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Prepared for

SAGA PETROLEUM A.S.

GEOCHEMICAL EVALUATION OF THE SAGA PETROLEUM A.S. 6407/2-3 WELL, DRILLED OFFSHORE NORWAY

July, 1987

GEOCHEMICAL EVALUATION AND CORRELATION STUDY OF THE SAGA PETROLEUM A.S. 6407/2-3 WELL

EXECUTIVE SUMMARY

The Nesna mudstones represented by the side wall core at 2399 metres are poor source rocks.

Interbeds of shale at (2595-2738.5 metres) in the Leka sands and at 2738.5-2910 metres in the Aldra are good or, occasionally, very good or rich source rocks. Similarly, the Hitra Formation (2910-3050 metres) shales are very good and the coals, below 2960 metres, rich source rocks.

Shows of condensate were detected in the Nesna mudstones, at 2614 metres in the Leka and at 3050± metres in the Hitra; further traces occur at 2911 metres. These migrated hydrocarbons correlate with those produced by DST-1 and DST-2.

The DST-2 (2427.8-2435.8 metres) and DST-1 (2508.7-2518.2 metres) condensates are identical and derived from a mature, but not highly mature, source rich in marine and terrestrial organic matter. Allowing for differences in apparent maturity the GC-MS data correlate these hydrocarbons with the Hitra shales whereas the carbon isotope data suggest that the interbedded coals are also contributing hydrocarbons.

M J Sauer

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FIGURE 1

WELL 6407/2-3

SUMMARY CHART

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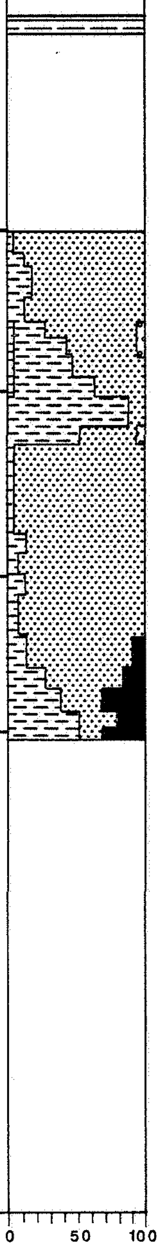
DEPTH	ZONE	AGE	HYDROCARBON SOURCE POTENTIAL	SHOW EVALUATION
2000				
~2399	A	NESNA	POOR HYDROCARBON POTENTIAL AT 2399± METRES.	WEAK SHOW OF CONDENSATE.
2500		NESNA		
	B	LEKA	GOOD SOURCE ROCKS WITH VERY GOOD AND RICH INTERBEDS.	SHOW CONDENSATE AT 2614± METRES WITH TRACES AT 2911 ± METRES AND A STRONGER SHOW AT 3050± METRES.
	C	ALDRA	MINOR TO SIGNIFICANT BUT VERY GOOD SHALES.	
3000	D	HITRA	SCATTERED INTERBEDS OF VERY GOOD SHALE AND RICH COAL.	
3500				

LITHOLOGY



Limestone, Siltstone, Dolomite, Sandstone, Shale, Evaporite, Mudstone, Igneous, Coal, L.C.M.

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APPENDIX (2) FIGURES

INTRODUCTION

This report presents a geochemical evaluation of the Nesna mudstones at 2399± metres and the 2595-3050 metre interval in the Saga Petroleum A.S. 6407/2-3 well.

The study was designed to evaluate the selected intervals in terms of source richness and to detect shows of migrated hydrocarbons. Assessment of kerogen type and of thermal maturity was not specified by the client. Analyses were performed to characterise the tested condensates and to correlate them to potential source rocks.

This project was authorised by A. Elvsborg who, together with Ms. E.S. Moe, specified the analytical format.

ANALYTICAL

A total of 25 ditch cuttings samples, 1 sidewall core (at 2399 metres), 2 condensate samples (DST-2 Stock tank oil, DST-1 Single flash condensate) and 2 gas samples (DST-1 and DST-2) were received and assigned to job number 1523.

The samples were analysed in accordance with contract number KO-EUG-86.019 Exhibit A (Scope of work).

Analyses performed in this study are as follows :

ANALYSIS	NUMBER OF ANALYSES
Total organic carbon	37
Rockeval Pyrolysis	22
C_{15+} extraction and chromatography	17
C_{15+} Saturates	17
C_{15+} Aromatics	17
GC-MS biomarker analyses	8
Carbon Isotopes extracts/fractions	43
Carbon Isotopes kerogen pyrolysates	4
API gravities	2
Sulphur, vanadium and nickel contents	2
Whole oil analyses	2
Carbon isotopes gases	1
Hydrogen/deuterium isotopes	1
C_1-C_8 Hydrocarbons	2

The results of these analyses are listed in tables 1 to 11 and presented graphically in figures 1 to 22.

A brief description of the analytical methods is enclosed at the back of this report.

GENERAL INFORMATION

Five (5) copies of the report have been forwarded to Ms. E.S. Moe, Saga Petroleum A.S., Hovik.

A copy of the data has been retained by Geochem for future consultation with authorised Saga personnel.

The remaining sample material will be handled as directed.

The results of this study are proprietary to Saga Petroleum A.S.

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CONCLUSIONS

Four zones - loosely based upon formation log tops - are recognised between 2399 metres and 3050 metres in the 6407/2-3 well.

Zone A is represented by a single sample of mudstone at 2399 metres, from the Nesna Formation. An organic carbon content of 1.50% suggests a good potential but the pyrolysate yield of 0.71 mg/g indicates that the mudstones represented by this sample are poor source rocks.

Zone B (2595-2738.5 metres) corresponds to the lower part of the Leka Formation (2581-2738.5 metres). The shales above 2620± metres have very good organic carbon contents (4.96-6.67%) but the shale beds in the underlying sands are somewhat leaner at 1.62-2.92%. Pyrolysate yields indicate good source potential (3.16-4.91 mg/g improving to very good at 2 713 metres (8.05 mg/g) and rich (28.3 mg/g) at 2595 metres.

Zone C (2738.5-2910 metres) is equivalent to the Aldra Formation; which chiefly consists of sands - with shaly interbeds. The shales generated 7.08-8.16 mg/g pyrolysate and, from the hydrogen indices (458-609), are believed to be oil prone. Per unit volume the Aldra shales represent a very good hydrocarbon source.

Zone D (2910-3050 metres) consists of sands with interbedded shales and coals from the Hitra Formation. The shales are rated as very good (6.71-9.80 mg/g pyrolysate) whereas the coals, below 2960± metres, are rich (107.7-246.5 mg/g pyrolysate).

Visual kerogen and vitrinite reflectance analyses were not specified by the client and the thermal maturity of the analysed sediments is therefore unknown. The available data suggest that, at best, they are marginally mature.

Shows of condensate, resembling the tested hydrocarbons at 2427.8-2435.8 metres (DST-2) and at 2508.7-2518.2 metres (DST-1), were detected in the Nesna mudstones at 2399 metres and at 2614± metres in the sandstones/shales of the Leka Formation. Further traces of these hydrocarbons were detected at the top of the Aldra (2911 metres) and in the deepest sample at 3050± metres.

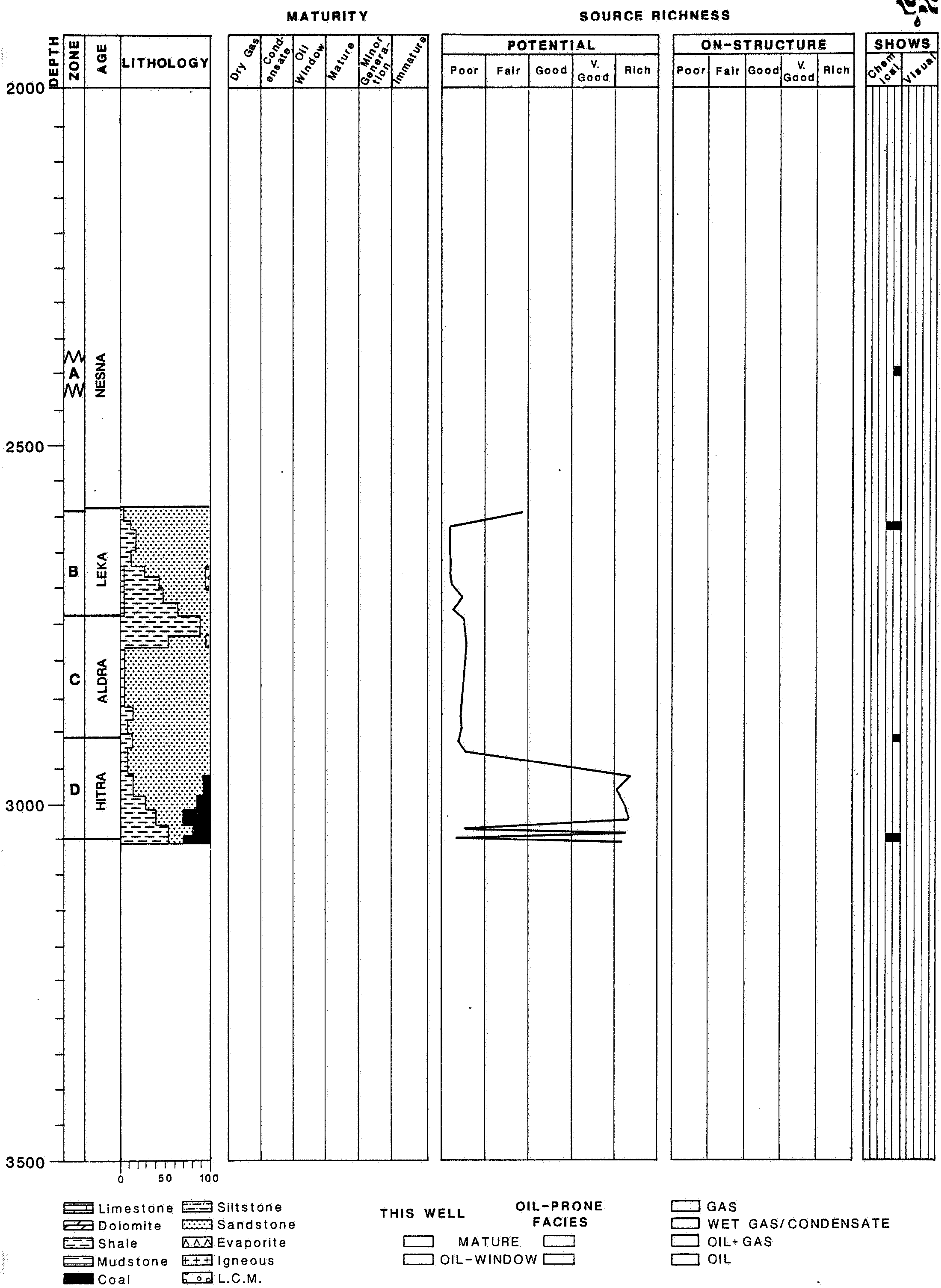
The saturates chromatograms of the condensates have a smooth profile suggesting a mature source. This is confirmed by the methyl phenanthrene index (MPI) values which correspond to top of 'oil window'.

C_{15+} aromatic hydrocarbon chromatograms and GC-MS fragmentograms indicate that the DST-1 and DST-2 condensates have a common source - containing a mixture of marine and terrestrial organic matter. The Nesna mudstones do not correlate with the condensates. Kerogen pyrolysate carbon isotope ratios correlate the Hitra shales, plus possibly the coals, with the tested fluids. The correlation based upon the GC-MS data is less obvious because of the appreciable difference in maturity between analysed source rocks and the condensates. Allowing for this effect the Hitra shales, rather than the coals with their predominance of C_{29} steranes, are the favoured source facies. It must be emphasised that the Nesna mudstone is leaner than expected for this unit and may, therefore, be atypical.

FIGURE 2

WELL 6407/2-3

RATING DIAGRAM



ZONATION

This zonation is based upon a consideration of the formation log tops and variations in the geochemical parameters. A total of four (4) zones are recognised.

ZONE A The Nesna mudstones are represented by a single sample at 2399 metres.

ZONE B (2595-2738.5 metres) includes the lower part of the Leka Formation (2581-2738.5 metres). Sandstones predominate at the top of this interval but the interbedded medium dark grey to medium grey shales become more abundant as the depth increases.
A fluorescent cut was detected in the sands below 1650± metres.

ZONE C (2738.5-2910 metres) corresponds to the Aldra Formation - which chiefly consists of shales above 2750± metres. Sands with minor to significant shales are present below this depth.
The sands down to 2860± metres exhibited a slow cut.

ZONE D (2910-3050± metres) is equivalent to the Hitra Formation. Sandstones are interbedded with minor to significant medium dark grey to medium grey shales and, below 2960± metres, coals.
No fluoresence was detected in the sands.

SOURCE RICHNESS

Visual kerogen analyses were not specified by the client and source richness has, therefore, been evaluated by the TOC and Rockeval pyrolysis analyses.

The Nesna mudstones have above average (1.56%) organic carbon contents, generated 0.71 mg/g pyrolysate and are poor source rocks.

Within the Leka Formation the shales have organic carbon contents which drop from 6.67-4.96% to less than 1.62% below 2620± metres but then improve to 1.89-2.92% in the basal 50± metres. In general these shales are good (3.16-4.91 mg/g pyrolysate) source rocks but are rich at 2595± metres and at 2713± metres have a very good (28.3 and 8.05 mg/g pyrolysate respectively) hydrocarbon potential. At 2690-2770± metres, however, thermal bitumen yields (S1) of 2.13-2.35 mg/g indicate non-indigenous hydrocarbons which can also influence (slightly) the pyrolysate (S2) yield.

Interbeds of shale in the Aldra sands commonly have organic carbon contents of 1.30-2.00% but reach a value of 4.09% at 2776± metres. There appears to be a significant variation in organic facies at the latter depth since the hydrogen index of 793 suggests that the richer medium dark grey shale and not the medium grey shale at 2776 metres has been analysed. Pyrolysate yields of 7.08-8.16 mg/g (resulting in hydrogen indices of 458-609) indicate very good source rocks are present in the Aldra.

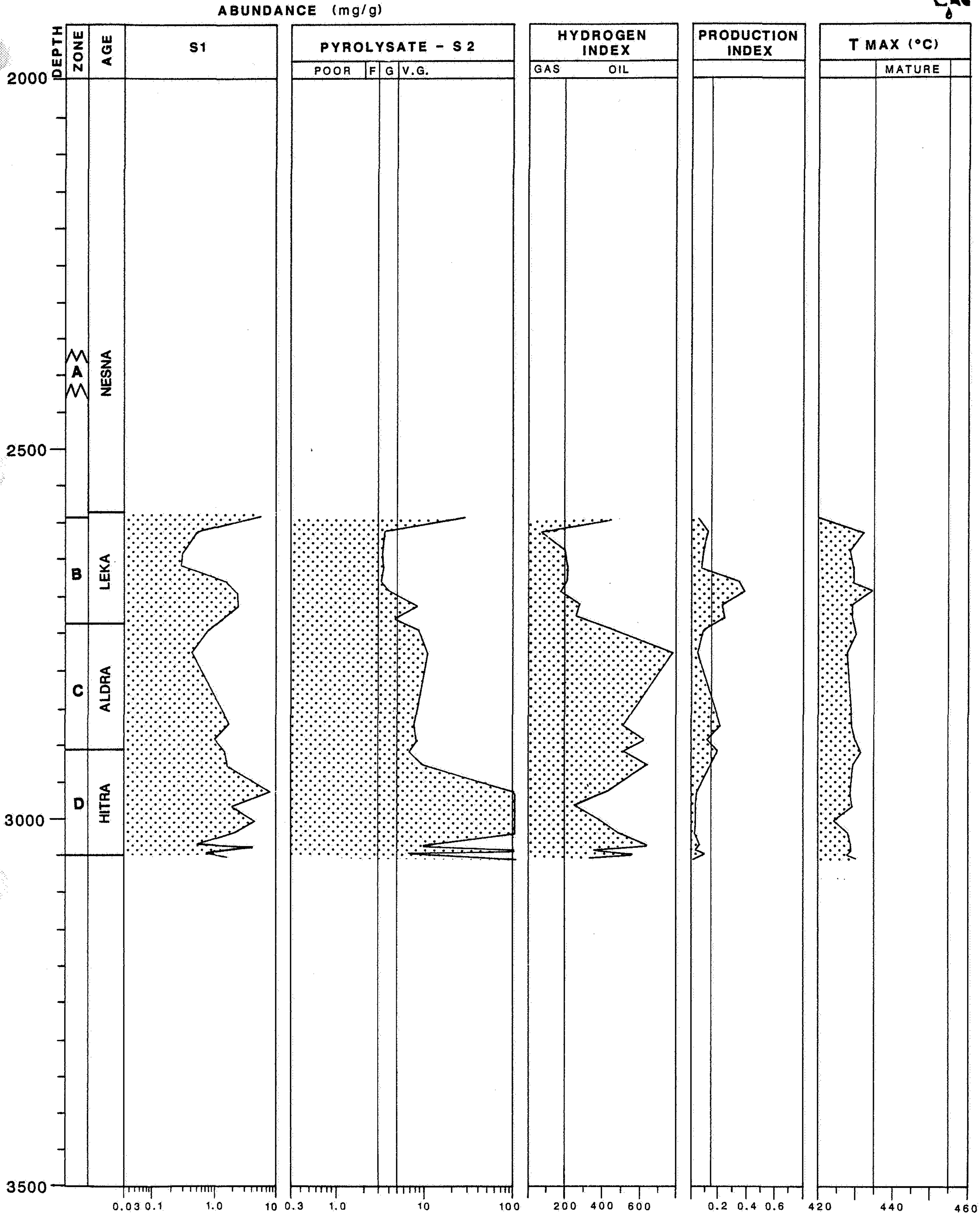
Organic carbon contents of 1.12-1.97% apply to the shaly interbeds in the Hitra whilst the coals, below 2960± metres are appreciably richer at 43.3-58.2%. Pyrolysate yields of 6.71-9.80 mg/g confirm that the shales have a very good hydrocarbon potential whereas the coals, generating 107.7-246.5 mg/g, are rich.

THERMAL MATURATION

Visual kerogen (spore colour) and vitrinite reflectance analyses were not specified by the client. The Rockeval Tmax values reach a maximum of 428-430°C which suggests that the analysed sediments are no more than marginally mature (0.5% Ro).

FIGURE 3 **ROCKEVAL PYROLYSIS**

WELL 6407/2-3

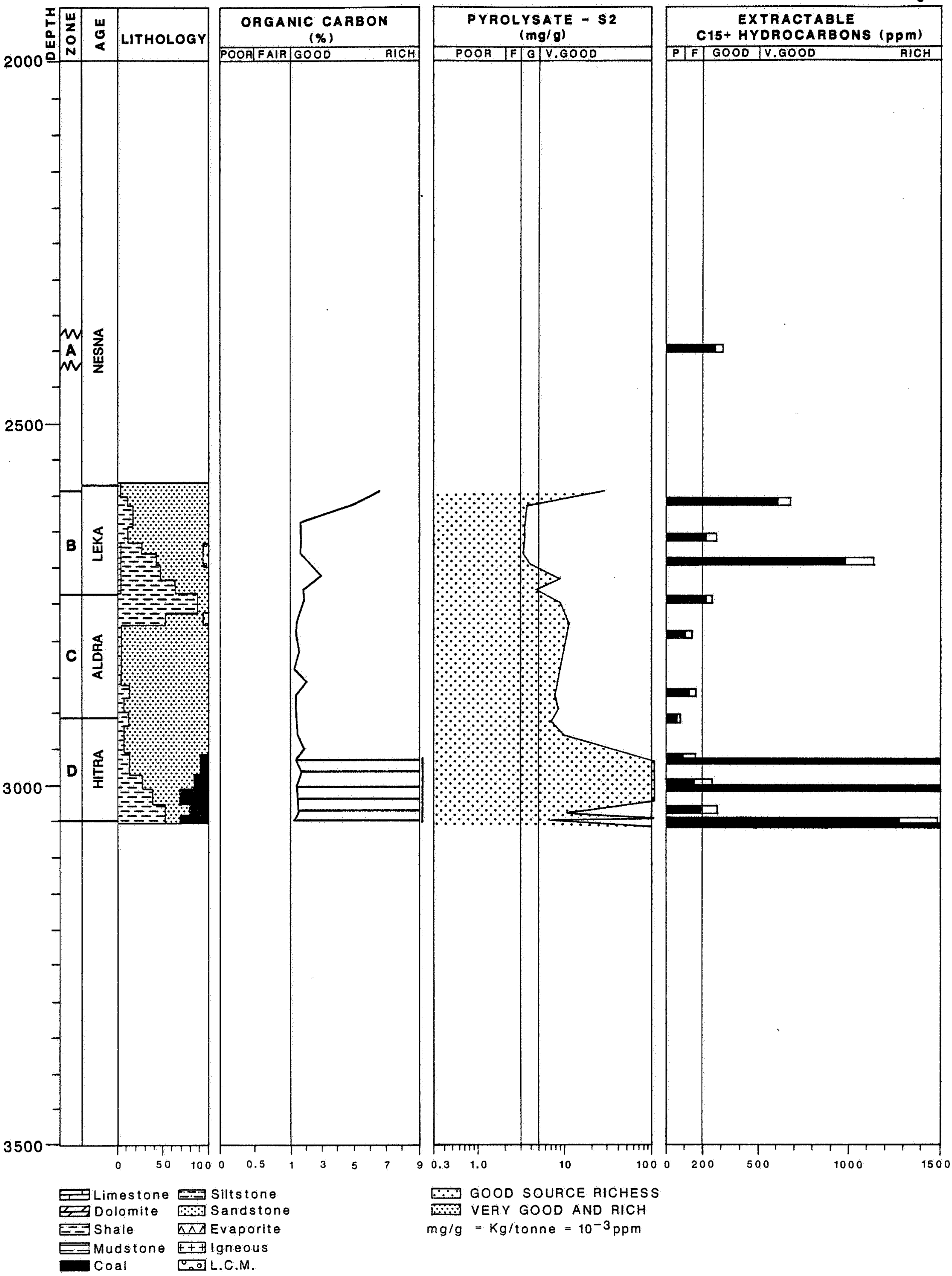


HYDROGEN INDEX = $\frac{S2}{TOC}$ PRODUCTION INDEX = $\frac{S1}{S1 + S2}$

FIGURE 4

WELL 6407/2-3

SOURCE RICHNESS



SHOW DETECTION AND CHARACTERISATION

Gas wetness data were not available for show detection because the light hydrocarbons analyses were not specified. The C_{15+} hydrocarbons data do, nonetheless, indicate shows of condensate resembling the tested fluids at 2427.8-2435.8 metres (DST-2) and at 2508.7-2518.2 metres (DST-1) within the analysed section. Thus, there is a weak show (312 ppm C_{15+} hydrocarbons, 57.8% of the total extract) in the Nesna shales at 2399 metres and a stronger show (672ppm, 77% of the total extract) in the sandstones/shales at 2614± metres. At 2690-2880± metres the C_{15+} hydrocarbons have saturates chromatograms which are typical of low toxicity mud additives. Traces of hydrocarbons resembling the tested condensates were detected at 2911± metres but they may be entrained hydrocarbons from the mud system. C_{15+} hydrocarbons from the underlying sediments have 'immature' features (strong add carbon paraffin preference, intense pristane peak) and are derived from the coals in this interval. The only exception being those from the shales (± sands) at 3050± metres, which yielded 1491ppm C_{15+} hydrocarbons (60% of the total extract). They closely resemble the DST-1 condensate.

HYDROCARBON CHARACTERISATION

The hydrocarbons tested at 2427.8-2435.8 metres (DST-2) and at 2508.7-2518.2 metres (DST-1) are condensates which have API gravities of 49.0° and 49.3°. These fluids have very low (less than 0.02%) sulphur contents and vanadium and nickel contents which are below the detection limit of 1ppm.

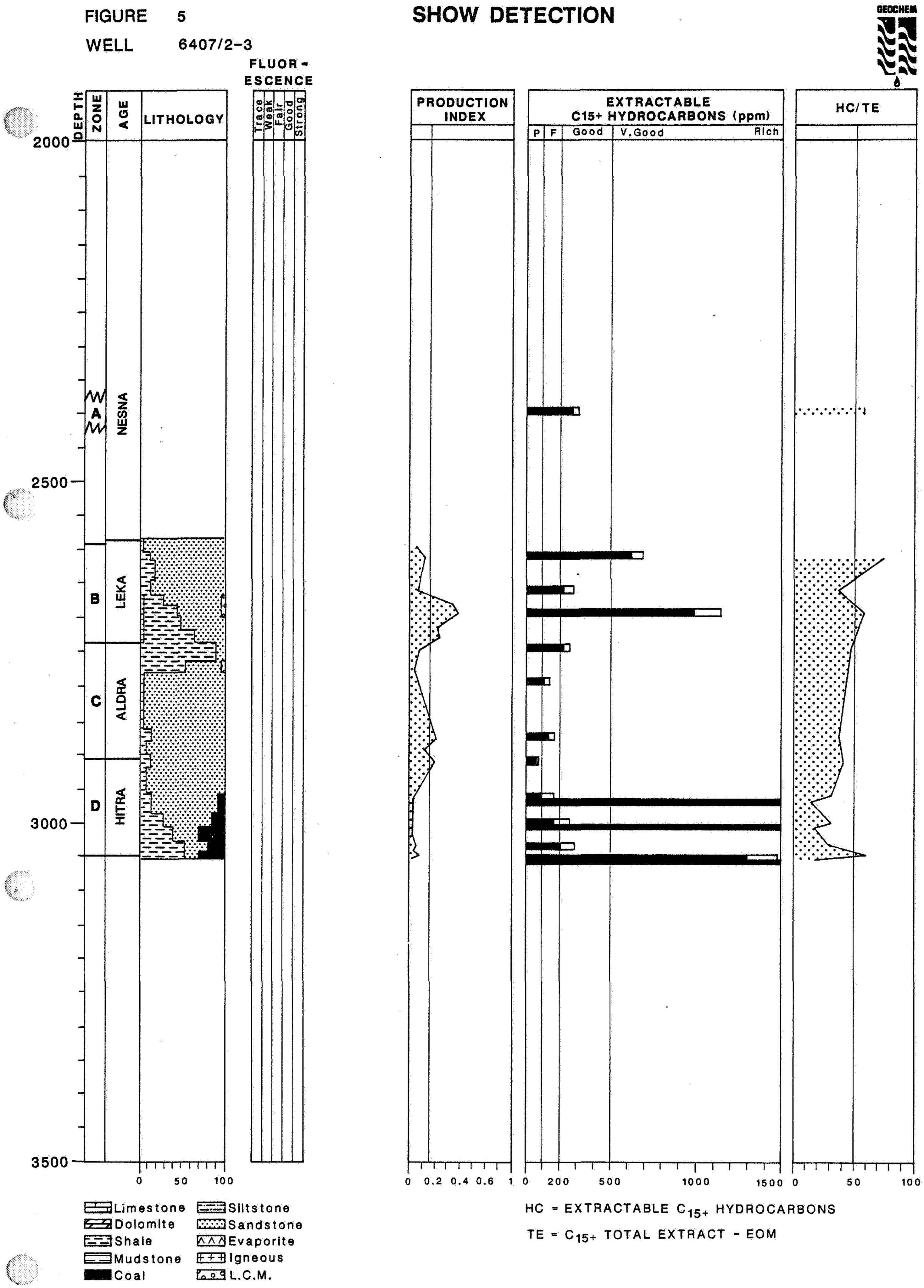
An analysis of the gases from DST-1 is reported in Table 11a and, of the liquids and recombined fluids in Table 11b. Details of the recombination method are included in Appendix 1.

A whole oil chromatogram of the DST-2 liquids displays a full range of C_4-C_{25} hydrocarbons whilst the DST-1 liquids appear to be depleted in C_4-C_8 species, but otherwise resemble the DST-2 sample. Loss of the lighter hydrocarbons from DST-1 may be due to evaporation or the manner in which the sample was collected (sample history is unknown). Alteration in the reservoir is thought to be unlikely since the light hydrocarbons are well represented in the DST-1 gas sample.

FIGURE 5

WELL 6407/2-3

SHOW DETECTION



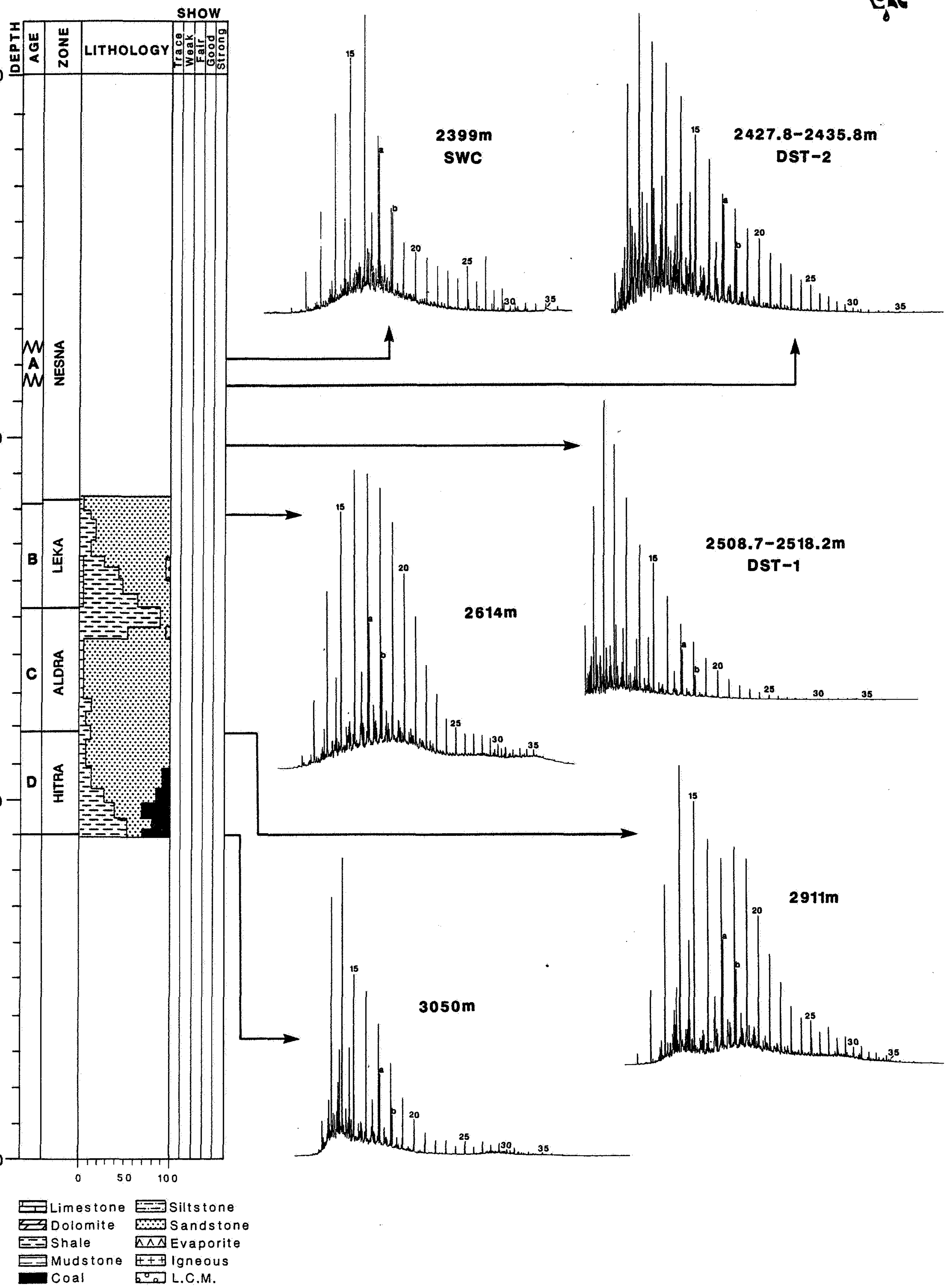
HC = EXTRACTABLE C_{15+} HYDROCARBONS

TE = C_{15+} TOTAL EXTRACT = EOM

FIGURE 6

WELL 6407/2-3

SHOW CHARACTERISATION



Appreciable pristane and phytane peaks on the C_{15+} saturates chromatograms suggest a mature, but not highly mature source. This is compatible with the smooth C_{15+} saturates alkane profile and MPI(1) value of 0.58 (from GC-MS). The latter is equivalent to a vitrinite reflectance of 0.75% (see Radke, Welte and Willsch, Advances in Organic Geochemistry, 1985 pp. 51-64).

Chromatograms of the C_{15+} aromatic hydrocarbons for the DST-2 and DST-1 liquids are identical and point to a common source for these fluids.

HYDROCARBON - SOURCE CORRELATION

Correlations between the tested condensates and the hydrocarbon shows have been discussed in the Hydrocarbon Characterisation Section. The relationship between these hydrocarbons and their potential soruce rocks is described here.

The most prospective source rocks are the shales and coals in Hitra Formation (Zone D). Saturates chromatograms of the hydrocarbons extracted from these source rocks commonly display immature features and appear to be unrelated to the more mature condensates. Apart from an enhancement in the phenanthrene peak (1), the C_{15+} aromatic chromatograms are closely similar and indicate that a correlation does, nonetheless, exist.

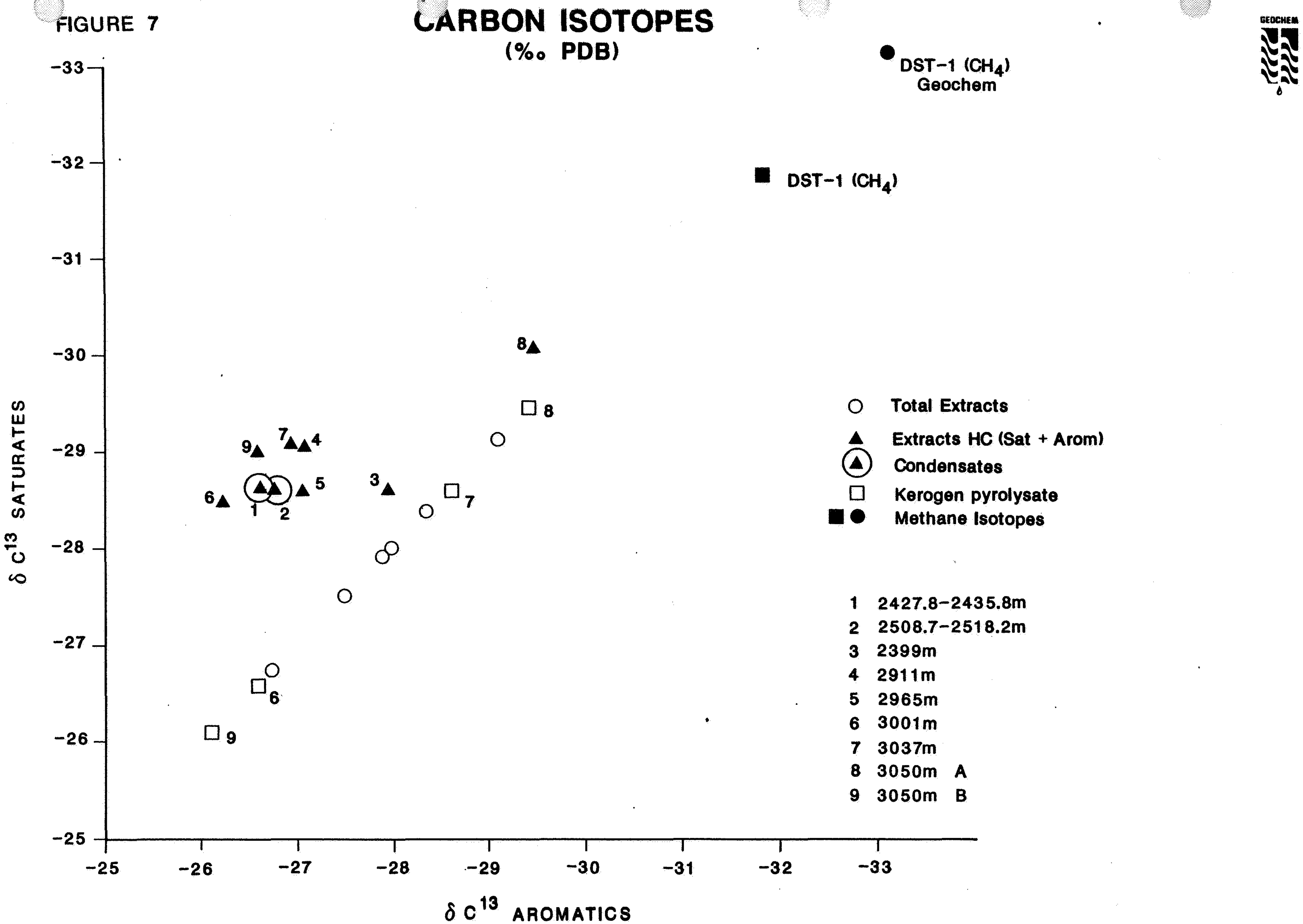
Kerogen pyrolysate isotope ratios for the coals ($-26.6^{o}/oo$) are heavier - more positive than that of the condensate saturates ($-28.6^{o}/oo$) but are close to the corresponding aromatics fraction at $-26.7^{o}/oo$. Kerogen pyrolysate isotope ratios for the Hitra shales ($-28.6^{o}/oo$ and $-29.4^{o}/oo$) are lighter than the coals, plot closer to the condensate values and suggest that these shales are a potential source for the tested fluids. The C_{15+} hydrocarbons extracted from the Hitra coals (clearly indigenous) also plot close to those of the condensates and thus, correlate. The coals, believed to be relatively more gas prone than the shales, generate gaseous products when pyrolysed which are not trapped and measured. Loss of these relatively light products results in an isotopically heavy pyrolysate but does not exclude the coals as a possible condensate source.

Correlations based upon the GC-MS data are complicated by the differences in apparent maturity between source and tested hydrocarbons. Furthermore, the condensates are believed to be depleted in C_{29} steranes because of their low boiling point. Thus the Nesna mudstones at 2399± metres have strong R isomer peaks which, together with the prominent moretanes (D, F and I), diminish with increasing maturity and could conceivably correlate with the condensates. However, peak Z (bisnorhopane) is present in the condensates but not the Nesna extracts. In this respect the Hitra shales represent a more prospective source. The coals at 3050± metres, although they have little trisnorhopane (A) and bisnorhopane (Z), have strong moretane peaks and cannot, therefore be eliminated as a possible source of the condensates.

Mass fragmentograms of steranes extracted from the coals are rich in C_{29} hydrocarbons (associated with terrigenous organic matter) whereas the condensates have more nearly equal amounts of C_{27} and C_{29} steranes. This effect may not, however, be source related (see above). Traces of condensate were detected in the Nesna mudstones and for this reason there is an apparently good correlation. If allowance is made for increases in maturity (e.g. diminution of R isomers, peaks J and T for example) then the steranes fragmentograms suggest that the Hitra shales, but not the coals, could be a source for the tested condensates.

In conclusion, the carbon isotope data favour the coals (1 shales) from the Hitra Formation as the preferred condensate source. The Nesna mudstones, represented by the sample at 2399± metres are poor source rocks and are not typical of this unit. Migrated condensate in these mudstones has obscurred the indigenous species and precludes hydrocarbon based correlations. The GC-MS data indicate that a correlation, albeit not very good, does exist between the Hitra shales and the tested condensates.

FIGURE 7



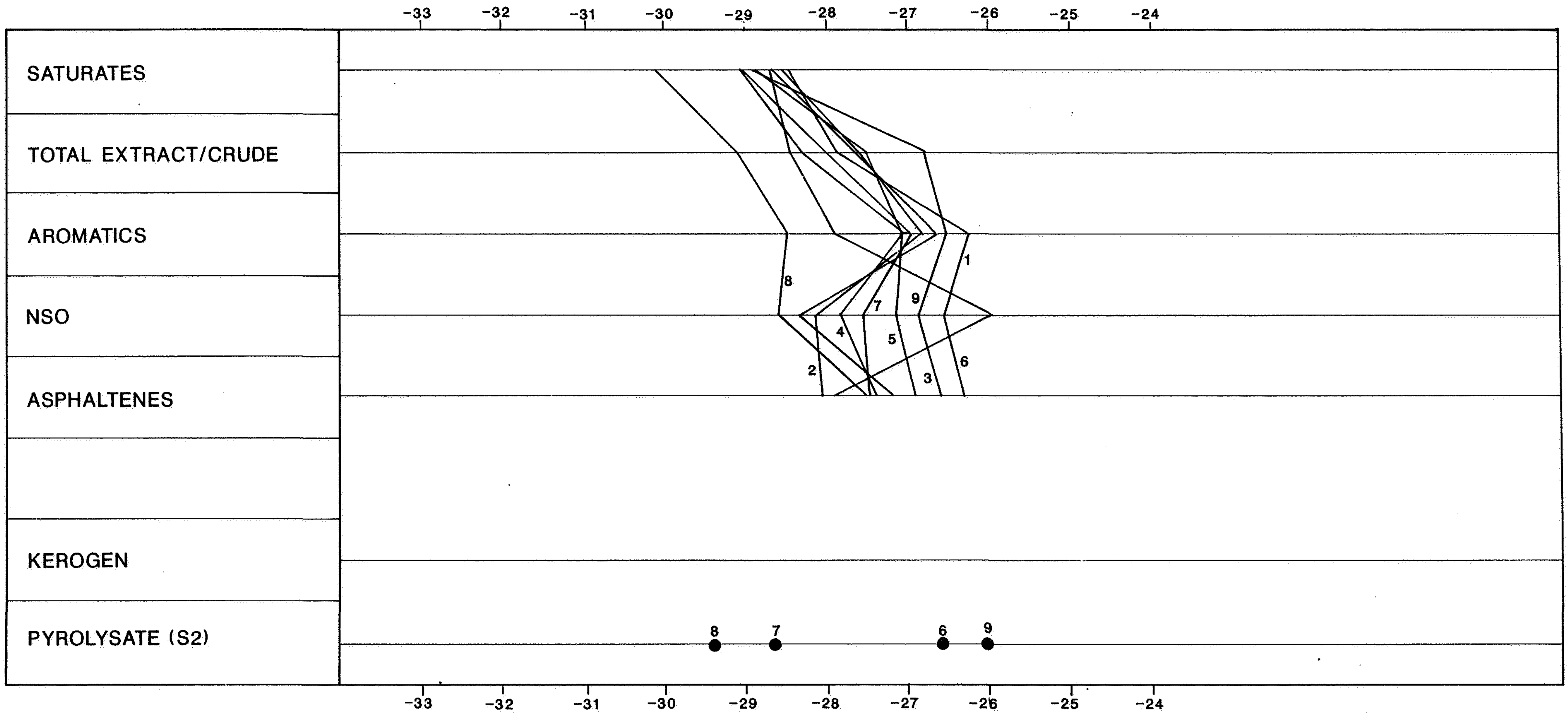
CARBON ISOTOPES
(‰ PDB)
GEOCHEM
DST-1 (CH_4)
Geochem
DST-1 (CH_4)
Total Extracts
Extracts HC (Sat + Arom)
Condensates
Kerogen pyrolysate
Methane Isotopes
1 2427.8-2435.8m
2 2508.7-2518.2m
3 2399m
4 2911m
5 2965m
6 3001m
7 3037m
8 3050m A
9 3050m B
δ C^{13} SATURATES
δ C^{13} AROMATICS
-33
-32
-31
-30
-29
-28
-27
-26
-25

FIGURE 8

WELL 6407/2-3

GALIMOV CARBON ISOTOPE PLOT
(‰, PDB)

1	2427.8-2435.8m
2	2508.7-2518.2m
3	2399m
4	2911m
5	2965m
6	3001m
7	3037m
8	3050m A
9	3050m B



APPENDIX 1

1. Analyse DST-1 gas sample by GC using thermal conductivity and F.I.D. detectors - Table 11a.

2. Given GOR 45.5 Sm^3/m^3
   and 1 mole gas occupies 22.4L at STP

3. Calculate moles of each component, per 45.5 cu m gas.
   e.g. methane 76.5%
   $$\text{moles methane} = \frac{45.5 \times 0.765 \times 1000}{22.4} = 1554$$

4. Analysis of DST-1 condensate - listed column 1 Table 11b

5. Calculate moles/cu m liquid - assuming average density 0.78g/ml (49° API).
   e.g. 0.48% isobutane mol. wt. 58
   $$\text{moles isobutane} = \frac{0.48}{100} \times 10^6 \times \frac{0.78}{58} = 64.6$$

6. Sum molar composition for gas and liquid phases and normalise - column 2 Table 11b.

7. Calculate equivalent volume for each component and normalise
   e.g. 0.9 mol % isobutane average liquid density 0.78 g/ml mol wt 58
   $$\text{volume ml} = \frac{0.9.58}{0.78} = 66.9 \text{ ml}$$

   Sum individual volumes and normalise
   Table 11b column 3

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
1523-061	2399m	A 98% Shaly mudstone, subfissile, mod hard, olive grey	5Y4/1	1.56,1.56
1523-004	2595m	A 95% Sandstone, blocky, medium grained, subangular, fairly well sorted, non-calc. cement, white	N9	
		B 5% Shale, subfissile to platy, soft to mod. hard, non-calc., medium dark grey Minor cavings Minor pyrites and lignite	N4	6.67
1523-006	2614m	A 85% Sandstone, blocky, medium grained, subangular, fairly well sorted, white	N9	
		B 15% Shale, subfissile, mod. hard, non-calc. to v. sl. calc., medium dark grey to medium grey Significant cavings Minor other shale and pyrites	N4-5	4.96
1523-009	2641m	A 80% Sandstone, mostly unconsolidated, medium grained, subangular, fairly well sorted, white	N9	
		B 10% Shale, platy, mod. hard, non-calc., medium dark grey Minor cavings	N4	1.58
		C 10% Shale/shaly claystone, subfissile, soft to mod. hard, non-calc., medium grey Minor cavings Minor other shale	N5	1.15,1.16
1523-011	2659m	A 85% Sandstone, blocky, medium grained, subangular, fairly well sorted, V. slow blooming cut, white	N9	
		B 15% Shale, platy to subfissile, mod. hard, non-calc., medium dark grey to medium grey Minor cavings Minor other shale	N4-5	1.62
1523-013	2677m	A 65% Sandstone, as 1523-011A V. slow blooming cut	N9	
		B 25% Shale, subfissile, mod. hard, sl. silty, non-calc., medium dark grey Minor to significant cavings	N4	1.55
		C 5% Claystone, blocky, soft, sl. calc., medium red Minor cavings	5R5/2	0.15
		D 5% LCM - metal		

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

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
1523-015	2695m	A 50% Sandstone, as 1523-011A V. slow blooming cut	N9	
		B 40% Shale, as 1523-013B Significant cavings	N4	2.03
		C 5% Claystone, as 1523-013C Minor cavings	5R5/2	0.14
		D 5% LCM - metal		
1523-017	2713m	A 50% Sandstone, blocky, fine - medium grained, subangular, fairly well sorted, white V. slow blooming cut	N9	
		B 45% Shale, subfissile to platy, mod. hard, non-calc., medium dark grey to medium grey Minor to significant cavings	N4-5	2.91,2.92
		C 5% Claystone, as 1523-013C Minor cavings Minor LCM	5R5/2	0.14
1523-019	2731m	A 60% Shale, as 1523-017B Minor to significant cavings	N4-5	1.89
		B 35% Sandstone, as 1523-017A V. slow blooming cut	N9	
		C 5% Claystone, as 1523-013C Significant cavings Minor LCM	5R5/2	0.17
1523-021	2749m	A 90% Shale, platy to subfissile, soft to mod. hard, non-calc., medium grey Significant cavings	N5	1.92,1.94
		B 10% Sandstone, as 1523-017A V. slow blooming cut Minor claystone LCM - cement and metal	N9	
1523-024	2776m	A 50% Shale, as 1523-021A Minor to significant cavings	N5	1.31
		B 40% Sand, unconsolidated, medium grained, subangular, fairly well sorted, white V. slow blooming cut	N9	
		C 5% Shale, platy, mod. hard, non-calc., medium dark grey Significant cavings	N4	4.09
		D 5% LCM - cement and metal Minor claystone		

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

TABLE 1
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GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
1523-026	2794m	A 95% Sand, as 1523-024B V. slow blooming cut	N9	
		B 5% Shale, as 1523-021A Significant cavings Minor other shale Minor LCM	N5	1.30
1523-028	2812m	A 95% Sand, as 1523-024B V. slow blooming cut	N9	
		B 5% Shale, as 1523-021A Significant cavings Minor pyrites	N5	1.30
1523-031	2839m	A 95% Sand, as 1523-024B V. slow blooming cut	N9	
		B 5% Shale, as 1523-021A Significant cavings Minor coal/lignite and pyrites Minor LCM	N5	2.00
1523-033	2857m	A 95% Sand, as 1523-024B V. slow blooming cut	N9	
		B 5% Shale, as 1523-021A Significant cavings Minor coal/lignite and pyritic Minor LCM	N5	2.00
1523-035	2875m	A 85% Sandstone, blocky, fine - medium grained, subangular, fairly well sorted, white to pinkish grey	N9-5YR8/1	
		B 15% Shale, platy to subfissile, mod. hard, non-calc., medium grey to medium dark grey Minor cavings Minor coal/lignite	N5-4	1.37
1523-037	2893m	A 90% Sandstone, mostly unconsolidated, fine - medium grained, subangular, fairly well sorted, white to pinkish grey	N9-5YR8/1	
		B 10% Shale, as 1523-035B Minor cavings Minor coal/lignite	N5-4	1.34
1523-039	2911m	A 85% Sandstone, as 1523-037A	N9-5YR8/1	
		B 15% Shale, as 1523-035B Minor to significant cavings Minor silica flour	N5-4	1.33
1523-041	2929m	A 90% Sandstone, as 1523-037A	N9-5YR8/1	
		B 10% Shale, as 1523-035B Minor to significant cavings Minor silica flour	N5-4	1.44,1.49

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

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ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
1523-043	2947m	A 90% Sand, unconsolidated, fine - medium grained, subangular, fairly well sorted, white	N9	
		B 5% Shale, subfissile, mod. hard, non-calc., medium grey to medium olive grey Significant cavings	N5-5Y5/1	1.12
		C 5% Shale, platy, mod. hard, non-calc., medium dark grey Minor cavings	N4	1.97
1523-045	2965m	A 75% Sandstone, blocky, fine - medium grained, subangular, fairly well sorted, pinkish grey Minor cavings	5YR8/1	
		B 15% Shale, as 1523-043B Significant cavings	N5-5Y5/1	1.39
		C 10% Coal, blocky, brittle, black	N1	58.20
1523-047	2983m	A 75% Sandstone, blocky, fine - medium grained, subangular, fairly well sorted, pinkish grey Minor cavings	5YR8/1	
		B 15% Shale, as 1523-043B Significant cavings	N5-5Y5/1	1.39
		C 10% Coal, as 1523-045C	N1	43.30
1523-049	3001m	A 55% Sandstone, as 1523-045A	5YR8/1	
		B 30% Shale, as 1523-043B Significant cavings	N5-5Y5/1	1.40
		C 15% Coal, as 1523-045C Significant cavings	N1	50.20
1523-051	3019m	A 40% Shale, as 1523-043B V. Slow blooming cut Significant cavings	N5-5Y5/1	1.47
		B 30% Sandstone, as 1523-045A Significant cavings	5YR8/1	
		C 30% Coal, as 1523-045C Significant cavings	N1	46.40
1523-053	3037m	A 55% Shale, platy to subfissile, mod. hard, non-calc., medium grey to medium olive grey	N5-5Y5/1	1.58,1.62
		B 25% Sandstone, as 1523-045A Significant cavings	5YR8/1	
		C 20% Coal, as 1523-045C Significant cavings	N1	57.40
1523-055	3050m	A 55% Shale, as 1523-053A Significant cavings	N5-5Y5/1	1.21
		B 30% Coal, as 1523-045C Significant cavings	N1	48.80
		C 10% Sandstone, as 1523-045A Significant cavings	5YR8/1	

S24

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

TABLE 2

ROCKEVAL PYROLYSIS DATA

GEOCHEM SAMPLE NUMBER	DEPTH	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	Production INDEX	Hydrogen INDEX	Oxygen INDEX	Tmax (%C)
1523-004B	2595	1.58	28.32	0.89	0.05	424.6	13.3	415
1523-006B	2614	0.48	3.60	0.66	0.12	72.6	13.3	432
1523-009B	2641	0.30	3.16	0.34	0.09	200.0	21.5	428
1523-011B	2659	0.27	3.35	0.37	0.07	206.8	22.8	429
1523-013B	2677	1.62	3.16	0.39	0.34	203.9	25.2	429
1523-015B	2695	2.13	3.66	1.09	0.37	180.3	53.7	434
1523-017B	2713	2.35	8.05	0.70	0.23	276.6	24.1	429
1523-019A	2731	1.68	4.91	0.52	0.25	259.8	27.5	429
1523-021A	2749	0.75	8.81	0.66	0.08	458.9	34.4	430
1523-024A	2776	0.42	10.39	0.40	0.04	793.1	30.5	427
1523-035B	2875	1.84	7.08	0.52	0.21	516.8	38.0	429
1523-037B	2893	1.00	8.16	0.65	0.11	609.0	48.5	430
1523-039B	2911	1.59	6.71	0.49	0.19	504.5	36.8	432
1523-041B	2929	1.63	9.27	0.53	0.15	643.7	36.8	429
1523-045C	2965	7.82	246.52	6.52	0.03	423.6	11.2	428
1523-047C	2983	1.93	107.74	9.35	0.02	248.8	21.6	429
1523-049C	3001	4.12	190.09	3.66	0.02	378.7	7.3	424
1523-051C	3019	2.05	222.19	4.65	0.01	476.8	10.0	427
1523-053A	3037	0.47	9.80	0.49	0.05	620.3	31.0	428
1523-053C	3037	3.73	197.19	4.11	0.02	343.5	7.2	428
1523-055A	3050	0.67	6.74	0.38	0.09	557.0	31.4	427
1523-055B	3050	1.57	160.52	6.31	0.01	328.9	12.9	430

TABLE 3

METHYL PHENANTHRENE INDEX (1) AND (2)

SAMPLE NUMBER		DEPTH	% AREA	% HEIGHT	% AREA	% HEIGHT
1523-061A		2399	0.74	0.58	0.66	0.60
1523-045C		2965	0.39	0.51	0.44	0.61
1523-049C		3001	0.38	0.40	0.49	0.41
1523-055A		3050	0.45	0.33	0.46	0.31
1523-055B		3050	0.47	0.47	0.62	0.54
1523-056	DST-2	2427.8-2435.8	0.77	0.48	0.90	0.63
1523-060	DST-1	2508.7-2518.2	0.43	0.45	0.28	0.37

$$\text{MPI (1)} = \frac{1.5 \quad (2\text{-MP} + 3\text{-MP})}{P + 1\text{-MP} + 9\text{-MP}}$$

$$\text{MPI (2)} = \frac{3 \quad (2\text{-MP})}{P + 1\text{-MP} + 9\text{-MP}}$$

P - Phenanthrene
2-MP, 3-MP, 9-MP - methyl phenanthrene

TABLE 4A
CONCENTRATION (PPM) OF EXTRACTED C_{15+} MATERIAL IN ROCK

JOB GEOCHEM SAMPLE NUMBER	LITHO	DEPTH	TOTAL EXTRACT	HYDROCARBONS			NON HYDROCARBONS			
				Saturates	Aromatics	TOTAL	Preciptd. Asphaltenes	Eluted NSO's	Non-eluted NSO's	TOTAL
1523-061A		2399	540	261	51	312	79	147	2	228
1523-006		2614	874	605	67	672	80	119	3	201
1523-011B		2659	729	203	69	271	169	283	6	457
1523-015B		2695	1918	985	161	1145	254	510	9	772
1523-021A		2749	523	208	48	256	89	172	5	267
1523-026		2794	305	108	27	135	106	63	1	170
1523-035		2875	446	129	38	166	106	171	2	280
1523-039		2911	184	63	14	77	54	53	1	108
1523-045		2965	483	93	61	154	118	206	4	329
1523-045C		2965	40938	4458	1207	5665	31115	4145	13	35273
1523-049		3001	814	150	105	255	194	361	4	559
1523-049C		3001	27405	3337	1389	4726	17468	5184	26	22679
1523-053A		3037	966	194	89	282	296	378	10	683
1523-055A		3050	2484	1276	215	1491	153	833	7	993
1523-055B		3050	28568	3614	1508	5121	17045	6371	30	23447

S — shale, **SS** — sandstone, **L** — limestone, **D** — dolomite, **M** — mixed, see Table 1.

TABLE 4B
COMPOSITION (NORMALISED %) OF C_{15+} MATERIAL

JOB / GEOCHEM SAMPLE NUMBER	LITHO	DEPTH	HYDROCARBONS: Saturates	HYDROCARBONS: Aromatics	NON HYDROCARBONS: Preciptd. Asphaltenes	NON HYDROCARBONS: Eluted NSO's	NON HYDROCARBONS: Non eluted NSO's
1523-061A		2399	48.39	9.43	14.64	27.17	0.37
1523-006		2614	69.28	7.68	9.13	13.58	0.33
1523-011B		2659	27.83	9.40	23.22	38.77	0.77
1523-015B		2695	51.36	8.37	13.24	26.58	0.45
1523-021A		2749	39.87	9.11	17.09	32.91	1.01
1523-026		2794	35.31	8.90	34.60	20.76	0.42
1523-035		2875	28.84	8.46	23.72	38.42	0.56
1523-039		2911	34.24	7.34	29.08	28.80	0.54
1523-045		2965	19.25	12.63	24.53	42.75	0.83
1523-045C		2965	10.89	2.95	76.00	10.13	0.03
1523-049		3001	18.42	12.89	23.81	44.35	0.53
1523-049C		3001	12.18	5.07	63.74	18.92	0.10
1523-053A		3037	20.06	9.18	30.65	39.12	0.99
1523-055A		3050	51.36	8.67	6.16	33.52	0.29
1523-055B		3050	12.65	5.28	59.67	22.30	0.11
1523-056	DST-2	2427.8-2435.8	89.79	6.37	0.45	3.18	0.21
1523-060	DST-1	2508.7-2518.2	88.62	7.06	0.53	3.18	0.61

S – shale, SS – sandstone, L – limestone, D – dolomite, M – mixed, see Table 1.

TABLE 5

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

JOB GEOCHEM SAMPLE NUMBER	LITHO	DEPTH	ORGANIC CARBON (wt. %)	HYDROCARBONS / TOTAL EXTRACT	HYDROCARBONS / ORG. CARBON	TOTAL EXTRACT / ORG. CARBON	SATURATES / AROMATICS
1523-061A		2399	1.53	57.82	2.04	3.53	5.13
1523-006		2614	0.89	76.96	7.55	9.82	9.02
1523-011B		2659	1.59	37.24	1.71	4.58	2.96
1523-015B		2695	2.37	59.73	4.83	8.09	6.14
1523-021A		2749	1.43	48.99	1.79	3.66	4.37
1523-026		2794	0.49	44.21	2.75	6.23	3.97
1523-035		2875	1.03	37.31	1.61	4.33	3.41
1523-039		2911	0.52	41.58	1.47	3.54	4.67
1523-045		2965	6.31	31.88	0.24	0.77	1.52
1523-045C		2965	59.50	13.84	0.95	6.88	3.69
1523-049		3001	6.30	31.31	0.40	1.29	1.43
1523-049C		3001	44.80	17.25	1.05	6.12	2.40
1523-053A		3037	3.29	29.24	0.86	2.94	2.18
1523-055A		3050	1.65	60.03	9.04	15.05	5.93
1523-055B		3050	58.30	17.93	0.88	4.90	2.40

S — shale, SS — sandstone, L — limestone, D — dolomite, M — mixed, see Table 1.

TABLE 6
COMPOSITION (NORMALISED %) OF C_{15+} SATURATE (PARAFFIN – NAPHTHENE) HYDROCARBONS

GEOCHEM SAMPLE NUMBER	061A	006	011B	015B	021A	026
DEPTH	2399.00	2614.00	2659.00	2695.00	2749.00	2794.00
SAMPLE TYPE	SWC					
nC15	19.64	12.68	5.05	42.00	47.46	18.29
nC16	22.56	14.55	8.21	13.37	12.71	11.64
nC17	12.66	13.93	9.94	7.64	8.47	10.93
nC18	7.14	13.20	10.66	6.68	5.93	11.88
nC19	4.71	11.54	8.76	4.77	4.24	10.21
nC20	4.06	8.94	7.58	3.34	2.54	8.31
nC21	3.90	6.76	6.24	2.39	2.54	6.18
nC22	3.41	4.47	5.84	1.91	1.69	4.51
nC23	3.25	3.12	6.08	1.91	1.69	3.09
nC24	2.60	1.98	4.97	1.43	.85	2.38
nC25	3.57	1.56	5.84	1.91	2.54	2.14
nC26	2.44	1.14	4.26	1.91	.85	1.90
nC27	4.55	1.14	5.52	2.39	1.69	1.66
nC28	1.62	1.04	3.16	1.91	1.69	1.19
nC29	1.95	.94	3.47	1.91	1.27	1.19
nC30	.49	.73	1.34	1.43	.85	.71
nC31	.49	.52	1.50	.95	.85	.71
nC32	.65	.42	.47	.95	.42	.95
nC33	.16	.52	.55	.48	.42	.95
nC34	.08	.42	.32	.48	.42	.71
nC35	.08	.42	.24	.24	.85	.48
Paraffin	46.32	44.83	44.64	61.35	40.69	40.72
Isoprenoid	8.57	4.71	3.07	3.51	2.76	3.38
Naphthene	45.11	50.47	52.29	35.14	56.55	55.90
CPI 1 Index	1.37	1.11	1.17	1.10	1.55	1.04
CPI 2 Index	1.75	1.05	1.48	1.11	1.58	1.06
CPI 3 Index	2.24	1.05	1.49	1.25	1.33	1.08
Prist/Phytane	1.59	1.52	1.64	2.00	1.67	1.33
Prist/nC17	.90	.46	.43	.50	.50	.43
Phytane/nC18	1.00	.31	.24	.29	.43	.30

$$\text{C.P.I. } 1 = \frac{1}{2}\left(\frac{C21+C23+C25+C27}{C20+C22+C24+C26} + \frac{C21+C23+C25+C27}{C22+C24+C26+C28}\right)$$

Job Number : 1523

$$\text{C.P.I. } 2 = \frac{1}{2}\left(\frac{C25+C27+C29+C31}{C24+C26+C28+C30} + \frac{C25+C27+C29+C31}{C26+C28+C30+C32}\right)$$

$$\text{C.P.I. } 3 = \frac{2x\ (C27)}{C26+C28}$$

CT – ditch cuttings CO – core SWC – sidewall core

GEOCHEM

TABLE 6
COMPOSITION (NORMALISED %) OF C_{15+} SATURATE (PARAFFIN – NAPHTHENE) HYDROCARBONS

GEOCHEM SAMPLE NUMBER	035	039	045	045C	049	049C
DEPTH	2875.00	2911.00	2965.00	2965.00	3001.00	3001.00
SAMPLE TYPE						
nC15	22.25	15.72	11.29	9.35	13.15	9.51
nC16	11.74	13.37	11.87	6.82	8.14	6.15
nC17	13.20	11.76	11.58	5.51	9.39	5.92
nC18	13.45	12.38	11.20	5.33	8.76	5.57
nC19	9.05	11.63	9.75	5.61	8.45	6.38
nC20	6.11	8.29	6.66	4.21	5.63	4.52
nC21	4.16	6.06	5.60	4.86	4.85	5.22
nC22	2.69	4.58	4.44	4.39	3.91	4.99
nC23	2.44	3.09	5.12	7.01	5.01	7.66
nC24	1.96	2.35	3.28	5.42	3.44	5.45
nC25	2.69	2.23	6.47	10.65	6.26	9.28
nC26	1.71	1.49	2.41	4.39	2.97	4.18
nC27	1.96	1.86	3.47	7.57	4.85	6.73
nC28	1.47	1.11	1.54	2.99	3.76	3.13
nC29	1.47	1.24	2.41	5.05	4.23	5.80
nC30	.73	.62	.77	1.96	1.56	1.97
nC31	.73	.87	.68	3.46	1.88	3.25
nC32	.49	.50	.48	1.50	.78	1.28
nC33	.49	.50	.58	2.24	.94	1.86
nC34	.73	.25	.19	.56	.94	.46
nC35	.49	.12	.19	1.12	1.10	.70
Paraffin	40.58	48.15	52.09	49.31	36.18	49.26
Isoprenoid	3.67	5.54	8.55	7.42	5.04	6.69
Naphthene	55.75	46.31	39.37	43.27	58.78	44.06
CPI 1 Index	1.17	1.09	1.50	1.69	1.40	1.57
CPI 2 Index	1.36	1.39	2.06	2.14	1.68	2.04
CPI 3 Index	1.23	1.43	1.76	2.05	1.44	1.84
Prist/Phytane	1.64	1.45	4.15	7.05	3.45	5.50
Prist/nC17	.43	.58	1.14	2.39	1.15	1.94
Phytane/nC18	.25	.38	.28	.35	.36	.38

$$\text{C.P.I. } 1 = \frac{1}{2}\left(\frac{C21+C23+C25+C27}{C20+C22+C24+C26} + \frac{C21+C23+C25+C27}{C22+C24+C26+C28}\right)$$

Job Number : 1523

$$\text{C.P.I. } 2 = \frac{1}{2}\left(\frac{C25+C27+C29+C31}{C24+C26+C28+C30} + \frac{C25+C27+C29+C31}{C26+C28+C30+C32}\right)$$

$$\text{C.P.I. } 3 = \frac{2x\ (C27)}{C26+C28}$$

CT – ditch cuttings CO– core SWC – sidewall core

TABLE 6

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

GEOCHEM SAMPLE NUMBER	053A	055A	055B
DEPTH	3037.00	3050.00	3050.00
SAMPLE TYPE			
nC15	11.88	22.91	11.92
nC16	15.36	20.75	9.03
nC17	15.47	16.44	7.03
nC18	12.33	11.59	5.65
nC19	8.30	7.01	5.90
nC20	5.38	4.58	3.89
nC21	3.92	2.70	4.39
nC22	2.80	1.89	4.02
nC23	3.36	1.89	6.52
nC24	2.13	1.08	4.52
nC25	3.48	1.62	8.78
nC26	1.91	1.08	3.89
nC27	3.03	1.62	6.65
nC28	1.91	1.08	2.89
nC29	2.91	1.35	5.14
nC30	1.12	.54	2.26
nC31	2.02	.81	3.89
nC32	.56	.27	1.13
nC33	.90	.40	1.76
nC34	.45	.13	.38
nC35	.78	.27	.38
Paraffin	47.83	49.14	56.48
Isoprenoid	6.81	7.02	6.66
Naphthene	45.36	43.84	36.85
CPI 1 Index	1.35	1.22	1.67
CPI 2 Index	1.85	1.62	2.11
CPI 3 Index	1.59	1.50	1.96
Prist/Phytane	2.97	2.12	6.23
Prist/nC17	.69	.59	1.45
Phytane/nC18	.29	.40	.29

$$C.P.I.\ 1 = \frac{1}{2}\left(\frac{C21+C23+C25+C27}{C20+C22+C24+C26} + \frac{C21+C23+C25+C27}{C22+C24+C26+C28}\right)$$

Job Number : 1523

$$C.P.I.\ 2 = \frac{1}{2}\left(\frac{C25+C27+C29+C31}{C24+C26+C28+C30} + \frac{C25+C27+C29+C31}{C26+C28+C30+C32}\right)$$

$$C.P.I.\ 3 = \frac{2x\ (C27)}{C26+C28}$$

CT – ditch cuttings CO – core SWC – sidewall core

TABLE 6

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

GEOCHEM SAMPLE NUMBER	056	060
DEPTH	2427.8-2435.8	2508.7-2518.2
SAMPLE TYPE	DST-2	DST-1
nC15	17.72	26.61
nC16	15.10	20.16
nC17	11.82	14.52
nC18	10.50	10.89
nC19	8.53	8.06
nC20	7.66	5.65
nC21	6.13	4.03
nC22	5.03	2.82
nC23	3.94	2.02
nC24	3.28	1.61
nC25	2.84	.81
nC26	1.97	.81
nC27	1.75	.40
nC28	1.09	.20
nC29	.88	.20
nC30	.44	.20
nC31	.44	.20
nC32	.22	.20
nC33	.22	.20
nC34	.22	.20
nC35	.22	.20
Paraffin	34.23	61.08
Isoprenoid	5.69	8.13
Naphthene	60.07	30.79
CPI 1 Index	1.05	1.00
CPI 2 Index	1.23	.86
CPI 3 Index	1.14	.80
Prist/Phytane	1.81	2.30
Prist/nC17	.91	.64
Phytane/nC18	.56	.37

$$\text{C.P.I. } 1 = \frac{1}{2}\left(\frac{C21+C23+C25+C27}{C20+C22+C24+C26} + \frac{C21+C23+C25+C27}{C22+C24+C26+C28}\right)$$

Job Number : 1523

$$\text{C.P.I. } 2 = \frac{1}{2}\left(\frac{C25+C27+C29+C31}{C24+C26+C28+C30} + \frac{C25+C27+C29+C31}{C26+C28+C30+C32}\right)$$

$$\text{C.P.I. } 3 = \frac{2x\ (C27)}{C26+C28}$$

CT – ditch cuttings CO – core SWC – sidewall core

NBS 22 STANDARD	

TABLE 7
CARBON ISOTOPE COMPOSITIONS ($^{o}/oo$, PDB)

GEOCHEM SAMPLE NUMBER	DEPTH	TOTAL EXTRACT WHOLE OIL	SATURATES	AROMATICS	NSO	ASPHALTENES	KEROGEN	PYROLYSATE S2
1523-056	2427.8-2435.8m		-28.60	-26.63	-28.34	-27.16		
1523-059	2508.7-2518.2m							
1523-060	2508.7-2518.2m		-28.59	-26.77	-28.34	-28.07		
1523-061A	2399m	-28.43 -28.38	-28.64	-27.94	-25.97	-27.92		
1523-039	2911m	-28.34	-29.07	-27.07	-27.80	-26.91		
1523-045C	2965m	-27.53	-28.63	-27.04	-27.17	-26.92		
1523-049C	3001m	-27.89	-28.49	-26.22	-26.56	-26.36		-26.56
1523-053A	3037m	-27.96	-29.08	-26.94	-27.55	-26.95		-28.61
1523-055A	3050m	-29.11	-30.12	-29.45	-29.59	-28.53		-29.42
1523-055B	3050m	-26.76	-28.98	-26.58	-26.88	-26.68		-26.06

TABLE 8
BIOMARKER MOLECULAR RATIOS

GEOCHEM SAMPLE NUMBER	SAMPLE DEPTH/ IDENTITY	SAMPLE TYPE	STERANES (m/z 217, 218)				TERPANES (m/z 191, 177)					
			$C_{29}\ \frac{\alpha\alpha\alpha\ 20S\ [Q]}{\alpha\alpha\alpha\ 20R\ [T]}$	$C_{29}\ \frac{\alpha\beta\beta\ 20R\ [R]}{\alpha\alpha\alpha\ 20R\ [T]}$	$C_{27}\ \frac{20S DIAST [A]}{20R DIAST [B]}$	$\frac{C_{27}\ \beta\beta}{C_{29}\ \beta\beta}$ (218)	$\frac{Tm [B]}{Ts [A]}$	$\frac{C_{29},\ 17\alpha\text{-}NH\ [C]}{[C] + C_{30},\ 17\alpha\text{-}H\ [E]}$	$C_{29}\ \frac{NM\ [D]}{[D] + NH\ [C]}$	$\frac{28,30\text{-}BNH\ [Z]}{[Z] + C_{29},\ 17\text{-}NH\ [C]}$	$\frac{28,30\text{-}BNH\ [Z]}{[Z] + 25,28,30\text{-}TNH\ (177)}$	$C_{31}\ \frac{20S\ [G]}{[G] + 20R\ [H]}$ %
1523-061	2399m		0.5	0.76	1.8	1.41	4.55	0.41	0.28	0.08	0.5	29%
1523-056	2427.8- 2435.8m		0.47	0.93	1.45	1.15	2.23	0.31	0.18	0.23	0.56	53%
1523-060	2508.7- 2518.2m		0.53	0.93	1.52	1.29	1.51	0.38	0.13	0.26	0.6	53%
1523-045	2965m		0.22	0.33	1.8	1	5.1	0.29	0.21	0.1	0.6	55%
1523-049	3001m		0.61	0.76	1.7	0.86	1.41	0.34	0.15	0.19	0.5	58%
1523-053	3037m		0.27	0.58	1.27	0.86	7.67	0.4	0.22	0.18	0.73	50%
1523-055A	3050m		0.22	0.53	1.2	0.9	3.43	0.36	0.3	0.27	0.61	38%
1523-055B	3050m		0.32	0.49	1.97	0.65	113.15	0.35	0.3	0.05		59%

[A] etc. REFERS TO IDENTIFICATION ON APPROPRIATE MASS FRAGMENTOGRAM **DIAST** – DIASTERANES **H** – HOPANE **NH** – NORHOPANE **BNH** – BISNORHOPANE

CT – ditch cuttings **CO** – core **SWC** – sidewall core **TNH** – TRISNORHOPANE **NM** – NORMORETANE

TABLE 8

PEAK AREA RATIOS

SAMPLE NUMBER	DEPTH (metres)	MPI 1	MPI 2	RATIO 1	RATIO 2	RATIO 3
1523-061	2399	0.7	0.8	0.33	0.39	0.17
1523-056	2427.8-2435.8	0.58	0.61	0.17	0.43	0.18
1523-060	2508.7-2518.2	0.58	0.62	0.08	0.41	0.42
1523-045	2965	0.42	0.5	0.07	0.23	0.52
1523-049	3001	0.42	0.49	0.2	0.22	0.17
1523-053	3037	0.43	0.49	0.15	0.26	0.17
1523-055A	3050	0.45	0.5	0.16	0.25	0.23
1523-055B	3050	0.37	0.45	0.13	0.22	0.1

TABLE 9

PEAK AREA DATA

(M/Z 217

SAMPLE NUMBER (depth)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1523-061 (2399m)	1963	1074	706	873	927	485	1144	1868	1103	1398	1293	301	175	461	370	615	650	977	574	1278
1523-056 (2427.8-2435.8m)	564	389	150	237	260	141	205	598	205	208	499	218	67	129	121	160	147	286	140	307
1523-060 (2508.7-2518.2m)	738	483	247	293	337	225	327	749	208	371	692	169	50	170	201	213	194	338	147	363
1523-045 (2965m)	449	248	174	267	276	150	193	705	166	163	456	220	79	106	140	161	189	277	158	839
1523-049 (3001m)	793	446	287	416	473	261	505	1095	443	1118	1036	305	263	412	326	528	649	811	585	1061
1523-053 (3037m)	1395	1096	736	562	644	438	1191	2802	960	1894	2325	283	187	496	584	1032	865	1827	962	3158
1523-055A (3050m)	915	762	436	225	340	281	698	1648	428	1560	1589	432		339	371	815	496	1162	528	2169
1523-055B (3050m)	142	72	55	80	86	88	107	698	110	141	650	259			154	262	379	591	260	1189

TABLE 9
PEAK AREA DATA
M/Z 218

SAMPLE NUMBER (depth)	AB	CD	EF
1523-061 (2399m)	2665	1230	1884
1523-056 (2427.8-2435.8m)	590	298	512
1523-060 (2508.7-2518.2m)	804	237	620
1523-045 (2965m)	523	191	519
1523-049 (3001m)	1207	760	1390
1523-053 (3037m)	2226	1069	2585
1523-055A (3050m)	1424	623	1567
1523-055B (3050m)	312	101	479

TABLE 9
PEAK AREA DATA
M/Z 177

SAMPLE NUMBER (depth)	A
1523-061 (2399m)	801
1523-056 (2427.8-2435.8m)	154
1523-060 (2508.7-2518.2m)	166
1523-045 (2965m)	76
1523-049 (3001m)	385
1523-053 (3037m)	745
1523-055A (3050m)	559
1523-055B (3050m)	

TABLE 9
PEAK AREA DATA
(M/Z 191

SAMPLE NUMBER (depth)	A	B	Z	C	C_1	X	D	E	F	G	H	I	J	J_1	K	K_1	L	L_1	M	M_1
1523-061 (2399m)	1745	7947	815	8869	1116	651	3572	12373	5926	4173	9996	4626								
1523-056 (2427.8-2435.8m)	234	522	203	655	58	175	144	1441	217	594	514	174	285	187	132	85	50	31		
1523-060 (2508.7-2518.2m)	241	365	254	722	212	156	109	1167	184	474	409	103	211	179	118	51	40	39		
1523-045 (2965m)	211	1077	115	1108	189	169	295	1534	445	769	611	310	307	253	142	131				
1523-049 (3001m)	602	850	396	1589	537	310	295	3020	423	1317	955	236	548	409	343	235	180	110	67	73
1523-053 (3037m)	657	5042	2077	9059	1232	1053	2633	13246	3926	5088	5117	1884	1600	1693	639	597	428	315		
1523-055A (3050m)	364	1252	878	2312	638	423	1016	3987	1240	1594	2553	1106	430	745	173	297	115	159		
1523-055B (3050m)	73	8260	329	6114	447	588	2719	11162	4799	6766	4730	3161	2323	1827	647	564	251	159		

TABLE 9

PEAK AREA DATA

SAMPLE NUMBER (depth)	M/Z 178		M/Z 192			M/Z 253			M/Z 231		
	P	3 MP	2 MP	9 MP	1 MP	C_{21}	C_{28}	C_{29}	C_{20}	C_{21}	C_{28}
1523-061 (2399m)	47083	18423	24502	23182	21014	544	2634	3988	500	510	983
1523-056 (2427.8-2435.8m)	17602	5083	5636	5747	4322	256	1330	1747	26	39	122
1523-060 (2508.7-2518.2m)	2856	866	1000	1162	761	230	509	709	6	34	67
1523-045 (2965m)	14592	2969	4497	6967	5299	295	525	1682	18	37	211
1523-049 (3001m)	9432	2060	2906	4471	3730	63	327	1163	26	35	100
1523-053 (3037m)	148284	31737	42675	52370	46481	1176	6242	17286	356	496	1960
1523-055A (3050m)	42436	9633	11789	14820	13561	962	4033	11873	123	110	639
1523-055B (3050m)	134229	24038	35677	60408	44039	313	2830	9704	260	361	1671

TABLE 10

BULK FLUID PROPERTIES

GEOCHEM SAMPLE NUMBER	1523-056	1523-060
Sample	DST-2	DST-1
Depth (m)	2427.8-2435.8	2508.7-2518.2
API gravity (°API)	49.0	49.3
Sulphur (%)	0.01	0.02
Vanadium (ppm)	<1.0	<1.0
Nickel (ppm)	<1.0	<1.0
C_{15+} Fraction (%)	47.4	46.1

GEOCHEM SAMPLE NUMBER	1523-059
Sample	DST-1 GAS
Methane H/D Isotope ratio	$-188^{o}/oo$
Methane carbon isotope ratio	$-33.0^{o}/oo$

TABLE 11A

C_1-C_8 HYDROCARBONS COMPOSITION

Geochem Sample No: 1523-059

Sample : DST-1 Gas Sample

COMPONENT	NORMALISED (%)
Methane	76.50
Ethane	4.90
Propane	3.90
iso-Butane	1.20
n-Butane	1.77
iso-Pentane	0.04
n-Pentane	0.04
2-Methyl pentane	0.035
n-Hexane	0.035
n-Heptane	0.035
Methyl cyclohexane	0.032
Nitrogen	8.86
Oxygen	2.25
Carbon dioxide	0.38
Carbon monoxide	0.02

TABLE 11B

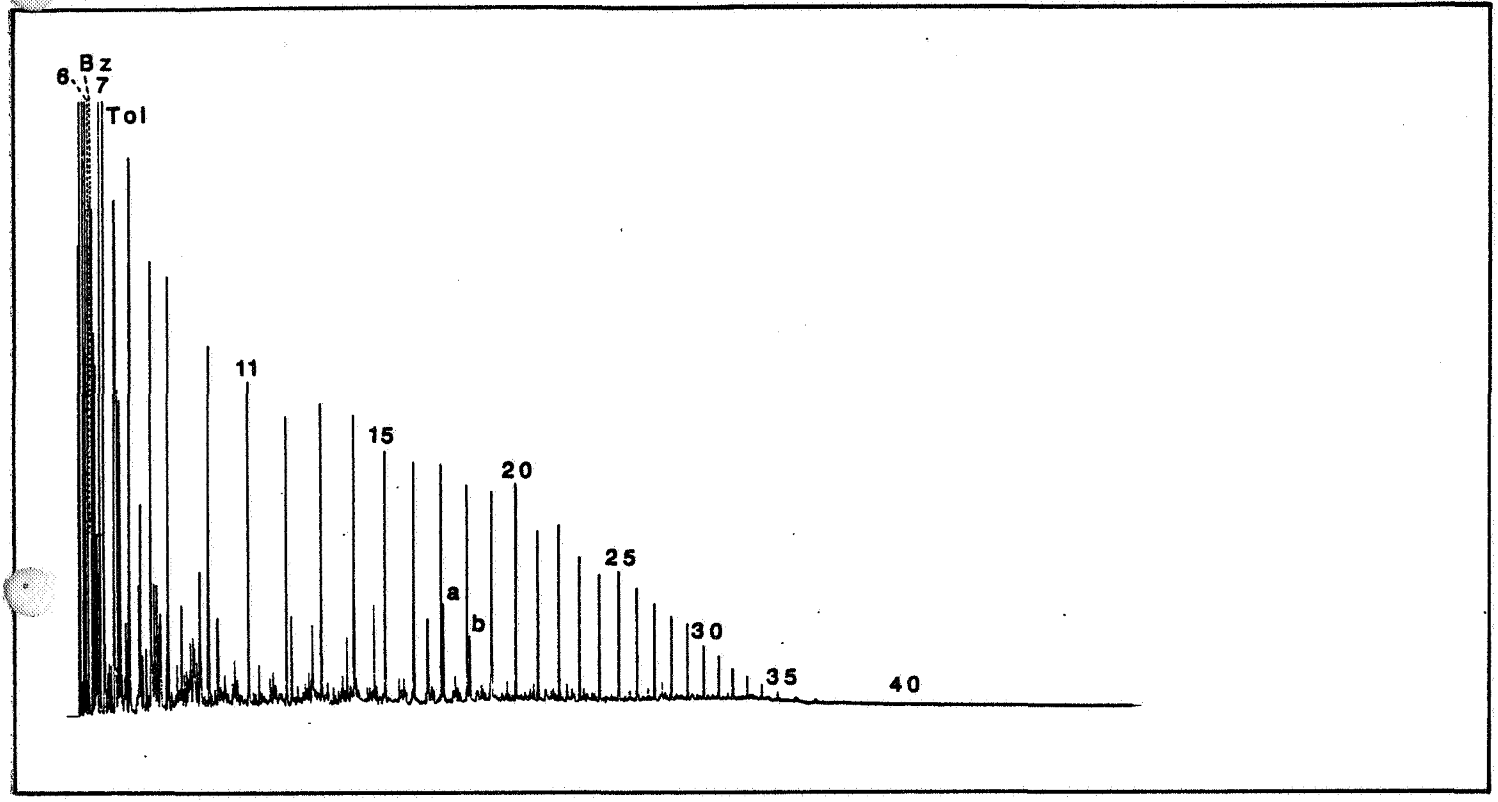
DETAILED HYDROCARBONS (C1-C8) ANALYSIS

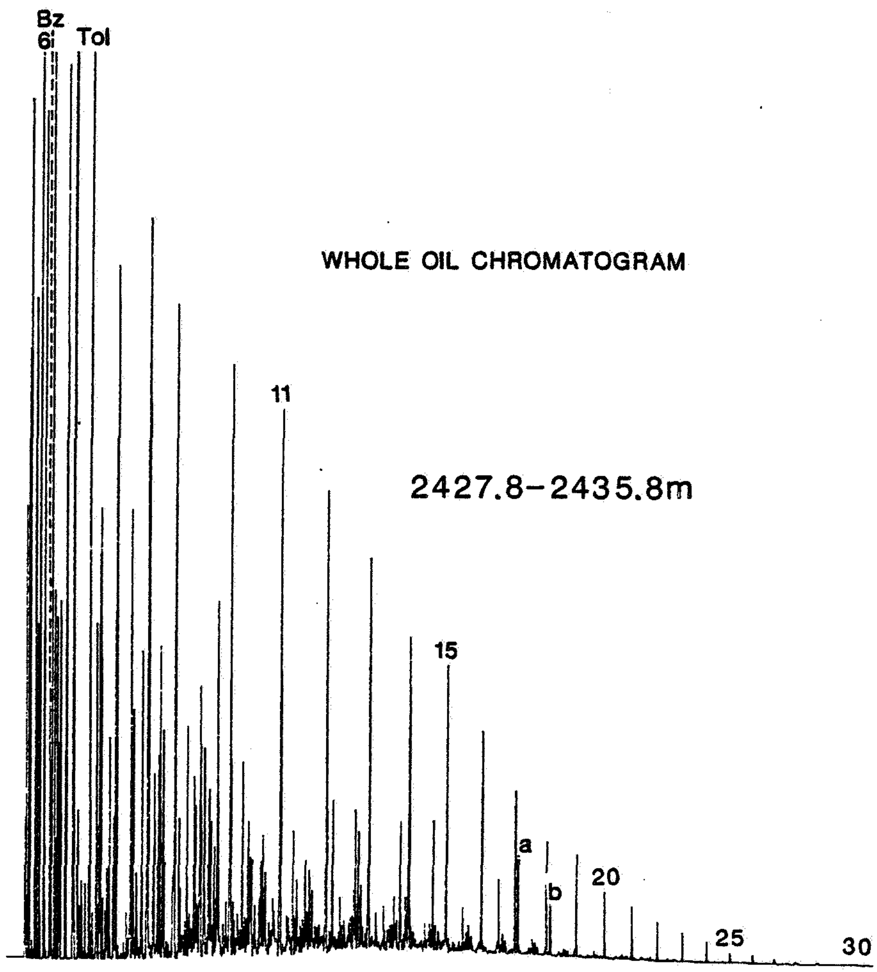
GEOCHEM SAMPLE			
NUMBER :	1523-060	Recombined Fluid	
DEPTH :	DST-1 CONDENSATE	Mole	Volume
	2508.7-2518.2m	(%)	(%)
methane	-	14.6	2.9
ethane	-	0.9	3.3
propane	-	0.7	0.4
nitrogen	-	1.7	0.3
oxygen	-	0.4	0.1
carbon dioxide	-	0.1	0.1
isobutane	0.48	0.9	0.6
n-butane	1.17	1.9	1.4
isopentane	1.49	1.6	1.4
n-pentane	2.37	2.6	2.3
2,2-dimethylB	0.26	0.2	0.2
cyclopentane(CP)	0.85	0.9	0.8
2,3-dimethylB	0.11	0.1	0.1
2-methylP	2.24	2.6	2.1
3-methylP	1.54	1.4	1.5
n-hexane	5.31	4.8	5.1
methylCP(MCP)	4.13	3.7	3.8
2,2-dimethylP	0.45	0.3	0.3
2,4-dimethylP	0.10	0.1	0.1
2,2,3-trimethylB	0.25	0.2	0.2
benzene	1.60	1.6	1.5
cyclohexane(CH)	0.72	6.1	6.3
3,3-dimethylP	-	-	-
1,1-dimethylCP	-	-	-
2-methylH	2.71	2.1	2.6
2,3-dimethylP	0.91	0.7	0.9
3-methylH	3.11	2.4	3.0
1,c,3-dimethylCP	1.65	1.3	1.6
1,t,3-dimethylCP	1.69	1.3	1.6
1,t,2-dimethylCP	2.64	2.0	2.0
3-ethylP	-	-	-
n-heptane	10.62	8.2	10.1
methylCH(MCH)	22.88	18.1	21.9
1,c,2-dimethylCP	-	-	-
toluene	12.80	8.7	9.9
n-octane	12.01	8.2	11.6

FIGURE 9a

WHOLE OIL CHROMATOGRAMS

WELL 6407/2-3





DST - 2 OIL SAMPLE

a - PRISTANE
b - PHYTANE

Bz - BENZENE
To - TOLUENE

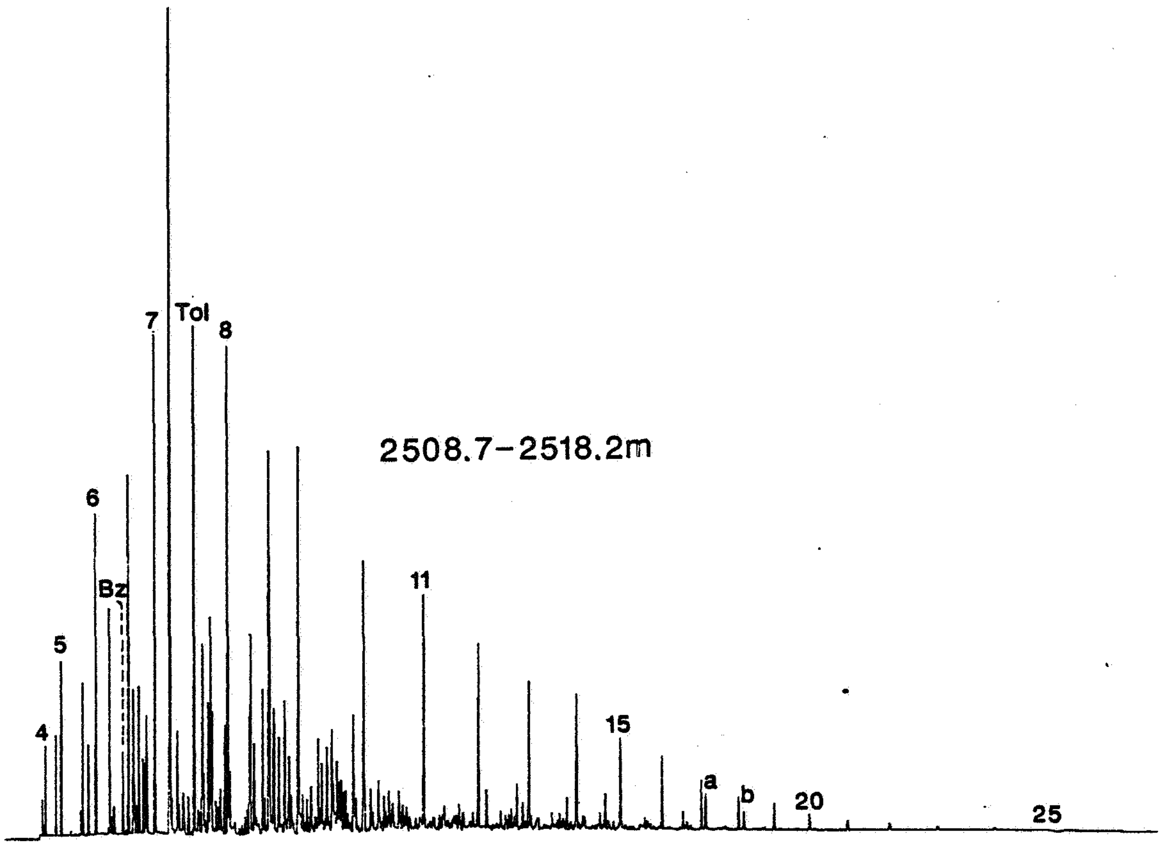
NORMAL PARAFFINS IDENTIFIED BY CARBON NUMBERS

FIGURE 9b

WHOLE OIL CHROMATOGRAMS

WELL 6407/2-3

GEOCHEM



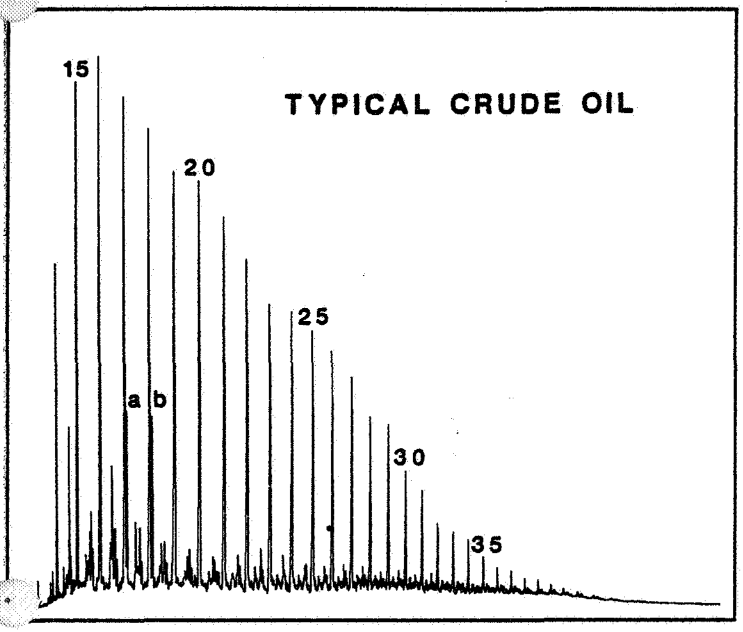
a - PRISTANE
b - PHYTANE

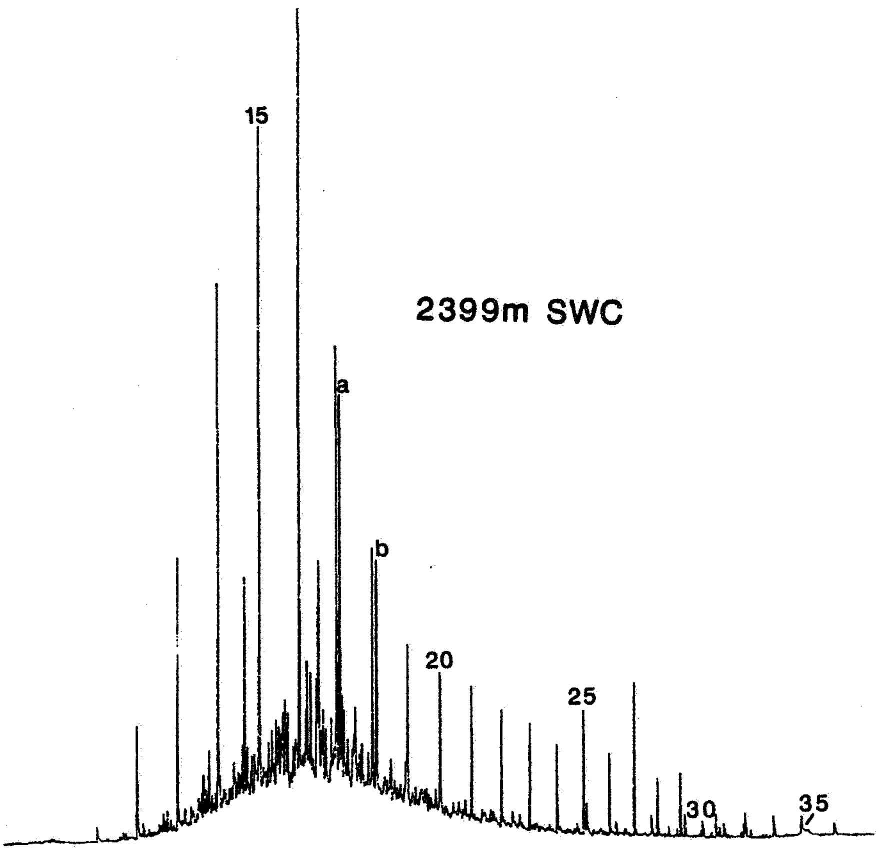
Bz - BENZENE
To - TOLUENE

NORMAL PARAFFINS IDENTIFIED BY CARBON NUMBERS

FIGURE 10a C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3





a - PRISTANE

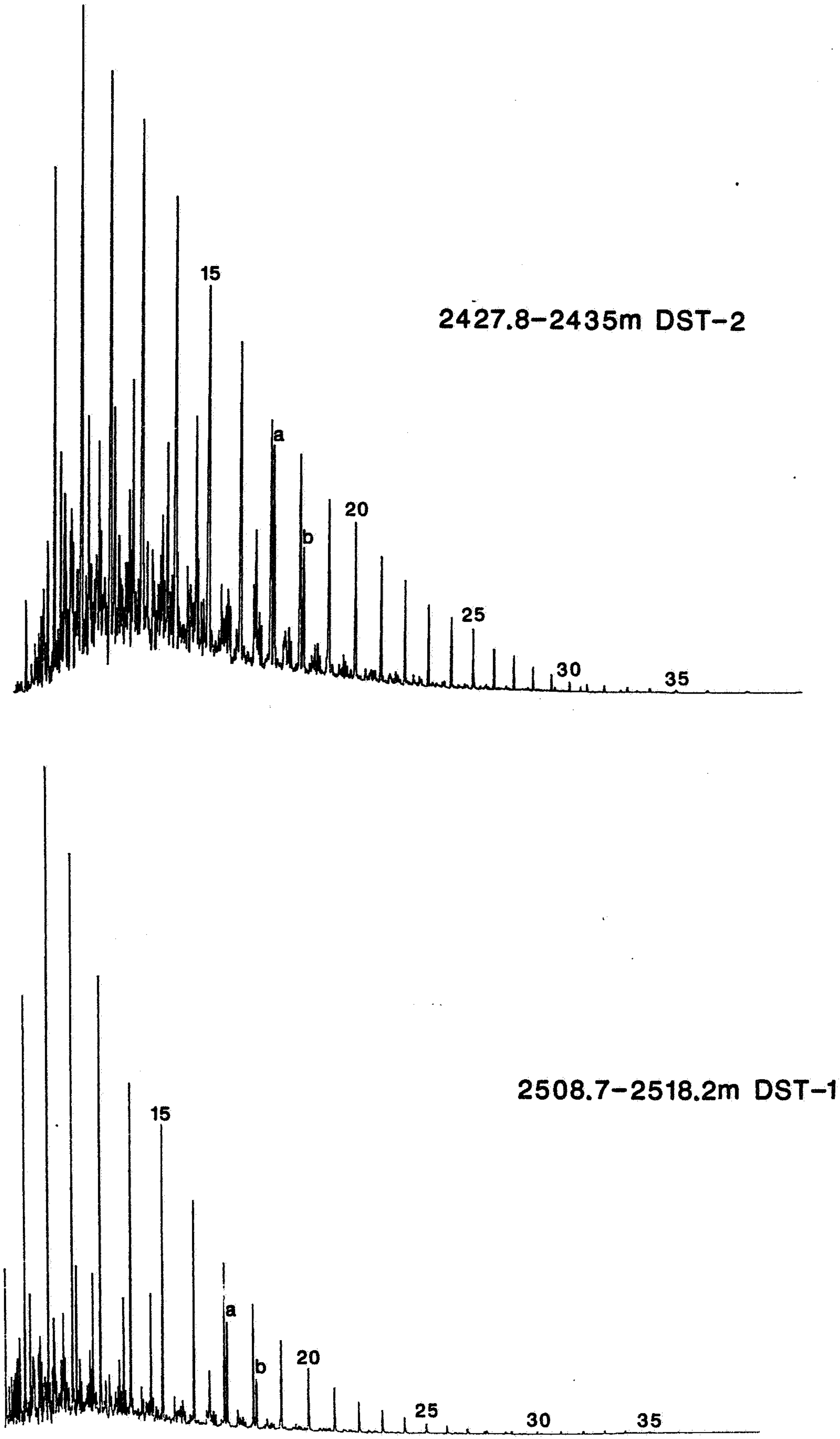
b - PHYTANE

CARBON NUMBERS OF NORMAL PARAFFINS INDICATED (20-n.C_{20})

FIGURE 10b

C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3



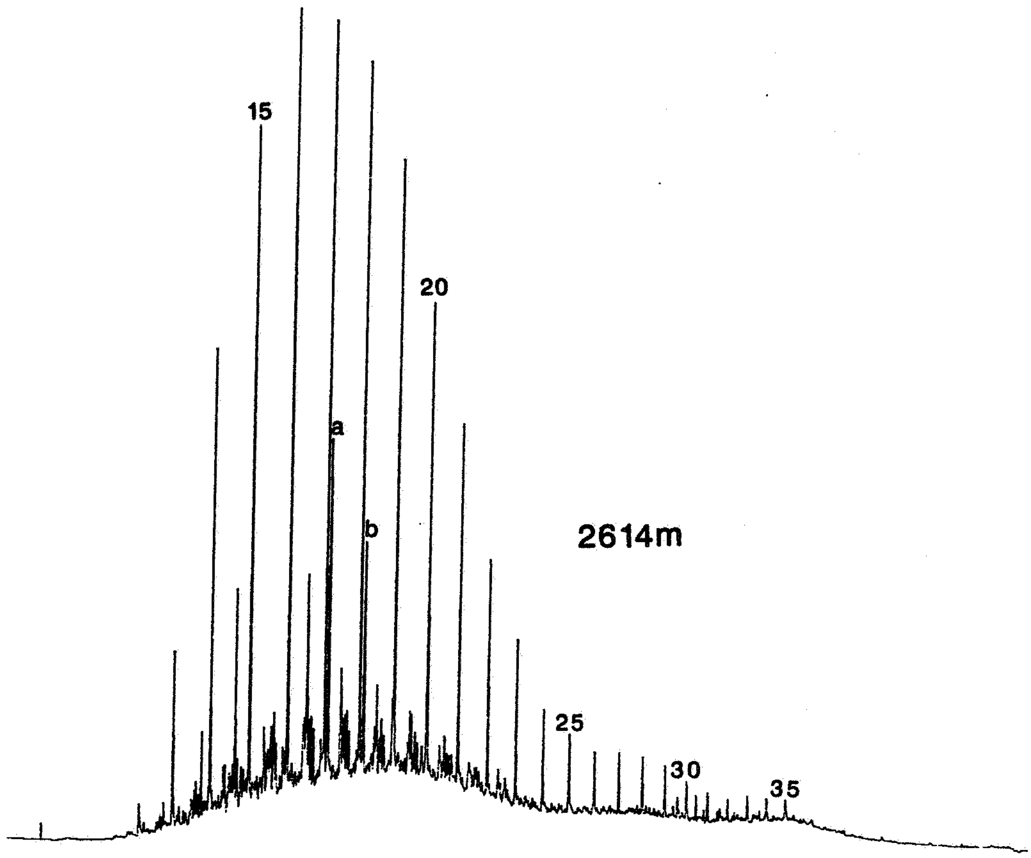
a = PRISTANE

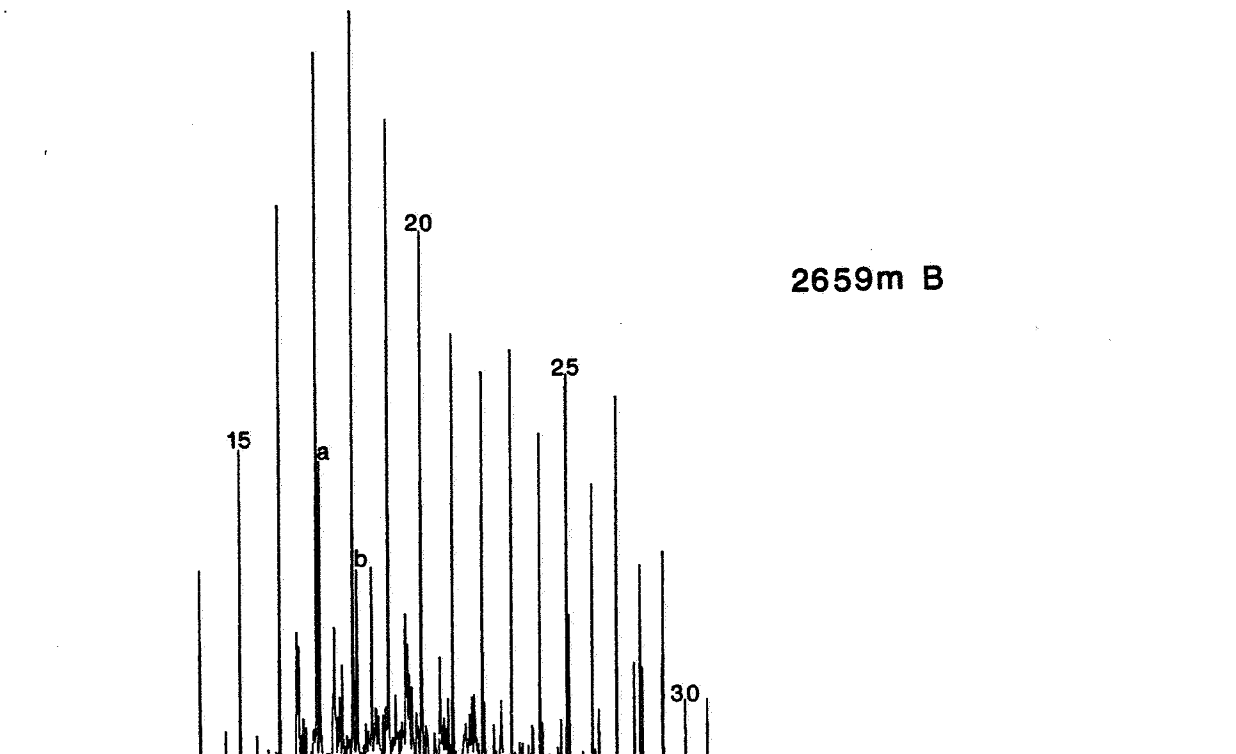
b = PHYTANE

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

FIGURE 10c C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3





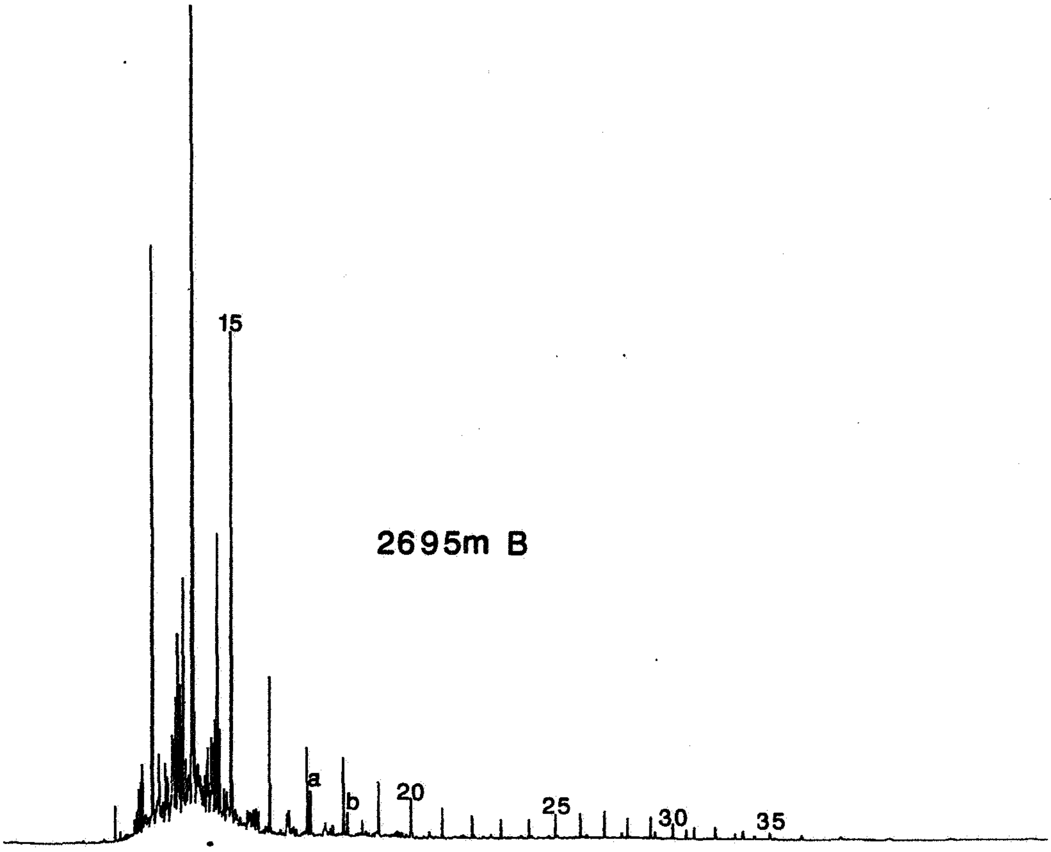
a = PRISTANE

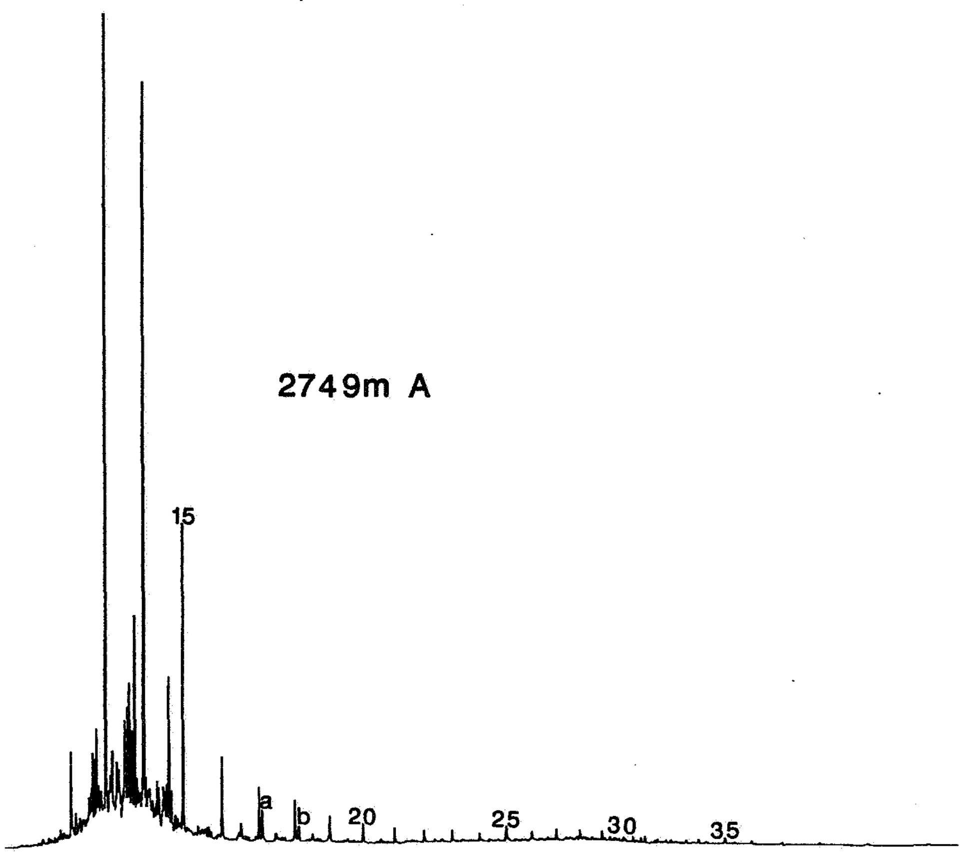
b = PHYTANE

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

FIGURE 10d C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3





a = PRISTANE

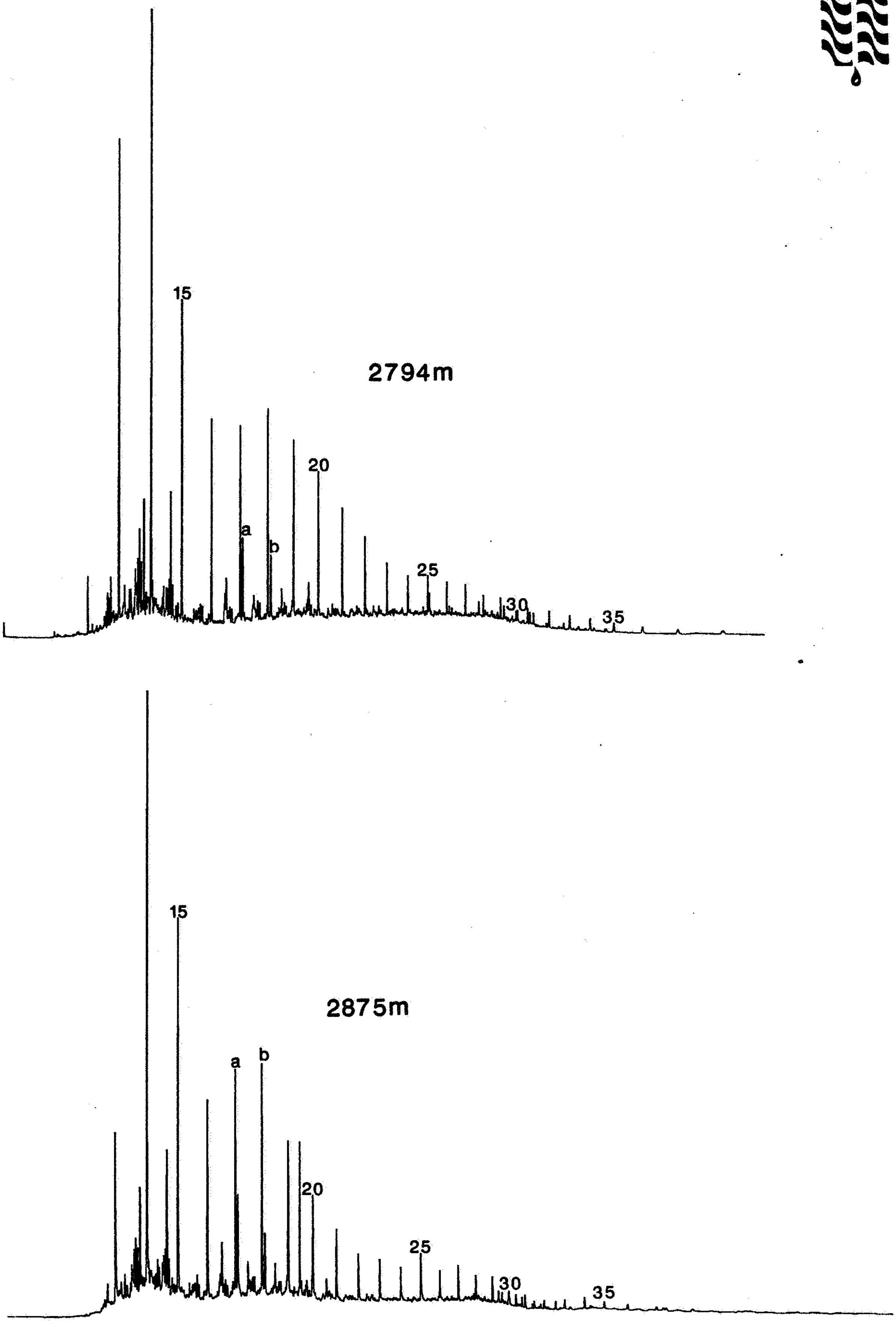
b = PHYTANE

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

FIGURE 10e

C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3



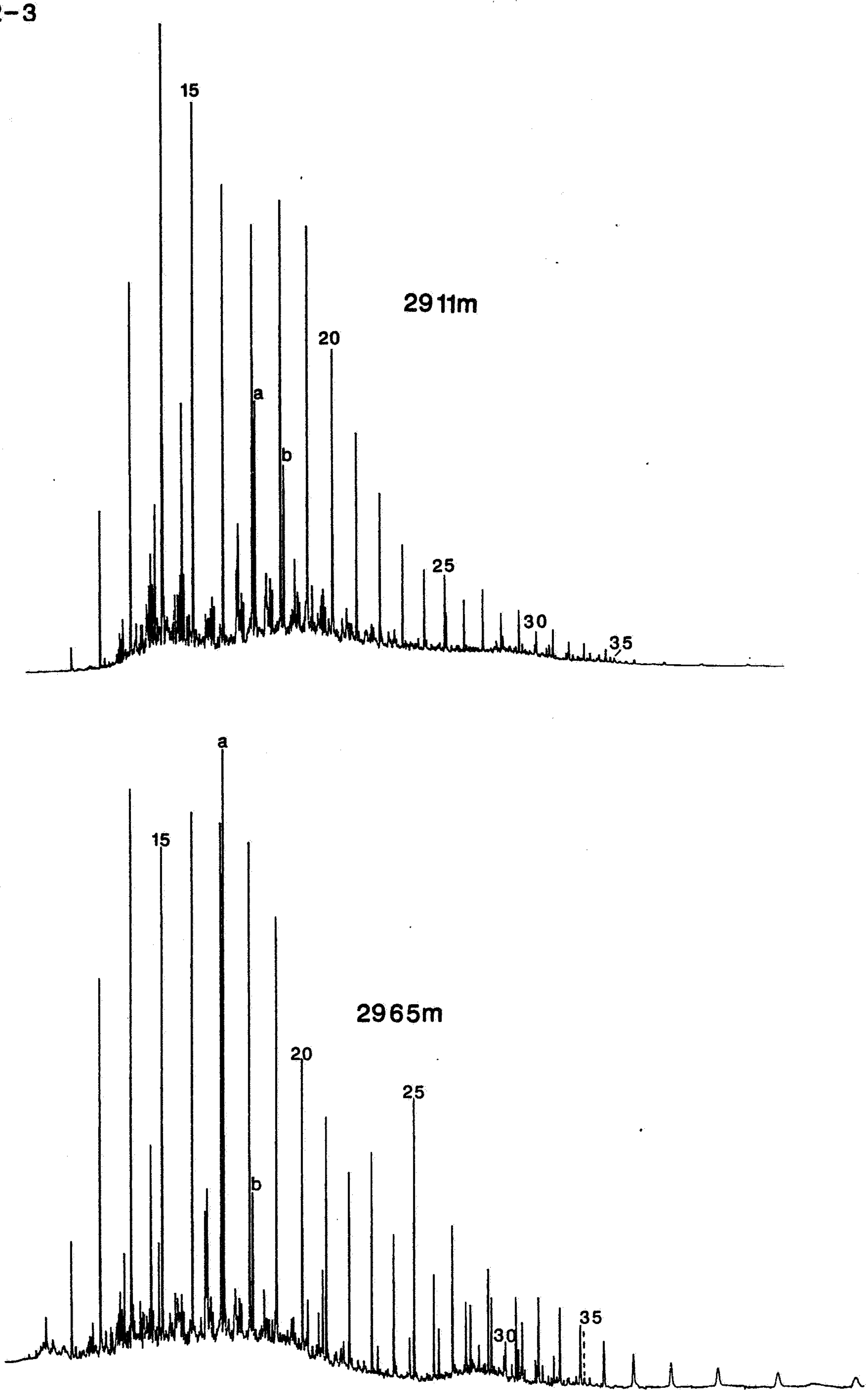
a = PRISTANE

b = PHYTANE

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

FIGURE 10f C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3



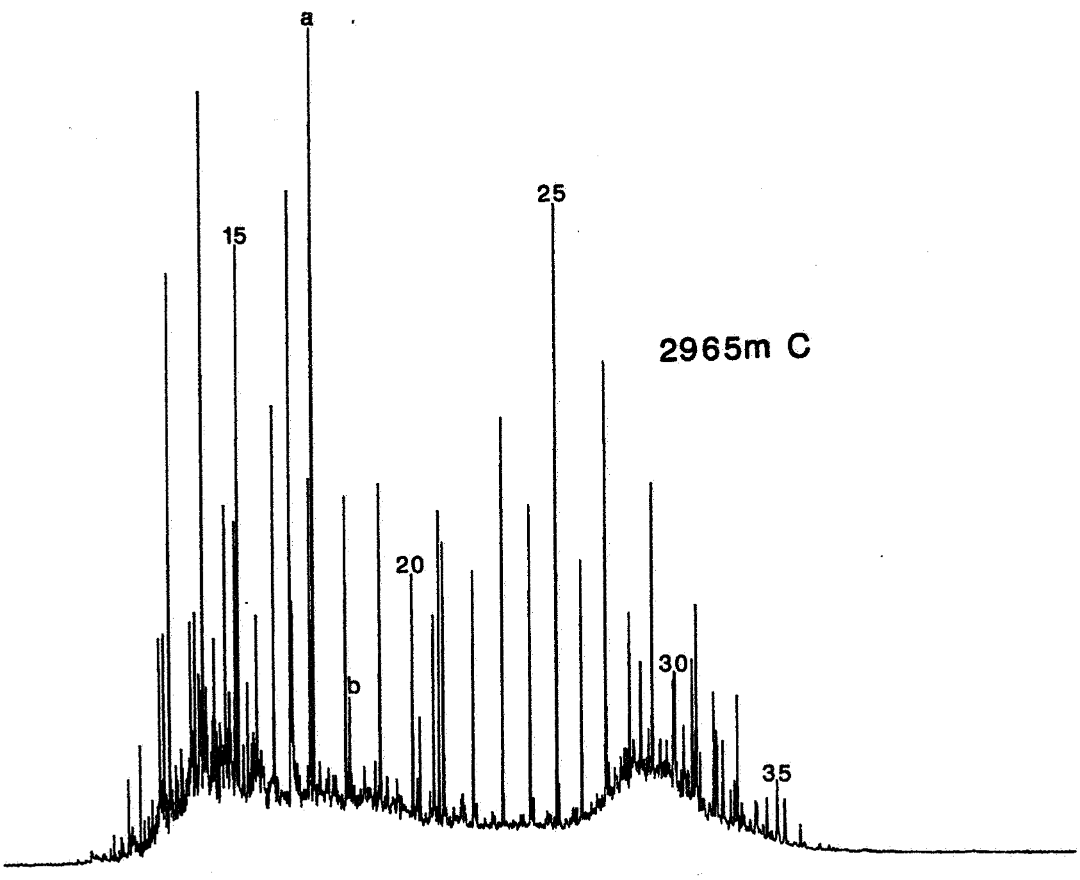
a = PRISTANE

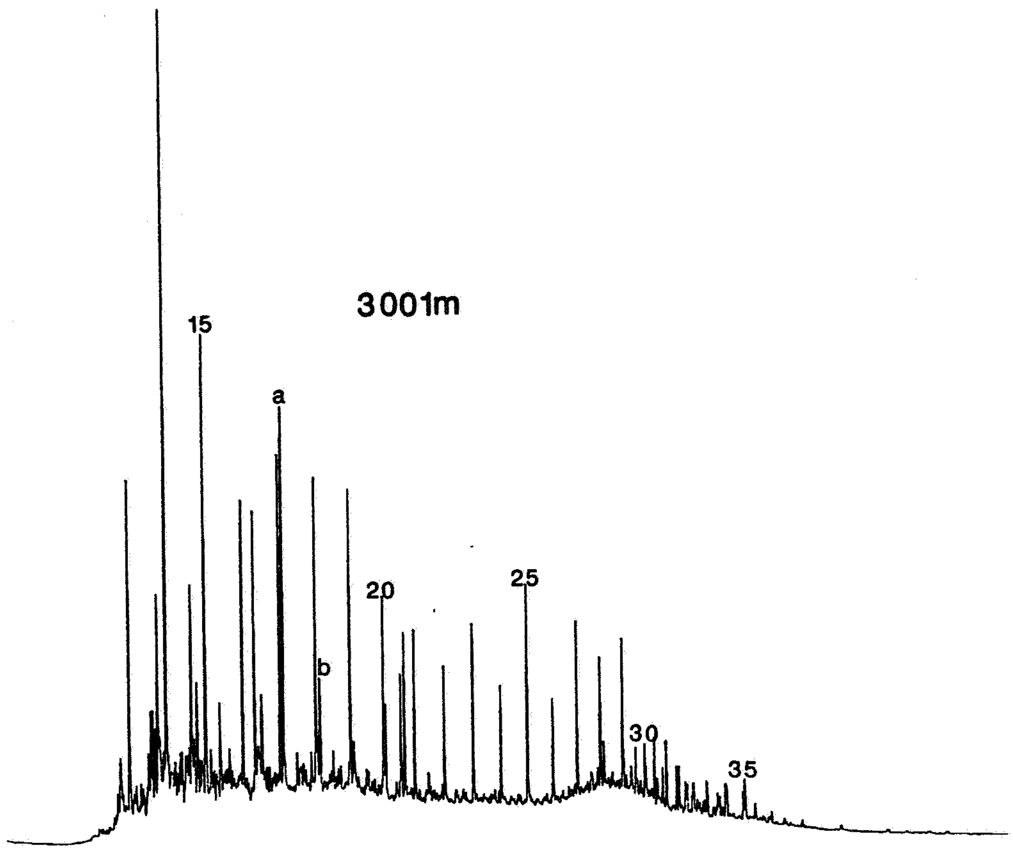
b = PHYTANE

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

FIGURE 10g **C_{15+} SATURATES CHROMATOGRAMS**

WELL 6407/2-3





a = PRISTANE

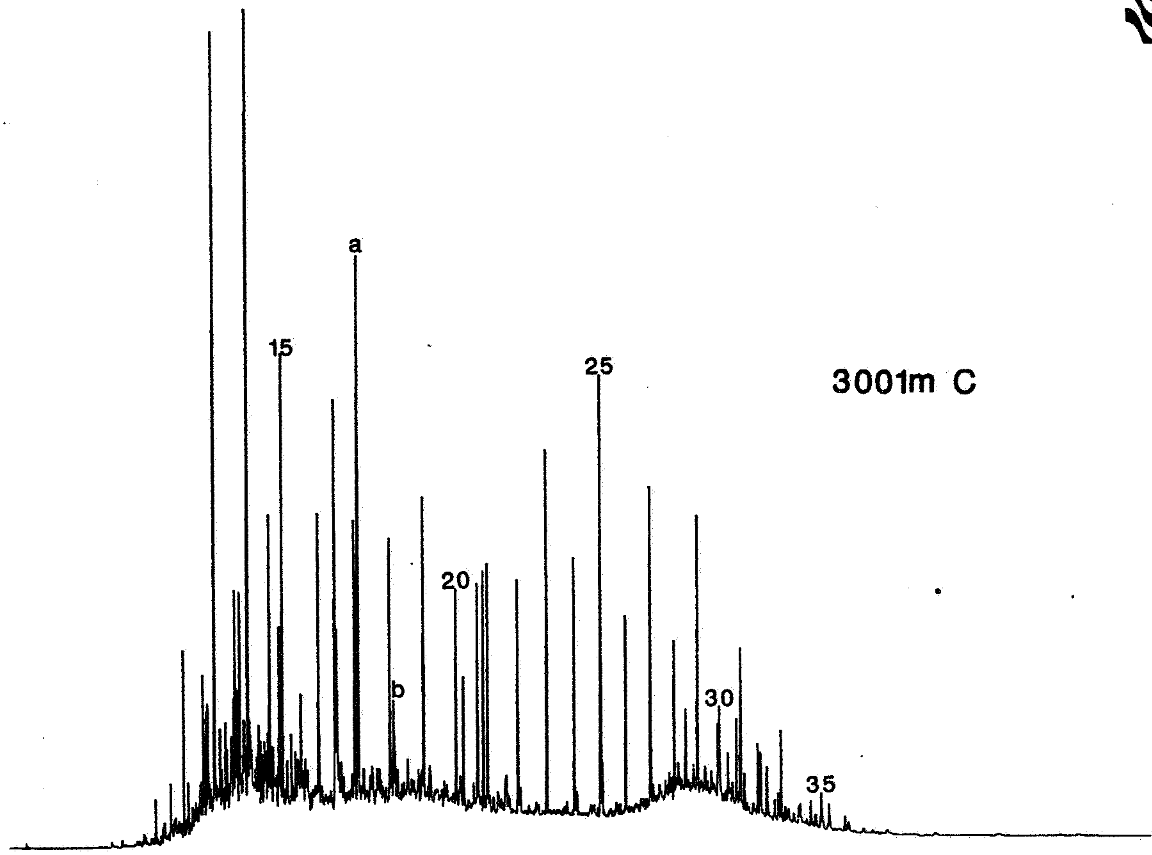
b = PHYTANE

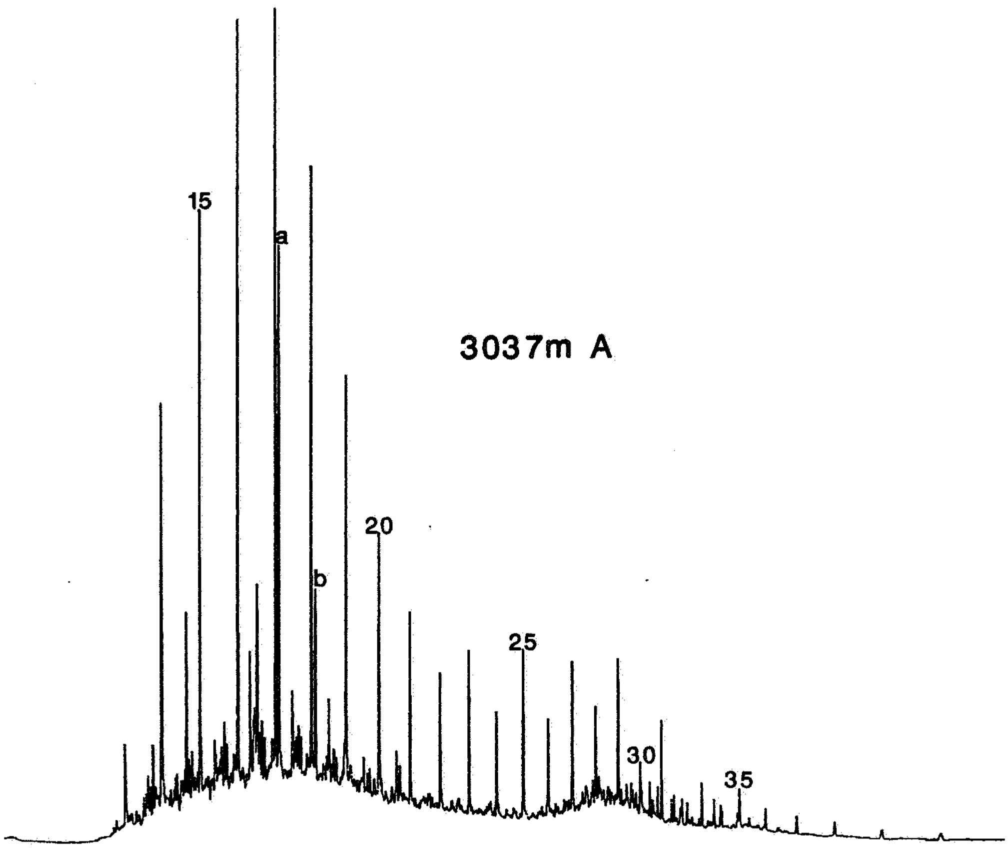
CARBON NUMBERS OF NORMAL PARAFFINS INDICATED (20 - nC_{20})

FIGURE 10h

C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3





a = PRISTANE

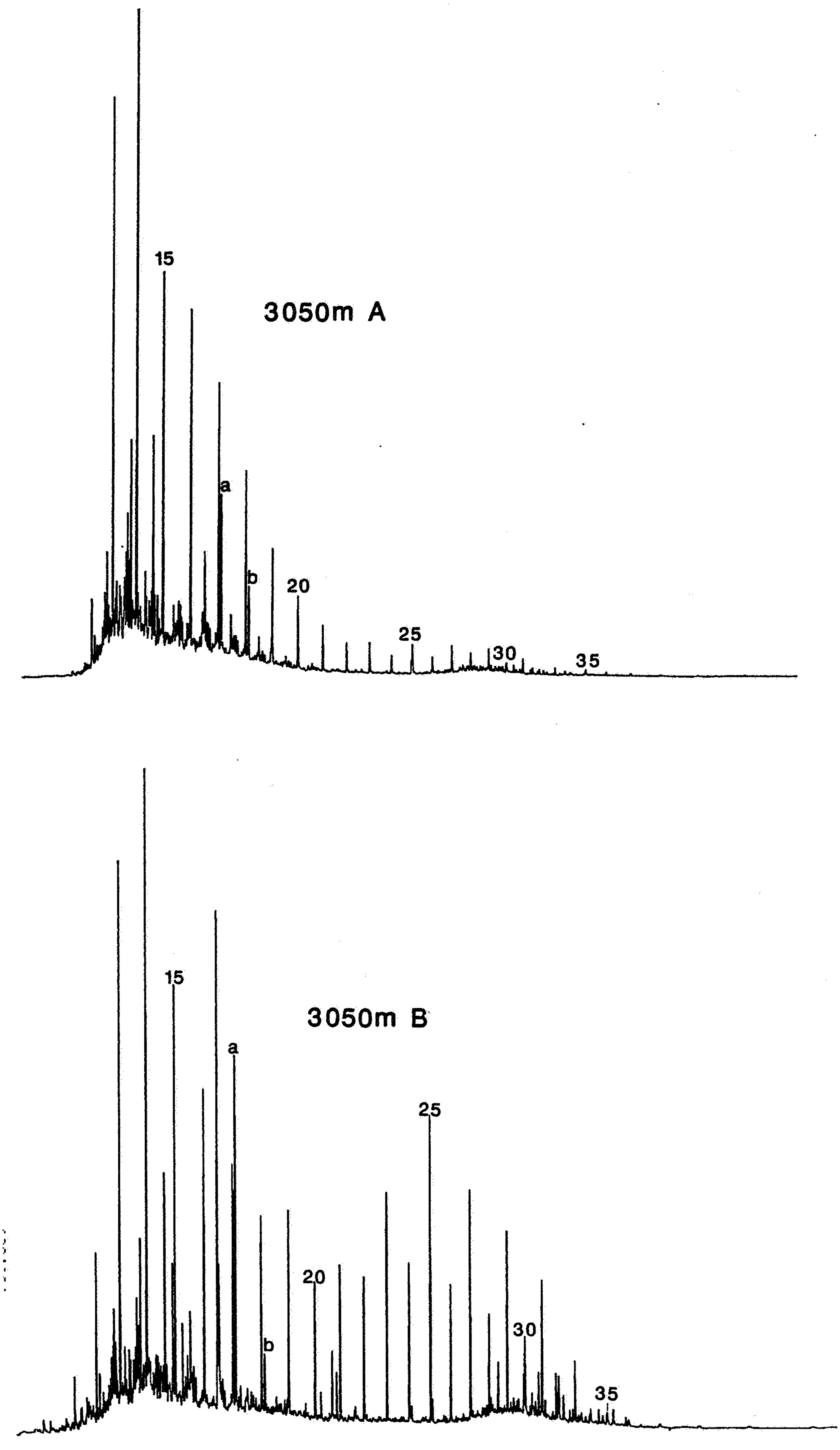
b = PHYTANE

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

FIGURE 10i

C_{15+} SATURATES CHROMATOGRAMS

WELL 6407/2-3



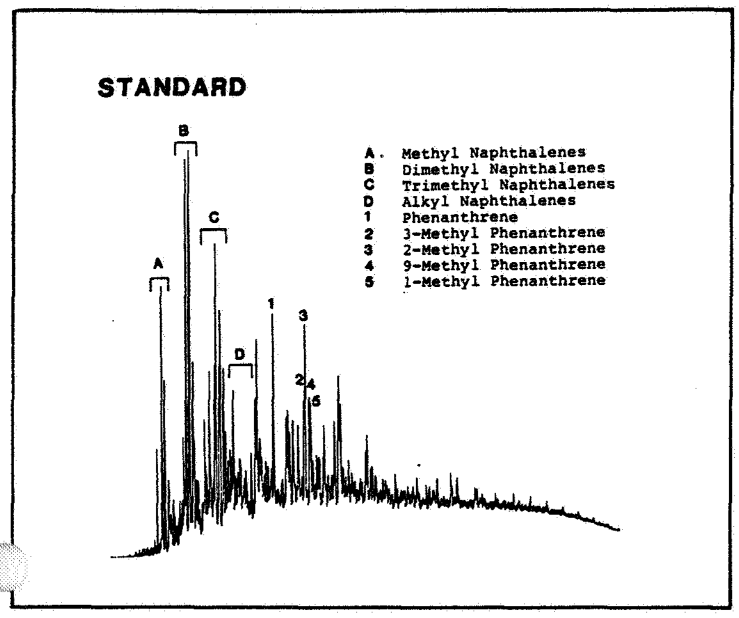
a = PRISTANE

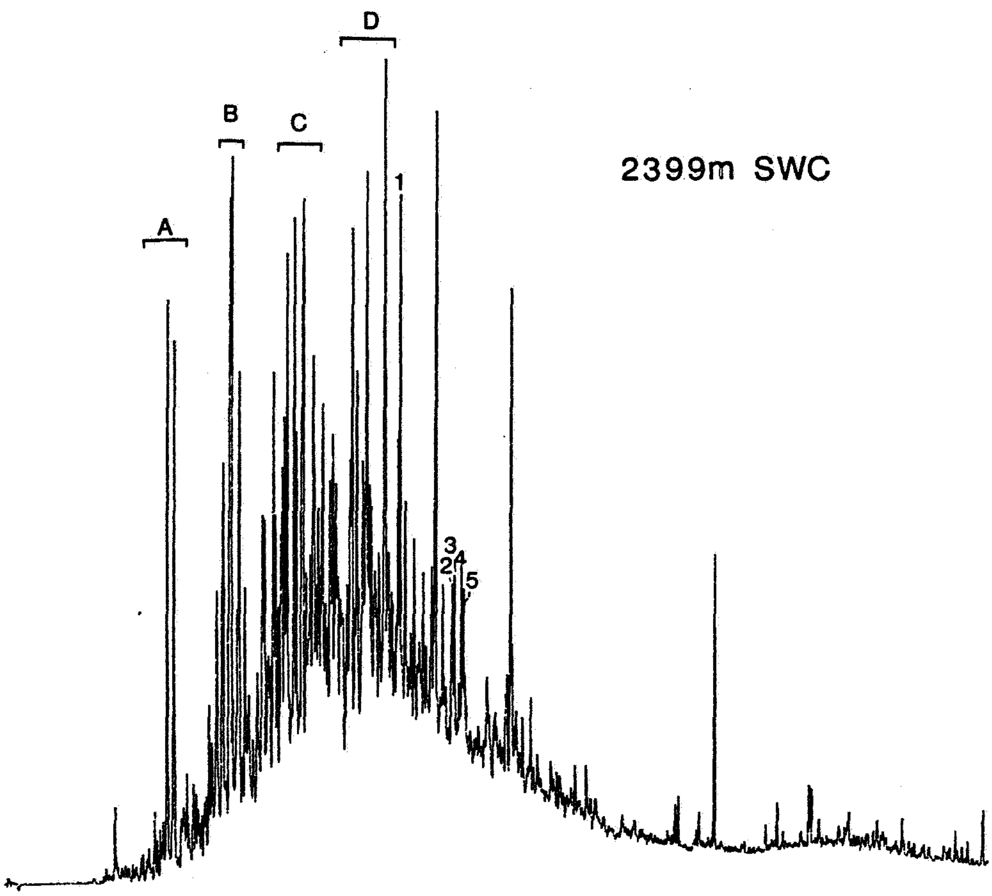
b = PHYTANE

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

FIGURE 11a C_{15+} AROMATIC CHROMATOGRAMS

WELL 6407/2-3



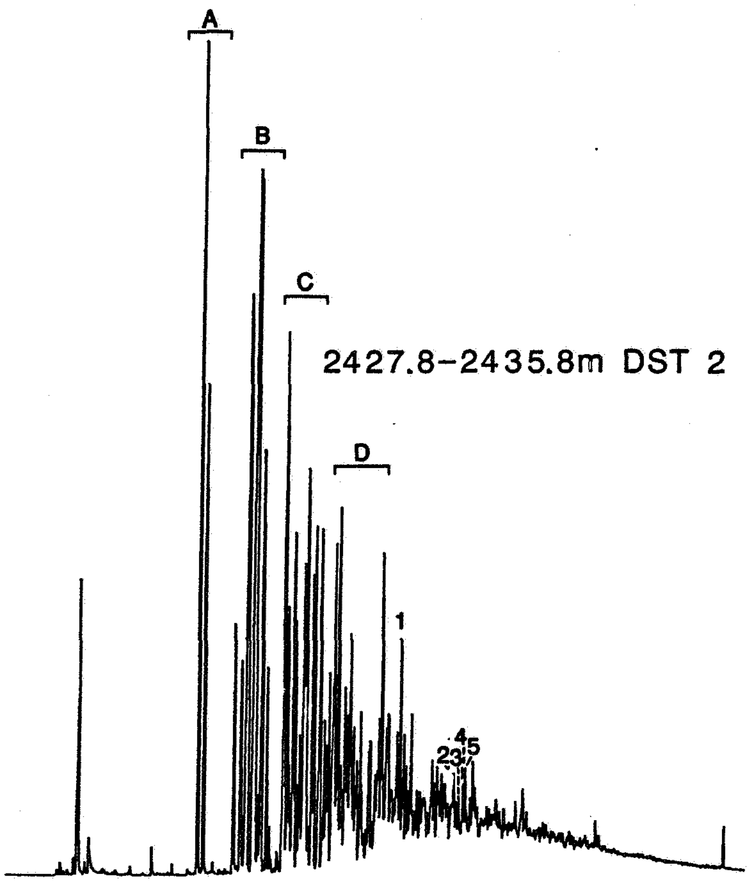


2399m SWC

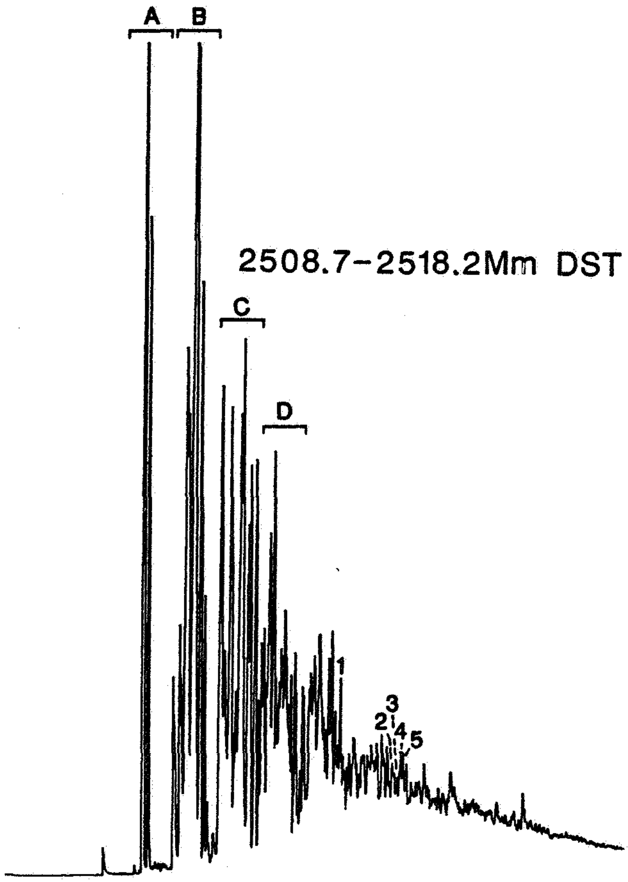
FIGURE 11b

C_{15+} AROMATIC CHROMATOGRAMS

WELL 6407/2-3



2427.8-2435.8m DST 2



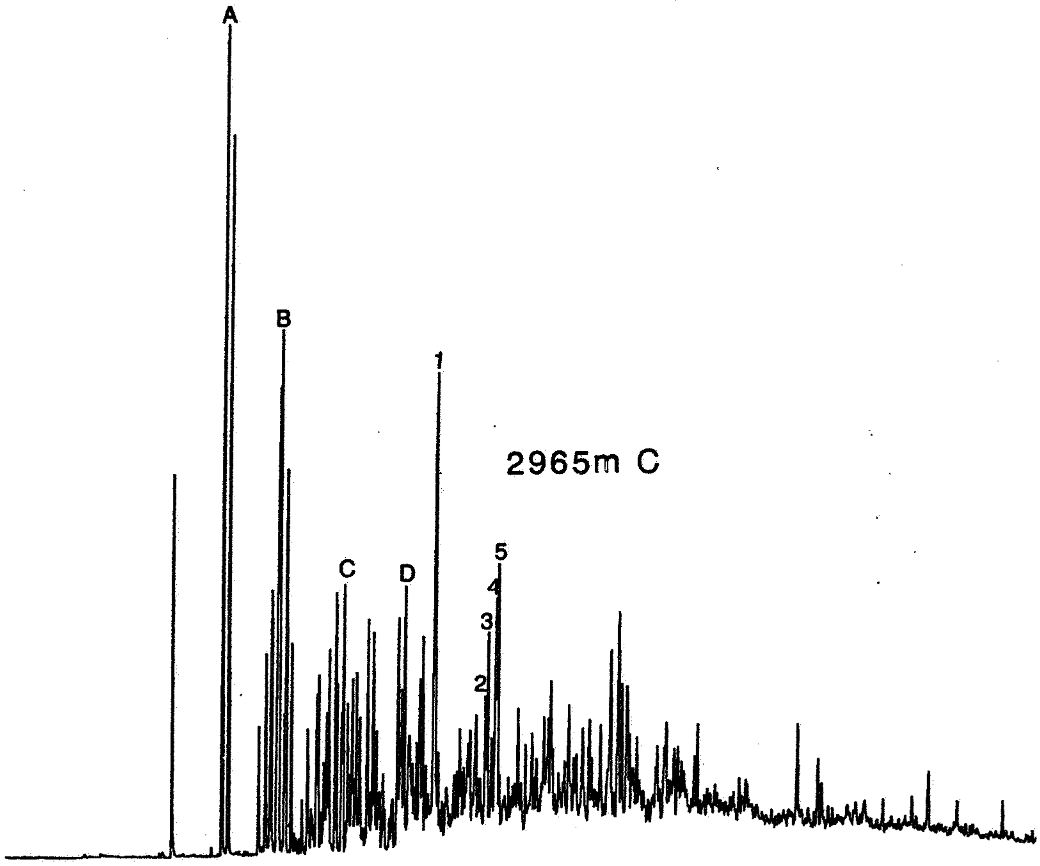
2508.7-2518.2Mm DST 1

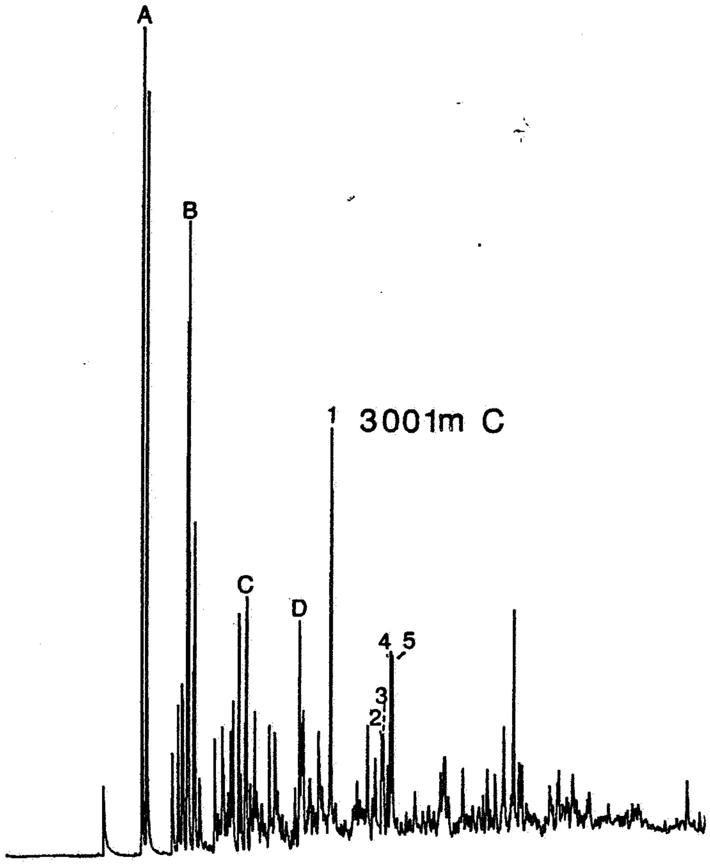
PEAK IDENTIFICATION ON FIRST SHEET

FIGURE 11c

C_{15+} AROMATIC CHROMATOGRAMS

WELL 6407/2-3



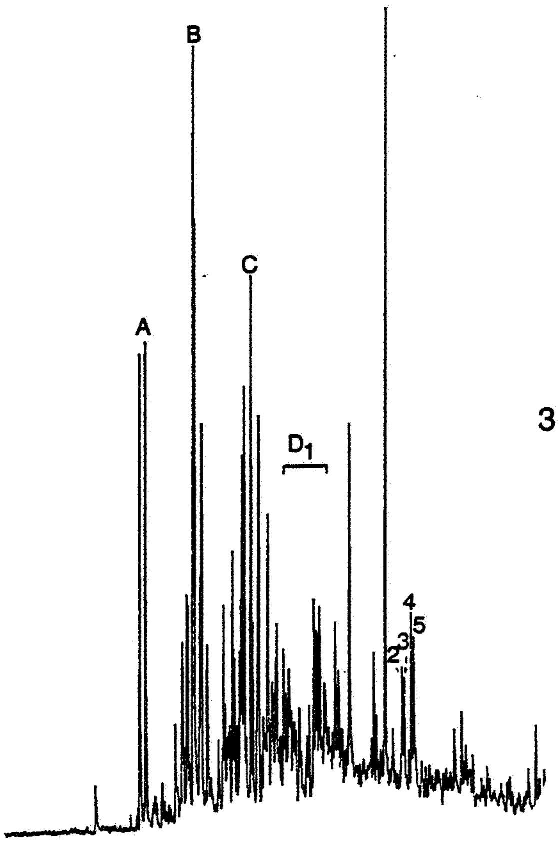


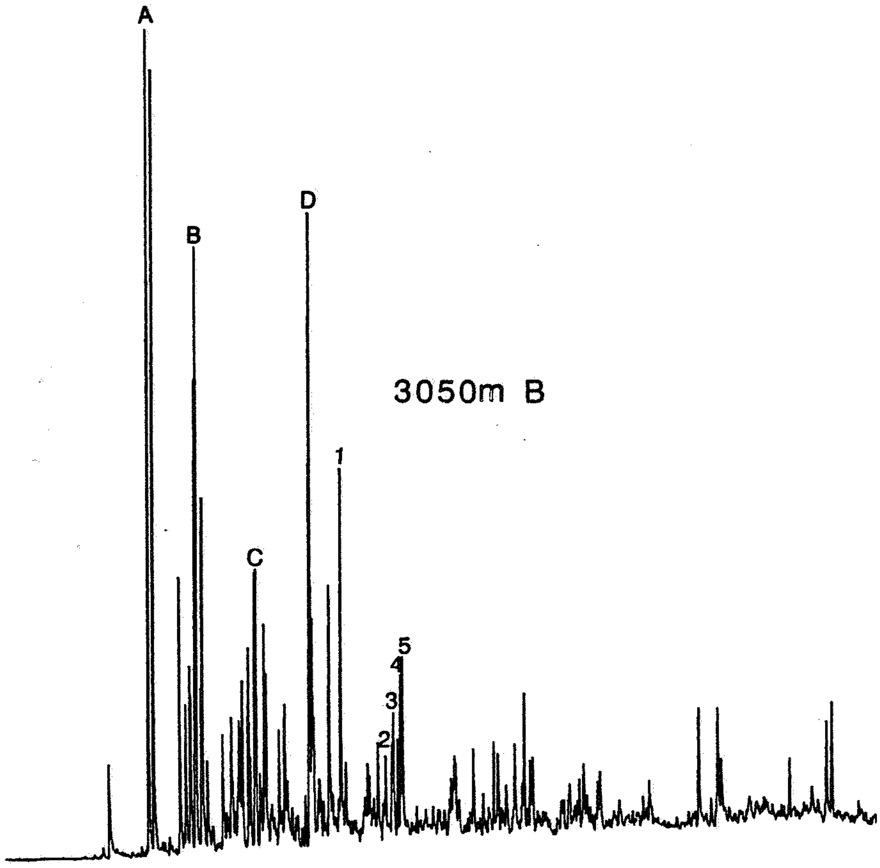
PEAK IDENTIFICATION ON FIRST SHEET

FIGURE 11d

C_{15+} AROMATIC CHROMATOGRAMS

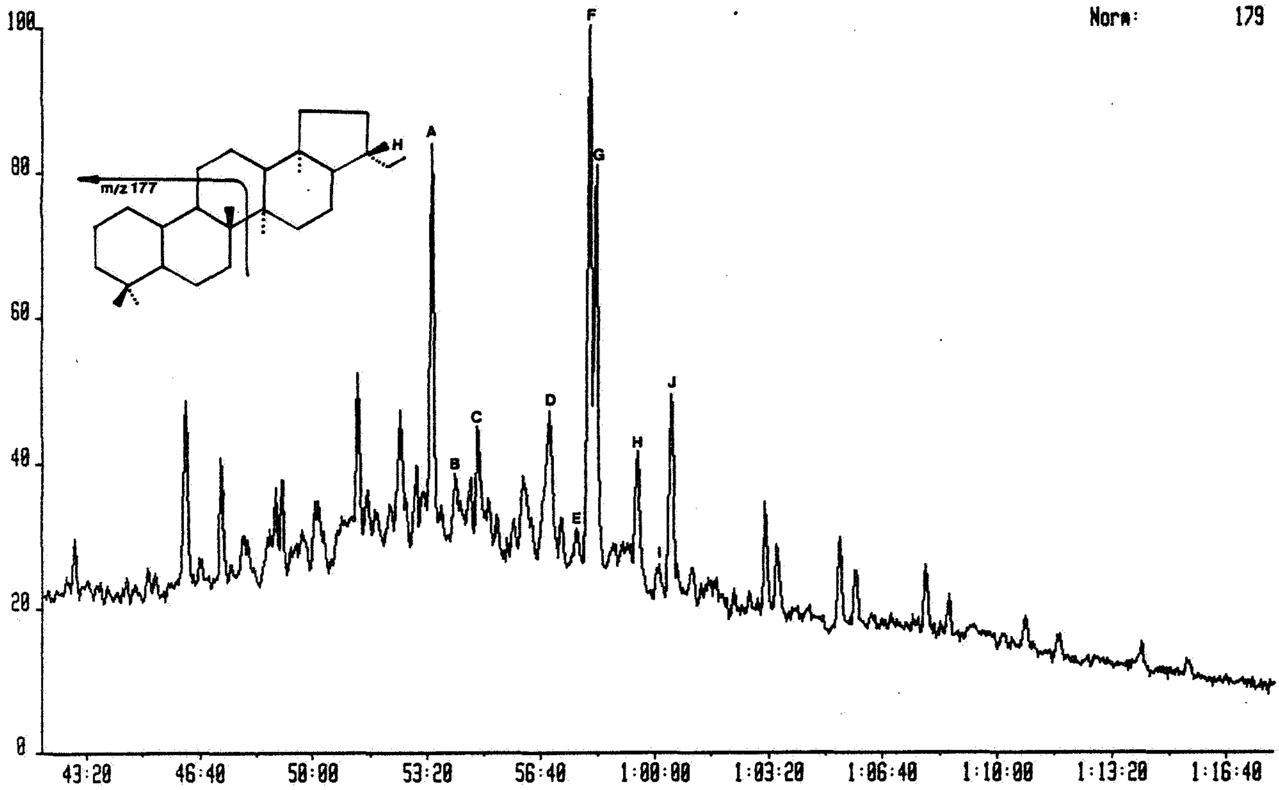
WELL 6407/2-3





PEAK IDENTIFICATION ON FIRST SHEET

GEH1A 30-JUN-87 Sir:Magnetic TS250 Acnt:GEOCHEM Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 177.1642
Text:STANDARD BIOMARKER



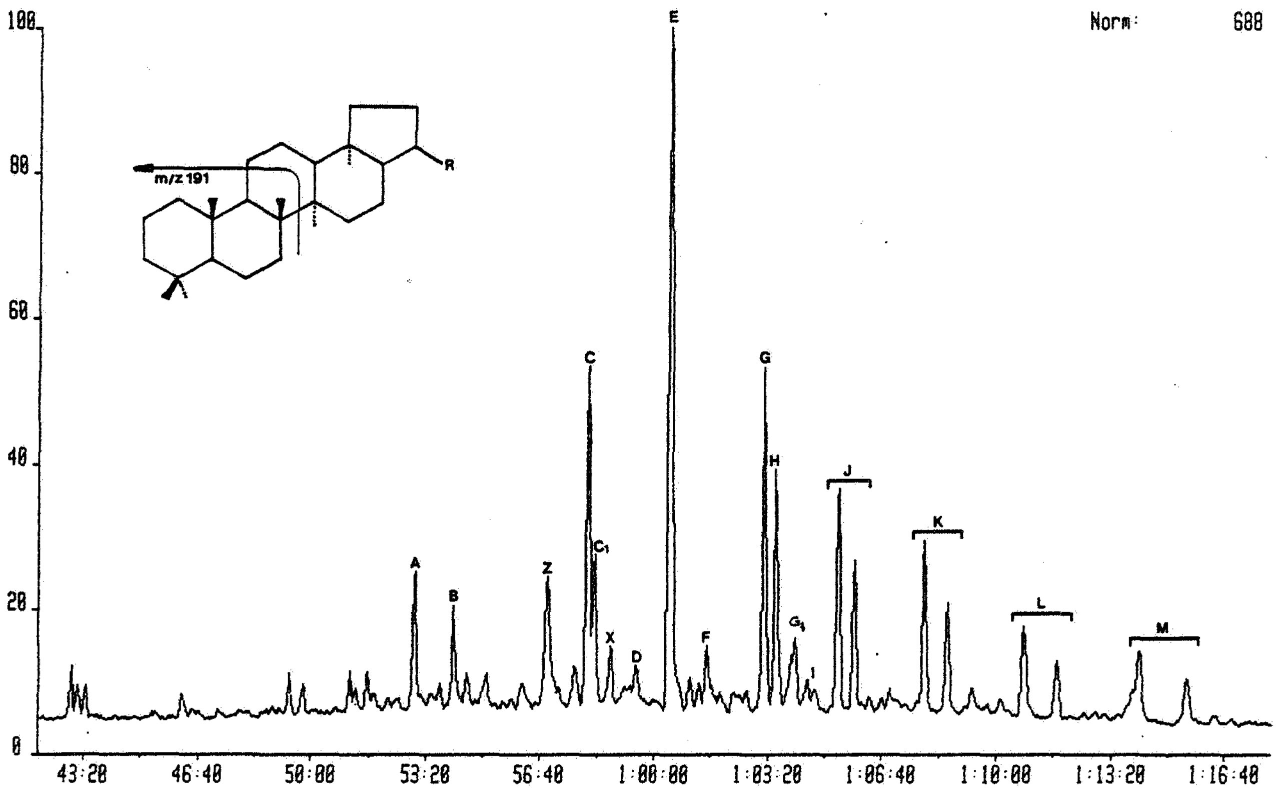
DEMETHYLATED HOPANES

(m/z 177 FRAGMENTOGRAM)

COMPOUND

A	17α(H), 18α(H), 21β(H) 25, 28, 30 - trisnorhopane
B	17β(H), 18α(H), 21α(H) 25, 28, 30 - trisnormoretane
C	17α(H) -25, 30 - bisnorhopane
D	17α(H), 18α(H), 21β(H) -28, 30 bisnorhopane
E	17α(H),-25 - norhopane
F	17α(H) -30 - norhopane
G	X
H	17α(H) -30 - normoretane
I	(22S) -17α(H) -25 - norhomohopane
J	(22R) -17α(H) -25 - norhomohopane

GEHIA 30-JUN-87 Sir:Magnetic TS250 Acnt:GEOCHEM Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 191.1798
Text:STANDARD BIOMARKER

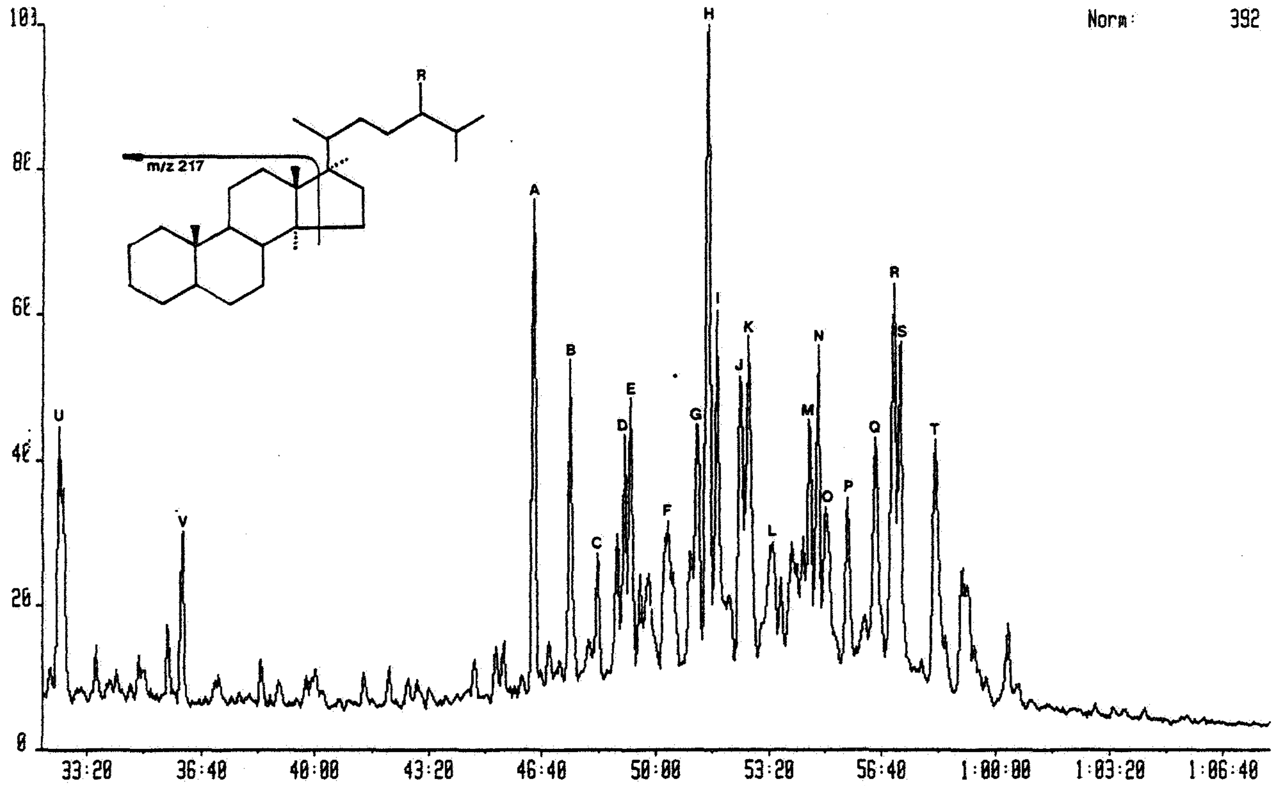


PEAK IDENTIFICATION FOR TRITERPANES (m/z 191)

A	18 α (H), 21 β (H) -22,29,30- trisnorhopane (Ts)
B	17 α (H), 21 β (H) -22,29,30- trisnorhopane Tm)
Z	17 α (H), 18 α (H) 21 (H) -28,30 bisnorhopane
C	17 α (H), 21 β (H) - norhopane
C_1	C_{29} pentacyclic triterpenoid (unidentified)
X	C_{30} pentacyclic triterpenoid (unidentified)
D	17 β (H), 21 α (H) -30 - normoretane
E	17 α (H), 21 β (H) - hopane
F	17 β (H), 21 α (H) - moretane
G	17 α (H), 21 β (H) - homohopane (22S)
H	17 α (H), 21 β (H) - homohopane (22R)
G_1	*Gammacerane*
I	17 β (H), 21 α (H) - homomoretane
J	17 α (H), 21 β (H) - bisnorhopane (22S and 22R)
K	17 α (H), 21 β (H) - trisnorhopane (22S and 22R)
L	17 α (H), 21 β (H) - tetrakishomohopane (22S and 22R)
M	17 α (H), 21 β (H) - pentakishomohopane (22S and 22R)

N	C_{20} Tricyclic Terpane
O	C_{21} Tricyclic Terpane
P	C_{23} Tricyclic Terpane
Q	C_{24} Tricyclic Terpane
R	C_{25} Tricyclic Terpane
S	C_{26} Tricyclic Terpane
T	C_{24} Tetracyclic Terpane
U	C_{28} Tricyclic Terpane
V	C_{29} Tricyclic Terpane
W	C_{30} Tricyclic Terpane

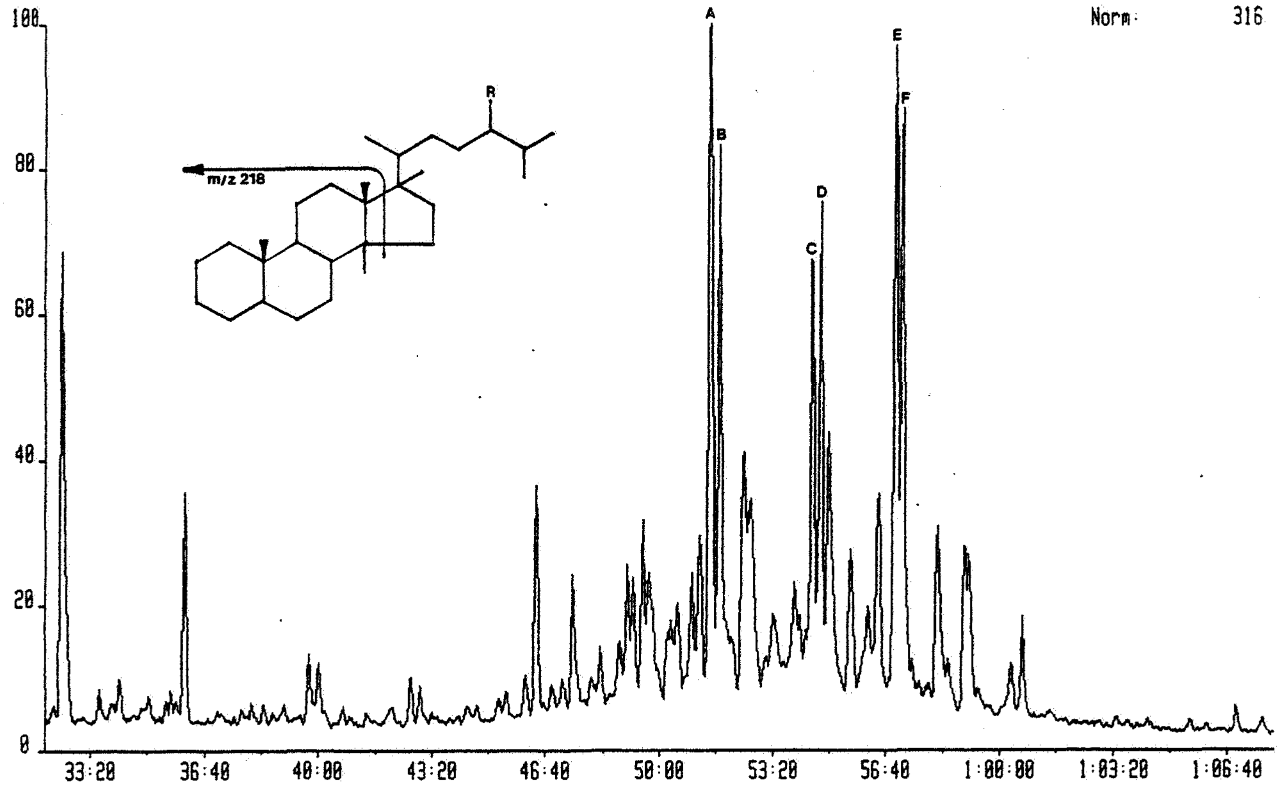
GEH1 16-JUN-87 Sir:Magnetic TS250 Acnt:GEOCHEM Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:BIOMARKER TEST RUN



STERANE IDENTIFICATION
(m/z 217 FRAGMENTOGRAM)

	COMPOUND	ELEMENTAL COMPOSITION
A	13β, 17α -diacholestane (20S)	$C_{27}H_{48}$
B	13β, 17α -diacholestane (20R)	$C_{27}H_{48}$
C	13α, 17β -diacholestane (20S)	$C_{27}H_{48}$
D	13α, 17β -diacholestane (20R)	$C_{27}H_{48}$
E	24-methyl - 13β, 17α -diacholestane (20S)	$C_{28}H_{50}$
F	24-methyl - 13β, 17α -diacholestane (20R)	$C_{28}H_{50}$
G	24-methyl - 13β, 17α -diacholestane (20S)	$C_{28}H_{50}$
+	14α, 17α -cholestane (20S)	$C_{27}H_{48}$
H	24-ethyl - 13β, 17α -diacholestane (20S)	$C_{29}H_{52}$
+	14β, 17β -cholestane (20R)	$C_{27}H_{48}$
I	14β, 17β -cholestane (20S)	$C_{27}H_{48}$
+	24-methyl - 13α, 17β -diacholestane (20R)	$C_{28}H_{50}$
J	14α, 17α -cholestane (20R)	$C_{27}H_{48}$
K	24-ethyl -13β, 17α-diacholestane (20R)	$C_{29}H_{52}$
L	24-ethyl -14α, 17α-diacholestane (20S)	$C_{29}H_{52}$
M	24-methyl -13β, 17β -cholestane (20S)	$C_{28}H_{50}$
N	24-ethyl -13β, 17β -diacholestane (20R)	$C_{29}H_{52}$
+	24-methyl -14α, 17β -cholestane (20R)	$C_{28}H_{50}$
O	24-methyl -14α, 17α -cholestane (20S)	$C_{28}H_{50}$
P	24-methyl -14α, 17α -cholestane (20R)	$C_{28}H_{50}$
Q	24-ethyl -14α, 17α -cholestane (20S)	$C_{29}H_{52}$
R	24-ethyl -14β, 17β -cholestane (20R)	$C_{29}H_{52}$
+	UNKNOWN STERANE	
S	24-ethyl -14β, 17β -cholestane (20S)	$C_{29}H_{52}$
T	24-ethyl -14α, 17α -cholestane (20R)	$C_{29}H_{52}$
U	5α(H)-pregnane	$C_{21}H_{36}$
V	5α(H)-bisnorcholane	$C_{22}H_{38}$

GEH1 16-JUN-87 Sir:Magnetic TS250 Acnt:GEOCHEM Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:BIOMARKER TEST RUN

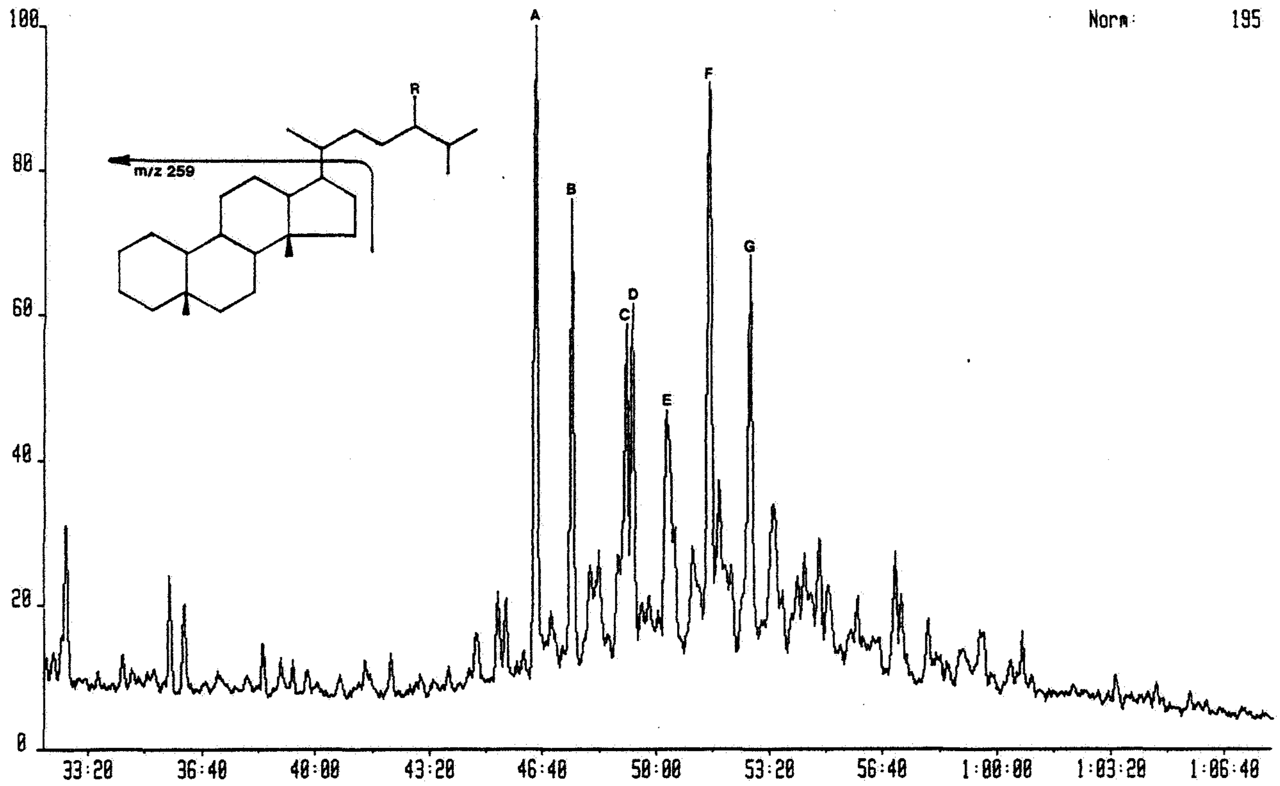


STERANE IDENTIFICATION

(M/Z 218 FRAGMENTOGRAM)

	COMPOUND	ELEMENTAL COMPOSITION
A	14β,17β-cholestane (20R)	$C_{27}H_{48}$
B	14β,17β-cholestane (20S)	$C_{27}H_{48}$
C	24-methyl-14β,17β-cholestane (20R)	$C_{28}H_{50}$
D	24-methyl-14β,17β-cholestane (20S)	$C_{28}H_{50}$
E	24-ethyl-14β,17β-cholestane (20R)	$C_{29}H_{52}$
F	24-ethyl-14β,17β-cholestane (20S)	$C_{29}H_{52}$

GEH1 16-JUN-87 Sir:Magnetic TS250 Acnt:GEOCHEM Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 259.2427
Text:BIOMARKER TEST RUN



STERANE IDENTIFICATION

(M/Z 259 FRAGMENTOGRAM)

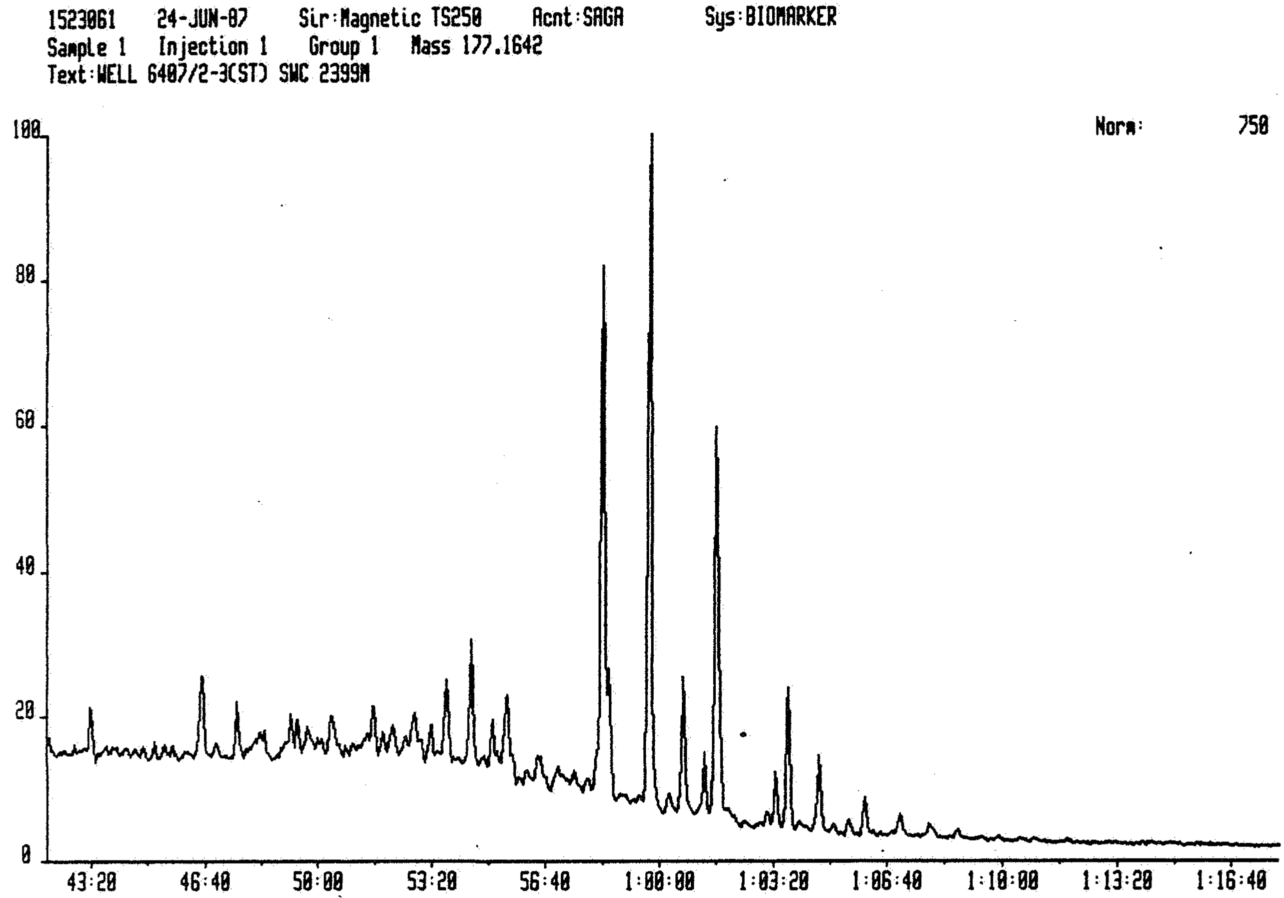
	COMPOUND	ELEMENTAL COMPOSITION
A	13β,17α-diacholestane (20S)	$C_{27}H_{48}$
B	13β,17α-diacholestane (20R)	$C_{27}H_{48}$
C	13α,17β-diacholestane (20R)	$C_{27}H_{48}$
D	24,-methyl-13β,17α-diacholestane (20S)	$C_{28}H_{50}$
E	24,-methyl-13β,17α-diacholestane (20R)	$C_{28}H_{50}$
F	24,-ethyl-13β,17α-diacholestane (20S)	$C_{29}H_{52}$
G	24,-ethyl-13β,17α-diacholestane (20R)	$C_{29}H_{52}$

FIGURE 12a

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES



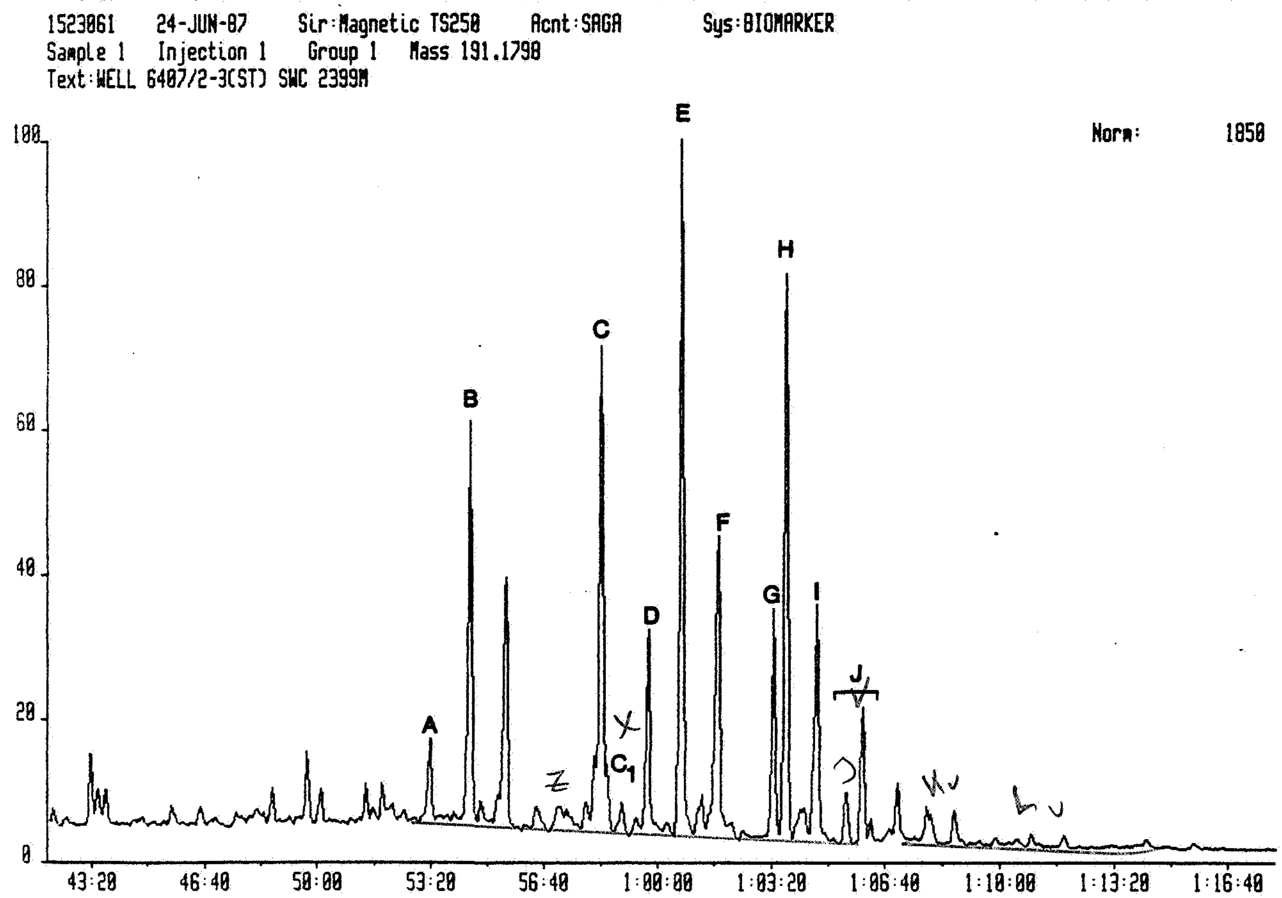


FIGURE 12a

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

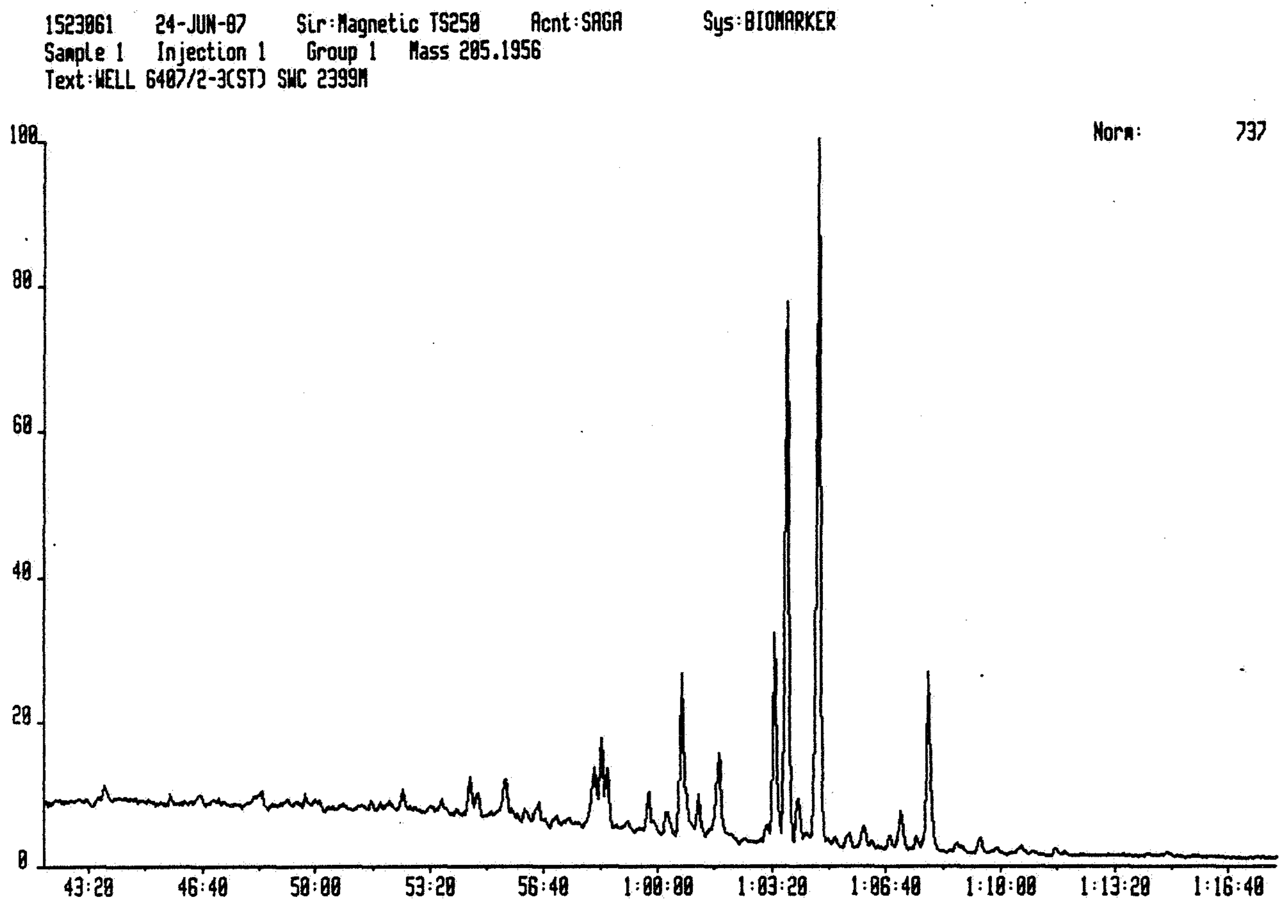


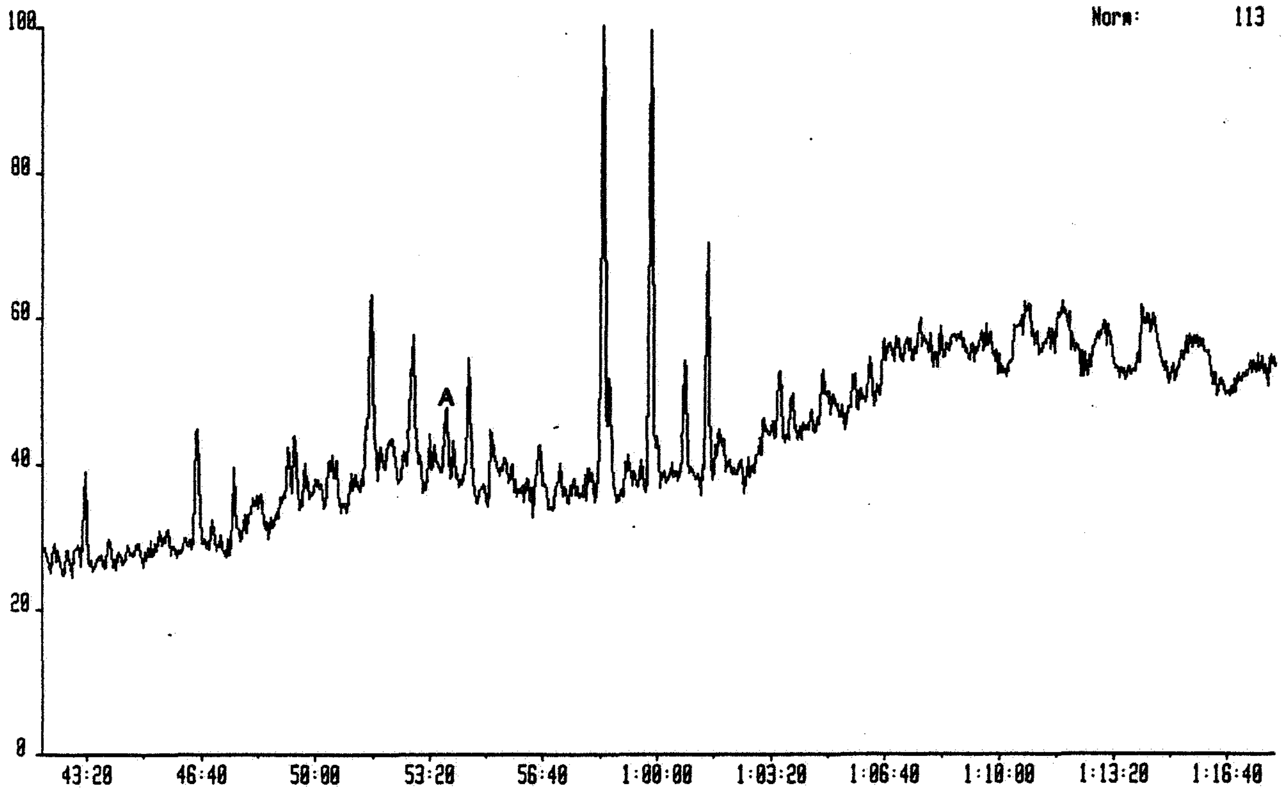
FIGURE 12b

MASS FRAGMENTOGRAMS

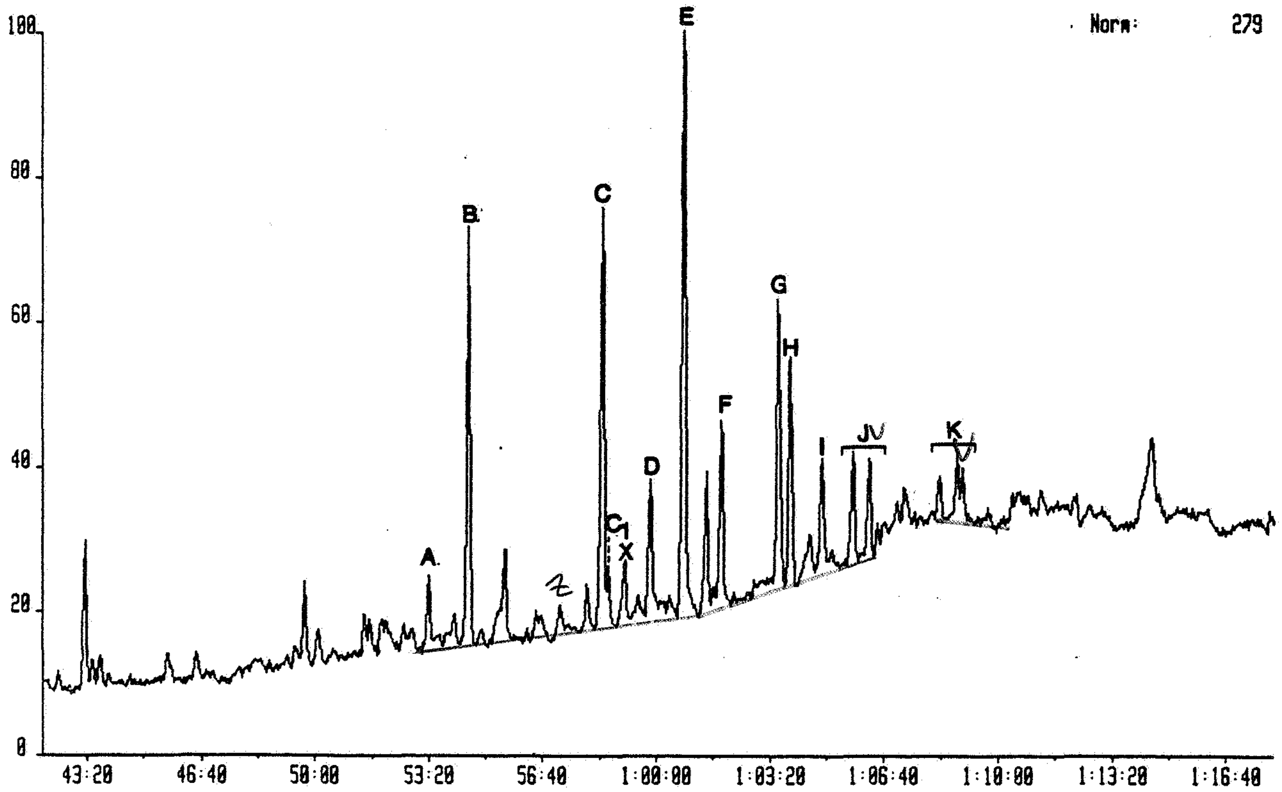
WELL 6407/2-3

TERPANES

1523045 11-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 177.1642
Text:WELL 6407/2-3(ST) 2965M



1523045 11-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 191.1798
Text:WELL 6407/2-3(ST) 2965M



MASS FRAGMENTOGRAMS

FIGURE 12b

WELL 6407/2-3

TERPANES

1523045 11-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 205.1956
Text:WELL 6407/2-3(ST) 2965M

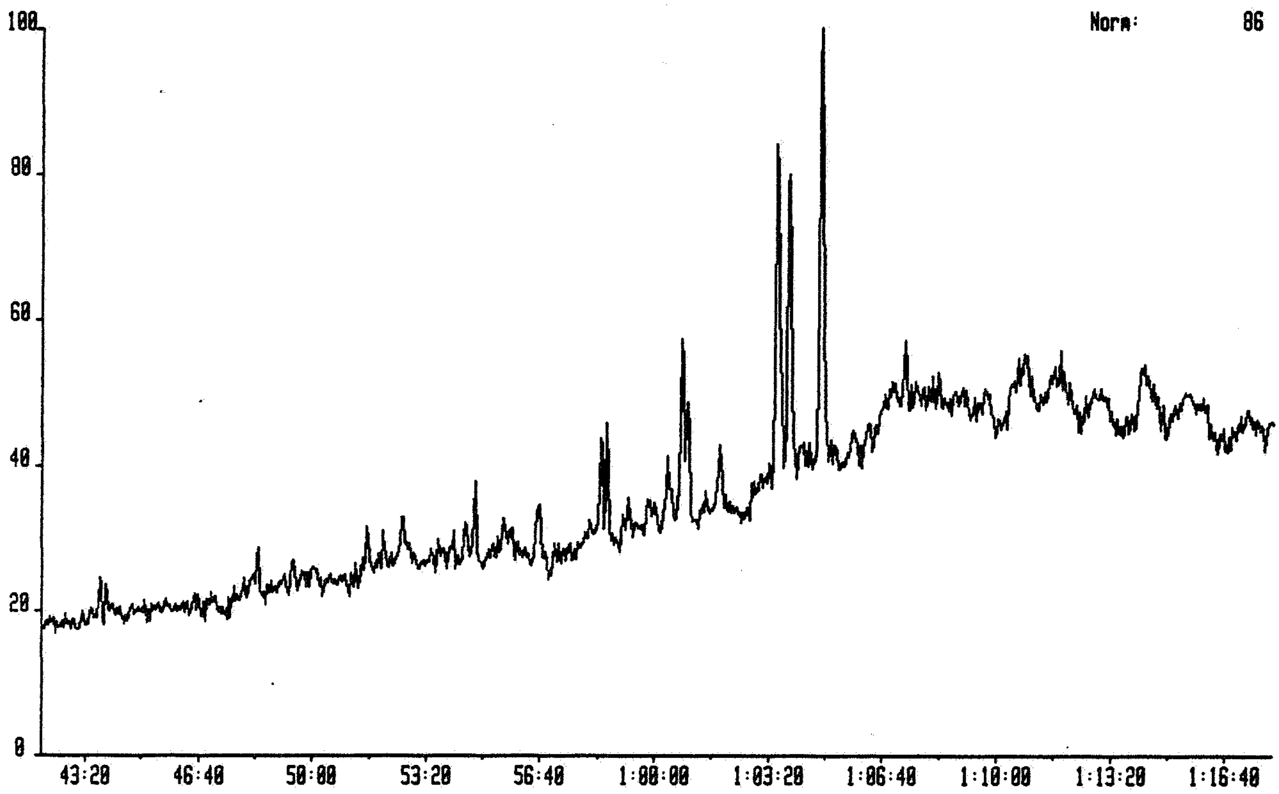


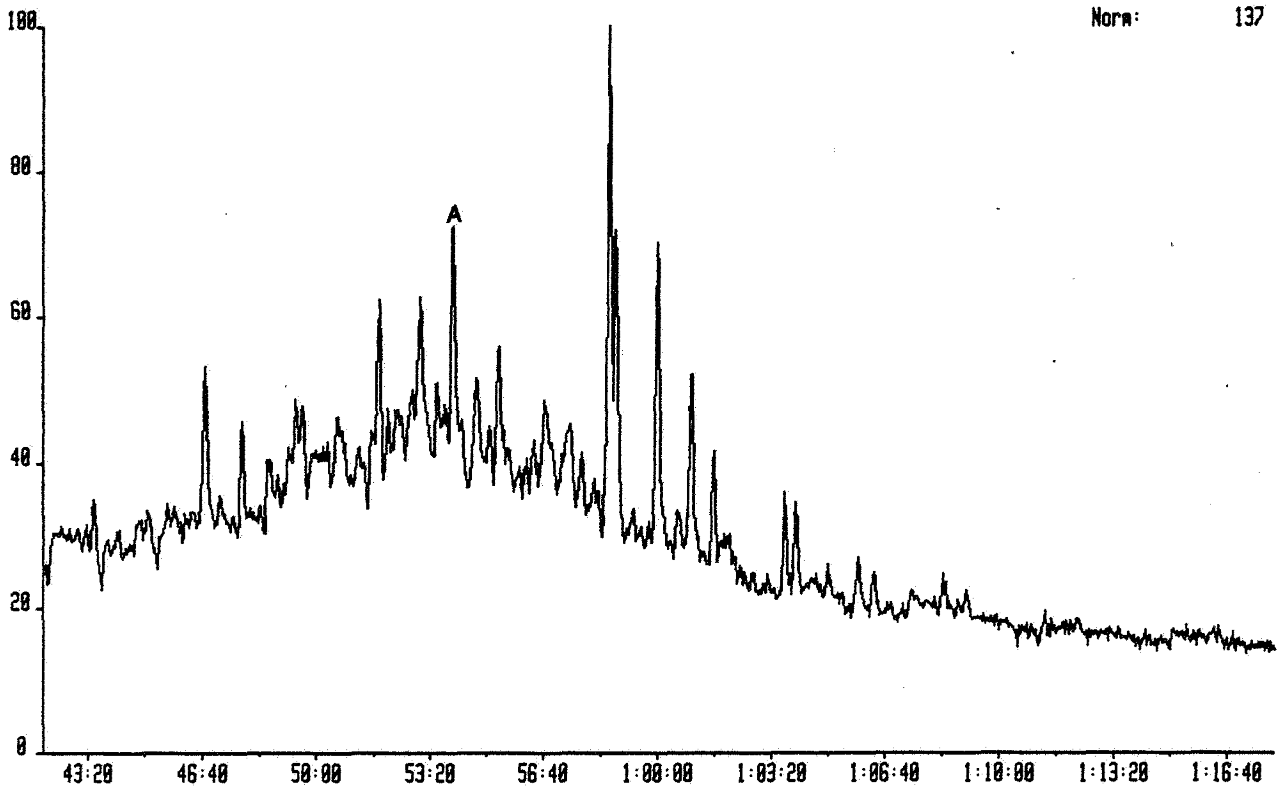
FIGURE 12c

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

1523049 15-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 177.1642
Text:WELL 6407/2-3(ST) 3001M



1523049 15-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 191.1798
Text:WELL 6407/2-3(ST) 3001M

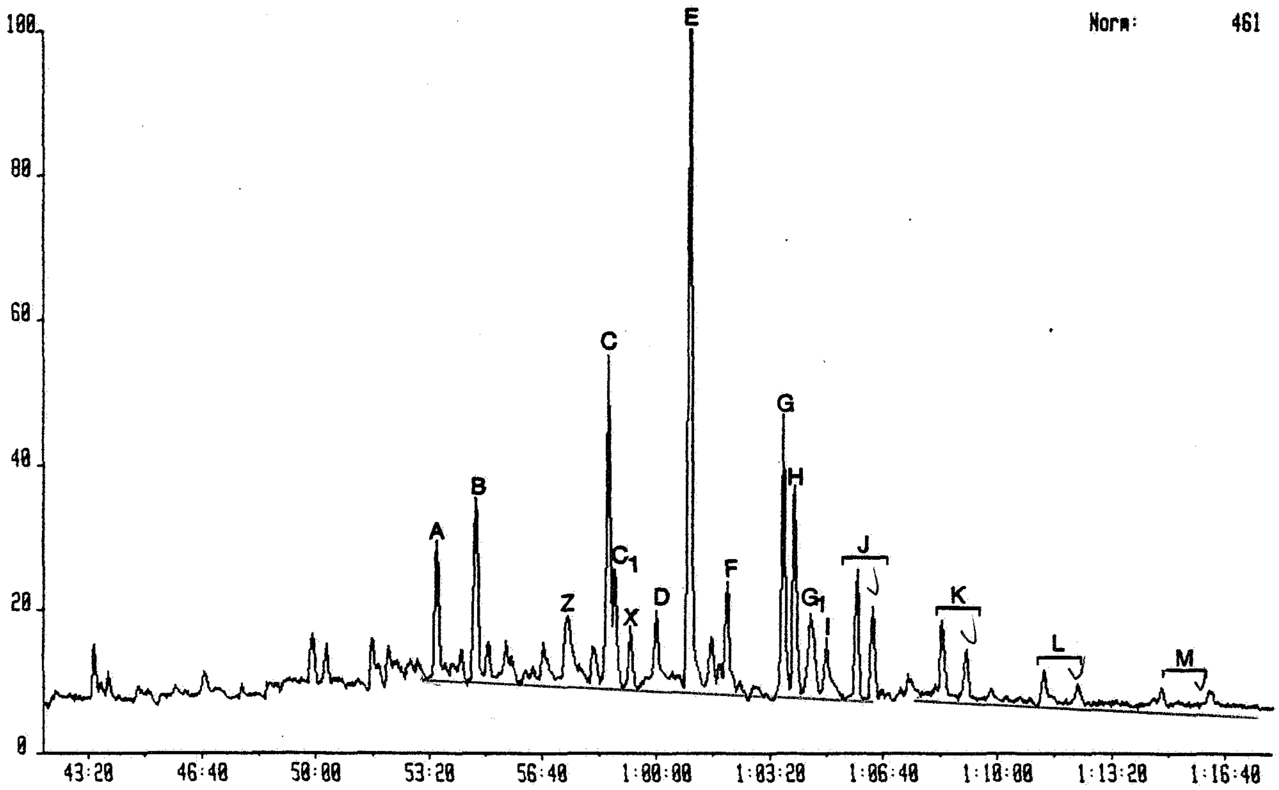


FIGURE 12c

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

1523049 15-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 205.1956
Text:WELL 6407/2-3(ST) 3001M

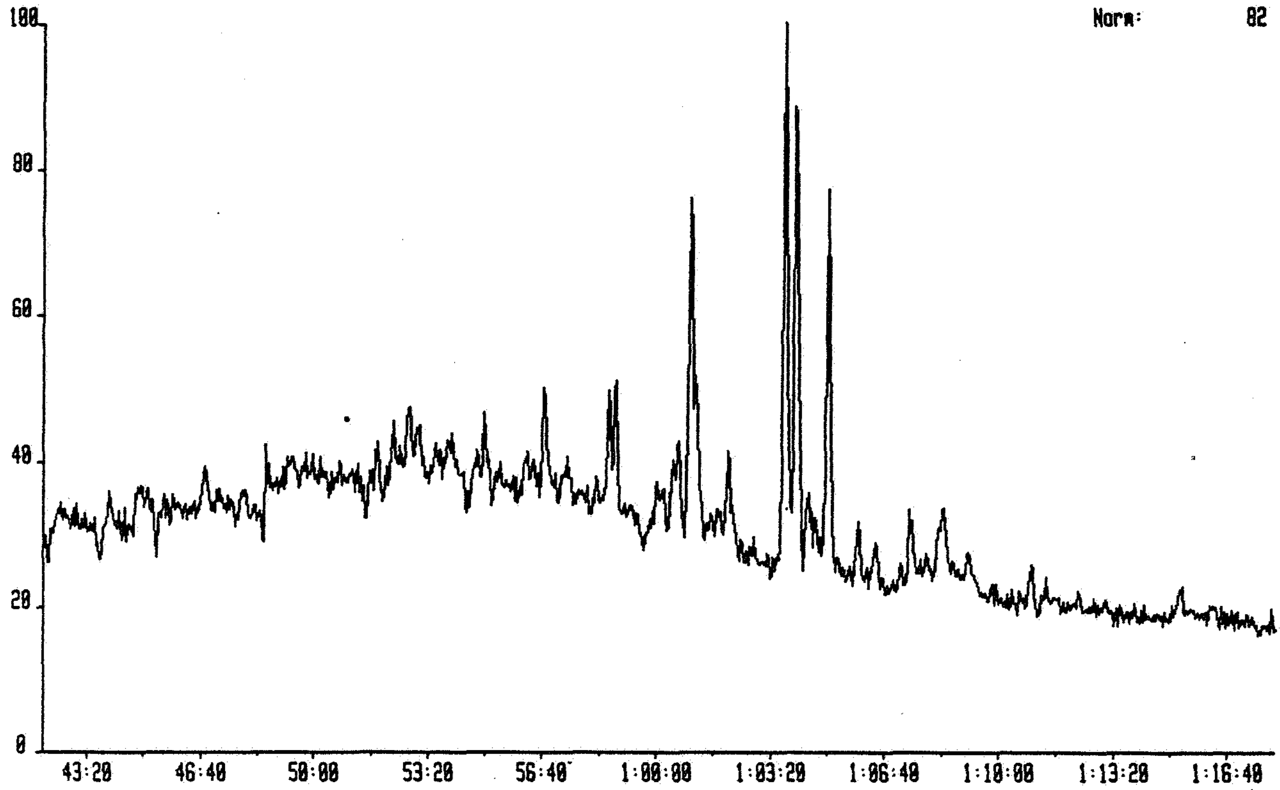


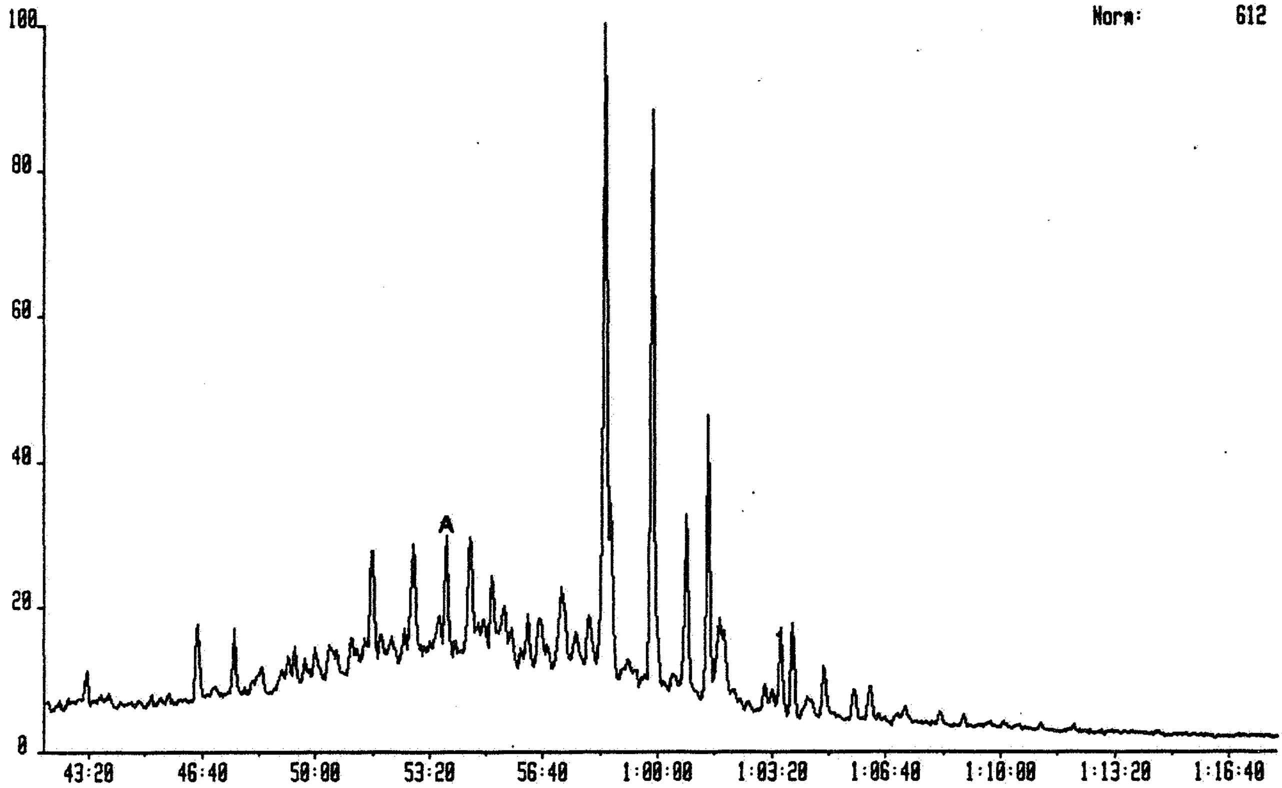
FIGURE 12d

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

1523053 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 177.1642
Text:WELL 6407/2-3(ST) 3037M



1523053 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 191.1798
Text:WELL 6407/2-3(ST) 3037M

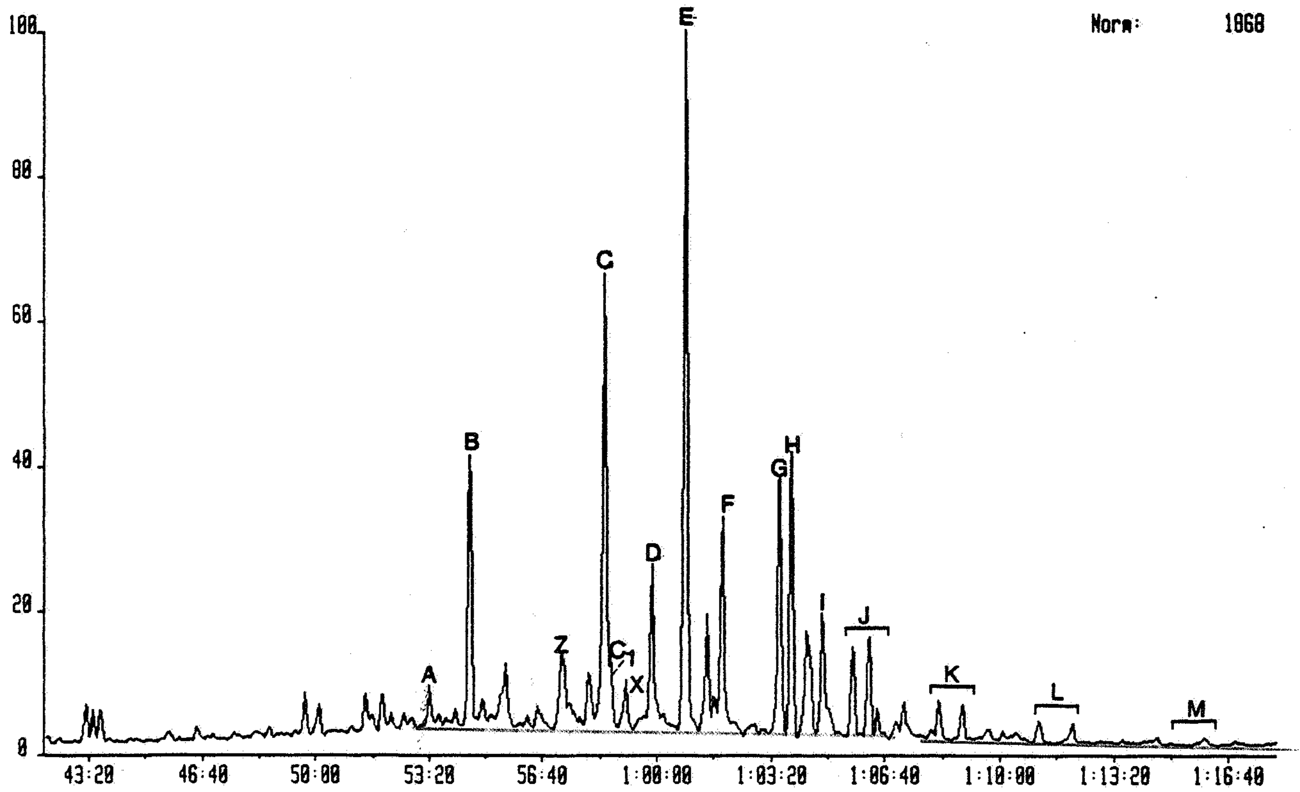


FIGURE 12d

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

1523053 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 205.1956
Text:WELL 6407/2-3(ST) 3037M

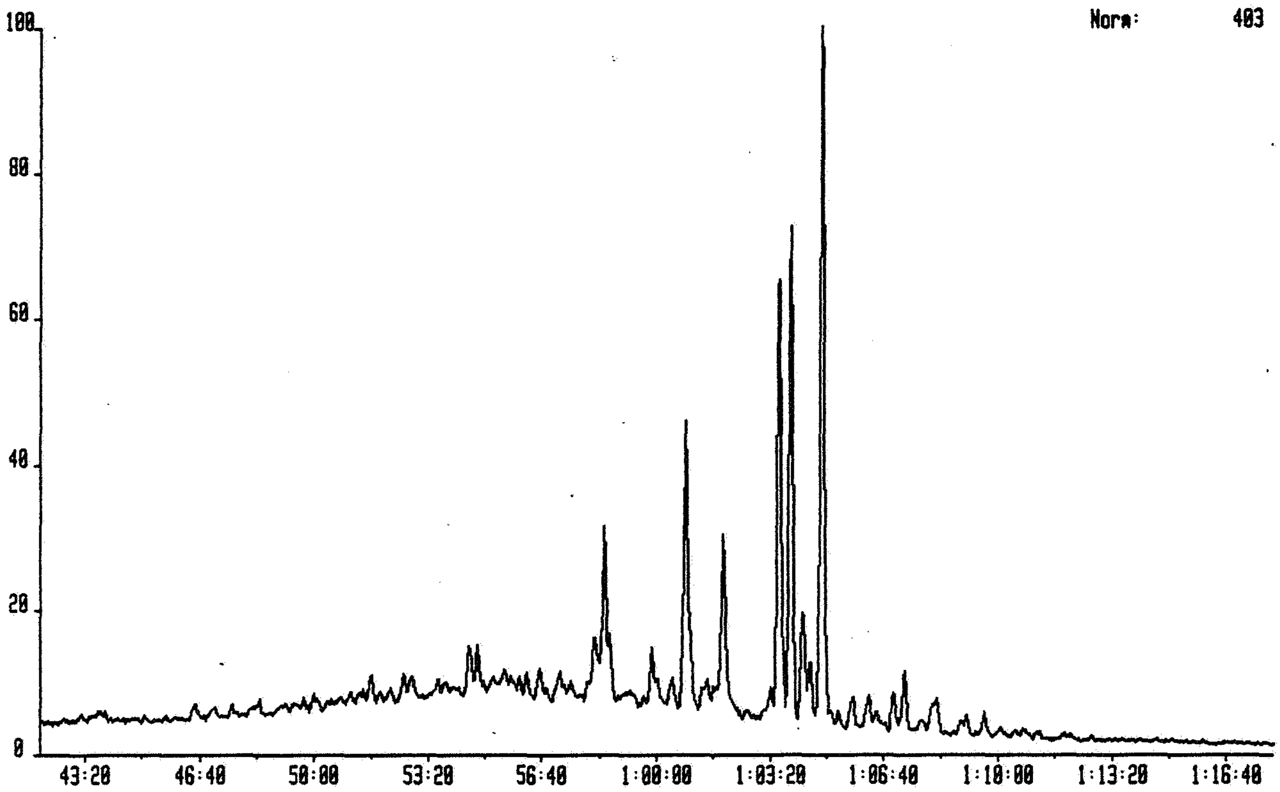
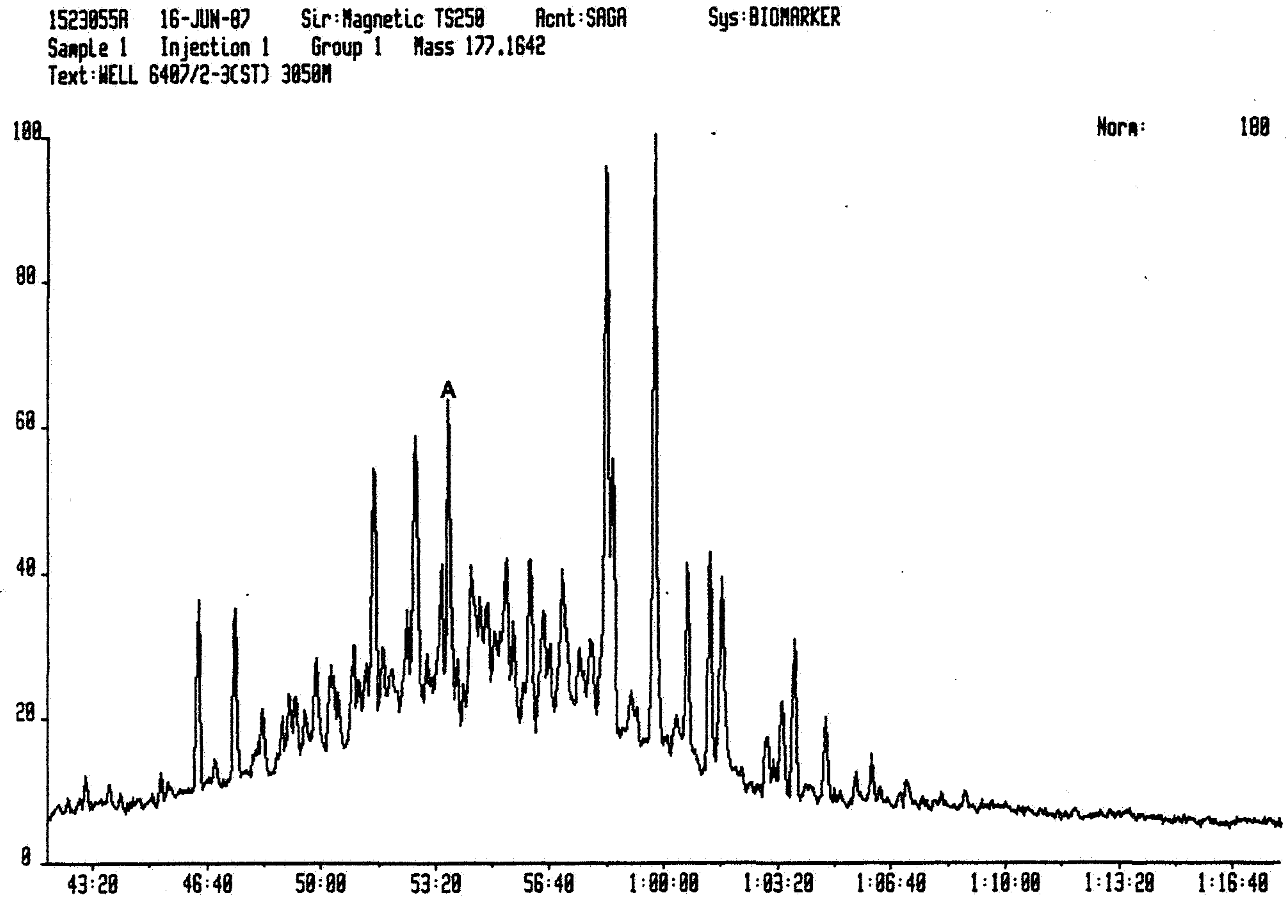


FIGURE 12e

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES



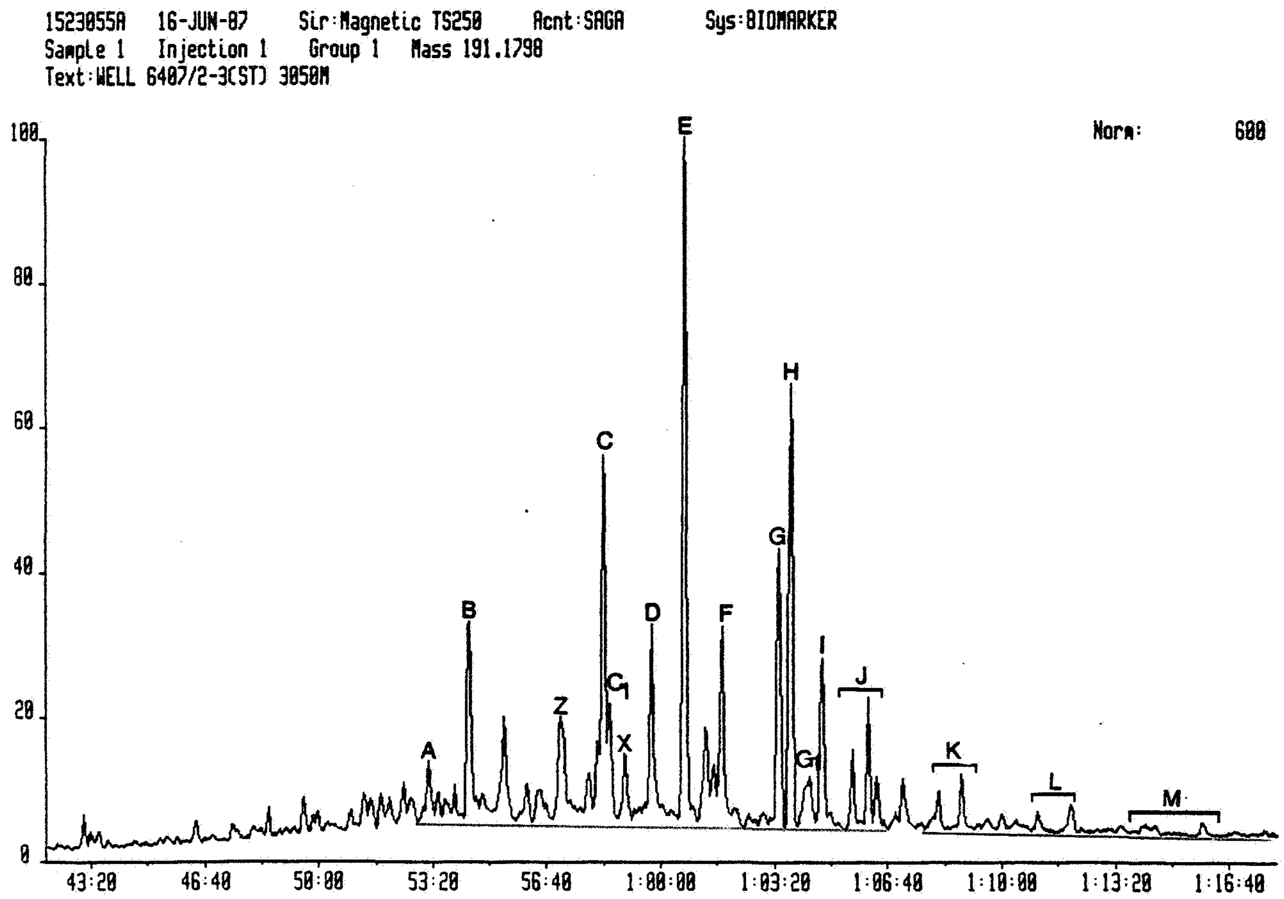


FIGURE 12e

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

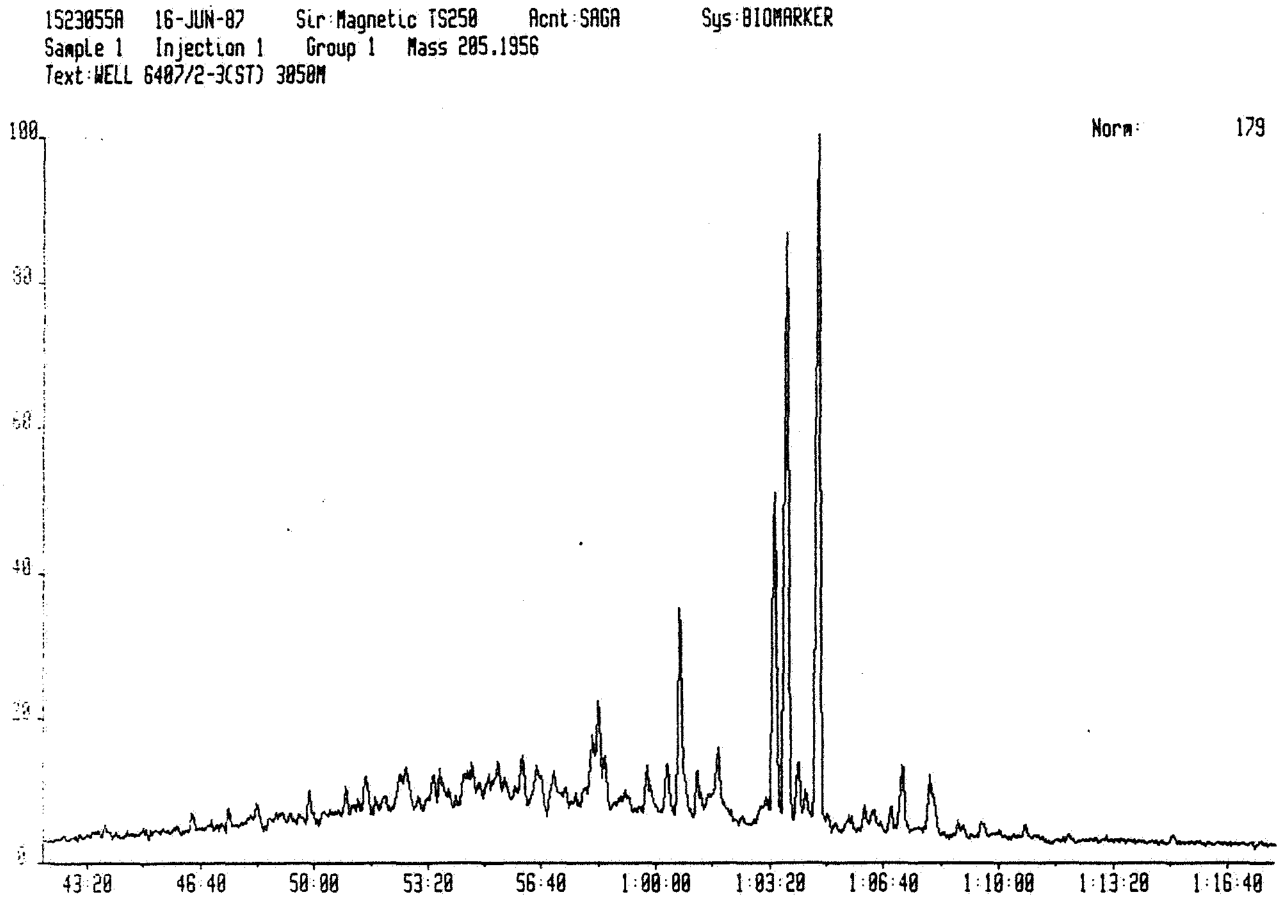


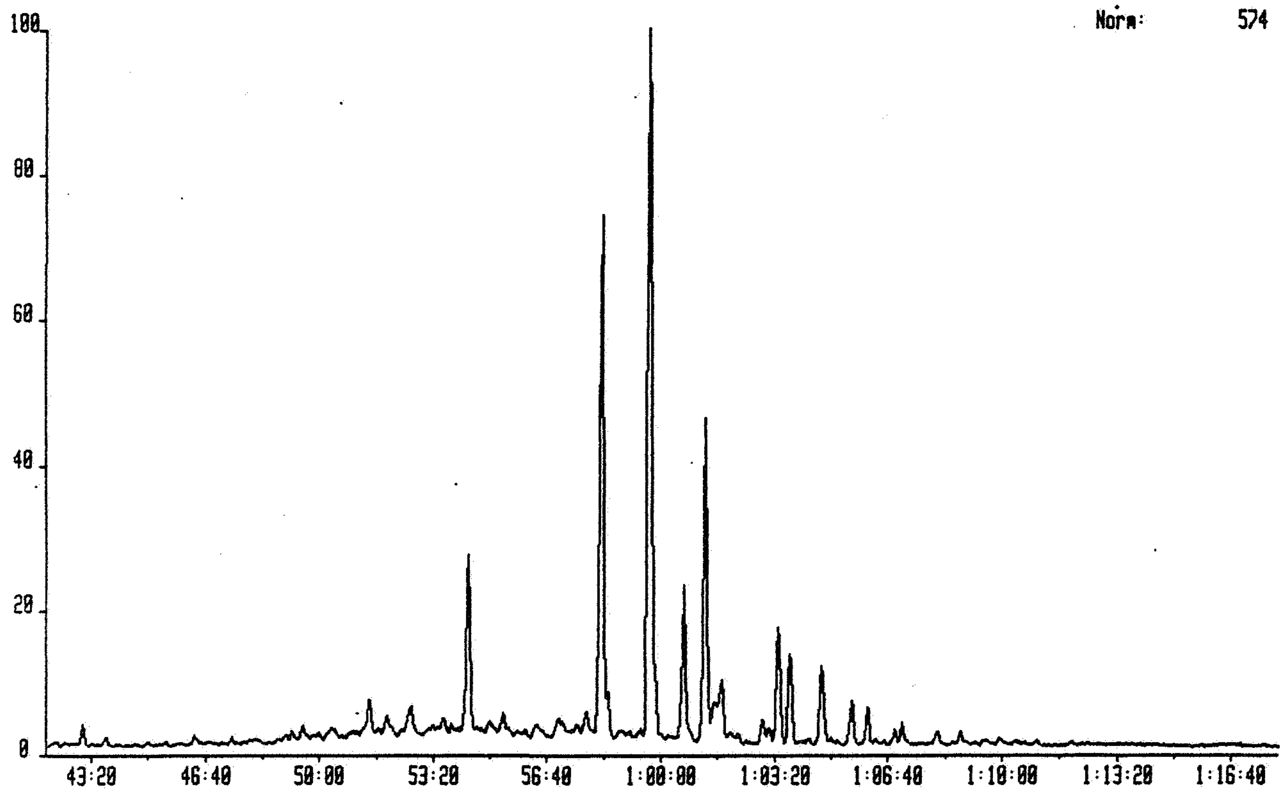
FIGURE 12f

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

15230558 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 177.1642
Text:WELL 6407/2-3(ST) 3050M



15230558 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 191.1790
Text:WELL 6407/2-3(ST) 3050M

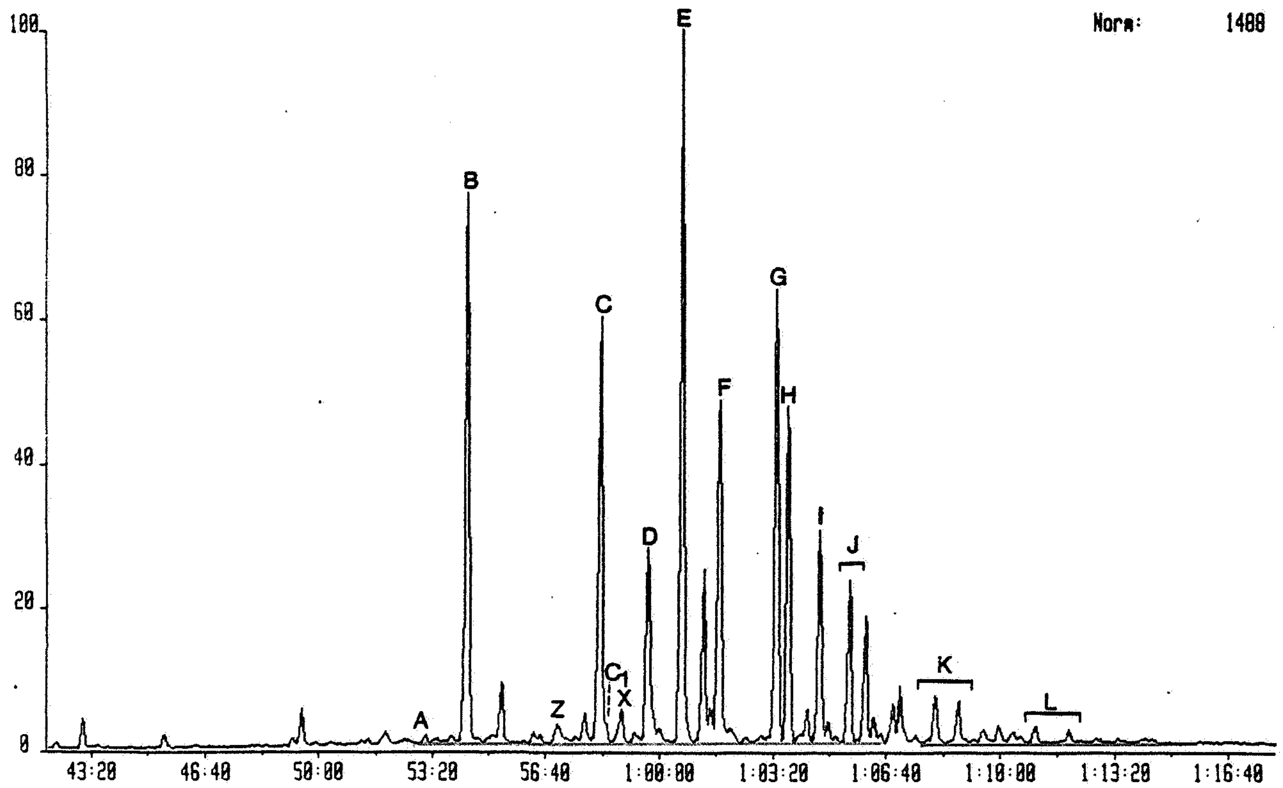


FIGURE 12f

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

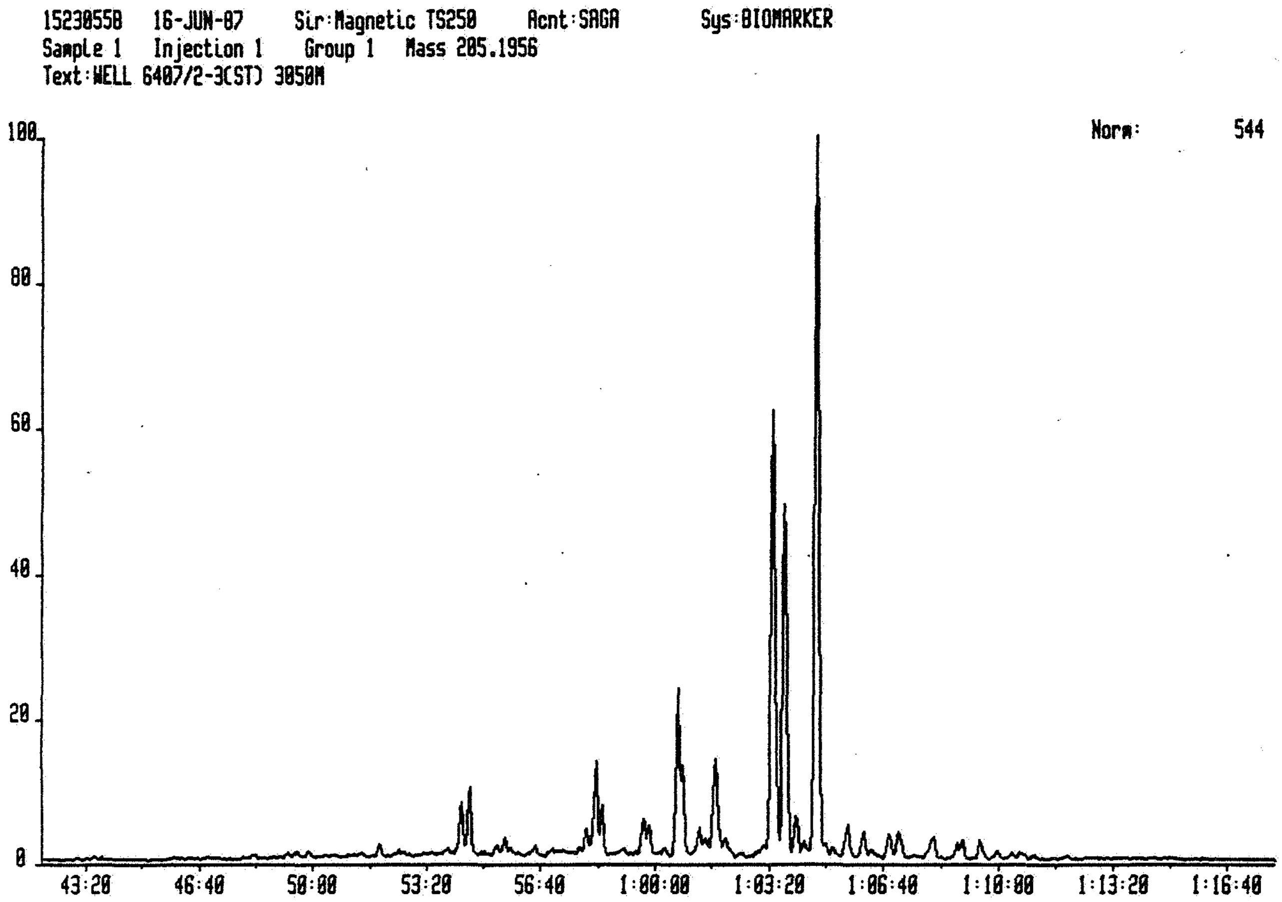
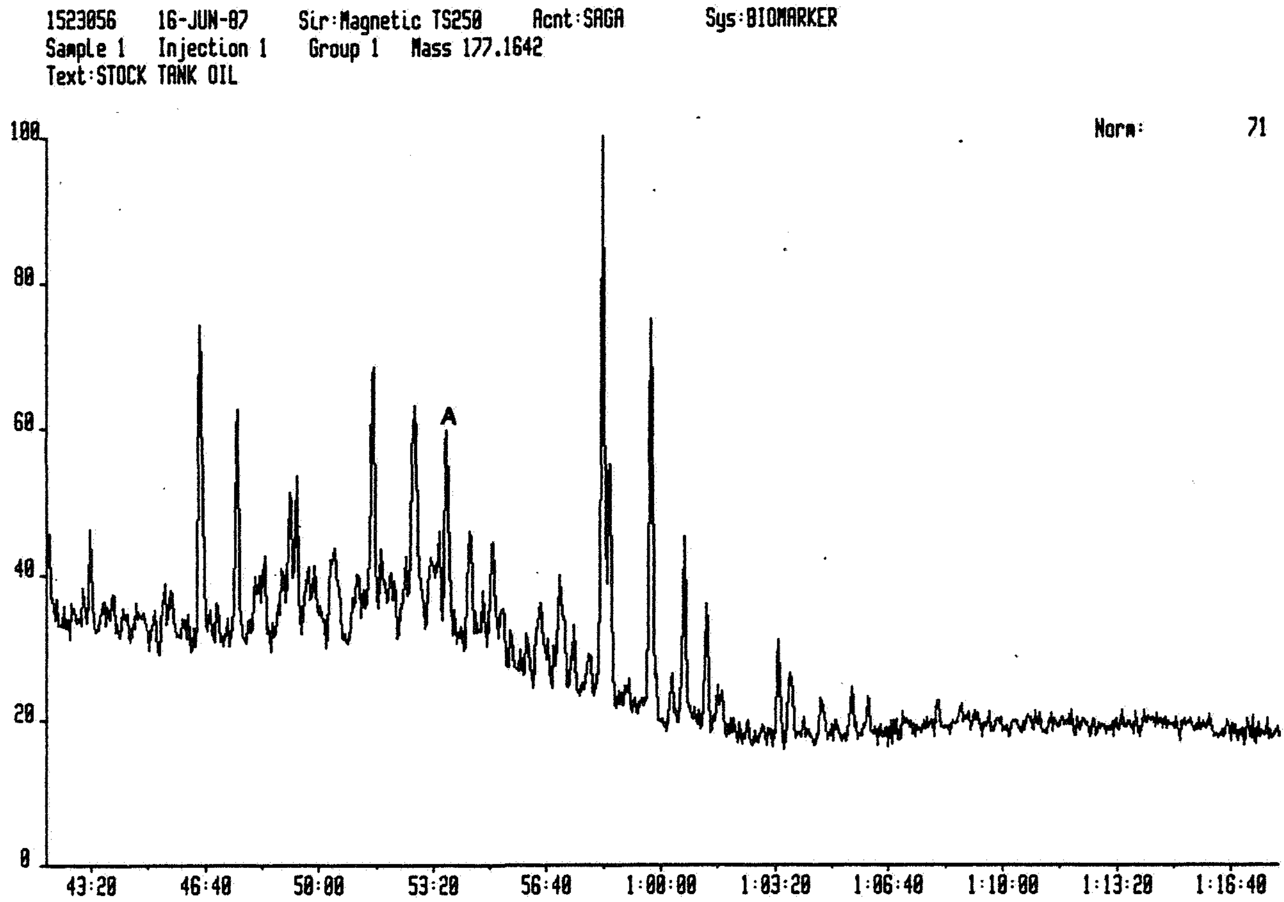


FIGURE 12g

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES



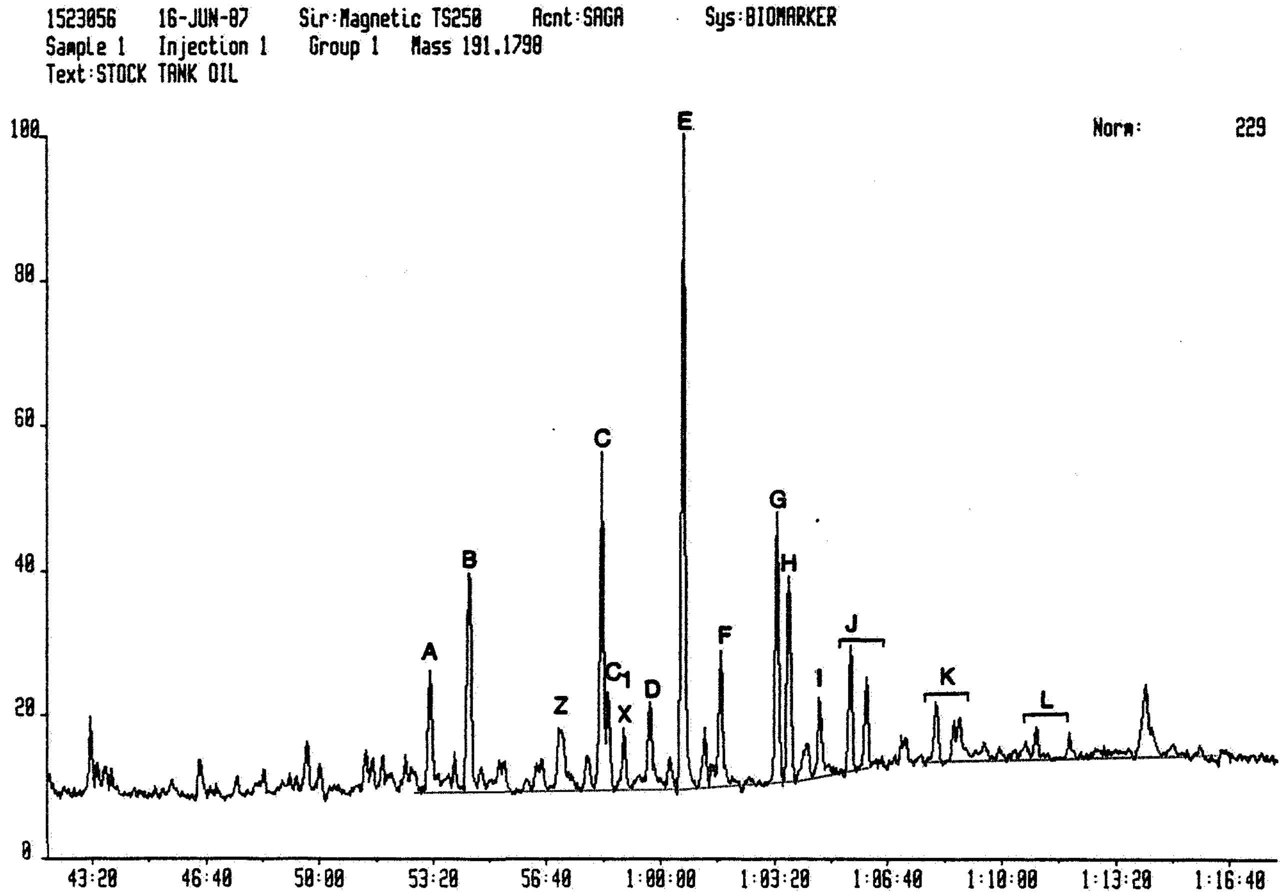


FIGURE 12g

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

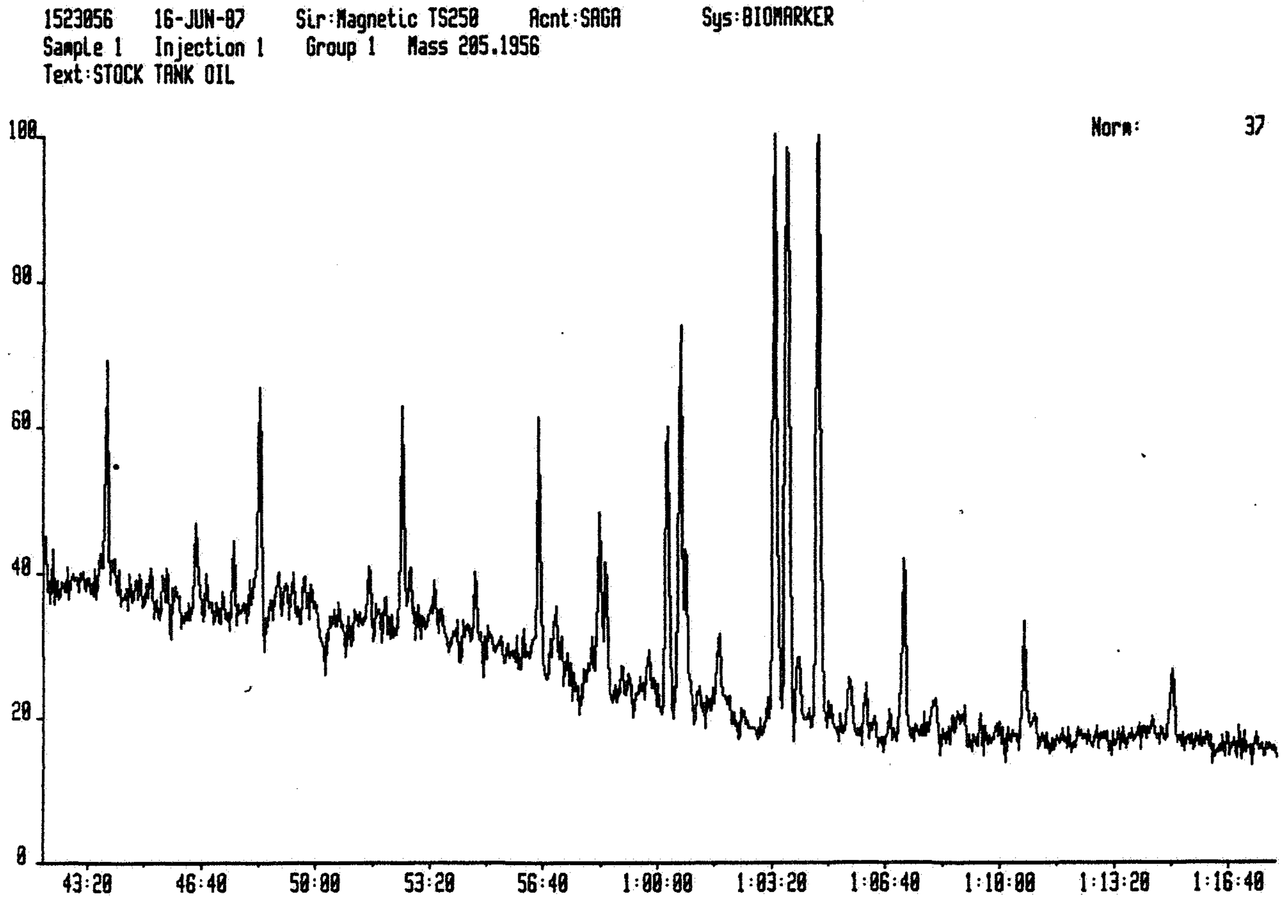


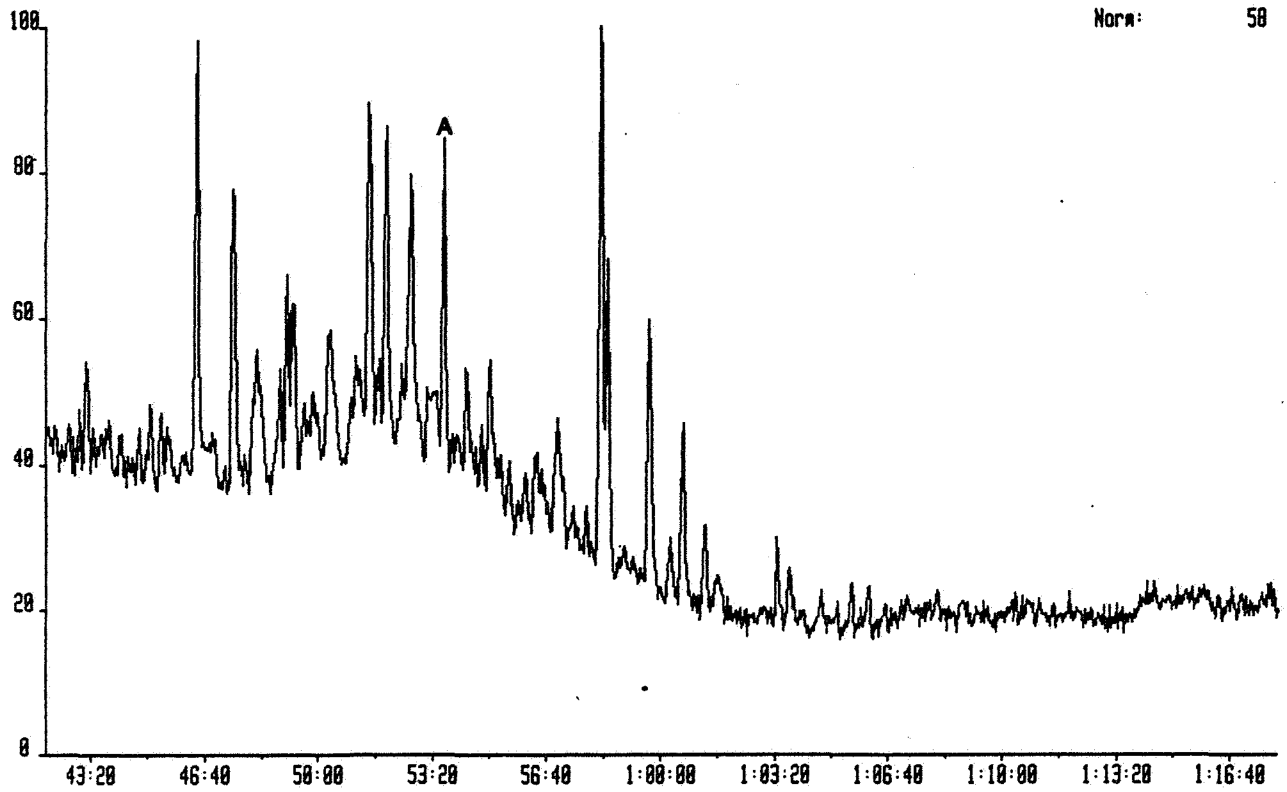
FIGURE 12h

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

1523060 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 177.1642
Text:SINGLE FLASH CONDENSATE



1523060 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 191.1798
Text:SINGLE FLASH CONDENSATE

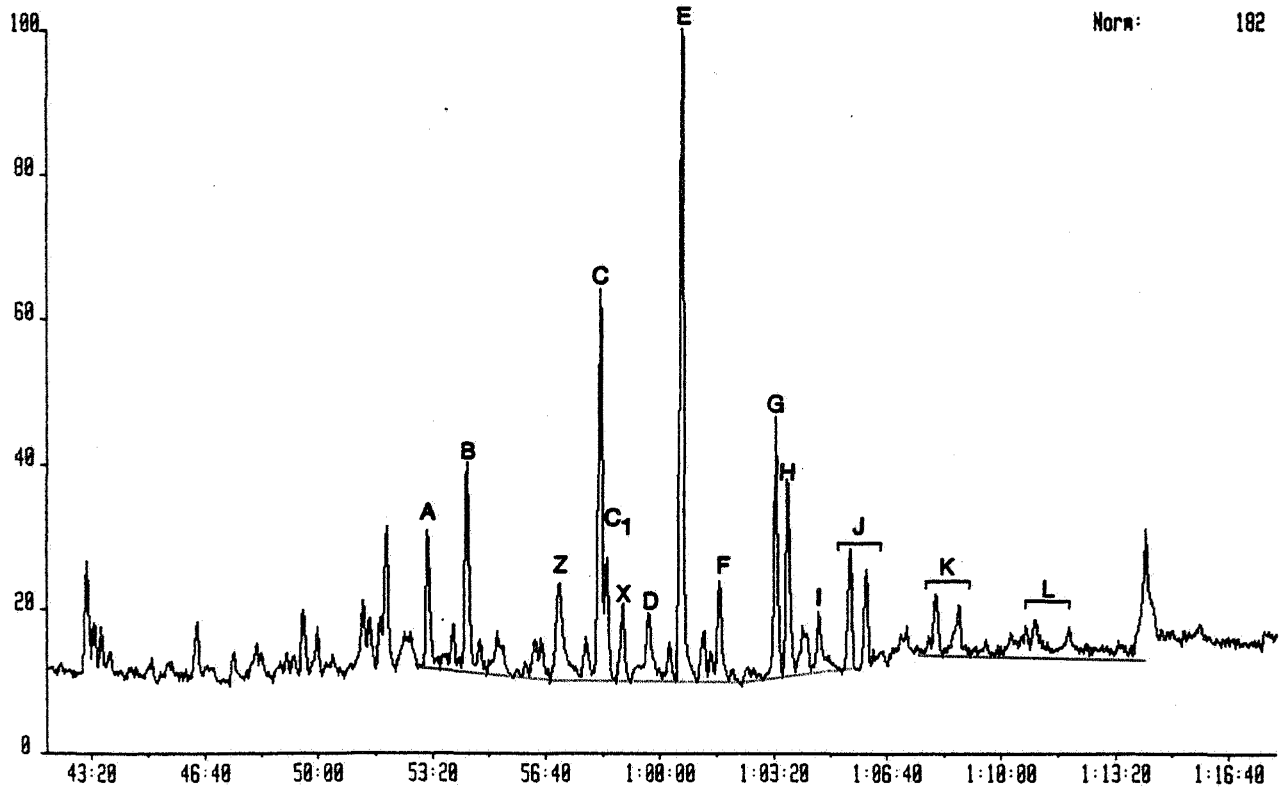


FIGURE 12h

MASS FRAGMENTOGRAMS

WELL 6407/2-3

TERPANES

1523060 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 205.1956
Text:SINGLE FLASH CONDENSATE

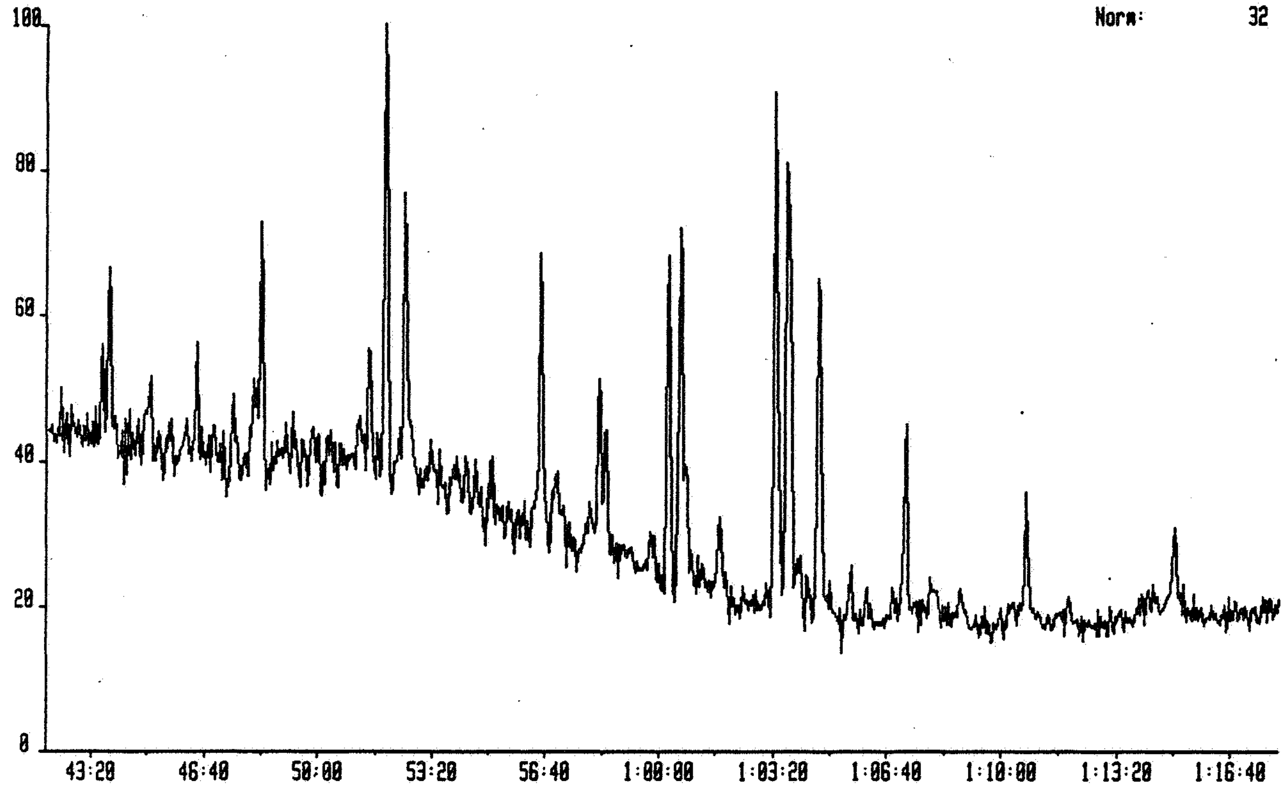


FIGURE 13a

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

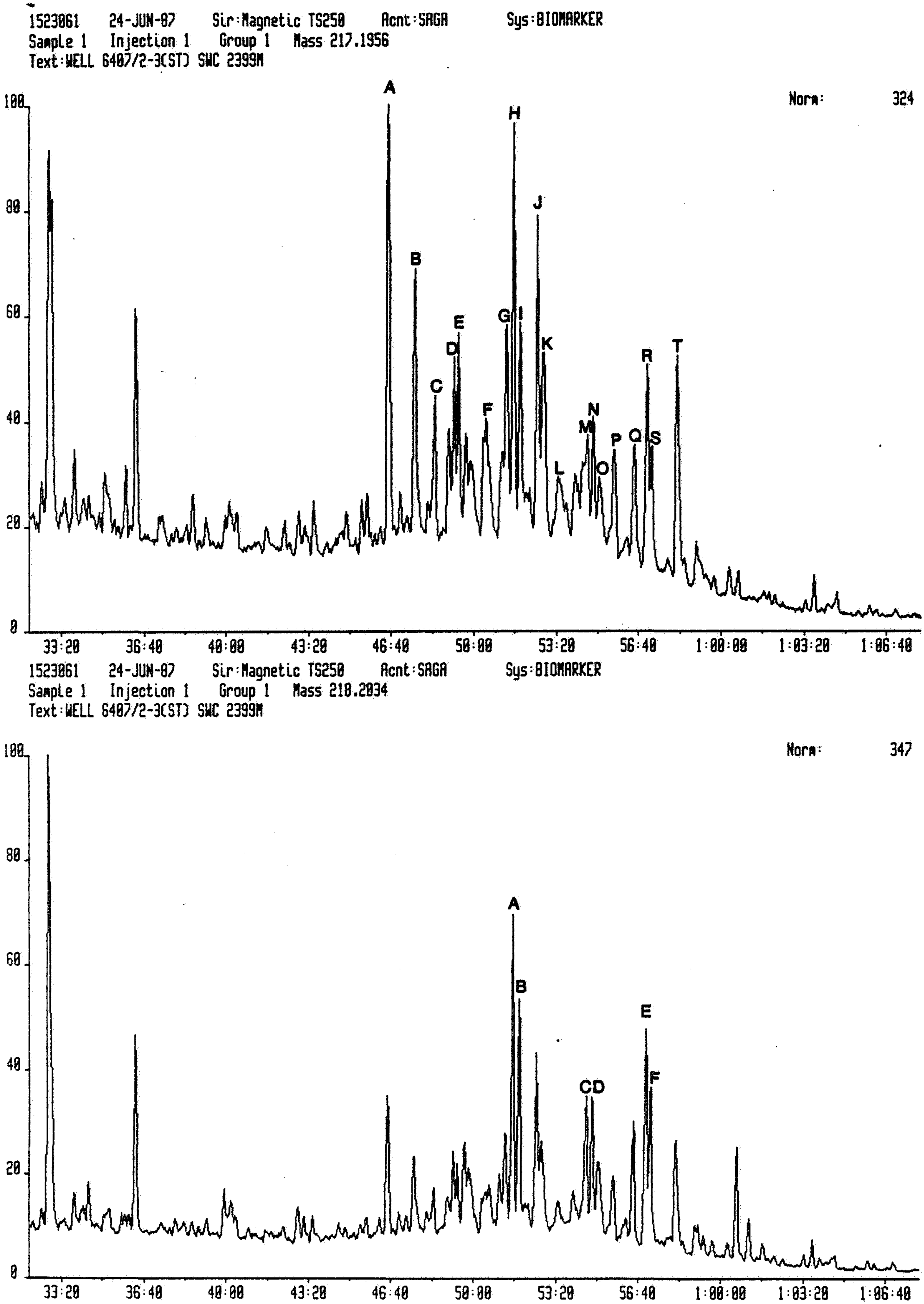


FIGURE 13a

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

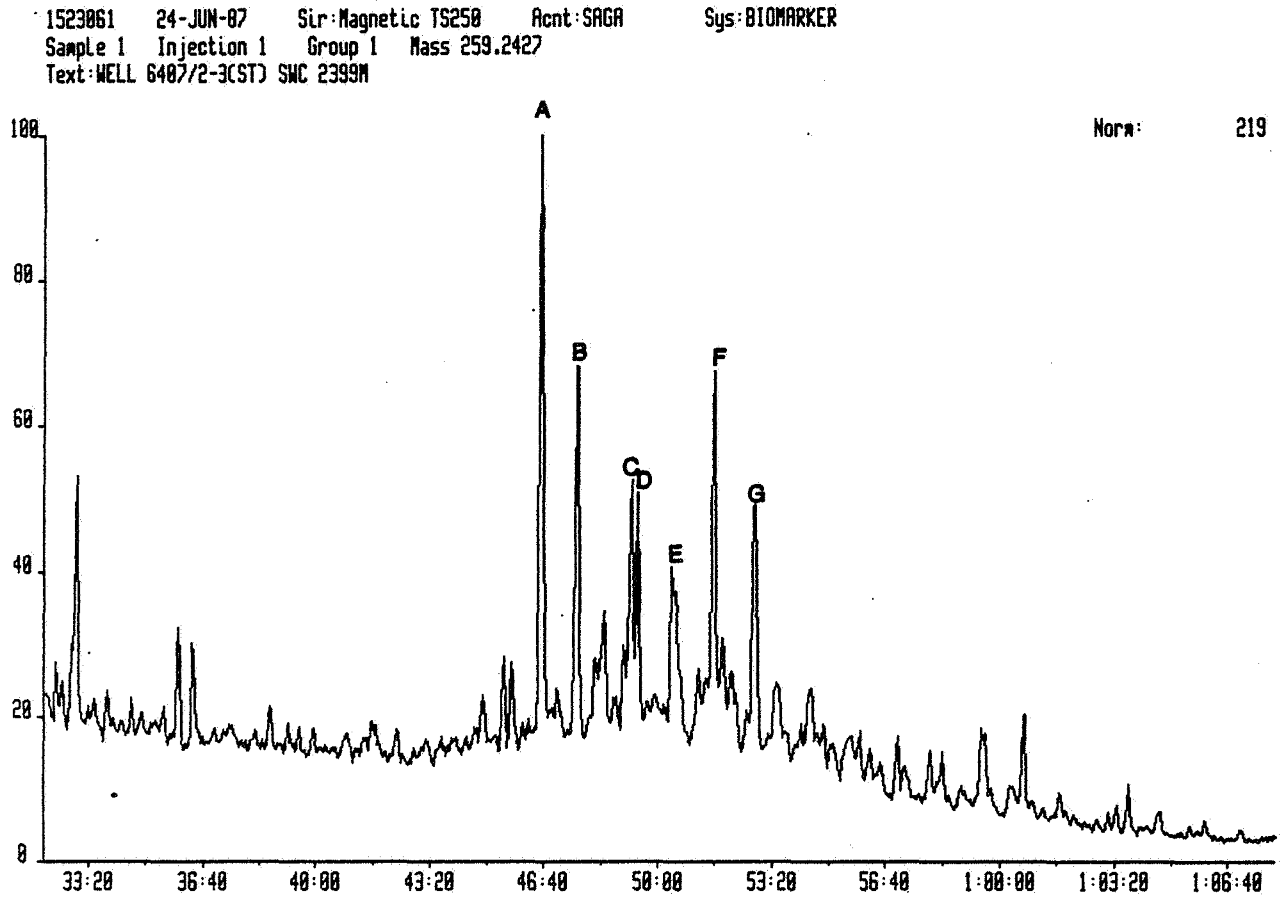


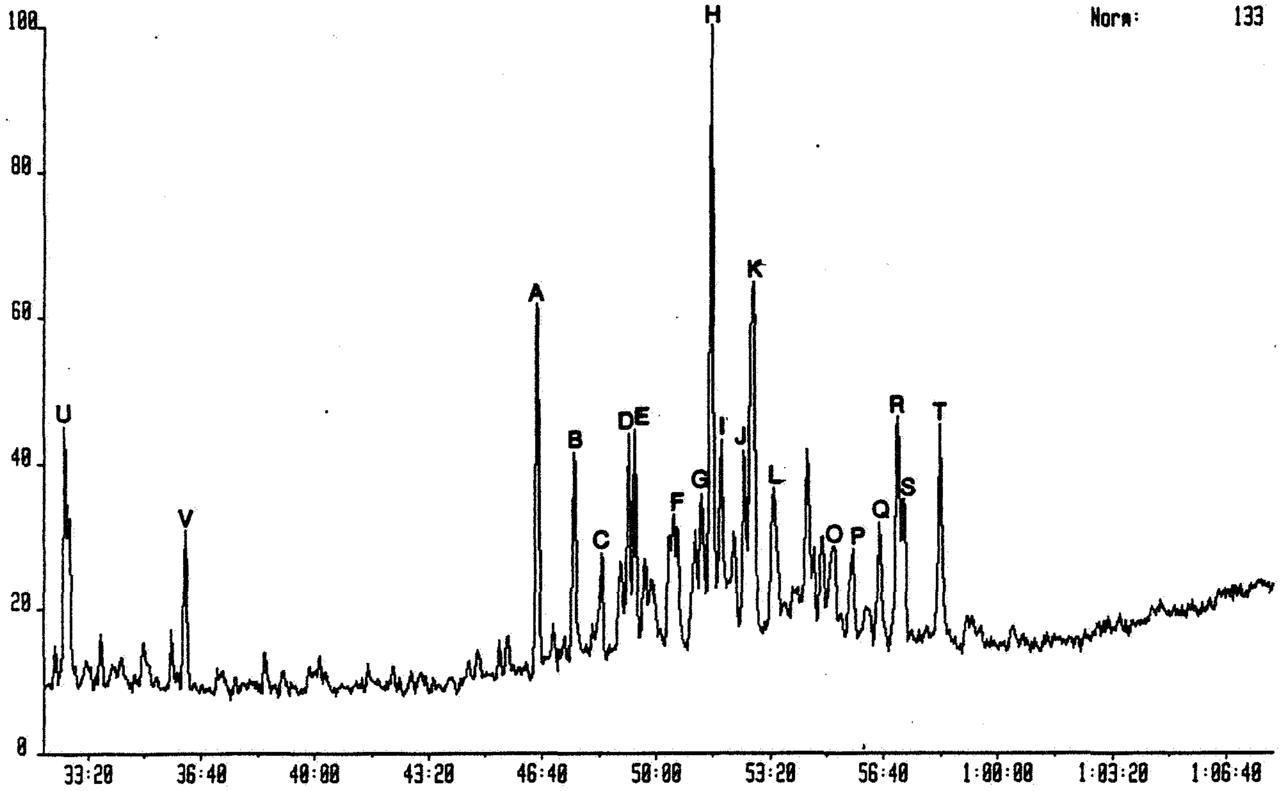
FIGURE 13b

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

1523045 11-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:WELL 6407/2-3(ST) 2965M



1523045 11-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:WELL 6407/2-3(ST) 2965M

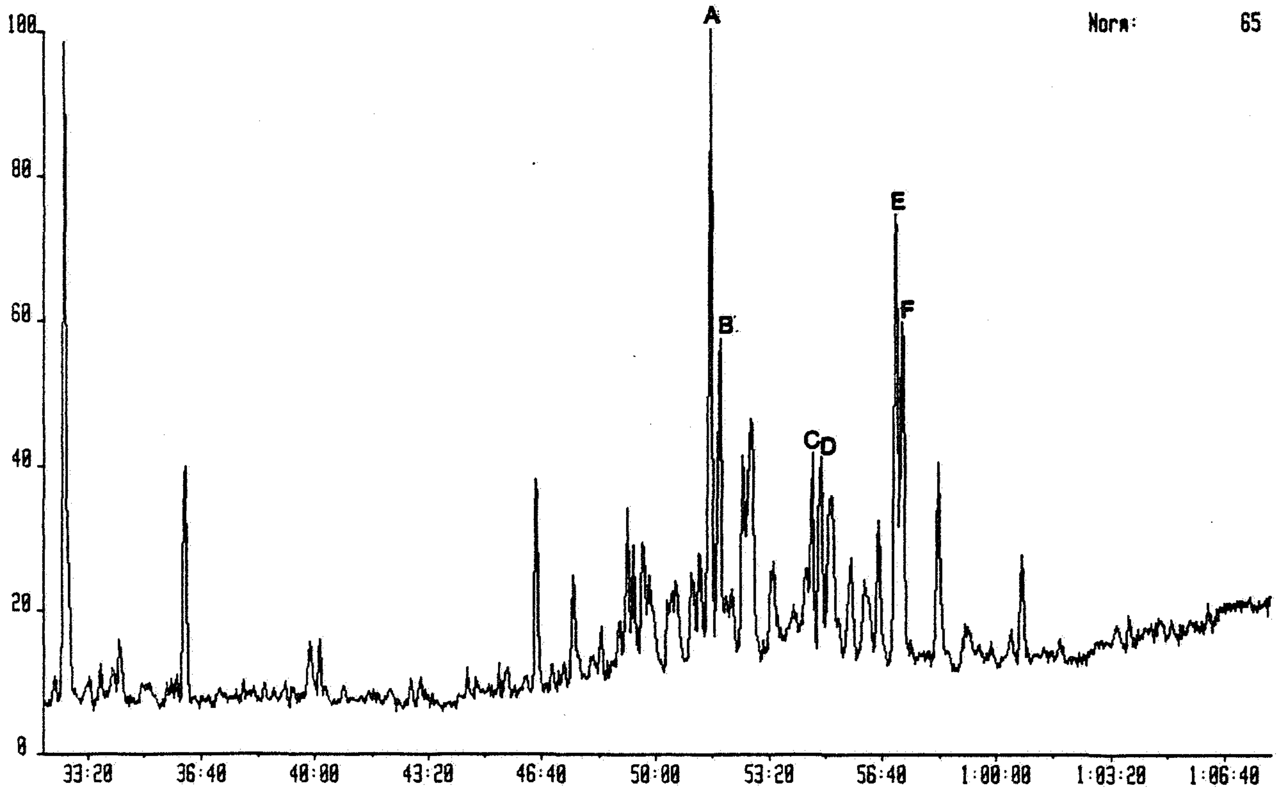


FIGURE 13b

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

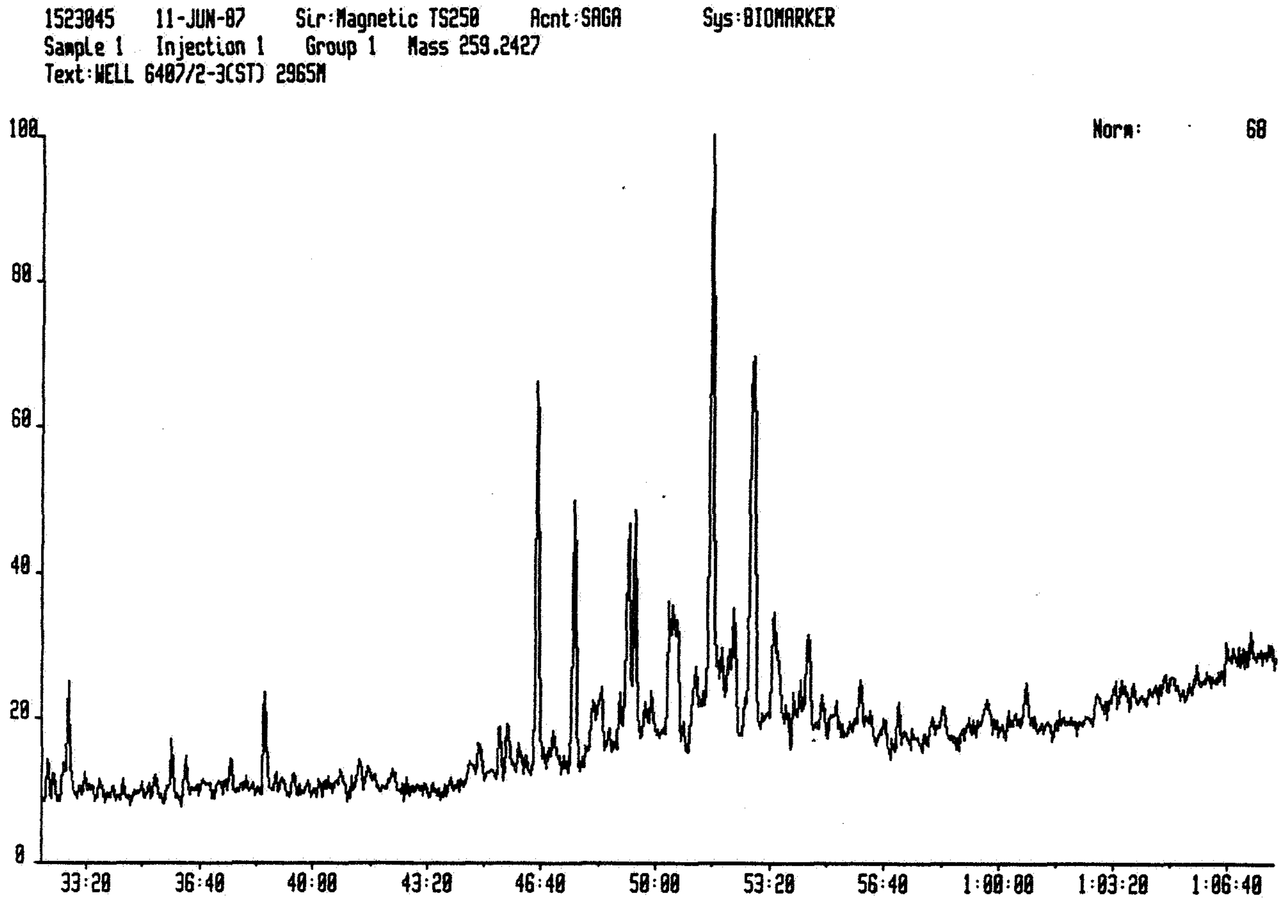


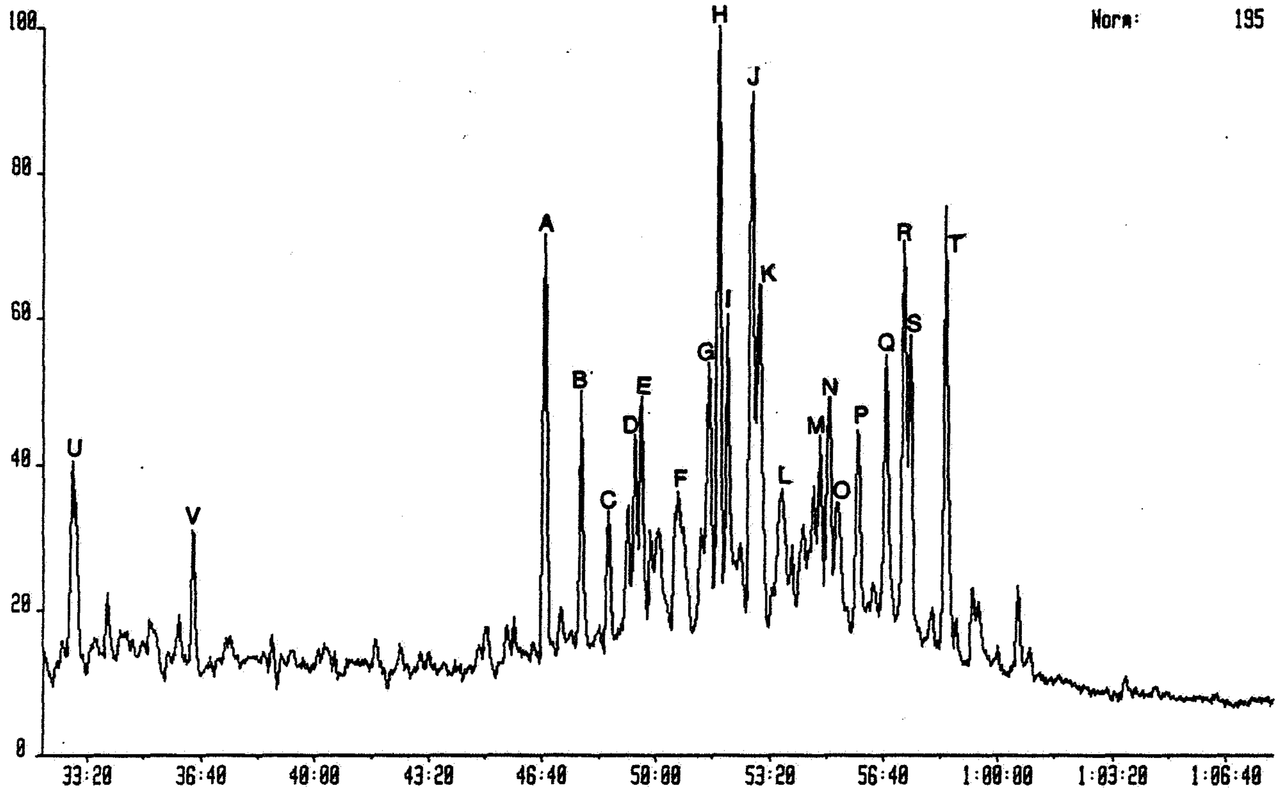
FIGURE 13c

MASS FRAGMENTOGRAMS

STERANES

WELL 6407/2-3

1523049 15-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:WELL 6407/2-3(ST) 3001M



1523049 15-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:WELL 6407/2-3(ST) 3001M

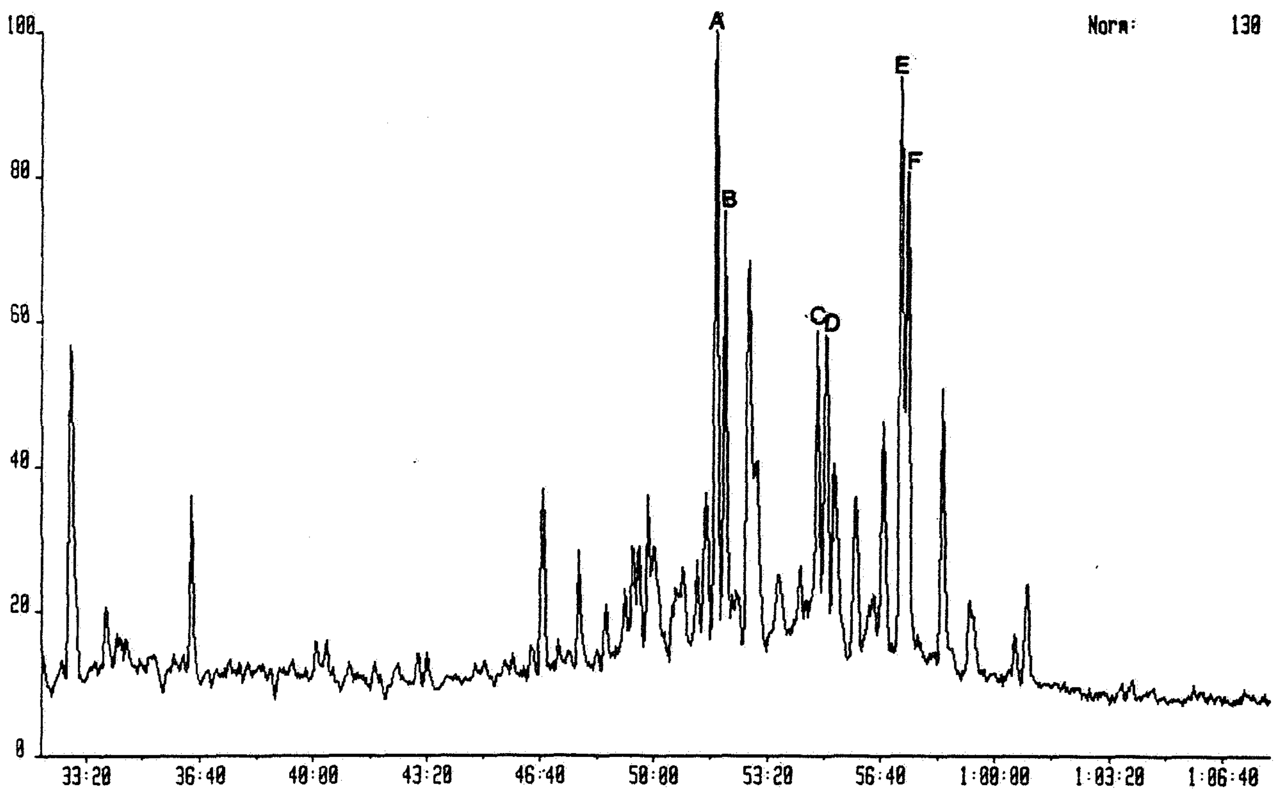


FIGURE 13c

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

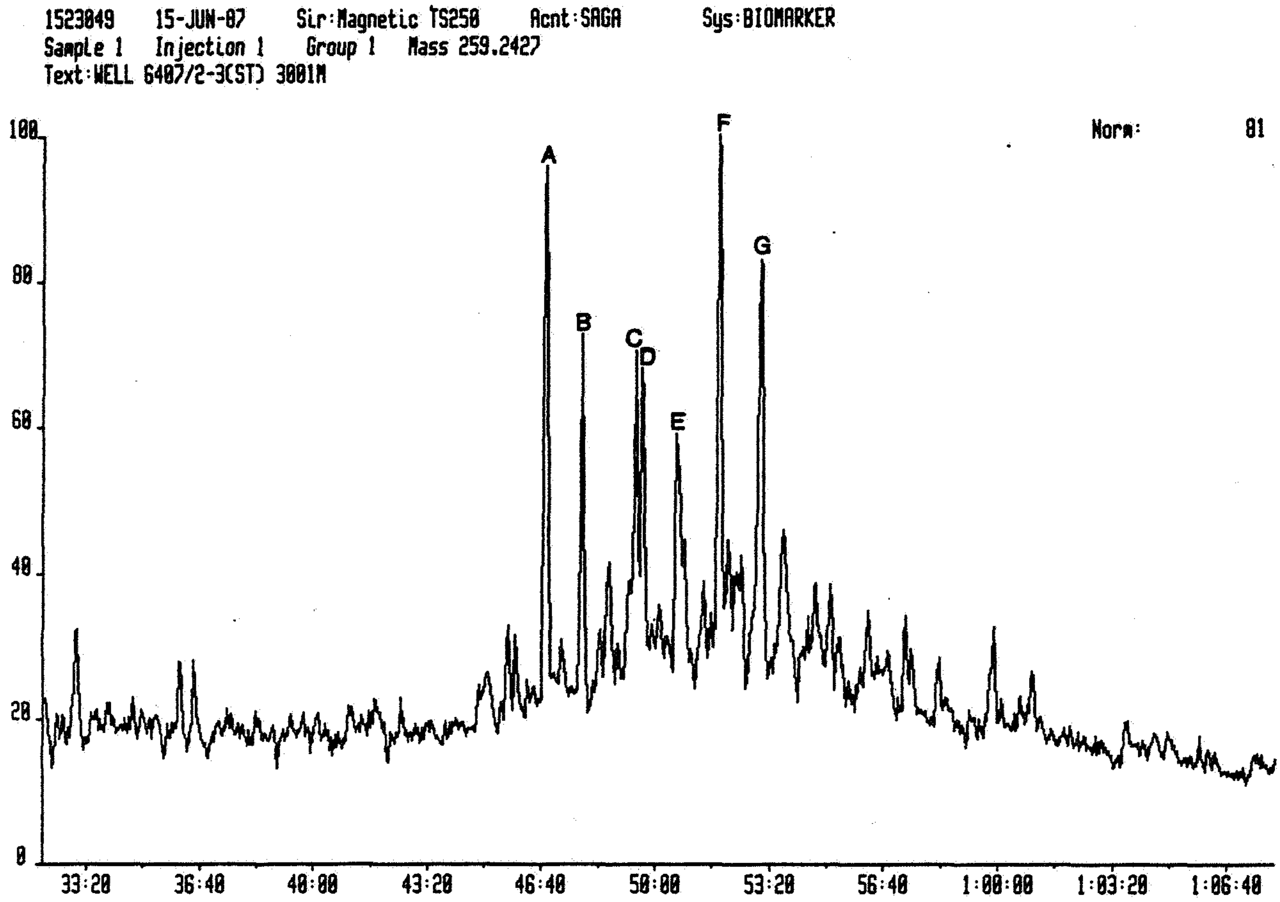


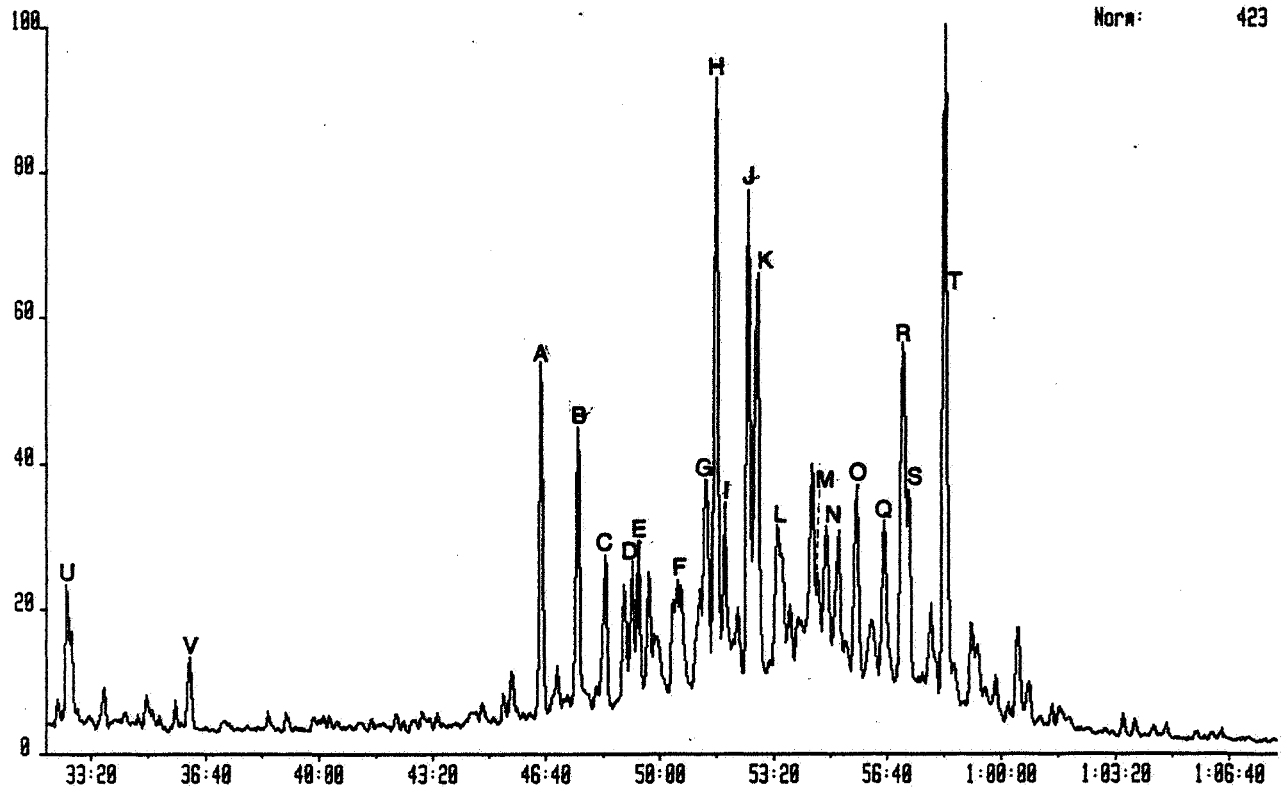
FIGURE 13d

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

1523053 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:WELL 6407/2-3(ST) 3037M



1523053 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:WELL 6407/2-3(ST) 3037M

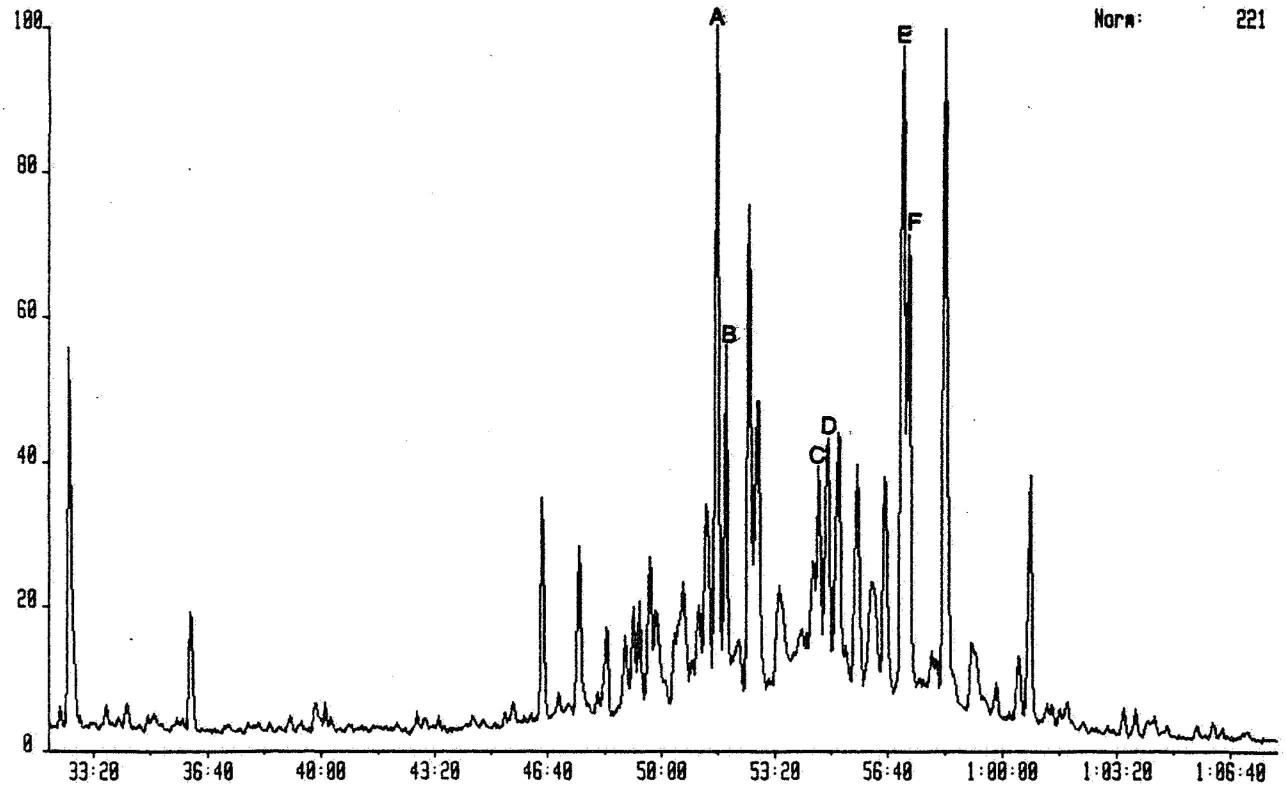


FIGURE 13d

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

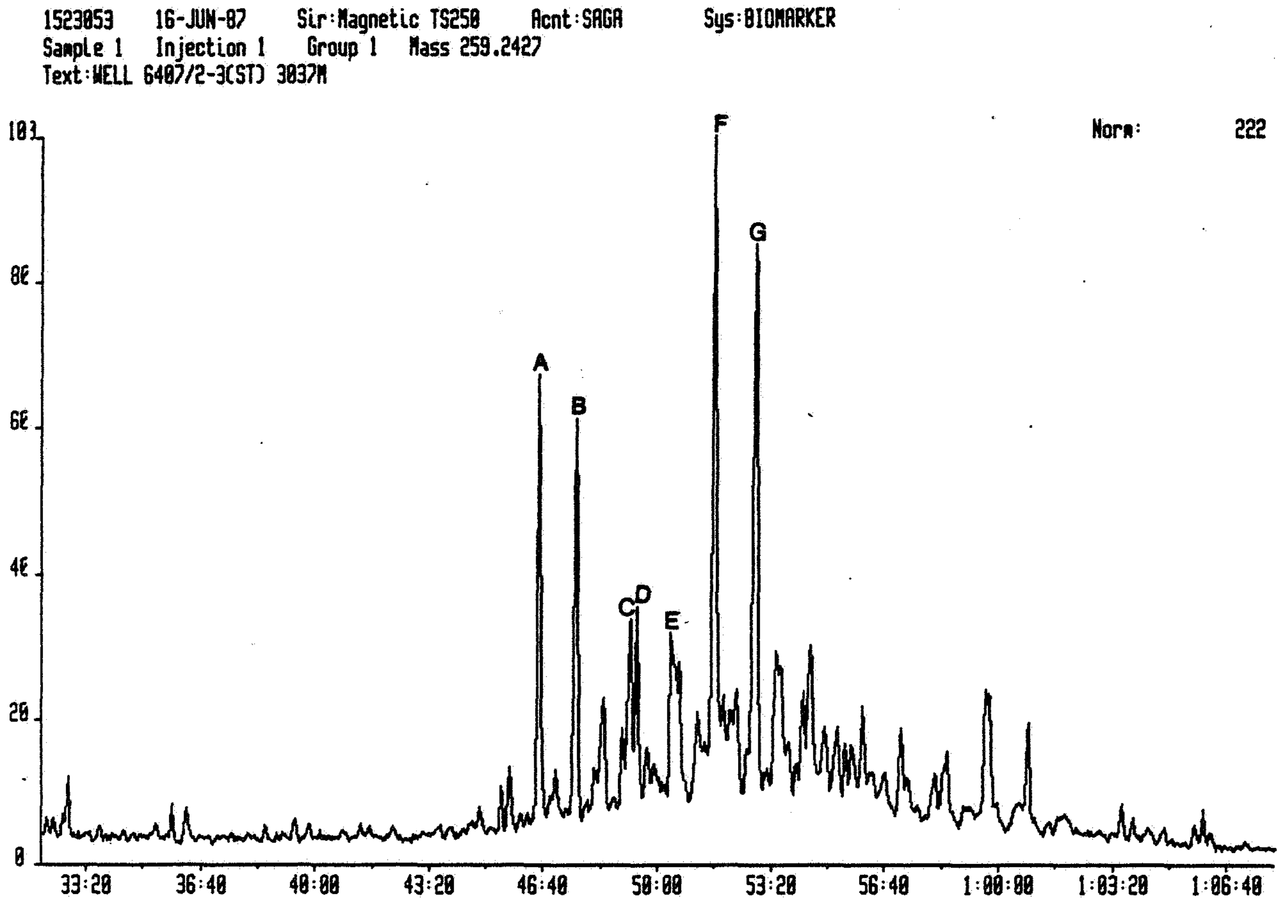
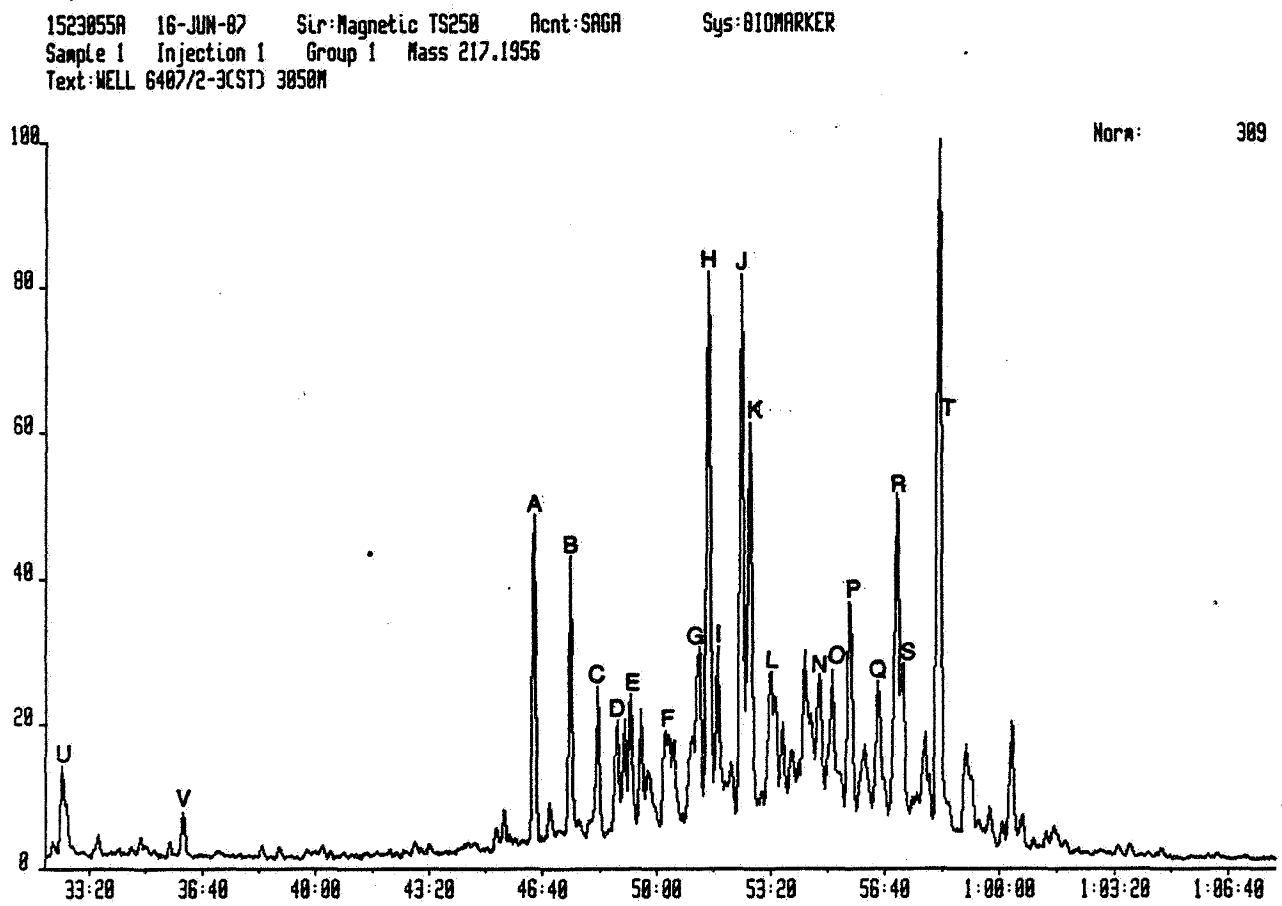


FIGURE 13e

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES



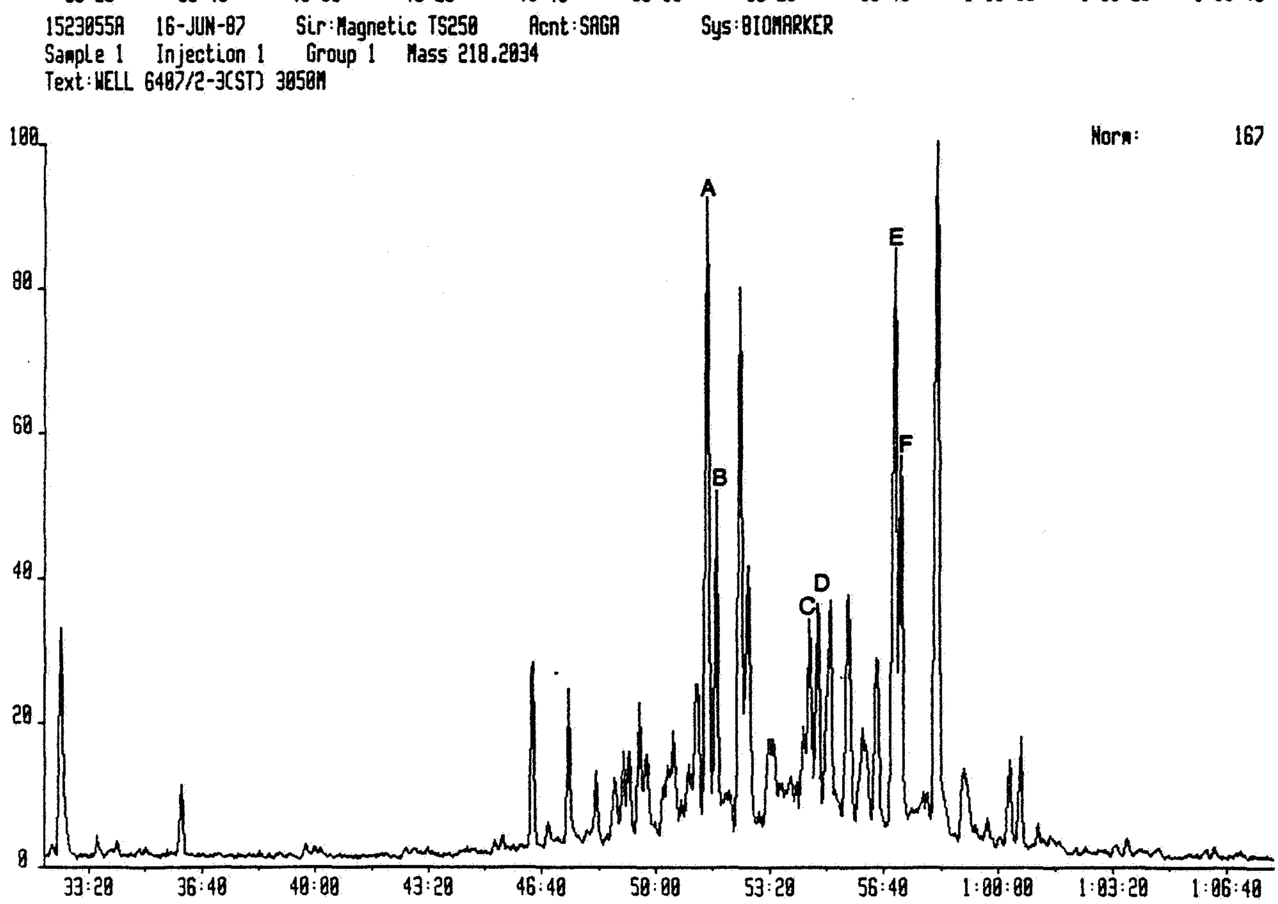


FIGURE 13e

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

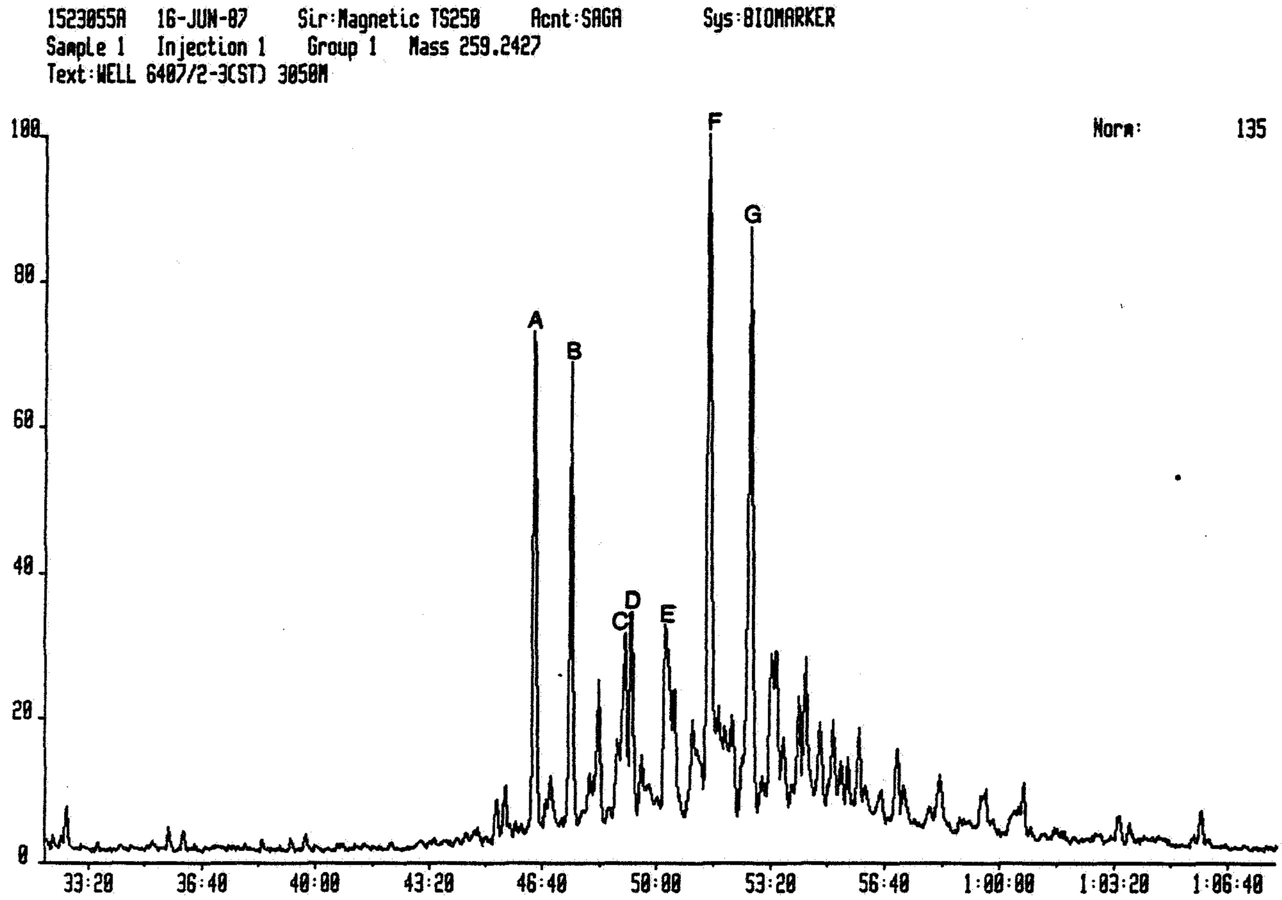


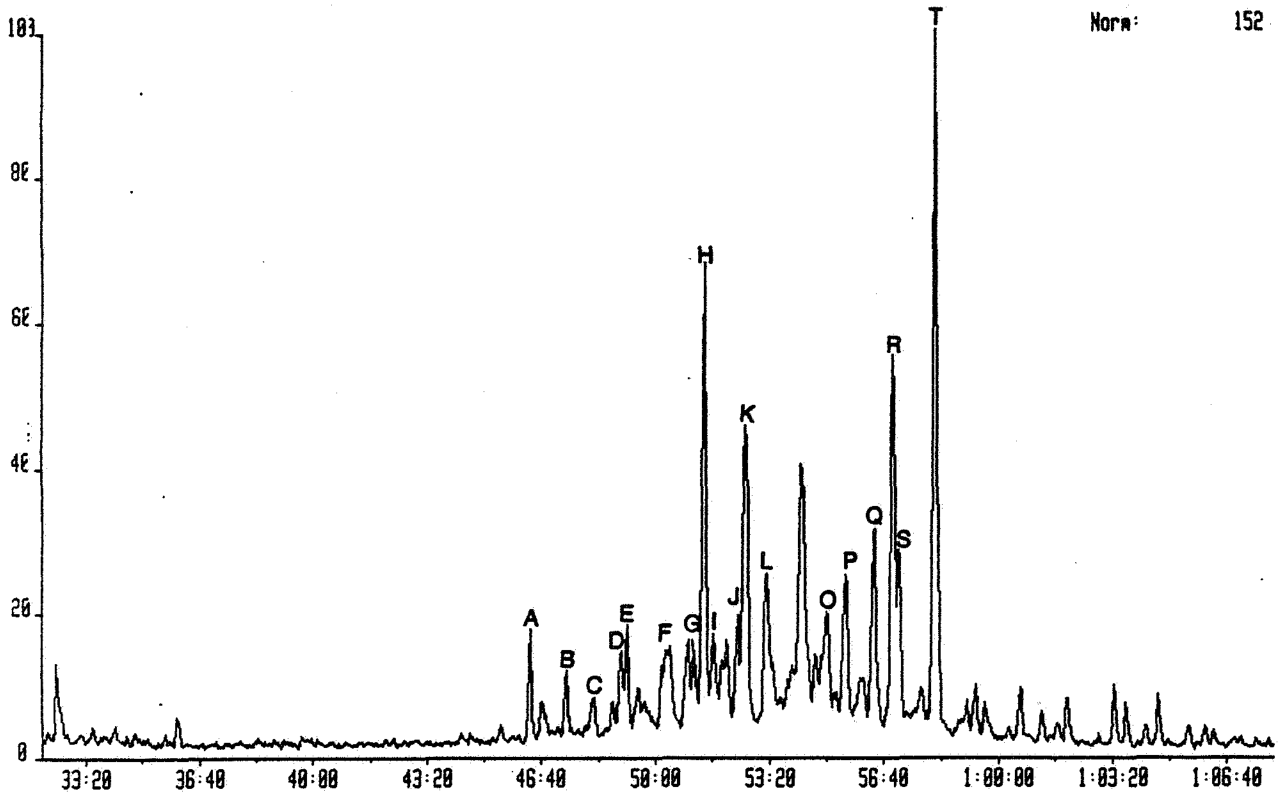
FIGURE 13f

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

15230558 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:WELL 6407/2-3(ST) 3050M



15230558 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:WELL 6407/2-3(ST) 3050M

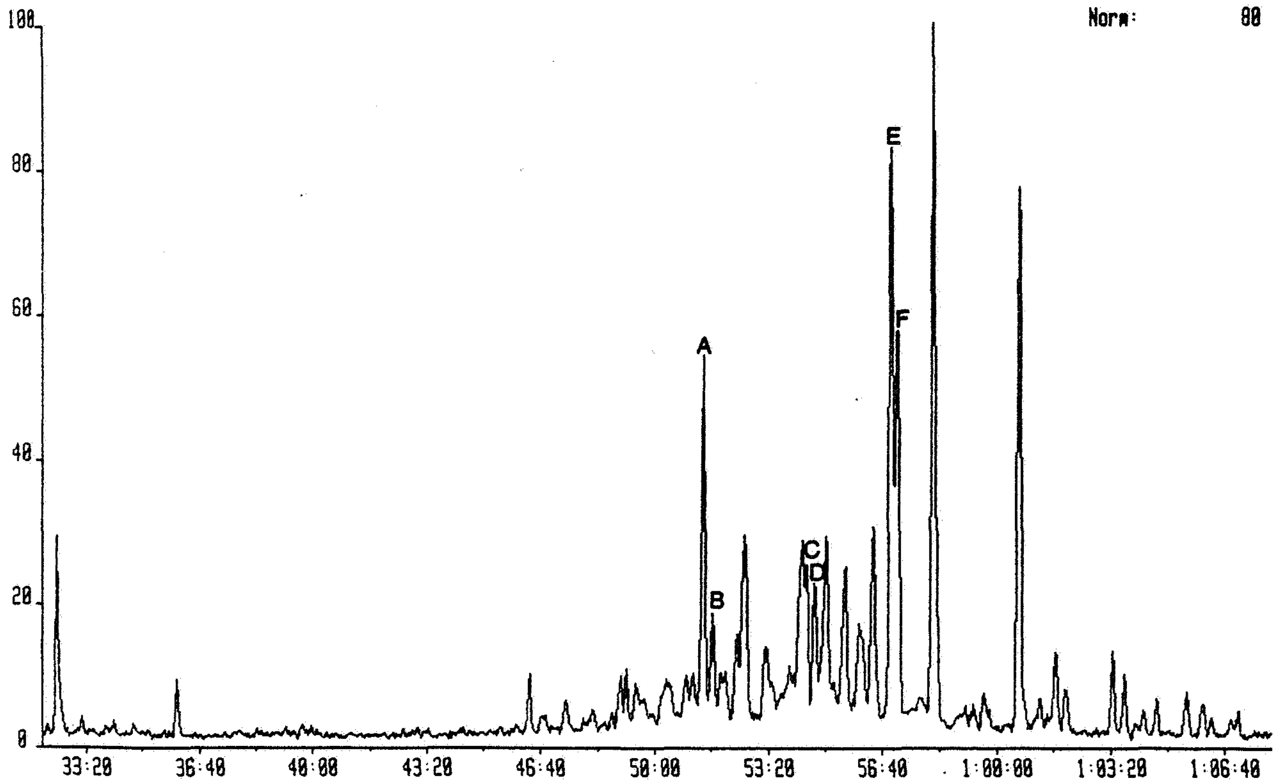


FIGURE 13f

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

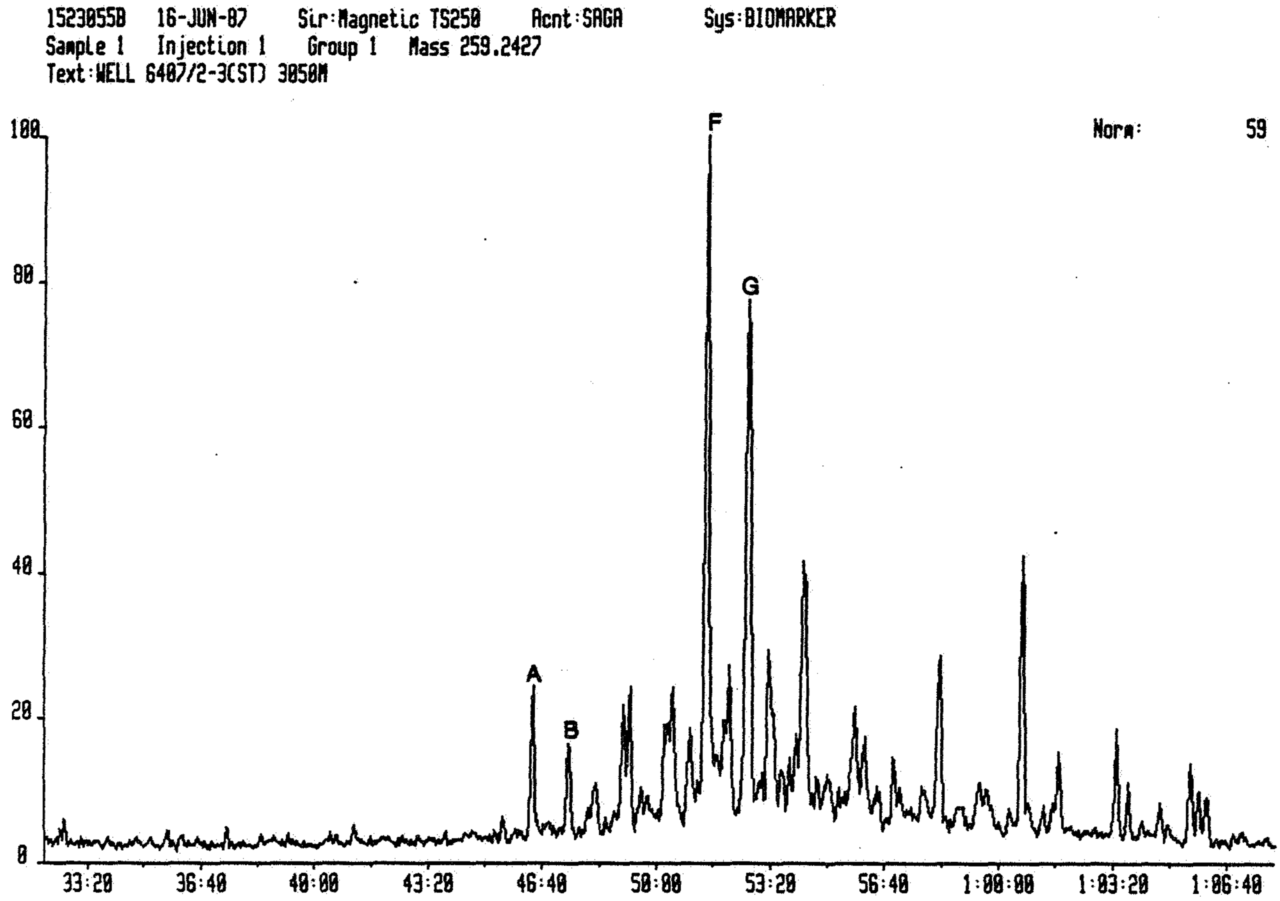


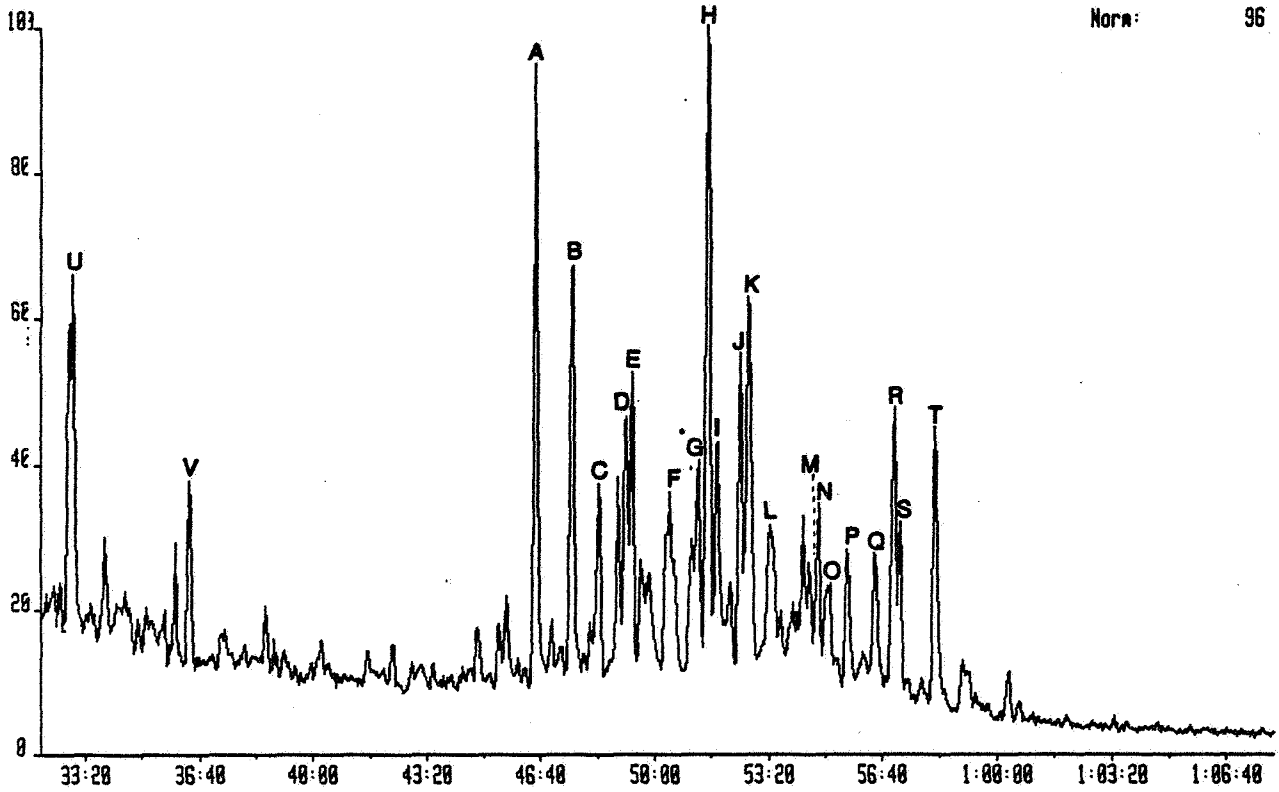
FIGURE 13g

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

1523056 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:STOCK TANK OIL



1523056 16-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:STOCK TANK OIL

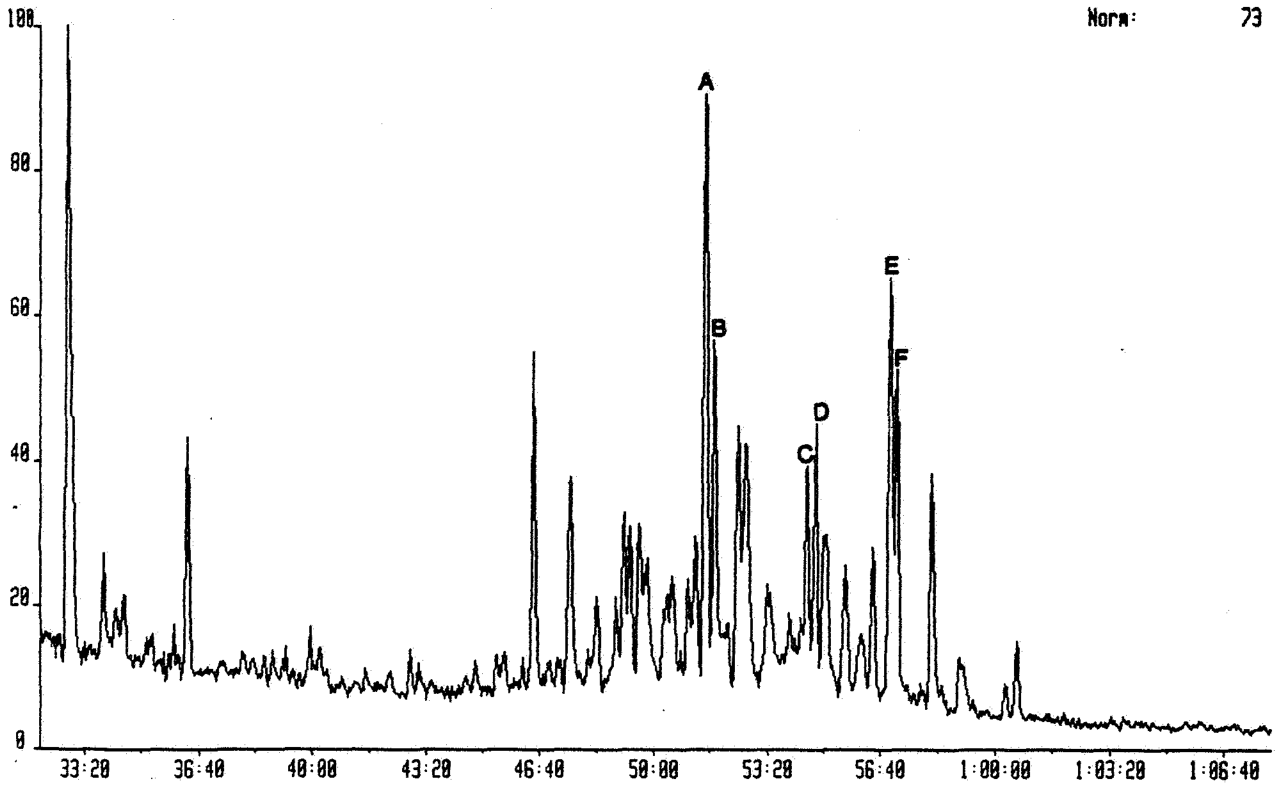


FIGURE 13g

WELL 6407/2-3

MASS FRAGMENTOGRAMS

STERANES

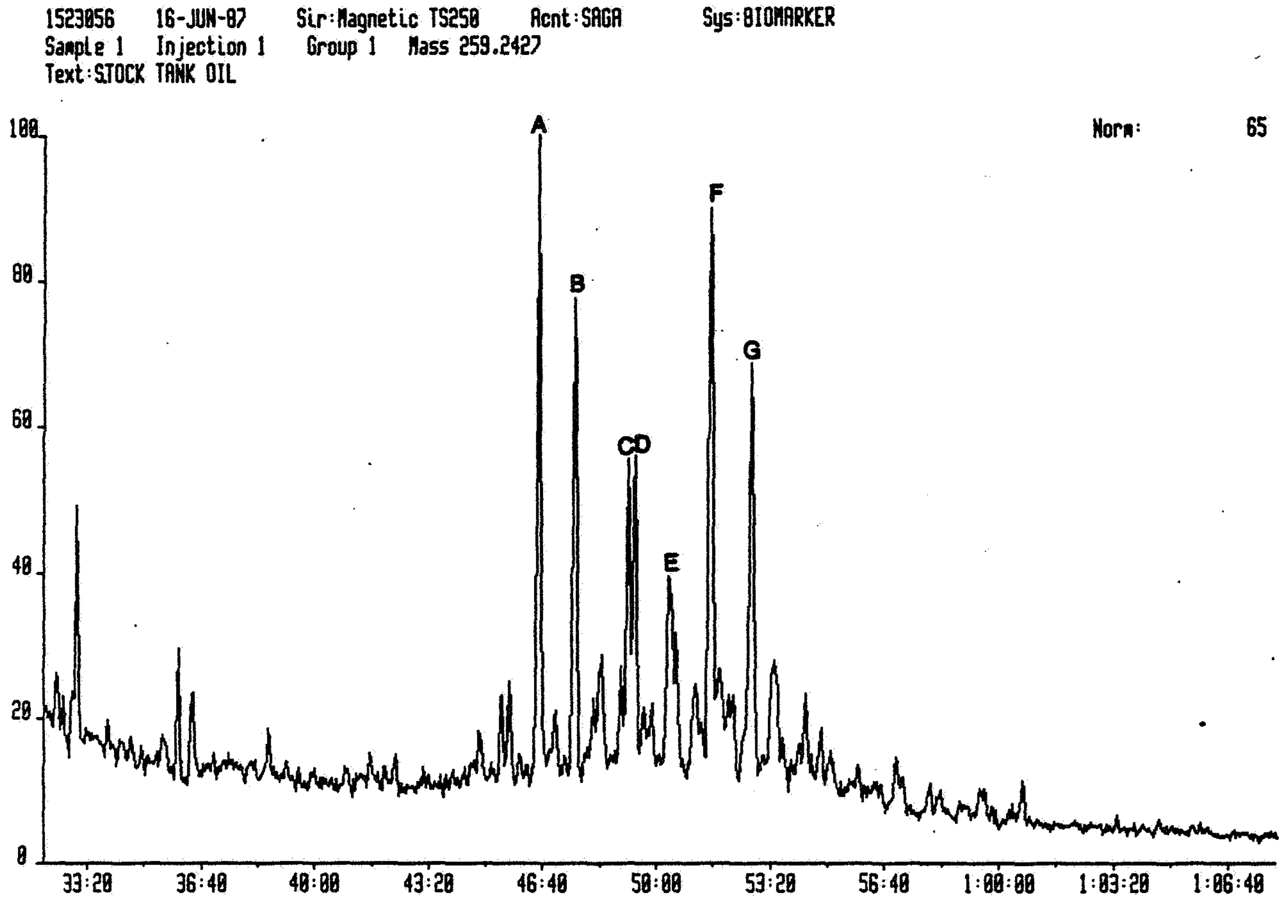


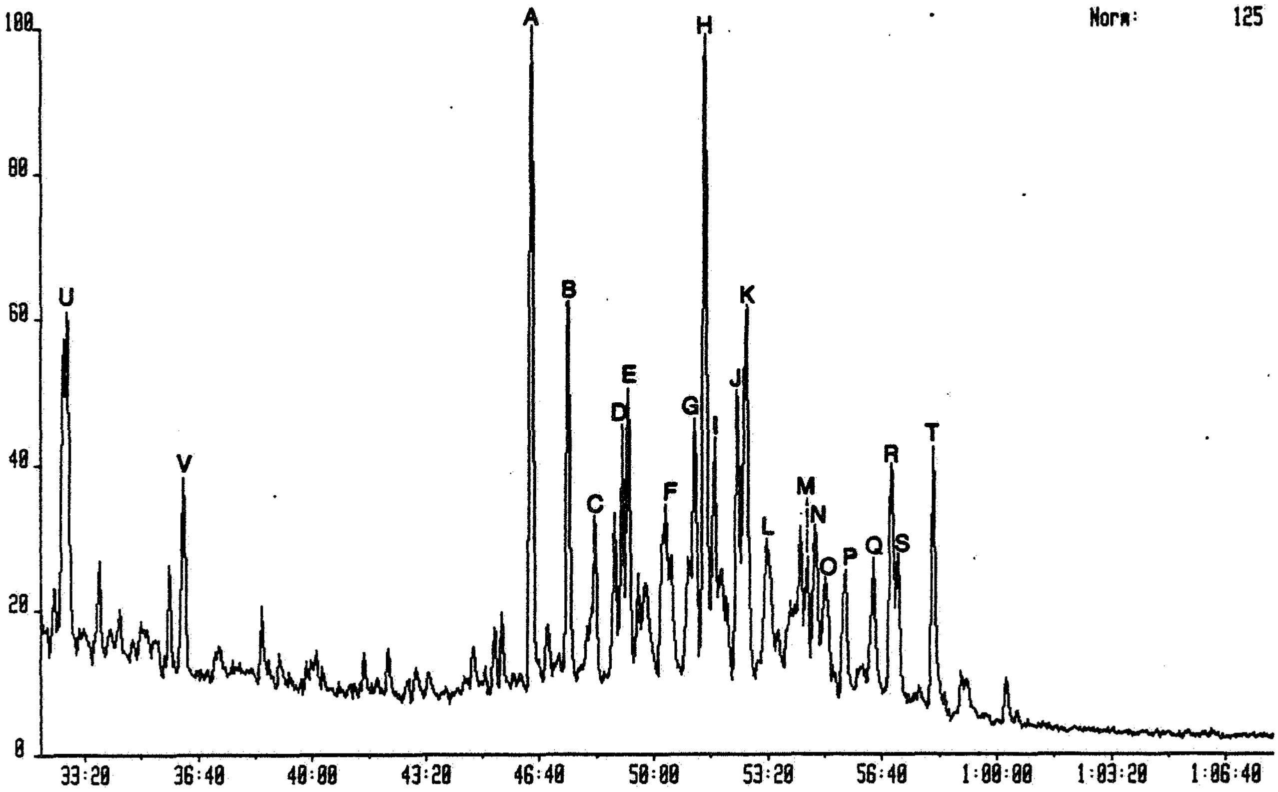
FIGURE 13h

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

1523060 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 217.1956
Text:SINGLE FLASH CONDENSATE



1523060 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 218.2034
Text:SINGLE FLASH CONDENSATE

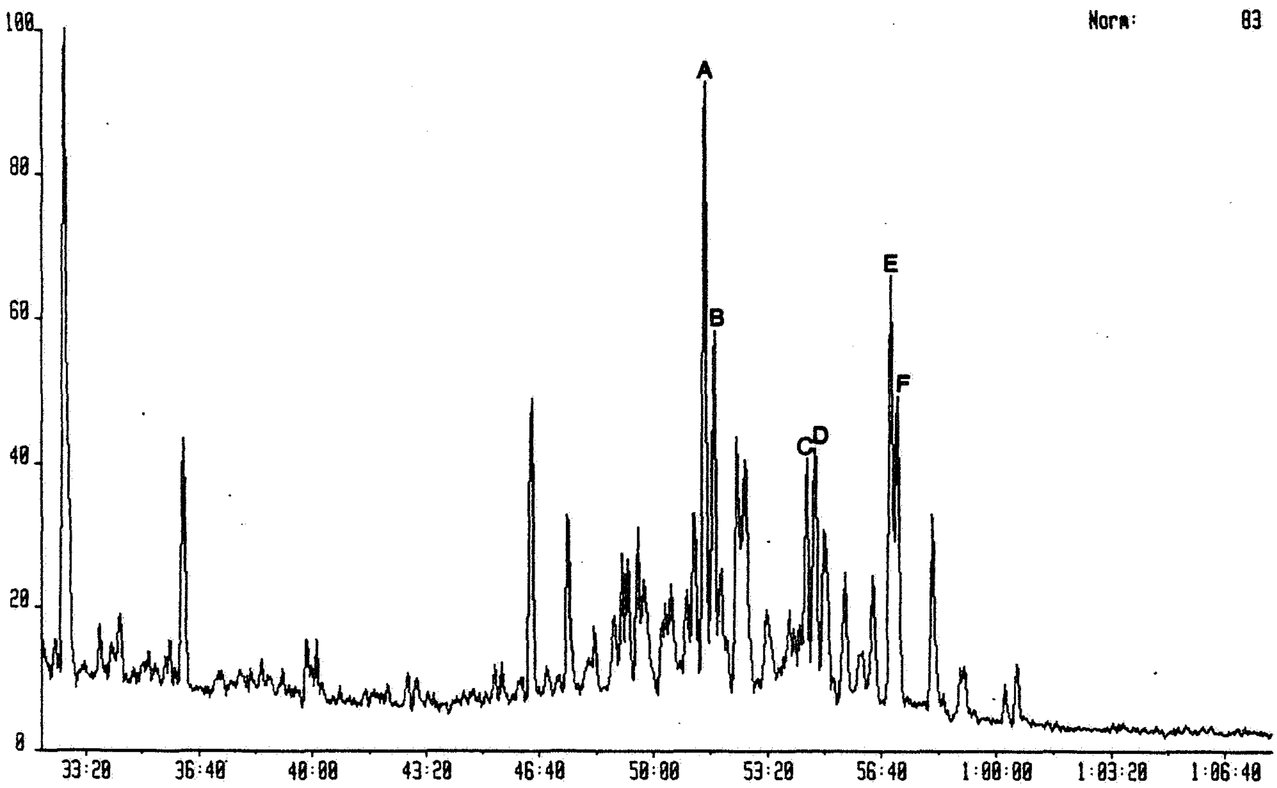


FIGURE 13h

MASS FRAGMENTOGRAMS

WELL 6407/2-3

STERANES

1523060 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:BIOMARKER
Sample 1 Injection 1 Group 1 Mass 259.2427
Text:SINGLE FLASH CONDENSATE

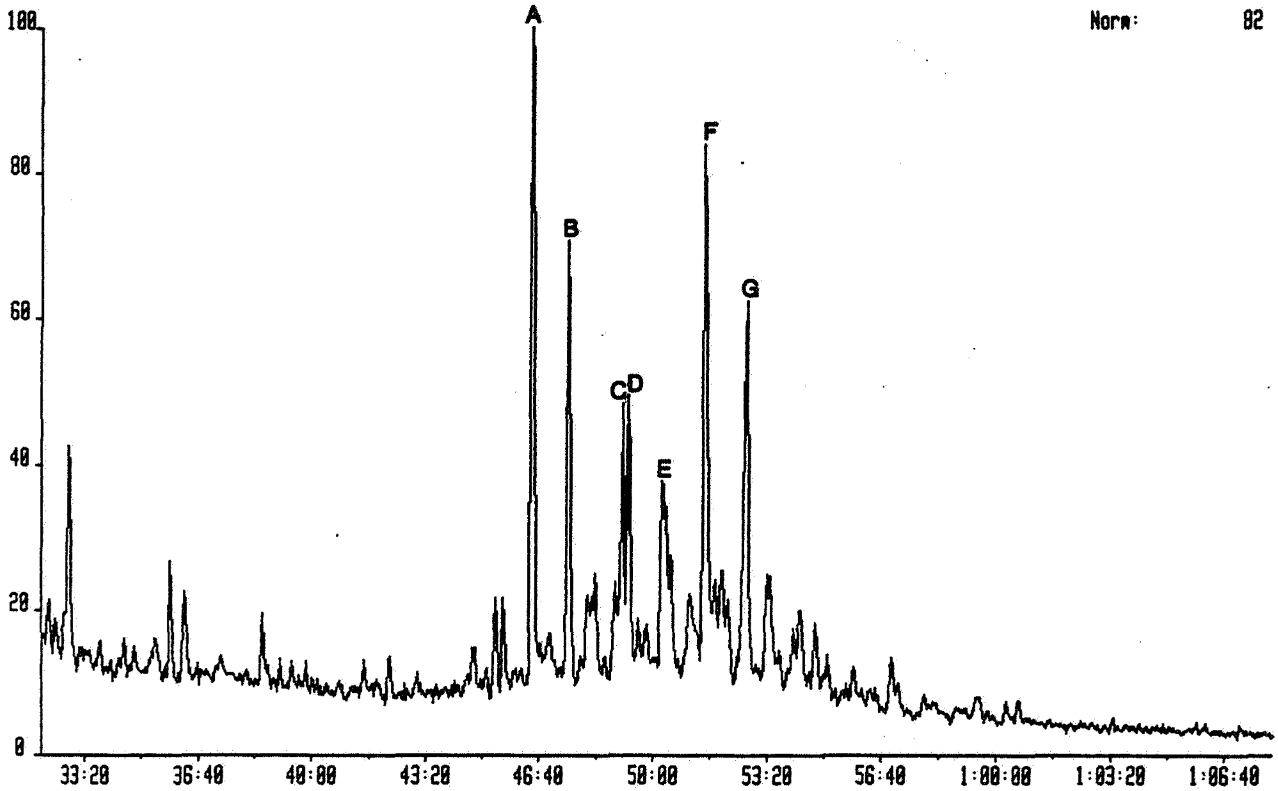


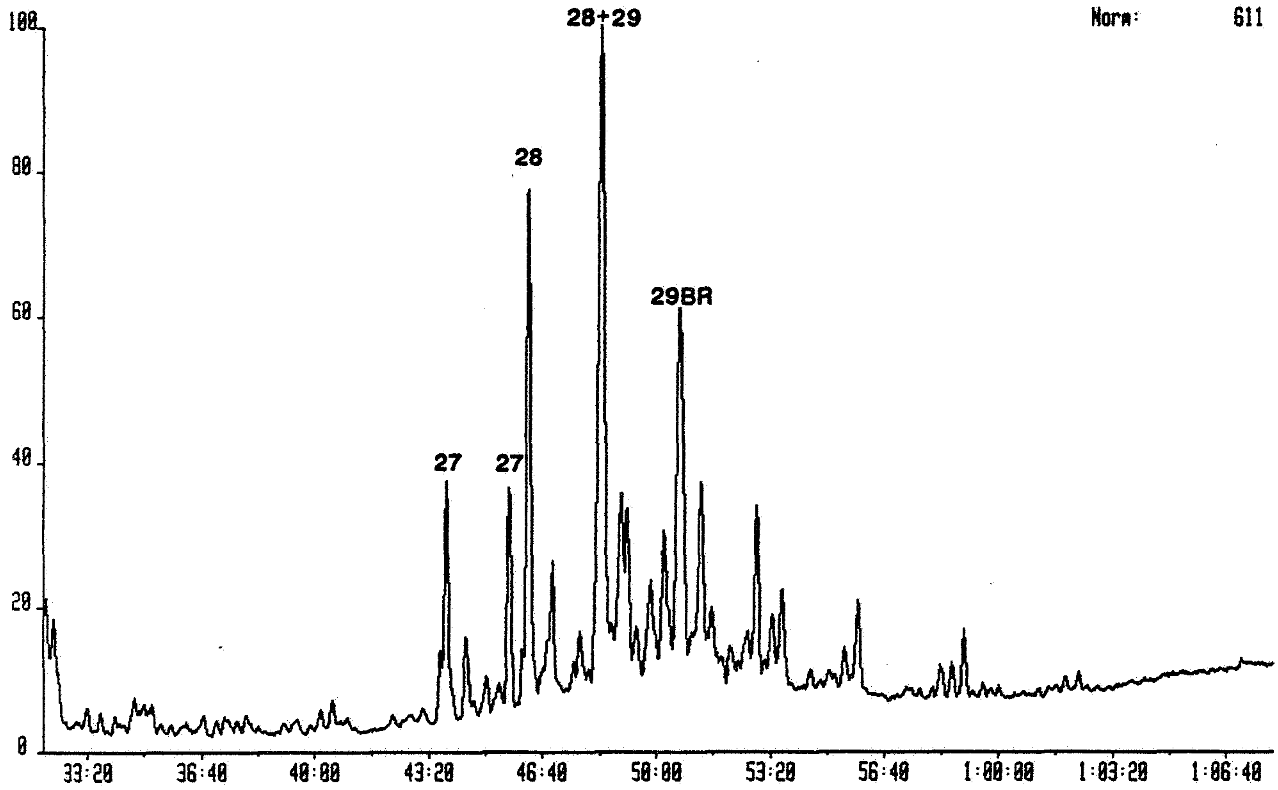
FIGURE 14a

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC

m/z 231 = TRIAROMATIC

1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 253.1956
Text:6407/2-3(ST) SWC 2399M



1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 231.2100
Text:6407/2-3(ST) SWC 2399M

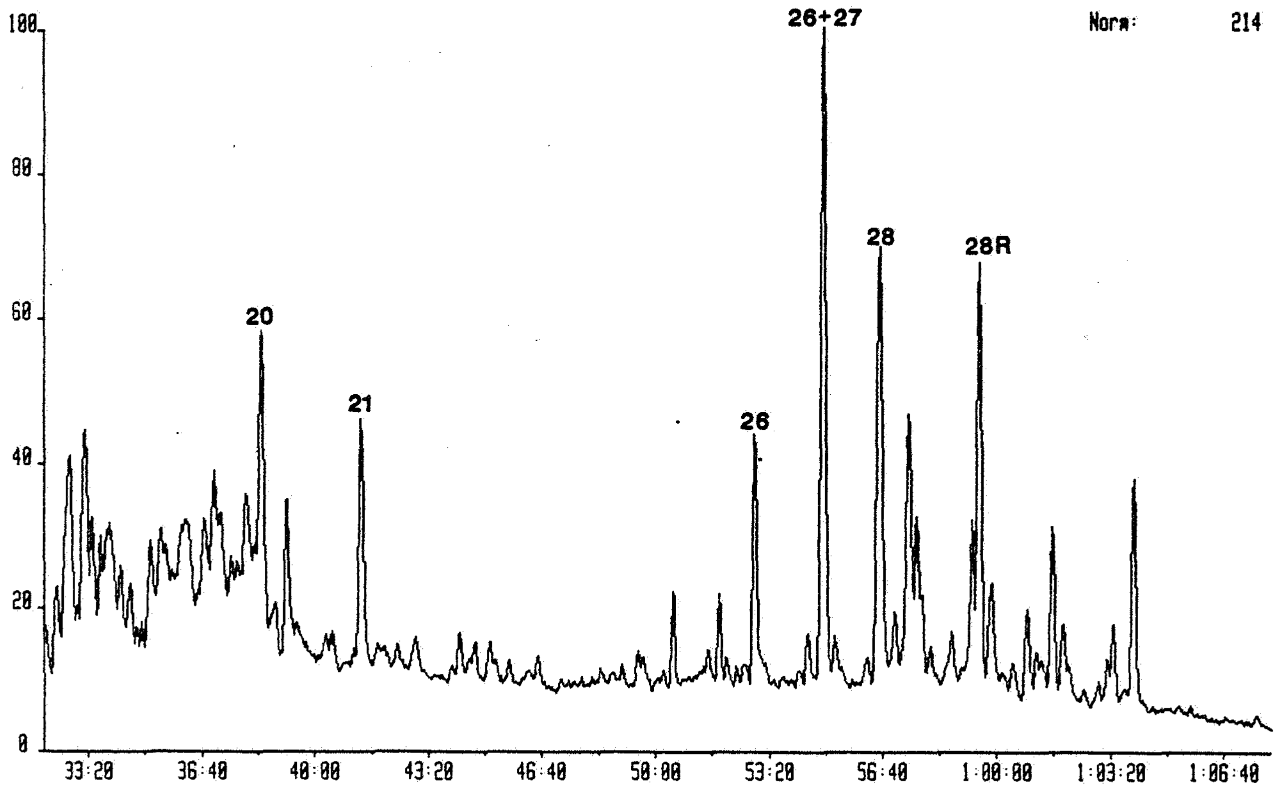


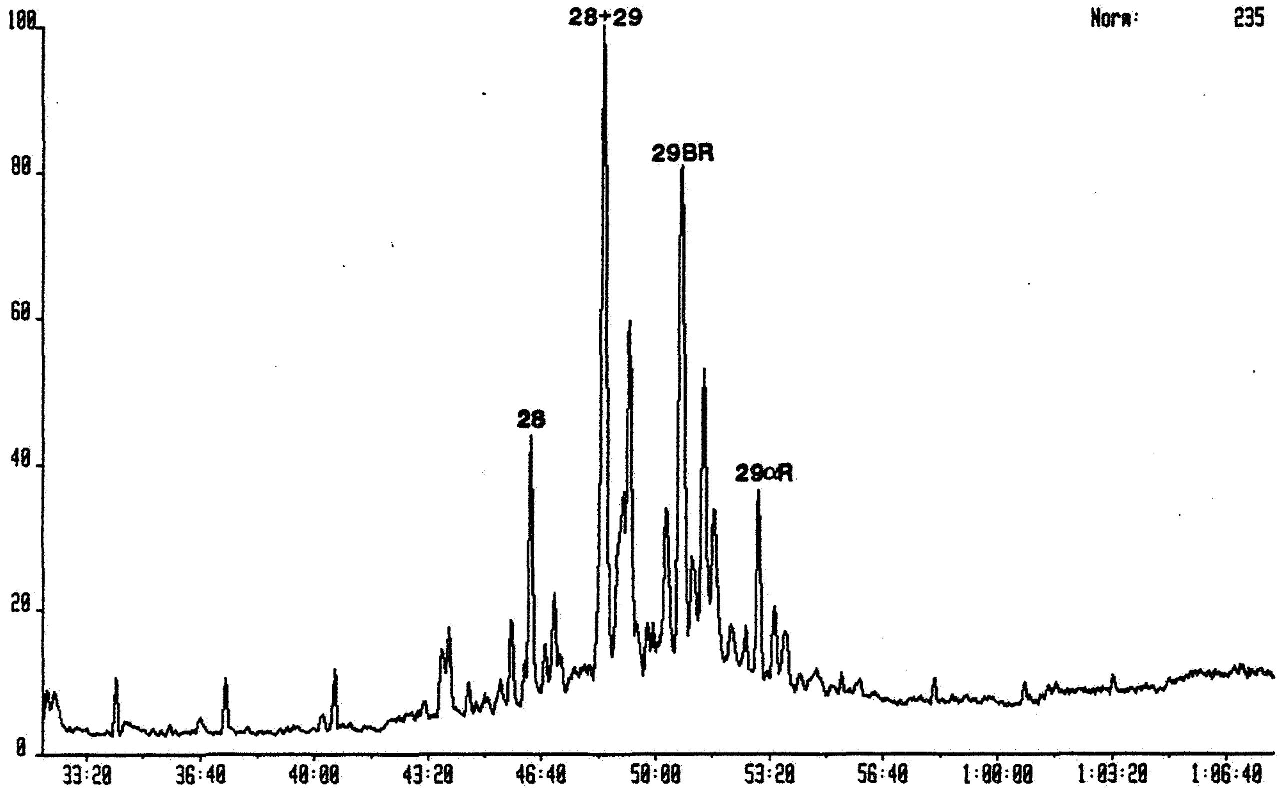
FIGURE 14b

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC

m/z 231 = TRIAROMATIC

1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 253.1956
Text:WELL 6407/2-3(ST) 2965M



1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 231.2100
Text:WELL 6407/2-3(ST) 2965M

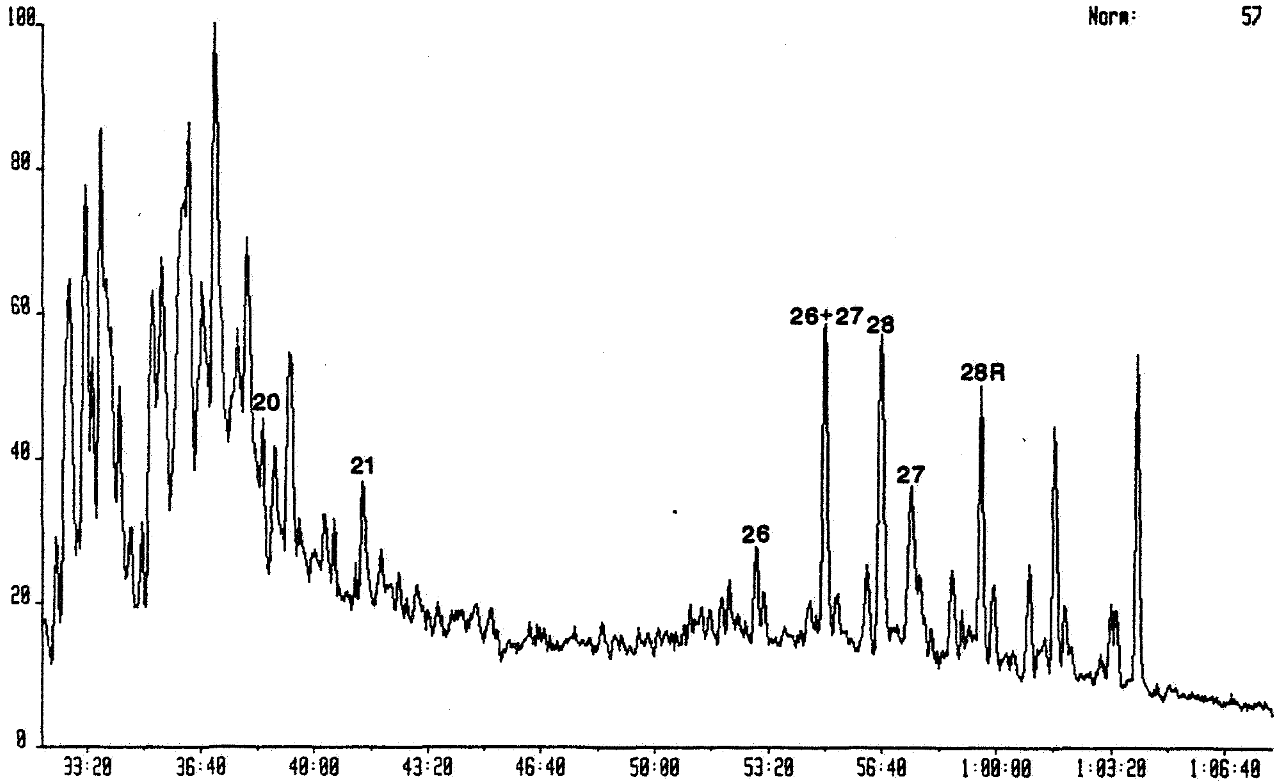
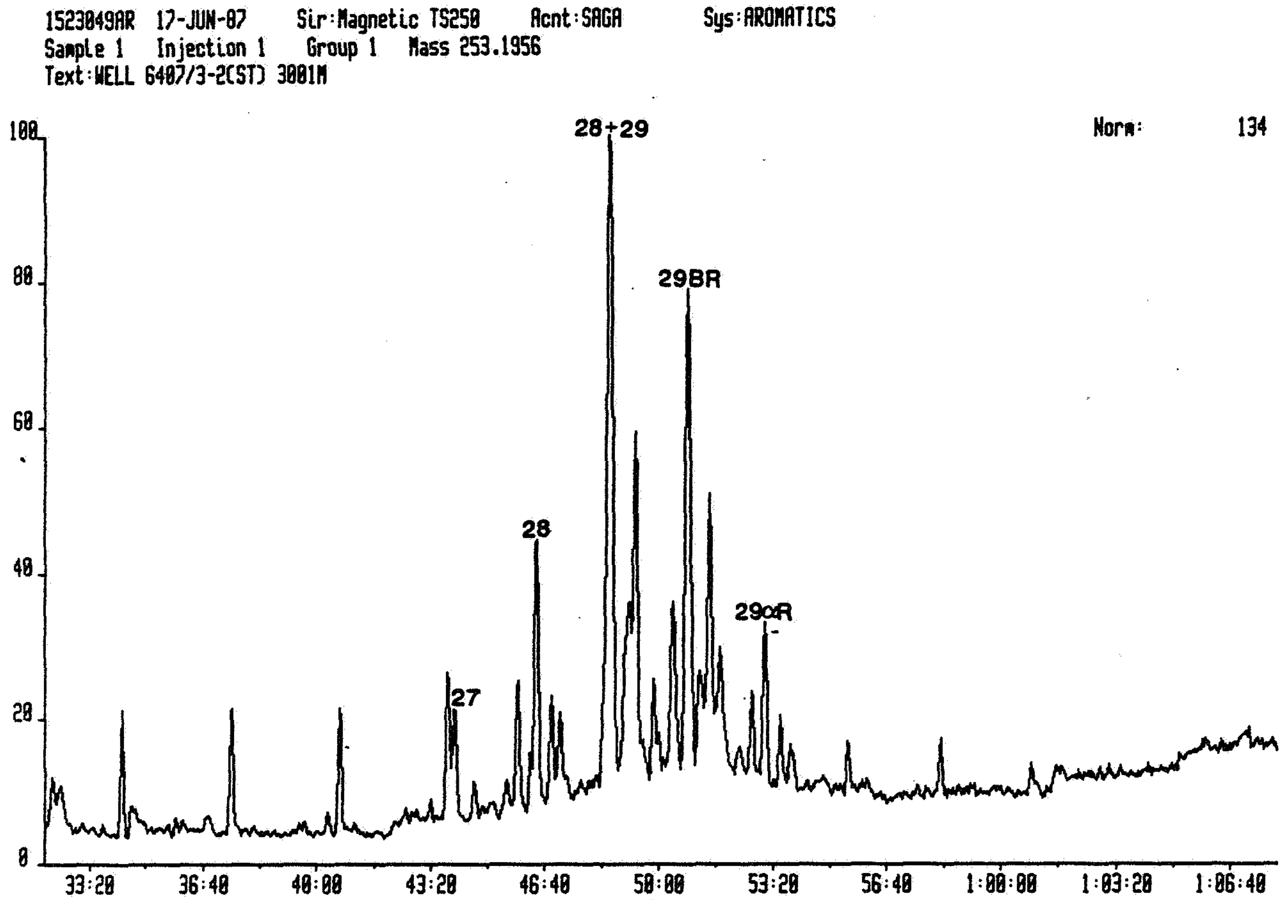


FIGURE 14c

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC
m/z 231 = TRIAROMATIC



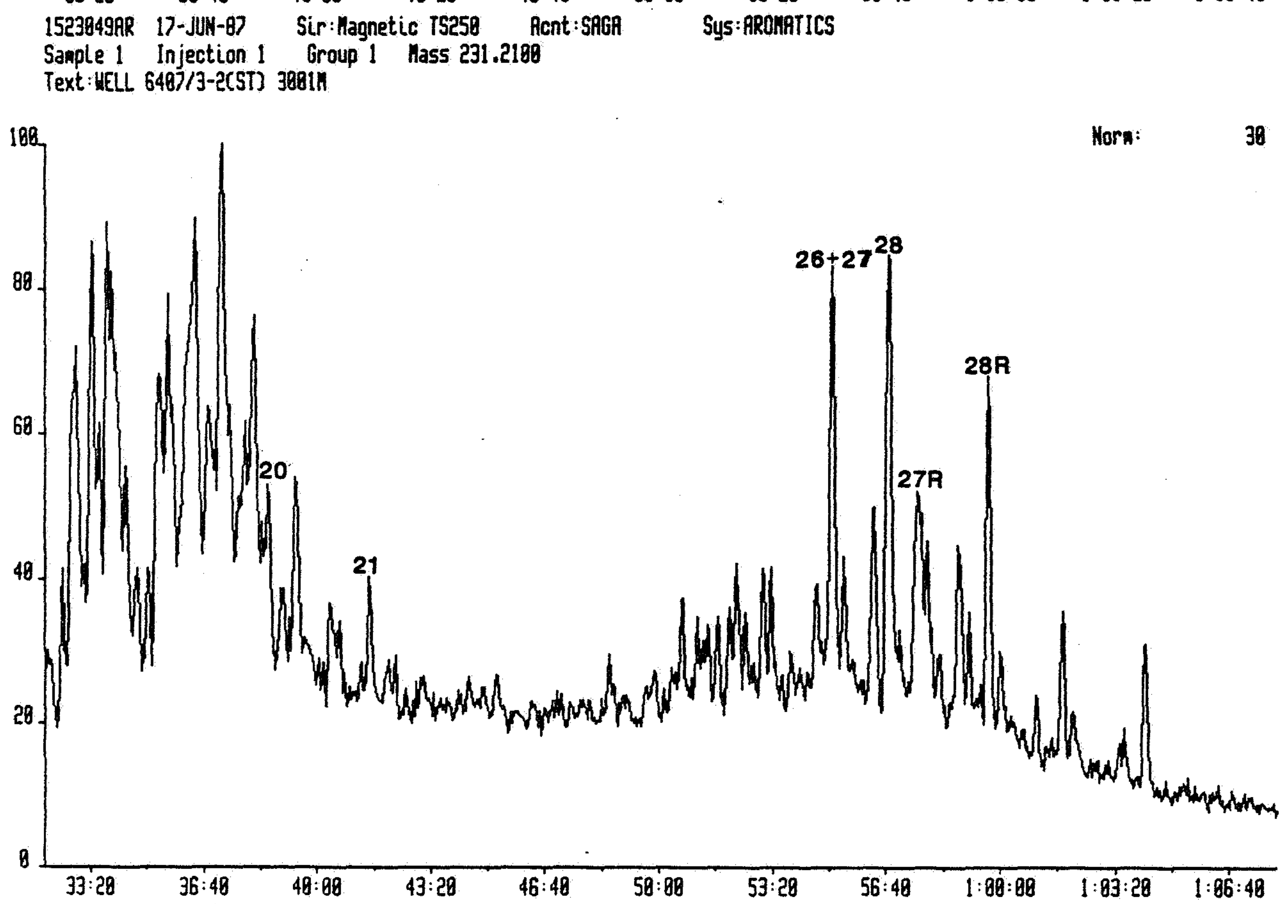
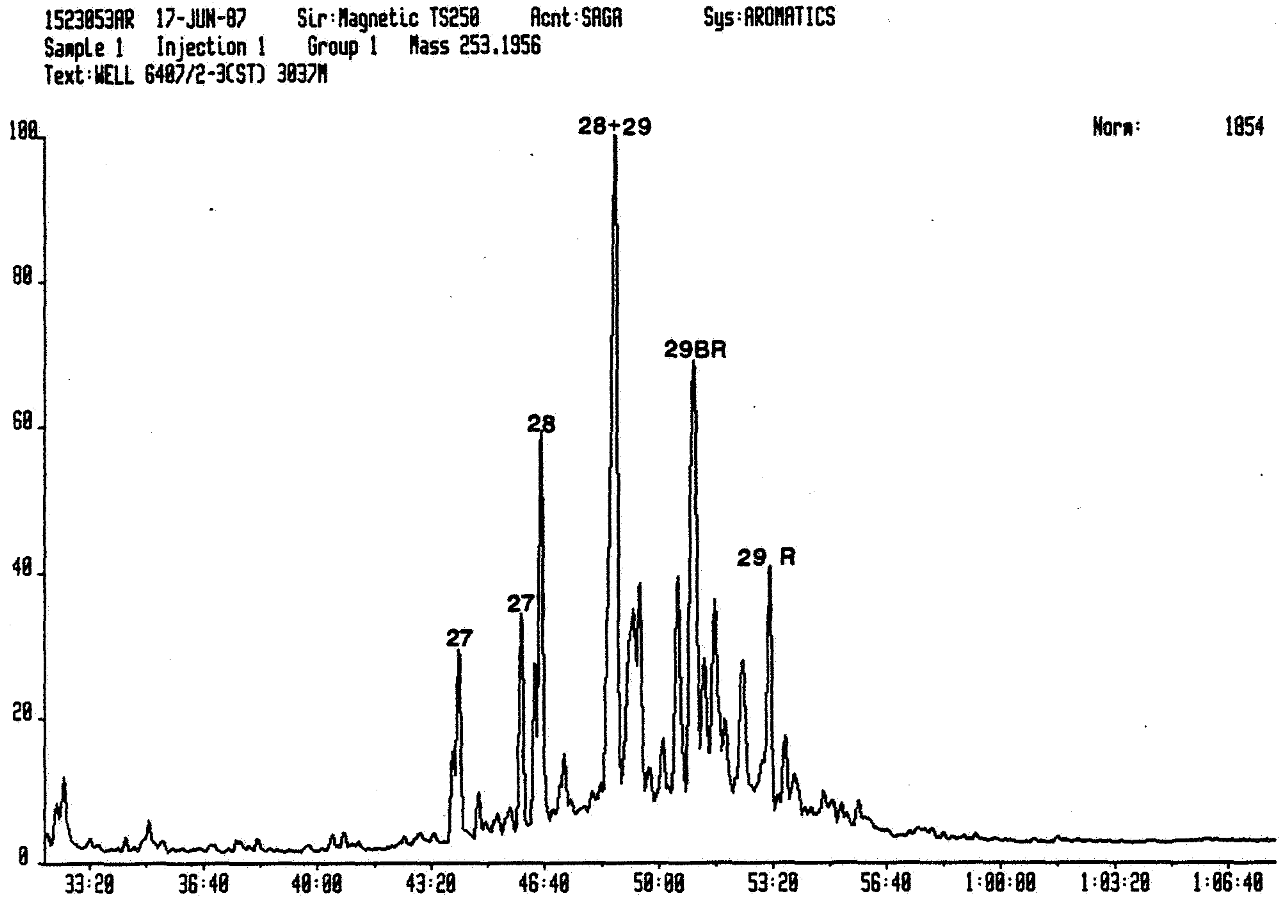


FIGURE 14d

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC
m/z 231 = TRIAROMATIC



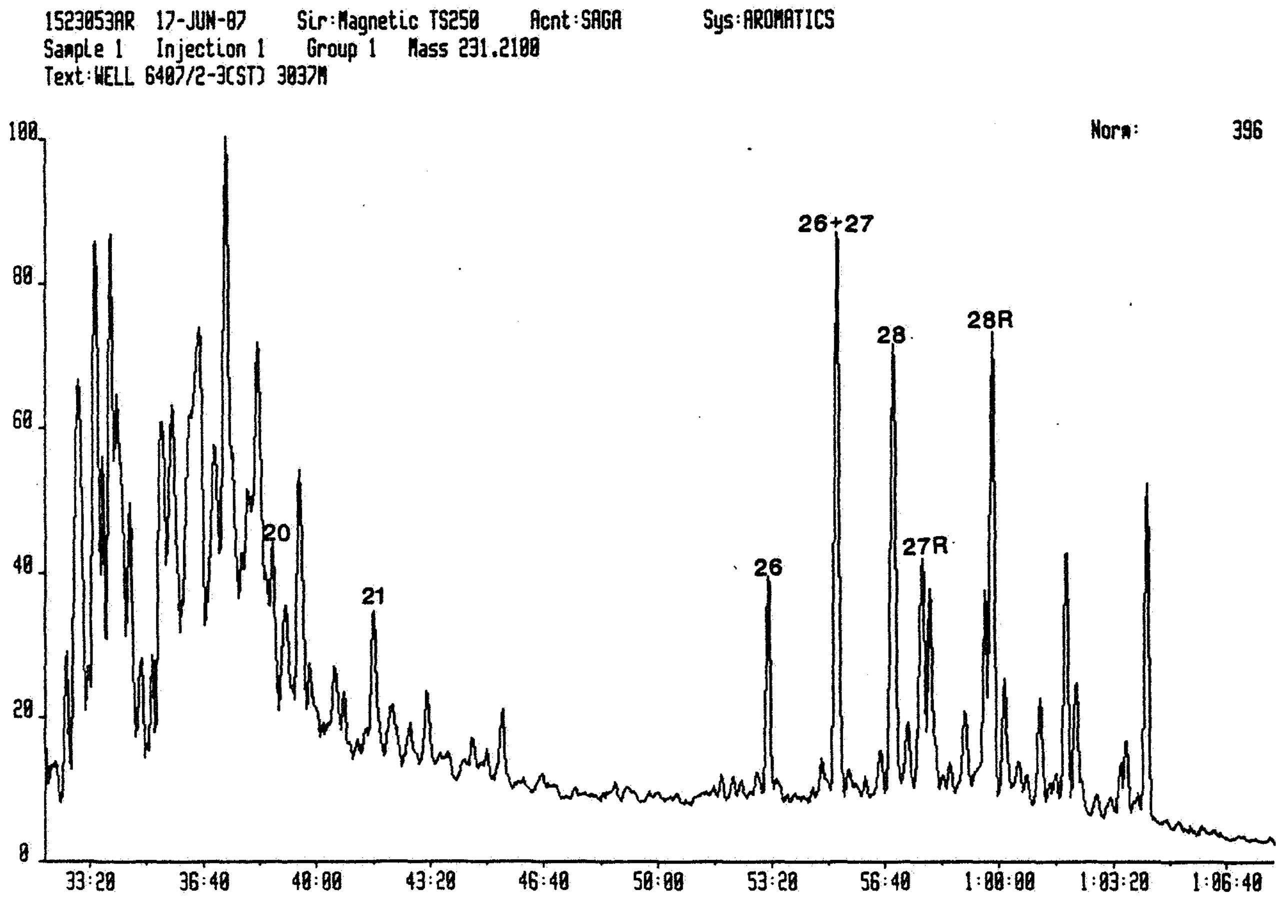


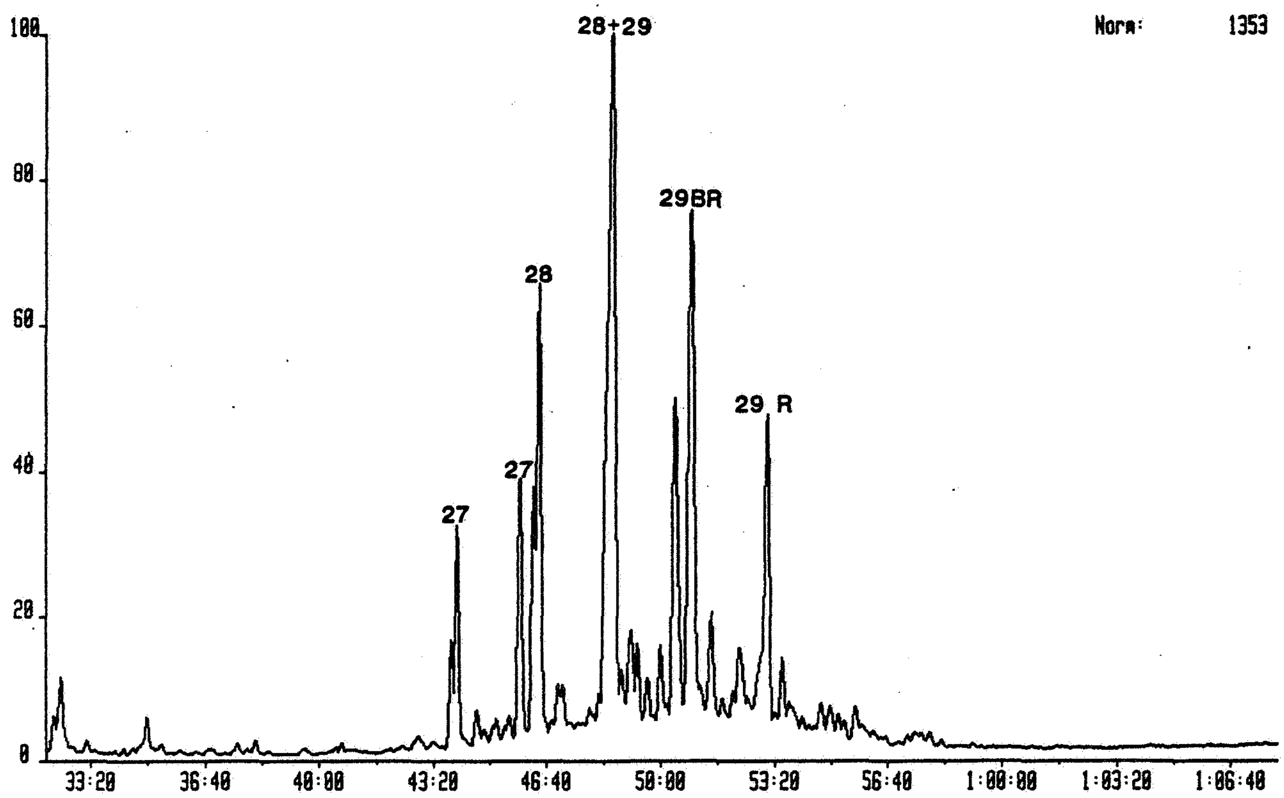
FIGURE 14e

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC

m/z 231 = TRIAROMATIC

1523055AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 253.1956
Text:WELL 6407/2-3(ST) 3050M



1523055AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 231.2100
Text:WELL 6407/2-3(ST) 3050M

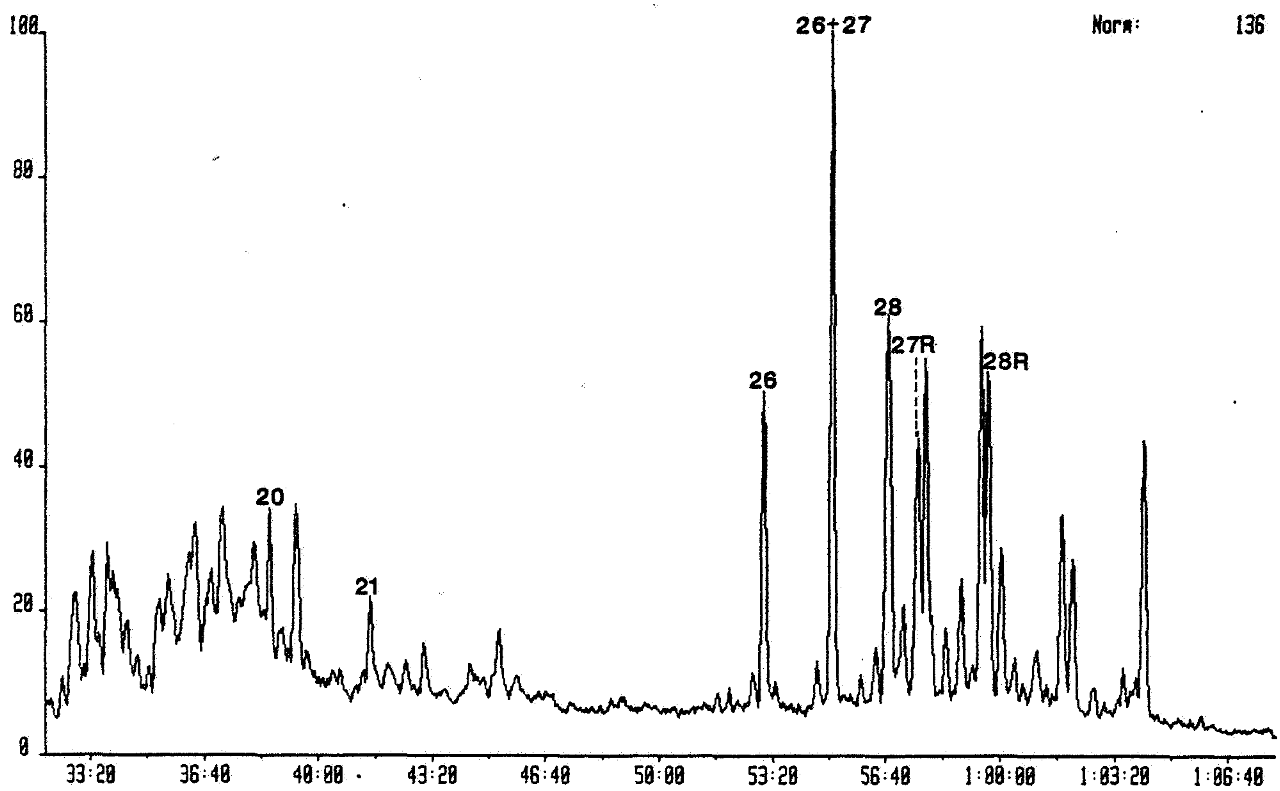


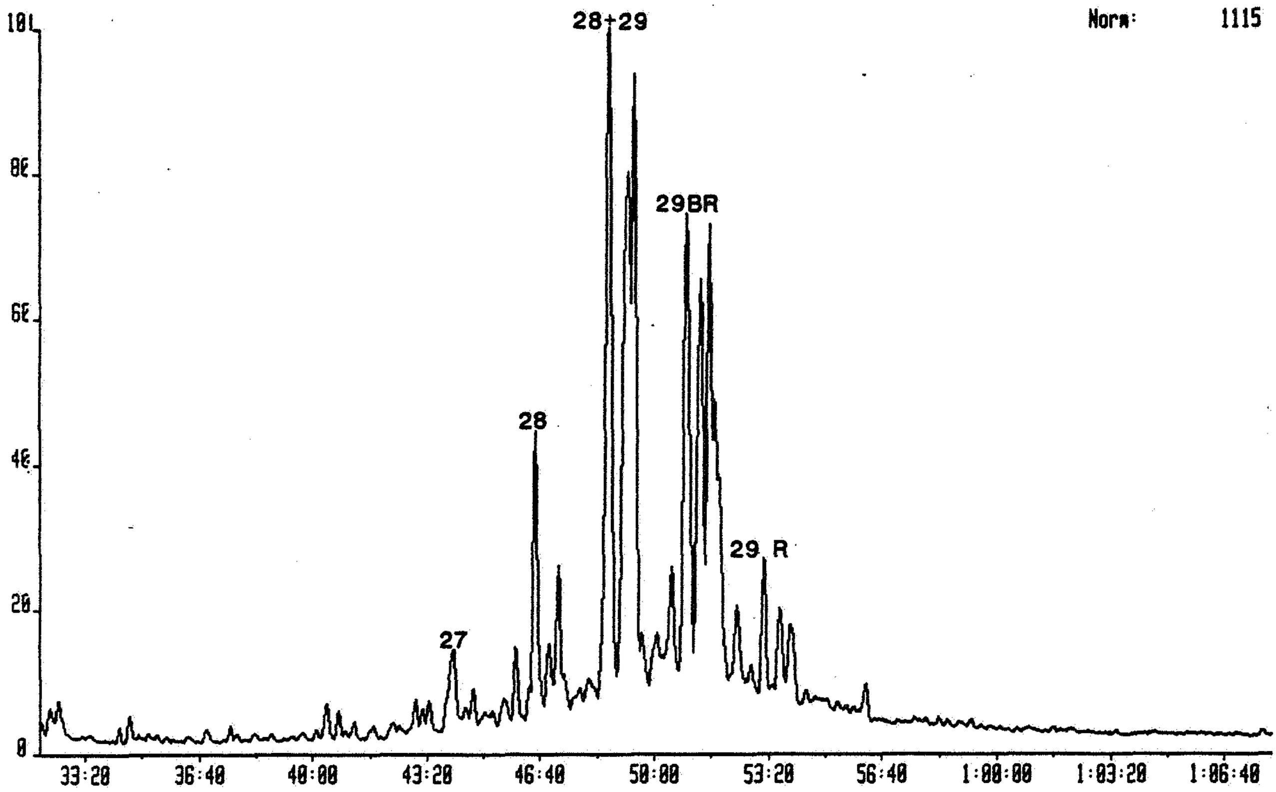
FIGURE 14f

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC

m/z 231 = TRIAROMATIC

1523055BR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 253.1956
Text:WELL 6407/2-3(ST) 3050M



1523055BR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 231.2100
Text:WELL 6407/2-3(ST) 3050M

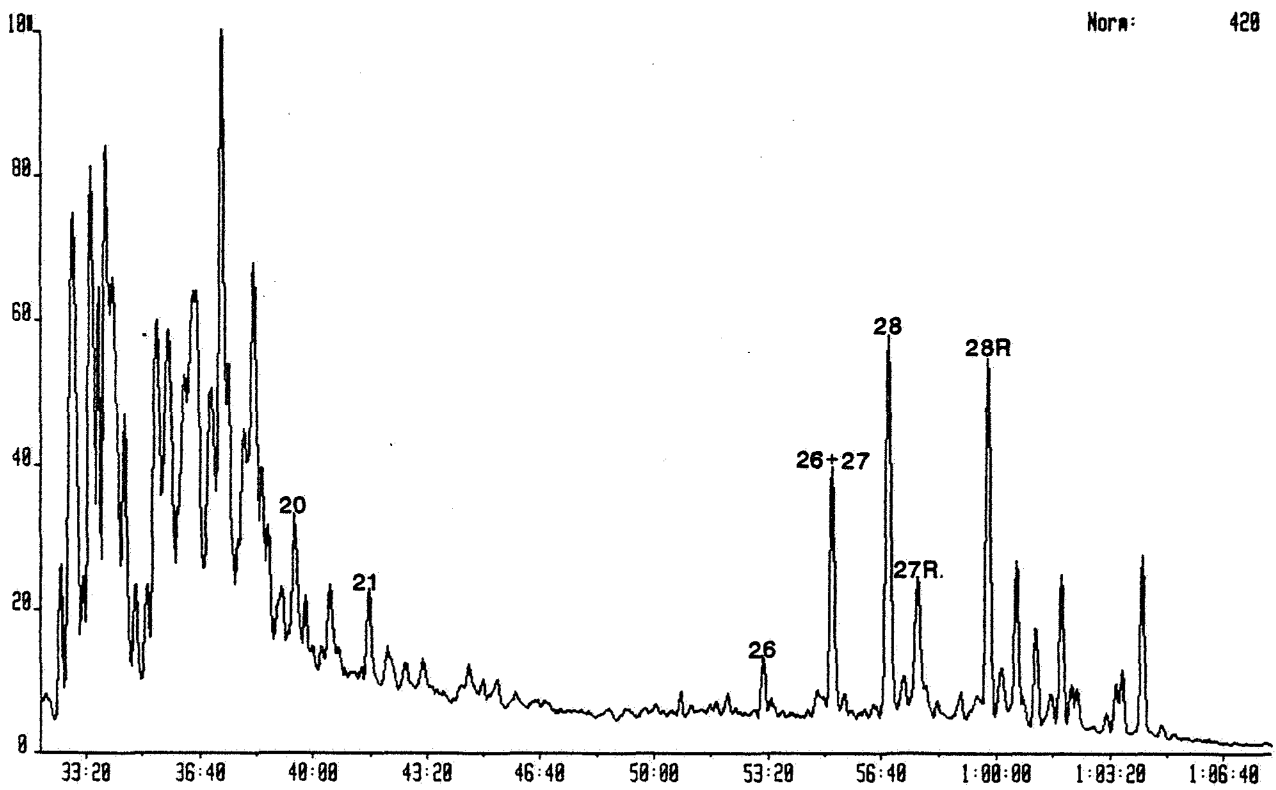


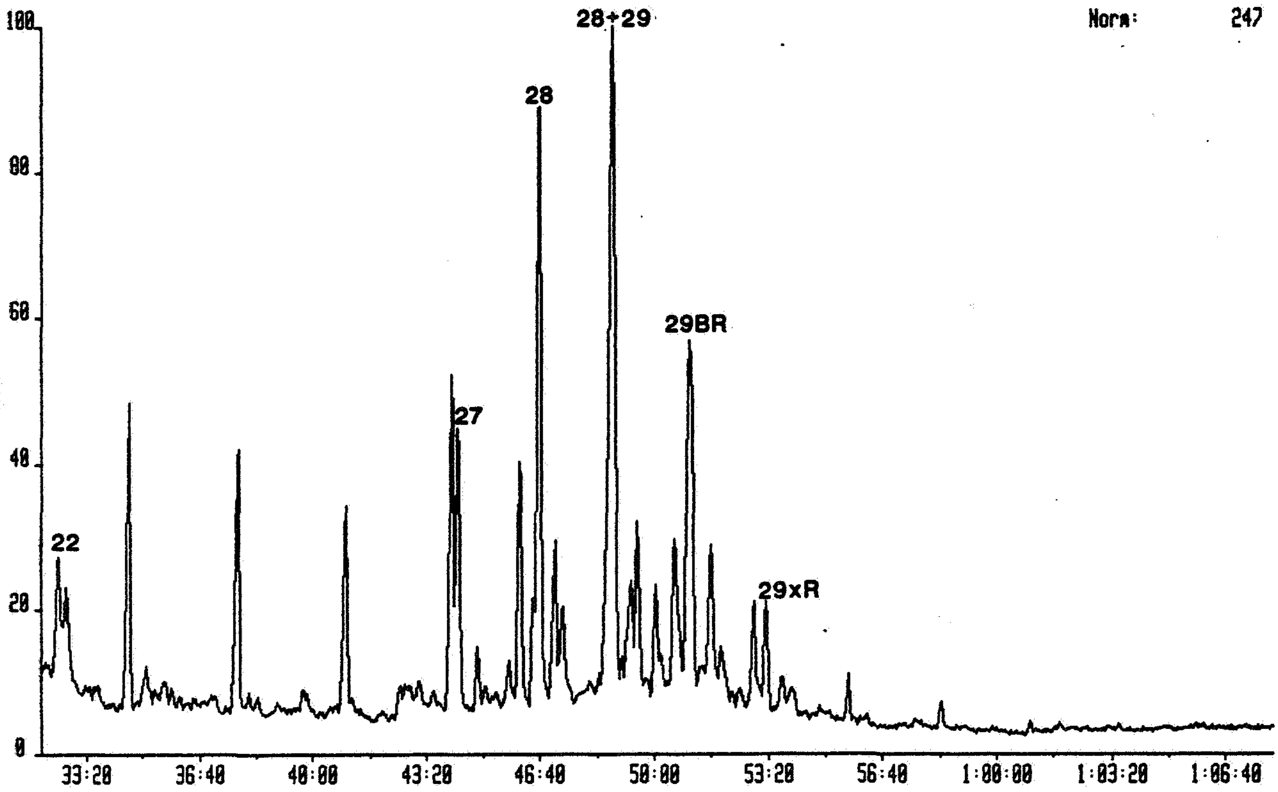
FIGURE 14g

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC

m/z 231 = TRIAROMATIC

1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 253.1956
Text:STOCK TANK OIL



1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 231.2100
Text:STOCK TANK OIL

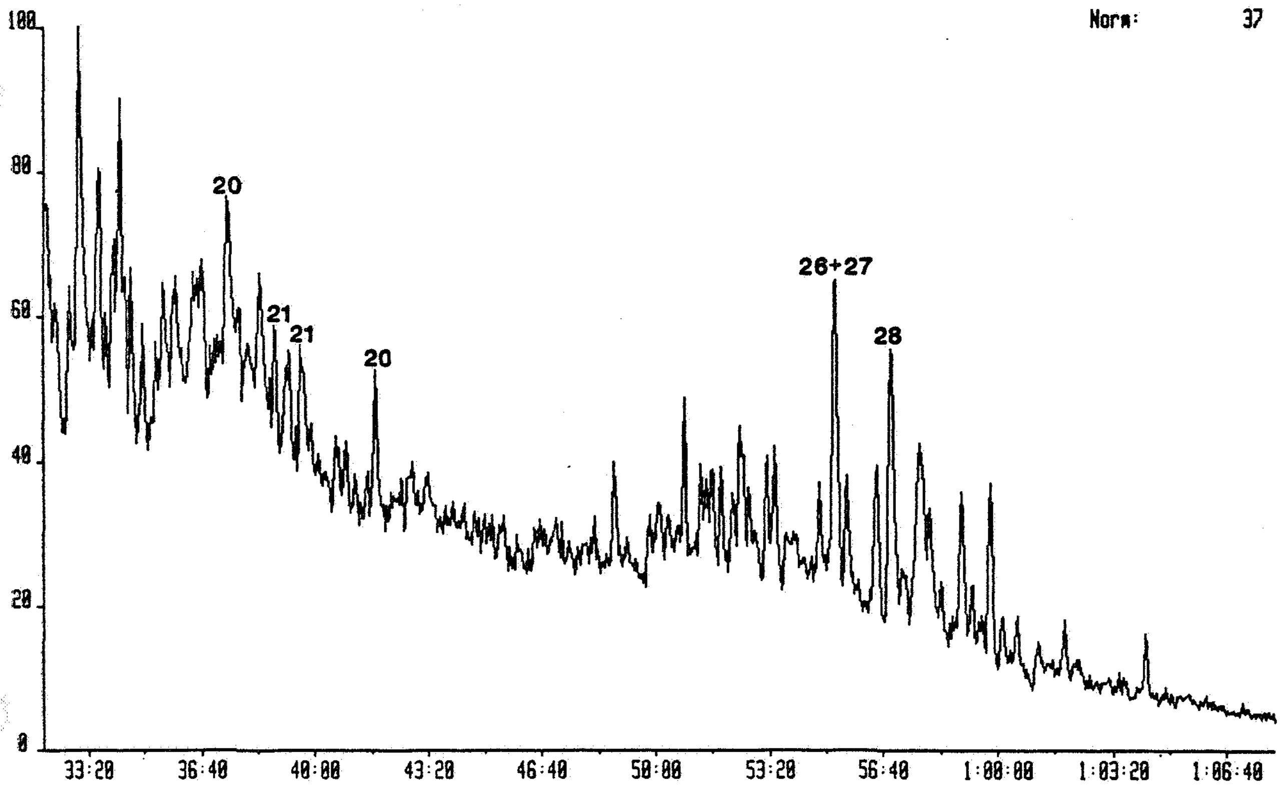


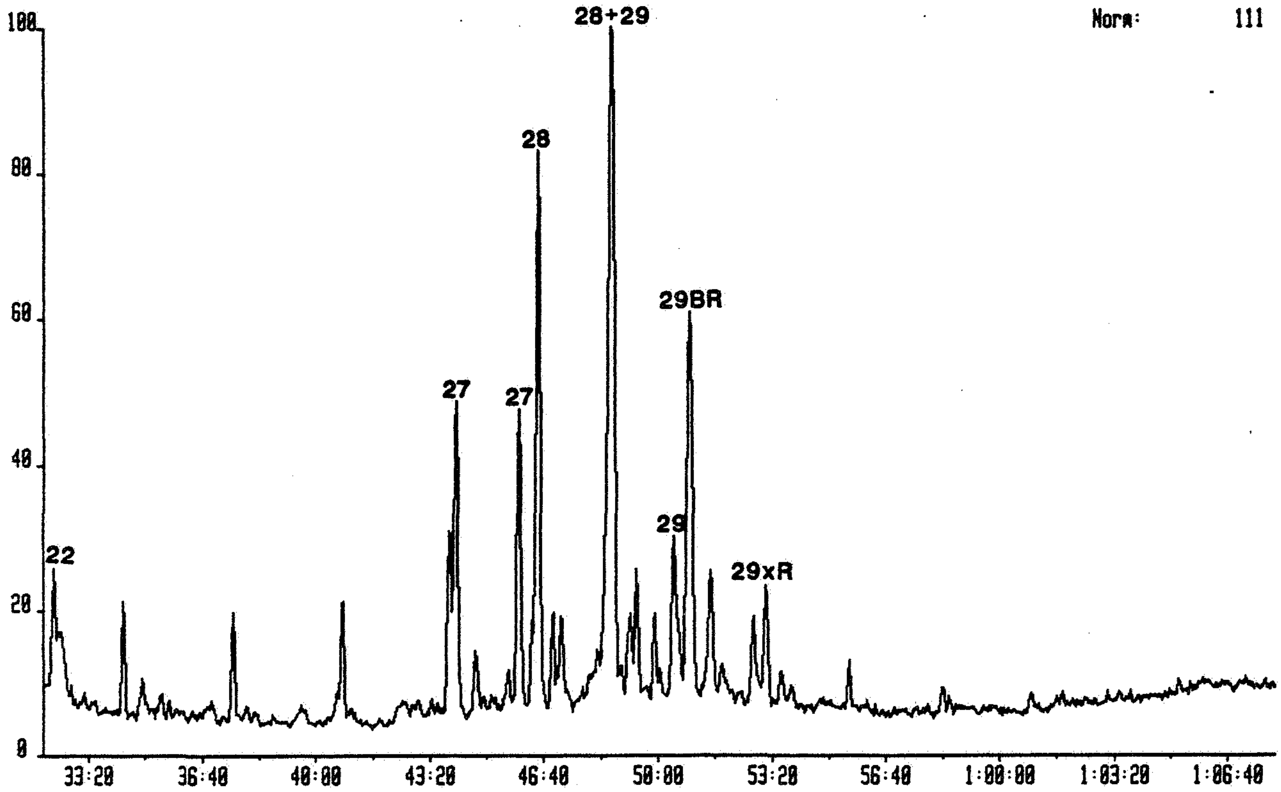
FIGURE 14h

MASS FRAGMENTOGRAMS

WELL 6407/2-3 AROMATIC STERANES m/z 253 = MONOAROMATIC

m/z 231 = TRIAROMATIC

1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 253.1956
Text:SINGLE FLASH CONDENSATE



1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 231.2100
Text:SINGLE FLASH CONDENSATE

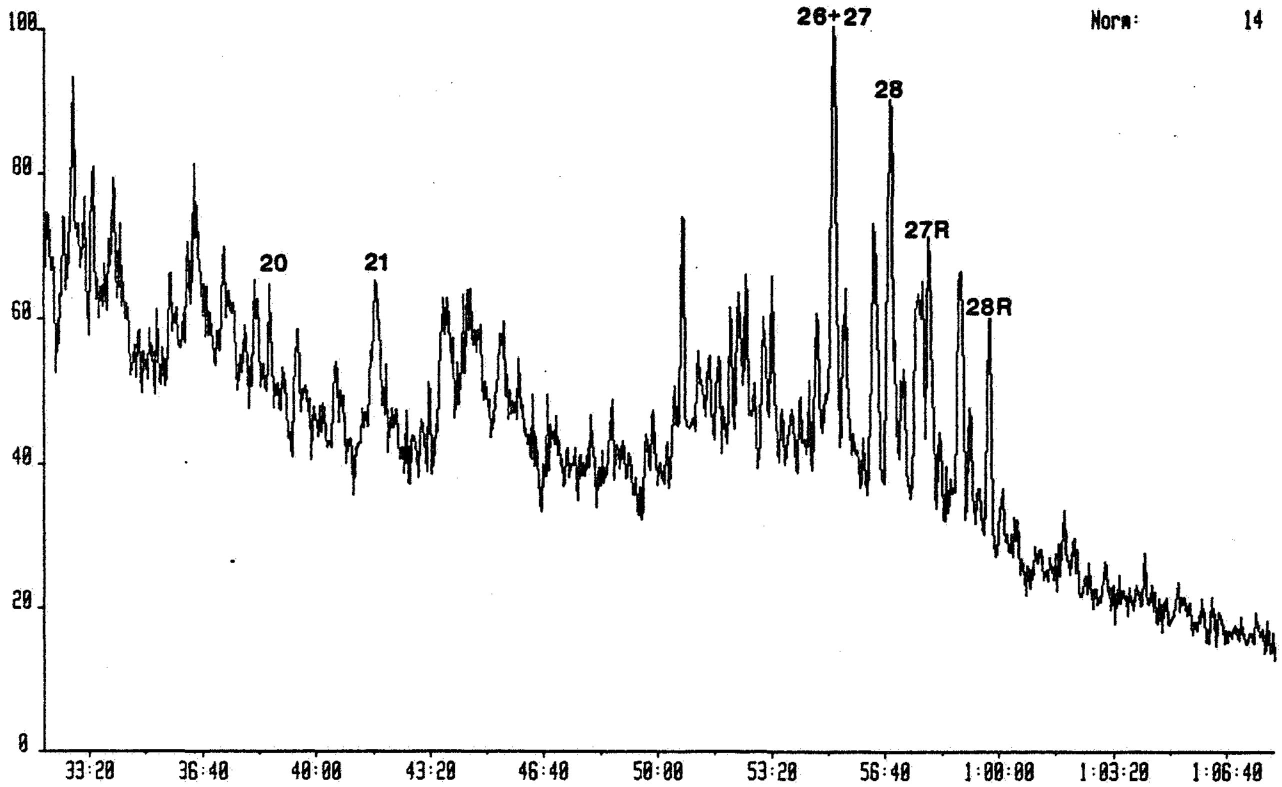


FIGURE 15a

MASS FRAGMENTOGRAMS

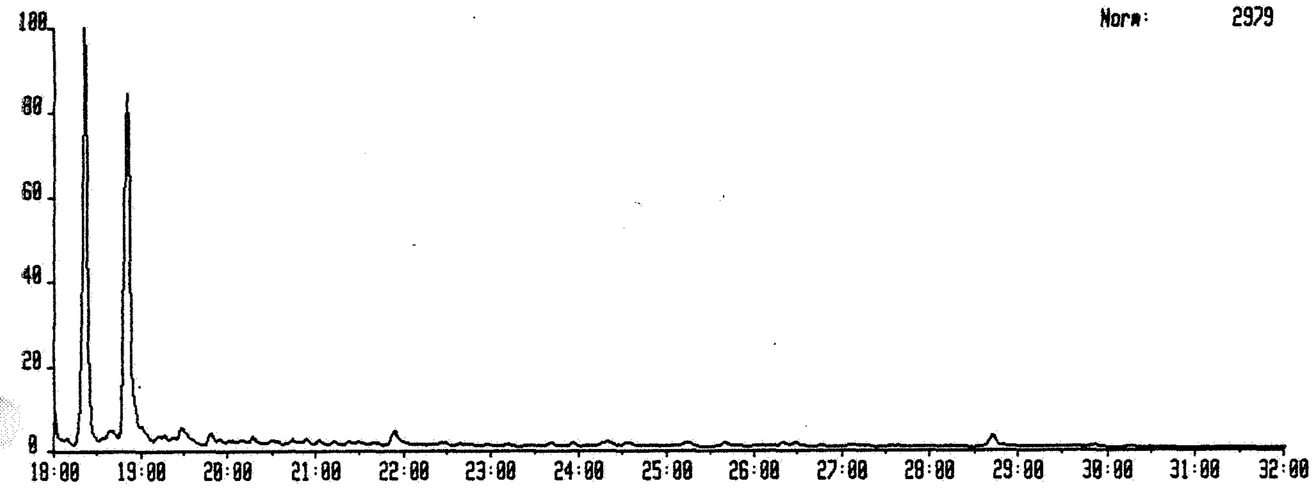
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

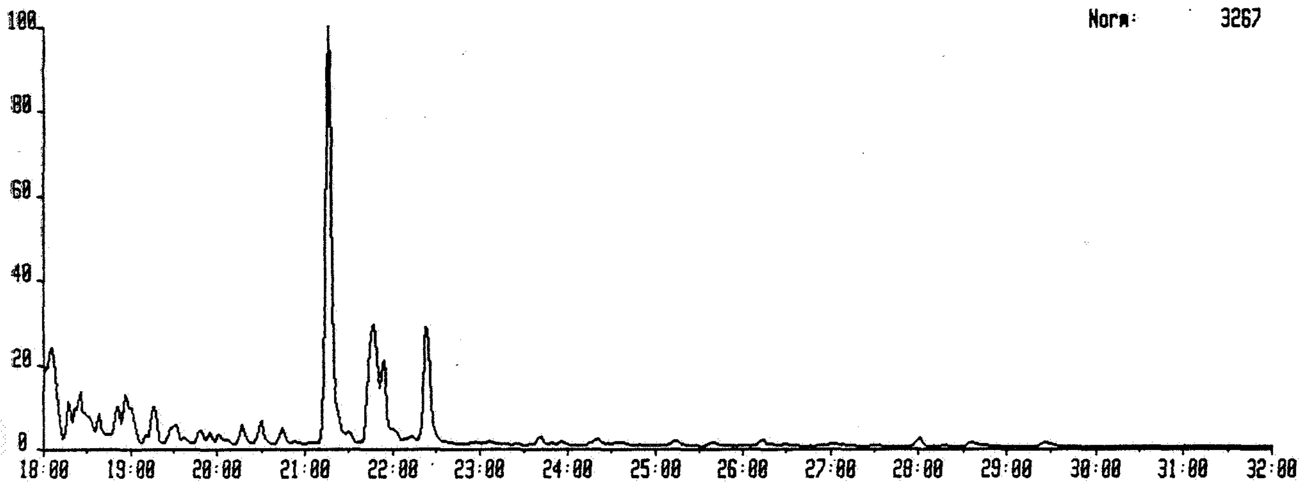
DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212

1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 184.0344
Text:6407/2-3(ST) SWC 2399M



1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 198.0501
Text:6407/2-3(ST) SWC 2399M



1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 212.0457
Text:6407/2-3(ST) SWC 2399M

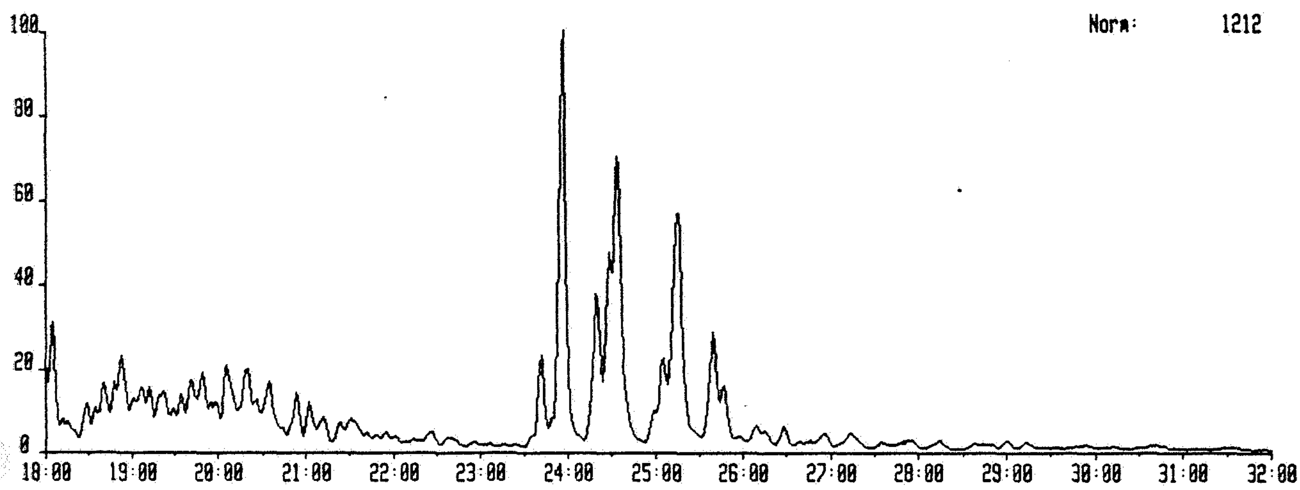


FIGURE 15a

MASS FRAGMENTOGRAMS

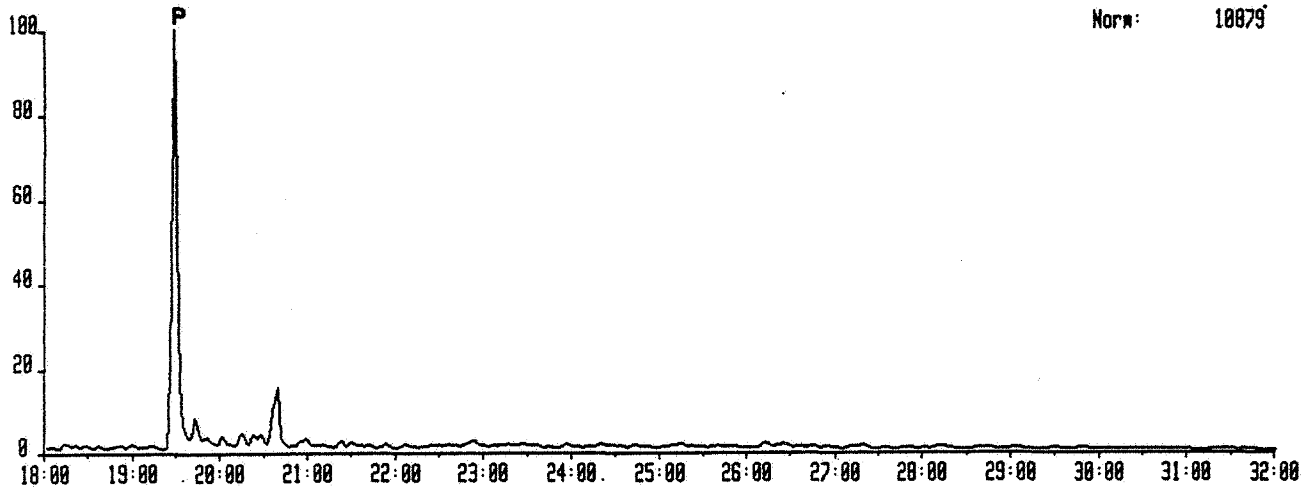
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

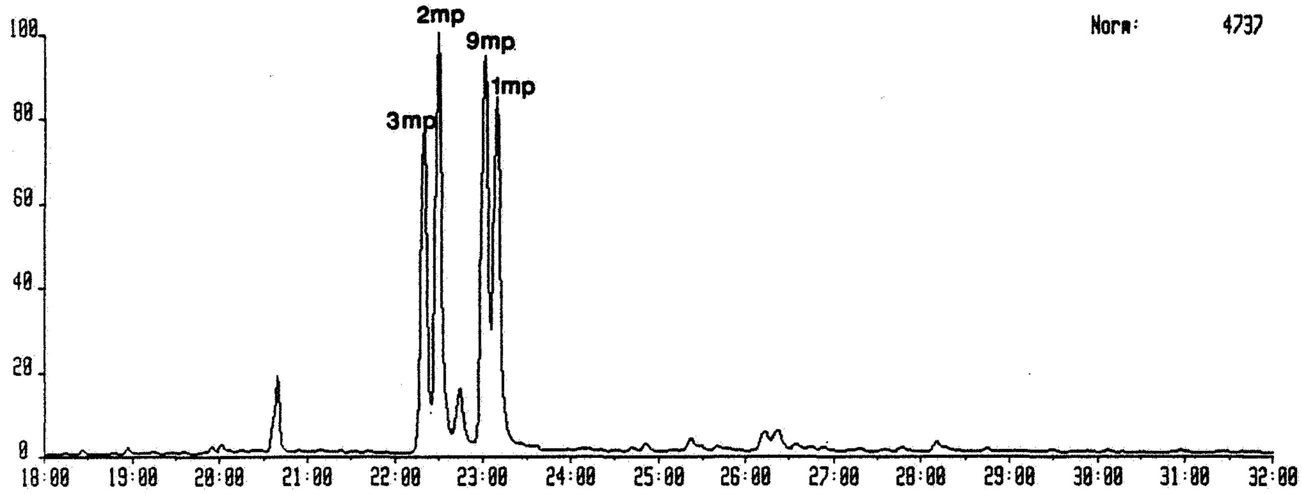
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:6407/2-3(ST) SWC 2399M



1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0920
Text:6407/2-3(ST) SWC 2399M



1523061AR 29-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:6407/2-3(ST) SWC 2399M

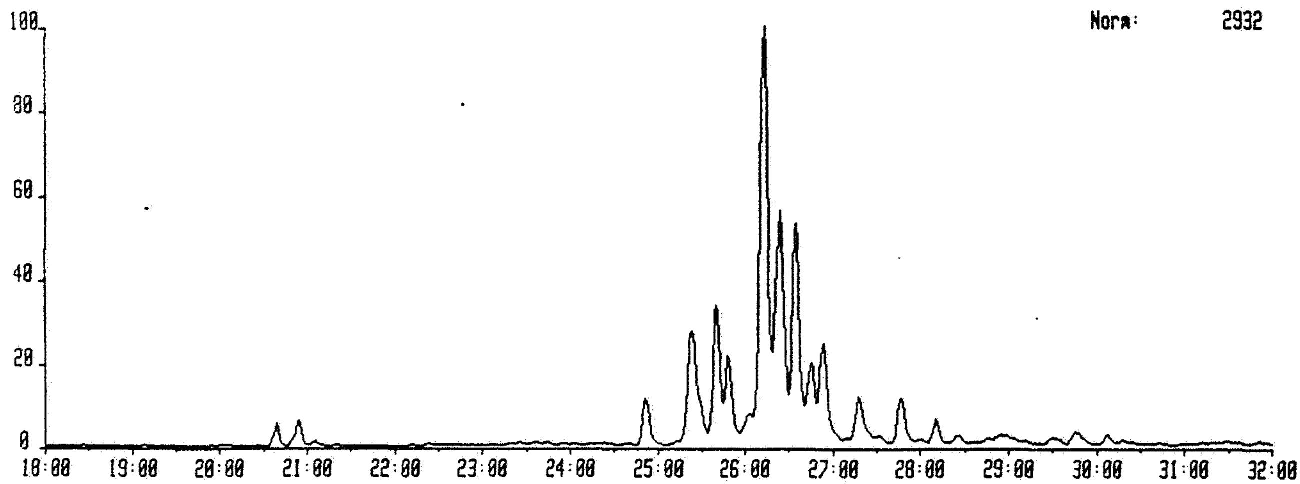


FIGURE 15b

MASS FRAGMENTOGRAMS

GEOCHEM

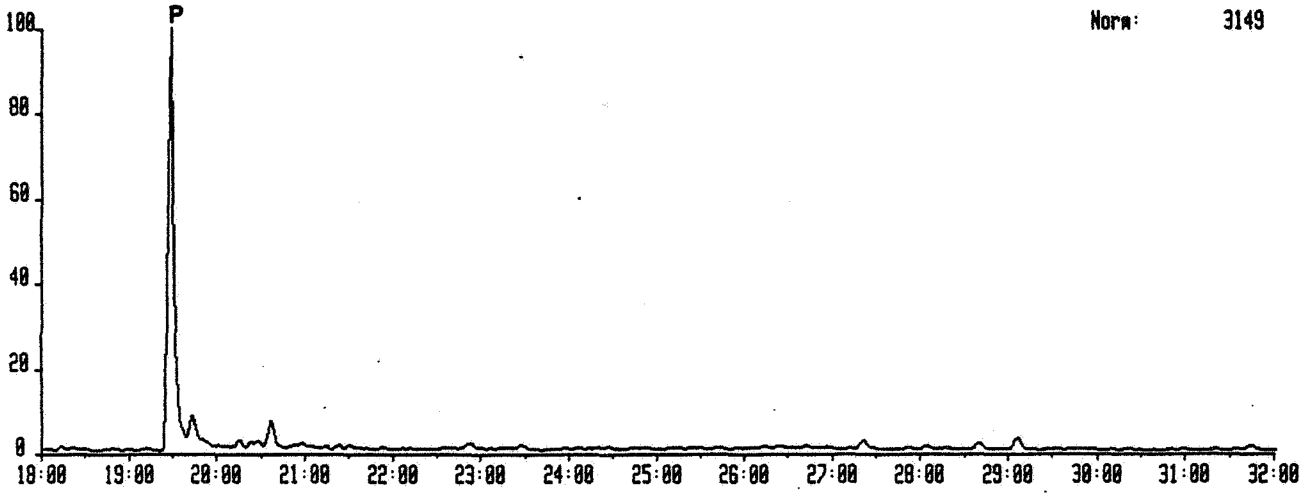
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

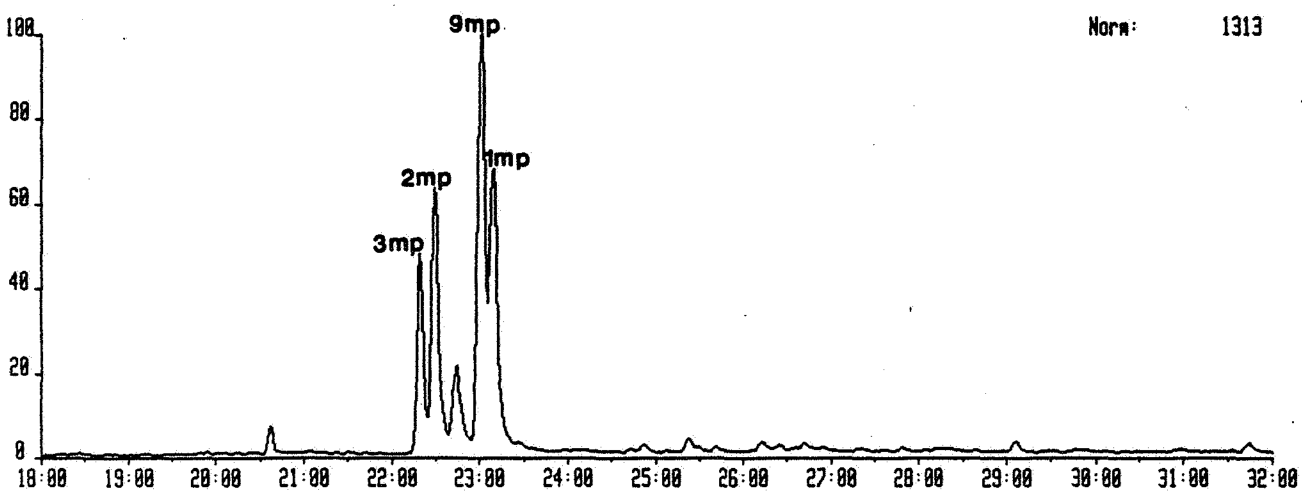
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:WELL 6407/2-3(ST) 2965M



1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:WELL 6407/2-3(ST) 2965M



1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:WELL 6407/2-3(ST) 2965M

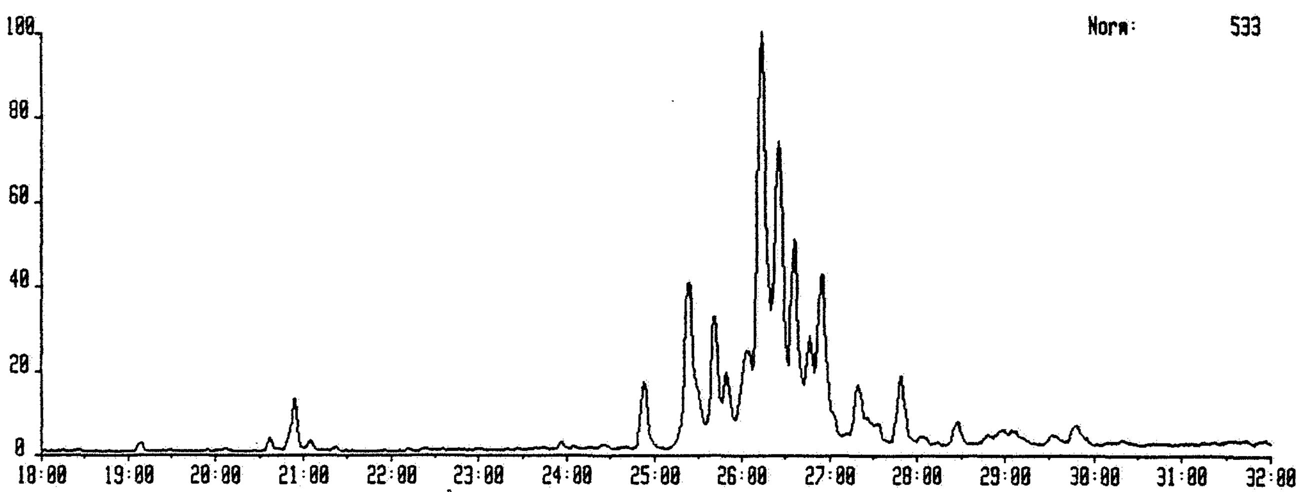


FIGURE 15b

MASS FRAGMENTOGRAMS

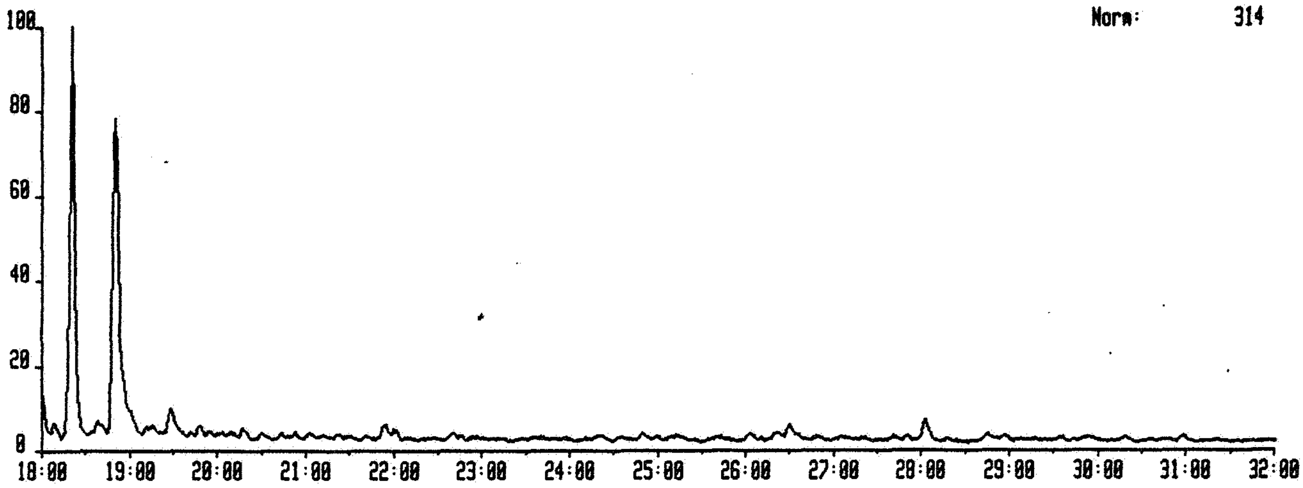
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

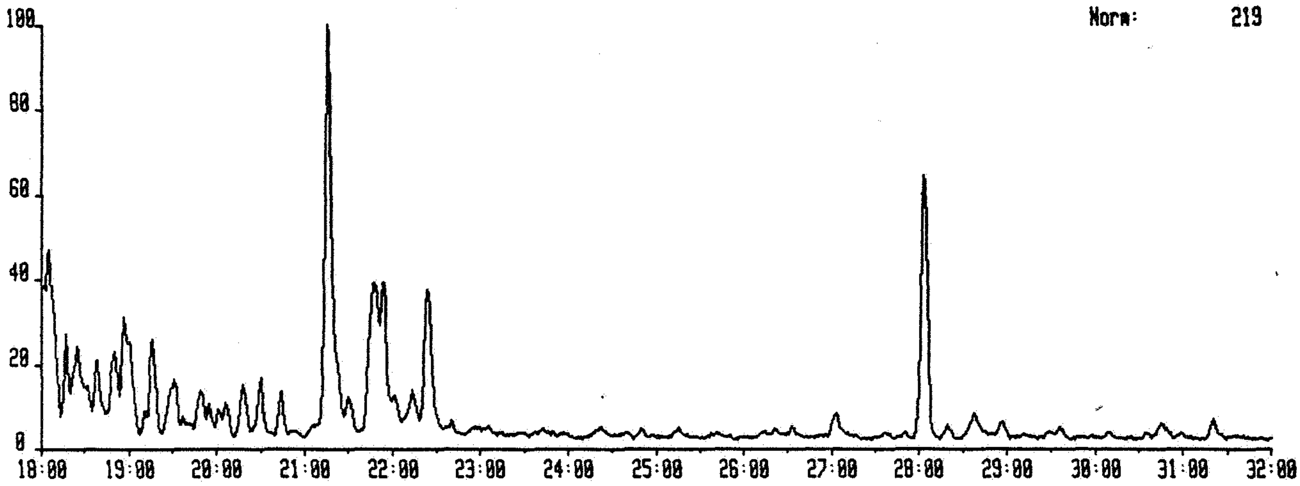
DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212

1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 184.0344
Text:WELL 6407/2-3(ST) 2965M



1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 198.0501
Text:WELL 6407/2-3(ST) 2965M



1523045AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 212.0457
Text:WELL 6407/2-3(ST) 2965M

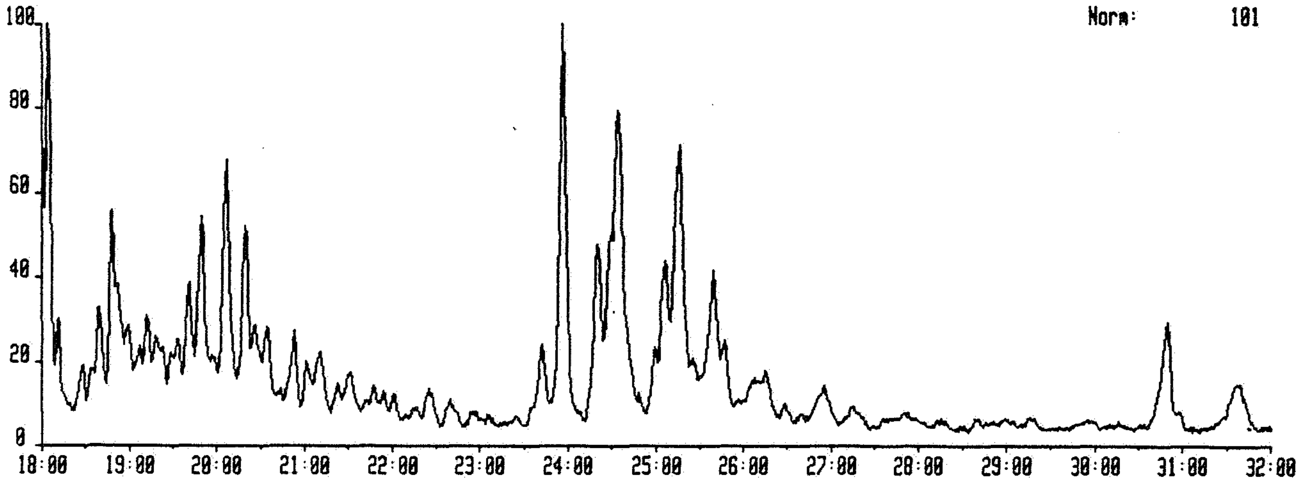


FIGURE 15c

WELL 6407/2-3

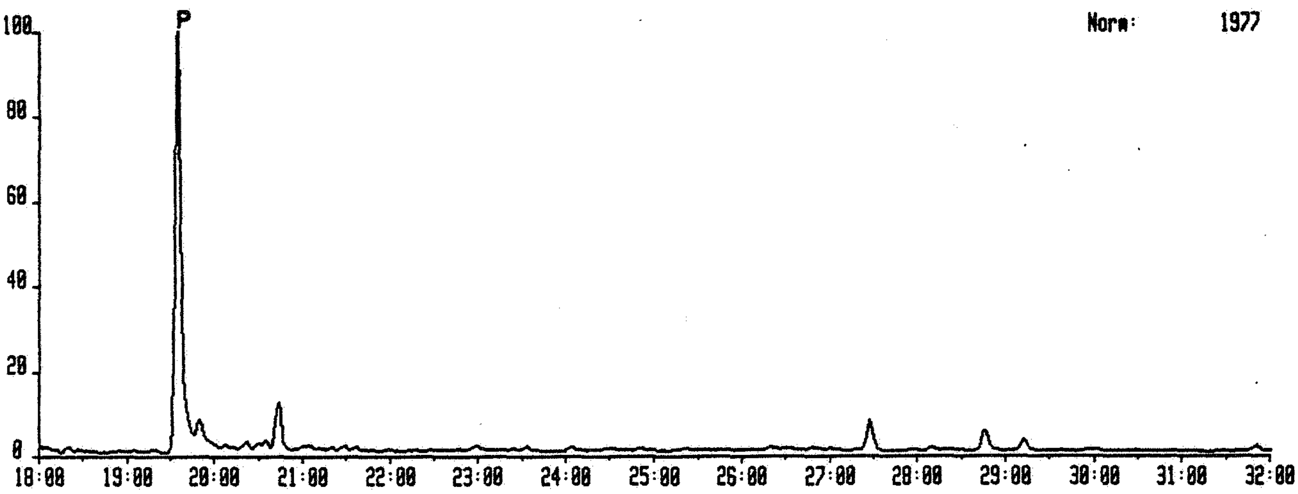
MASS FRAGMENTOGRAMS

C_{15+} AROMATIC HYDROCARBONS

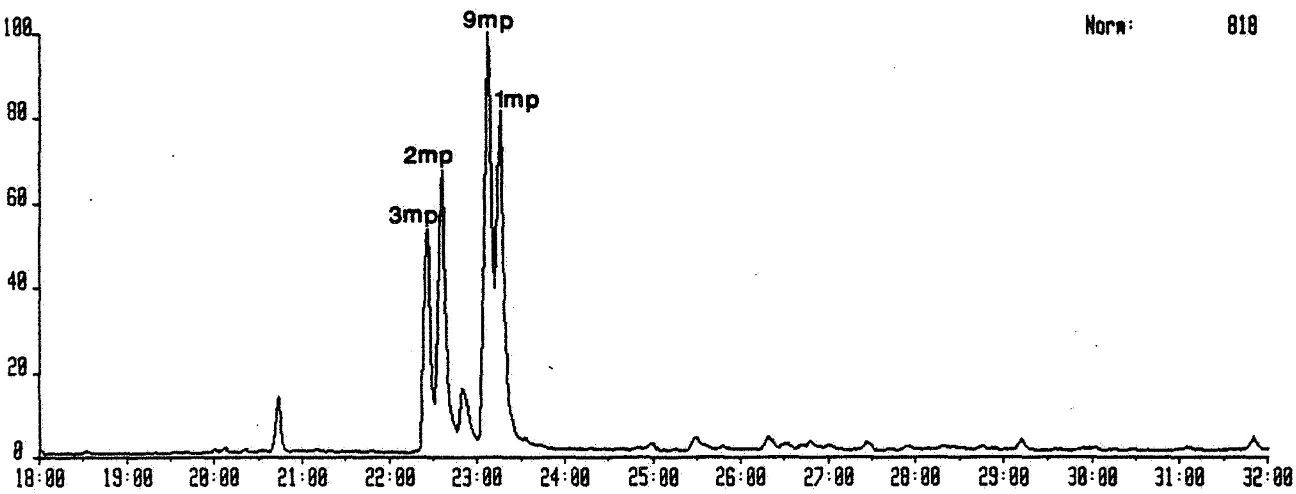
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523049AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:WELL 6407/3-2(ST) 3001M



1523049AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:WELL 6407/3-2(ST) 3001M



1523049AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:WELL 6407/3-2(ST) 3001M

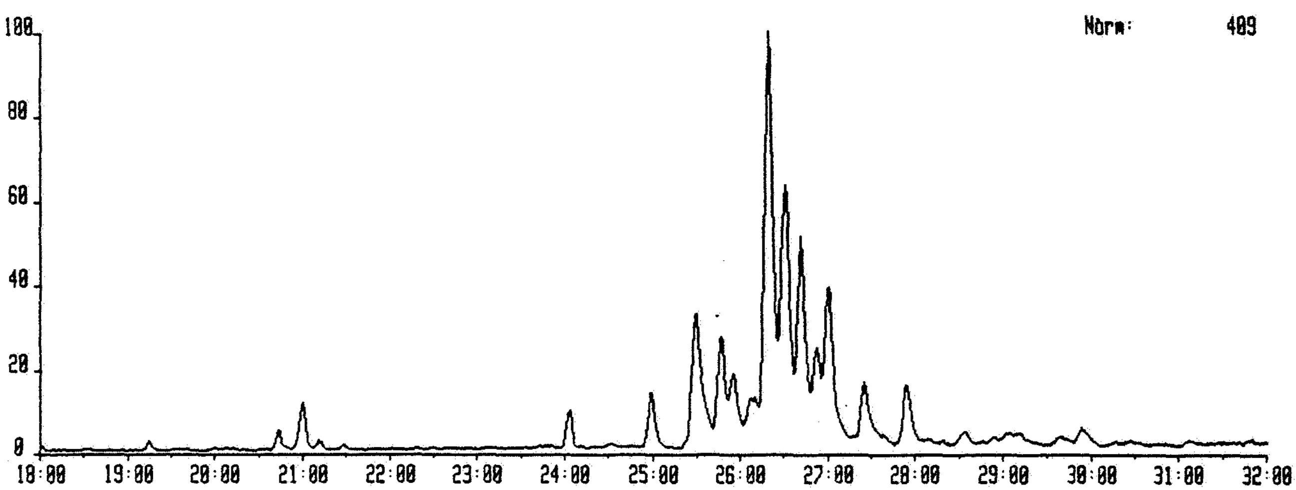


FIGURE 15c

WELL 6407/2-3

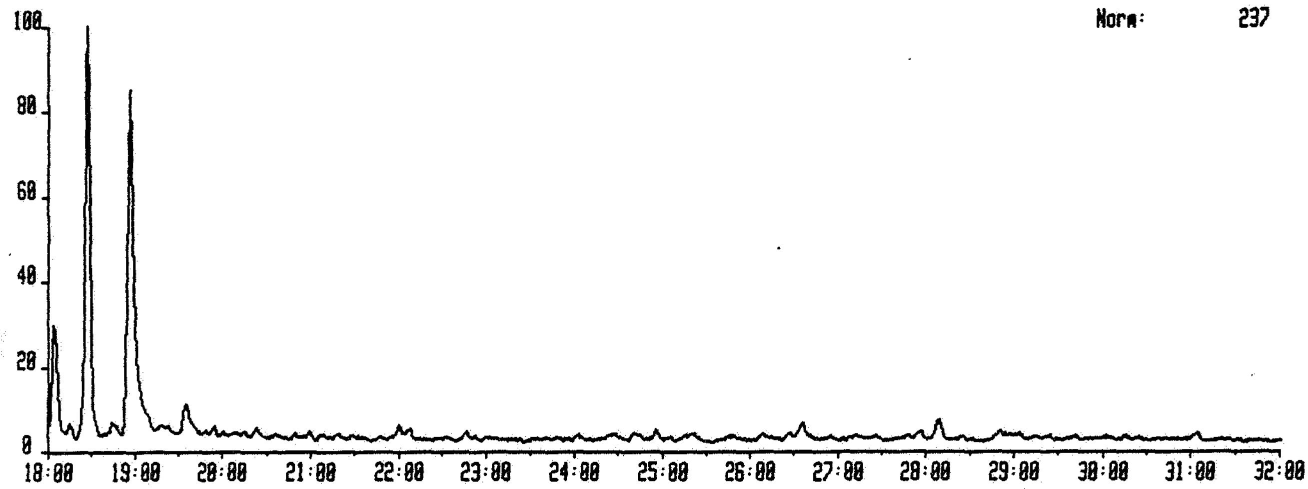
MASS FRAGMENTOGRAMS

C_{15+} AROMATIC HYDROCARBONS

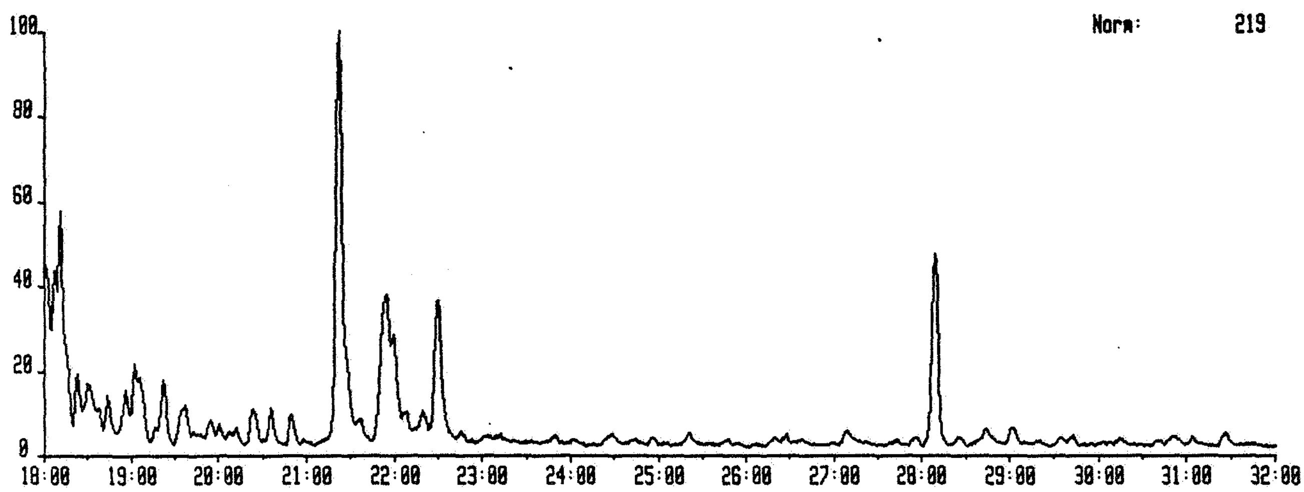
DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212

1523049AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 184.0344
Text:WELL 6407/3-2(ST) 3001M



1523049AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 198.0501
Text:WELL 6407/3-2(ST) 3001M



1523049AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 212.0457
Text:WELL 6407/3-2(ST) 3001M

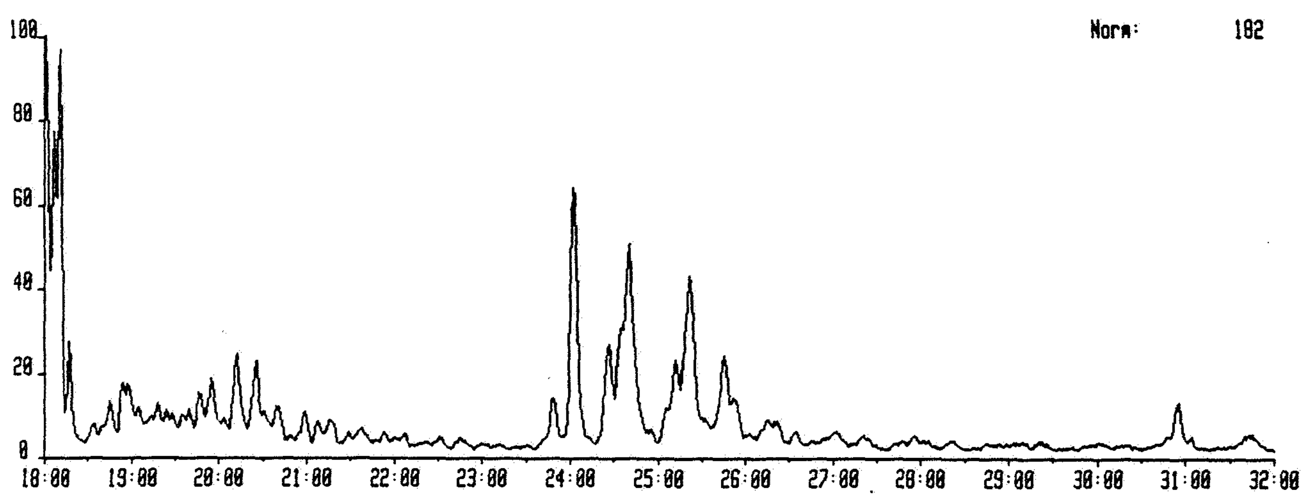


FIGURE 15d

WELL 6407/2-3

MASS FRAGMENTOGRAMS

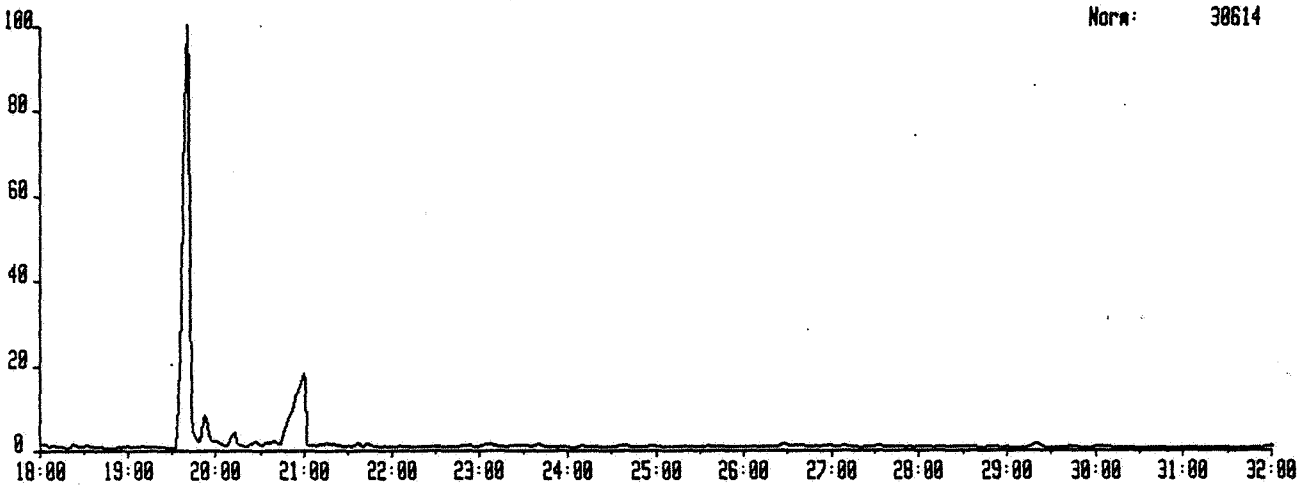
C_{15+} AROMATIC HYDROCARBONS

PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

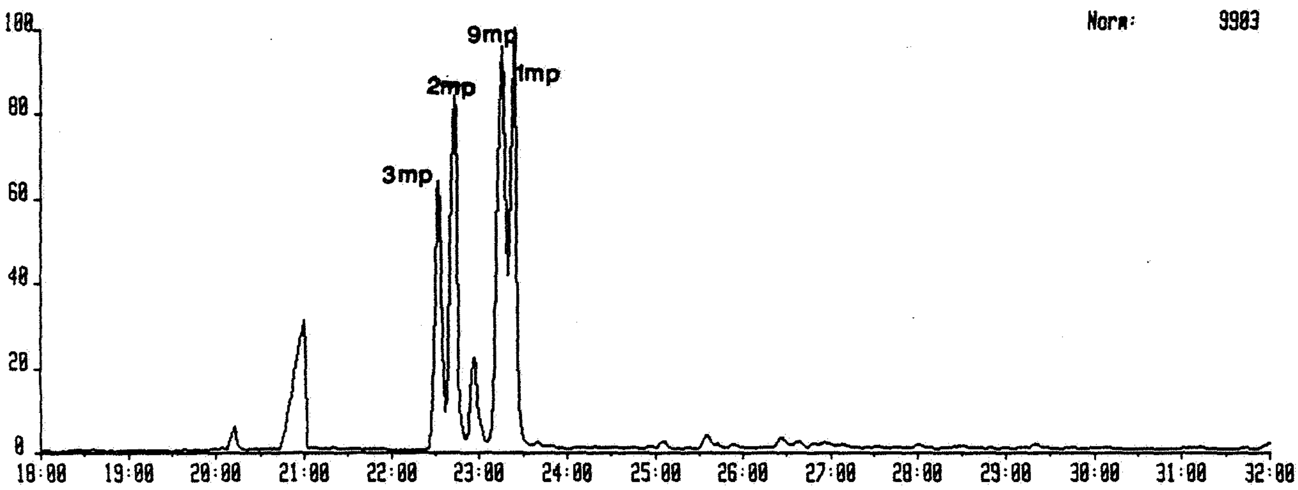
m/z 178,192,206

GEOCHEM

1523053AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:WELL 6407/2-3(ST) 3037M



1523053AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:WELL 6407/2-3(ST) 3037M



1523053AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:WELL 6407/2-3(ST) 3037M

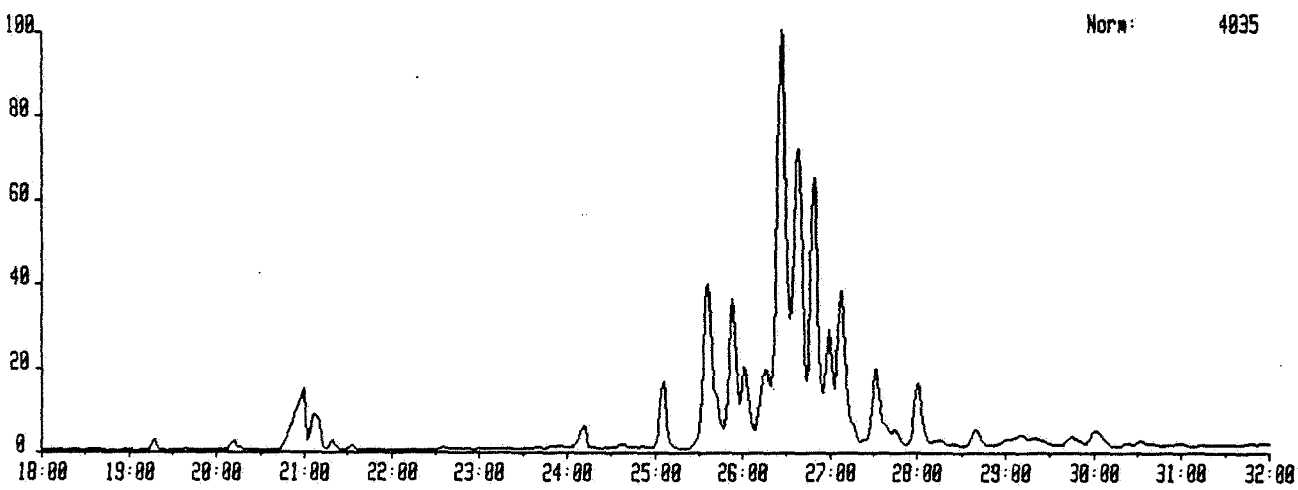


FIGURE 15d

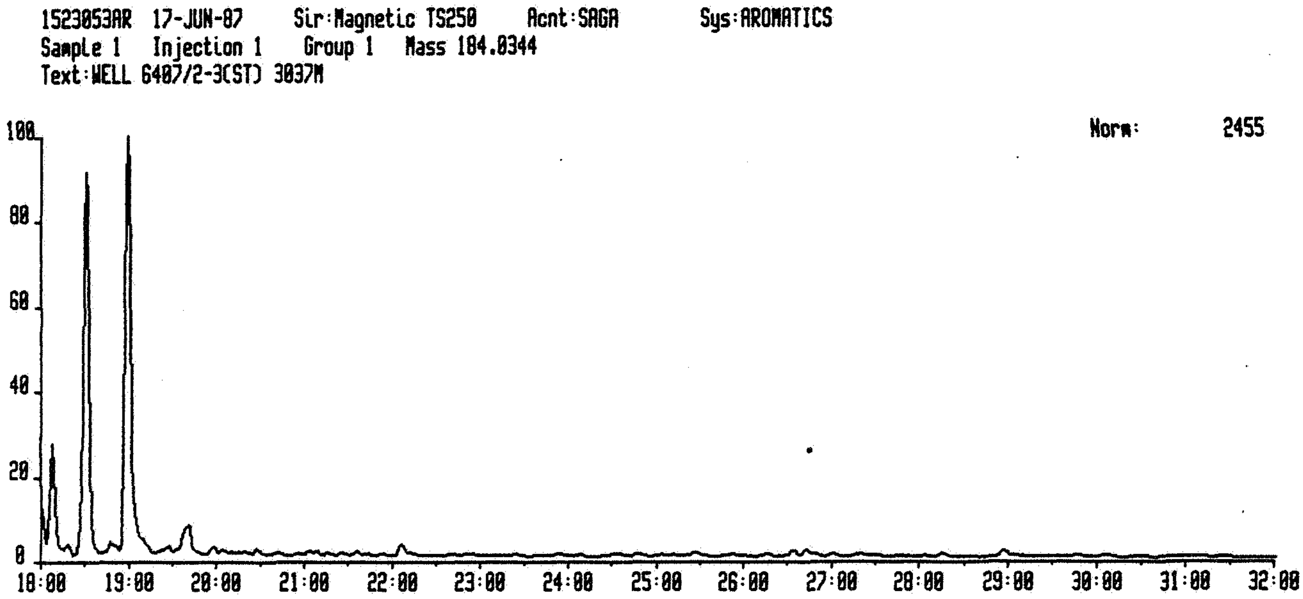
MASS FRAGMENTOGRAMS

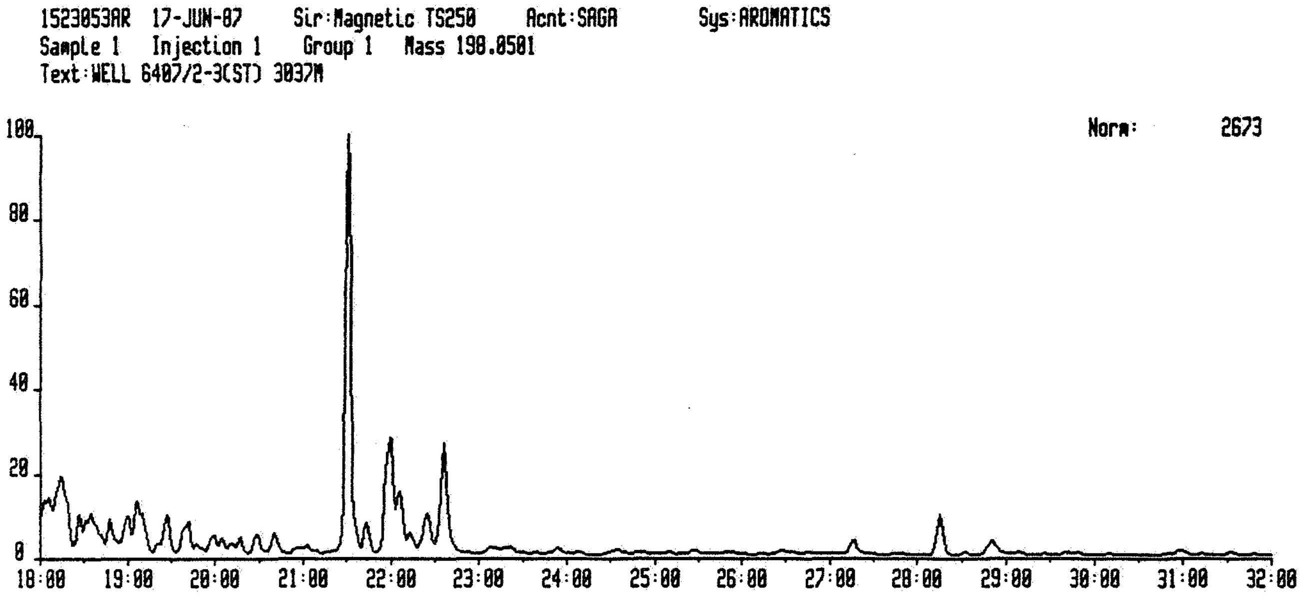
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212





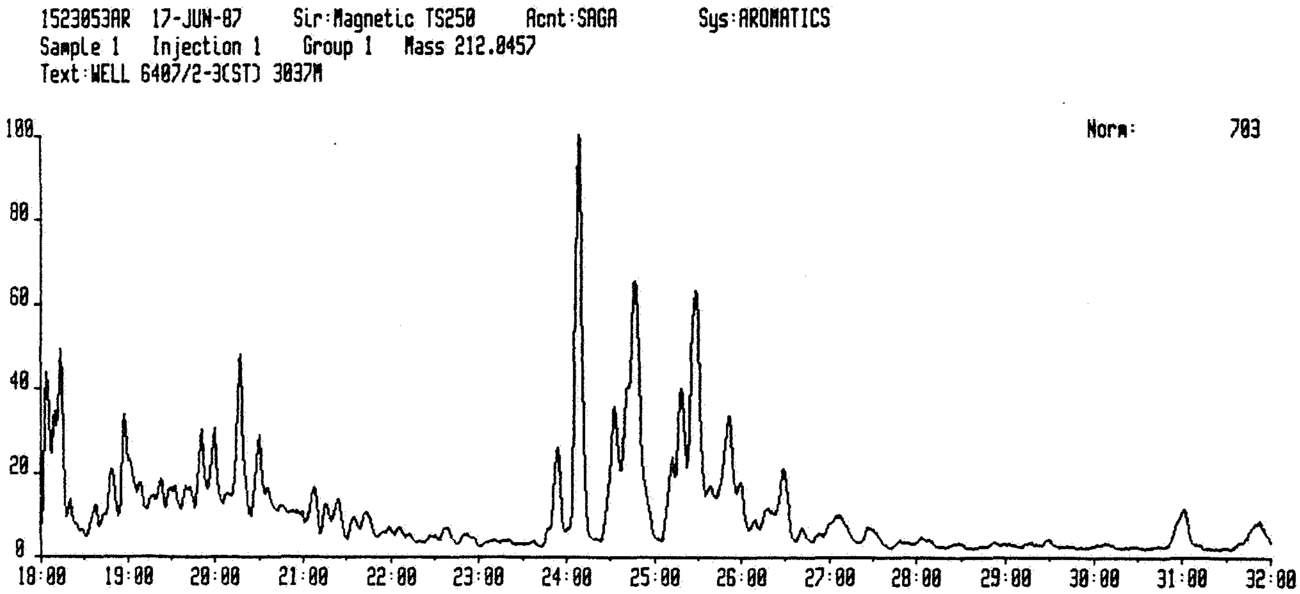


FIGURE 15e

MASS FRAGMENTOGRAMS

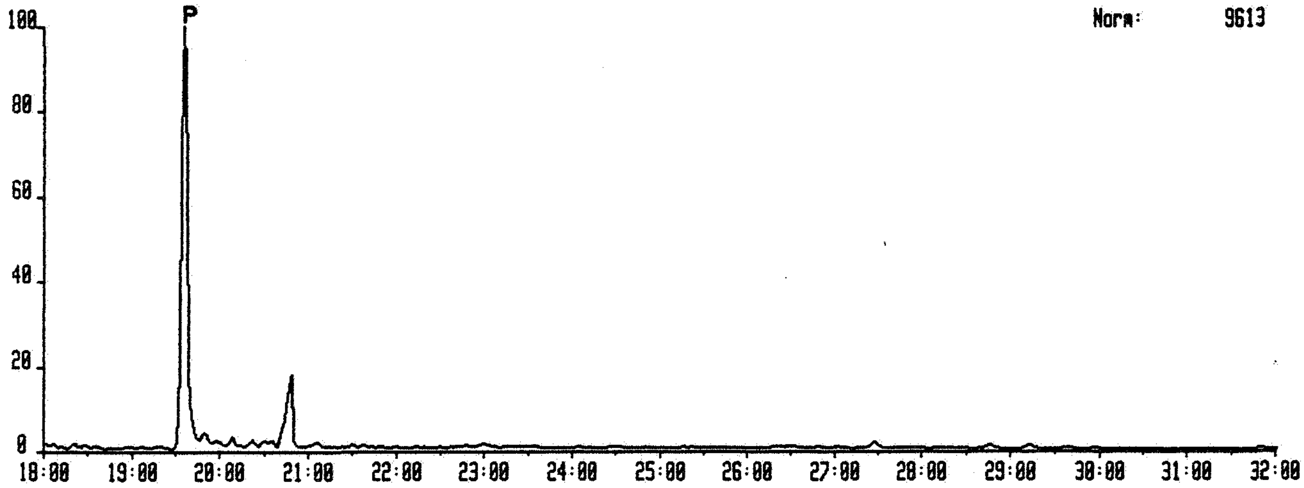
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

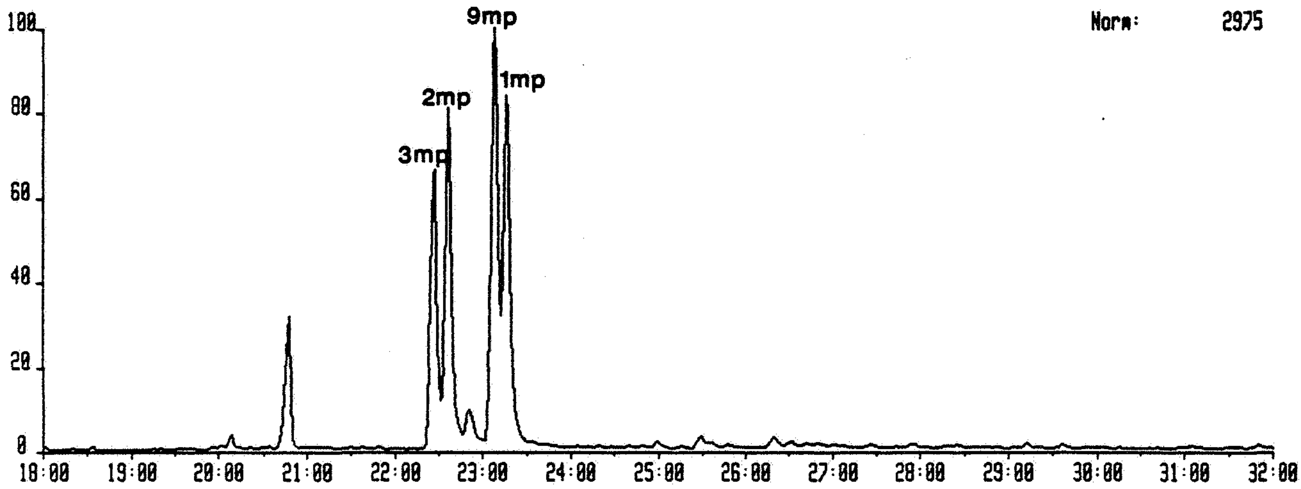
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523055AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:WELL 6407/2-3(ST) 3050M



1523055AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:WELL 6407/2-3(ST) 3050M



1523055AR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:WELL 6407/2-3(ST) 3050M

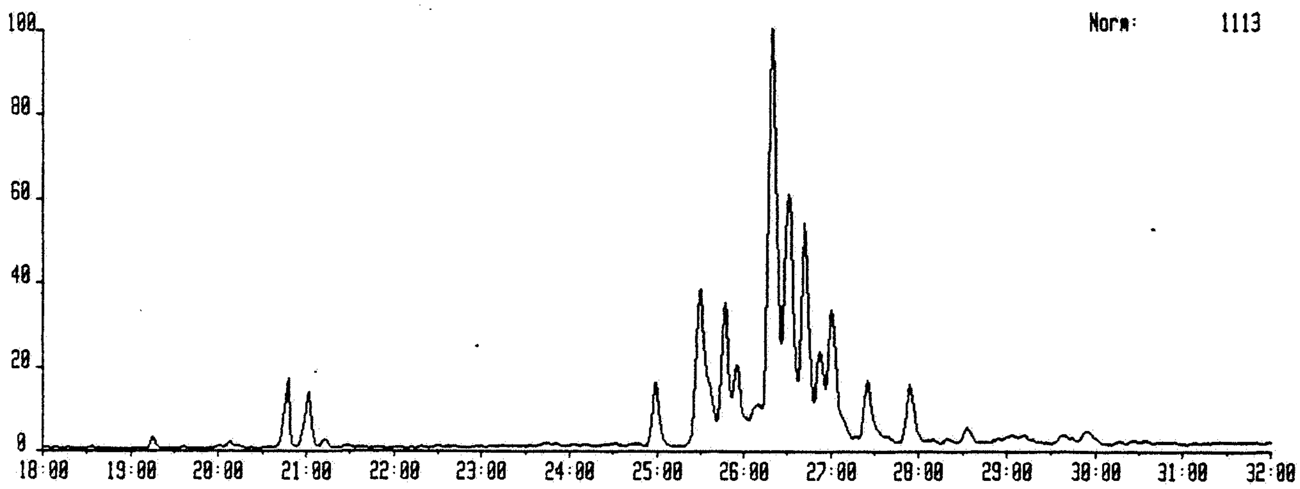


FIGURE 15e

MASS FRAGMENTOGRAMS

WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212

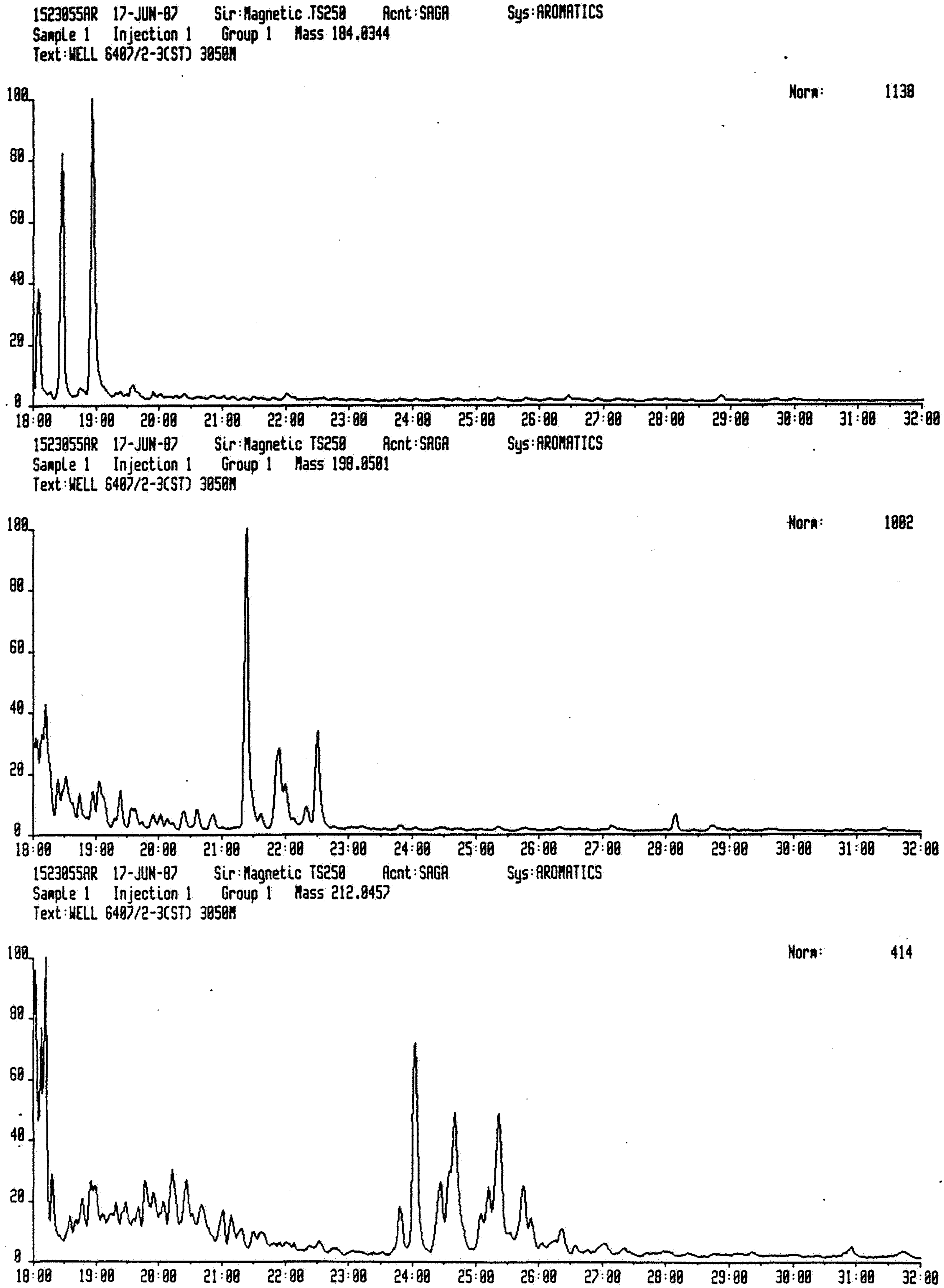


FIGURE 15f

MASS FRAGMENTOGRAMS

GEOCHEM

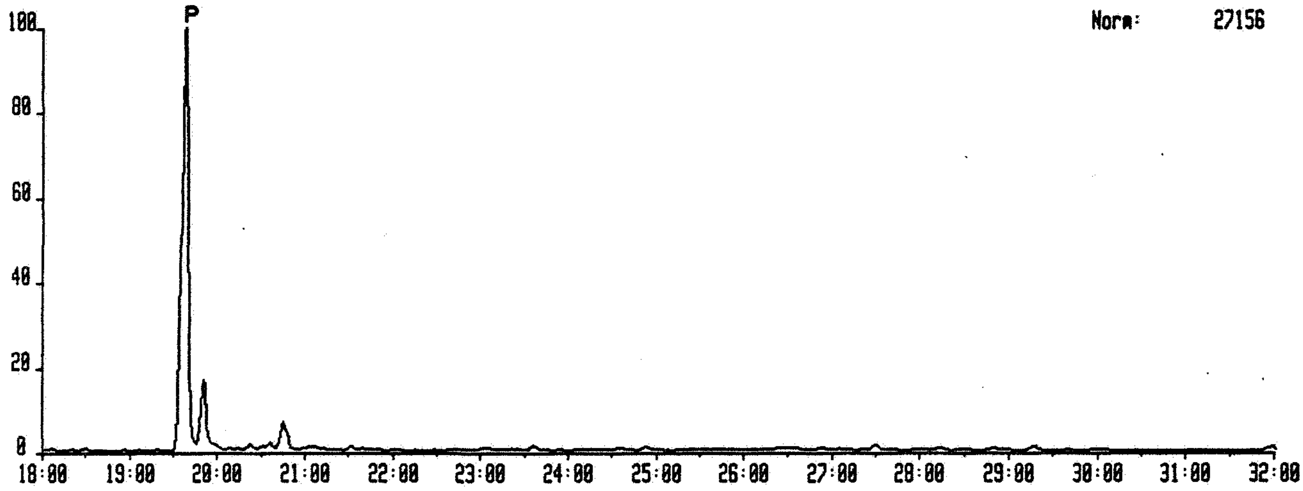
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

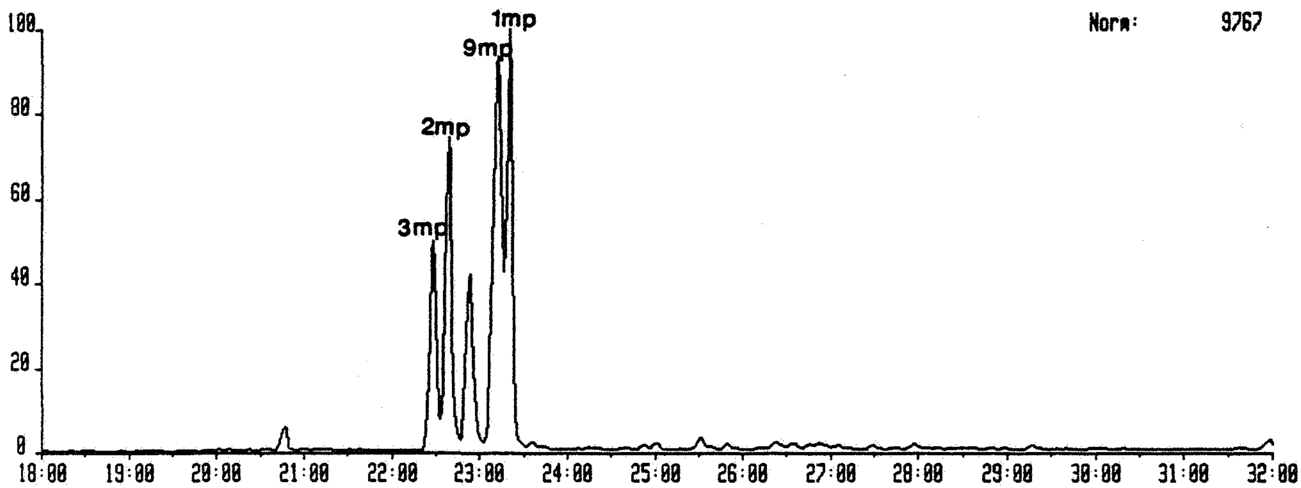
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523055BR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:WELL 6407/2-3(ST) 3050M



1523055BR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:WELL 6407/2-3(ST) 3050M



1523055BR 17-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:WELL 6407/2-3(ST) 3050M

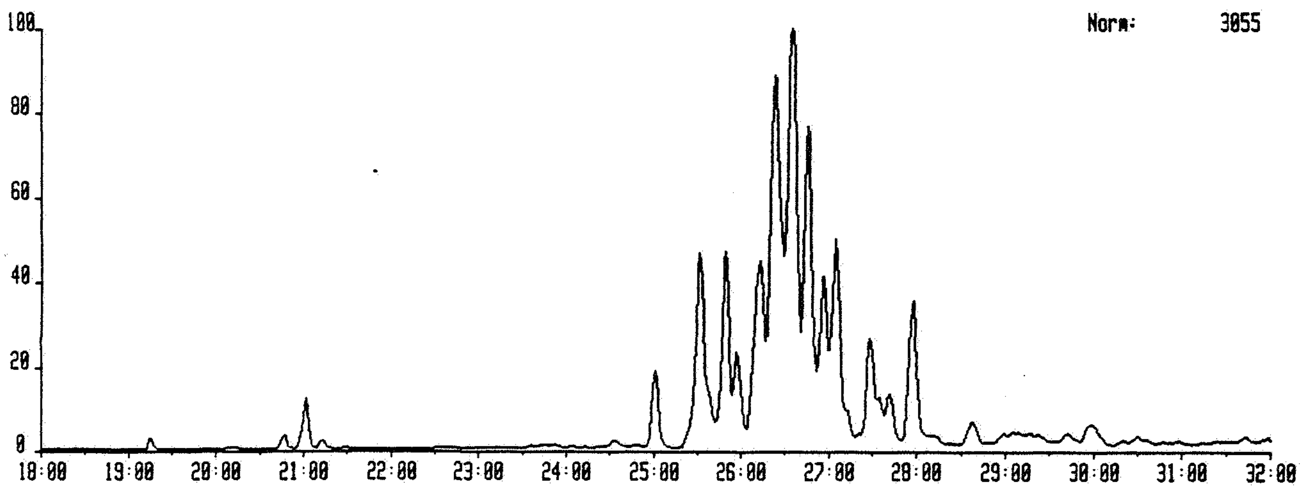


FIGURE 15f

MASS FRAGMENTOGRAMS

WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212

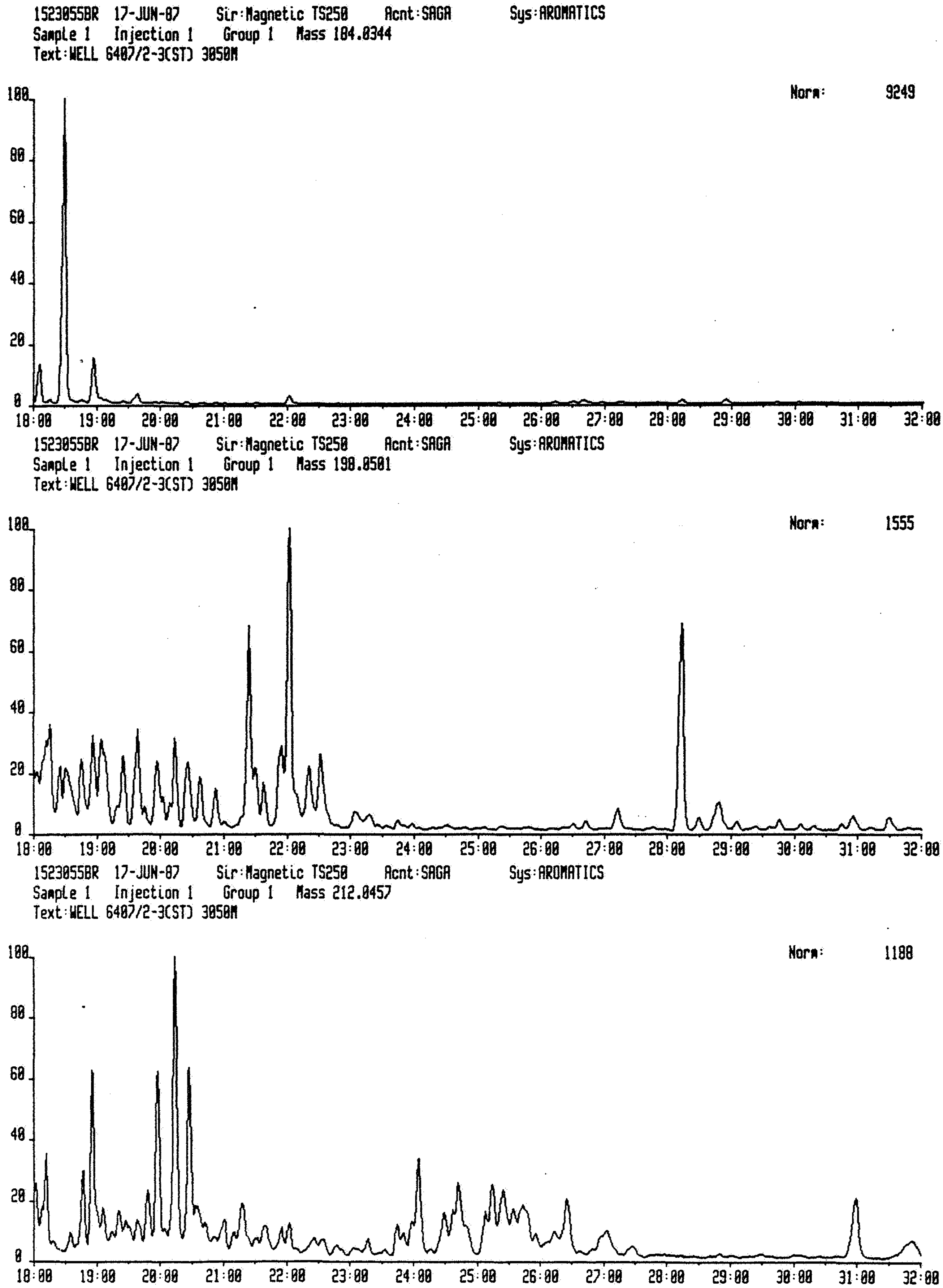


FIGURE 15g

MASS FRAGMENTOGRAMS

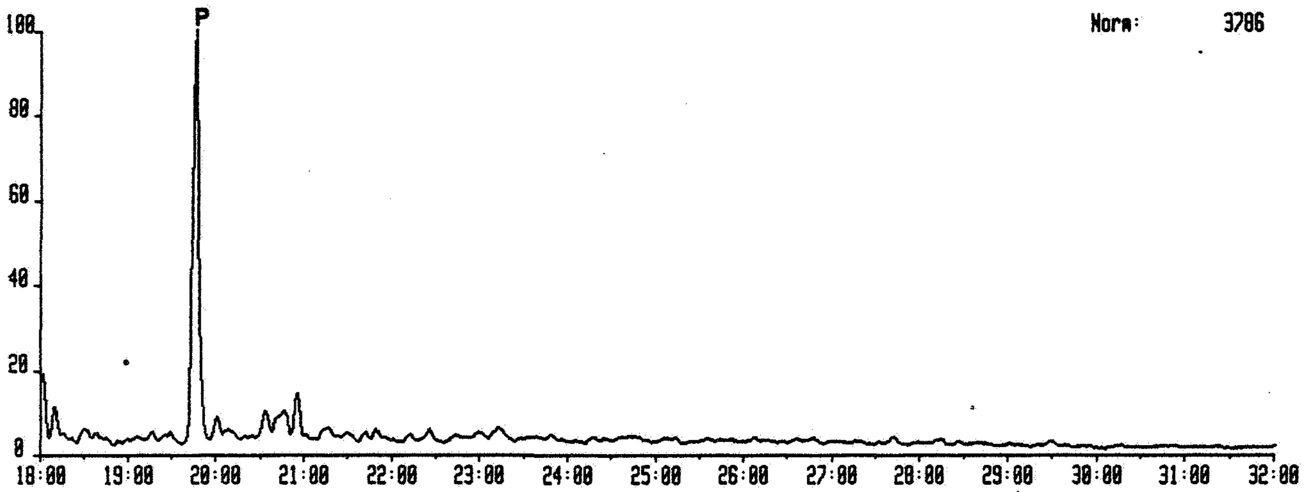
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

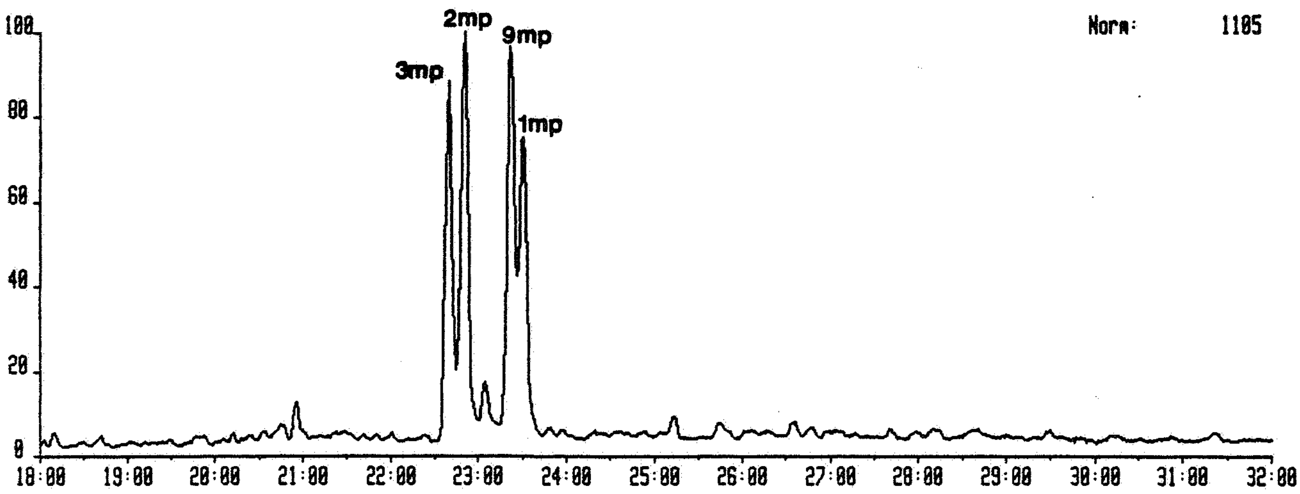
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:STOCK TANK OIL



1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:STOCK TANK OIL



1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1088
Text:STOCK TANK OIL

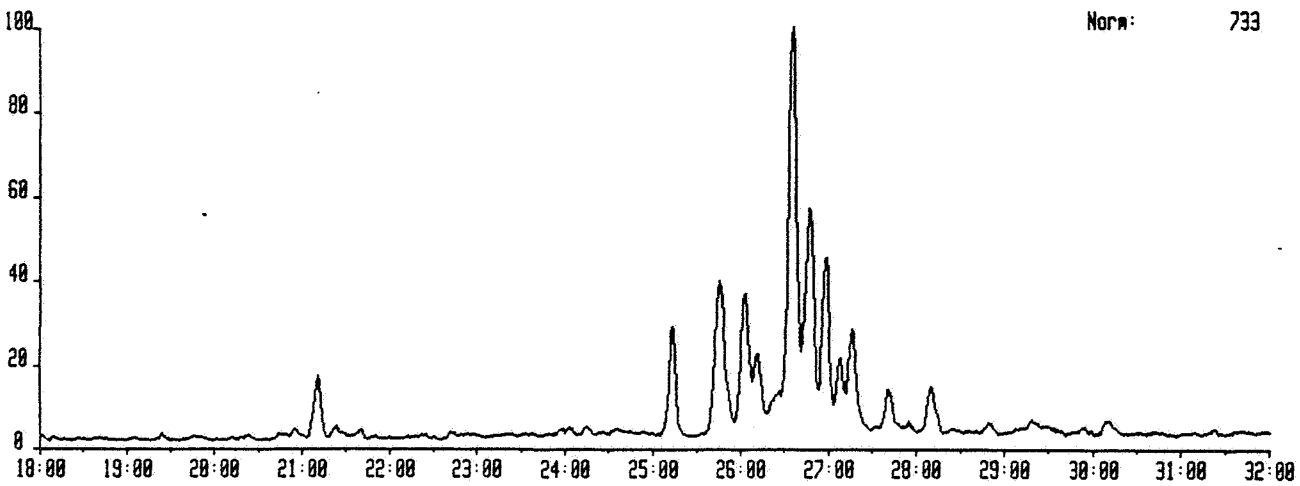


FIGURE 15g

MASS FRAGMENTOGRAMS

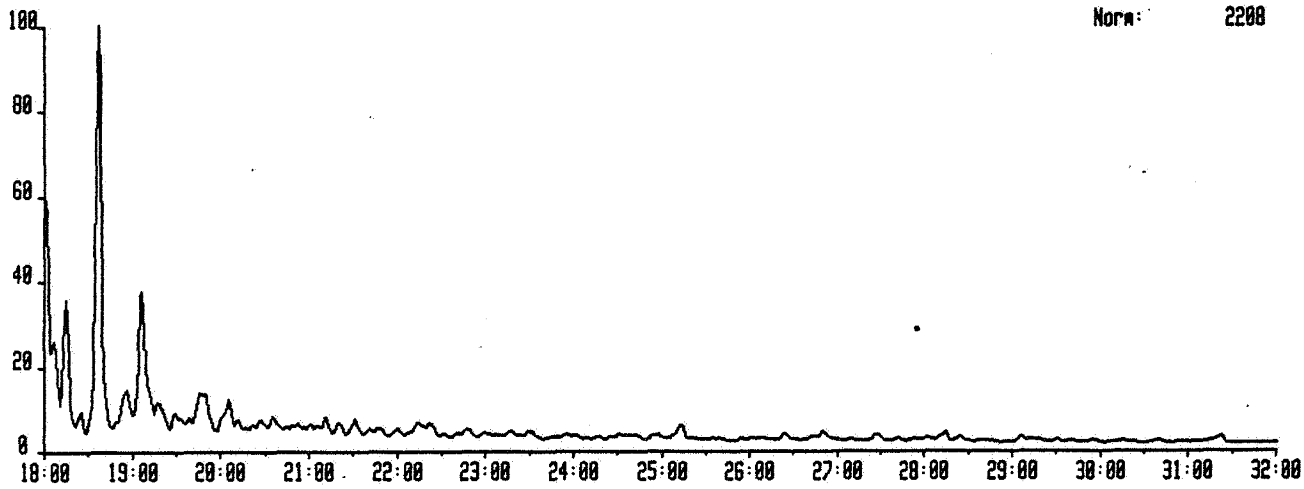
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

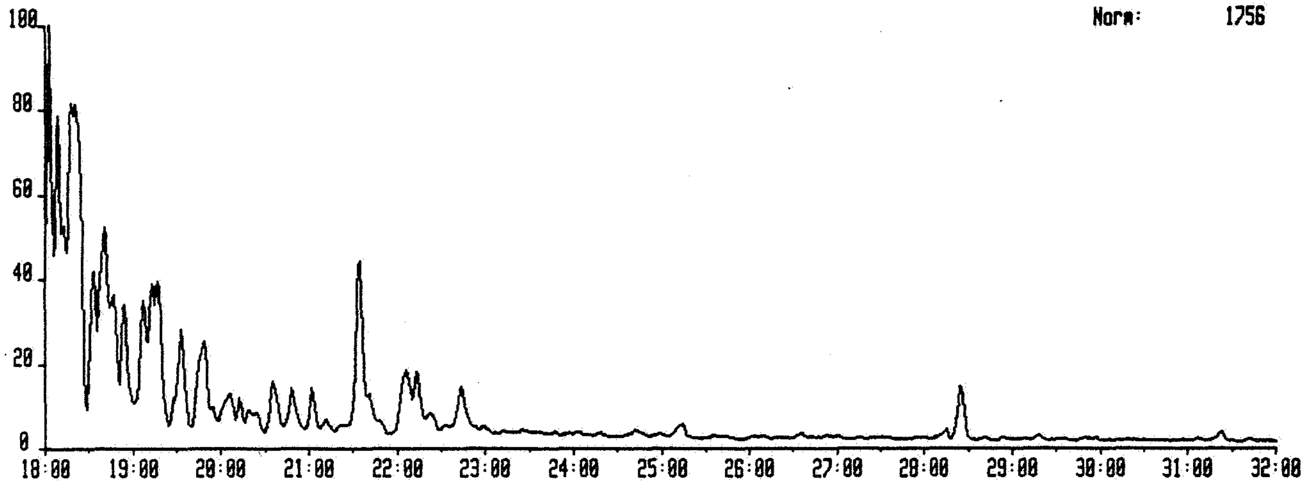
DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184,198,212

1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 184.0344
Text:STOCK TANK OIL



1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 198.0501
Text:STOCK TANK OIL



1523056AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 212.0457
Text:STOCK TANK OIL

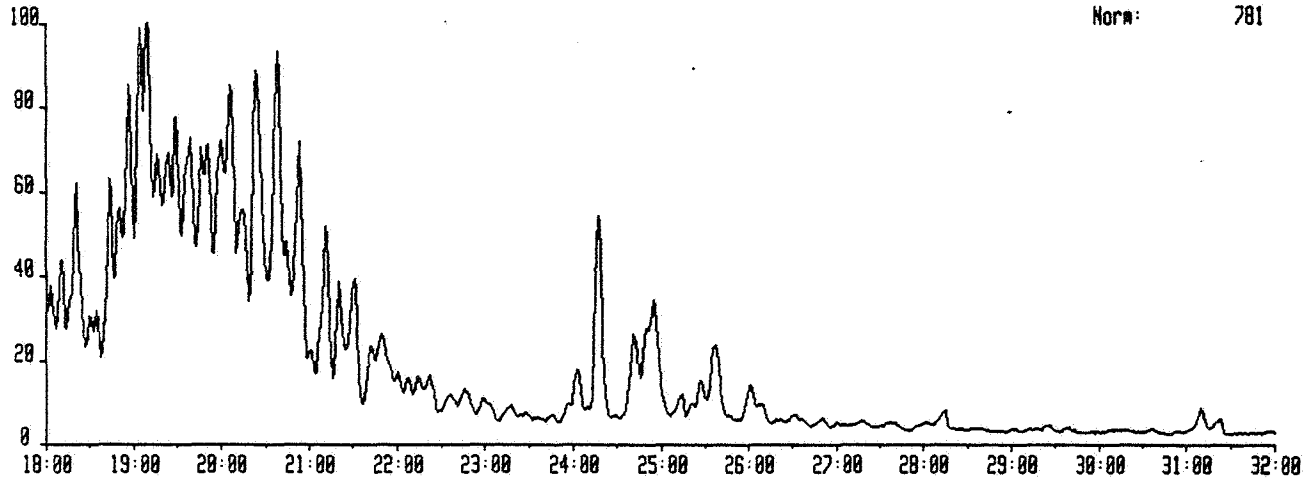


FIGURE 15h

MASS FRAGMENTOGRAMS

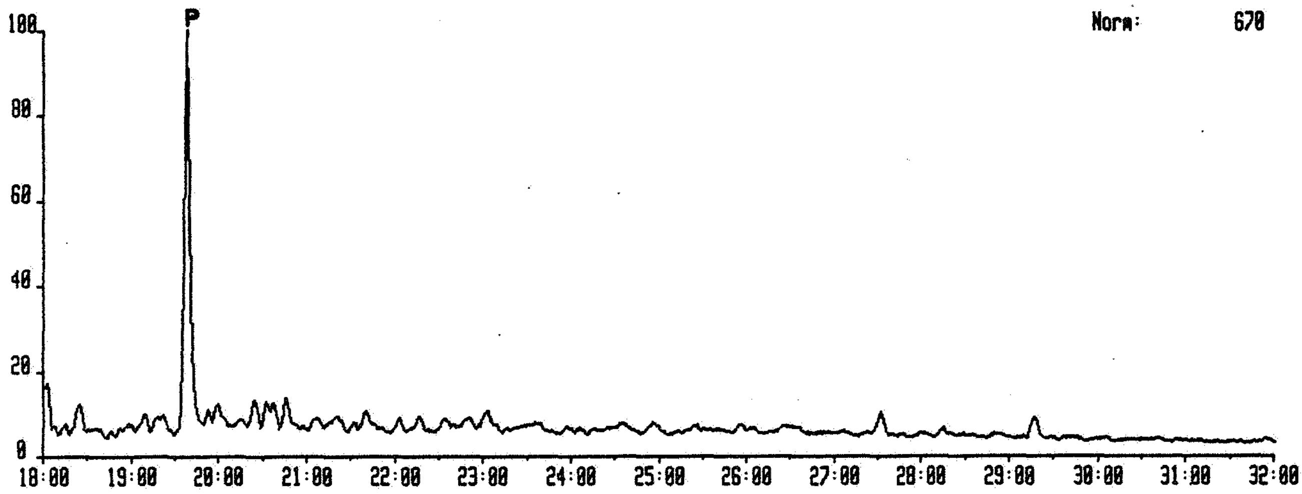
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

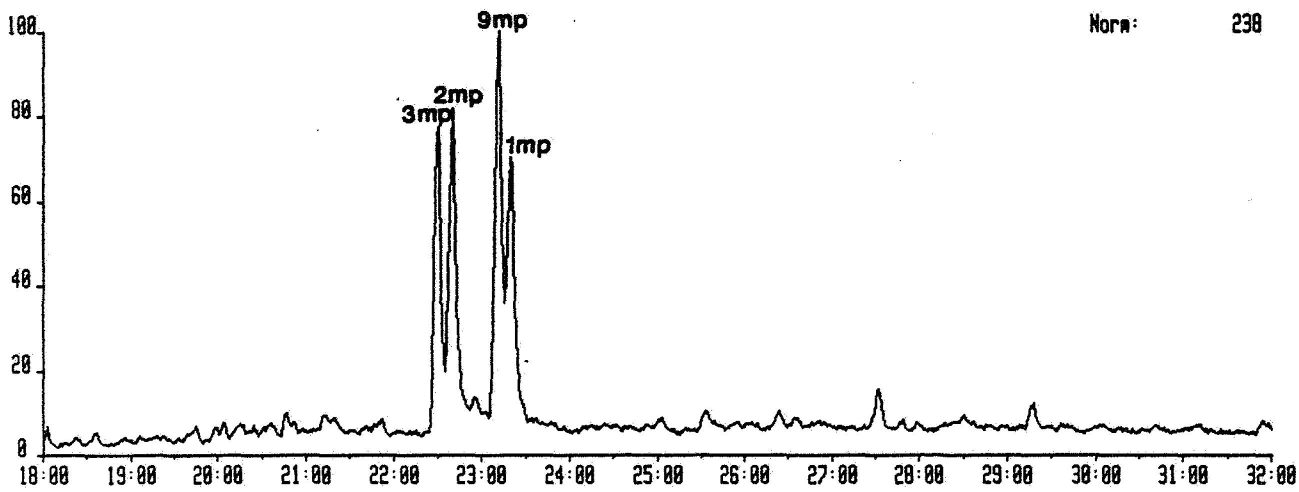
PHENANTHRENE AND ALKYL PHENANTHRENE SERIES

m/z 178,192,206

1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 178.0782
Text:SINGLE FLASH CONDENSATE



1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 192.0928
Text:SINGLE FLASH CONDENSATE



1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 206.1080
Text:SINGLE FLASH CONDENSATE

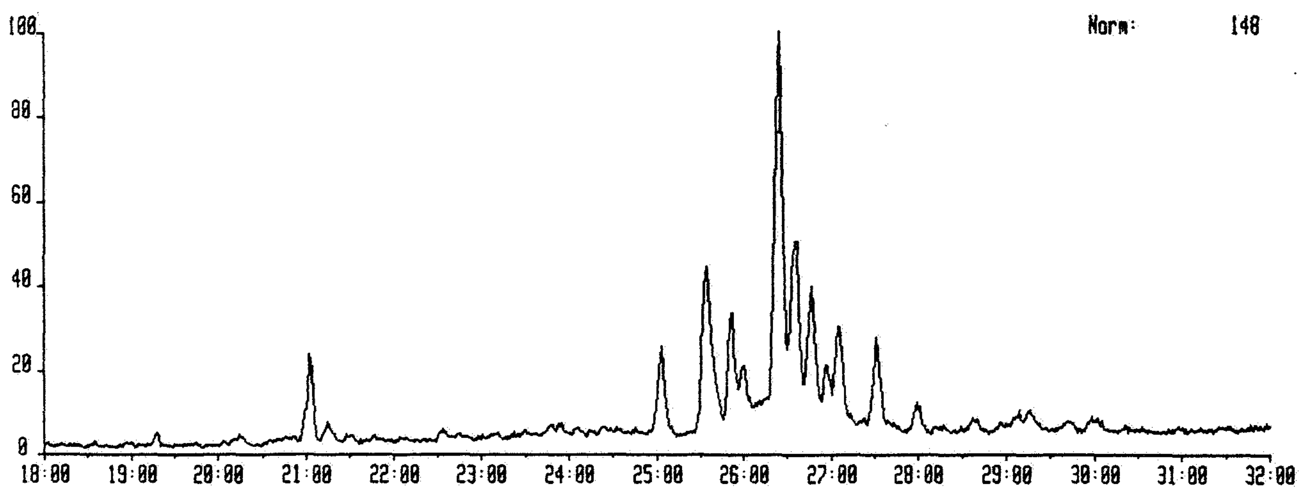


FIGURE 15h

MASS FRAGMENTOGRAMS

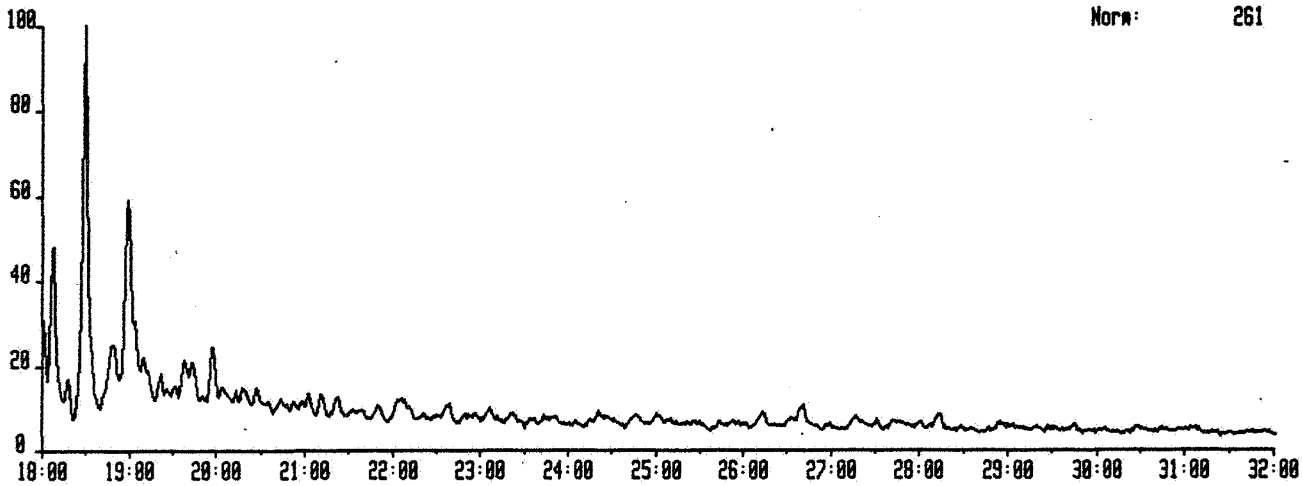
WELL 6407/2-3

C_{15+} AROMATIC HYDROCARBONS

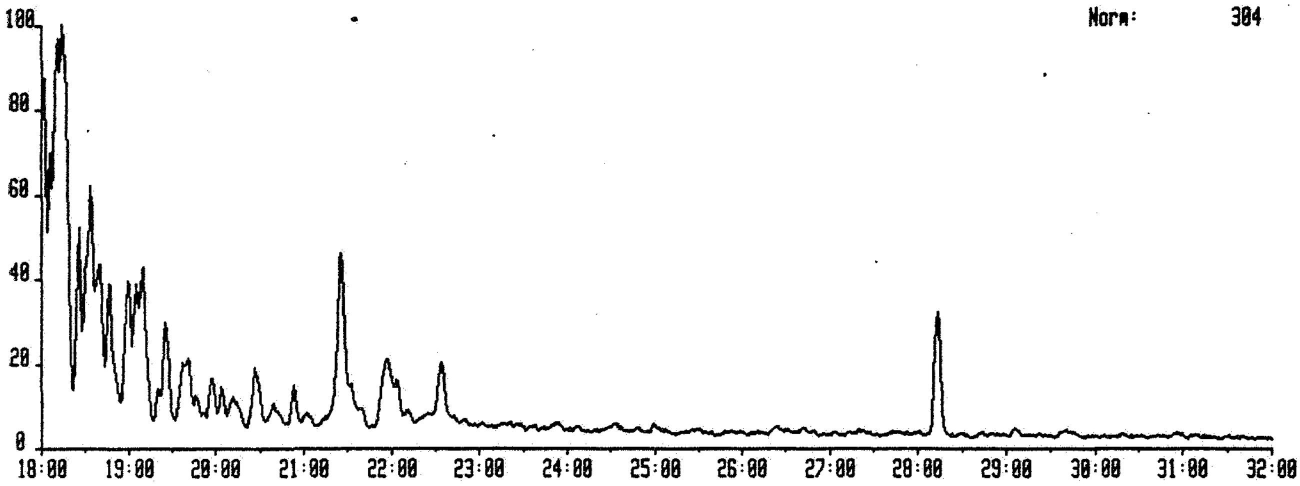
DIBENZOTHIOPHENE AND ALKYL DIBENZOTHIOPHENE SERIES

m/z 184.198.212

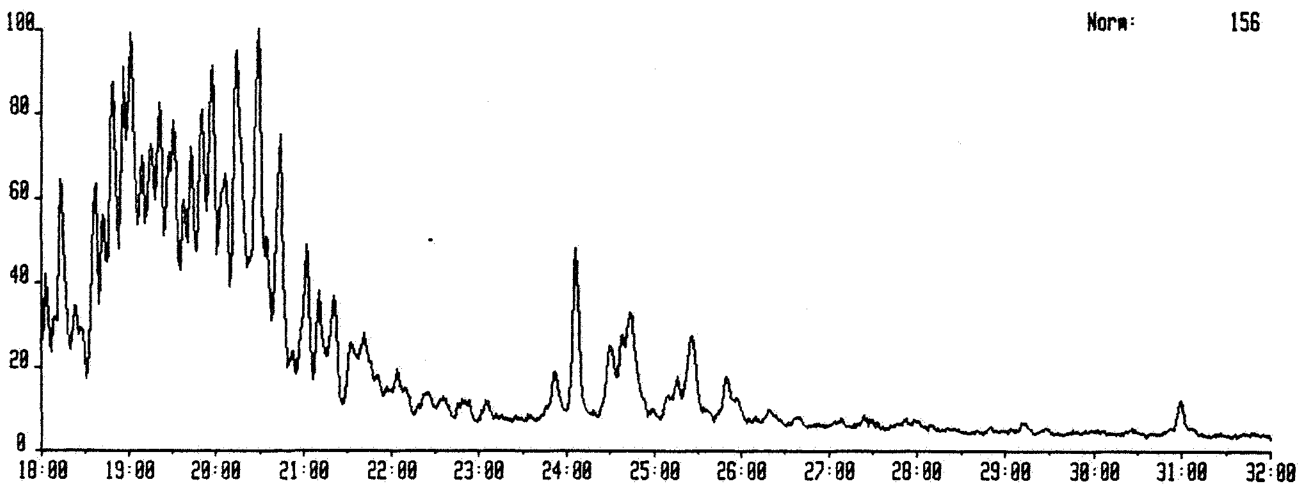
1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 184.0344
Text:SINGLE FLASH CONDENSATE



1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 198.0501
Text:SINGLE FLASH CONDENSATE



1523060AR 19-JUN-87 Sir:Magnetic TS250 Acnt:SAGA Sys:AROMATICS
Sample 1 Injection 1 Group 1 Mass 212.0457
Text:SINGLE FLASH CONDENSATE



BRIEF DESCRIPTION OF THE ANALYSES PERFORMED BY GEOCHEM

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

A) C_1-C_7 LIGHT HYDROCARBON ANALYSIS

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

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

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

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

B) SAMPLE WASHING AND HAND PICKING

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

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

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

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

C) ORGANIC CARBON ANALYSIS

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

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

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

D) MINI-PYROLYSIS

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

E) DETAILED C_4-C_7 HYDROCARBON ANALYSIS

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

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

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

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

F) KEROGEN TYPE AND MATURATION

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

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

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

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

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

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

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

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

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

G) VITRINITE REFLECTANCE

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

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

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

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

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

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

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

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

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

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

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

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

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

The normal paraffin carbon preference indices (C.P.I.) indicate if odd (values in excess of 1) or even (values less than 1) normal paraffins are dominant.

Strong odd preferences (± strong pristane peaks) are characteristic of immature land plant organic matter whilst even preferences (± strong phytane peaks) suggest a reducing environment of deposition. With increasing maturity, values approach 1.0 and oils are typically close to 1.0. The indices are calculated using the following formulae:

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

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

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

K) PYROLYSIS

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

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

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

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

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

L) <u>CORRELATION STUDY ANALYSES</u>

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

- detailed C_4-C_7 hydrocarbon (gasoline range) analysis. See Section E. Although these hydrocarbons can be affected by migrational/alteration processes, they commonly provide a very useful correlation parameter.

- capillary gas chromatography of the C_{15+} paraffin-naphthenes. See section J. The branched±normal paraffin distributions are used to "fingerprint" the samples.

- capillary chromatograms of whole oils and of the C_{4+} fraction of source rocks.

- capillary gas chromatography of C_{15+} aromatic hydrocarbons. Separate chromatograms of the hydrocarbons and of the sulphur-bearing species are reproduced.

- high pressure liquid chromatograms.

- mass spectrometric carbon isotope analyses of crude oil and rock extract fractions and of kerogen separations. A powerful tool for comparing hydrocarbons and correlating hydrocarbons to organic matter. With this technique the problem of source rock contamination can be avoided. The data are recorded on x-y or Galimov plots.

- mass fragmentograms (mass chromatograms) of fragment ions characteristic of selected hydrocarbon groups such as the steranes and terpanes. The fragmentograms provide a convenient and simple means of presenting detailed mass spectrometric data and are used as a sophisticated fingerprinting technique. This provides the ultimate resolution for correlating hydrocarbons and facilitates the examination of hydrocarbon classes.

- vanadium and nickel contents.

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

M) ANALYSES FOR SPECIAL CASES

M-1) ELEMENTAL KEROGEN ANALYSIS

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

M-2) SULPHUR ANALYSIS

The abundance of sulphur in source rocks and crude oils.

M-3) CARBONATE CONTENT

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

M-4) NORMAL PARAFFIN ANALYSIS

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

M-5 SOLID BITUMEN EVALUATION

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

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

N) CRUDE OIL ANALYSIS

N-1) API GRAVITY

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

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

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

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

N-5) FRACTIONAL DISTILLATION

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

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