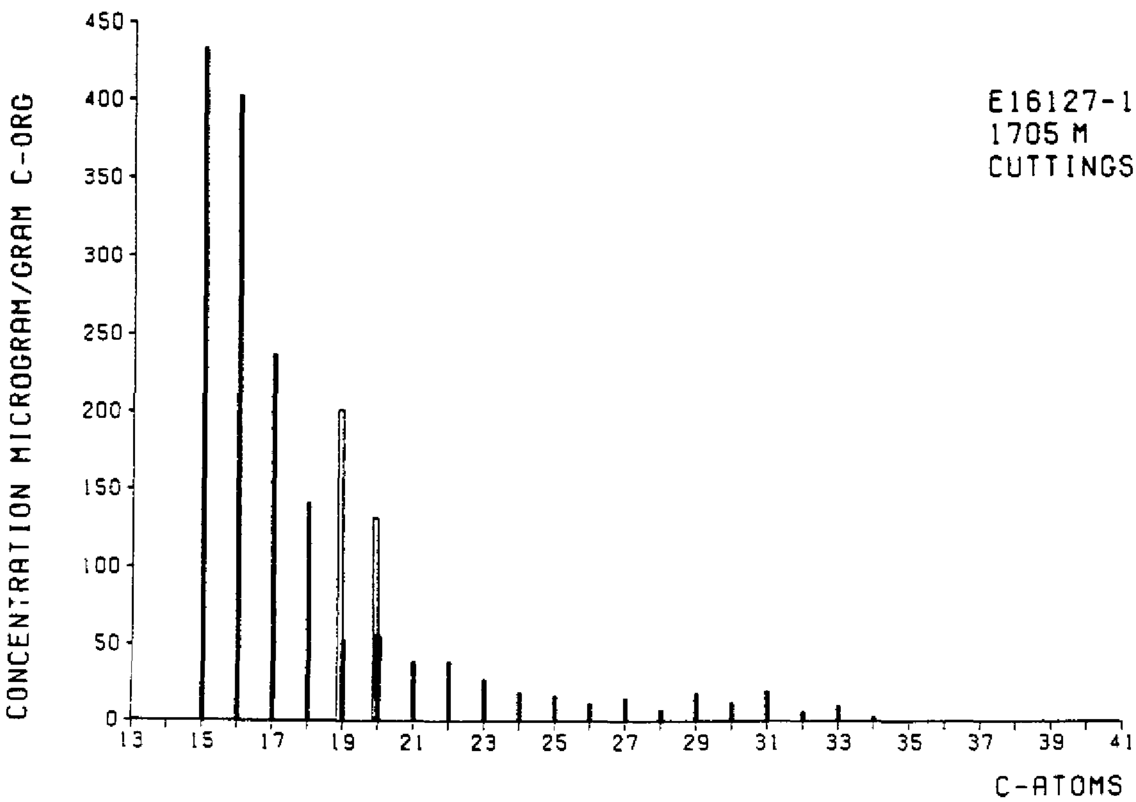

E16127-1
1705 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8l

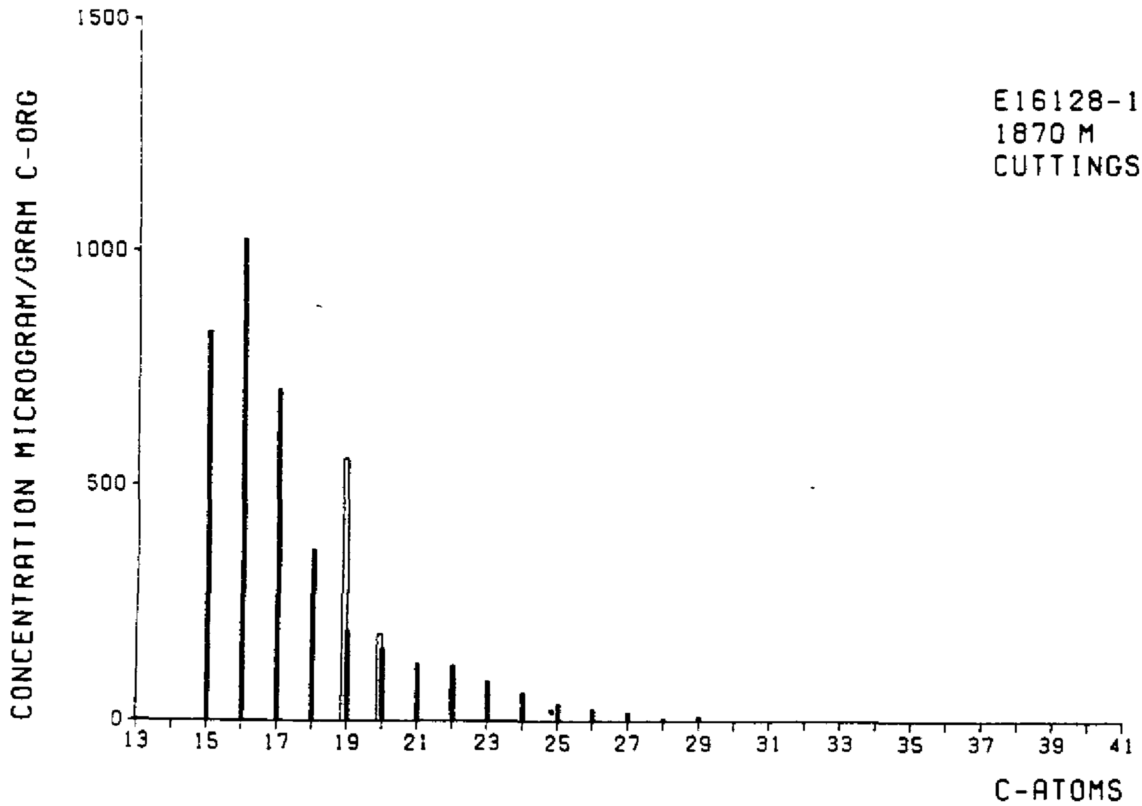

E16128-1
1870 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8m

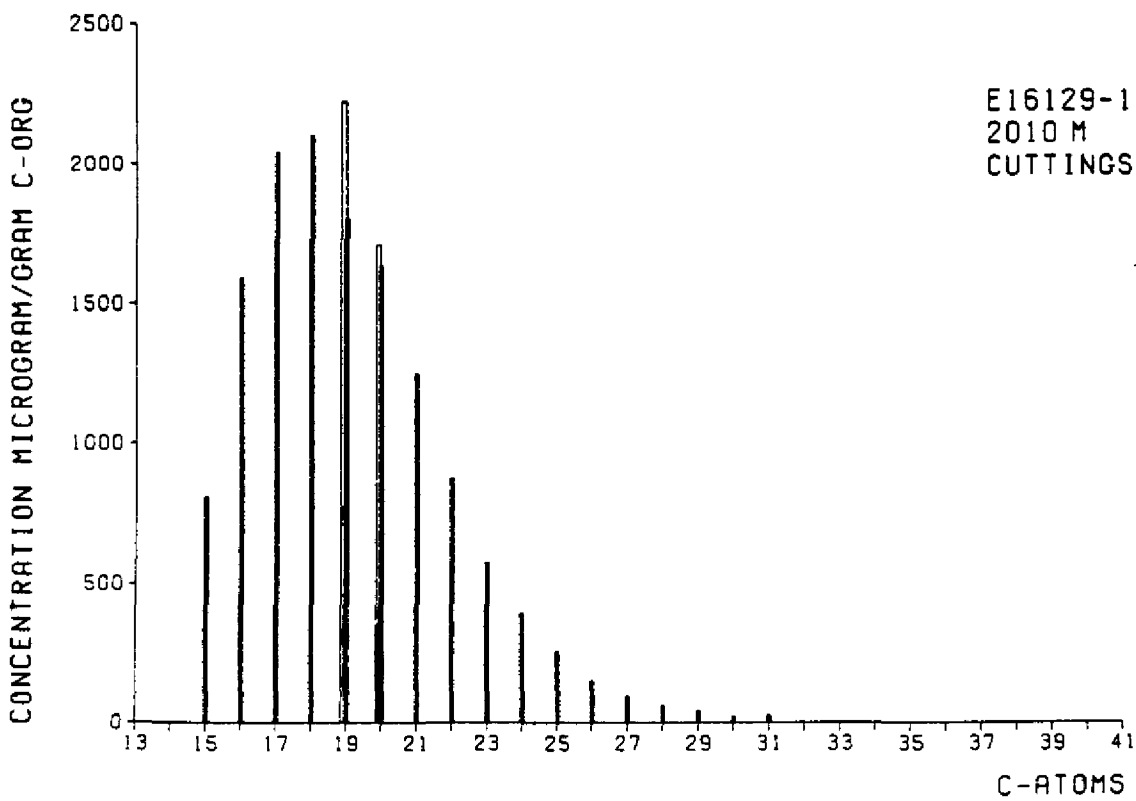
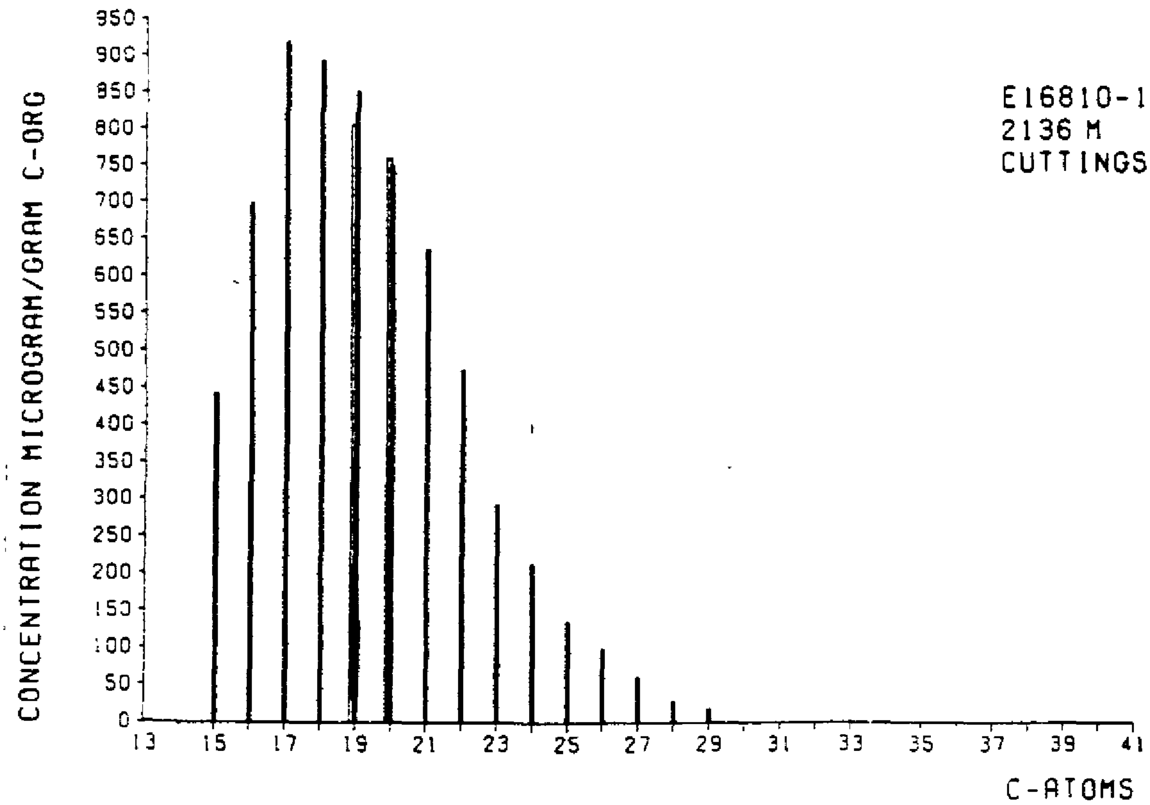
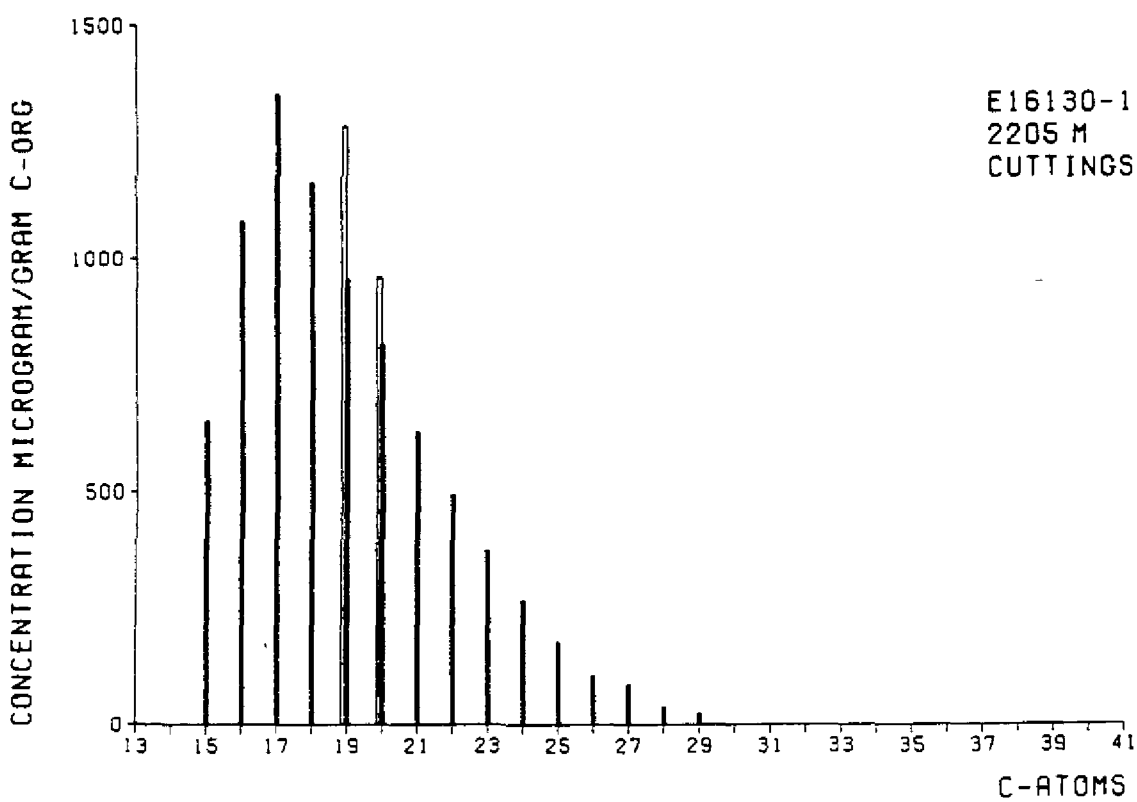

E16129-1
2010 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8n



E16810-1
2136 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8o



E16130-1
2205 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8p

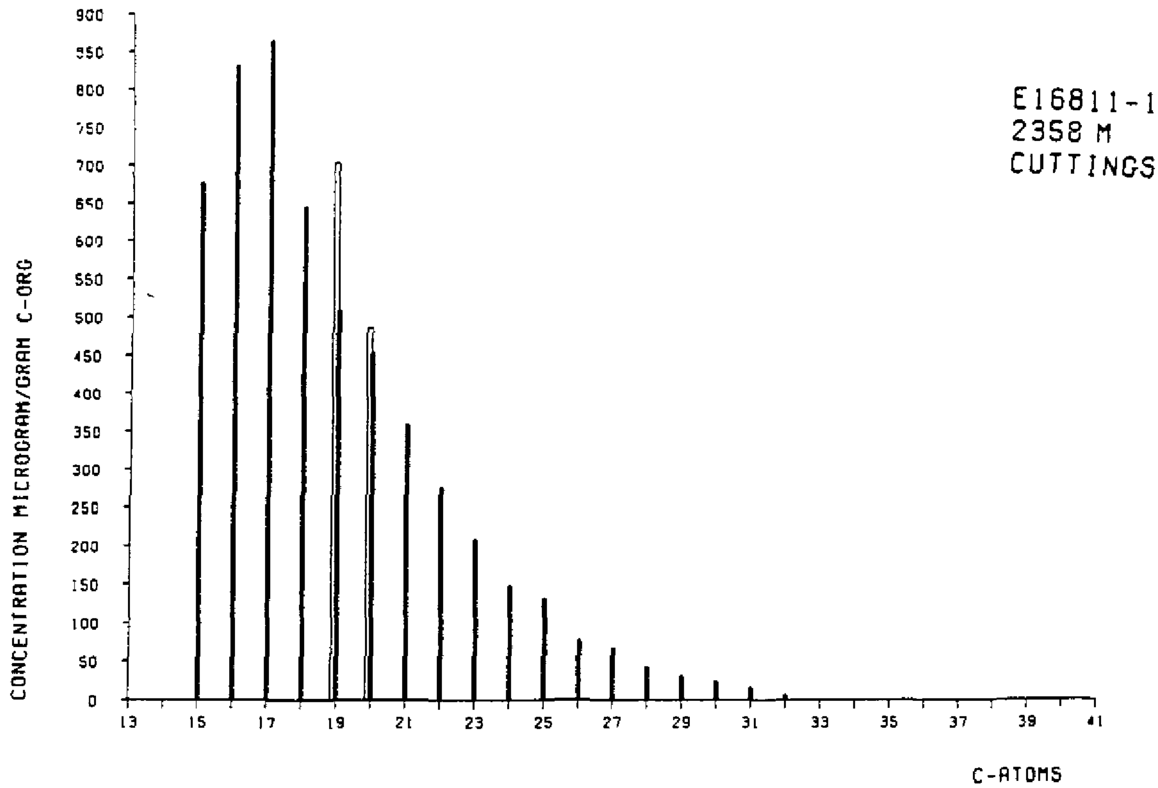

E16811-1
2358 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8q

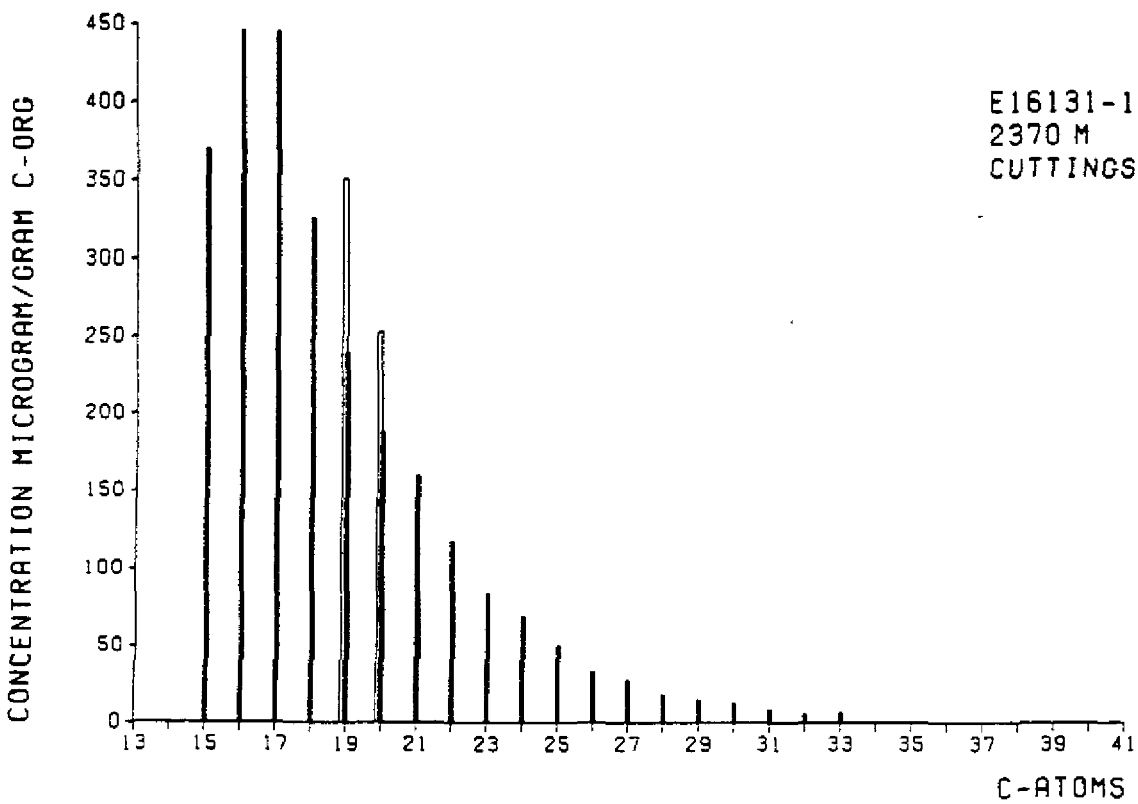
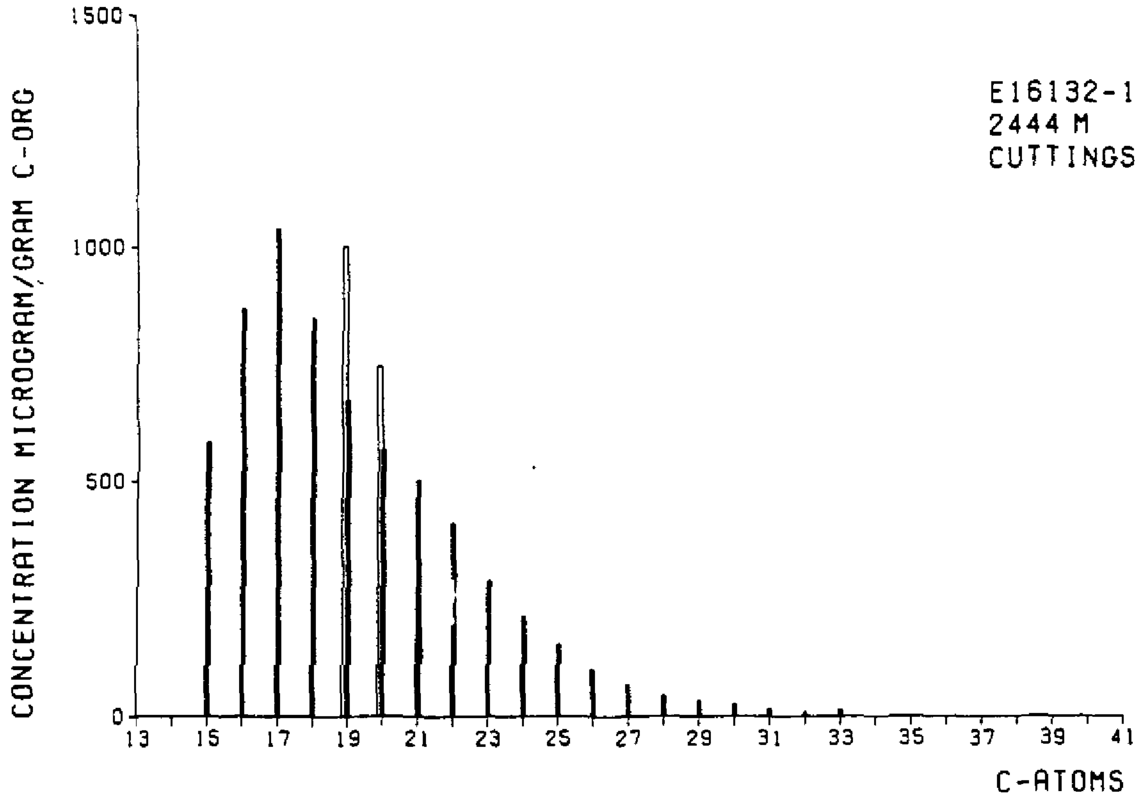

E16131-1
2370 M
CUTTINGS
CONCENTRATION MICROGRAM/GRAM C-ORG
C-ATOMS

Fig. 8r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CONCENTRATION MICROGRAM/GRAM C-ORG
E16132-1
2444 M
CUTTINGS
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27
29
31
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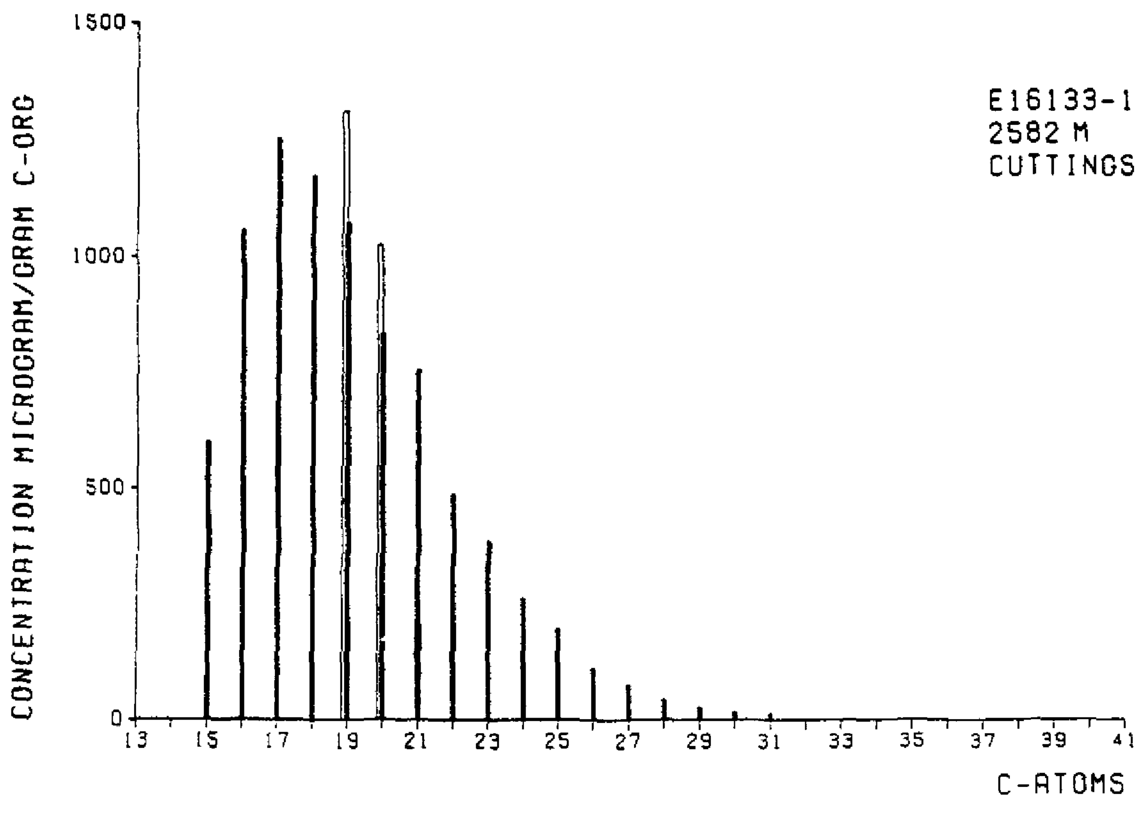
35
37
39
41
C-ATOMS

Fig. 8s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CONCENTRATION MICROGRAM/GRAM C-ORG
E16133-1
2582 M
CUTTINGS
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37
39
41
C-ATOMS

Fig. 8t

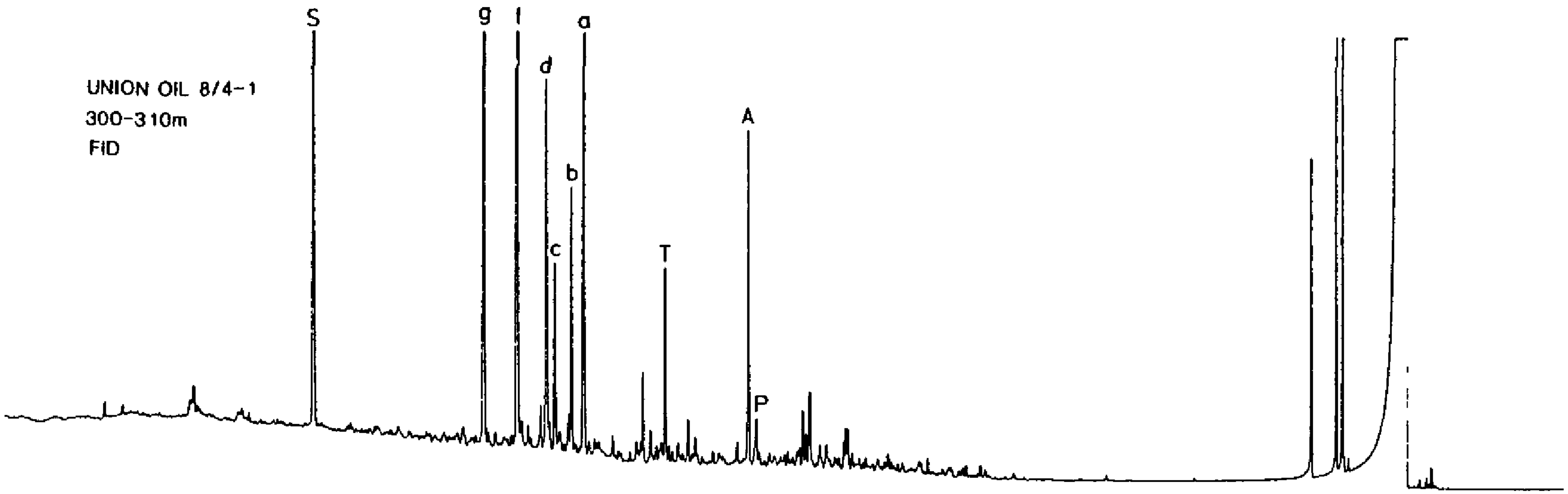


Fig. 9a

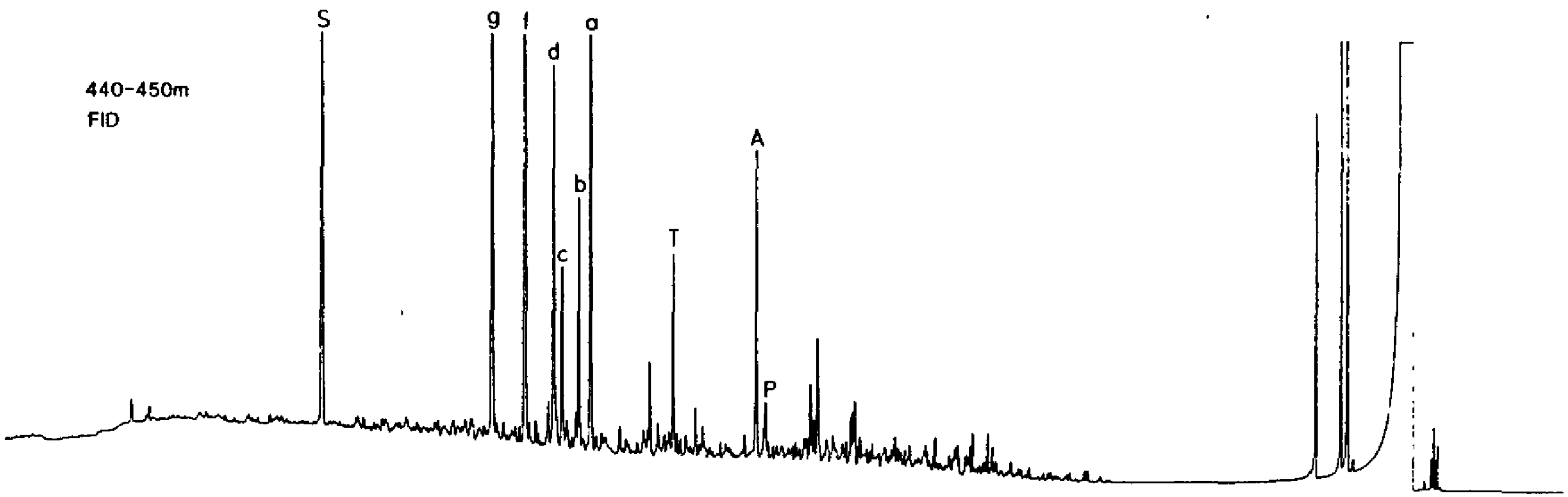


Fig. 9b

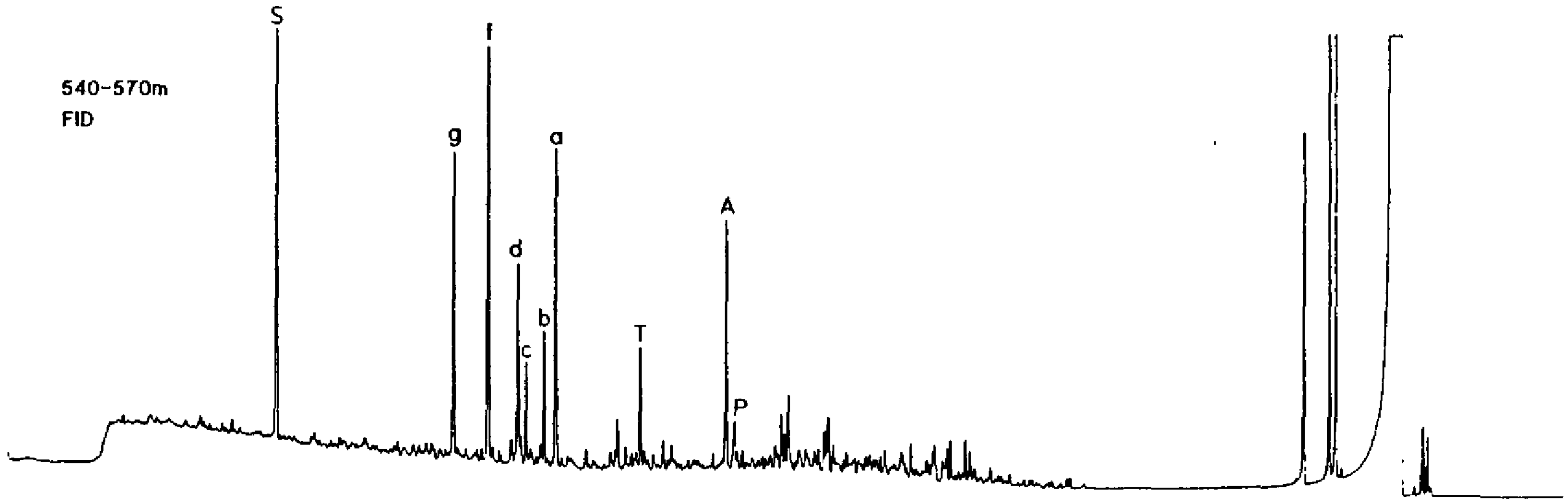


Fig. 9c

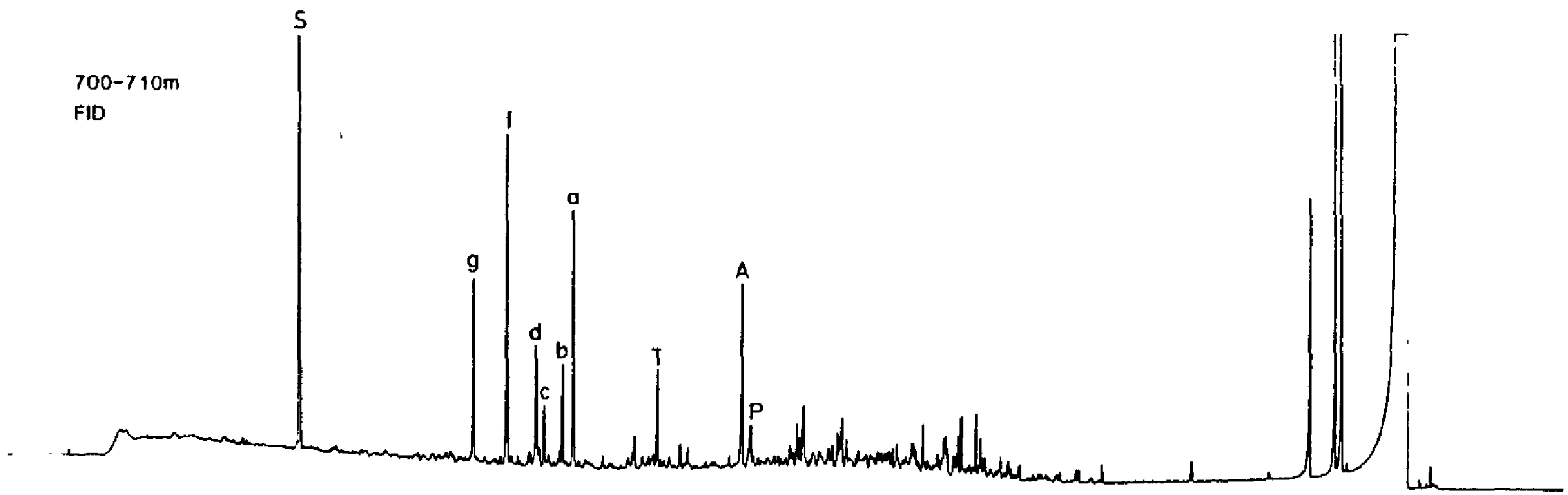


Fig. 9d

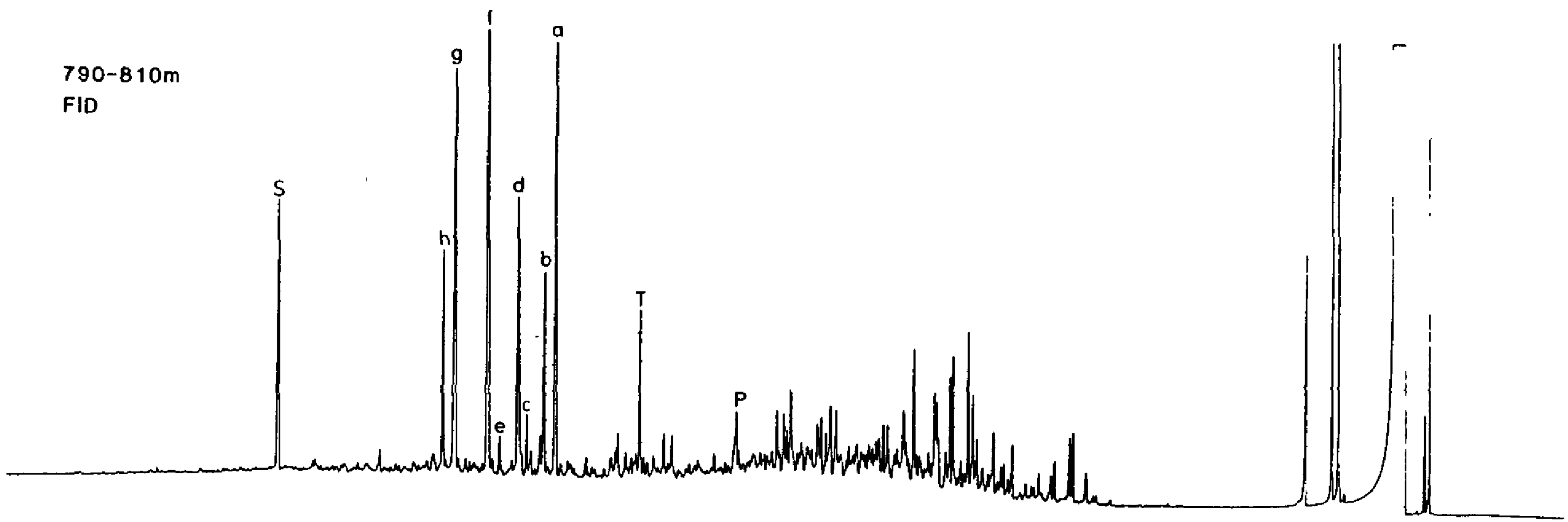


Fig. 9e

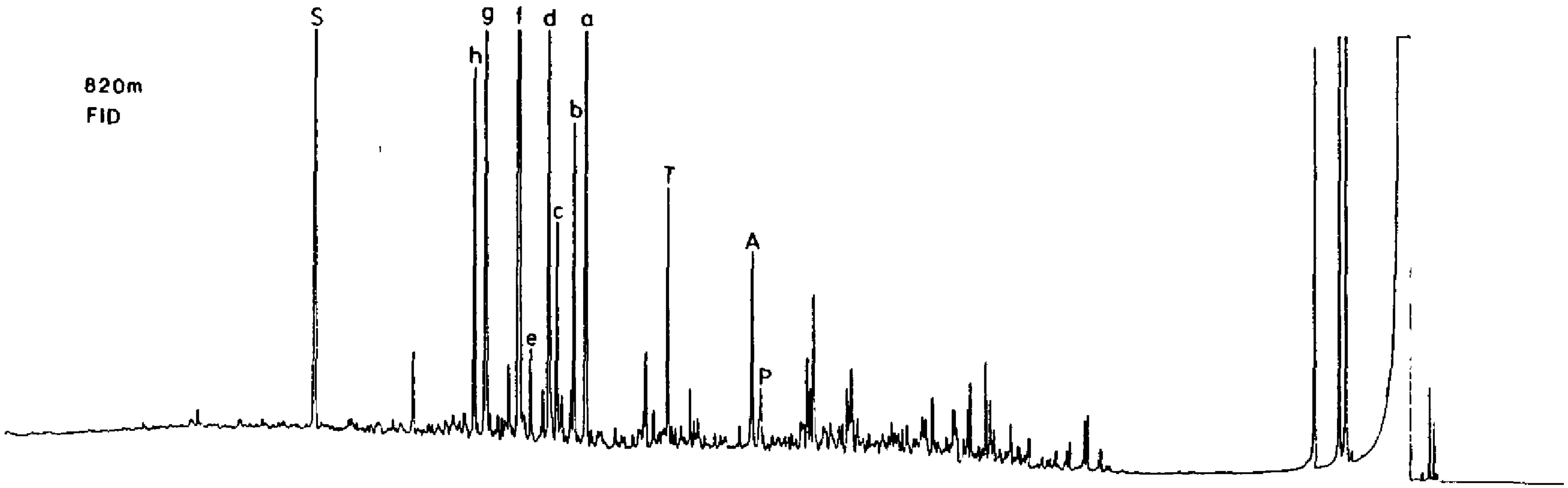


Fig. 9f

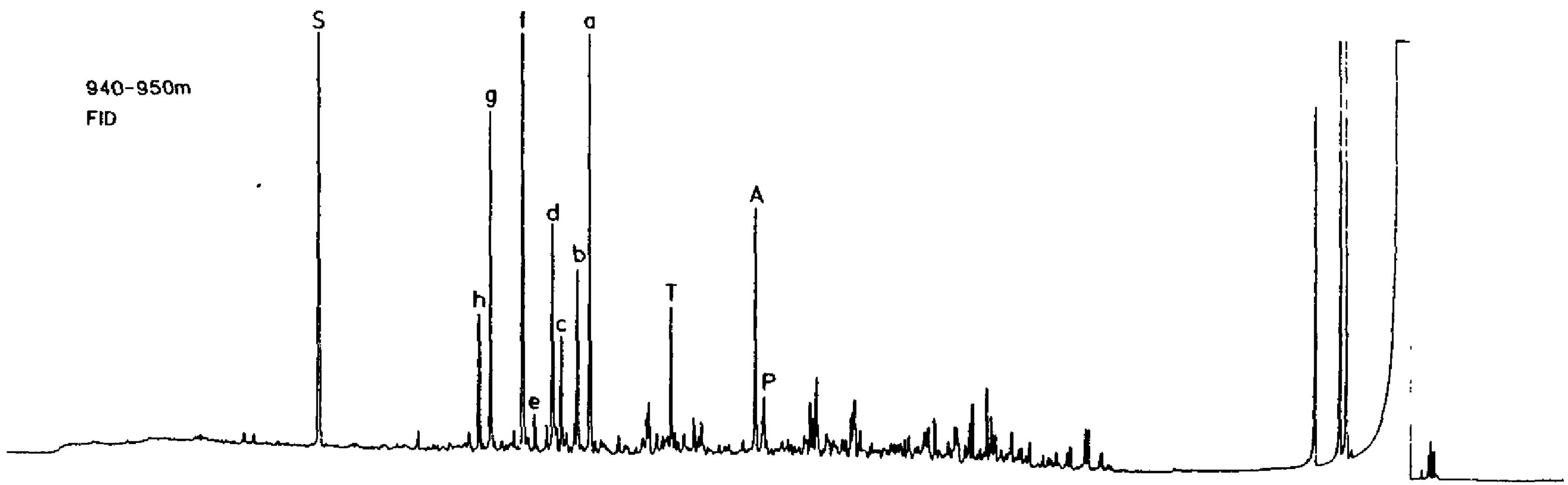


Fig. 9g

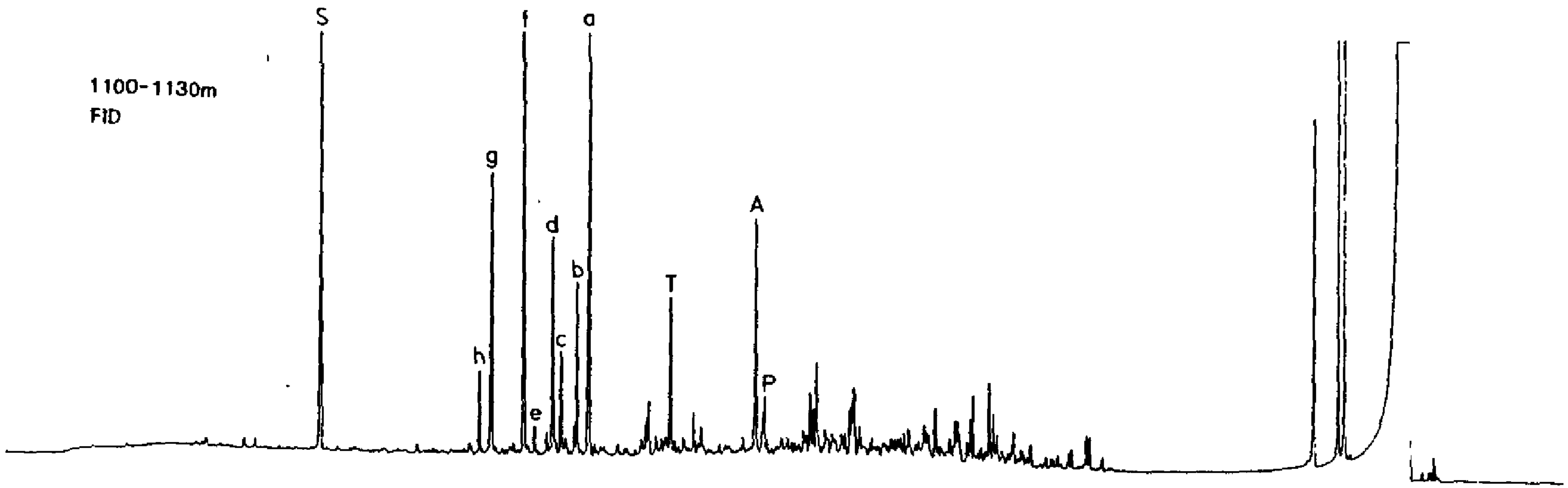


Fig. 9h

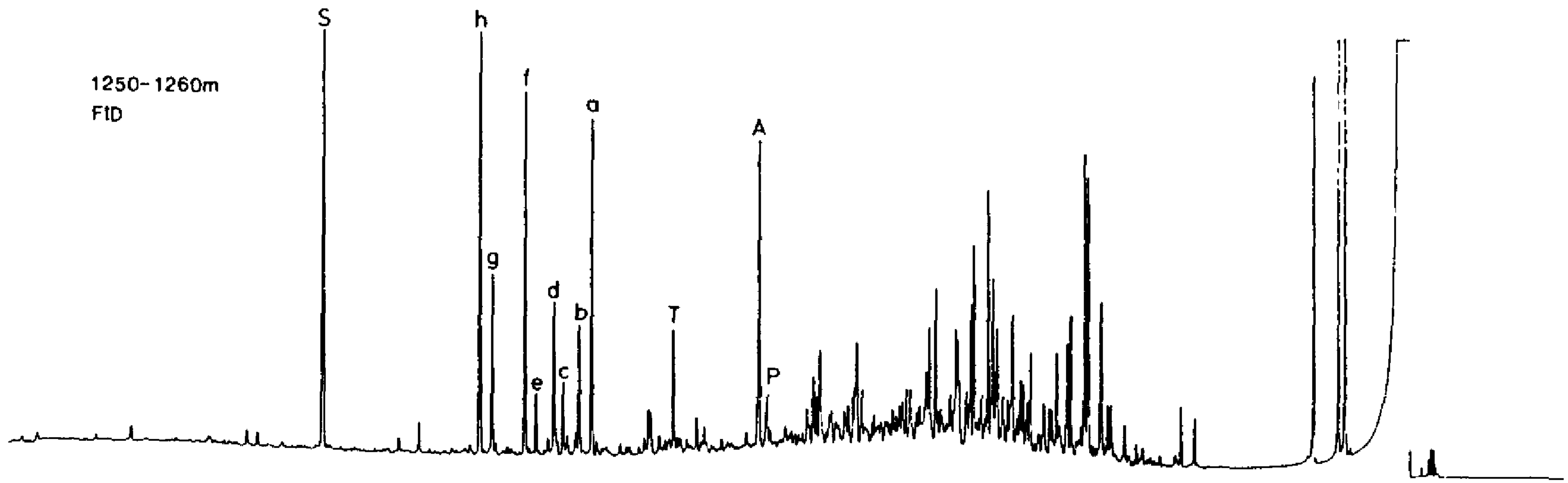


Fig. 9i

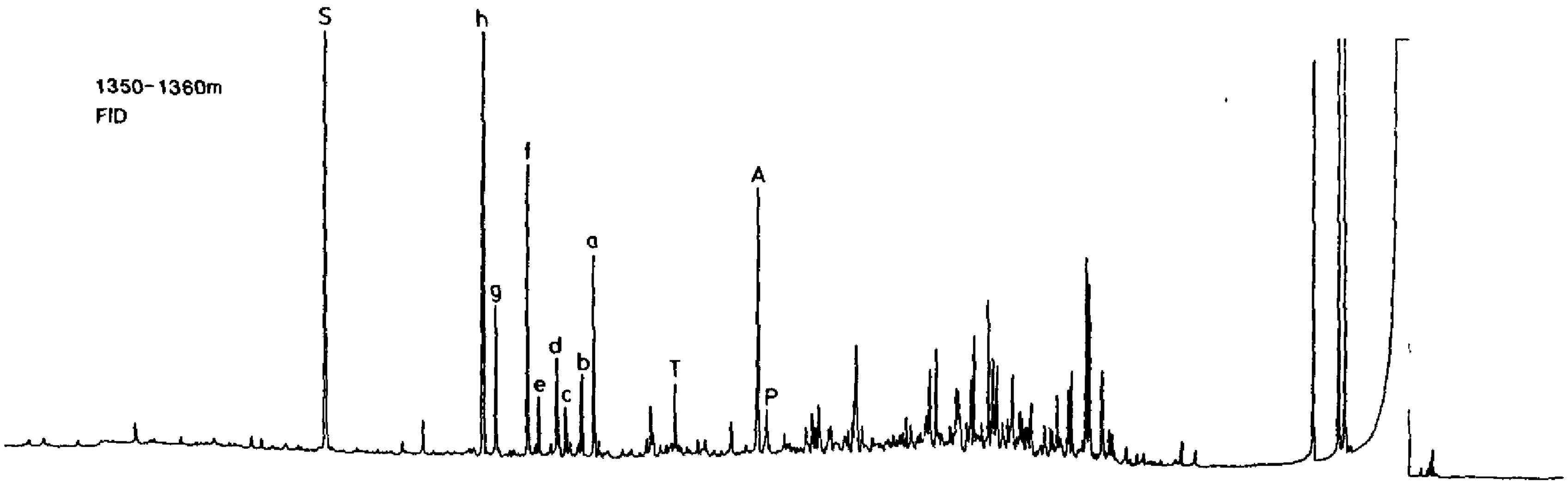


Fig. 9j

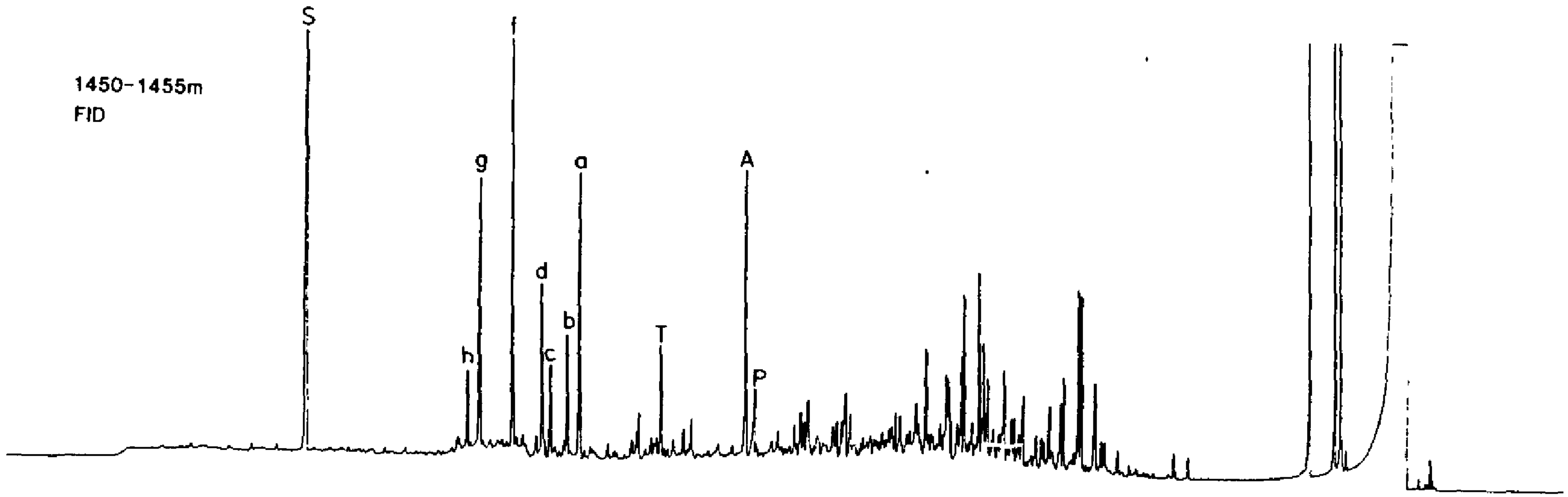


Fig. 9k

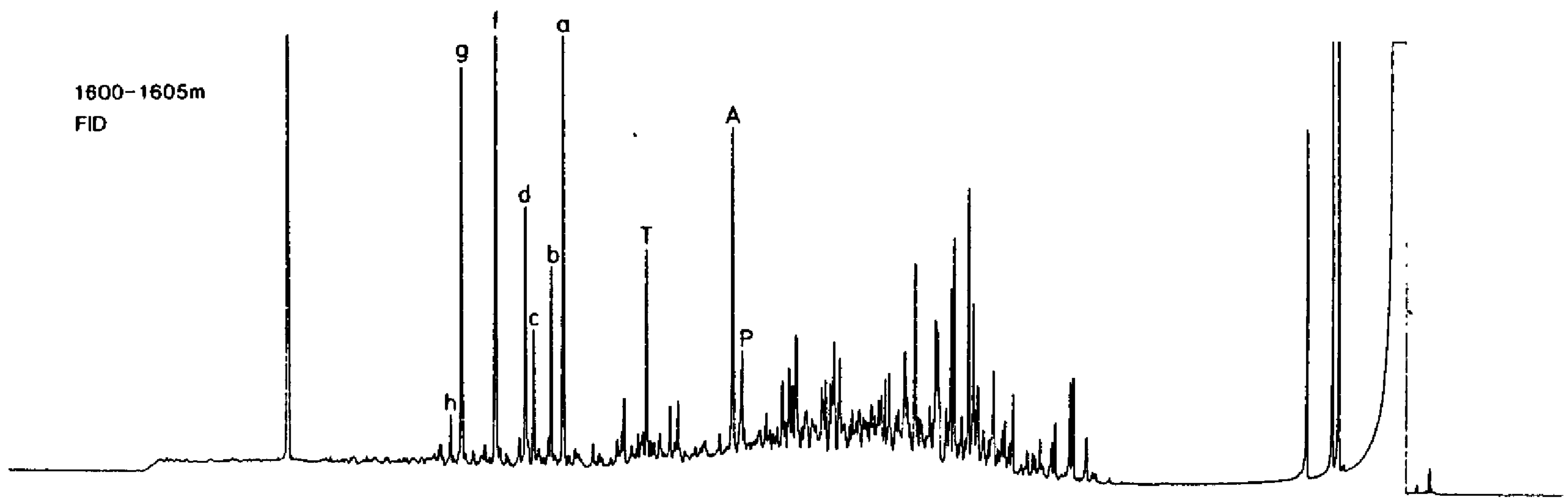


Fig. 91

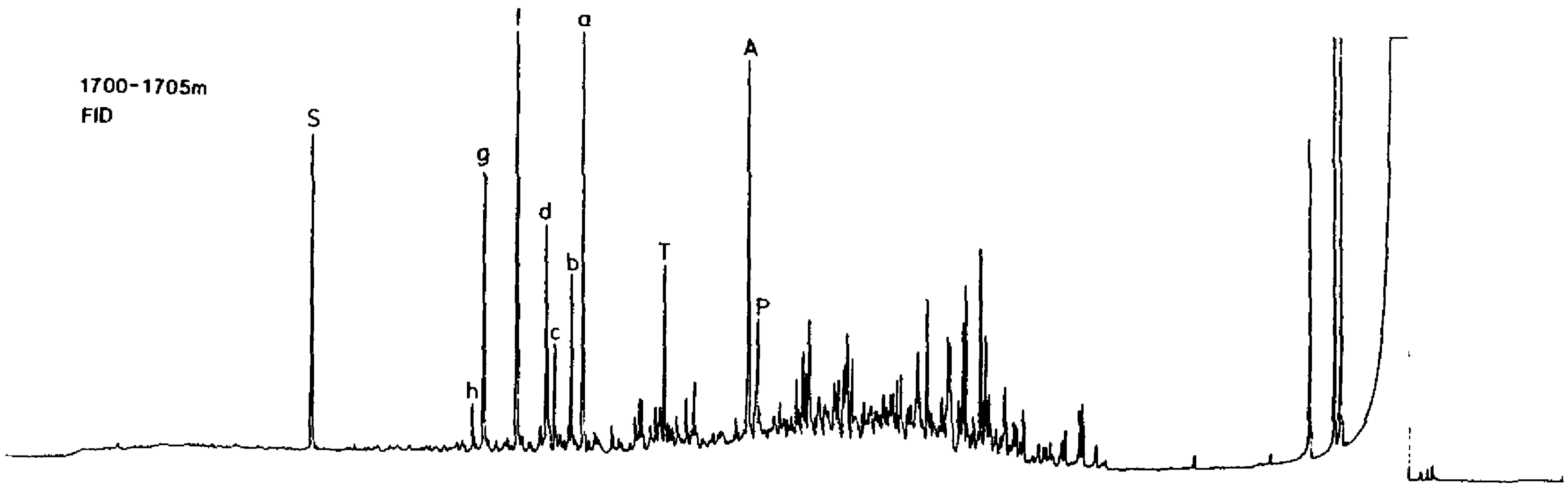


Fig. 9m

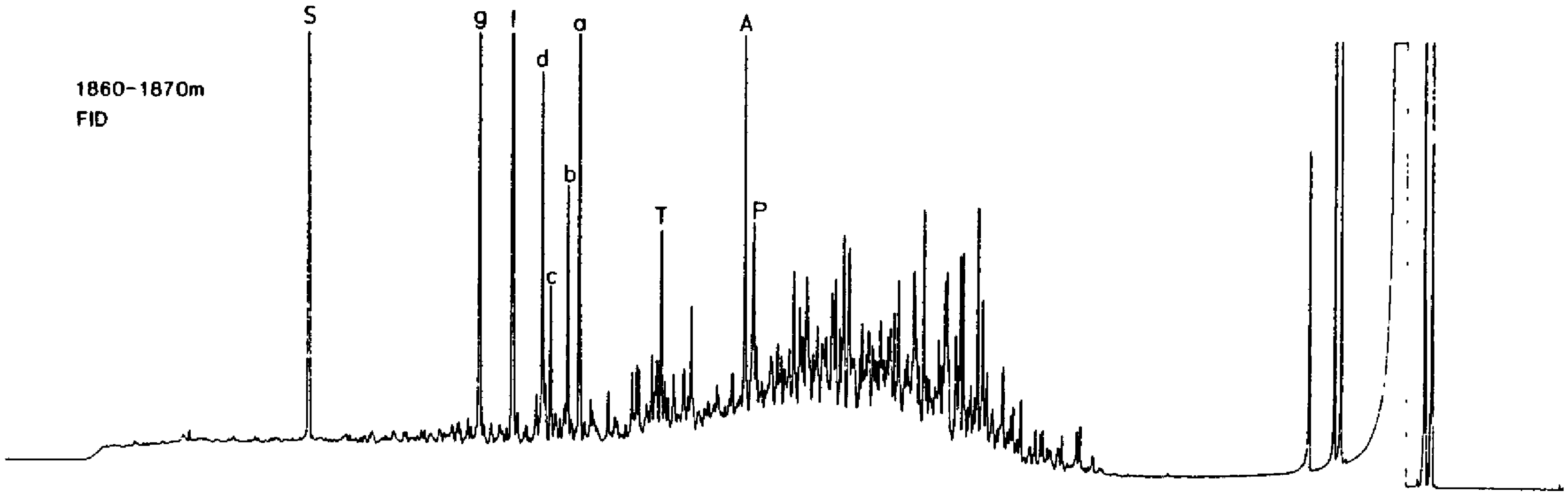


Fig. 9n

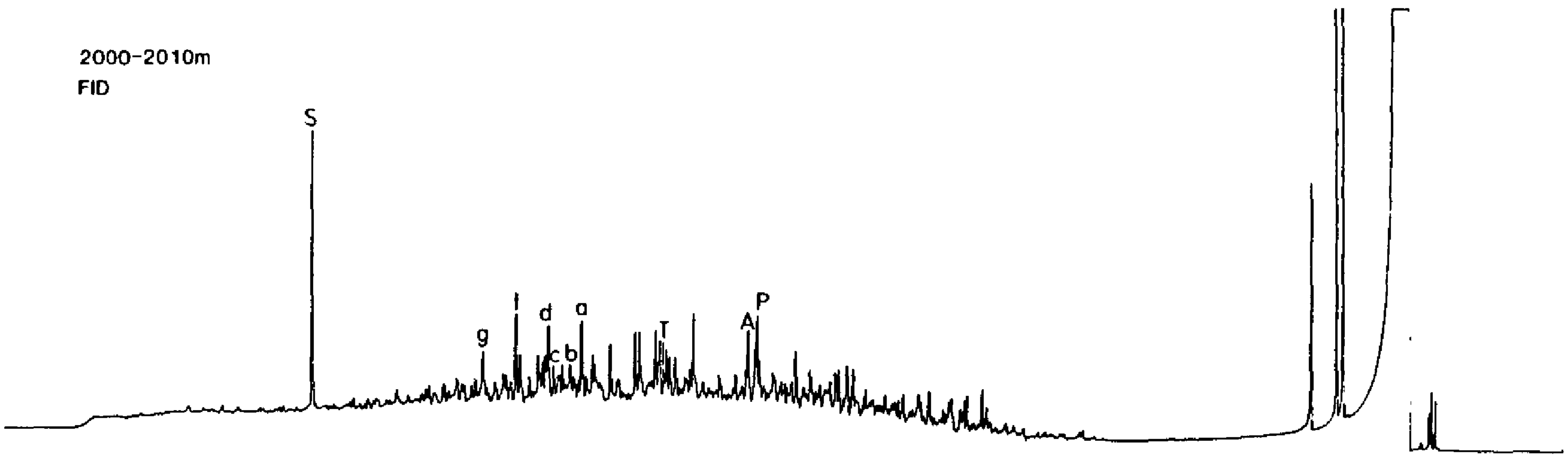


Fig. 9o

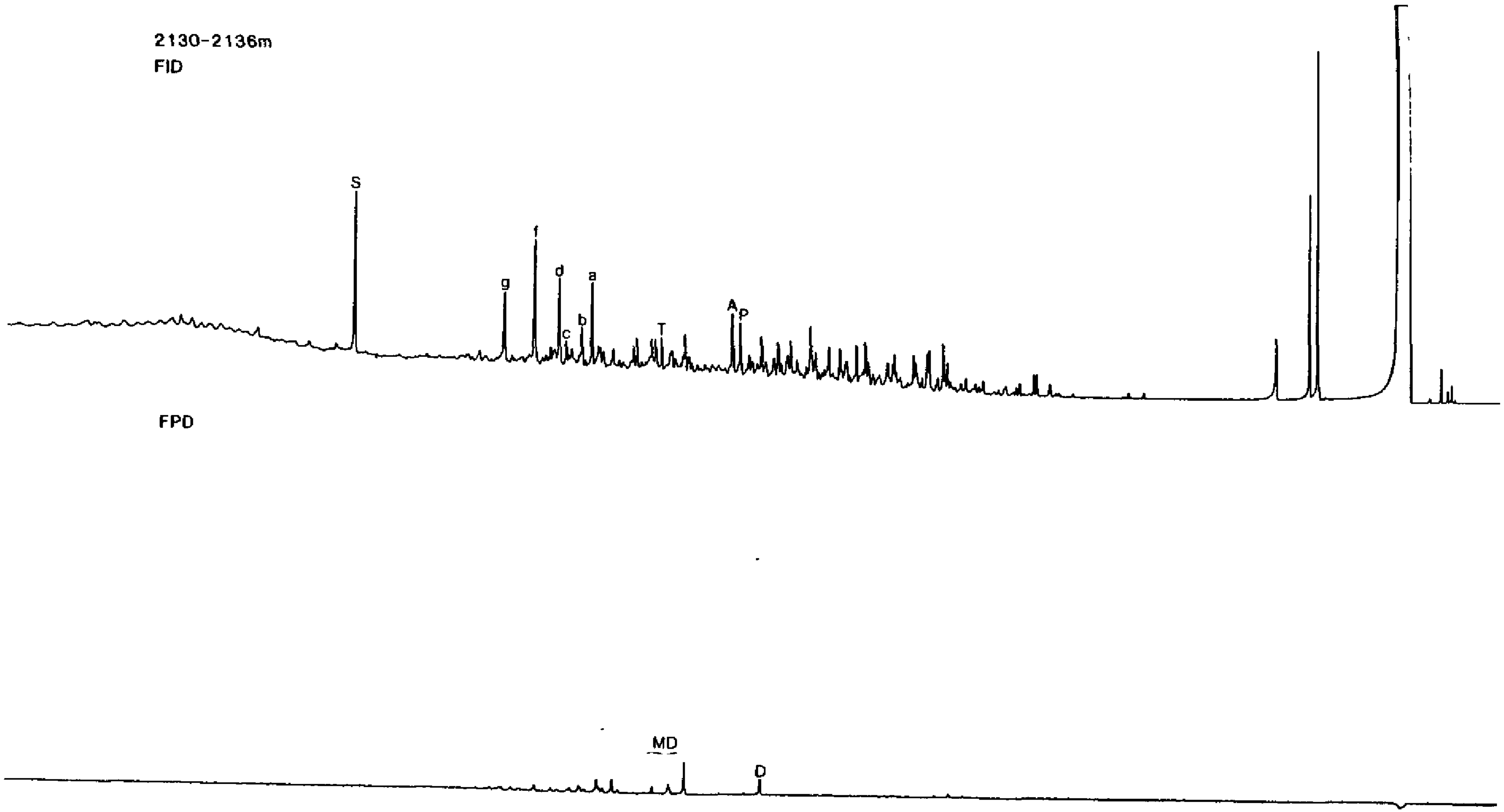


Fig. 9p

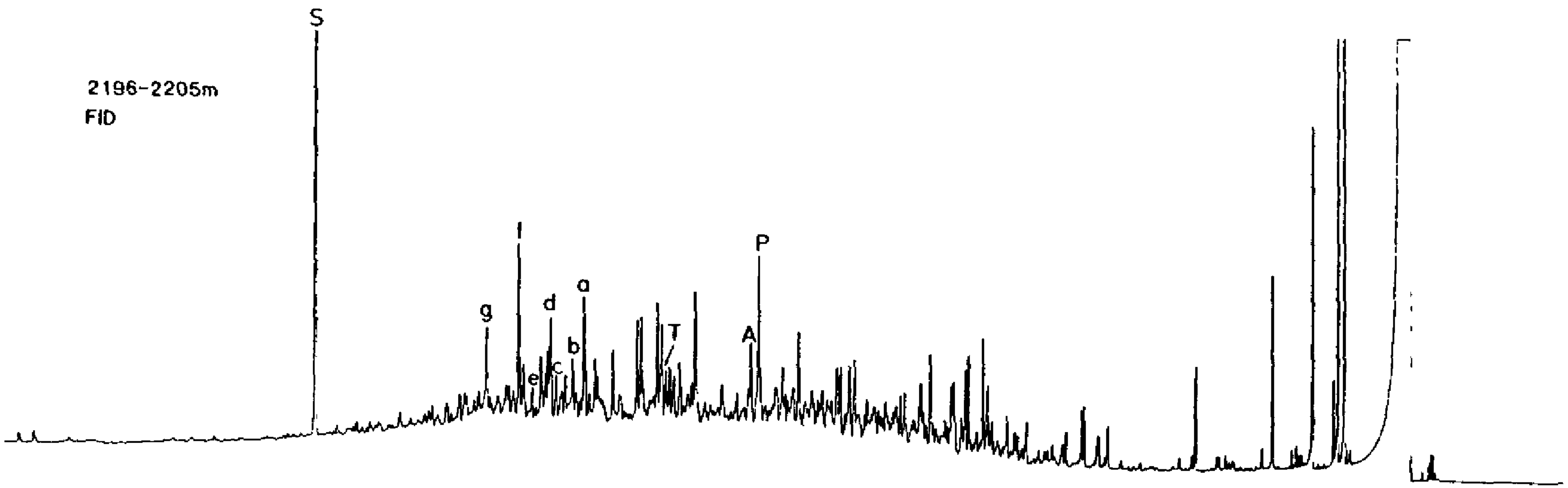


Fig. 9q

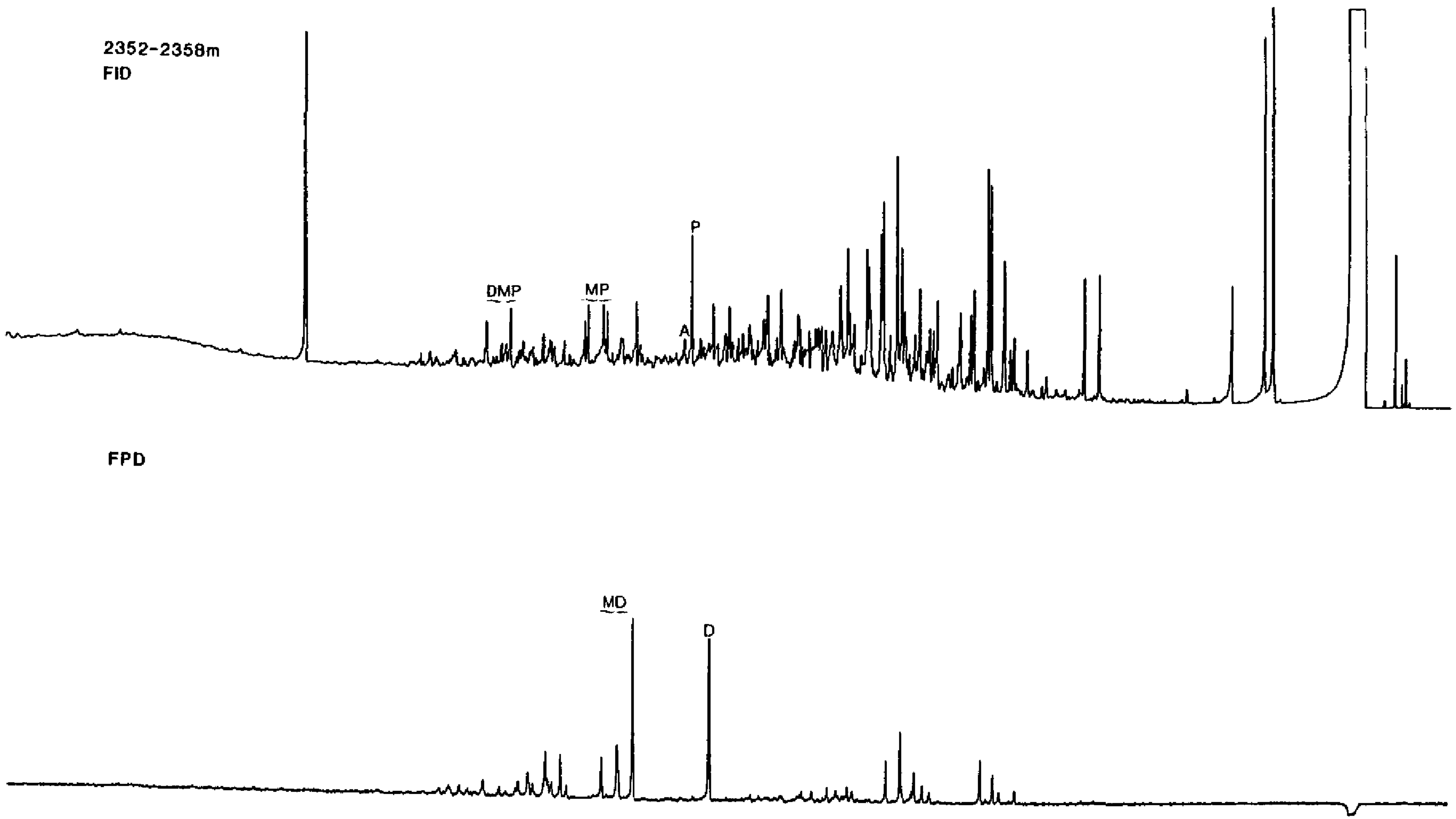


Fig. 9r

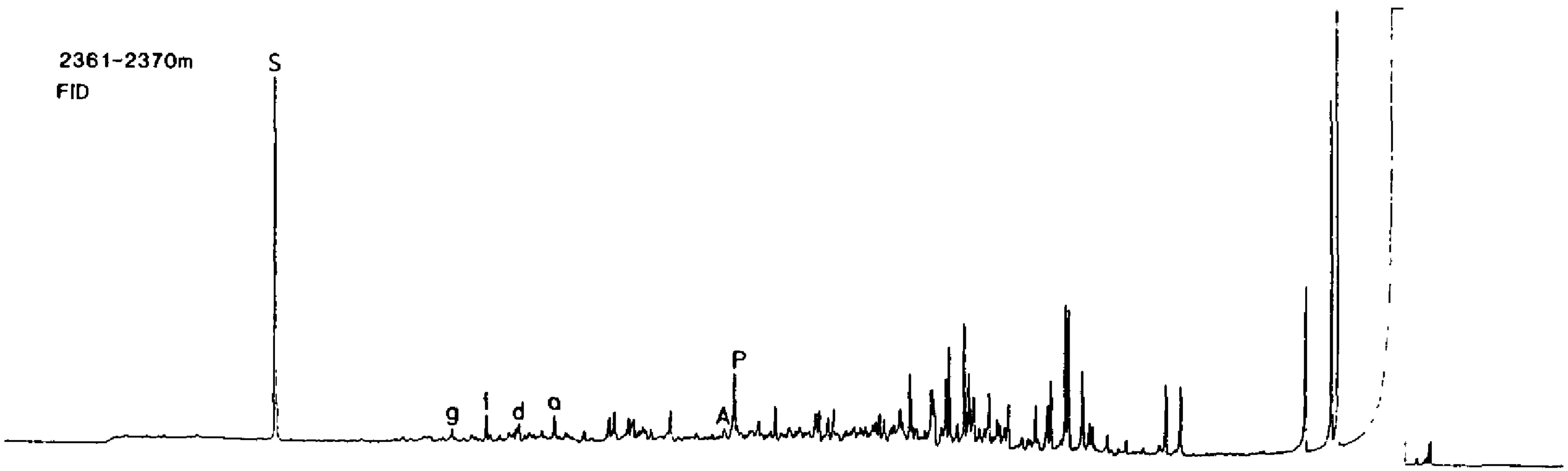


Fig. 9s

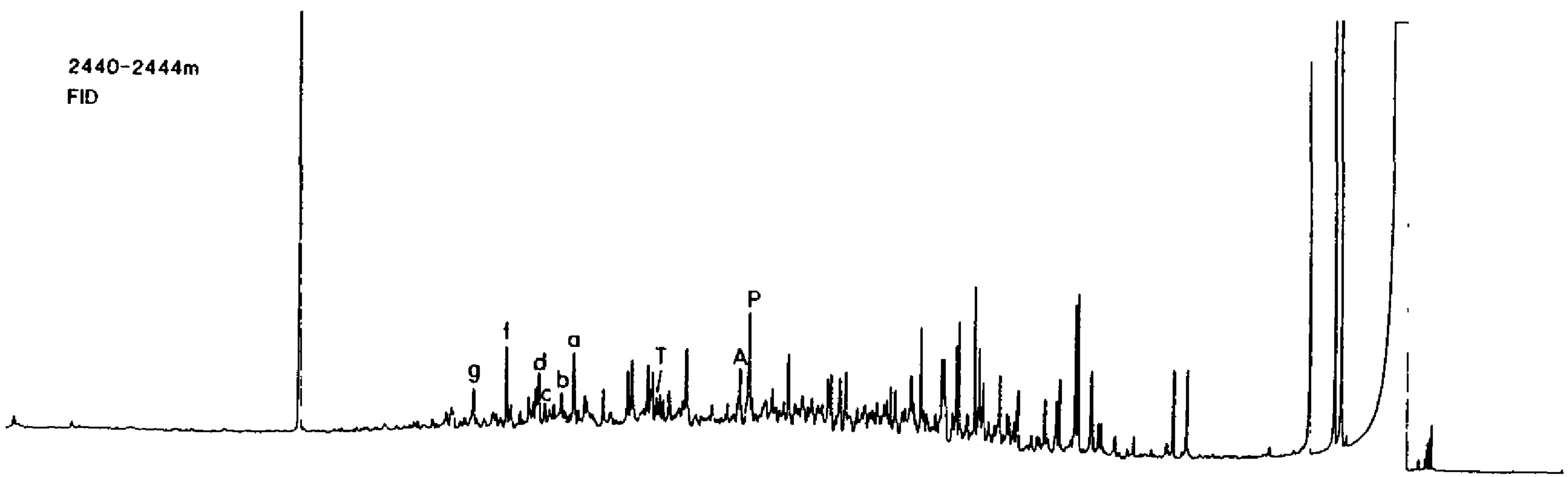


Fig. 9t

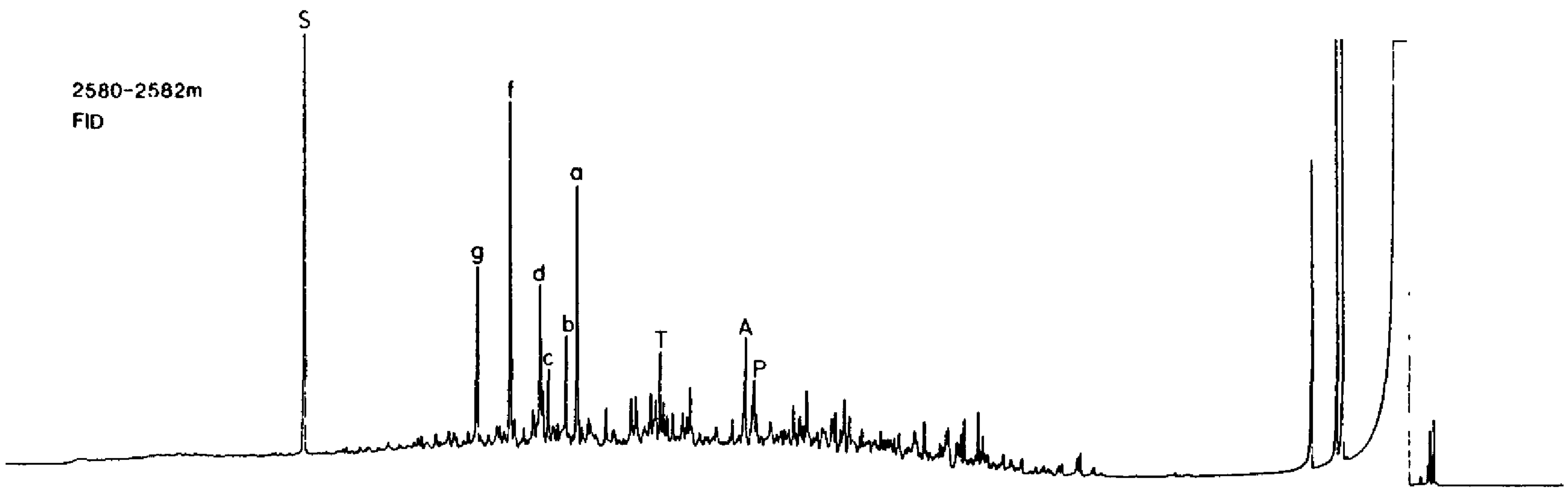


Fig. 9u

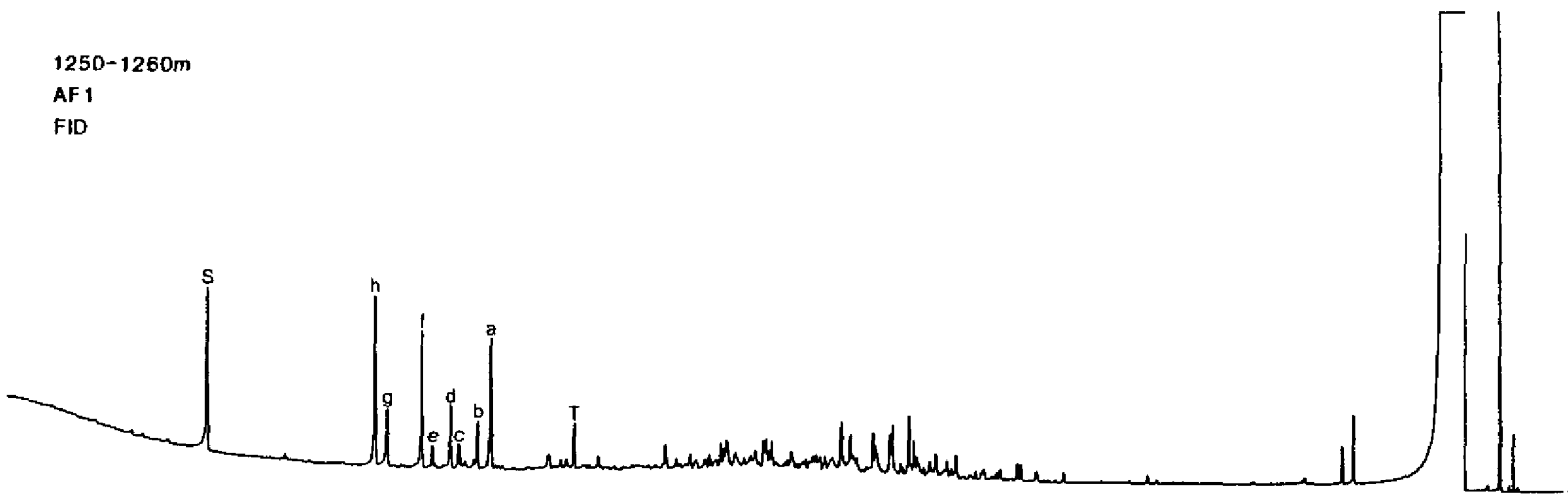


Fig. 10 a

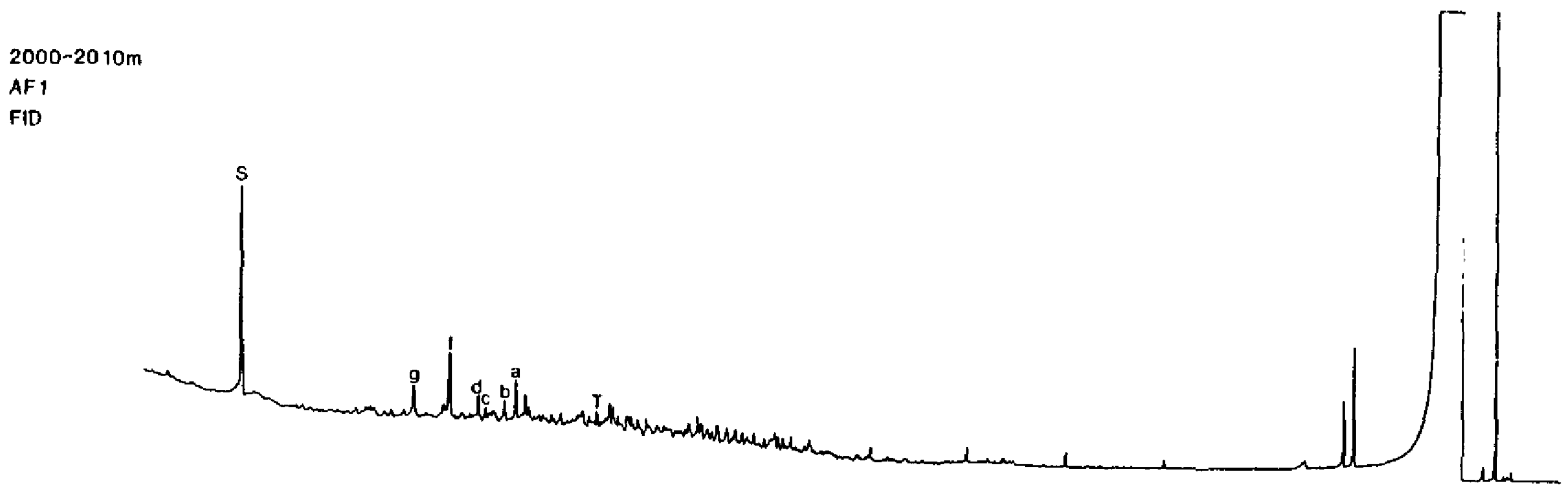


Fig. 10b

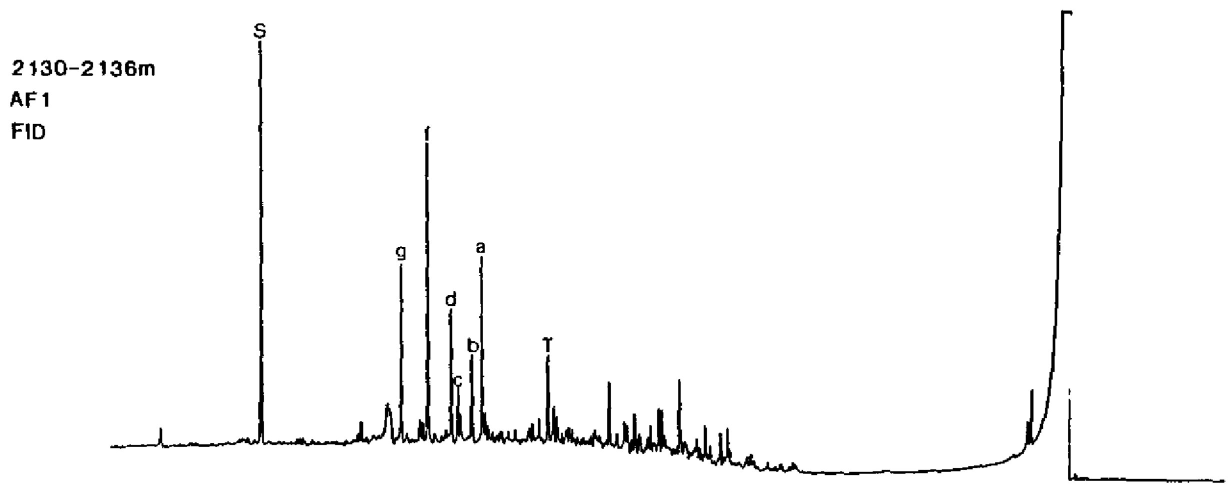


Fig. 10c

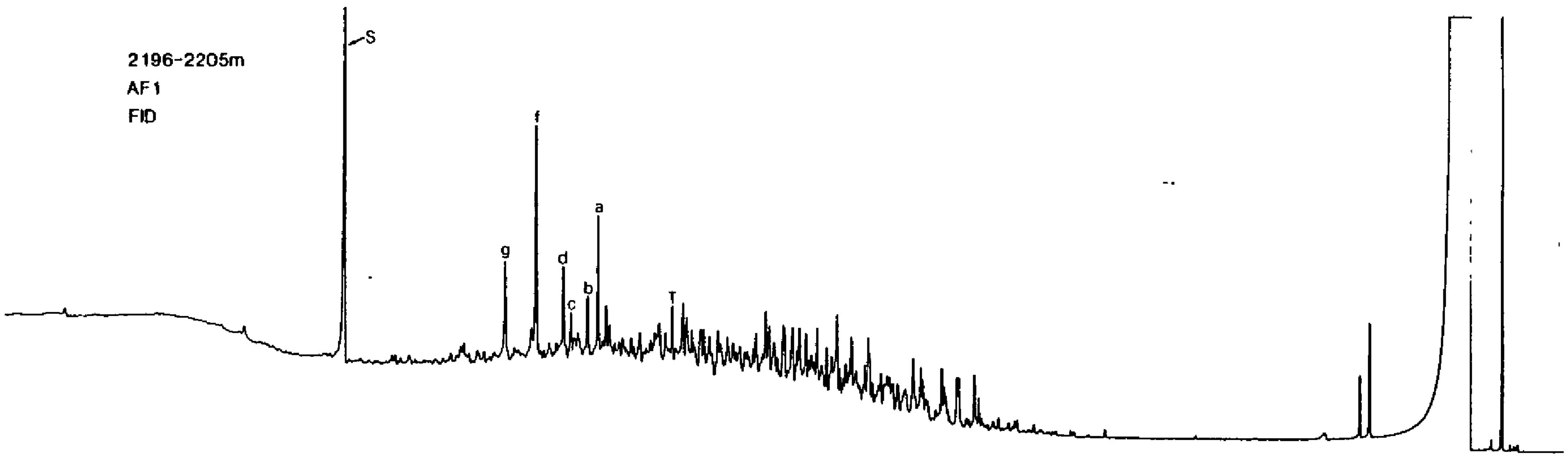


Fig. 10d

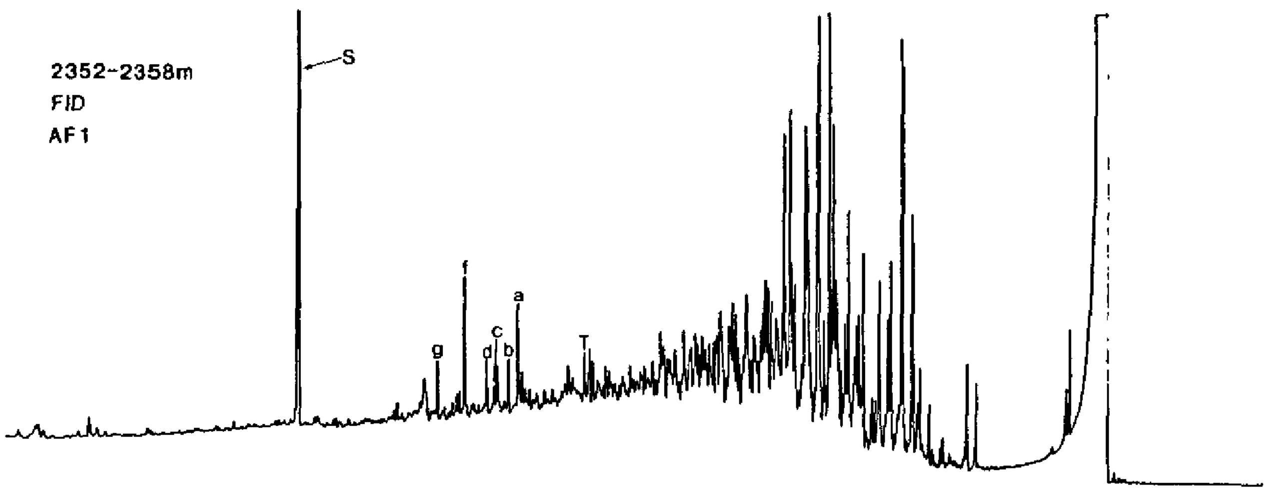


Fig. 10e

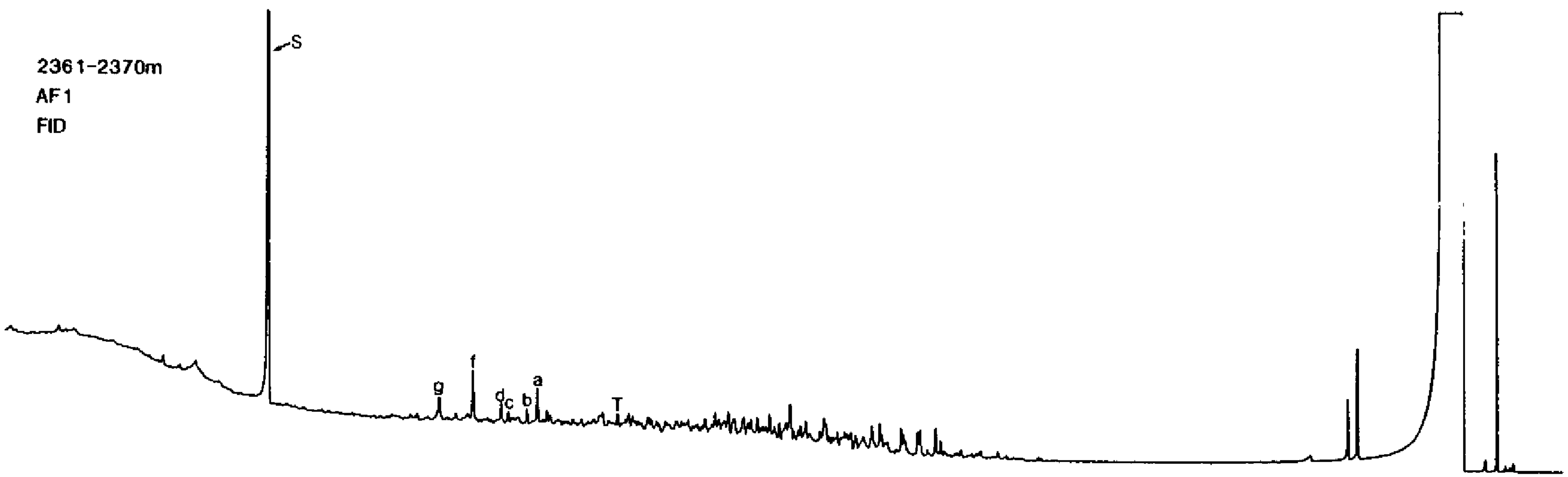


Fig. 10f

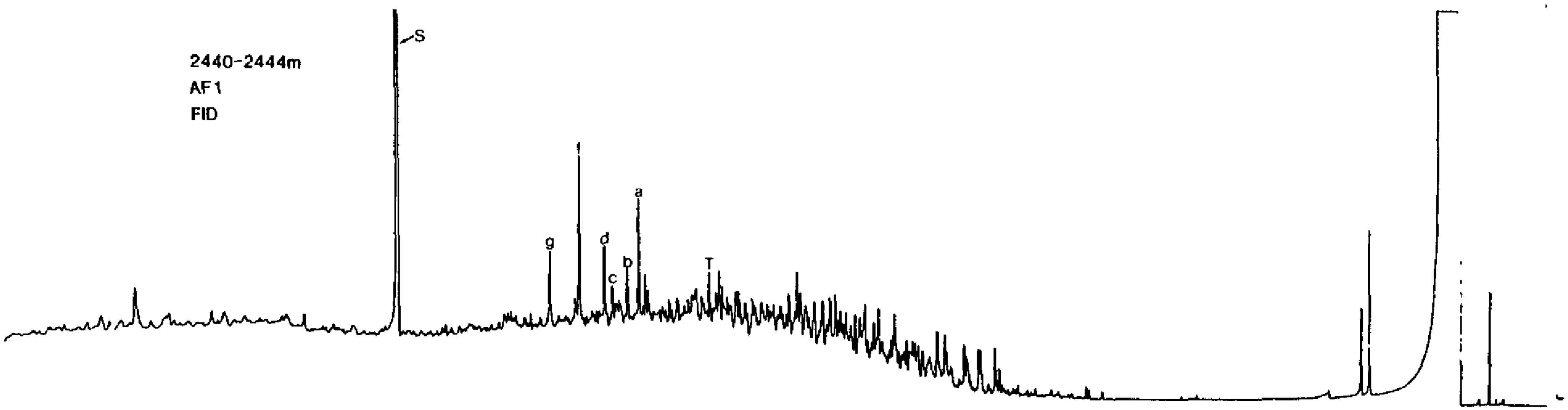


Fig. 10g

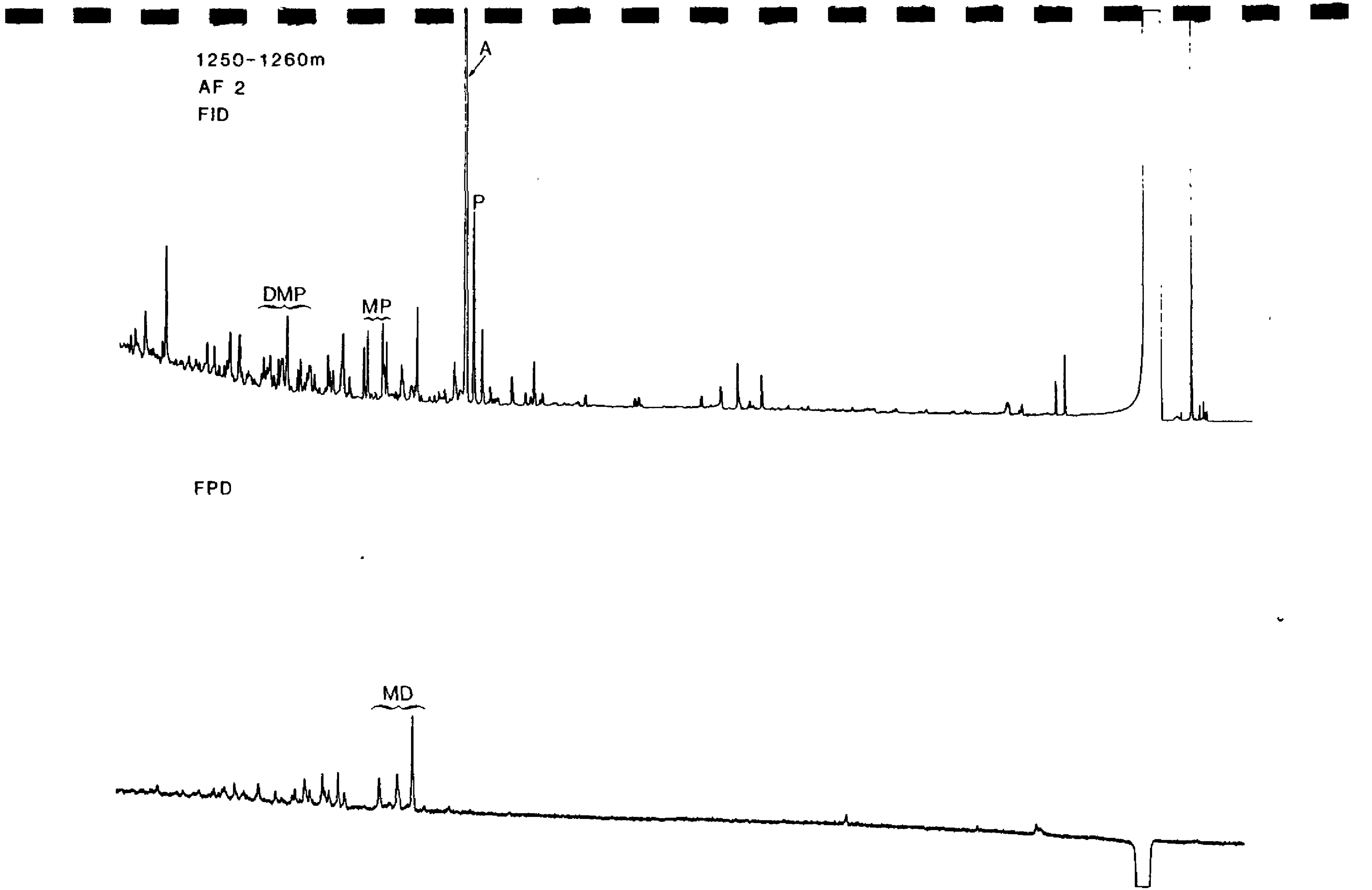


Fig. 11a

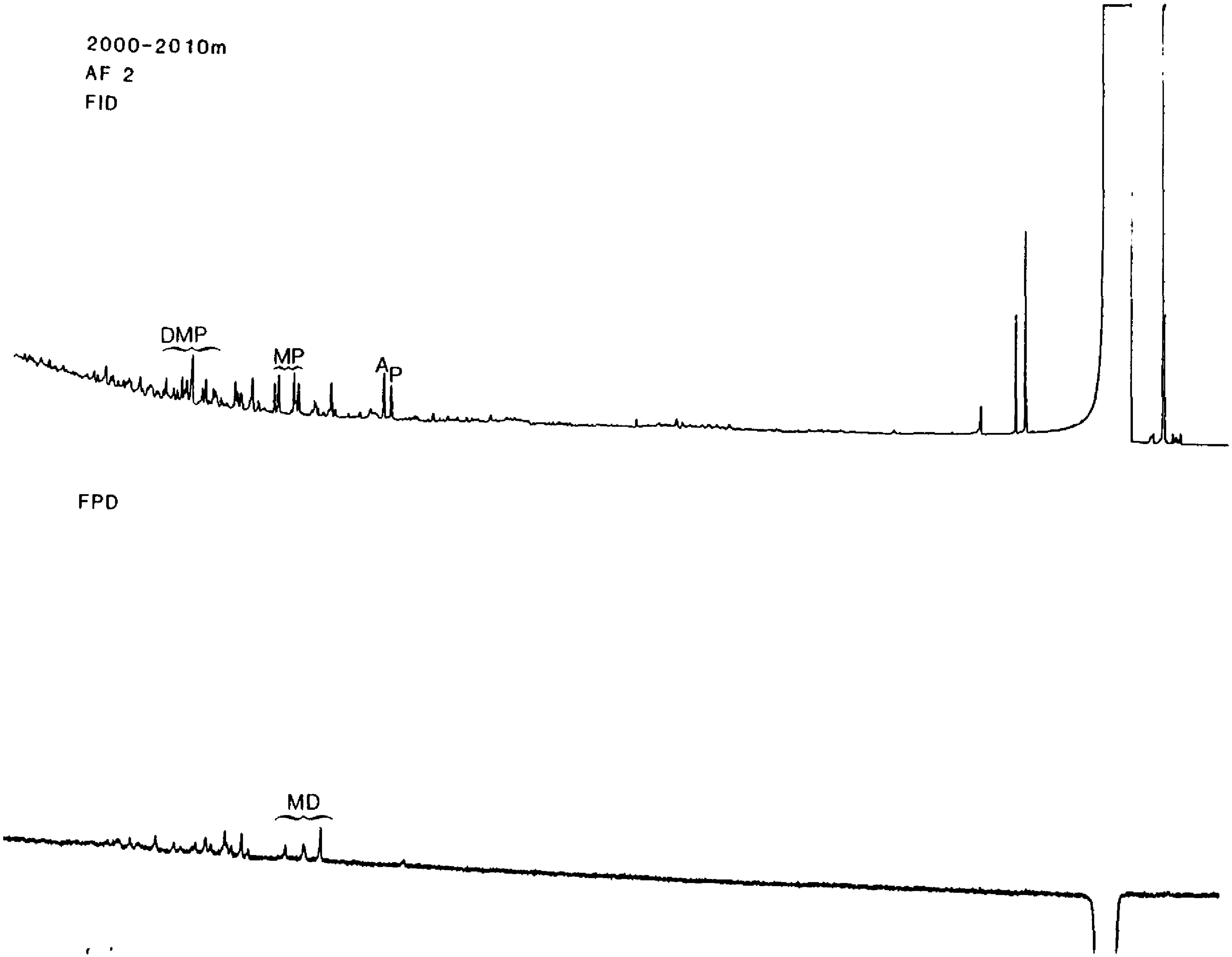


Fig. 11b

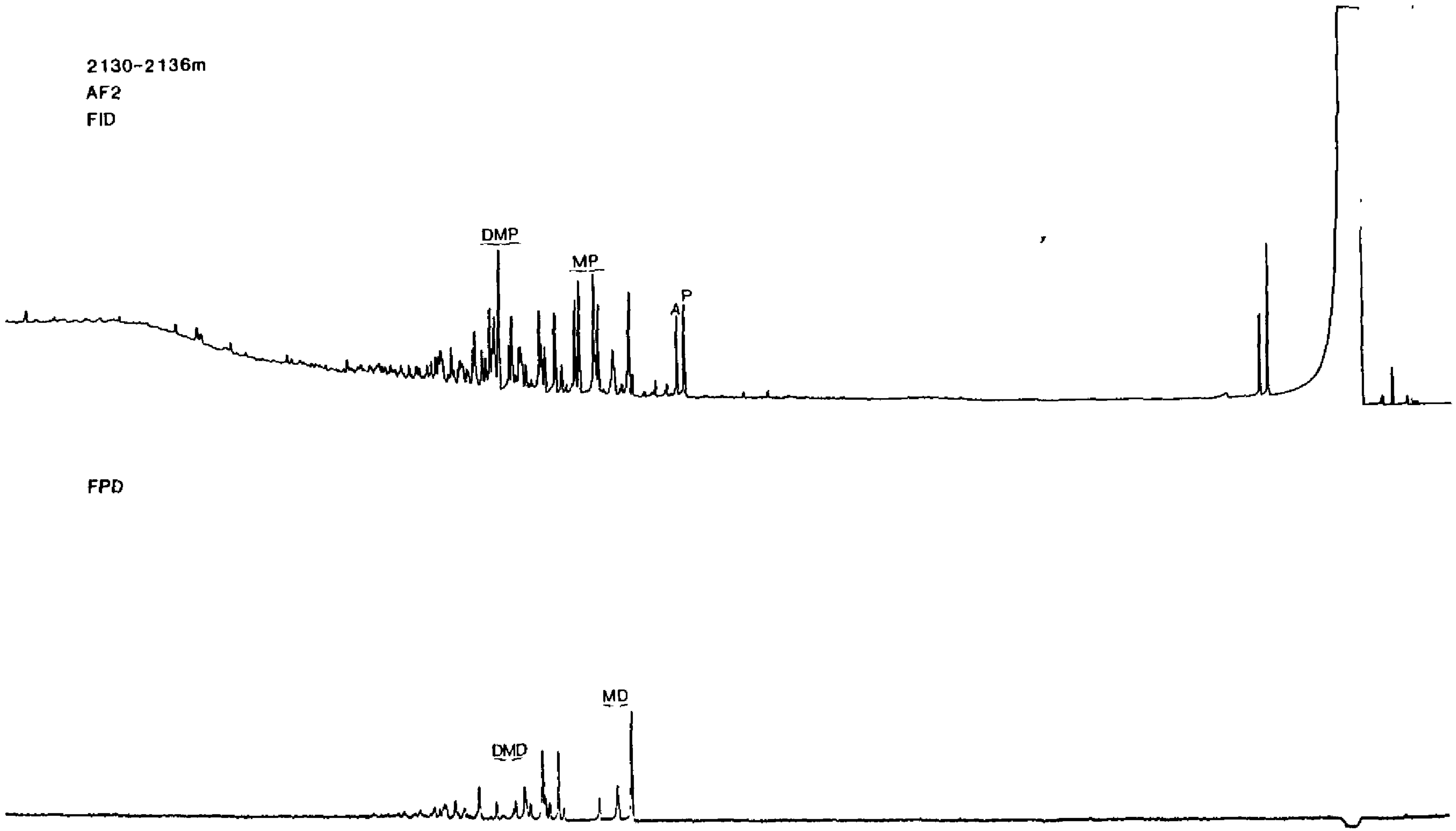


Fig. 11c

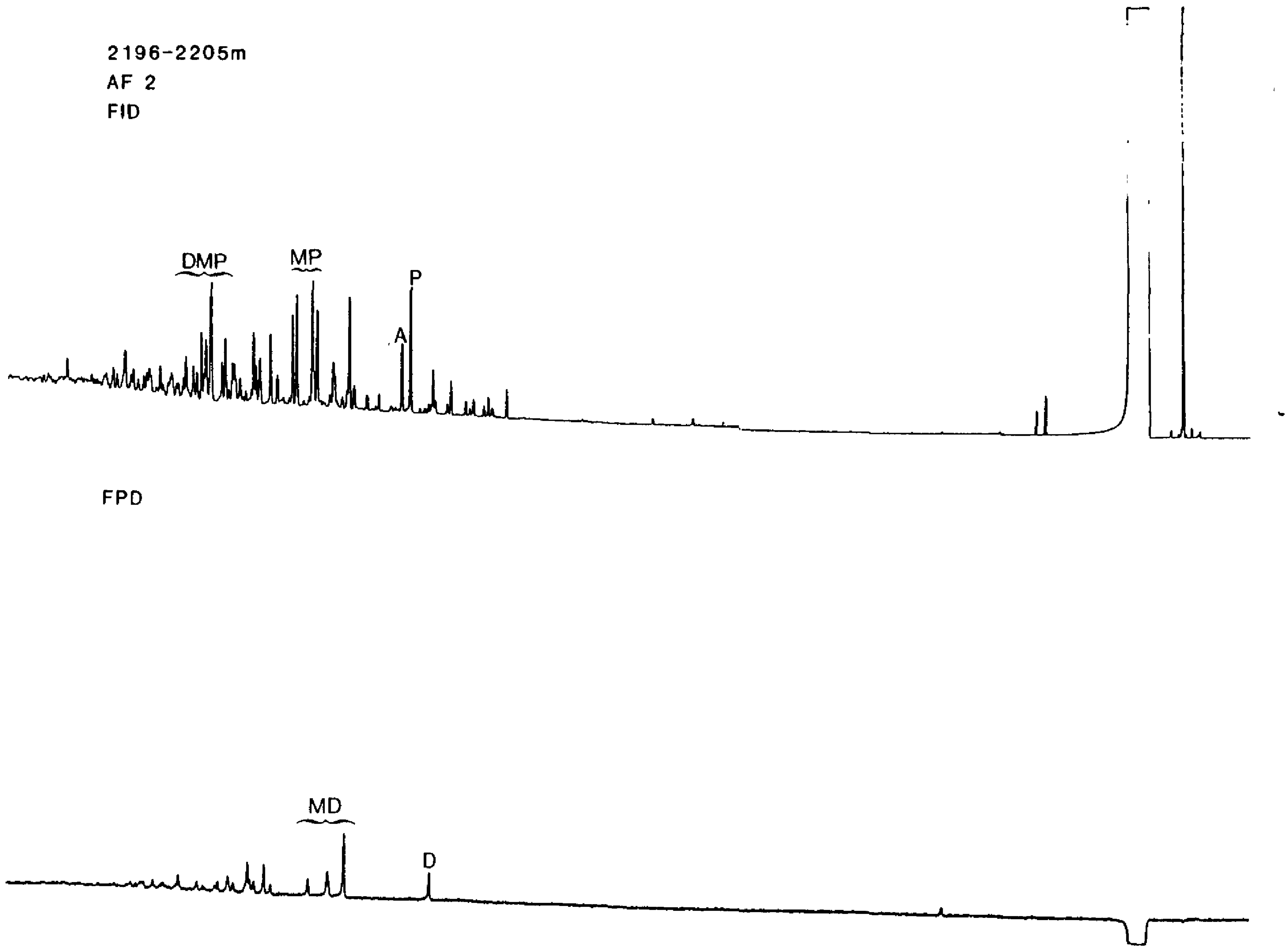


Fig. 11d

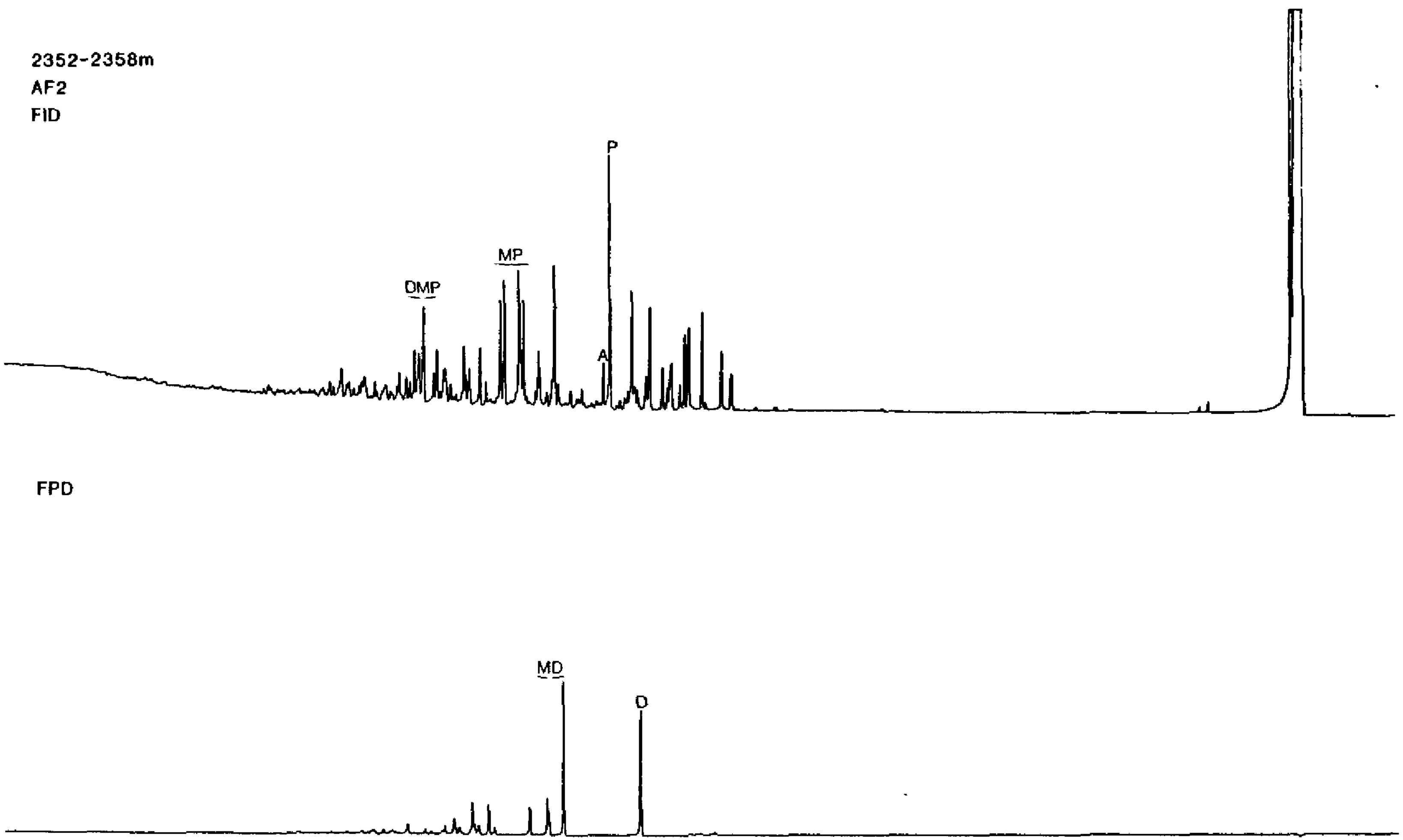


Fig. 11e

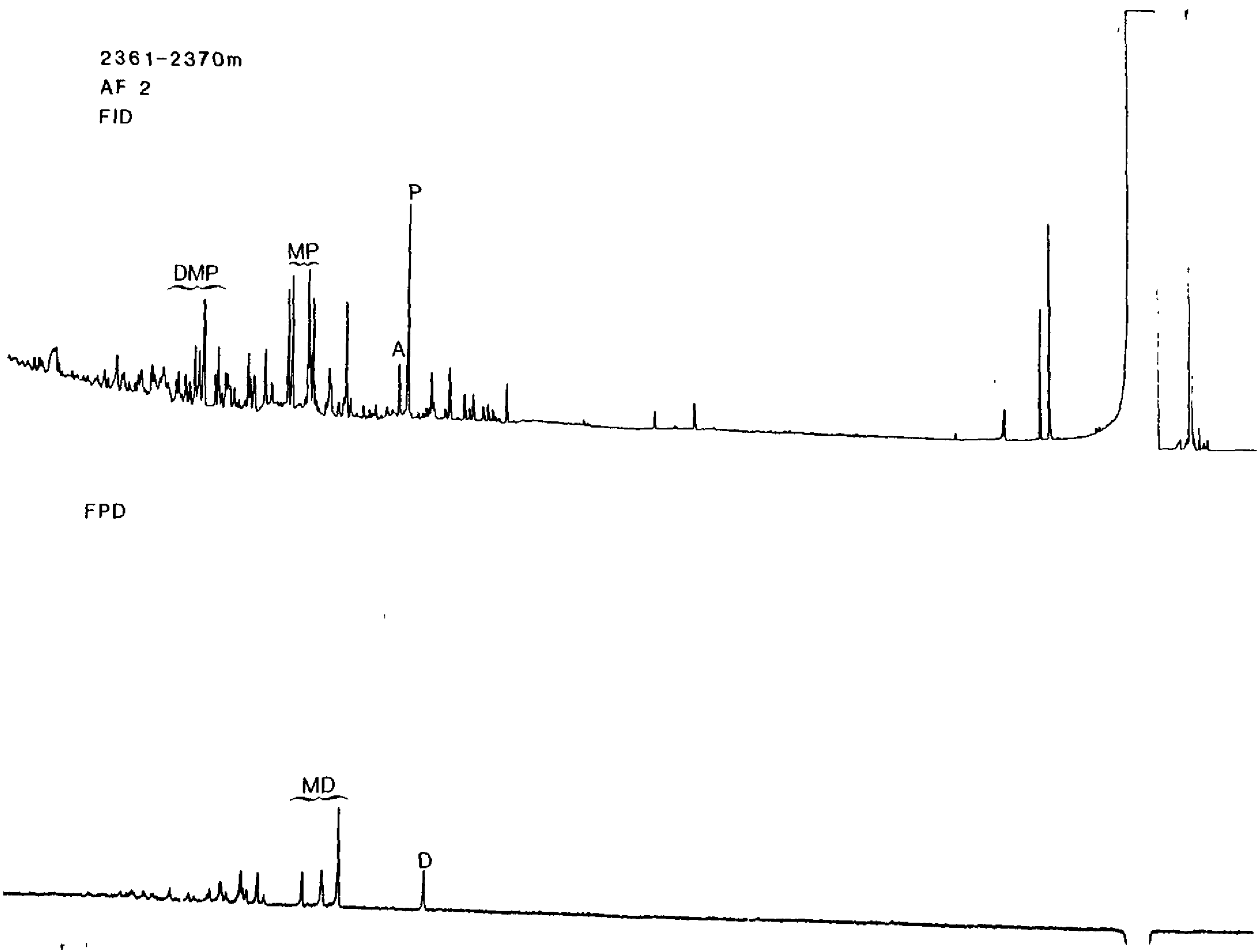


Fig. 11f

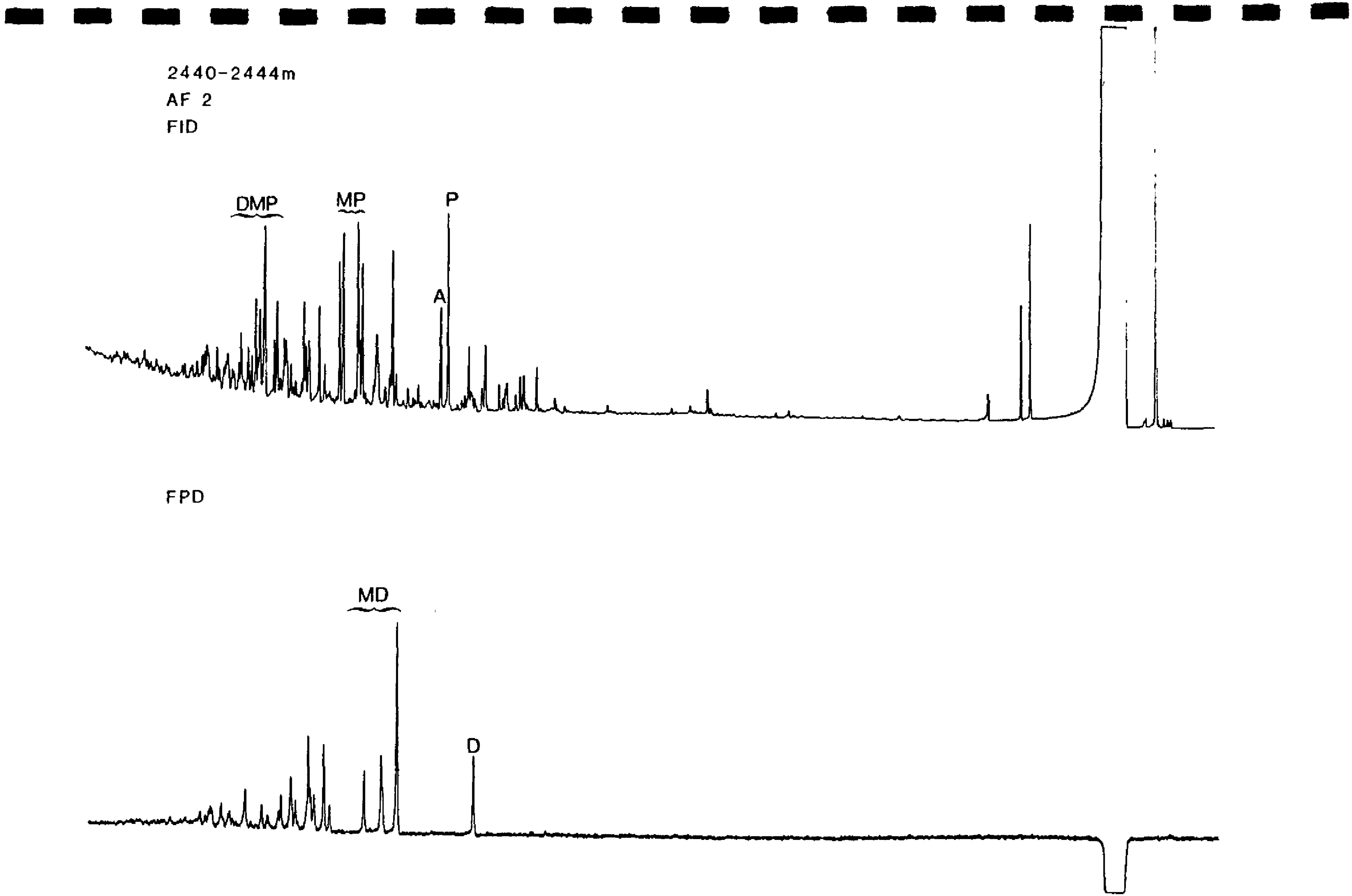


Fig. 11g

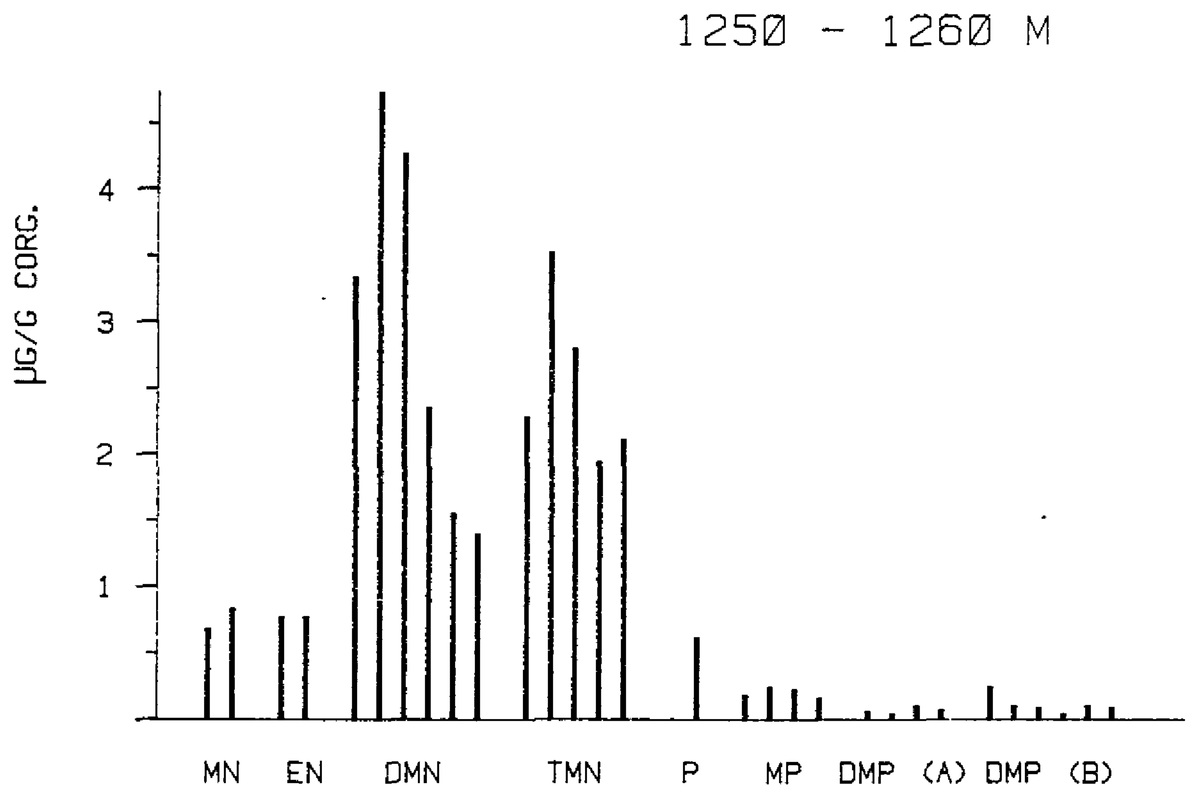


Fig. 12a

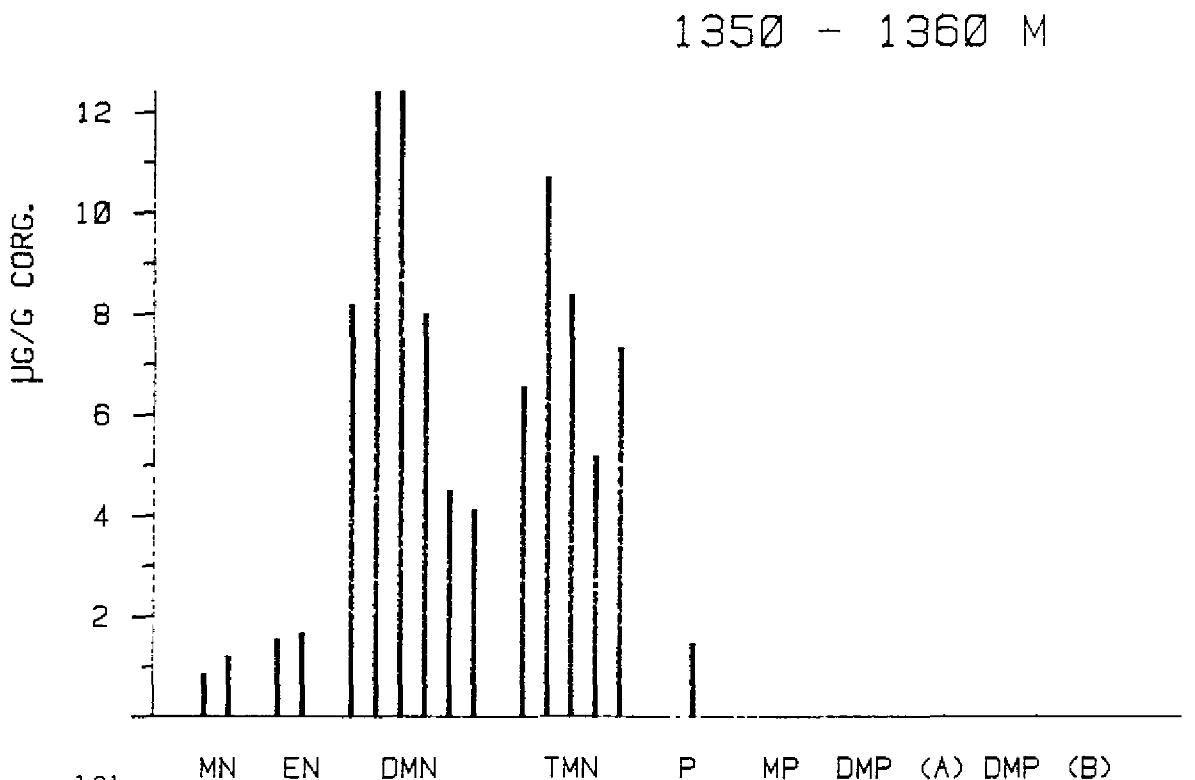


Fig. 12b

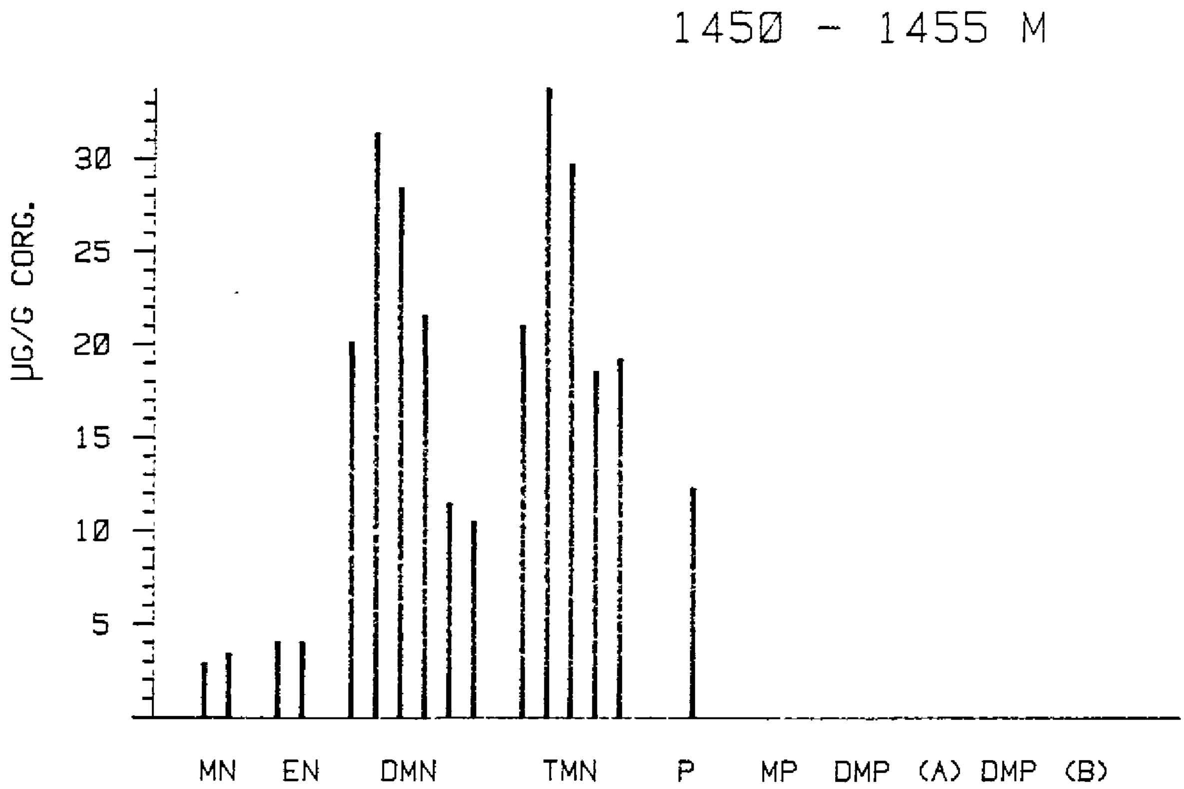


Fig. 12c

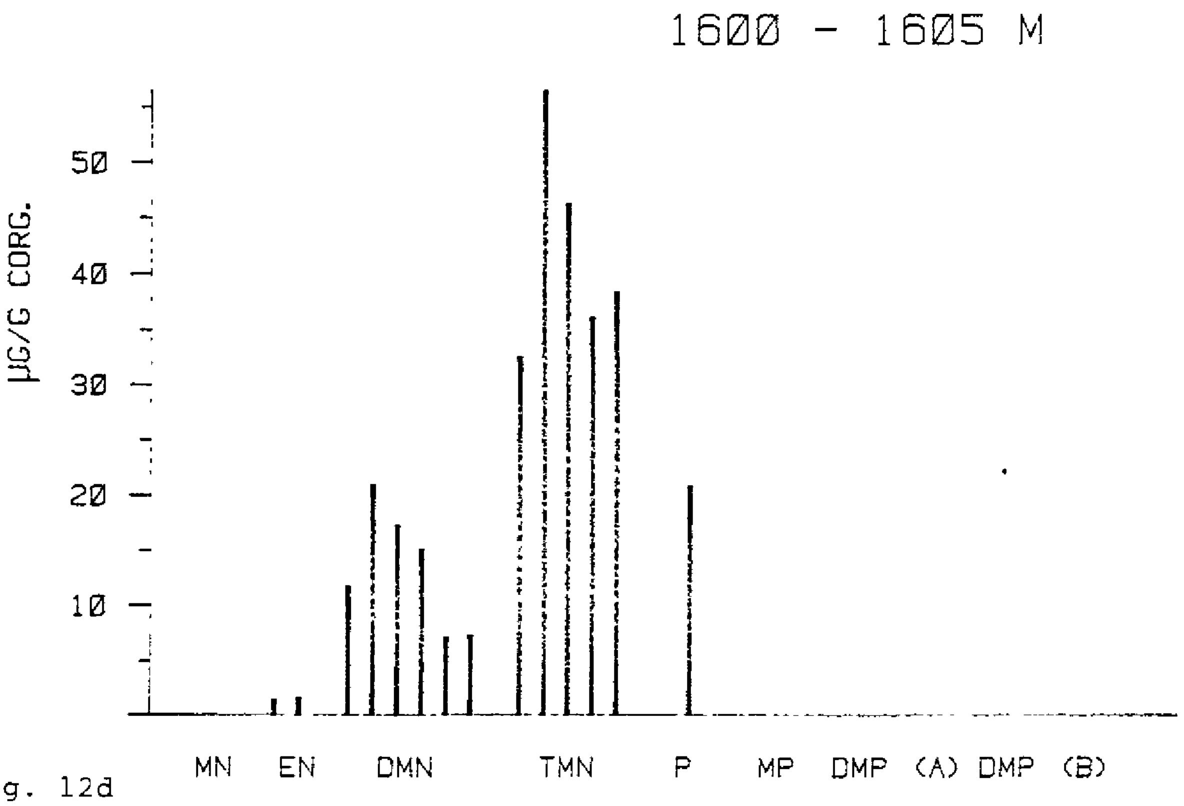


Fig. 12d

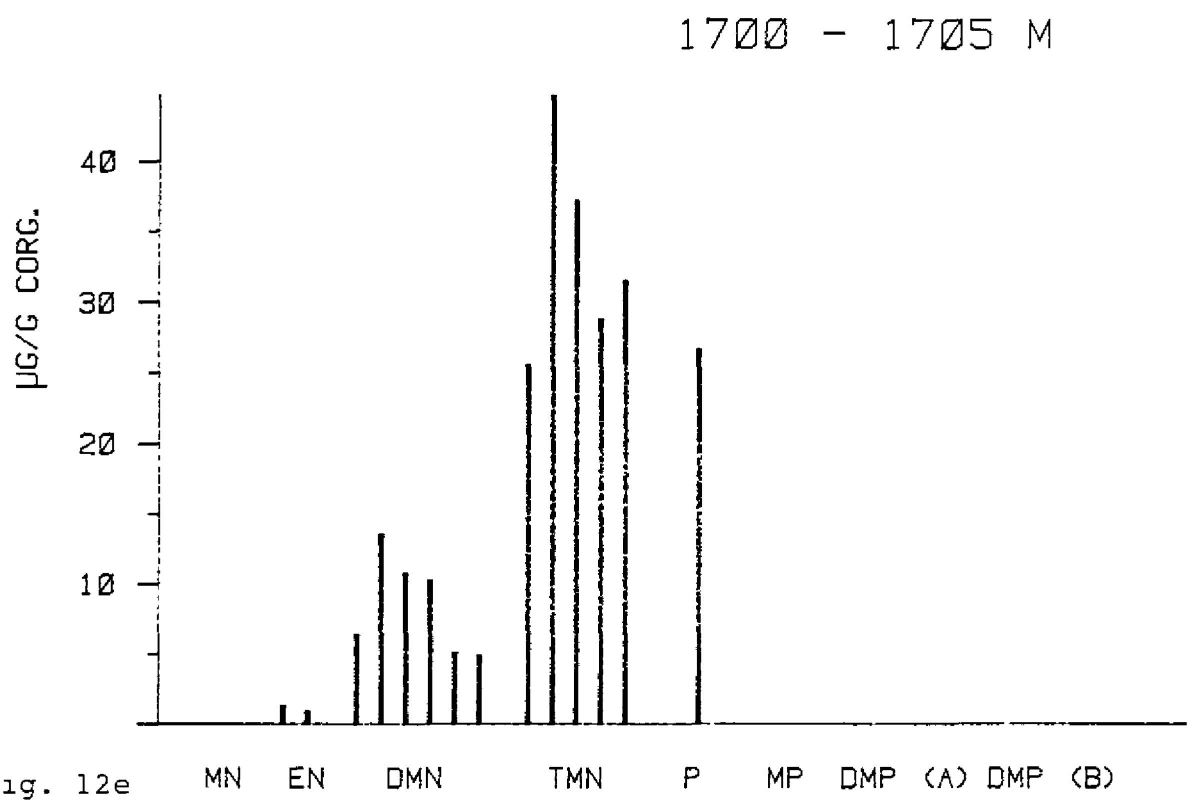


Fig. 12e

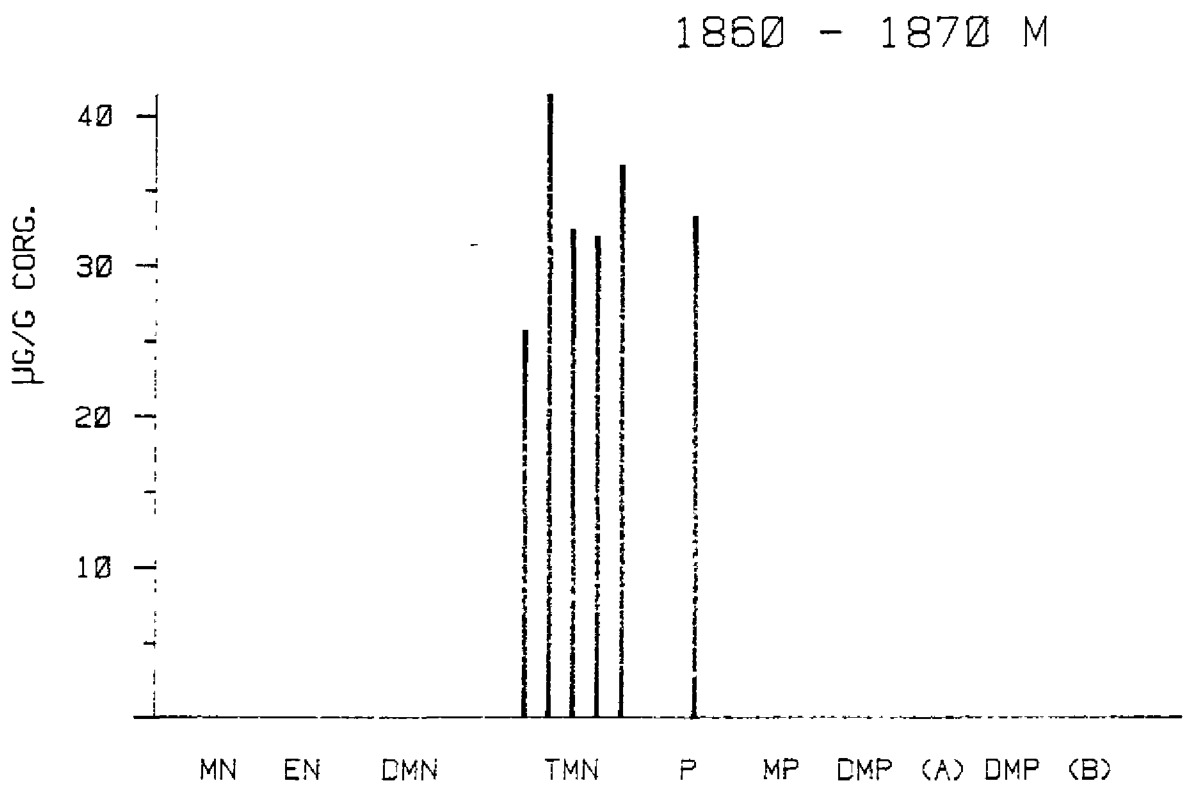


Fig. 12f

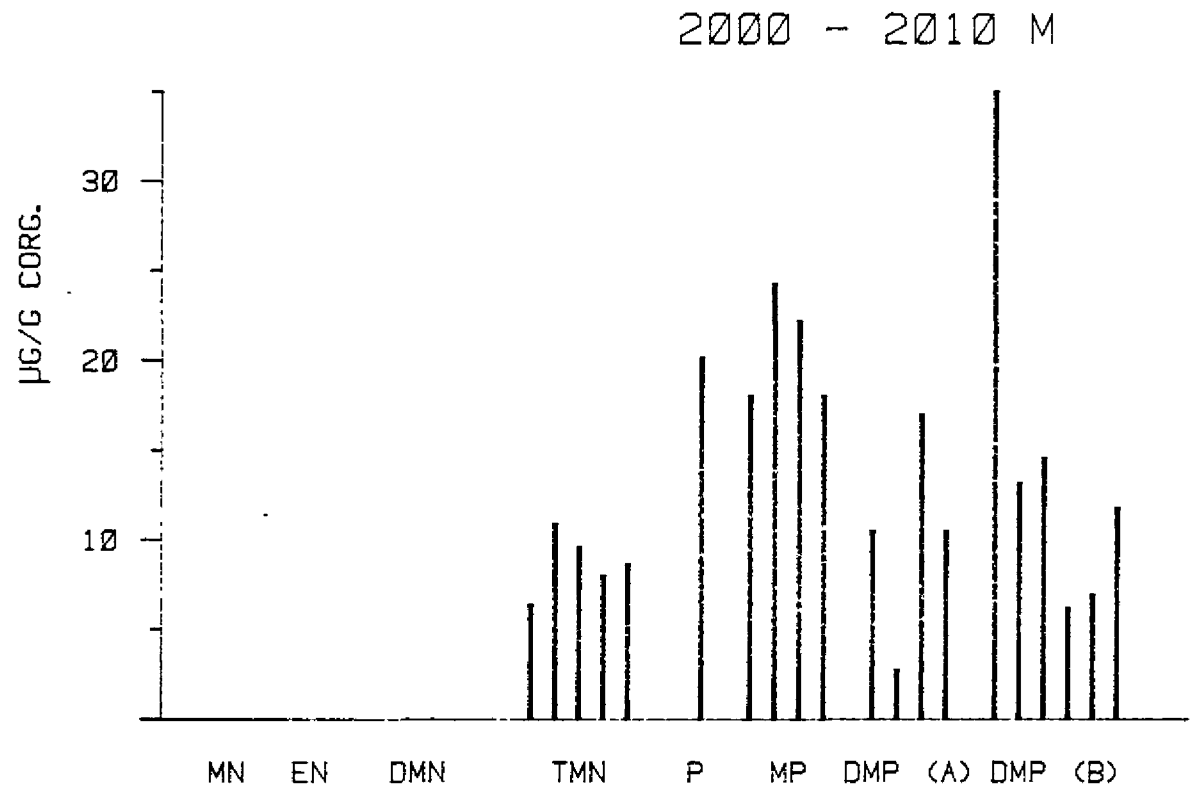


Fig. 12g

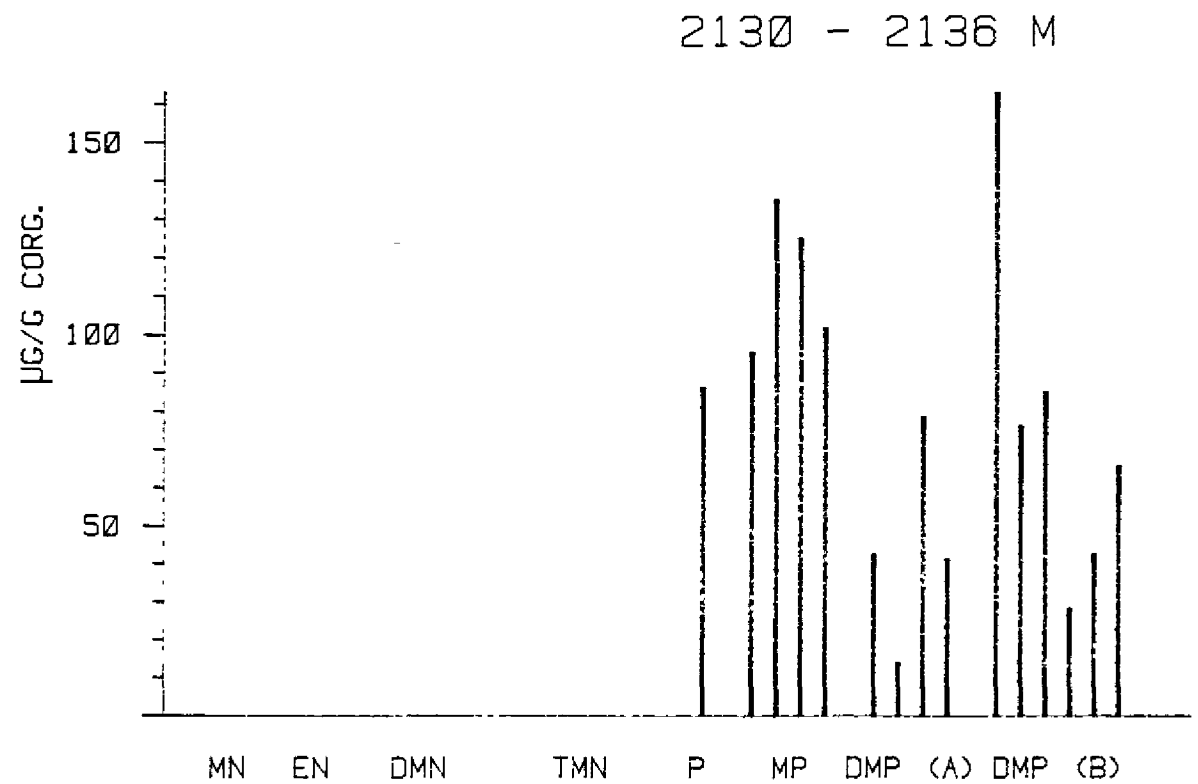


Fig. 12h

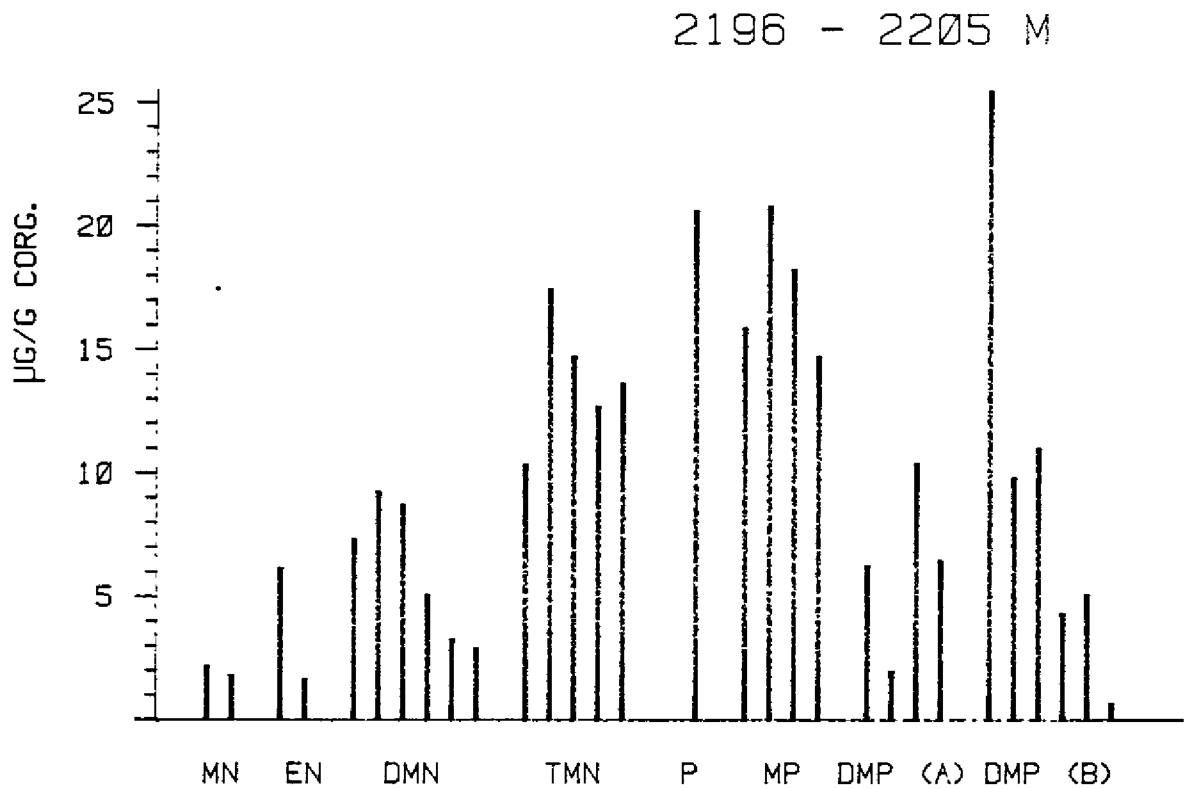


Fig. 12i

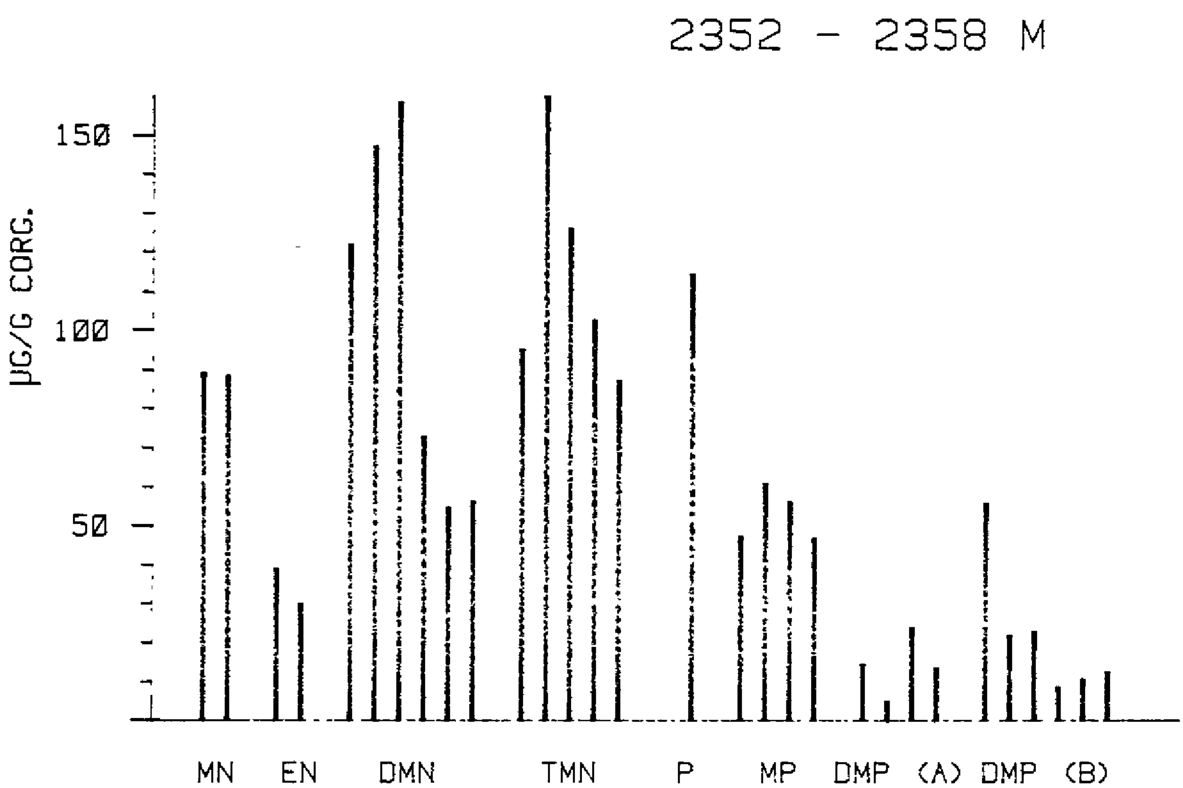


Fig. 12j

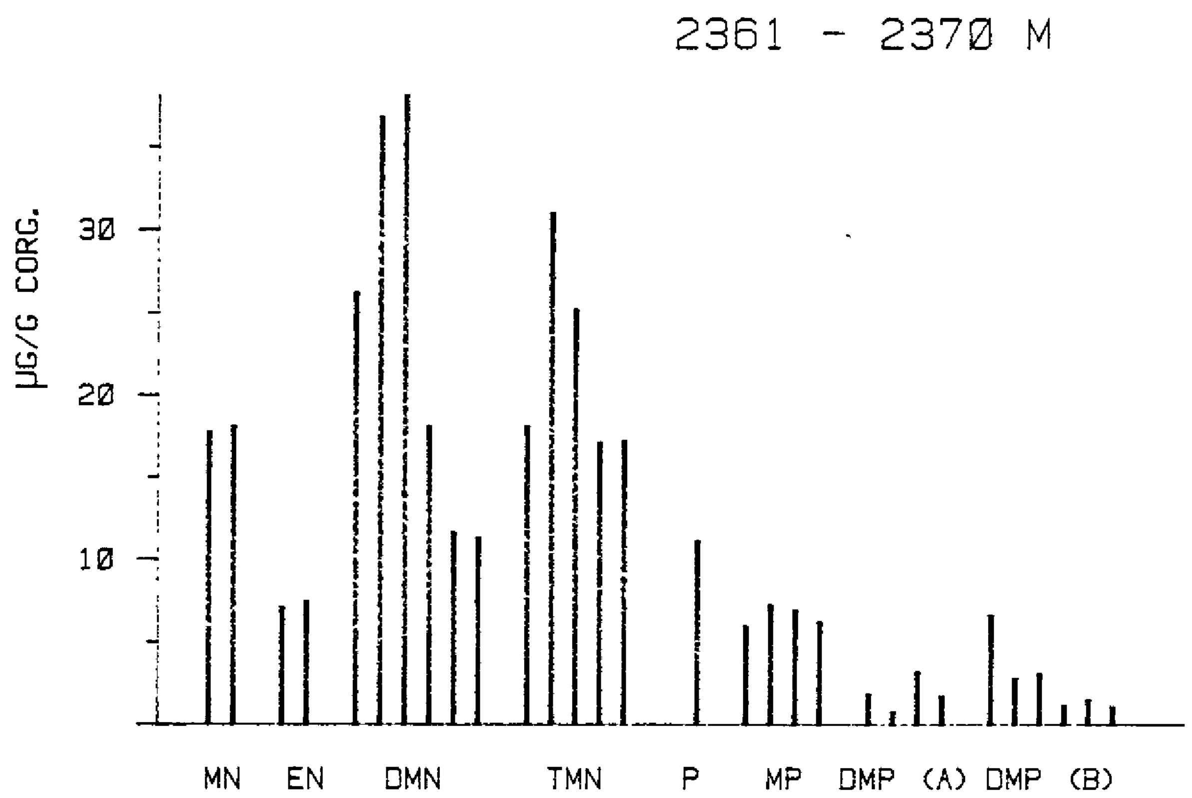


Fig. 12k

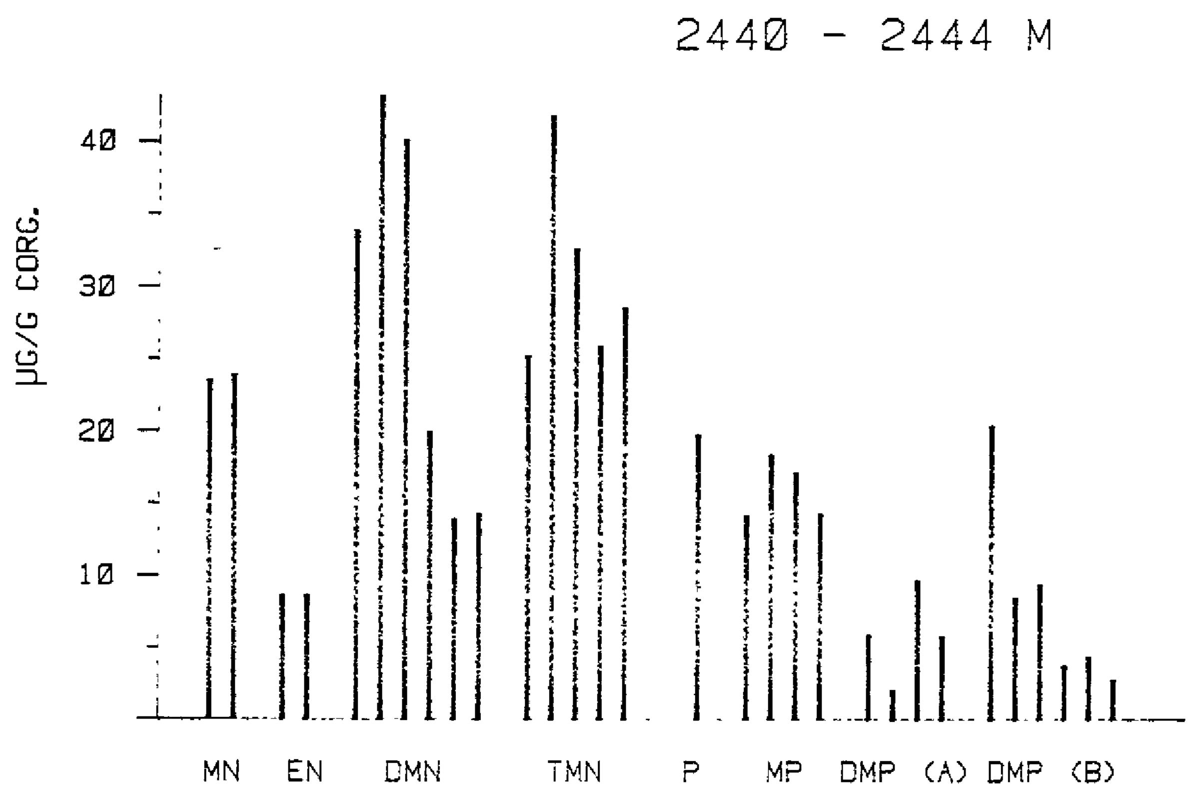
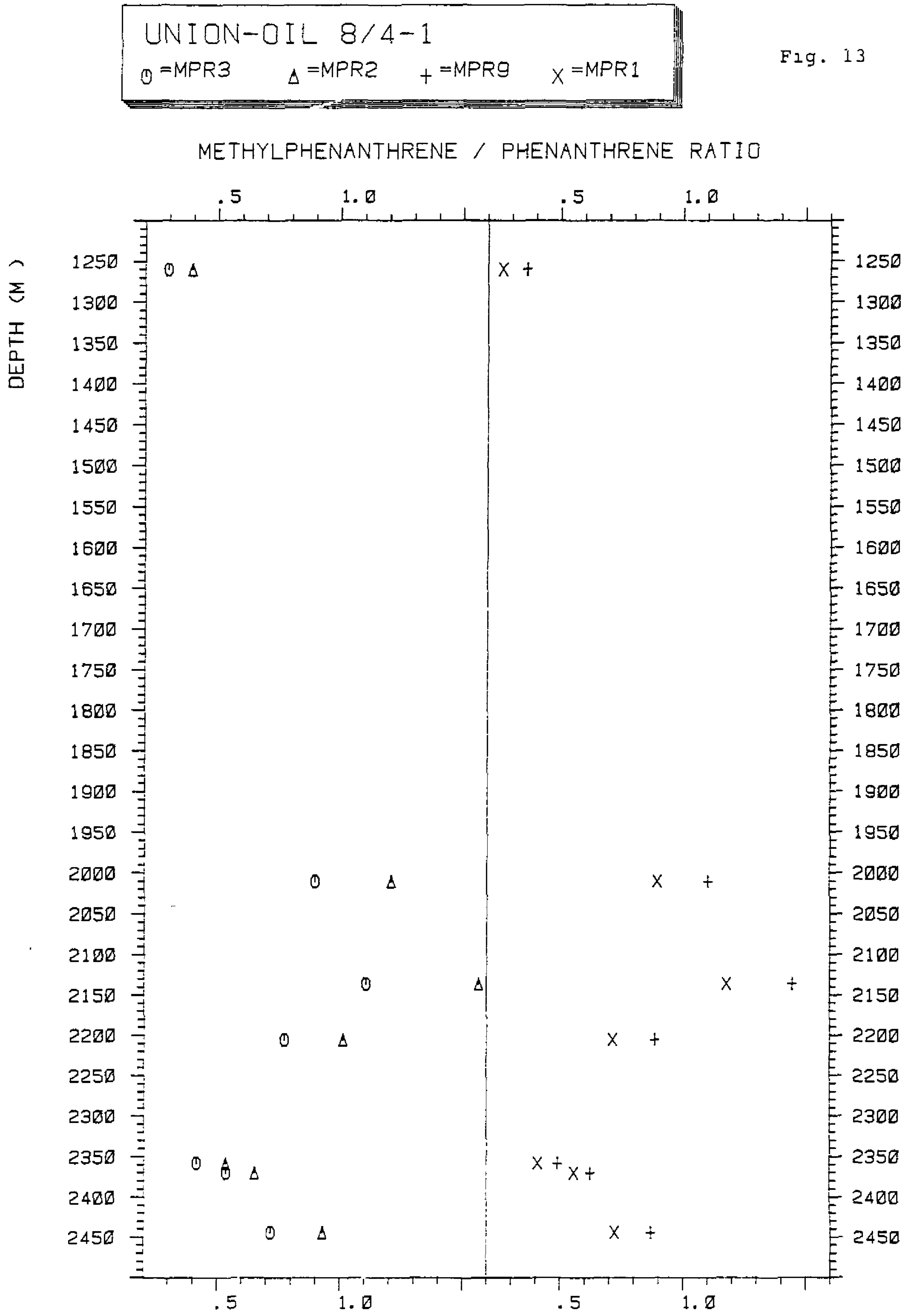


Fig. 12l

Fig. 13



UNION-OIL 8/4-1
O =MPR3
Δ =MPR2
+ =MPR9
X =MPR1
METHYLPHENANTHRENE / PHENANTHRENE RATIO
.5
1.0
.5
1.0
DEPTH (M)
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050
2100
2150
2200
2250
2300
2350
2400
2450

As no depths or lithological descriptions were provided it was difficult to sort out cavings, reworked rock and the true lithology at any point. It has to be assumed that the E-numbers increase with depth.

The top of the well E-15173 - E-15213 is poor in organic material - dominantly inertinite and reworked vitrinite. There appears to be much reworked vitrinite of about 0.55 - 0.58% Ro.

From this point (sample E-15225) the nature and amount of organic material changes. From here there is generally a moderate organic content which is dominantly bituminite and associated bitumen staining which is very heavy in places. Very low Ro values are recorded from this section and this could be affected by bitumen staining. The organic material is also very corroded. However spore fluorescence seems to agree well with a low maturity. Low inertinite Ro of 0.6% confirms the maturity.

From E-15321 to E-15402 inclusive is a very poor zone with low organic contents and dominantly reworked vitrinite or small inertinite fragments. Most of the samples cannot be assessed for maturity and the others are vague.

Samples E-15452 to E-15594 have poor organic contents and low vitrinite contents. However, there does seem to be a trace of higher Ro primary vitrinite though this is very variable (the values seem so dispersed because there are so few per sample that the each sample cannot average out properly).

Sample E-15173: Claystone and Sandstone, Ro = 0.33 (2) and 0.56 (8)
The sample has a very low organic content which is dominated by small, rounded inertinite fragments. There is a trace of bitumen staining. The highest population is probably reworked. There are signs of oxidation in some clasts. Examination in ultra-violet light reveals a trace of green fragments, possibly spores and one very bright orange (hydrocarbon?) speck.

Sample E-15187: Claystone and drilling mud, Ro = 0.42 (2) and 0.57 (3)
There is a low organic content which is dominantly small inertinite fragments with an occasional bituminite fragment. There is a low content of poor vitrinite of apparently two populations (this could be an artefact caused by the low number of readings) of which the higher may be reworked. Ultra-violet light shows green fluorescence from resin.

Sample E-15198: Claystone, Ro = 0.38 (1) and 0.58 (8)
There is a low organic content and this is dominantly small inertinite fragments. There are occasional bituminite fragments and there is a low but very varied population of vitrinite. The most reliable particle was Ro = 0.48% and this may be a good average for the sample. No fluorescence is observed.

Sample E-15213: Varied Claystones, Ro = 0.55 (9)
The sample has a poor organic content which is dominantly inertinite as small, rounded particles. There are a few bitumen wisps but very little poor vitrinite. The distribution of values is poor and the particles could be reworked. No fluorescence is observed.

Sample E-15225: Claystone, Ro = 0.29 (15)
There is a moderate organic content. Bituminite and associated bitumen staining are very dominant. The vitrinite is subordinate and very low Ro. There is a low inertinite content. There is a good distribution of values. No fluorescence is observed.

Sample E-15238: Claystone, Ro = 0.31 (17)
The sample has a low to moderate organic content. This is dominated by poor, corroded vitrinite and bituminite. There is an overall dark brown (bitumen?) staining which is locally heavy. There is a low inertinite content. Ultra-violet light shows a trace of green/yellow and yellow fluorescence from spores.

Sample E-15254: Claystone/Siltstone, Ro = 0.30 (15)
The sample has a low to moderate organic content which is dominantly low reflecting vitrinite and bituminite. There is only a trace of inertinite and small bitumen staining. The vitrinite is in a poor condition. Ultra-violet light shows green fluorescence from spores.

Sample E-15277: Claystone and chalk?, Ro = 0.29 (21)
The sample has a moderate organic content. This is dominated by very poor (corroded) vitrinite with subordinate bituminite and very little inertinite. Bitumen staining is variable throughout. Ultra-violet light shows green fluorescence from possible spore fragments and one orange hydrocarbon speck.

Sample E-15267: Claystone, Ro = 0.31 (16)
There is a low to moderate organic content. This is dominantly very small, corroded vitrinite and bituminite particles. There is a low inertinite content which has a low Ro (0.6%). The organic material is generally very dirty and the lithology has an overall brown staining. Ultra-violet light shows fluorescence from one green/yellow and one yellow/orange spore.

Sample E-15293: Claystone, Siltstone, drilling mud and chalk, Ro = 0.31 (2)
There is a low organic content. Some clasts have a very heavy concentration of bitumen wisps and bitumen staining but there is very little vitrinite and inertinite. It is a very poor, mixed sample. No fluorescence is observed.

Sample E-15321: Claystone, Siltstone, drilling mud, Ro = 0.60 (2)
The organic content in this sample is very low. It consists dominantly of reworked vitrinite and inertinite. There are two particles of possible primary vitrinite. The high value could indicate that these are reworked. No fluorescence is observed.

Sample E-15341: Limestone and Claystone, No Determination Possible
The sample contains only a trace of bituminite and some inertinite/reworked vitrinite. No fluorescence is observed.

Sample E-15374: Limestone/marl?, Ro = 0.45 (1)/N.D.P.?
The main lithology is very white, fine grained and barren of organic material. The one reading is from within a small claystone clast and is probably contaminant. No fluorescence is observed.

Sample E-15402: Limestone/marl?, No Determination Possible
The sample is as E-15374 but not quite as pure. There is a trace of reworked vitrinite and small rounded inertinite particles. There is some oxidised pyrite. No fluorescence is observed.

Sample E-15452: Red claystone, Ro = 0.90 (3)/N.D.P.?
The sample has a low to moderate content of reworked and inertinite material. All of the organic material is gnarled. There are three possible primary vitrinite particles but the amount of obvious oxidation makes their value very doubtful. No fluorescence is observed.

Sample E-15497: Claystone, Ro = 0.39 (4), 0.63 (1) and 0.95 (1)
The sample is very rich in bituminite but very poor in all other organic material. There are signs of oxidation and the values are very widely spread. The sample is poor for vitrinite reflectance. Ultra-violet light shows green to green/yellow fluorescence from spores and a trace of resin.

Sample E-15526: Claystone and sandstone, Ro = 0.41 (1) and 0.79 (1)
This is a poor sample. The organic material is dominantly bituminite with bitumen staining. There is some inertinite with good fusinite cell structures. There are two possible vitrinite fragments but their Ro's are very different. Ultra-violet light shows green and green/yellow fluorescence from spores.

Sample E-15594: Calcareous claystone/siltstone, Ro = 0.78 (1)
The sample is almost barren. There are a few very small, rounded inertinite fragments and the occasional wisp of bitumen-like material which is very corroded. There is one very small vitrinite fragment. No fluorescence is observed.

E-15422, 2133m: Claystone, Rp=0.75(7)
The sample has a low organic content which is dominantly inertinite and reworked vitrinite. The best vitrinite stringer has an Ro of 0.69%. One claystone probably caved is very rich in bitumen. Some of the sample is red and oxidised. No fluorescence is observed.

Sample E-15494, 2202m: Claystone, No Determination Possible
The sample is very rich in bitumen wisps which follow the microbedding and are often associated with bitumen straining. Otherwise there is a trace of inertinite but no true vitrinite. No fluorescence is observed.

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Vitrinite Reflectance measurements

TABLE NO.:
WELL NO.: 8/4-1

Sample	Depth (m)	Vitrinite reflectance	Fluorescence in UV light	Exinite content
E-15173	300	0.33 (2), 0.56 (8)	Trace of green fragments (spores?) and one bright orange hydrocarbon speck	Trace?
E-15187	440	0.42 (2) 0.57 (3)	Trace of green resin	Nil
E-15198	550	0.38 (1) 0.58 (8)	Nil	Nil
E-15213	700	0.55 (9)	Nil	Nil
E-15225	820	0.29 (15)	Nil	Nil
E-15238	950	0.31 (17)	Trace green/yellow and yellow spores	Trace
E-15254	1110	0.30 (15)	Trace green spores	Trace
E-15277	1350	0.29 (21)	Trace green fragments (spores?) and one orange hydrocarbon speck	Trace?
E-15267	1250	0.31 (16)	One green/yellow and one yellow/orange spore	Trace
E-15293	1450	0.31 (2)	Nil	Nil
E-15321	1600	0.60 (2)	Nil	Nil
E-15341	1700	N.D.P.	Nil	Nil
E-15374	1865	0.45 (1)? N.D.P.?	Nil	Nil

IKU

Vitrinite Reflectance measurements

TABLE NO.:
WELL NO.: 8/4-1

Sample	Depth (m)	Vitrinite reflectance	Fluorescence in UV light	Exinite content
E-15402	2005	N.D.P.	Nil	Nil
E-15429	2133	0.72(6)	Nil	Nil
E-15452	2202	0.90 (3)	Nil	Nil
E-15494	2358	N.D.P.	Nil	Nil
E-15497	2367	0.39 (4) 0.63 (1) 0.85 (1)	Green and green/yellow spores and resin (caved?)	Trace
E-15526	2442	0.41 (1) 0.79 (1)	Green and green/yellow spores (caved?)	Trace
E-15594	2580	0.78 (1)	Nil	Nil

060/M/ah/3