



THE HYDROCARBON HABITAT OF THE GIPPSLAND BASIN

A NON-EXCLUSIVE STUDY

APPENDIX 3 : GEOCHEMISTRY

by
Analabs

PETROLEUM DIVISION

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GIPPSLAND BASIN GEOCHEMICAL STUDY

for

PHILLIP D. CONNARD PTY. LTD.

JUNE, 1986

HYDROCARBON SOURCE ROCK / CRUDE OIL

STUDY OF THIRTEEN WELLS IN THE

OFFSHORE GIPPSLAND BASIN

SUMMARY

- The Latrobe source rocks analysed in this study are organic rich and contain appreciable quantities of both oil and gas prone, terrestrial organic matter. Sediments are moderately mature to mature (oil generative) and have probably sourced the six crudes analysed in this study.
- Diterpane biomarker distributions and gas chromatograms from extracted source rocks indicate considerable local variation in organic source material. These variations have probably given rise to minor differences in the oils from this basin. However, all oils in this study were originally mature 'waxy' crudes sourced predominantly from land plant material containing a significant component from Mesozoic conifer resins. The Dolphin 1 and West Seahorse 1 crudes have undergone bacterial attack and are mildly biodegraded.
- GC/MS maturity parameters are generally unreliable in this basin. However C₂₉ sterane ratios indicate that the Dolphin 1 and Bream 2 oils are probably less mature than the other oils.
- Diterpane biomarker distributions indicate the source rocks from Tarwhine 1, Veilfin 1 and Hermes 1 show the greatest affinity with the crude oils.
- All oils show extremely high C₁₅ alkyl cyclohexane/C₃₀ hopane ratios. This ratio is significantly lower in the source rocks. The difference does not preclude the possibility that these oils and source rocks are related. It is more probable that in the crudes the C₁₅ alkyl cyclohexane has been concentrated relative to the C₃₀ hopane during migration due to its greater mobility.
- In Marlin A-6 the n-alkane distribution in a C₁₂₊ saturate chromatogram, a low pristane/phytane ratio and the diterpane biomarker distribution indicate that the depositional environment and organic source material is somewhat different in this sample from other source rocks characterised in this study.

Steve Cadman
June 1986.

INTRODUCTION

Organic geochemical analyses have been undertaken on cuttings and crude oil samples from thirteen wells in the offshore Gippsland Basin.

The purpose of this study has been to characterise and correlate the hydrocarbon source rocks and reservoir hydrocarbon recovered from these wells.

Analytical

Upon arrival at Analabs, all cuttings samples underwent total organic carbon analysis. The richest of these were then submitted to Rock-Eval pyrolysis analysis. (Open file TOC and Rock-Eval pyrolysis data was provided by P. Connard for four of the wells used in this study). On the basis of the above screening analyses, six source rock samples were selected for solvent extraction, separation by liquid chromatography, C₁₂⁺ saturate chromatography and GC/MS analysis of the branched cyclic fraction.

The six crude oil samples analysed in this study underwent C₁-C₃₁ whole oil gas/liquid chromatography and GC/MS analysis.

The source rocks and oils included in this study are listed below:

SOURCE ROCKS

<u>Well name</u>	<u>Interval Analysed</u>
Bream 2	9230 ft to 10657ft
Hermes 1	2800m to 4450m (Open file)
Marlin A-6	4500 ft to 10950ft (Open file)
Selene 1	3030m to 3450m (Open file)
Snapper 1	9750 ft to 10470ft
Tarwhine 1	2550m to 2960m
Veilfin 1	3000m to 3510m
Volador 1	3459m to 4554m

CRUDE OIL

<u>Well name</u>	<u>Sample Depth</u>
Bream 2	6347ft
Dolphin 1	4000ft
Halibut A-1	7500ft
Marlin A-24	3183m
Tuna A-2	1996m to 2005m
West Seahorse 1	1417m

The results of the various analyses undertaken in this study can be located in the following:

SOURCE ROCKS

<u>Type of Analysis</u>	<u>Figure</u>	<u>Table</u>
Bream 2		
Total organic carbon determination		1
Rock-Eval pyrolysis		1
Extract/liquid chromatography		2
C ₁₂ + saturate gas chromatography	1	3
GC/MS - saturates	2	4
Hermes 1		
Total organic carbon determination		5
Rock-Eval pyrolysis		5
Extract/liquid chromatography		6
C ₁₂ + saturate gas chromatography	3	7
GC/MS - saturates	4	8
Marlin A-6		
Total organic carbon determination		9
Rock-Eval pyrolysis		9
Extract/liquid chromatography		10
C ₁₂ + saturate gas chromatography	5	11
GC/MS - saturates	6	12
Snapper 1		
Total organic carbon determination		13
Rock-Eval pyrolysis		13
Extract/liquid chromatography		14
C ₁₂ + saturate gas chromatography	7	15
GC/MS - saturates	8	16
Tarwhine 1		
Total organic carbon determination		17
Rock-Eval pyrolysis		17
Extract/liquid chromatography		18
C ₁₂ + saturate gas chromatography	9	19
GC/MS - saturates	10	20
Veilfin 1		
Total organic carbon determination		21
Rock-Eval pyrolysis		21
Extract/liquid chromatography		22
C ₁₂ + saturate gas chromatography	11	23
GC/MS - saturates	12	24
Selene 1		
Total organic carbon determination		25
Rock-Eval pyrolysis		25
Volador 1		
Total organic carbon determination		38
Rock-Eval pyrolysis		38

CRUDE OILS

<u>Type of Analysis</u>	<u>Figure</u>	<u>Table</u>
Bream 2		
C ₁ -C ₃₁ whole oil GLC	13	26
GC/MS - saturates	14	27
Dolphin 1		
C ₁ -C ₃₁ whole oil GLC	15	28
GC/MS - saturates	16	29
Halibut A-1		
C ₁ -C ₃₁ whole oil GLC	17	30
GC/MS - saturates	18	31
Marlin A-24		
C ₁ -C ₃₁ whole oil GLC	19	32
GC/MS - saturates	20	33
Tuna A-2		
C ₁ -C ₃₁ whole oil GLC	21	34
GC/MS - saturates	22	35
West Seahorse 1		
C ₁ -C ₃₁ whole oil GLC	23	36
GC/MS - saturates	24	37

A description of these analyses may be found in the Theory and Methods section located at the rear of this report.

General Information

Copies of this report have been sent to P.D. Connard, who provided vitrinite reflectance data from maturation models. Dr. R. Alexander of the Western Australian Institute of Technology provided an interpretative report on the diterpanes identified in the GC/MS analyses. Any questions related to this report may be directed to Steve Cadman of Analabs, located in Perth, Western Australia.

A. HYDROCARBON SOURCE CHARACTER

Bream 2

Cuttings samples analysed between 9230ft and 10657ft in the Bream 2 well show excellent organic richness (Many TOC values in excess of 10.0% were recorded for this interval). Hydrogen indices (Table 1) are moderately high and suggest organic matter is 'mixed' in origin with appreciable quantities of both oil prone and gas prone material present.

Vitrinite reflectance data indicates sediments at these depths lie within the oil window and are probably approaching the stage of peak oil generation. This is confirmed by the high S_1 volatile hydrocarbon yields recorded from all samples that have undergone Rock-Eval pyrolysis analysis. It is apparent from this data that significant hydrocarbon generation has commenced in these rocks.

Washed and dried cuttings between 10340ft and 10430ft underwent solvent extraction. This sample has an excellent total extract yield and proved to be rich in aromatic and NSO compounds (Table 2). This is probably due to both the coaly nature of these sediments (coals are typically rich in aromatic compounds) and the fact that the more mobile saturate fraction may have already been preferentially expelled from these source rocks.

The $C_{12}+$ saturate chromatogram from this sample (Figure 1), shows a predominance of high molecular weight n-alkanes. The relative abundance of these 'waxy' compounds suggests these source rocks are terrestrial in origin, while a high pristane/phytane ratio (Table 3) may indicate they were deposited in a relatively oxidising depositional environment.

However the gc trace from this sample is somewhat unusual in that it shows a slight bimodal n-alkane distribution, with minor 'baseline humps' around C_{14} and C_{29} . These features may be caused by the presence of quantities of resinite, which is known to source hydrocarbons at low thermal maturities. The gc trace from this sample is remarkably similar to that obtained from a source rock in Tarwhine 1.

GC/MS analysis (Table 4) gave T_s/T_m and C_{30} hopane/ C_{30} moretane ratios that are unusually low for a sample that is thought to be approaching optimum thermal maturity. However, the C_{29} 20S/ C_{29} 20R sterane ratio appears to have equilibrated, and is probably a more accurate indicator of thermal maturity.

As would be expected from a terrestrially derived source rock, C_{29} steranes and diasteranes predominate over the C_{27} steranes and diasteranes (Table 4). Small quantities of phyllocladanes and kauranes were identified on the 123 ion. These biomarkers are thought to originate from Permian or Mesozoic conifer resins. C_{19} and C_{20} isopimeranes were also found on this ion confirming that organic matter in this sample was derived predominantly from land plants.

In summary, the source rocks analysed in Bream 2 are organic rich, mature and oil generative. Organic matter is thought to be derived from land plants. There is some suggestion that the cuttings sample at 10340ft to 10430ft may contain significant quantities of resinite although this is uncertain. The source rocks at this depth appear similar in character to those at 2610-2660m in Tarwhine 1.

Hermes 1

Data from a total of one hundred and thirty-nine (139) total organic carbon and Rock-Eval pyrolysis analyses between 2800m and 4565m is available on 'open file' for the Hermes 1 well. Organic richness (TOC) is variable over this interval. The coal horizons gave TOC values in excess of 20% TOC, while the more argillaceous and arenaceous sediments typically average around 3.0% TOC.

Rock-Eval pyrolysis yields, (S_1+S_2) are good throughout. Maturation modelling suggests sediments below 4200m are moderately mature and are in the early stages of oil generation. Hydrogen indices generally range between 200 and 300 (Table 5), indicating an abundance of both oil and gas prone organic matter. Below 4200m, however, where sediments are thought to be oil generative, hydrogen indices are slightly lower.

A coal rich sample at 4270-4300m was extracted. As would be expected, it gave a good total extract yield, rich in aromatic compounds (Table 7). The $C_{12}+$ saturate chromatogram (Figure 3) exhibits a terrestrial character with a predominance of high molecular weight 'waxy' n-alkanes. As in source rocks from other wells in this study the pristane/phytane ratio (Table 6) suggests these sediments were deposited in a relatively oxidising environment.

The above sample was also submitted for GC/MS analysis. As in some other samples selected for GC/MS in this study the T_s/T_m maturity parameters seems anomalously low. However the C_{30} hopane/ C_{30} moretane and the C_{29} 20S/ C_{29} 20R sterane maturity parameters (Table 8) both indicate this sample is probably moderately mature.

The low C_{27}/C_{29} sterane and diasterane ratios confirm the terrestrial origins of the organic matter in this interval. The phyllocladane, kaurane, beyerane and C_{19} isopimerane biomarkers derived from Mesozoic conifer resins and land plants were identified on the 123 and 191 ions.

In summary, the organic rich, moderately mature source rocks encountered below 4200m in Hermes 1 are rich in organic matter derived from land plants and have probably sourced quantities of both oil and gas.

Marlin A-6

Open file total organic carbon and Rock-Eval pyrolysis data show samples between 5450ft and 10850ft in Marlin A-6 are exceptionally rich. In these coaly sediments TOC values average around 40% TOC. However, hydrogen indices are only moderately high (Table 9), suggesting source rocks are predominantly gas prone, although significant quantities of oil prone organic matter are probably present in certain intervals, (particularly around 9800-10050ft and 10600-10850ft).

Maturation modelling indicates sediments below 7700ft are moderately mature and are in the early stages of oil generation (0.60% to 0.80% Ro). Excellent S₁ volatile hydrocarbon and S₂ hydrocarbon generating potential yields obtained from this interval (Table 9) show appreciable quantities of gas and minor amounts of oil may have been sourced from these rocks.

Solvent extraction of a cuttings sample at 9620-9710ft gave an excellent total extract yield, rich in aromatic compounds and with a terrestrial character. However, the C₁₂₊ saturate chromatogram (Figure 5) does not show as great a predominance of high molecular weight n-alkanes as in source rocks from Bream 2 or Snapper 1.

GC/MS analysis indicates sediments at 9620ft to 9710ft although in the early stages of oil generation, have probably not attained full thermal maturity. Ts/Tm and C₂₉ 20S/C₂₉ 20R sterane ratios have not yet equilibrated while the C₃₀ hopane/C₃₀ moretane ratio is still relatively low (Table 12).

As in other source rocks analysed in this study the low C₂₇/C₂₉ sterane and diasterane ratios indicate a predominantly land plant source for the organic matter in this interval. However the cuttings sample at 9620-9710ft does show relatively high concentrations of C₂₇ steranes and may reflect slight organic facies change. This seems to be corroborated by the configuration of the C₁₂₊ saturate chromatogram from this sample (Figure 5). Here the gc trace does not show as great a predominance of the high molecular weight 'waxy' n-alkanes as other source rock from wells in this study. An n-alkane 'hump' centred around carbon number 17 is also evident. In addition the pristane/phytane ratio is significantly lower, in this sample, suggesting a slightly different depositional environment.

Large quantities of phyllocladanes and kauranes on the 123 ion indicate a significant input from Mesozoic conifer resins. Small quantities of C₁₉ and C₂₀ isopimeranes (land plant biomarkers) were also identified on this ion.

In summary, the sediments around 9620-9710ft in the Marlin A-6 well are organic rich, moderately mature (early oil generative) and are dominated by organic matter derived from land plants. However, there may have been a minor contribution from either a marine or freshwater algal source. The depositional environment appears to have been less oxidising in Marlin A-6 than in other source rocks analysed in this study.

Snapper 1

Although total organic carbon values are considerably lower in samples from Snapper 1 organic richness in the interval 9750ft to 10470ft is still very good, (TOC values average approximately 3.0%). Hydrogen indices tend to be low, suggesting organic matter is predominantly gas prone (Table 13).

These sediments are thermally mature and are at the stage of peak oil generation (0.80 to 0.90% Ro from maturation modelling data). This is confirmed by Tmax temperatures of around 440°C. S₁ volatile hydrocarbon yields suggest significant quantities of gas have probably been generated from these sediments.

One of the richer cuttings samples at 10170-10260ft was extracted. It gave a moderately good total extract yield, rich in aromatics and apparently depleted in saturates. This has probably been caused by both the aromatic rich nature of coaly sediments and the fact that the expulsion of generated hydrocarbon from these source rocks may have lead to a depletion of the saturate fraction in the remaining volatile hydrocarbons (Table 14).

The C₁₂+ saturate chromatogram is typical of a mature terrestrially derived source rock (Figure 7). A high pristane/phytane ratio indicates these sediments have probably been deposited in a relatively oxidising depositional environment.

GC/MS maturity parameters (Table 16) suggest the sediments at 10170-10260ft have not yet attained optimum thermal maturity. (Ts/Tm and C₂₉ 20S/C₂₉ 20R sterane ratios have not yet equilibrated). However Ts/Tm ratios are unreliable in coaly sediments, particularly those deposited in a peat swamp environment. Consequently it is thought probable that hydrocarbon generation has commenced in sediments around this interval.

C₂₇/C₂₉ sterane and diasterane ratios are low in the sample submitted for GC/MS analysis, confirming the terrestrial origin of the organic matter at 10170-10260ft.

Phyllocladanes and beyerane (Mesozoic conifer resin biomarkers) are present on the 123 ion. However, the kauranes are absent in this sample. C₁₉ and C₂₀ isopimeranes and the unnamed C_x biomarker (191 ion), (all of which are taken to have originated from land plant^x), were also identified.

In conclusion, although the source rocks analysed in Snapper 1 are not as organic rich as source rocks from other wells in this study it is probable that quantities of gas have been generated from these sediments. The abundance of biomarkers from land plant material and the predominance of high molecular weight 'waxy' n-alkanes indicate a terrestrial source for these sediments.

Tarwhine 1

Twenty-one (21) cuttings samples between 2550m and 2960m from this well were submitted for TOC and Rock-Eval pyrolysis determination. Organic richness (TOC) was found to be fair to good in most instances. The richest horizons were encountered at 2610-2660m and 2770-2820m. Here, TOC values exceeded 3.0% (Table 17). Hydrogen indices are only moderately high suggesting organic matter is predominantly gas prone but may contain a minor oil prone component.

Thermal maturity of the sediments analysed in Tarwhine 1 is uncertain. However, data from the Veilfin 1 well suggests the interval analysed in Tarwhine 1 is marginally to moderately mature and in the initial or early stages of hydrocarbon generation. This seems to be confirmed by Tmax temperatures which range between 435°C and 440°C for these source rocks.

Volatile hydrocarbon yields (S_1) are considerably poorer than in other wells included in this study. This reflects the slightly lower thermal maturities and organic richness (TOC) encountered in the Tarwhine 1 source rocks. However, S_1 yields in excess of 0.35 mg/g were still recorded, indicating quantities of gas have probably been generated from these sediments.

As in other wells in this study, solvent extraction of one of the richer samples gave a good extract yield rich in aromatics and a saturate fraction dominated by high molecular weight, terrestrially sourced 'waxy' n-alkanes.

The character of the $C_{12}+$ saturate chromatogram from this sample is very similar to that of the extracted source rock from Bream 2. Although the high molecular weight n-alkanes predominate, the n-alkane distribution is distinctly bimodal (Figure 9). In addition a small 'baseline' hump is present around carbon number 14. As in the Bream 2 sample, it is possible that this is caused by the presence of significant quantities of resinitic organic matter.

GC/MS analysis gave a very low T_s/T_m ratio (Table 20). The $C_{29} 20S/C_{29} 20R$ sterane ratio is probably a more accurate indicator of this samples thermal maturity in this instance.

As in source rocks from other wells in this study GC/MS indicates organic matter is predominantly terrestrial in origin. This is based on low C_{27}/C_{29} sterane and diasterane ratios and the presence of Mesozoic conifer and land plant biomarker molecules (beyerane, kauranes, phyllocladanes, and C_{19} , C_{20} isopimeranes).

In summary, it is thought that the source rocks analysed in Tarwhine 1 are probably of sufficient thermal maturity and organic richness to have sourced moderate quantities of gas and minor quantities of oil. Organic matter is terrestrial in origin and as in the Bream 2 sample, source rocks around 2610-2660m may contain appreciable quantities of resinite. However, this is uncertain.

Veilfin 1

Organic richness (TOC) is generally very good in twenty-six (26) samples analysed between 3000m and 3510m in Veilfin 1. Exceptionally rich horizons are found around 3200-3210m, 3360-3370m and 3460-3490m where TOC values exceed 10.0%. In these richer intervals, hydrogen indices typically exceed 200 (Table 21), indicating appreciable quantities of oil prone organic matter are probably present, at these depths.

The sediments analysed in Veilfin 1 are thought to be moderately mature to mature. Peak oil generation has probably been attained below 3400m. Tmax temperatures correlate well with this interpretation, rising to in excess of 440°C below the above depth.

It is probable that the richer source rocks below 3200m in Veilfin 1 have generated significant quantities of both oil and gas as S_1 volatile hydrocarbon yields at these depth are high. The richest sample at 3460-3490m was solvent extracted and gave an extract yield extremely rich in aromatic and NSO compounds. As in other wells of this study, the high aromatic content is probably due to both the coaly nature of these sediments and the fact that the more mobile saturate compounds generated from these source rocks may have already been expelled. The n-alkane distribution in the $C_{12}+$ saturate chromatogram (Figure 11) is characteristic of a mature terrestrially derived source rock.

This is confirmed by GC/MS analysis. Phyllocladanes, kauranes, beyeranes, (Mesozoic conifer resin biomarkers on the 123 ion), C_{19} , C_{20} isopimeranes (land plant biomarkers on the 123 ion), the unnamed C_x land plant biomarker on the 191 ion and low C_{27}/C_{29} sterane and diasterane ratios (Table 24), all indicate a predominantly terrestrial land plant source.

The T_s/T_m maturity parameters from GC/MS data is thought to be unreliable in this instance. However, the C_{30} hopane/ C_{30} moretane maturity parameter is high and the C_{29} 20S/ C_{29} 20R sterane ratio is approaching equilibration, confirming sediments around this depth are thermally mature.

In summary, it is likely that the organic rich sediments below 3400m in the Veilfin 1 well have sourced moderate quantities of both oil and gas. It is likely that the liquid hydrocarbons generated from these source rocks are rich in high molecular weight waxy n-alkanes and land plant biomarkers.

Selene 1

'Open file' TOC and Rock-Eval pyrolysis data is available on forty-seven (47) samples between 3030 and 3450m in the Selene 1 well. Organic richness (TOC) is good to excellent in sediments between 3080m and 3450m (Coaly horizons at 3240-3250m, 3350-3360m and 3370-3390m gave exceptionally good TOC yields). Hydrogen indices generally exceed 300 and suggest that abundant oil prone organic matter is present in these source rocks.

The thermal maturity of these sediments is uncertain. Tmax data (Table 25) suggests these rocks are immature to marginally mature. However good S₁ volatile hydrocarbon yields indicates that hydrocarbon generation may have begun and that these excellent potential source rocks encountered in Selene 1 have attained a higher thermal maturity.

Extract and GC/MS data is unavailable for this well.

Volador 1

'Open file' total organic carbon and Rock-Eval pyrolysis data from sixteen sidewall cores between 3549.9m and 4554m in this well show organic richness, although variable, is generally very good to excellent. Hydrogen indices are moderately high, indicating quantities of both oil and gas prone organic matter are present at most depths.

Sediments within this interval are moderately mature to mature. It is apparent from the excellent S_1 volatile hydrocarbon yields recorded in many instances that appreciable quantities of both oil and gas have probably been sourced from these rocks.

Extract and GC/MS data is unavailable for source rocks from this well.

B. CRUDE OIL CHARACTERISATION

Bream 2

C₁-C₃₁ whole oil gas/liquid chromatography of the Bream 2 oil (Figure 13 shows the low molecular weight, volatile hydrocarbons are missing from this sample. Normally this would be taken as evidence that the oil had been extensively water-washed. However, in this instance it is thought more likely that the volatiles have escaped during poor sample storage. Unfortunately, this has made the maturity and source parameters based on the C₄ to C₇ hydrocarbons (Table 26) meaningless.

GC/MS analysis of the oil gave values for maturity parameters (Table 27) which suggest the oil is only moderately mature. However large quantities of C₁₅ alkyl cyclohexane were identified on the 83 ion. The presence of large quantities of this compound suggests acidophyllic bacteria has been active in the depositional environment. These bacteria are most active in a peat-swamp environment. Organic matter that has originated in this environment tends to have low Ts/Tm ratios. Consequently this oil may be more mature than the GC/MS maturity parameters suggest. Alternatively, the high levels of C₁₅ alkyl cyclohexanes observed in the Bream 2 oil, (and in all other oils in this study), may be due in part to a migration effect. The low molecular weight C₁₅ alkyl cyclohexane would migrate with greater ease than the C₃₀ hopane, giving rise to reservoired crudes enriched with C₁₅ alkyl cyclohexane with respect to C₃₀ hopane.

Low C₂₇/C₂₉ sterane and diasterane ratios indicate the Bream oil has been sourced from terrestrial organic matter. As in most of the source rocks analysed in this study, phyllocladanes, kauranes, beyerane (originating from Mesozoic conifer resins) and the C₁₉, C₂₀ isopimeranes (land plant biomarkers) were all identified on GC/MS fragmentograms from this oil.

In summary, the crude oil recovered from 1943m in Bream 2 is probably mature and derived predominantly from land plant material. Organic source material may have been deposited in a peat swamp environment. This oil appears to have lost its low molecular weight components due to poor sample storage. Consequently, it is uncertain as to whether water-washing has occurred. The Bream oil does not appear to have undergone any biodegradation.

Dolphin 1

Whole oil gas/liquid chromatography of the Dolphin 1 oil shows this crude has undergone mild biodegradation. The low molecular weight n-alkanes have been selectively removed leaving small amounts of the higher molecular weight 'waxy' n-alkanes between carbon numbers 22 and 32 (Figure 15). The biodegradation is not thought to have been severe as high molecular weight n-alkanes, the isoprenoids (pristane, phytane), the alkyl cyclohexanes and the steranes do not appear to have been affected. In severe cases of biodegradation, demethylated hopanes are often found on the 177 ion. These compounds are not present in the Dolphin crude. However, the removal of the low molecular weight n-alkanes has rendered maturity and source parameters based on the C₄-C₇ fraction of the oil useless.

GC/MS analysis of this oil showed that the 18 α (H) hopane (Ts), the 17 (H) hopane (Tm) and the C₃₀ moretane compounds are absent. This may be due to some peculiar feature of the organic source material.

C₁₅ alkyl cyclohexane is present in large quantities (Table 29) and indicates that organic matter may have been deposited in a peat swamp environment. However, the migration effect mentioned in the discussion of the Bream oil has probably contributed to the high C₁₅ alkyl cyclohexane/C₃₀ hopane ratio.

As in other oils in this study the Dolphin 1 crude has been sourced from terrestrial organic matter - C₂₉ steranes and diasteranes were identified on the 218 and 259 ions as were the phyllocladane, kaurane, beyerane and isopimerane biomarkers on their respective ions.

In summary the crude oil analysed from the Dolphin 1 well is thought to be a mildly biodegraded mature napthenic oil. It has been sourced from terrestrial organic matter.

Halibut A-1

As in the Bream 2 oil the crude oil analysed from Halibut A-1 has lost its low molecular weight volatile compounds. It is possible that this has been due in part to water-washing but it is thought more likely that poor sample storage is responsible.

Ts/Tm and C₂₉ 20S/C₂₉ 20R sterane maturity parameters from GC/MS analysis (Table 31), suggest this oil is mature. However this is not confirmed by the ratio of C₃₀ hopane to C₃₀ moretane.

Fragmentograms of the 191 ion tend to show high levels of baseline noise, in comparison to the height of the C₃₀ moretane peak. Consequently, it is quite probably that some of this noise has been integrated into the C₃₀ moretane peak, giving an anomalously low C₃₀ hopane/C₃₀ moretane ratio. This is probably true for most oils in this study. Consequently this maturity parameter is to be regarded with suspicion.

The Halibut oil shows a strong similarity to the Tuna A-2 crude, (although the C₂₇ steranes and diasteranes are totally absent from the Tuna oil). A predominance of C₂₉ steranes and diasteranes and the occurrence of land plant biomarkers (phyllocladanes, kauranes, beyerane and C₁₉, C₂₀ isopimeranes) indicates the Halibut crude was sourced from terrestrial organic matter. C₁₅ alkyl cyclohexanes are relatively abundant in this oil, although not in as great a concentration as in other oils in this study.

Marlin A-24

Although the Marlin oil has lost its low molecular weight volatile hydrocarbons through poor sample storage, the whole oil chromatogram from this sample (Figure 19-1), shows a greater predominance of high molecular weight compounds and is probably slightly 'waxier' than the other oils in this study.

A high C_{30} hopane/ C_{30} moretane ratio and a C_{29} 20S/ C_{29} 20R sterane ratio that is approaching equilibration suggests this oil is mature. (The value of the Ts/Tm maturity parameter has probably been depressed by a peat swamp depositional environment).

C_{29} steranes and diasteranes predominate over the C_{27} steranes and diasteranes and the land plant biomarkers found in the other oils (phyllocladanes, kauranes, beyeranes and isopimeranes) are also present in the Marlin A-24 crude.

In summary, the Marlin oil can be characterised as a mature, waxy crude sourced from terrestrial organic matter probably deposited in a peat swamp environment. It is uncertain whether the oil has undergone any water washing, but there is no evidence to suggest this oil has been biodegraded.

Tuna A-2

As in the Bream, Halibut and Marlin oils, the Tuna A-2 crude has lost its low molecular weight volatile hydrocarbons. Again, this is thought to be due to the effects of poor sample storage rather than water-washing. Although comparison of the oils is made difficult by the loss of their 'light ends', the Tuna oil seems to be very similar to the oil recovered from Halibut A-1.

GC/MS maturity parameters (Table 35) suggest this oil is probably mature. However, as in other oils in this study, these parameters tend to be erratic and may not be an accurate reflection of the crudes true maturity.

C₂₉ steranes and diasteranes predominate over C₂₇ steranes and diasteranes, indicating a terrestrial source for this oil. Phyllocladanes, beyerane, kauranes (from Mesozoic conifer resins), C₁₉, C₂₀ isopimeranes and the unnamed 'C_x' land plant biomarkers were identified on fragmentograms of their respective ions.

As in all oils analysed, a high level of C₁₅ alkyl cyclohexane with respect to C₃₀ hopane was recorded. This may indicate that acidophyllic bacteria have been active in a peat swamp depositional environment. Alternatively, the high levels of C₁₅ alkyl cyclohexane could be a migration effect. (C₁₅ alkyl cyclohexane would migrate with greater ease than the C₃₀ hopane, giving rise to high levels of the former compound in a reservoired crude).

In summary, Tuna A-2 oil is a mature waxy crude, similar to the Halibut oil, sourced from terrestrial organic matter.

West Seahorse 1

The oil recovered from 1417m in West Seahorse 1 is thought to be a mildly biodegraded crude, very similar to the Dolphin 1 oil.

Bacteria have selectively removed the low molecular weight n-alkanes, leaving the high molecular weight 'waxy' n-alkanes relatively unaffected. As in the Dolphin oil, the isoprenoids, alkyl cyclohexanes and steranes appear to have been unaffected by the biodegradation.

Because of the removal of the low molecular weight n-alkanes the maturity and source parameters based on the C₄-C₇ fraction (Table 36), should be treated with suspicion.

The C₂₉ 20S/C₂₉ 20R sterane ratio (Table 37), indicates this oil is mature. As in other crudes in this study the Ts/Tm and C₃₀ hopane/C₃₀ moretane maturity parameters are considered to be unreliable.

The West Seahorse 1 oil has been sourced from terrestrial organic matter. C₂₉ steranes and diasteranes predominate, (C₂₇ steranes and diasteranes are completely absent), and the land plant biomarkers found in the other oils (phyllocladanes, kauranes, beyerane, isopimeranes) are also present in the West Seahorse crude.

High levels of C₁₅ alkyl cyclohexanes may be a source feature in part but are likely to have been strongly influenced by migration effects.

In summary, the West Seahorse 1 oil is a mature, mildly biodegraded, terrestrially sourced crude. It is very similar to the Dolphin 1 oil but may have undergone slightly less biodegradation, (greater concentrations of high molecular weight n-alkanes are present in the West Seahorse 1 oil).

C. CRUDE OIL CORRELATION

Analysis of the diterpane biomarkers by R. Alexander, (see attached report) showed that all crudes in this study contain a complex mixture of diterpanes with a major 16 α (H)-phylocladane component. Fragmentograms of the 123 ion for each oil are very similar. Only the West Seahorse 1 crude appears slightly different, in that the phylocladane component is significantly reduced in this sample.

Establishing definite relationships between the oils on the basis of GC/MS and glc data is made difficult by the following:

- (i) low molecular weight, volatile components of the oils are missing due to poor sample storage.
- (ii) The Ts/Tm maturity parameter is unreliable in coaly peat swamp depositional environments.
- (iii) The C₃₀ hopane/C₃₀ moretane maturity parameter is also of little value, as the 'baseline noise' on fragmentograms of the 191 ion has probably given rise to spurious C₃₀ moretane values.
- (iv) Two of the oils have been mildly biodegraded (West Seahorse 1, Dolphin 1).

However, on the basis of C₂₉ 20S/C₂₉ 20R sterane maturity parameter values, the Bream 2 and Dolphin 1 oils both seem to be of slightly lower thermal maturity than the other four oils in this study.

In addition the Halibut and Tuna oils seem to be very similar. Ts/Tm, C₂₉ 20S/C₂₉ 20R sterane and C₁₅ alkyl cyclohexane/C₃₀ hopane ratios correlate well in these samples.

However further analytical work to establish the precise thermal maturity of these oils is probably necessary before more accurate oil-oil correlations can be made. Aromatic gas/liquid chromatography may be useful to that end.

D. OIL-SOURCE ROCK CORRELATION

There seems little doubt that the coal rich Latrobe source rocks have sourced the six oils analysed in this study. Generally, the Latrobe sediments are organic rich and have attained sufficient thermal maturity to have sourced appreciable quantities of both oil and gas.

The diterpane land plant biomarkers are found, in varying degrees in all oils and source rocks. As noted by R. Alexander, however, the distributions of diterpanes are more varied in the sediments than in the crude oils. Source rocks in which the distribution of diterpanes best match that of the crude oils are in Tarwhine 1, Veilfin 1 and Hermes 1 (see attached report).

Chromatograms from extracted source rocks exhibit a marked terrestrial character with a predominance of high molecular weight n-alkanes. The 'waxy' crudes analysed in this study possess a similar character. (It is probable that the West Seahorse 1 and Dolphin 1 oils were also 'waxy' crudes before being biodegraded).

GC/MS analysis shows that all oils contain extremely high levels of C₁₅ alkyl cyclohexane with respect to C₃₀ hopane. However the source rocks contain only low to moderate levels of this compound. This difference between the oils and the source rocks is not thought to be significant. It is probable that C₁₅ alkyl cyclohexane has been concentrated in the reservoir hydrocarbons due to its relative ease of migration compared to the high molecular weight C₃₀ hopane.

FIGURE 1
BREAM 2, 10340'-10430'
Saturate Fraction
C₁₂⁺ GLC

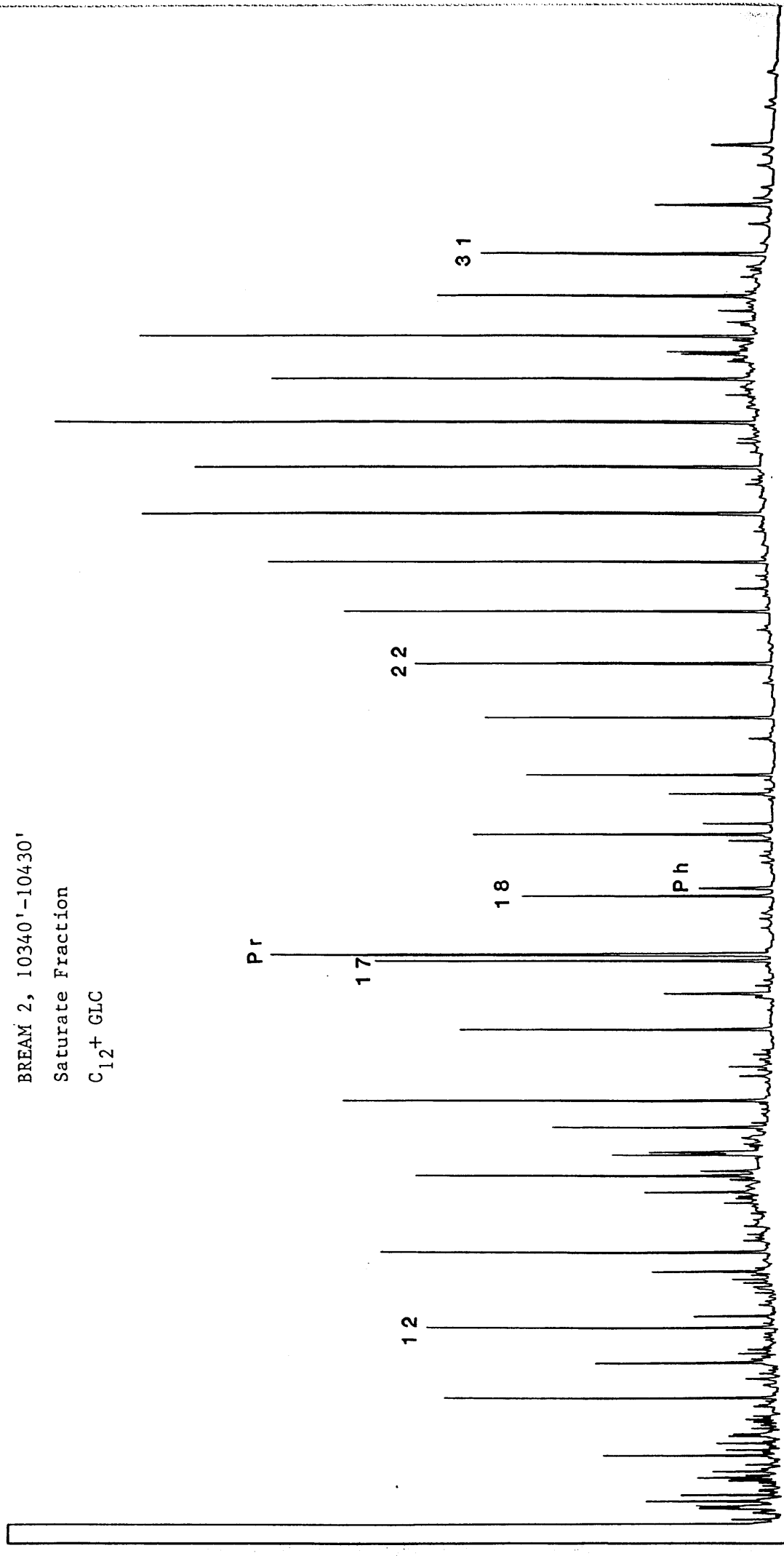
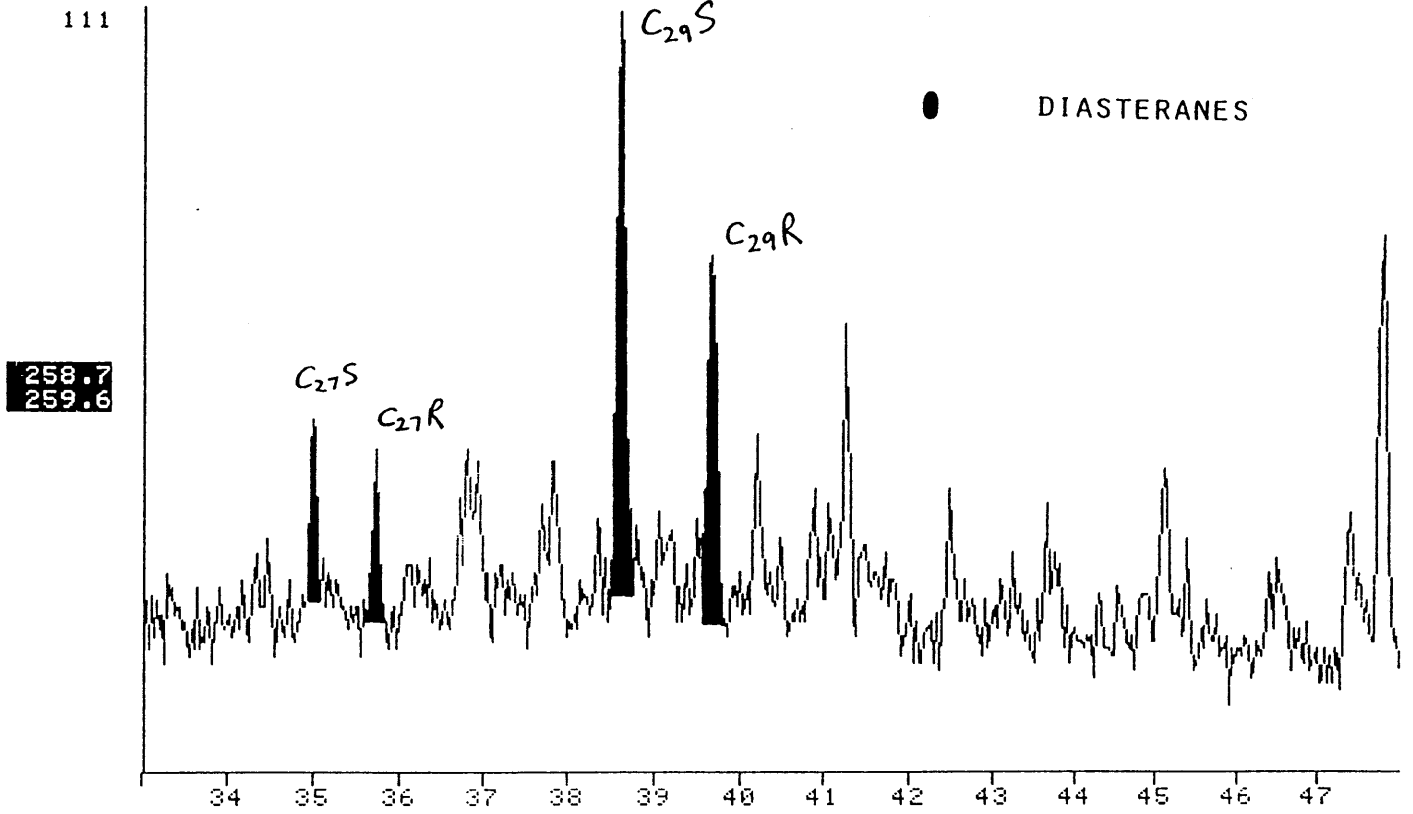


FIGURE 2-1

NAME BREAM 10340-10430. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/90ul. COL#56. P.CONN

FRN 6004



NAME BREAM 10340-10430. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/90ul. COL#56. P.CONN

FRN 6004

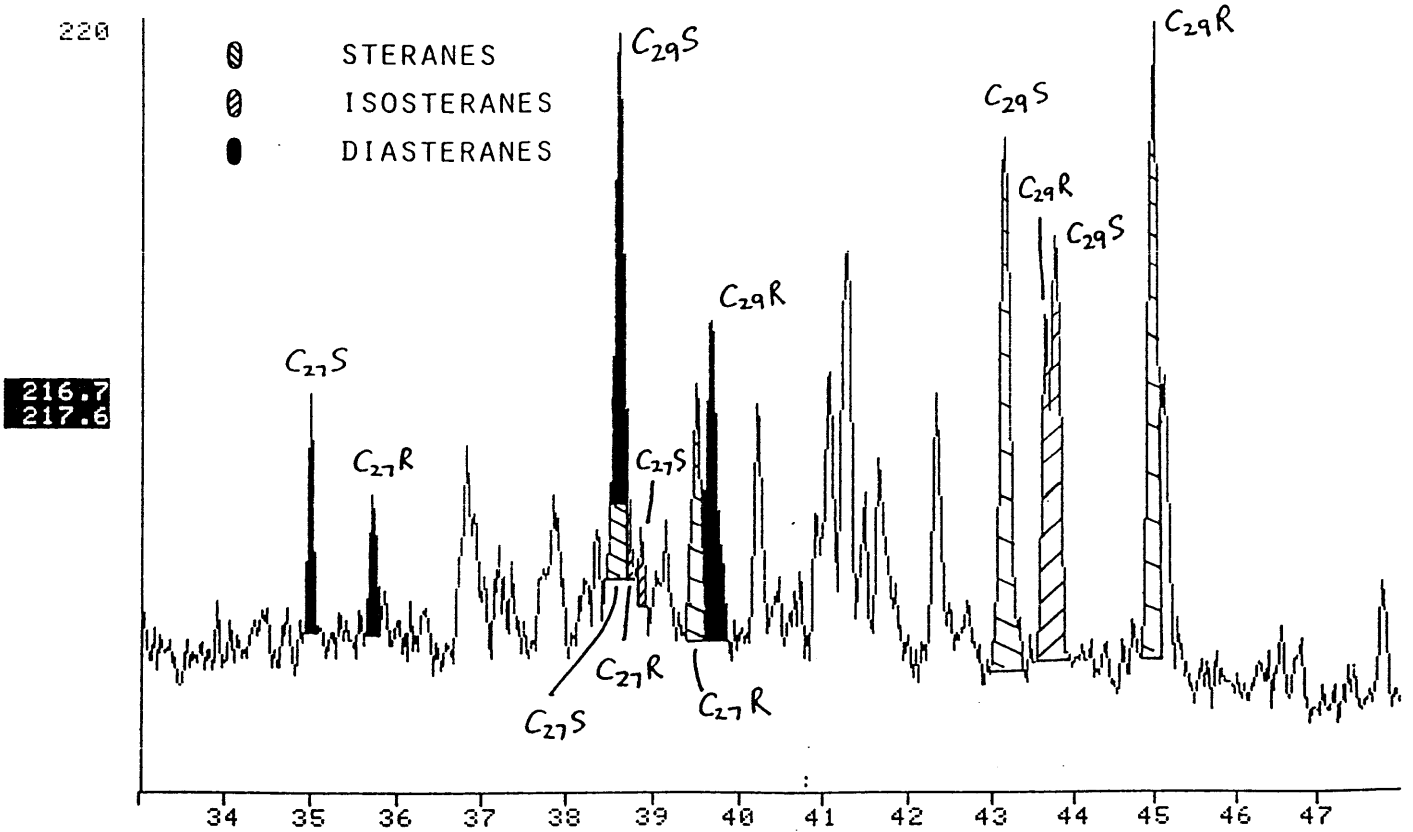
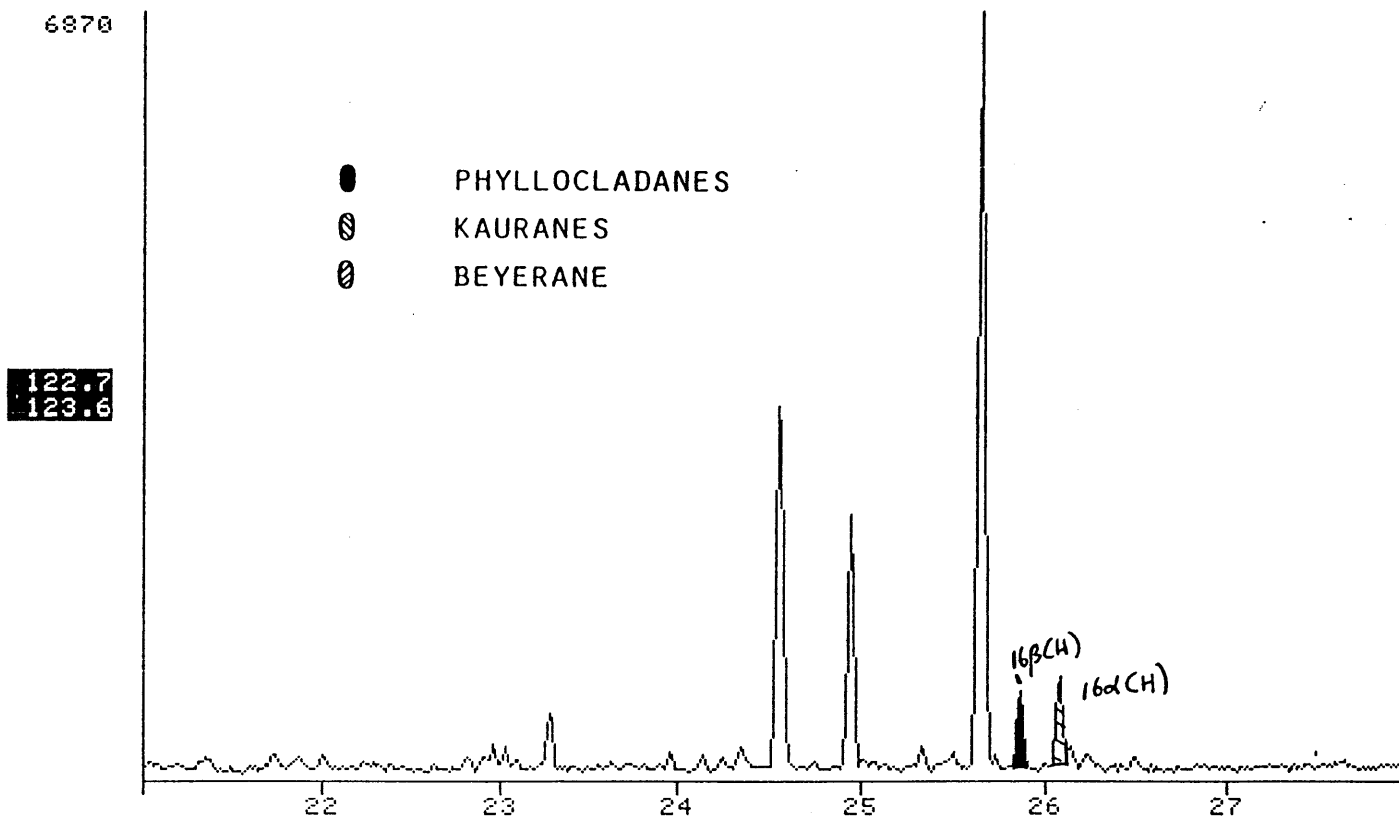


FIGURE 2-2

NAME BREAM 10340-10430. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/90ul. COL#56. P.CONN

FRN 6004



NAME BREAM 10340-10430. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/90ul. COL#56. P.CONN

FRN 6004

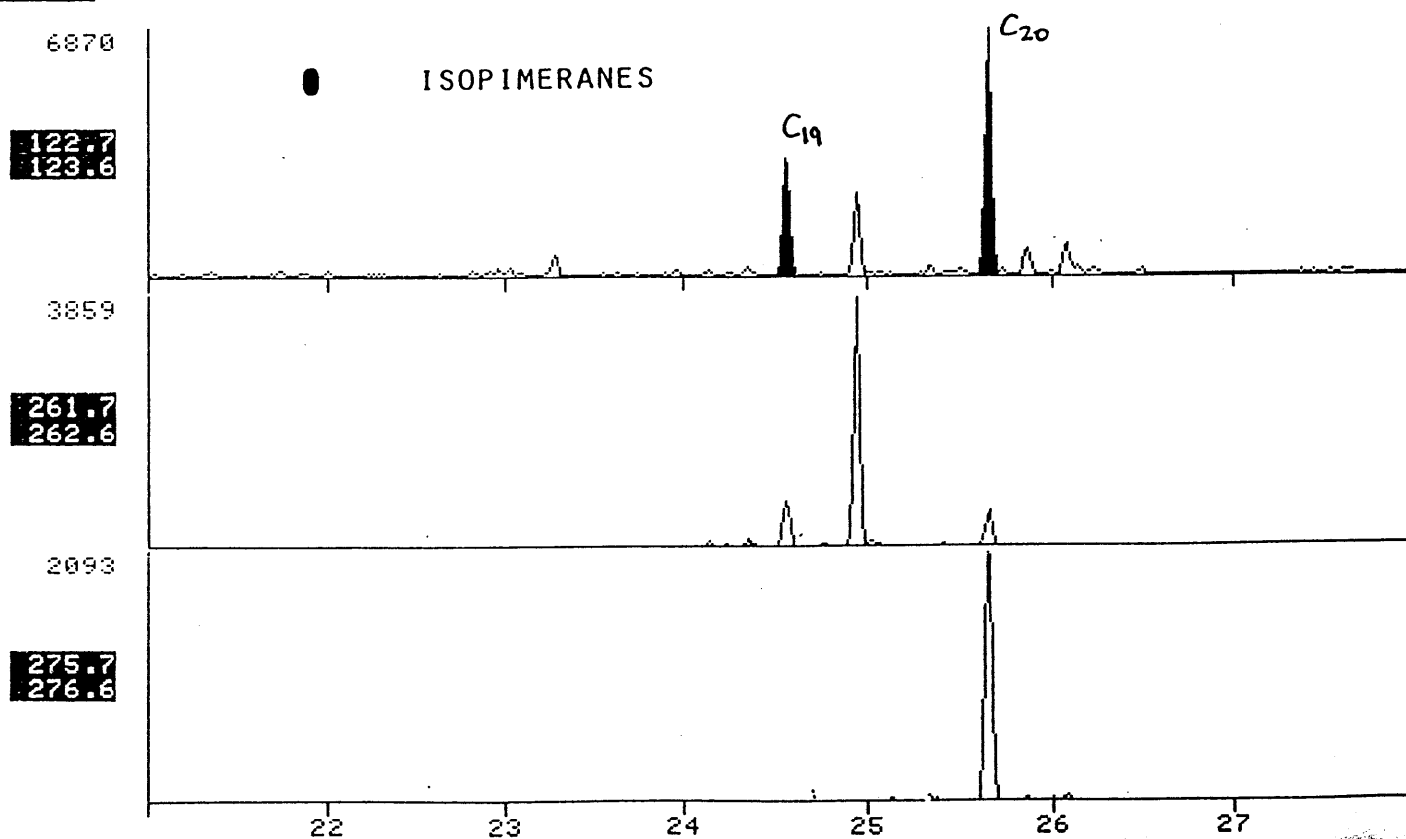


FIGURE 2-3

NAME BREAM 10340-10430. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/90ul. COL#56. P.CONN

FRN 6004

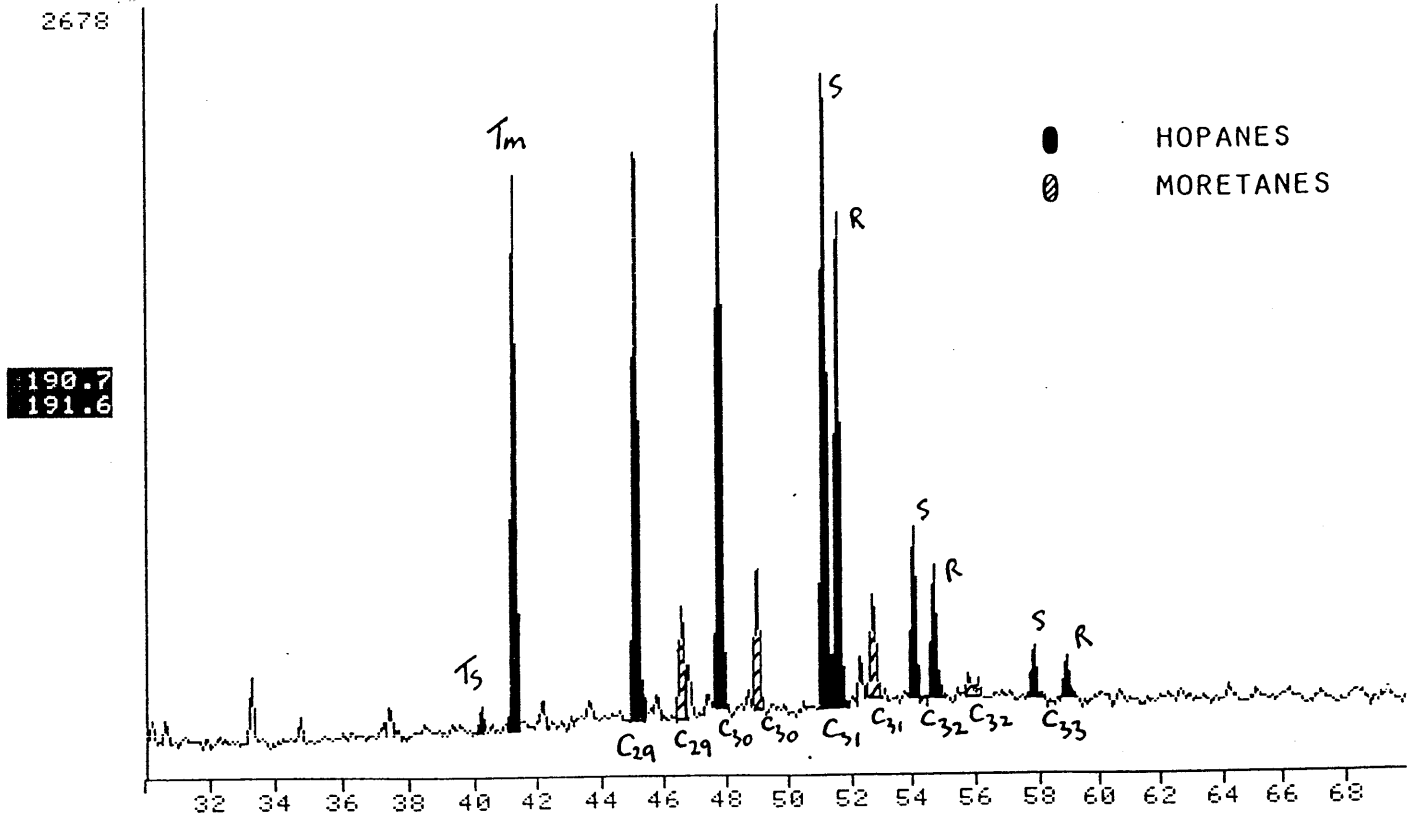


FIGURE 3
HERMES 1, 4270-4300ft
Saturate Fraction
C₁₂+ GLC

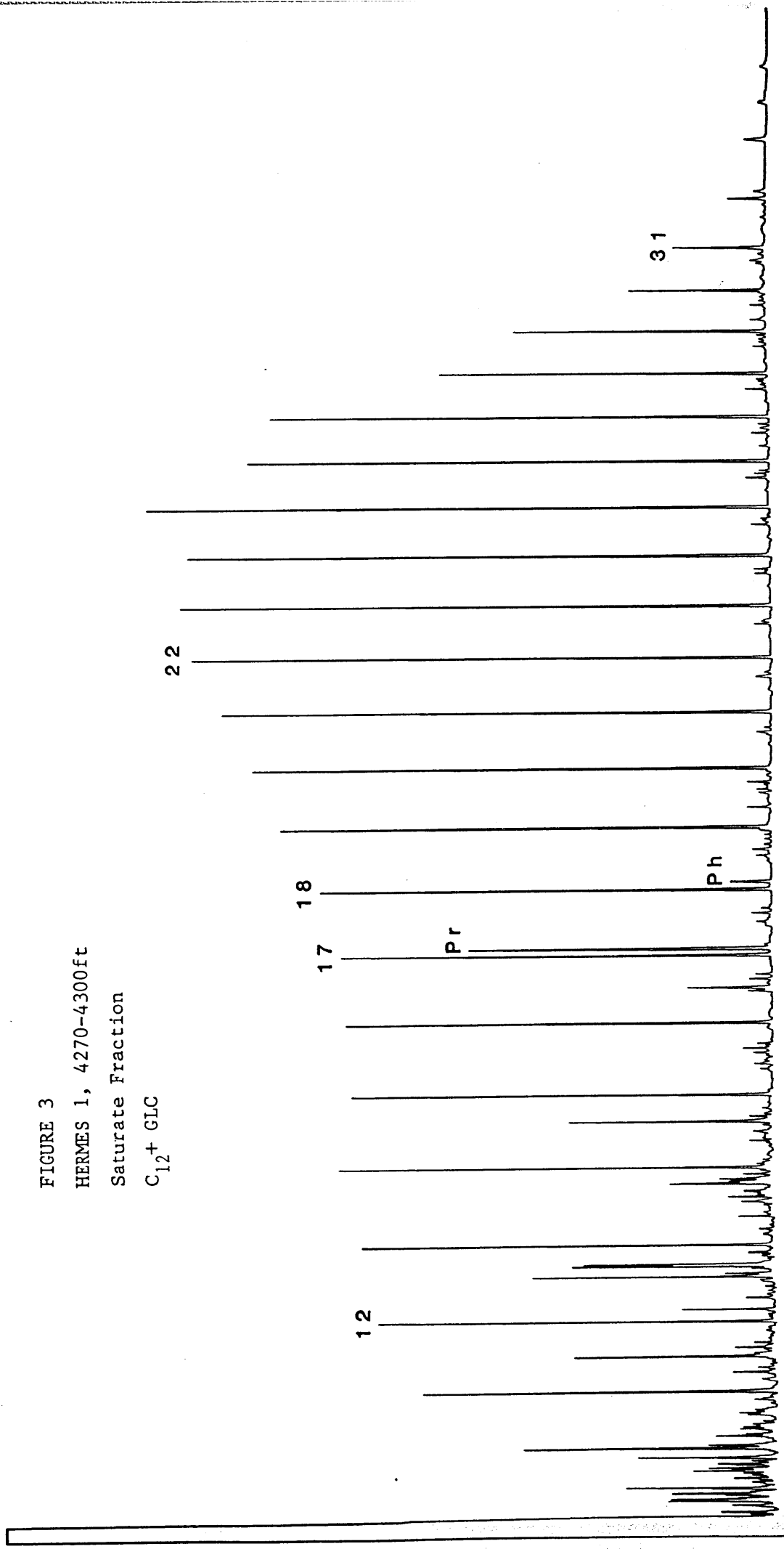
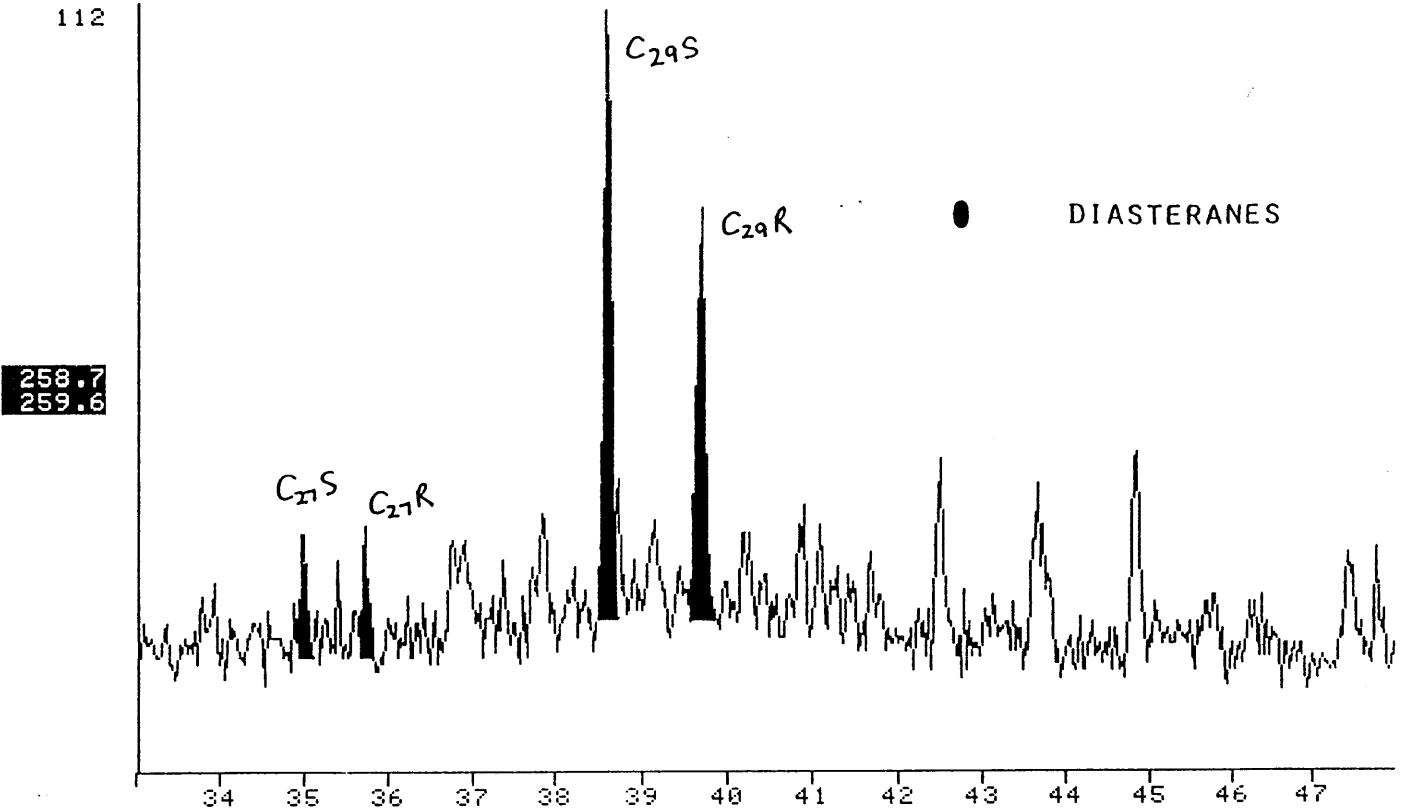


FIGURE 4-1

NAME HERMES, 4270-4300. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC. 0.2ul/250ul. COL#56. P.CON

FRN 5999



NAME HERMES, 4270-4300. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC. 0.2ul/250ul. COL#56. P.CON

FRN 5999

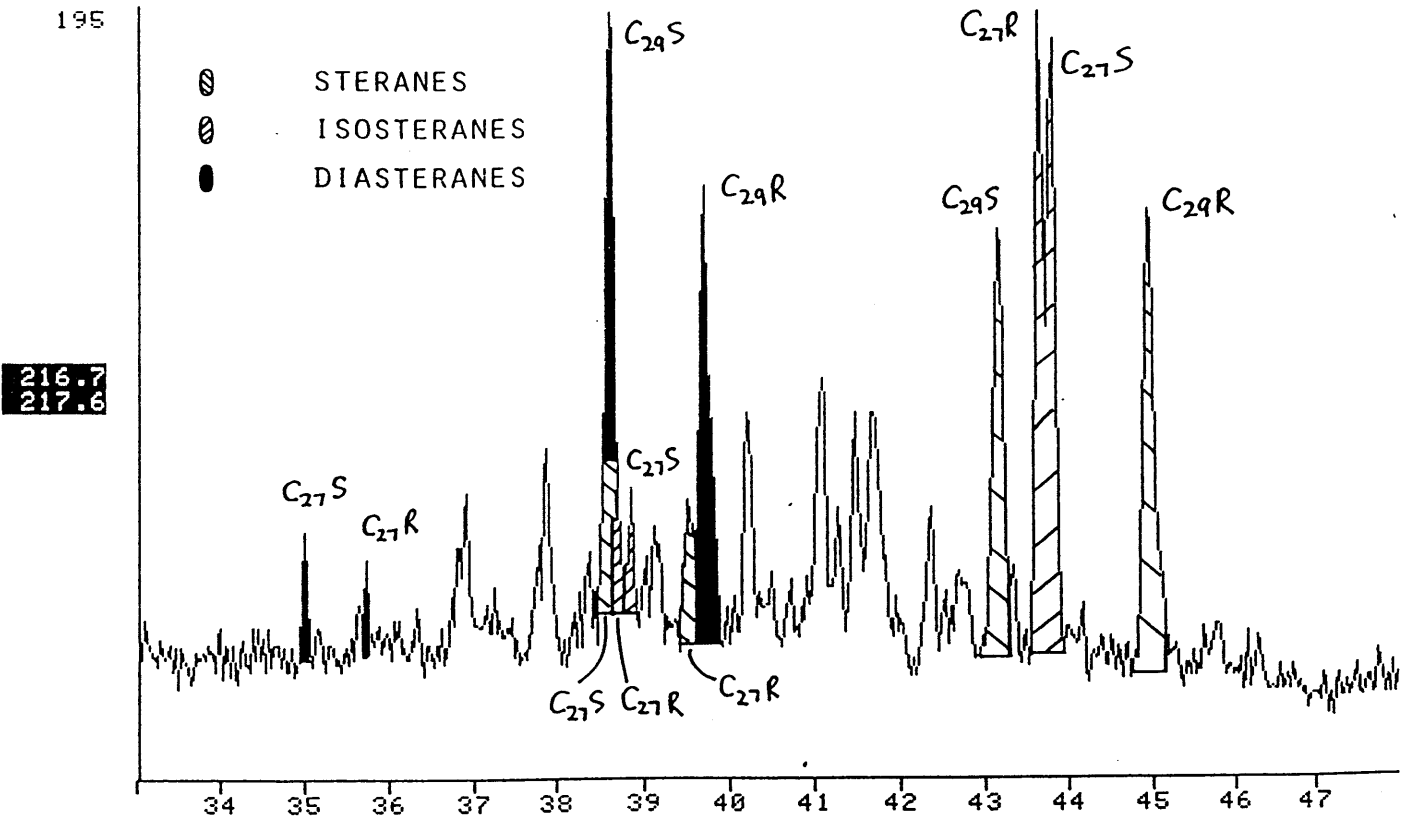
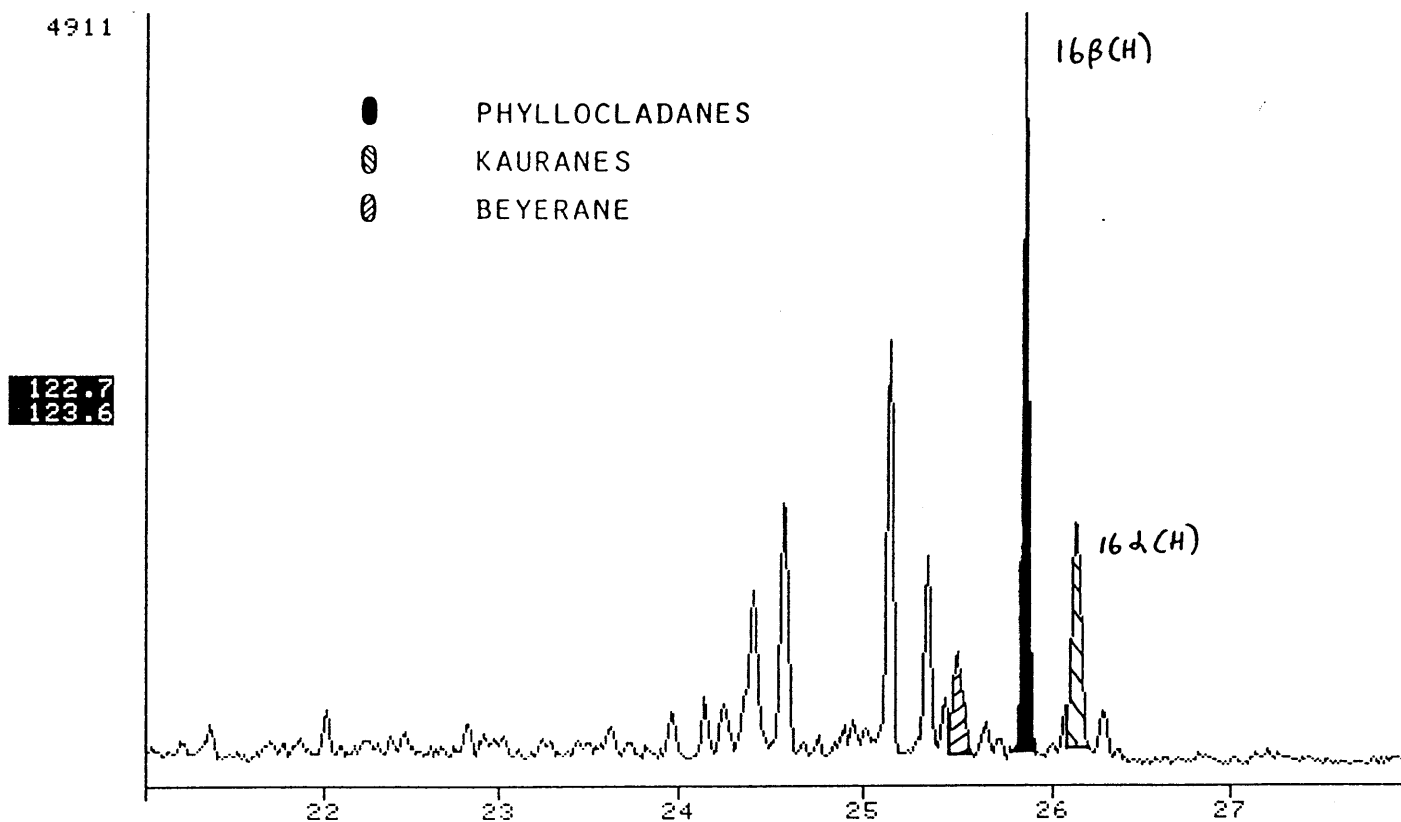


FIGURE 4-2

NAME HERMES, 4270-4300. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 27-5-86. GEC. 0.2ul/250ul. COL#56. P.COM

FRN 5999



NAME HERMES, 4270-4300. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 27-5-86. GEC. 0.2ul/250ul. COL#56. P.COM

FRN 5999

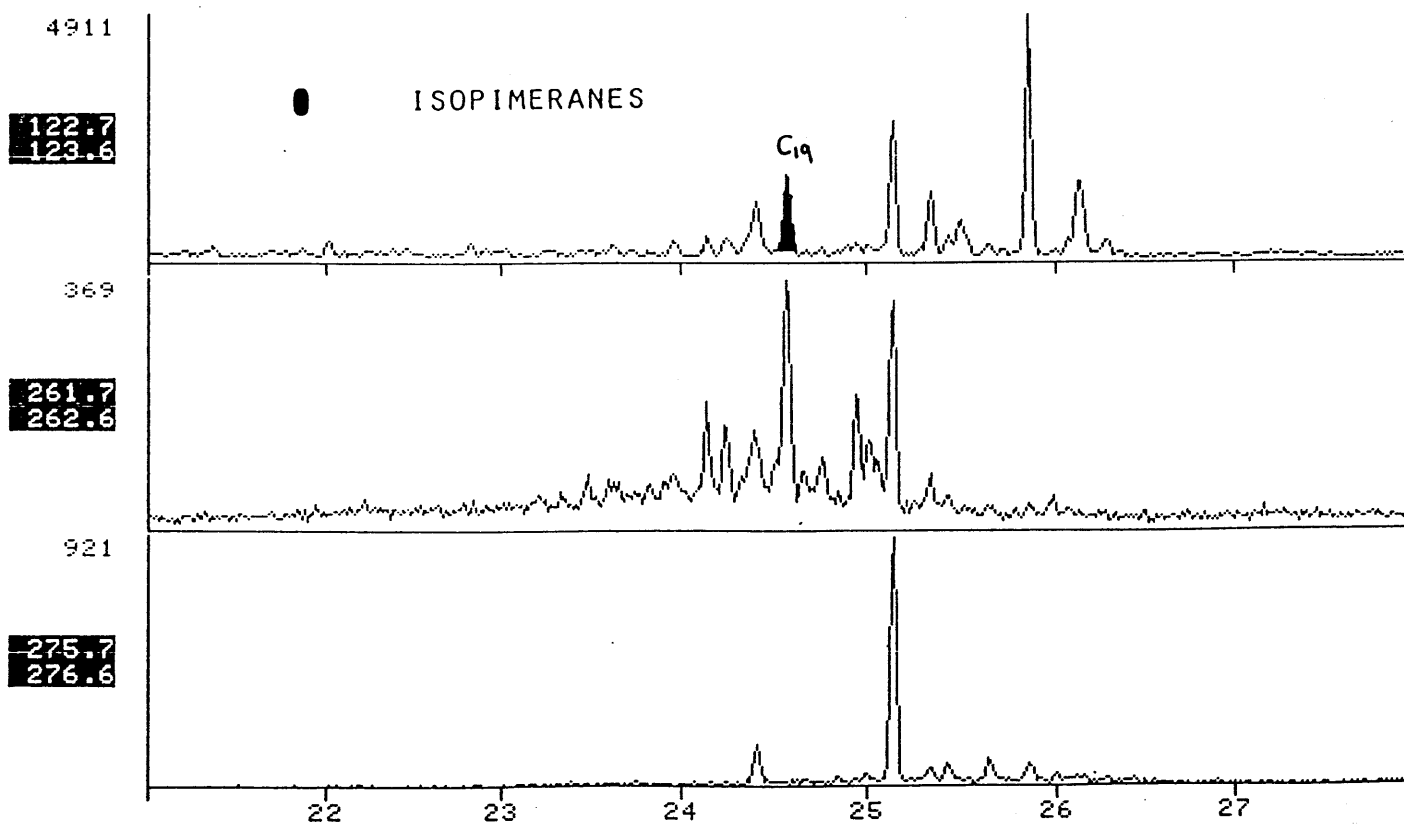


FIGURE 4-3

NAME HERMES, 4270-4300. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC. 0.2ul/250ul. COL#56. P.COM

FRN 5999

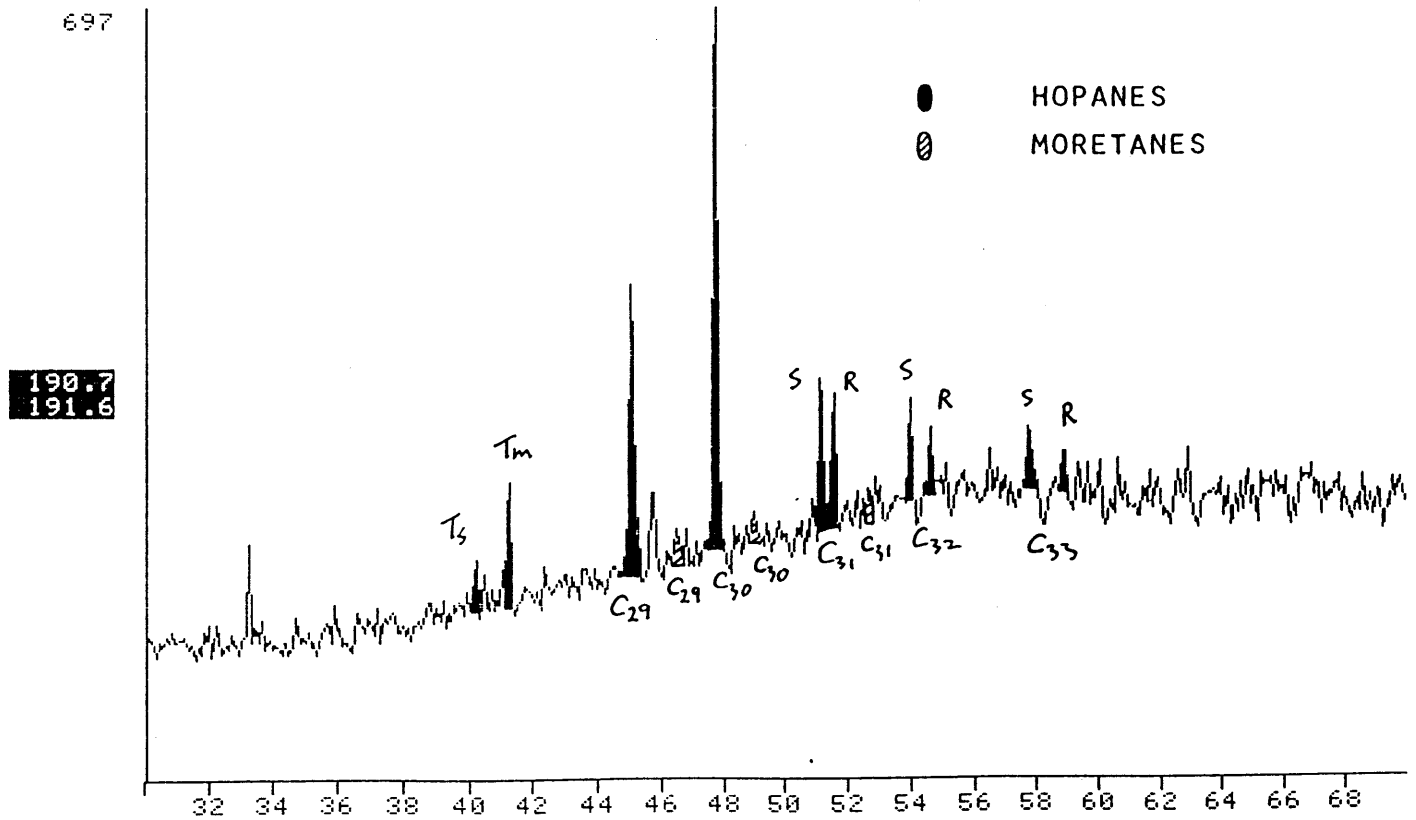


FIGURE 5
MARLIN A-6, 9620-9710ft
Saturate Fraction
C₁₂+ GLC

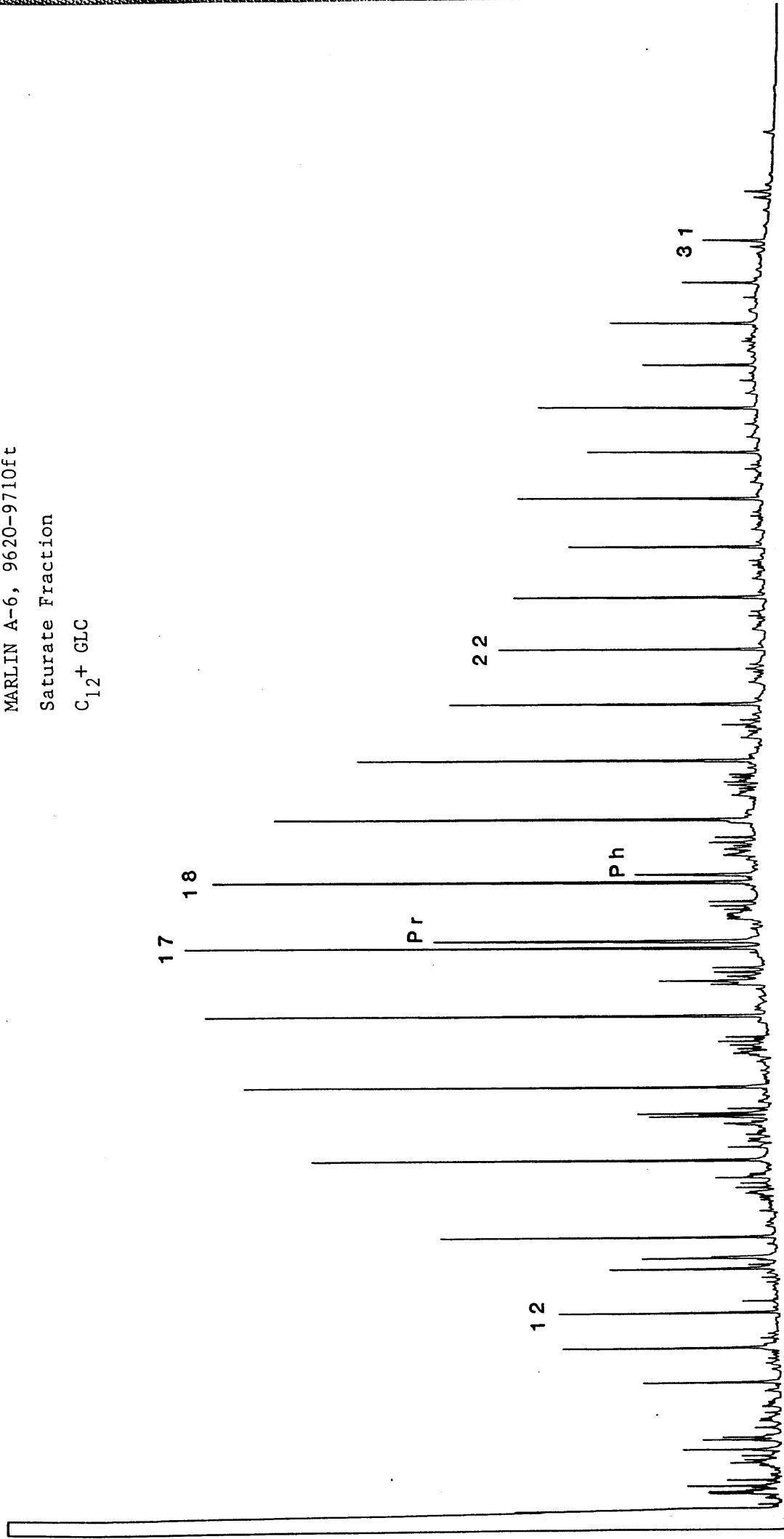
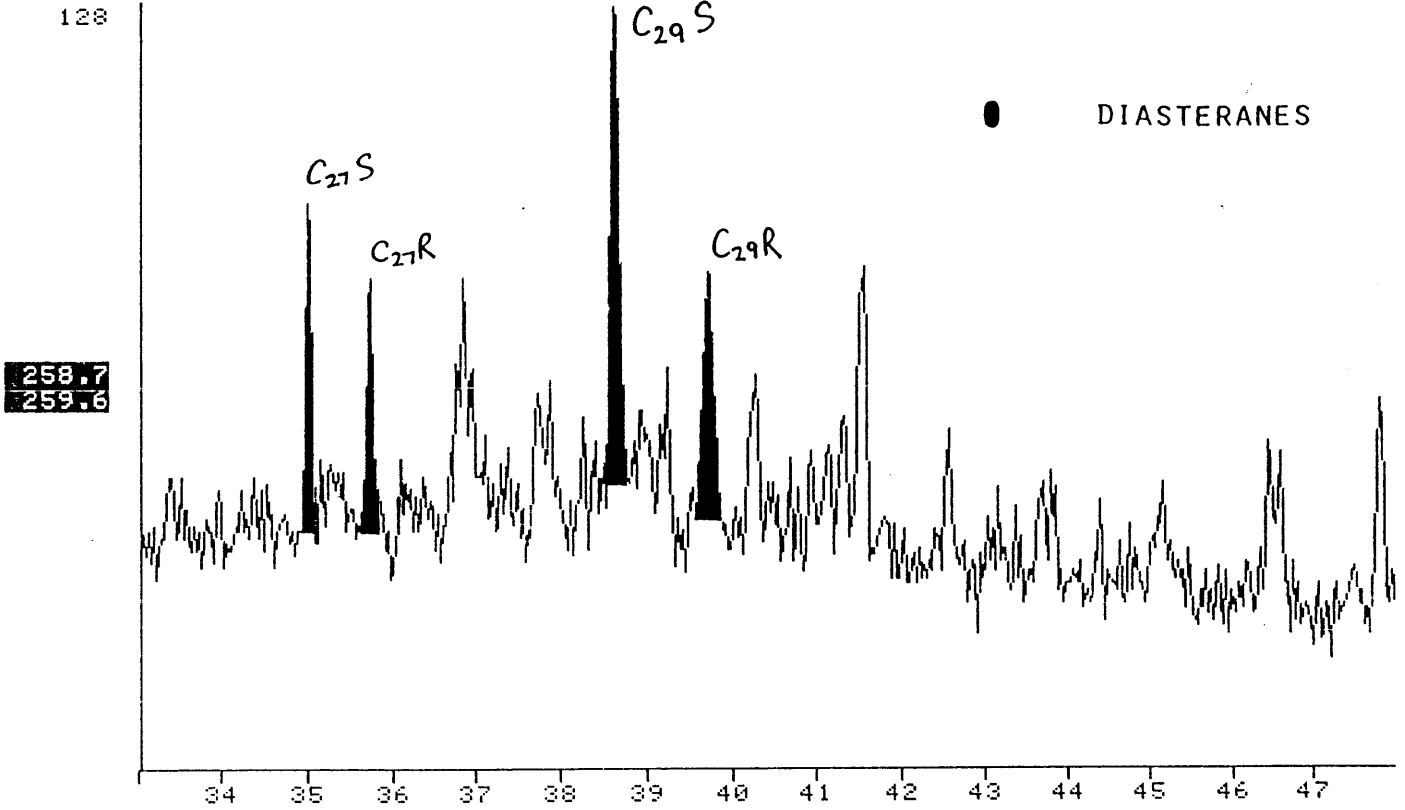


FIGURE 6-1

NAME MARTIN A-6, 9620-9710. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC.0.2ul/400ul. COL#56. P.CONN

FRN 5998



NAME MARTIN A-6, 9620-9710. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC.0.2ul/400ul. COL#56. P.CONN

FRN 5998

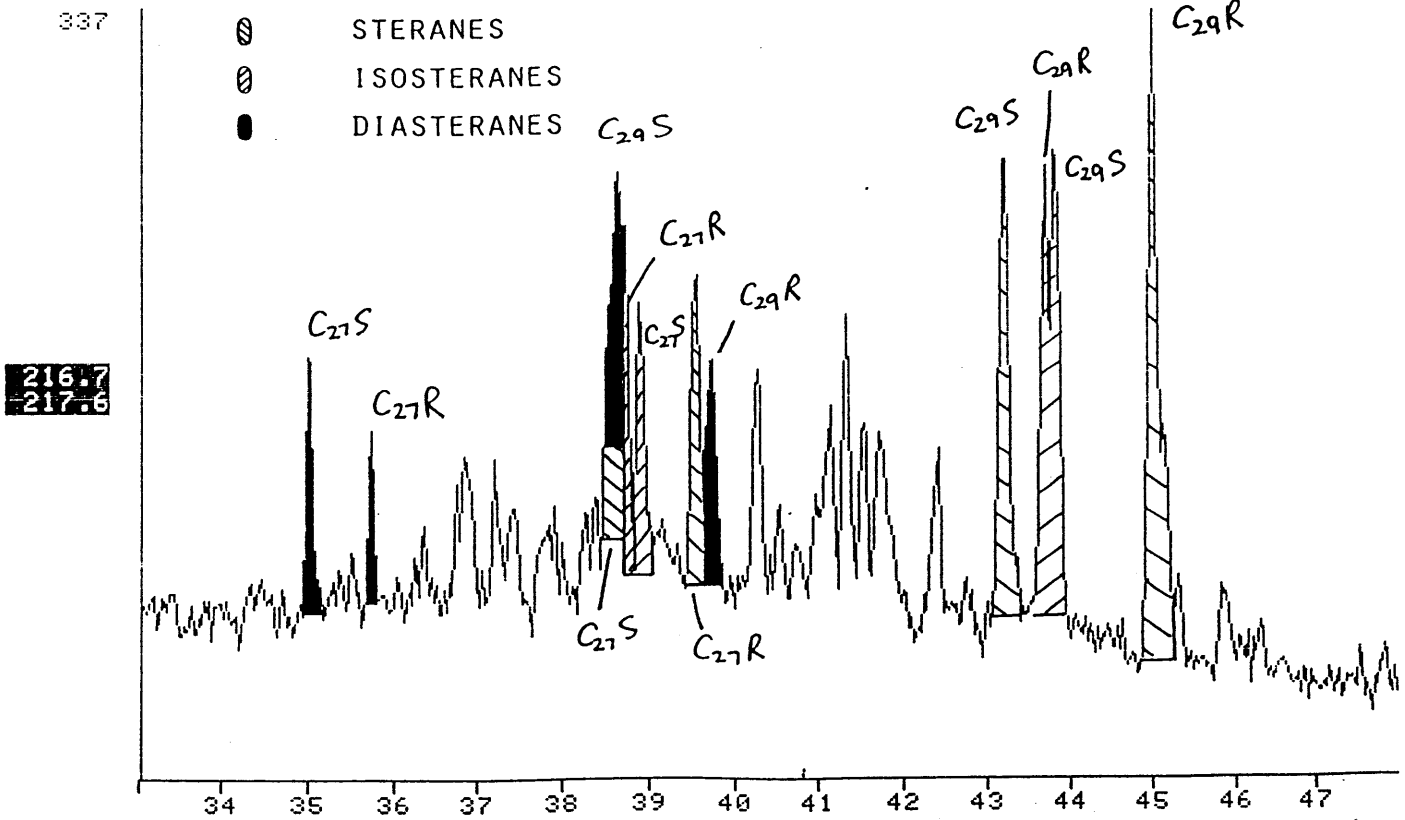
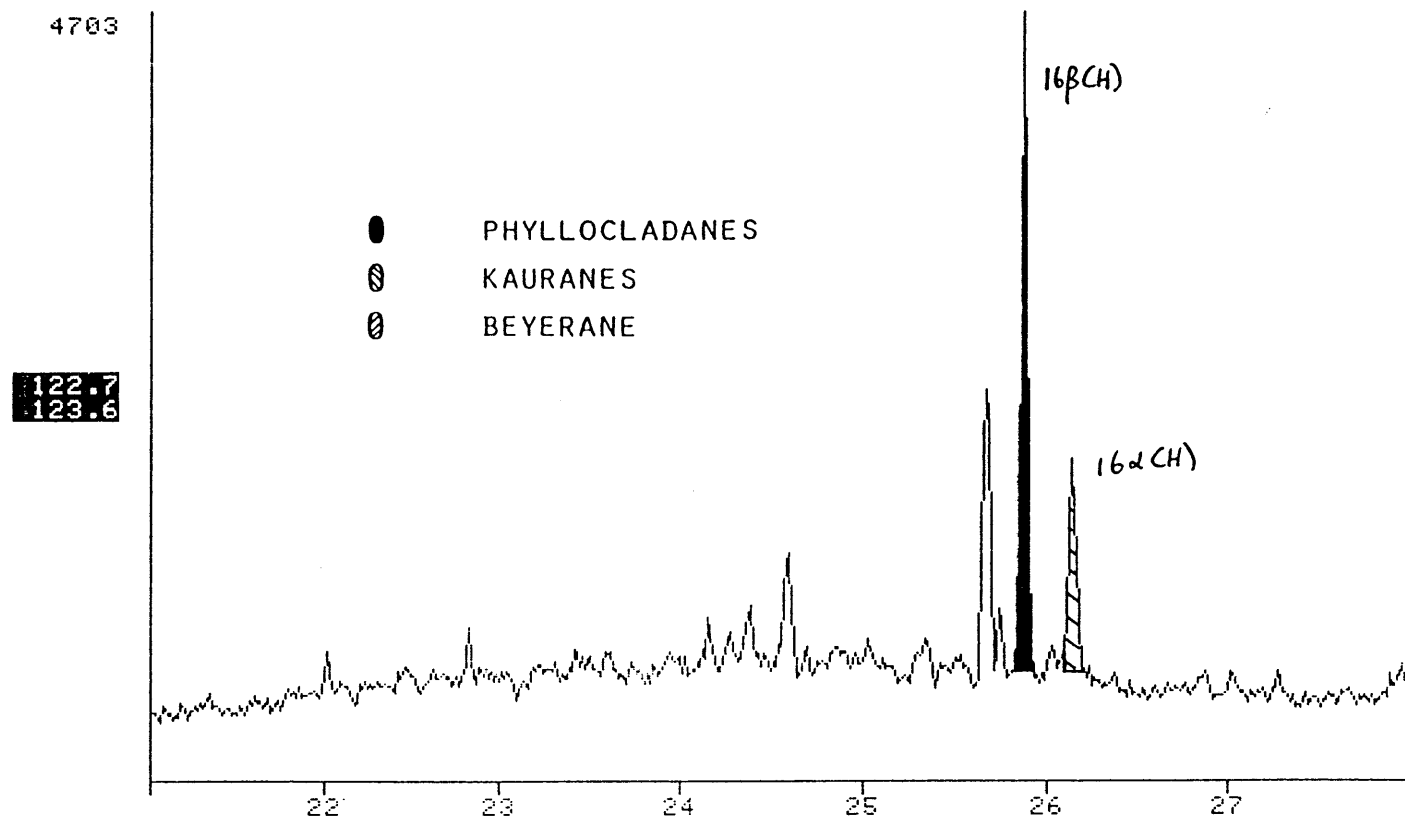


FIGURE 6-2

NAME MARTIN A-6, 9620-9710. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC.0.2ul/400ul. COL#56. P.CONN

FRN 5998



NAME MARTIN A-6, 9620-9710. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 27-5-86. GEC.0.2ul/400ul. COL#56. P.CONN

FRN 5998

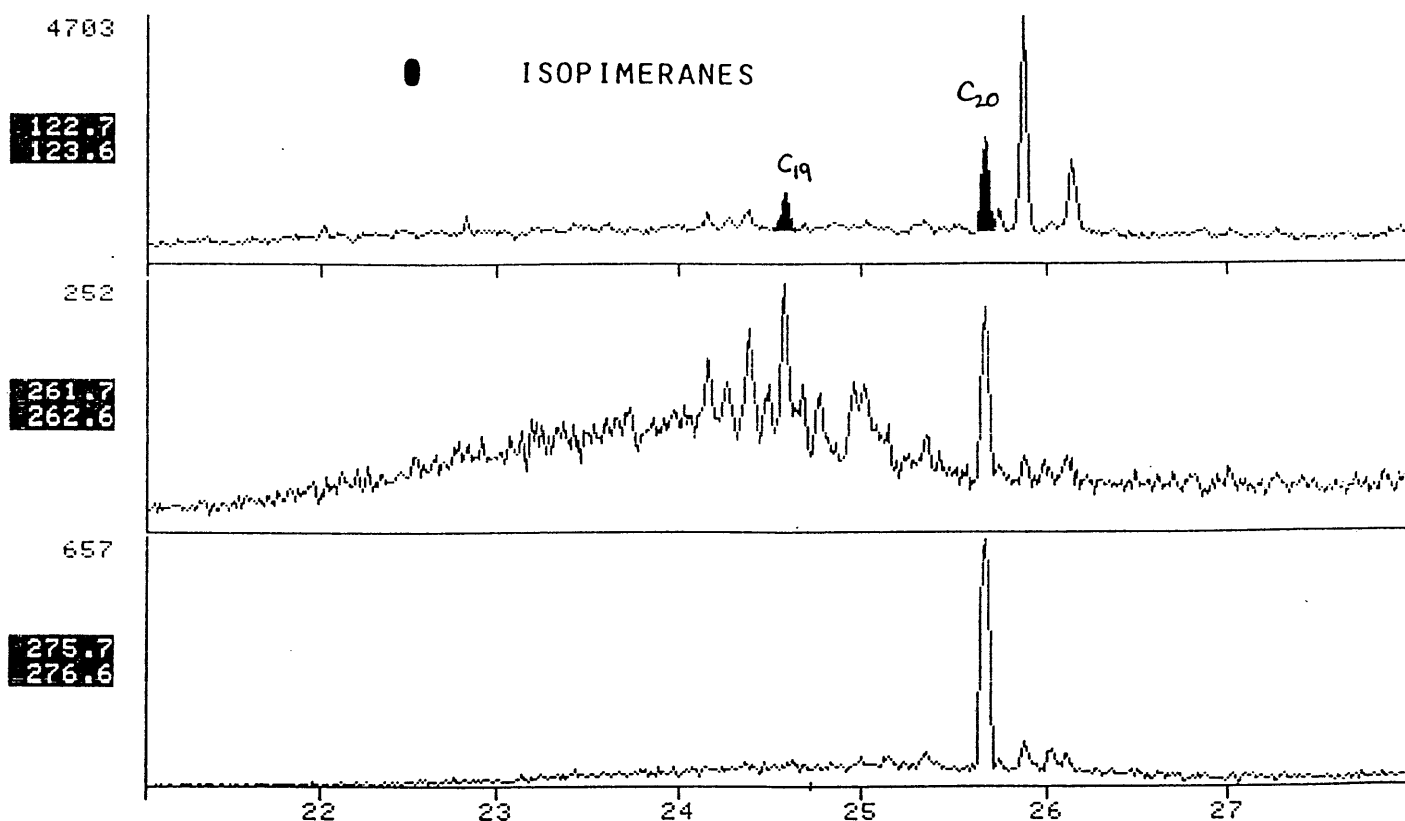


FIGURE 6-3

NAME MARTIN A-6, 9620-9710. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC: 27-5-86. GEC.0.2ul/400ul. COL#56. P.CONN

FRN 5998

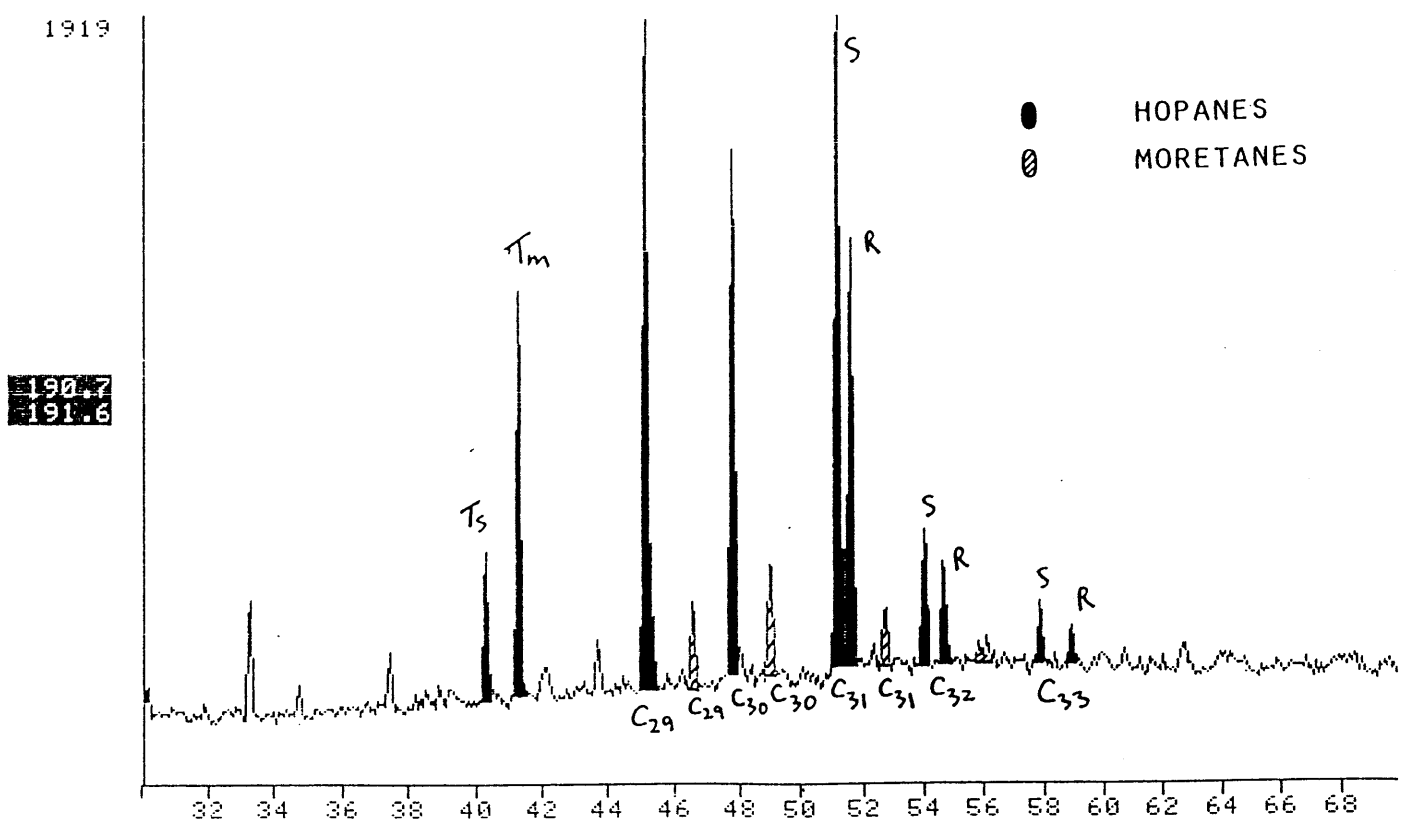


FIGURE 7
SNAPPER 1, 10170'-10260'
Saturate Fraction
C₁₂+ GLC

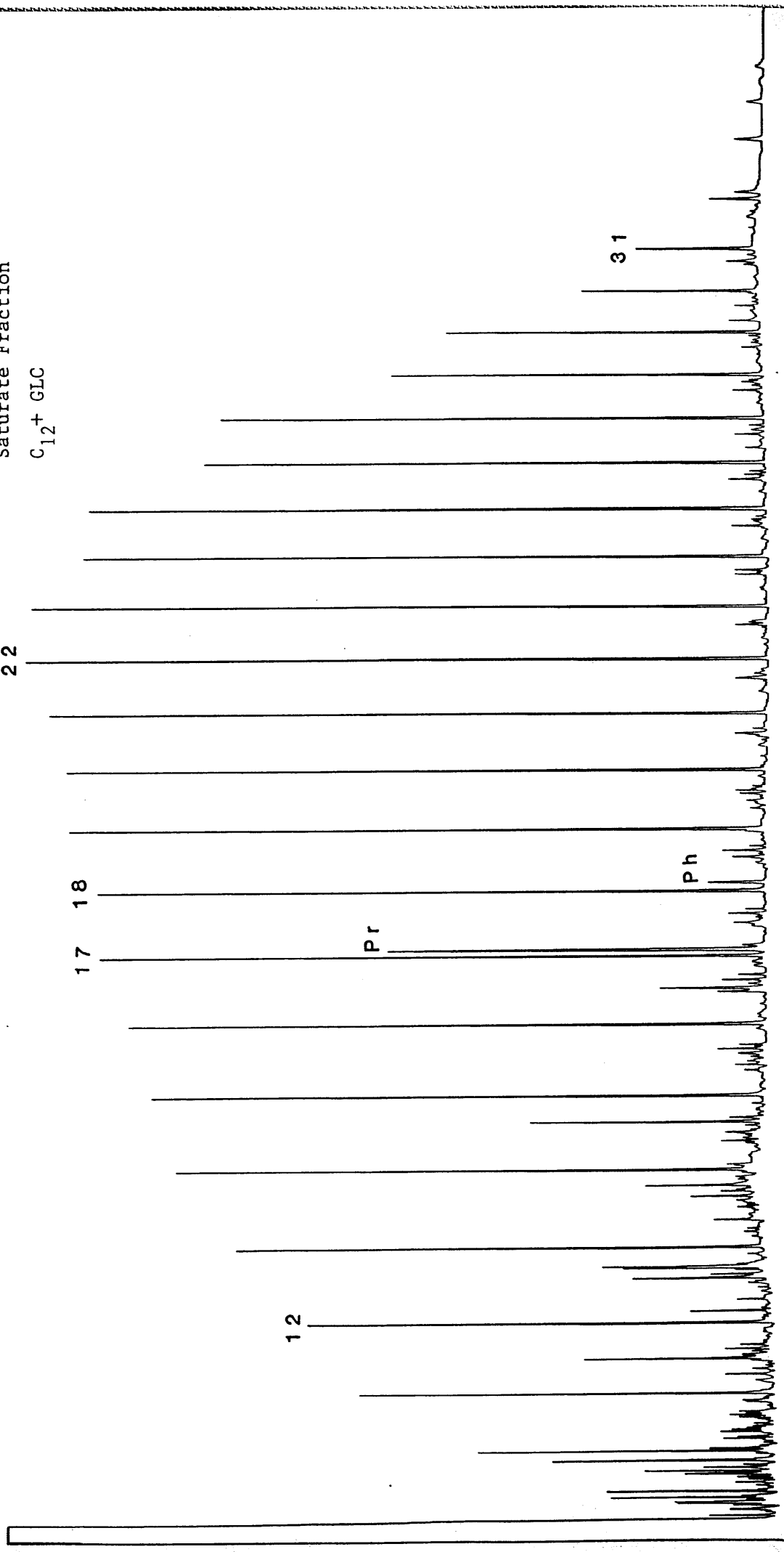
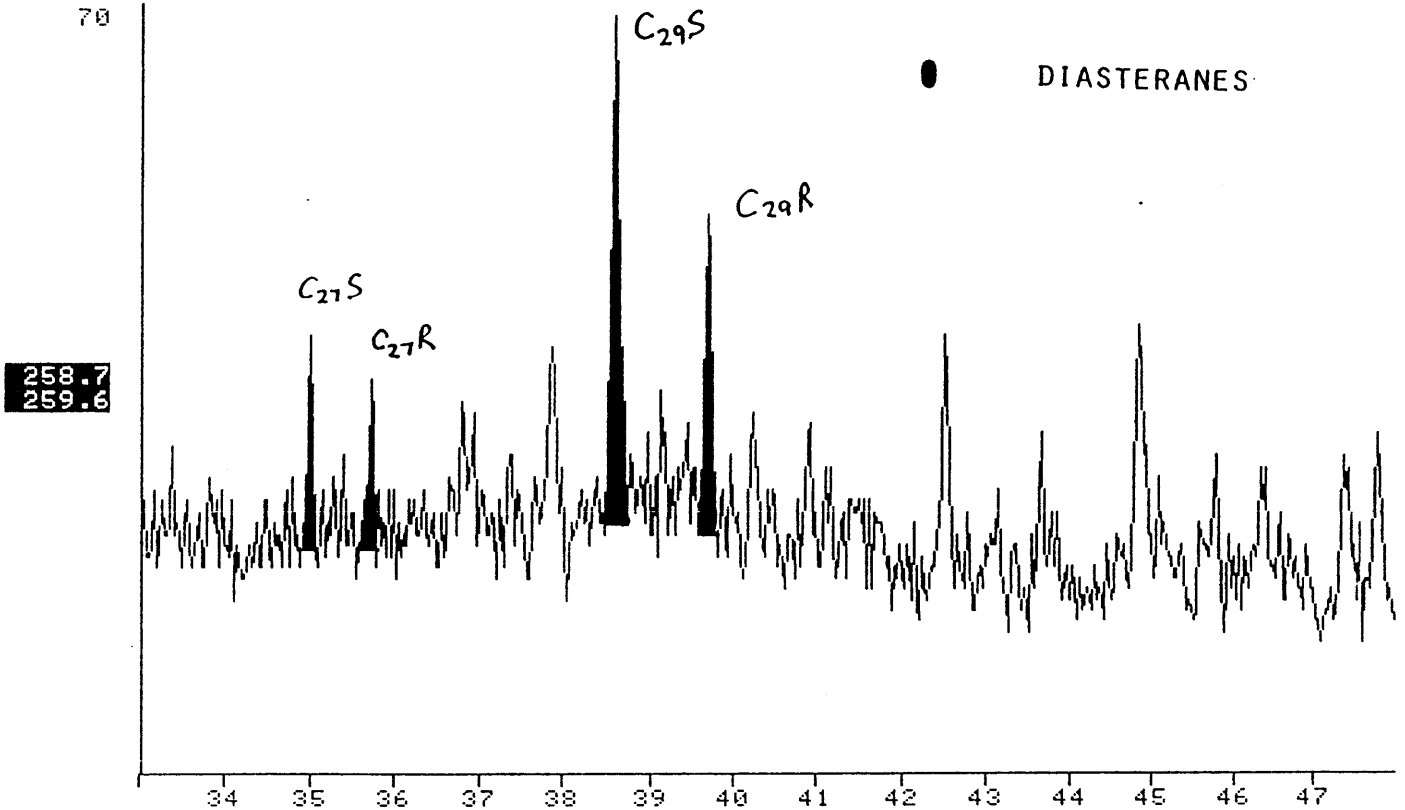


FIGURE 8-1

NAME SNAPPER 10170-10260. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/250ul. COL#56.

FRN 6005



NAME SNAPPER 10170-10260. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/250ul. COL#56.

FRN 6005

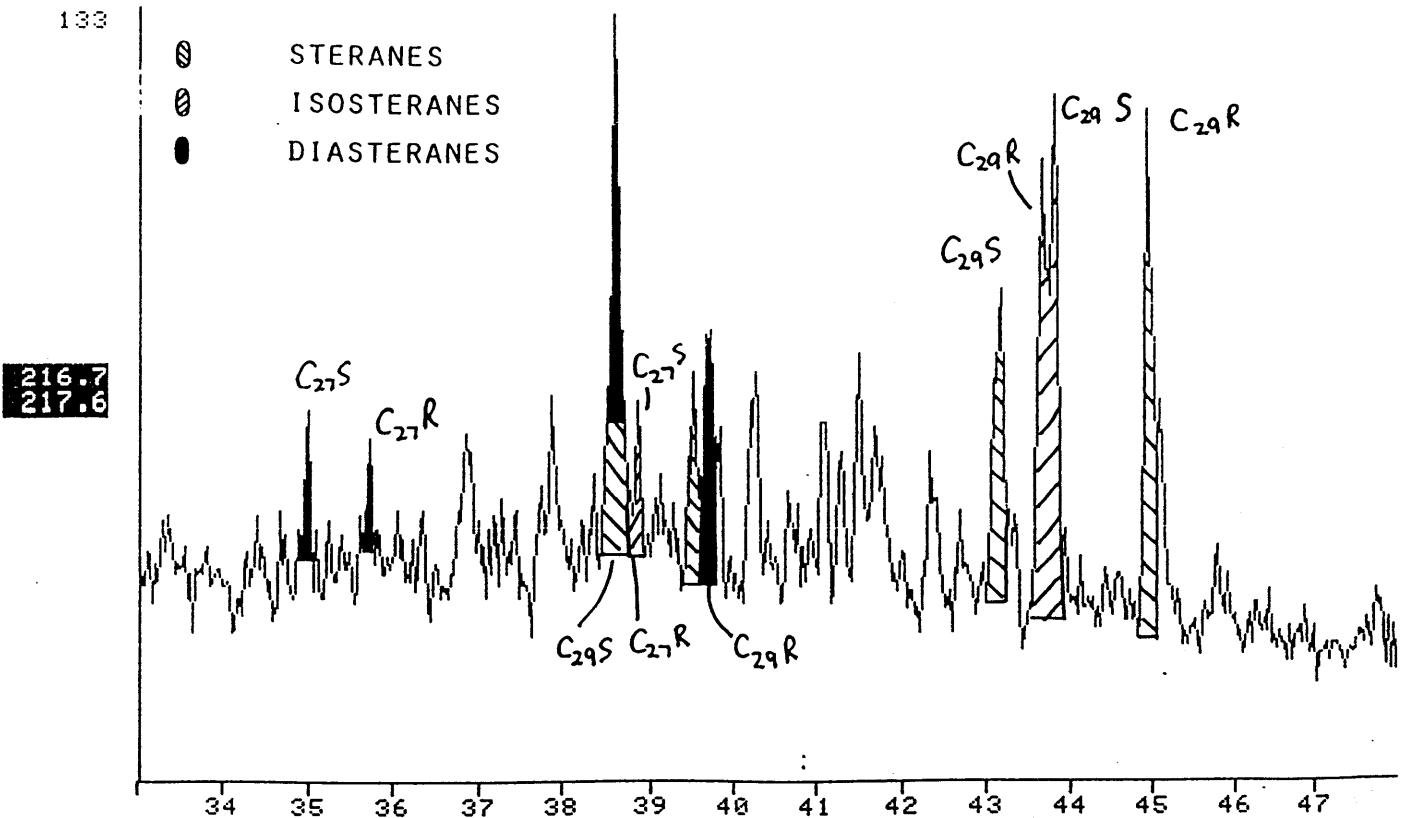
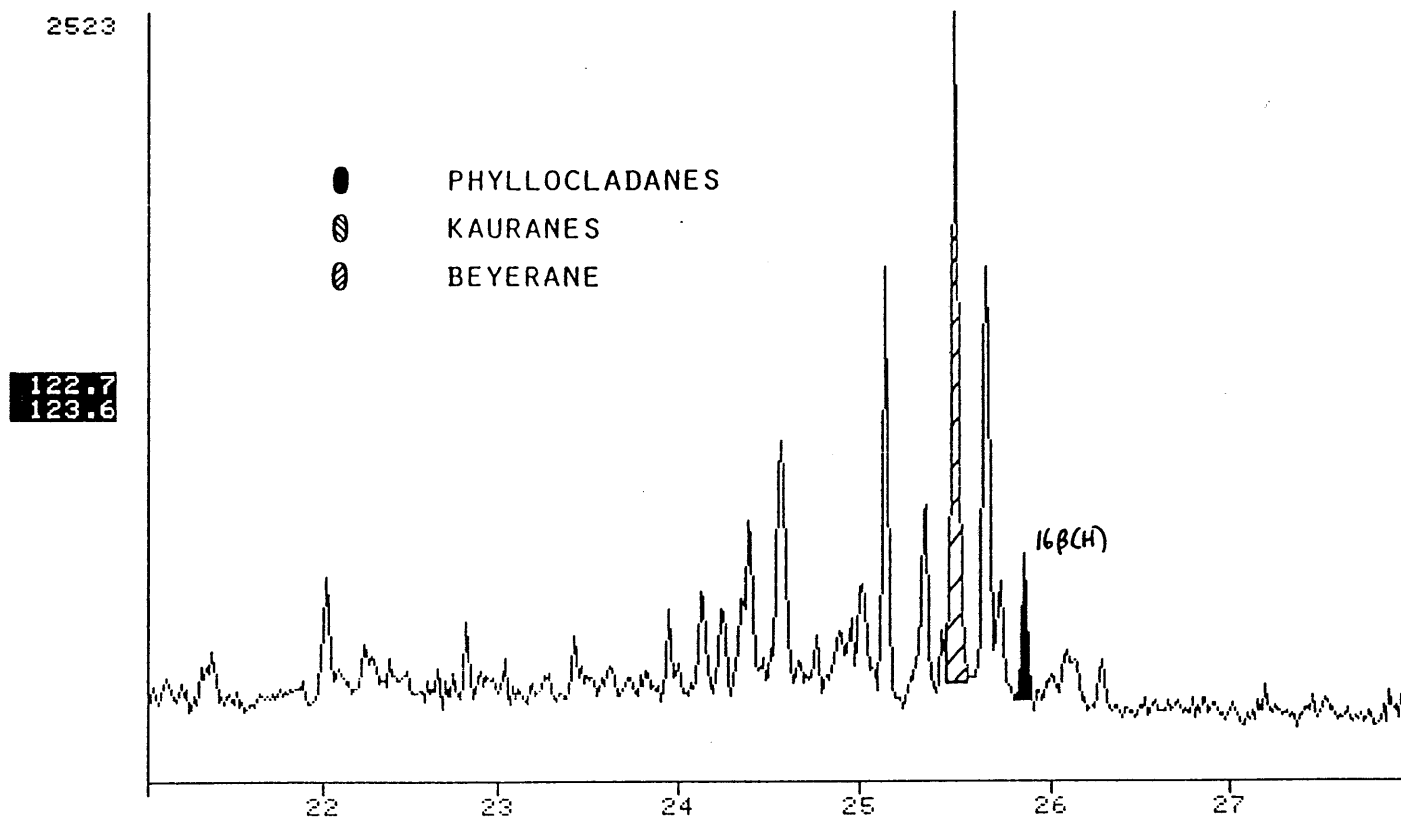


FIGURE 8-2

NAME SNAPPER 10170-10260. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 28-5-86. GEC. 0.2ul/250ul. COL#56.

FRN 6005



NAME SNAPPER 10170-10260. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 28-5-86. GEC. 0.2ul/250ul. COL#56.

FRN 6005

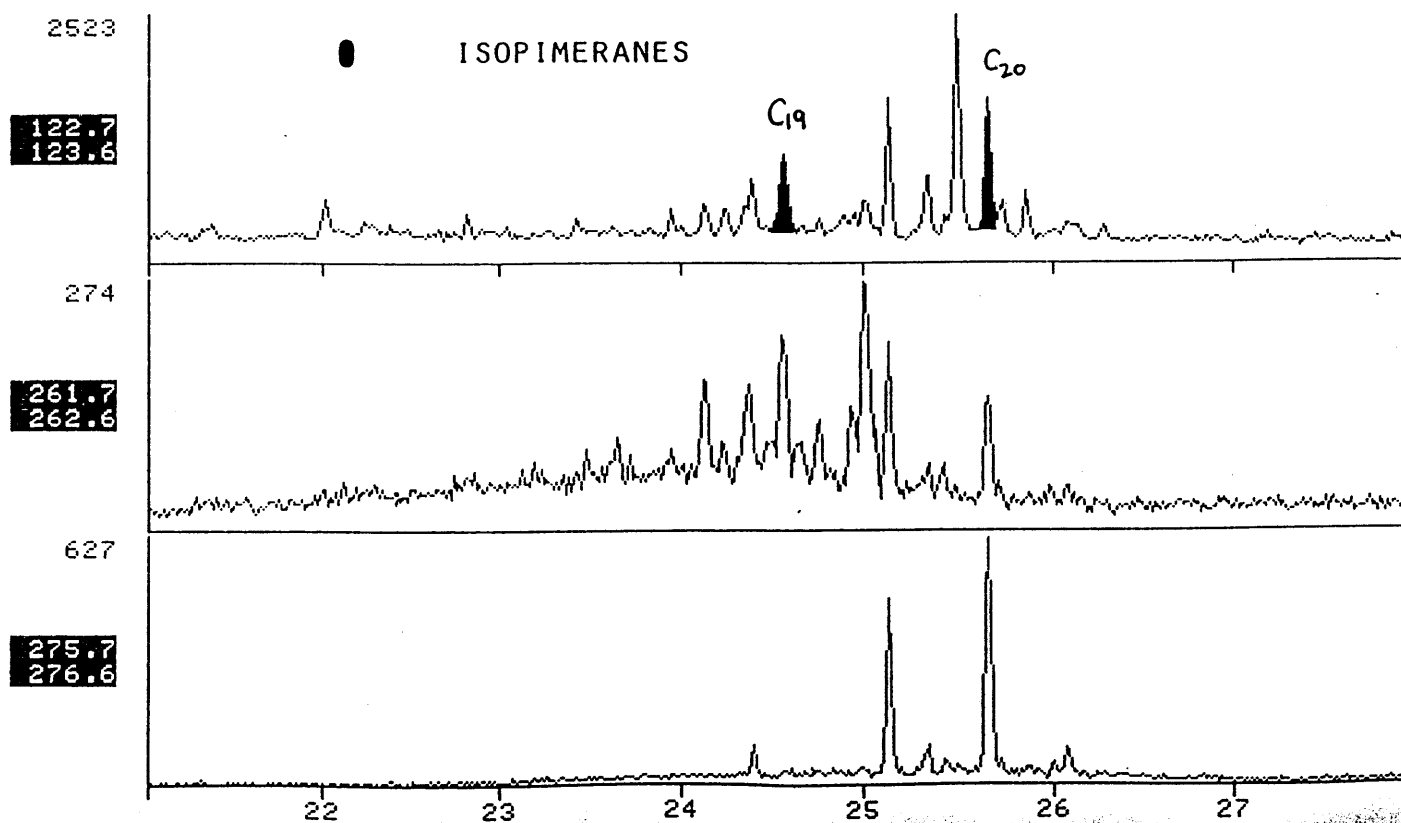


FIGURE 8-3

NAME SNAPPER 10170-10260, BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/250ul. COL#56.

FRN 6005

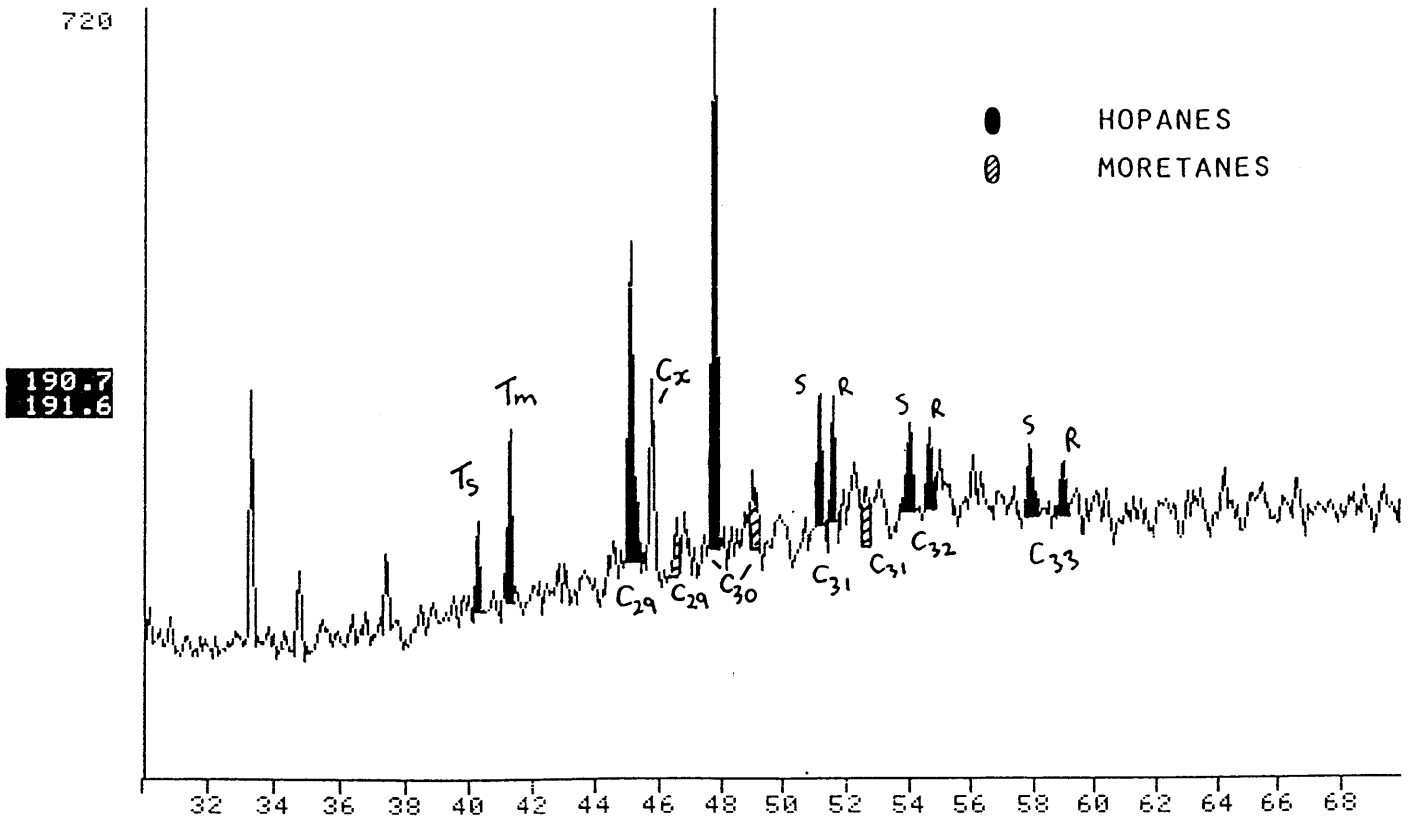


FIGURE 9

TARWHINE 1, 2610-2660m

Saturate Fraction

C₁₂+ GLC

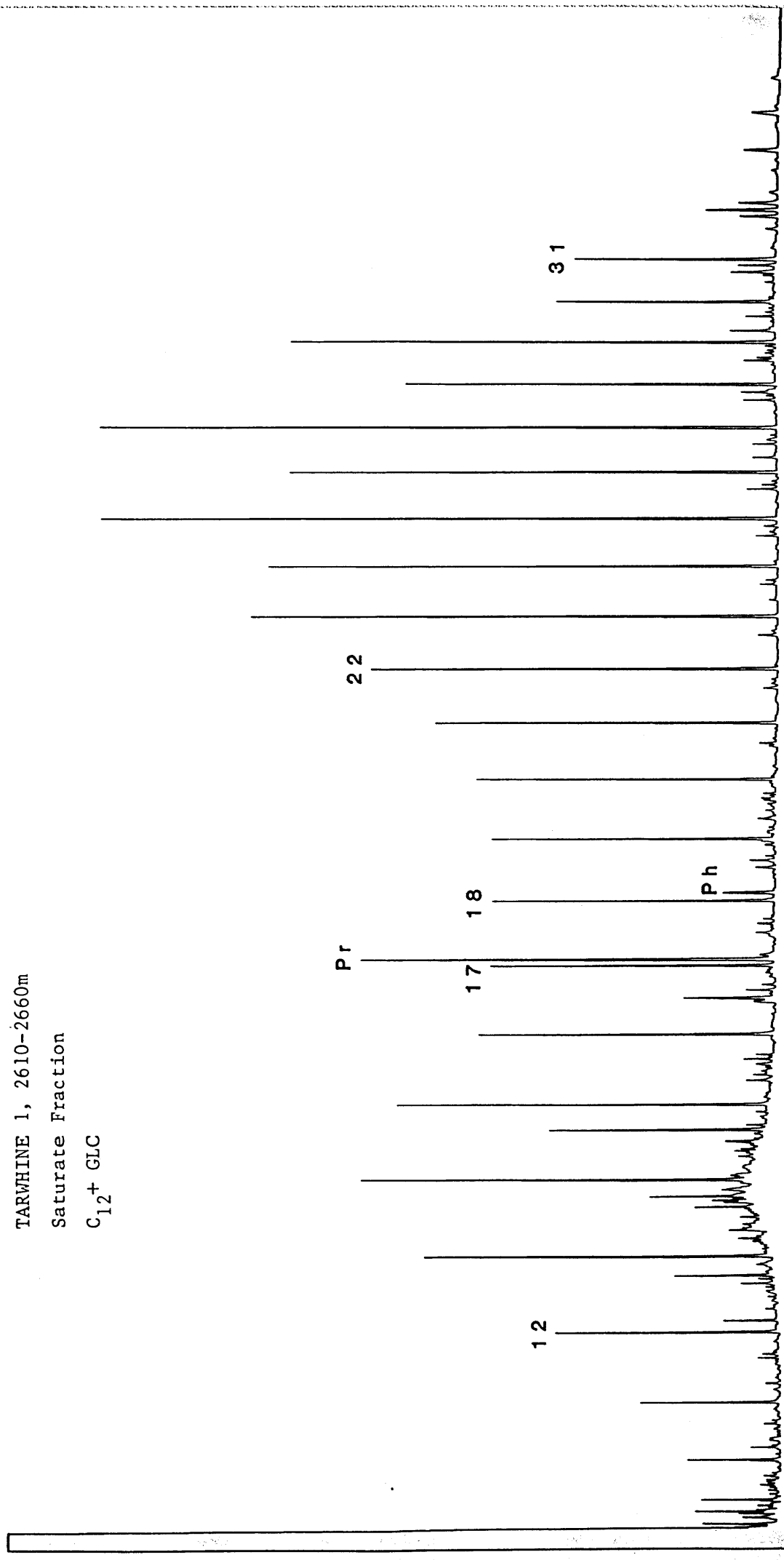
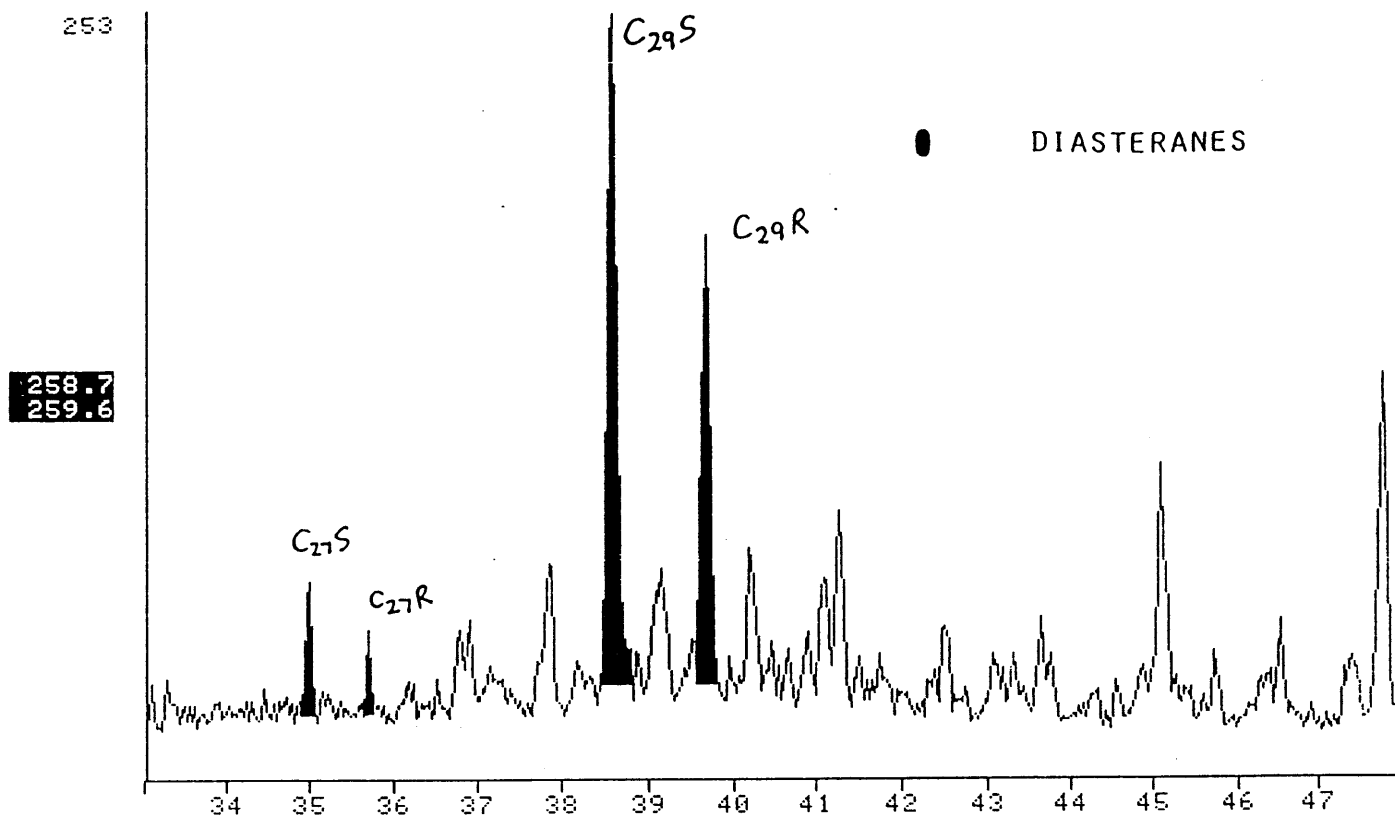


FIGURE 10-1

NAME TARWHINE 2610-2660. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 29-5-86. GEC. 0.2ul/70ul COL#56. P.CONNA

FRN 6006



NAME TARWHINE 2610-2660. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 29-5-86. GEC. 0.2ul/70ul COL#56. P.CONNA

FRN 6006

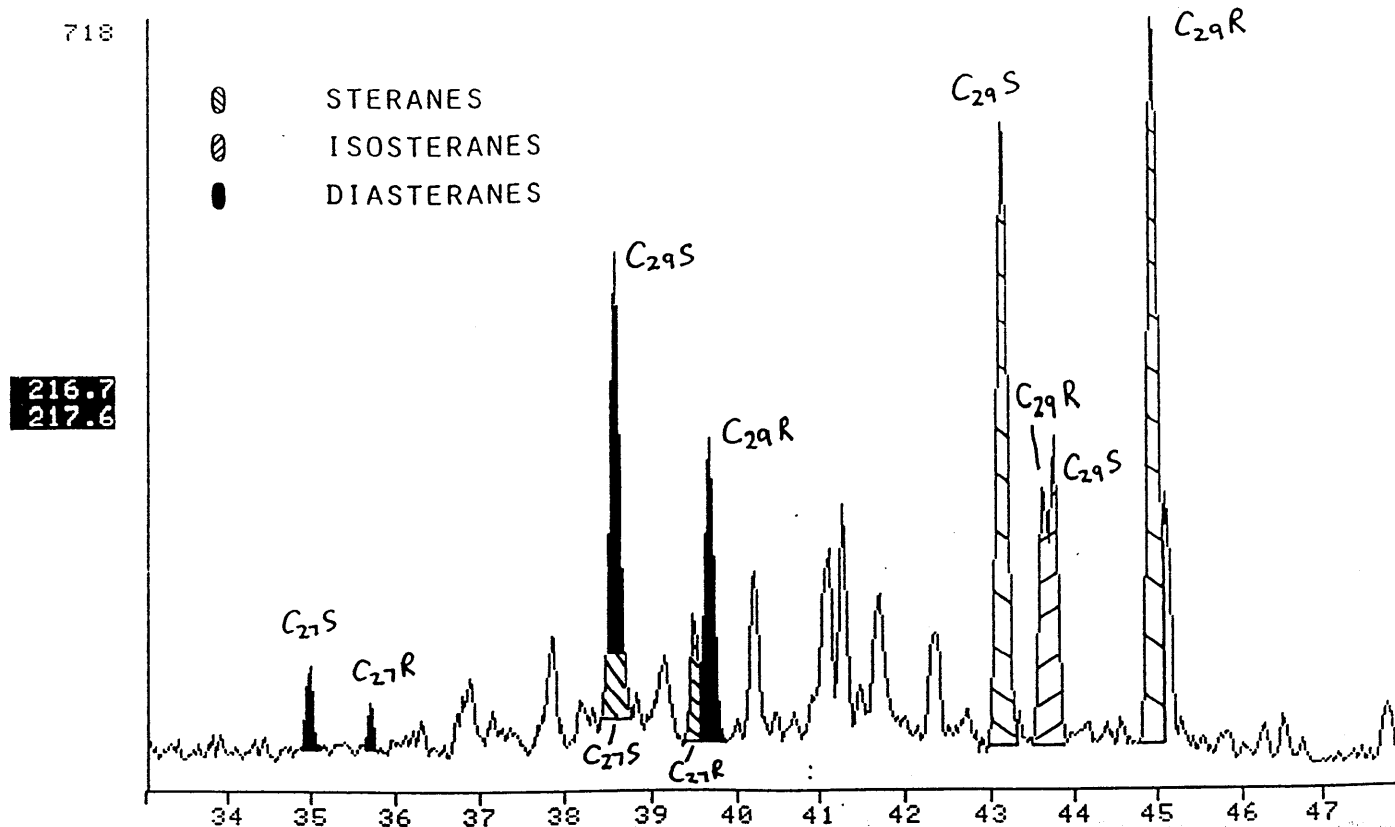
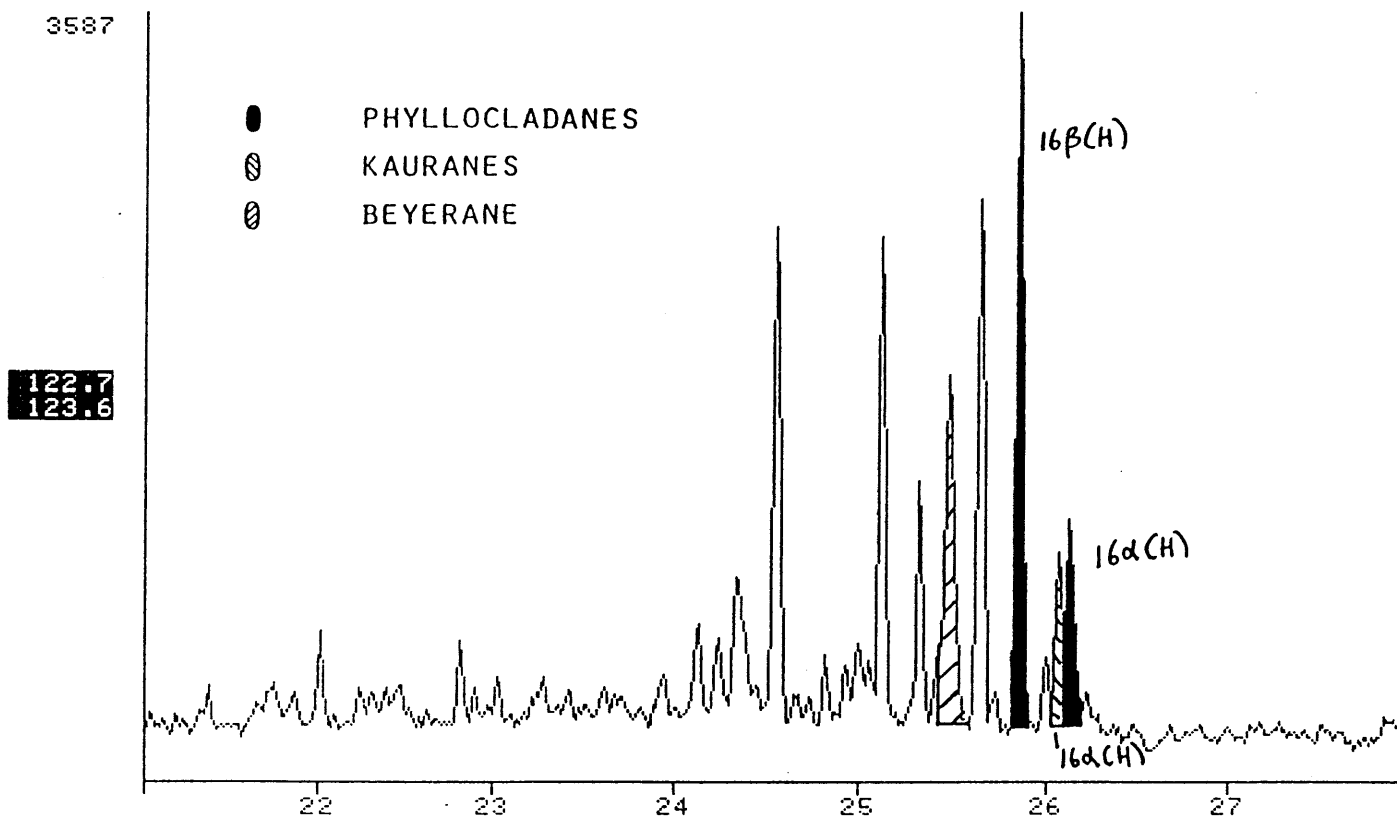


FIGURE 10-2

NAME TARWHINE 2610-2660. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 29-5-86. GEC. 0.2ul/70ul COL#56. P.CONNA

FRN 6006



NAME TARWHINE 2610-2660. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 29-5-86. GEC. 0.2ul/70ul COL#56. P.CONNA

FRN 6006

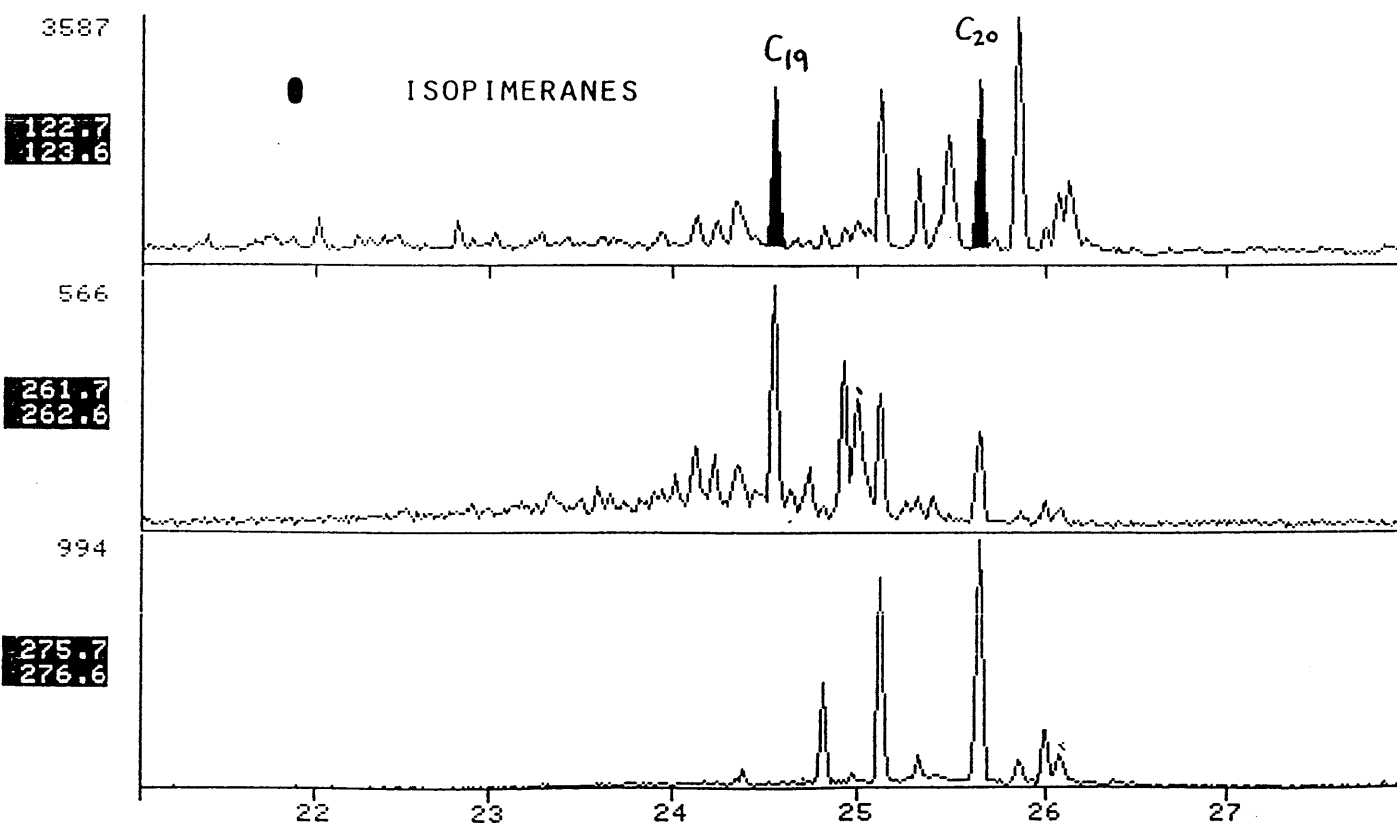


FIGURE 10-3

NAME TARWHINE 2610-2660. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 29-5-86. GEC. 0.201/7001 COL#56. P.CONNA

FRN 6006

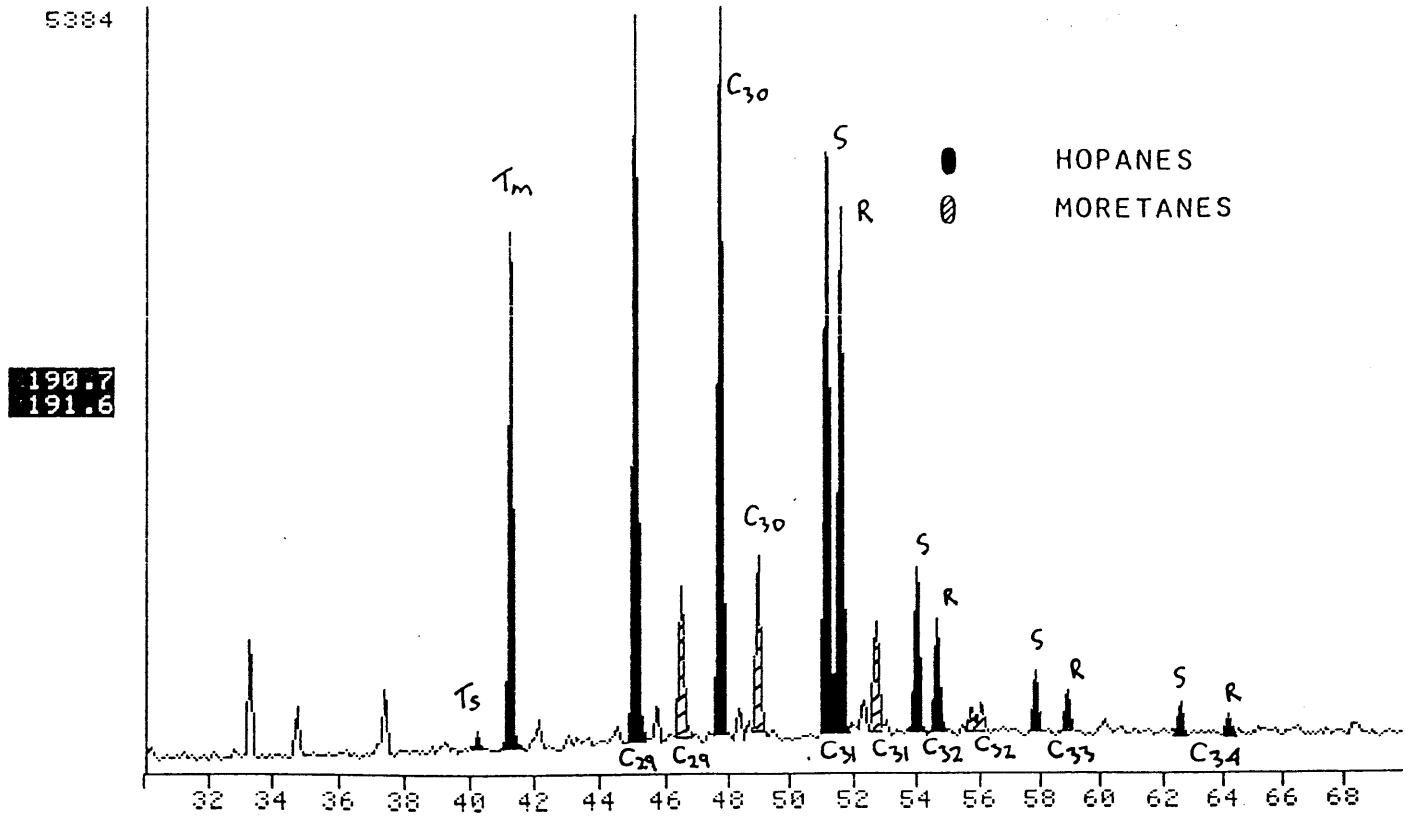


FIGURE 11
VEILFIN 1, 3460-3490m
Saturate Fraction
C₁₂+ GLC

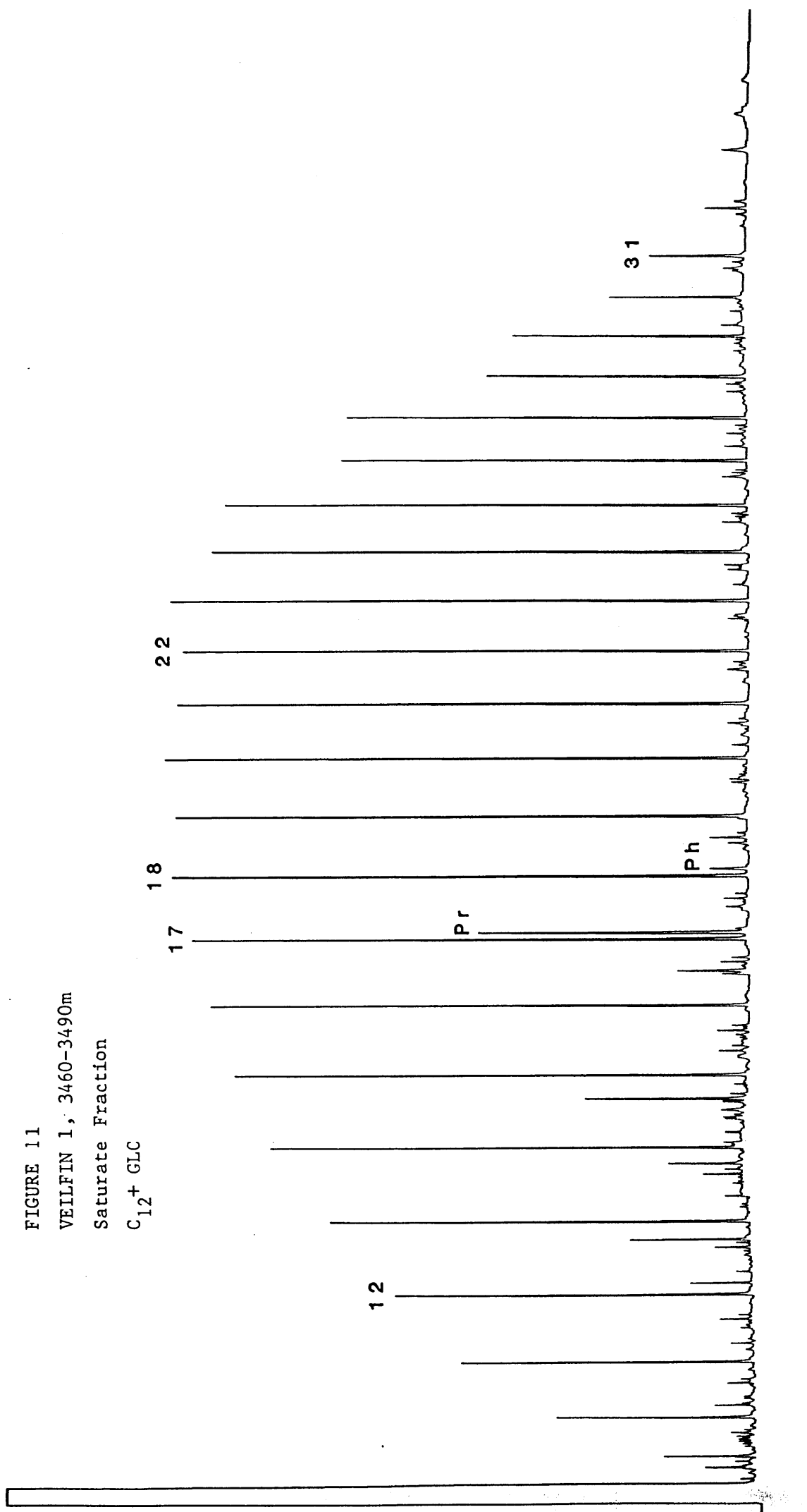
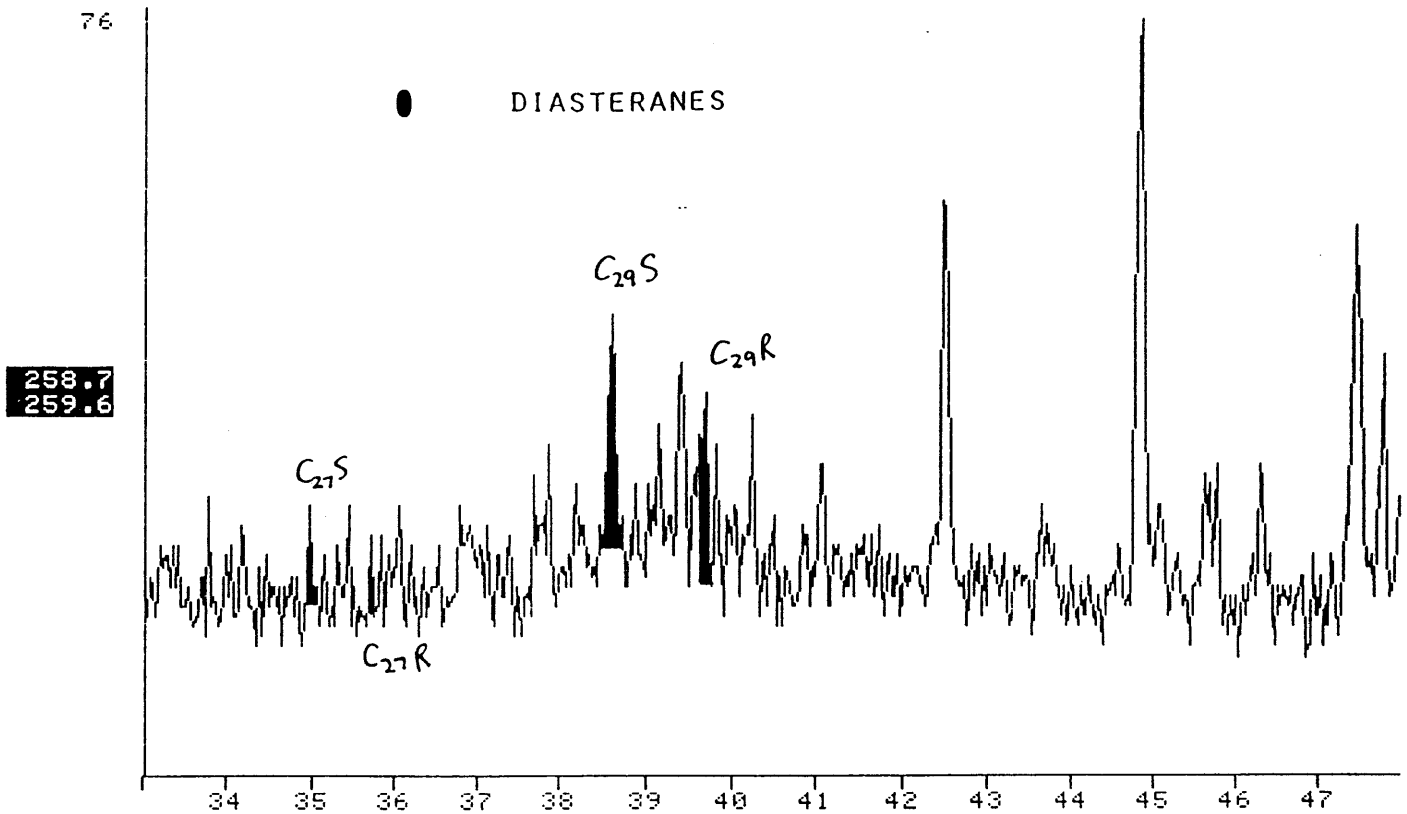


FIGURE 12-1

NAME VEILFIN, 3460-3490. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/100ul. COL#56. P.COM

FRN 6003



NAME VEILFIN, 3460-3490. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/100ul. COL#56. P.COM

FRN 6003

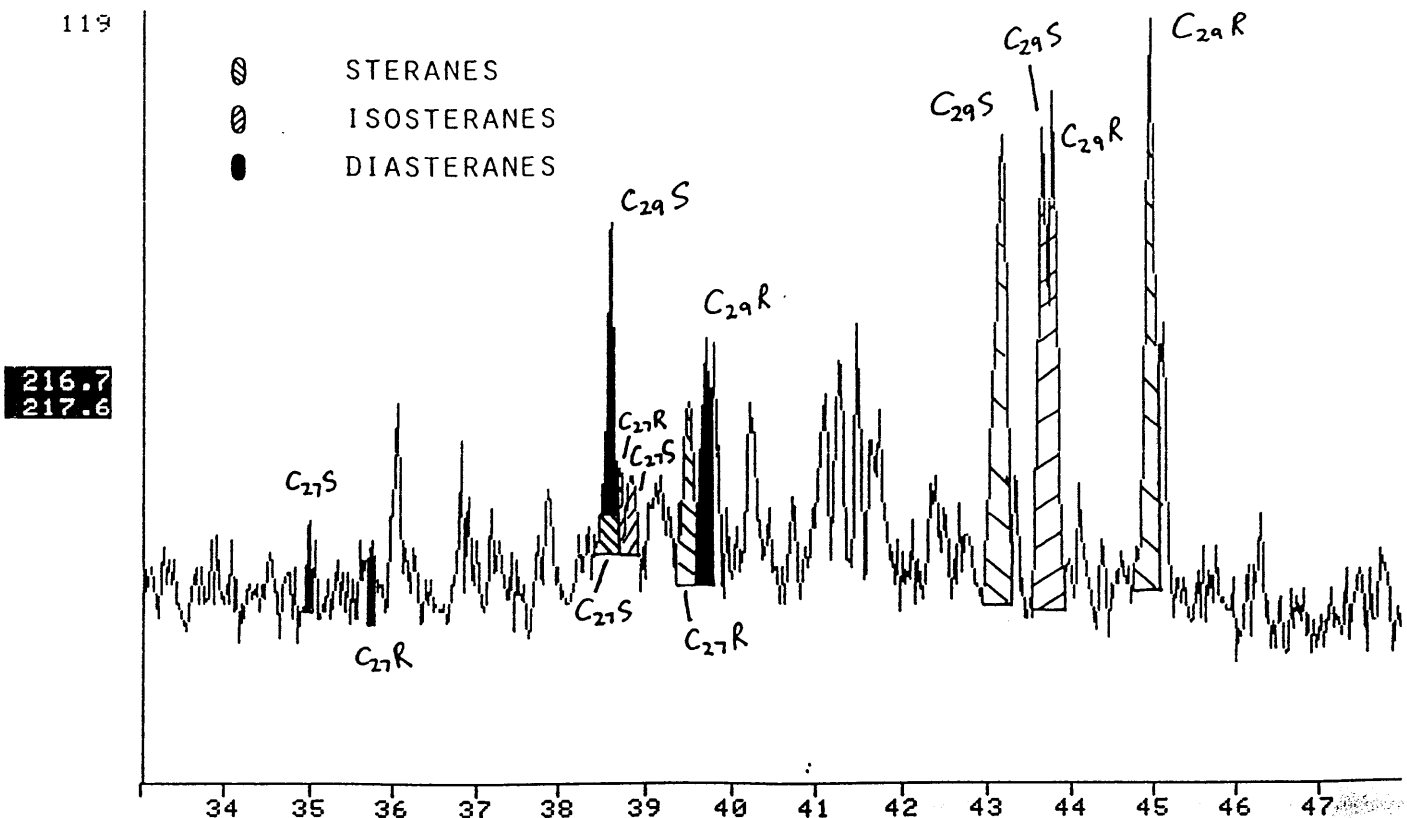
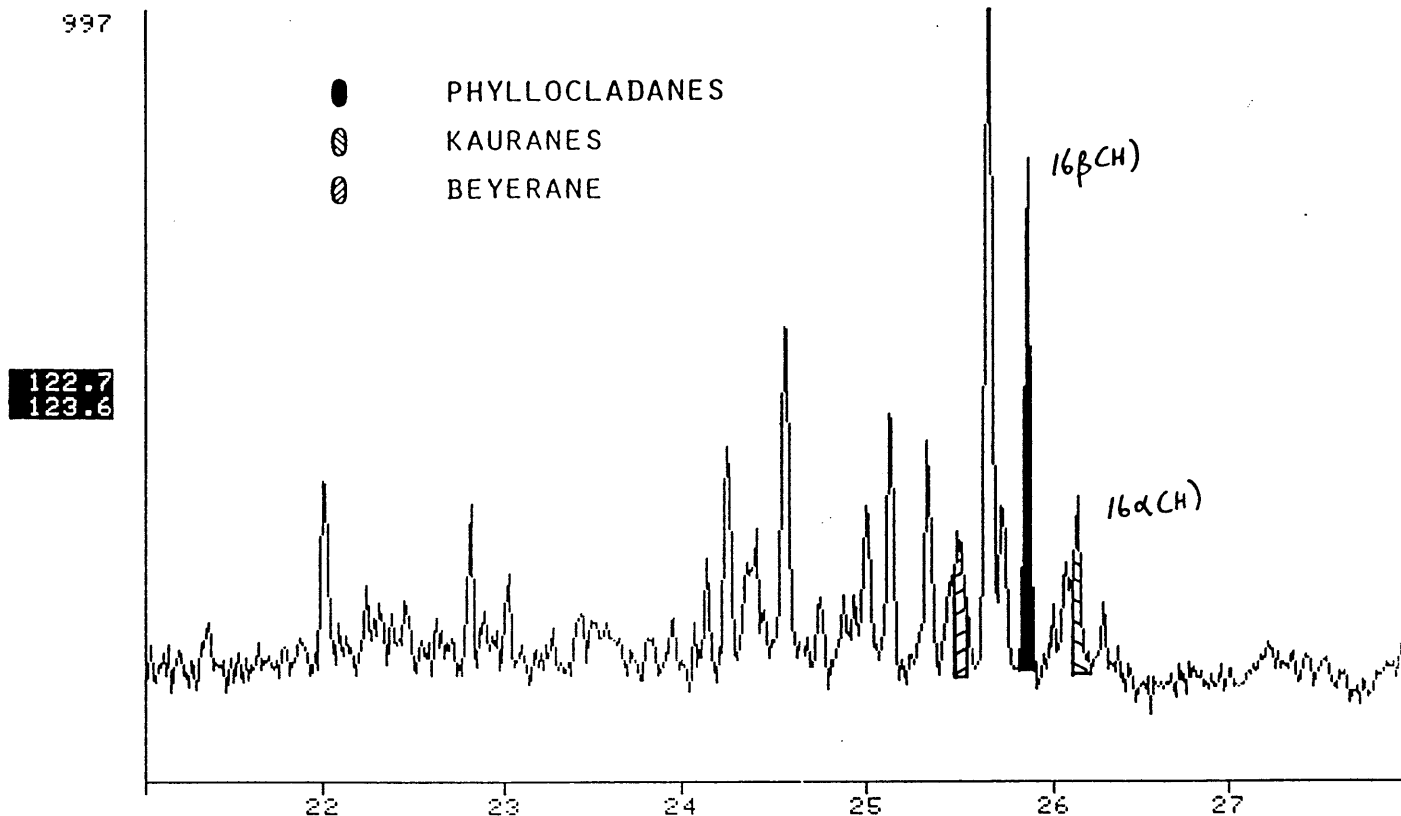


FIGURE 12-2

NAME VEILFIN, 3460-3490. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 28-5-86. GEC. 0.2ul/100ul. COL#56. P.CON

FRN 6003



NAME VEILFIN, 3460-3490. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 28-5-86. GEC. 0.2ul/100ul. COL#56. P.CON

FRN 6003

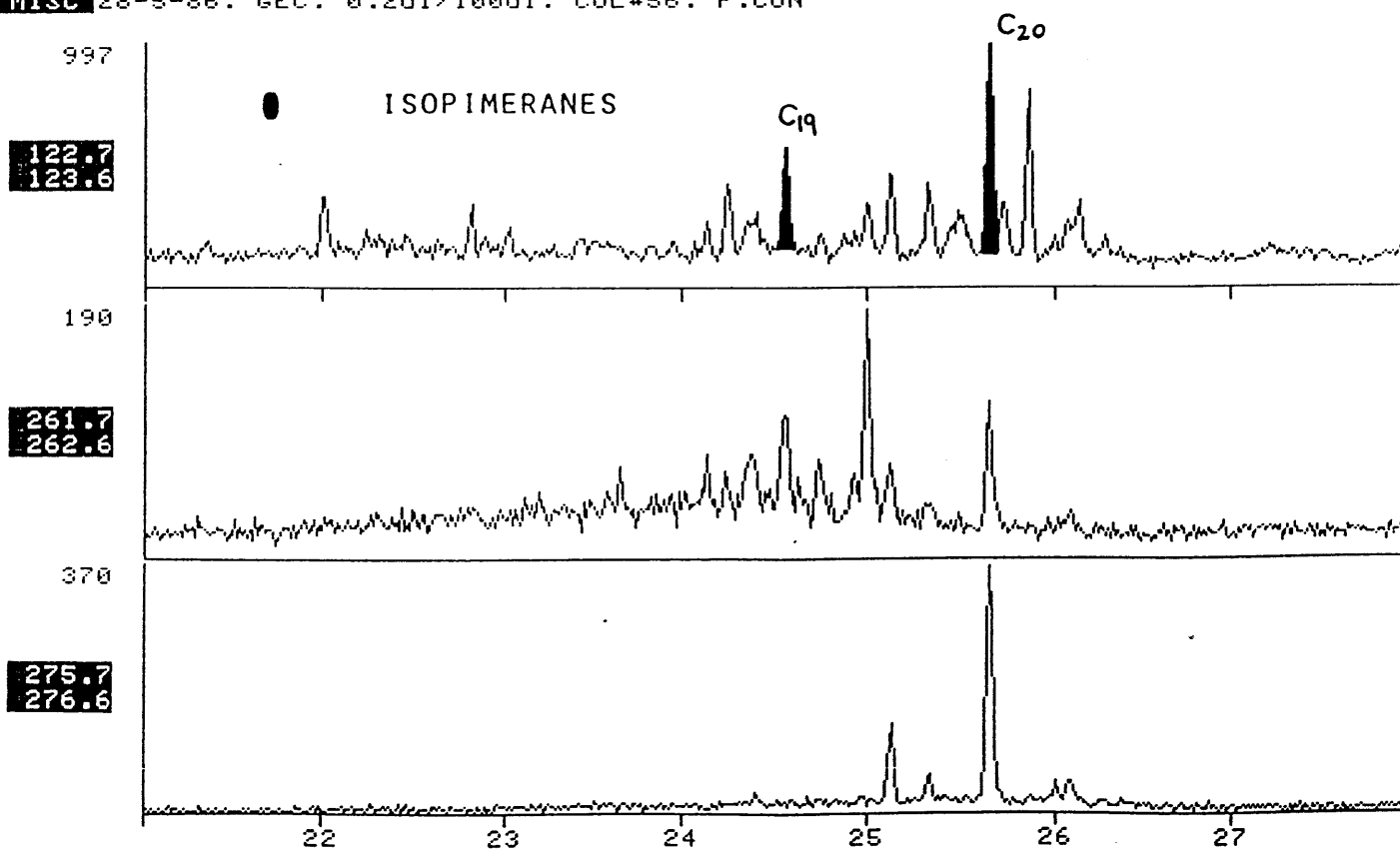


FIGURE 12-3

NAME VEILFIN, 3460-3490. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 28-5-86. GEC. 0.2ul/100ul. COL#56. P.COM

FRN 6003

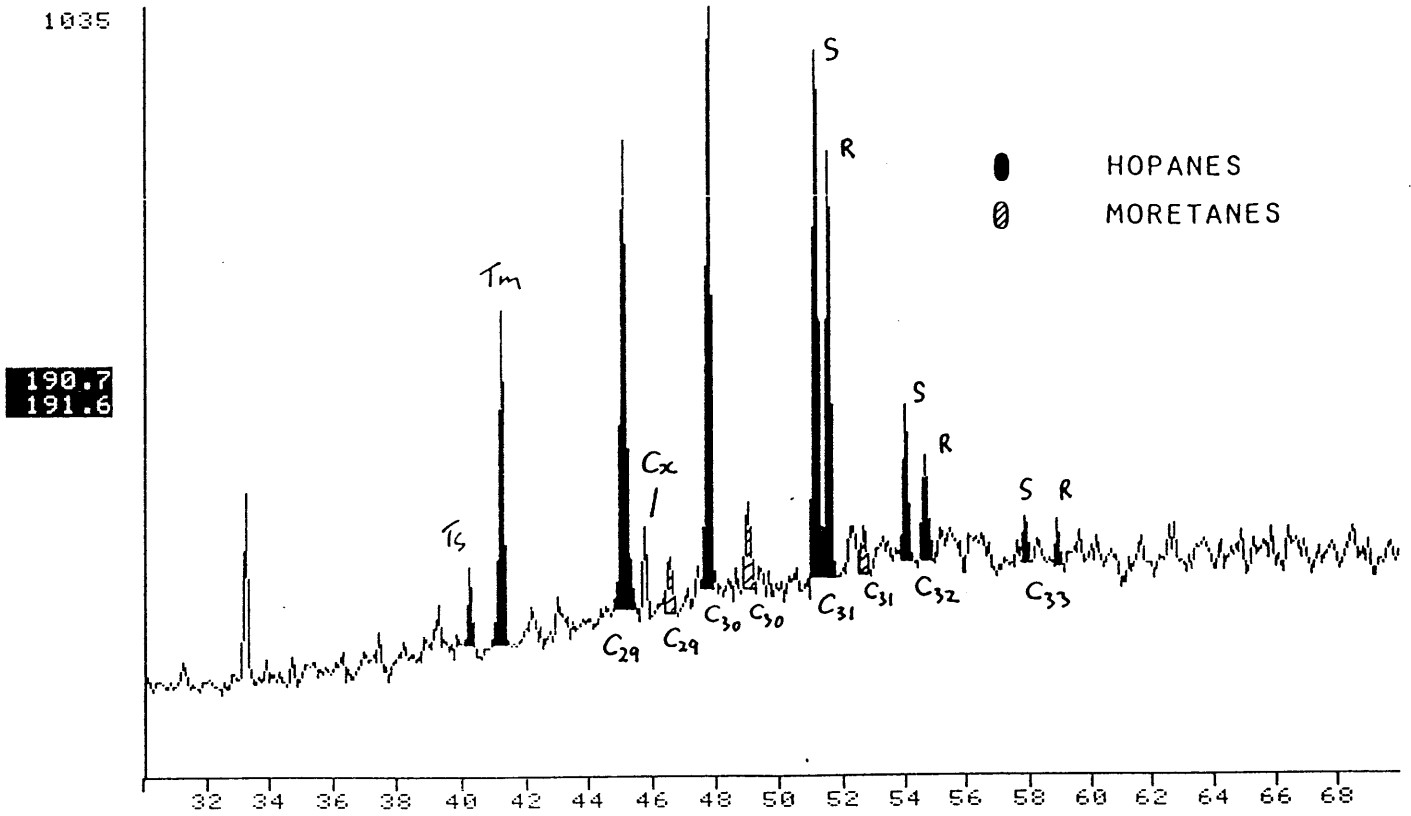


FIGURE 13
BREAM 2, 6347ft (1943m)
Whole Oil
C₁-C₃₁ GLC

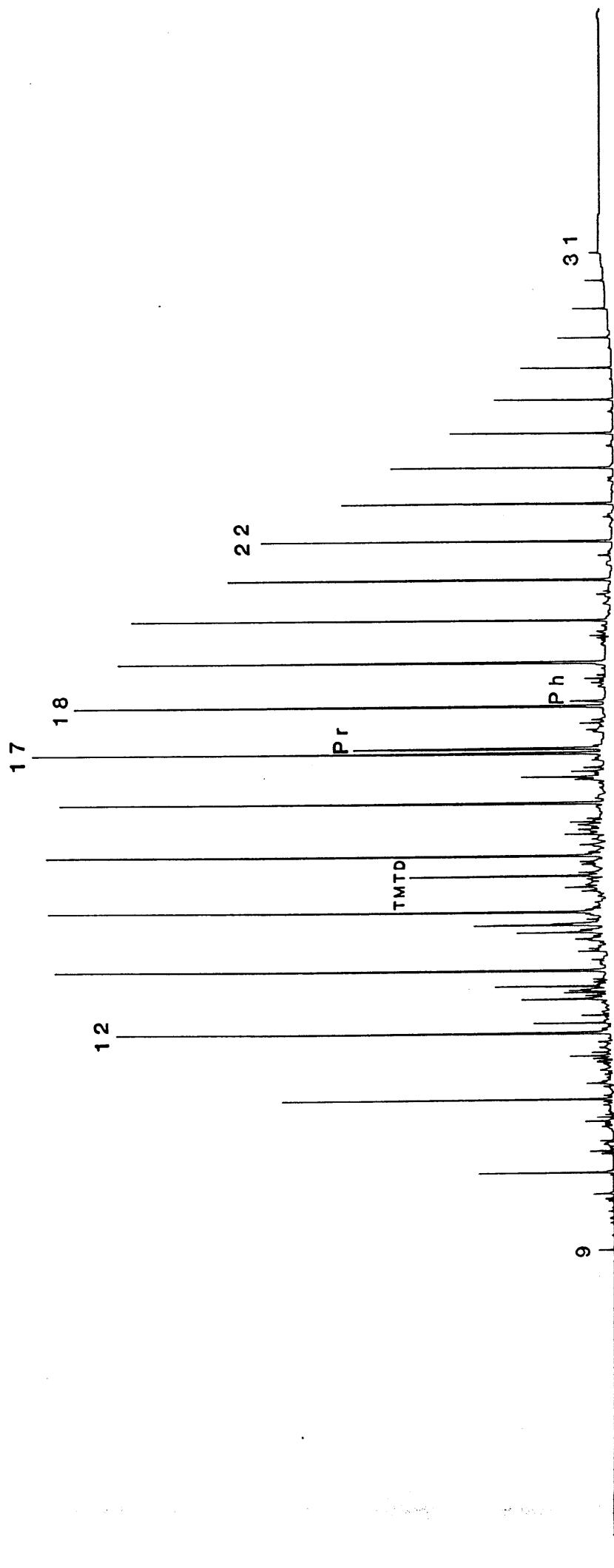
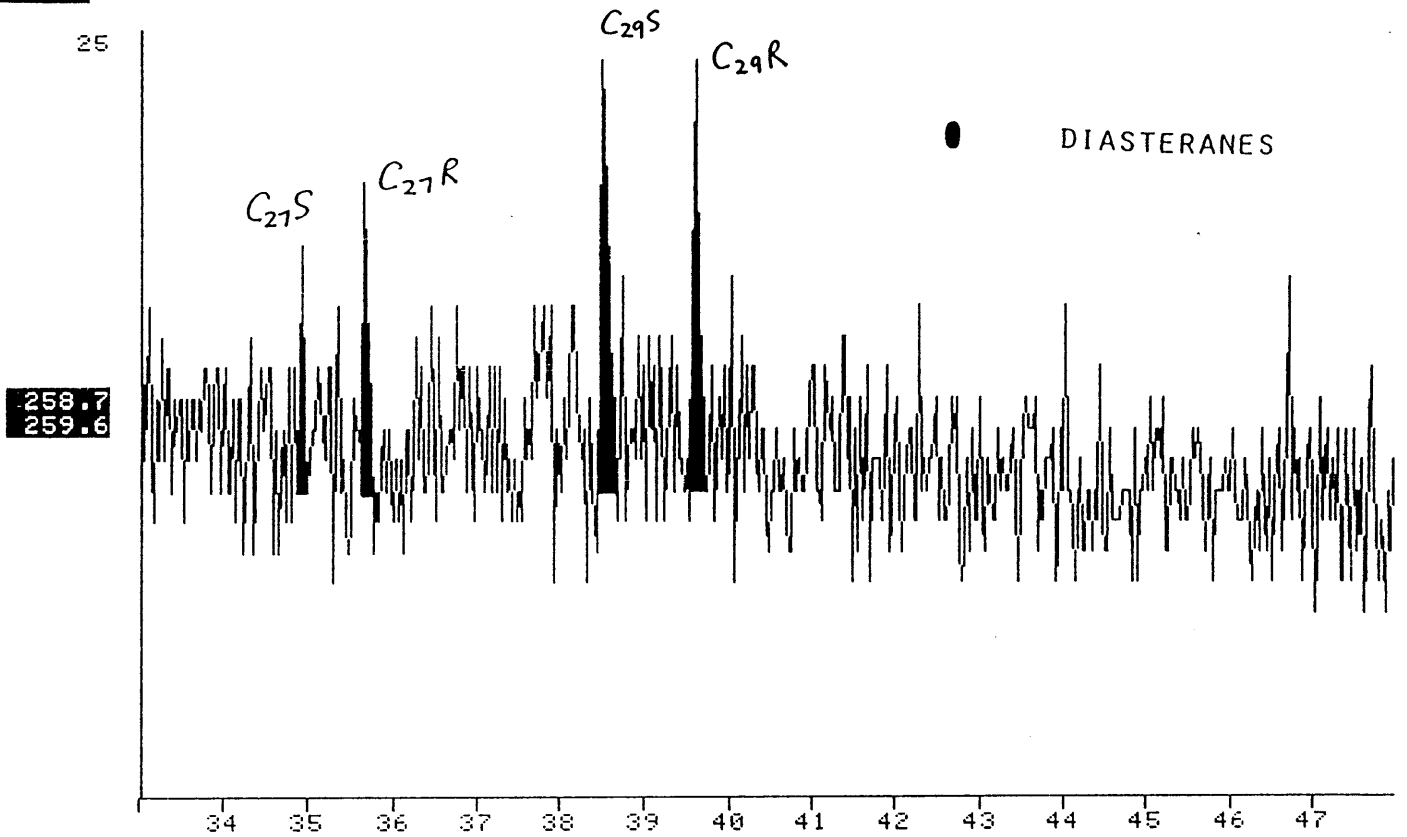


FIGURE 14-1

NAME BREAM OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2ul/550ul. COL#56. P.C00#

FRN 6007



NAME BREAM OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2ul/550ul. COL#56. P.C00#

FRN 6007

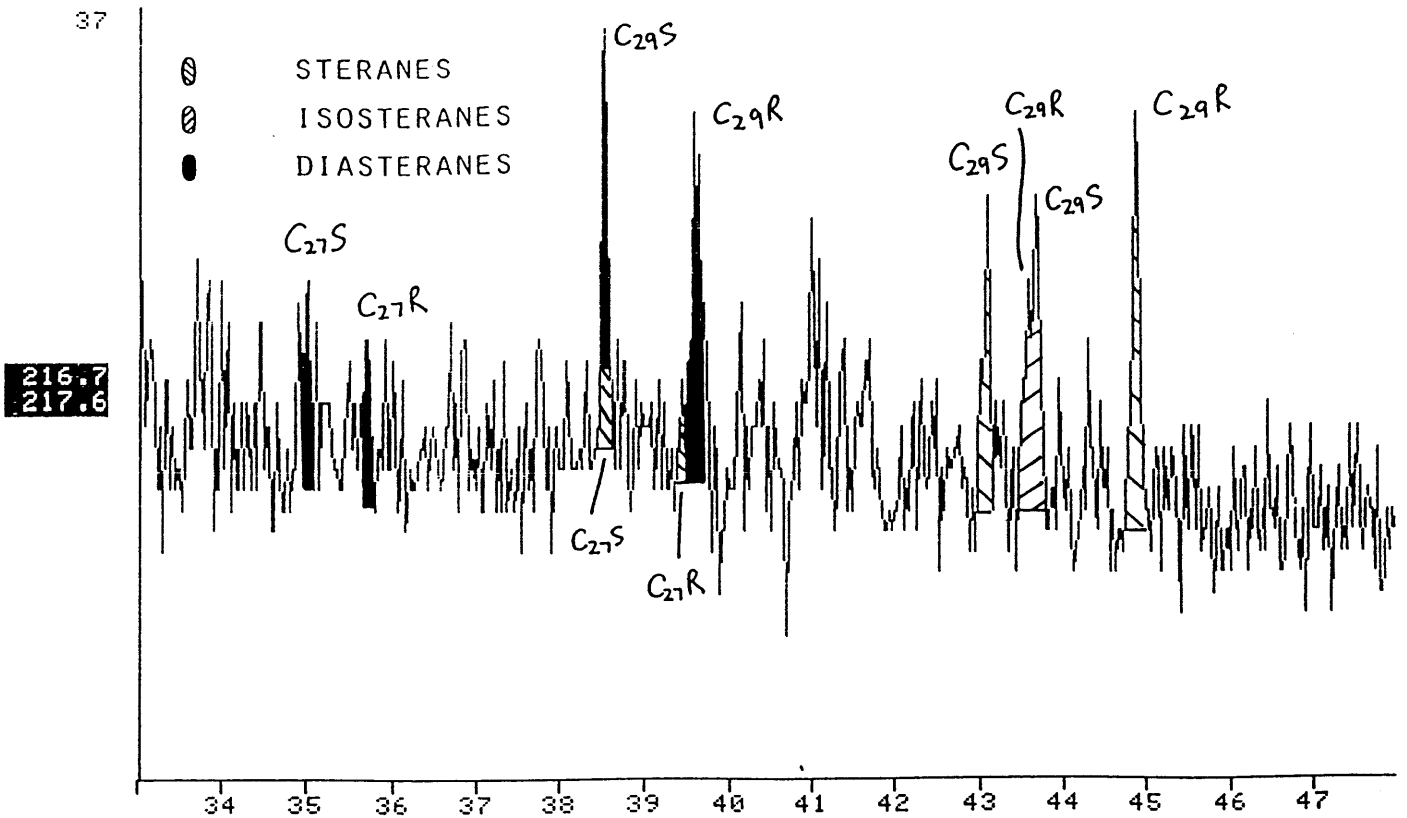
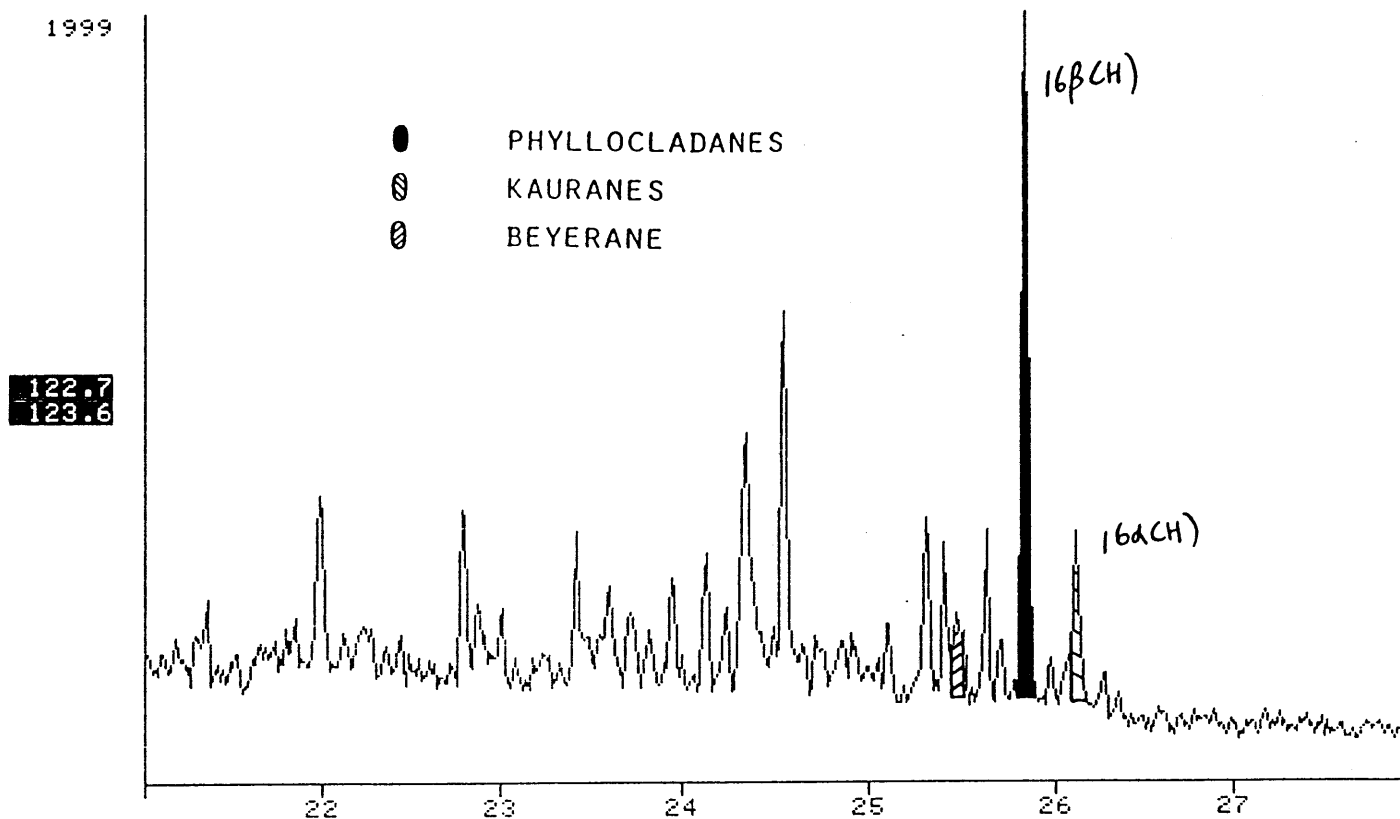


FIGURE 14-2

NAME BREAM OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 3-6-86. GEC. 0.2ul/550ul. COL#56. P.CO0#

FRN 6007



NAME BREAM OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 3-6-86. GEC. 0.2ul/550ul. COL#56. P.CO0#

FRN 6007

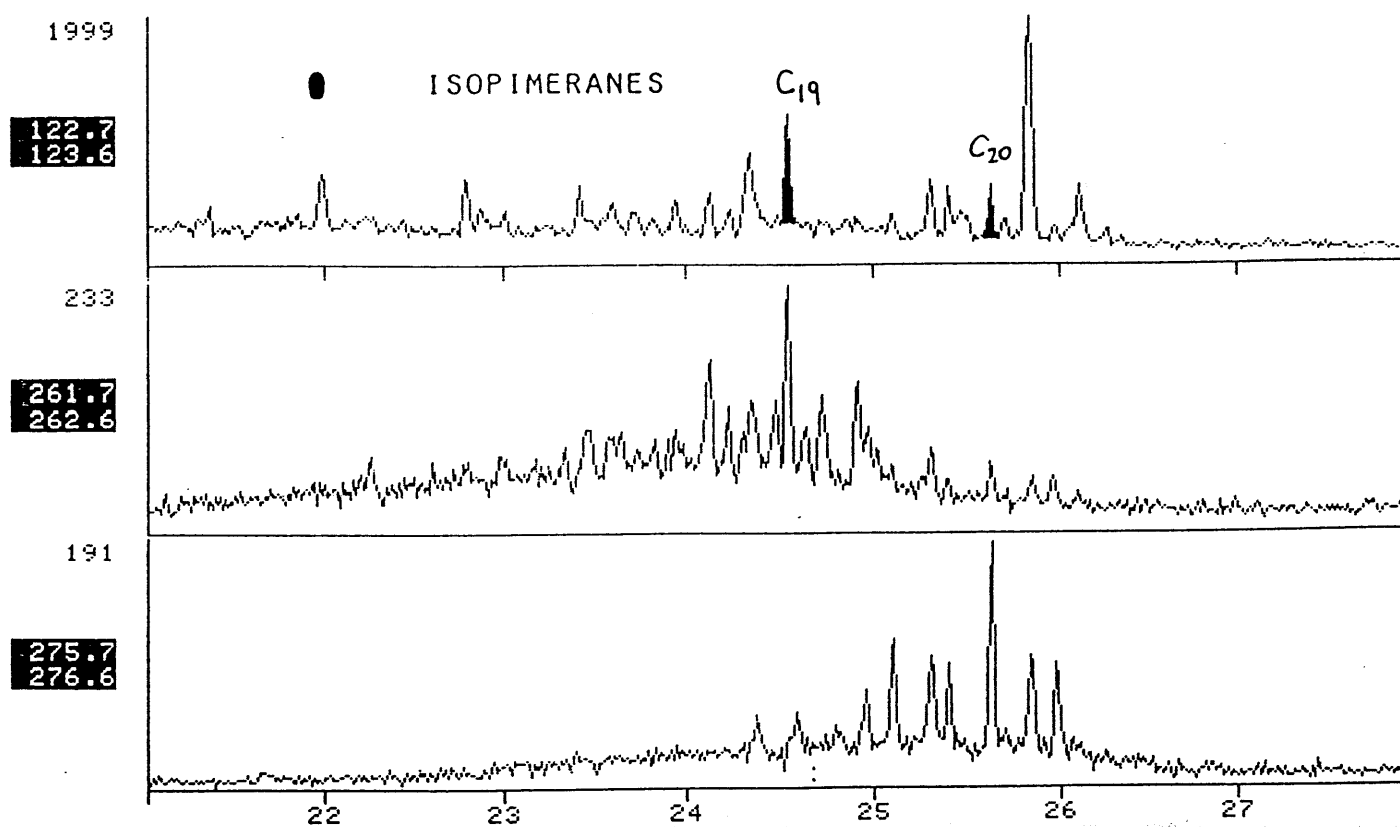


FIGURE 14-3

NAME BREAM OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC. 3-6-86. GEC. 0.2ul/550ul. COL#56. P.C00#

FRN 6007

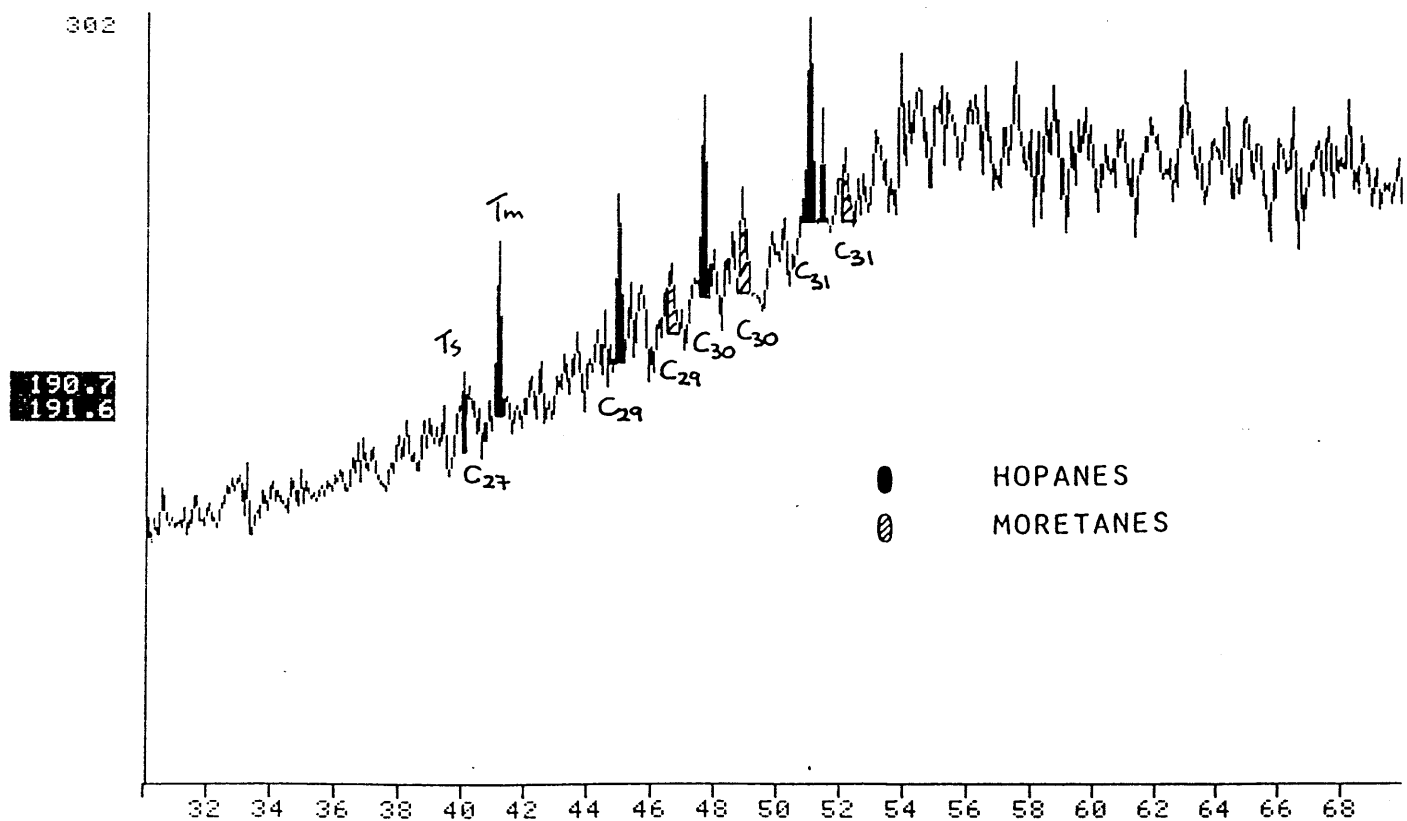


FIGURE 15
DOLPHIN 1, 4000ft (1219m)
Whole Oil
C₁-C₃₁ GLC

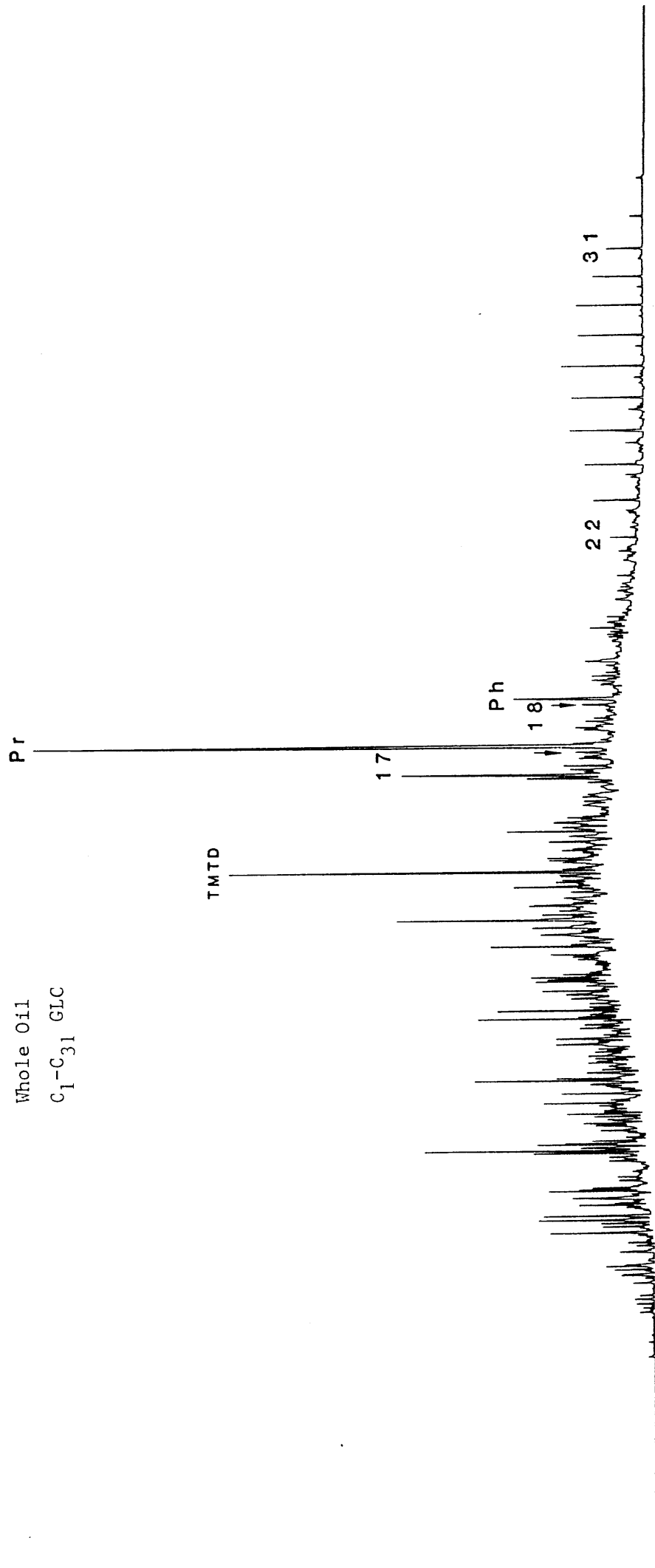
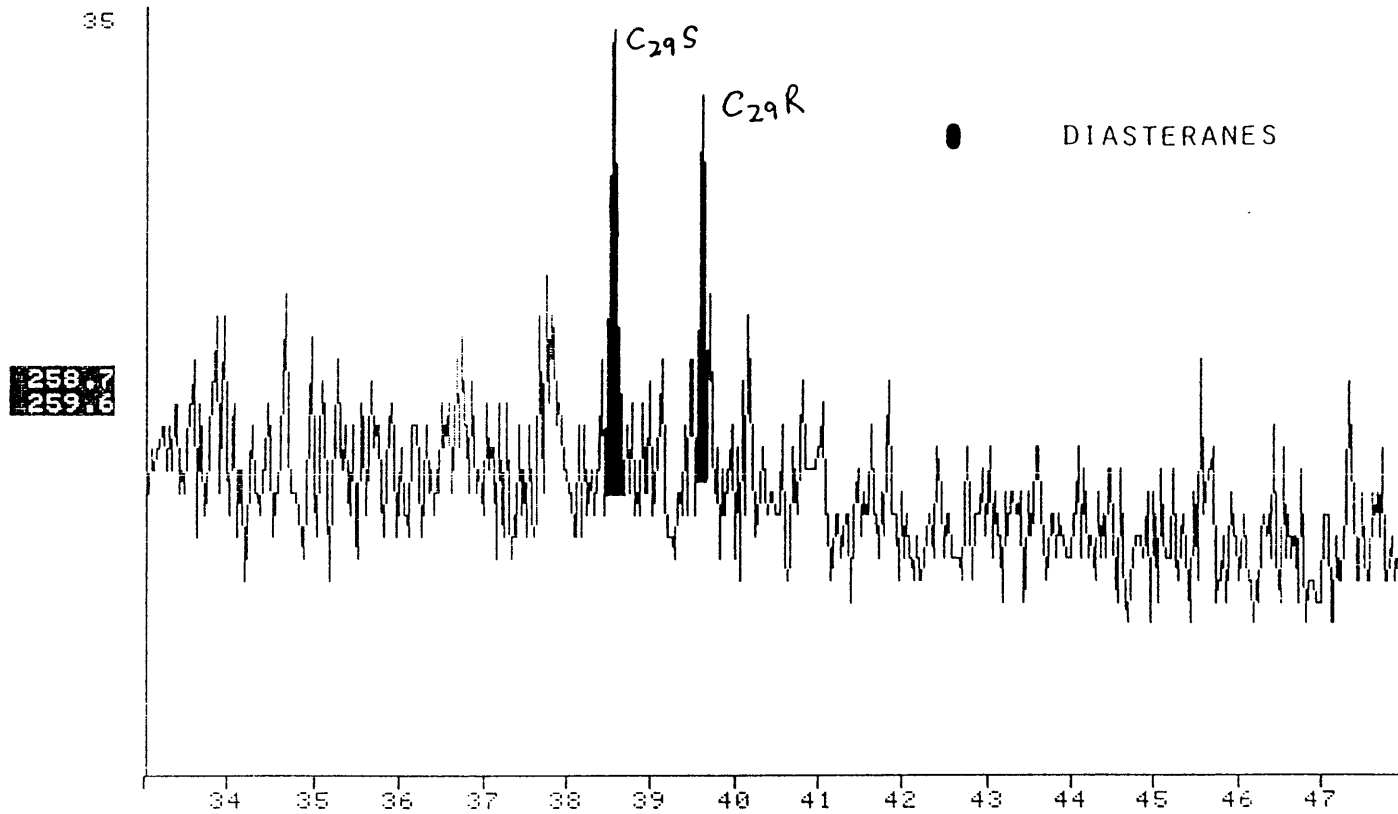


FIGURE 16-1

NAME DOLPHIN OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 4-6-86. GEC. 0.201/32001. COL#56. P.CONN

FRN 6009



NAME DOLPHIN OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 4-6-86. GEC. 0.201/32001. COL#56. P.CONN

FRN 6009

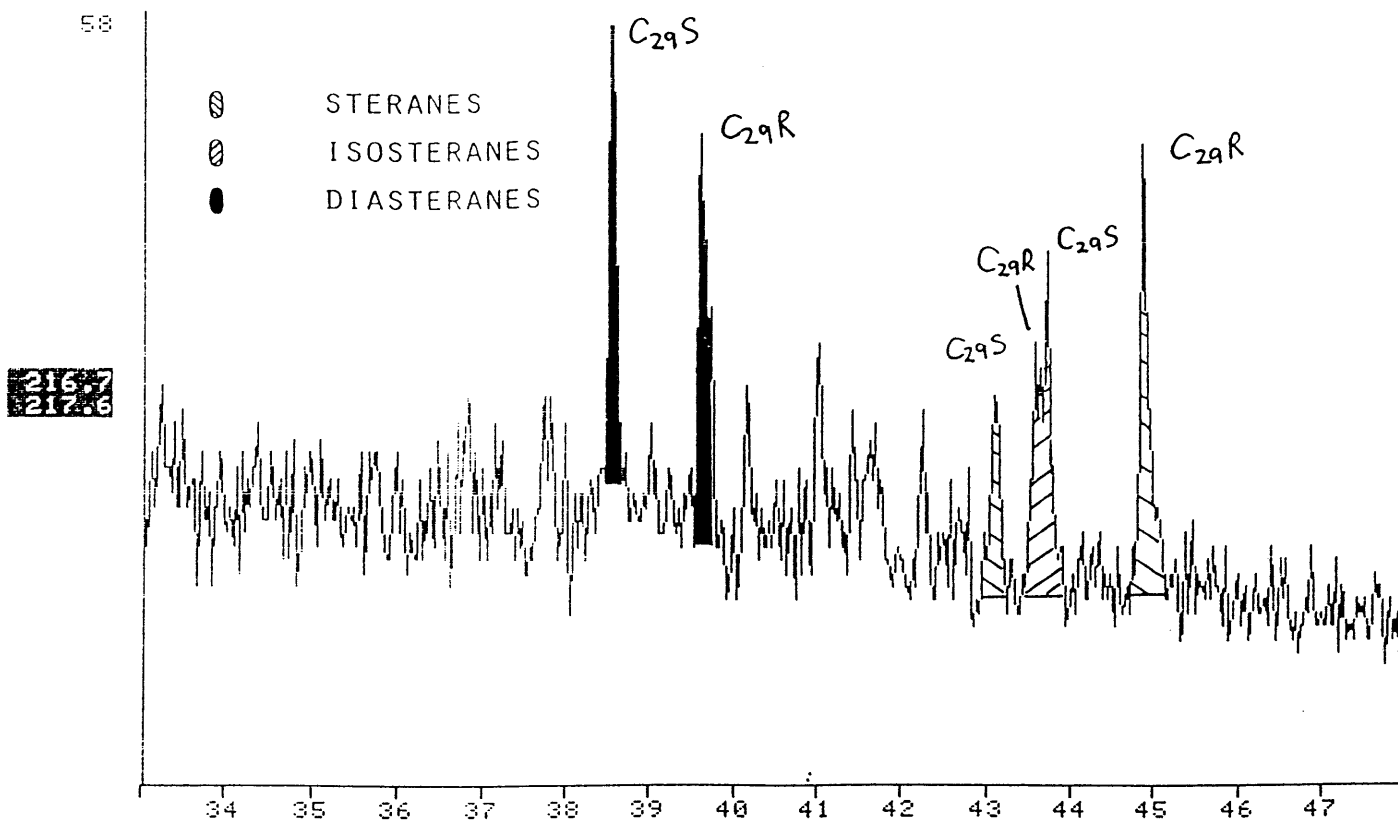
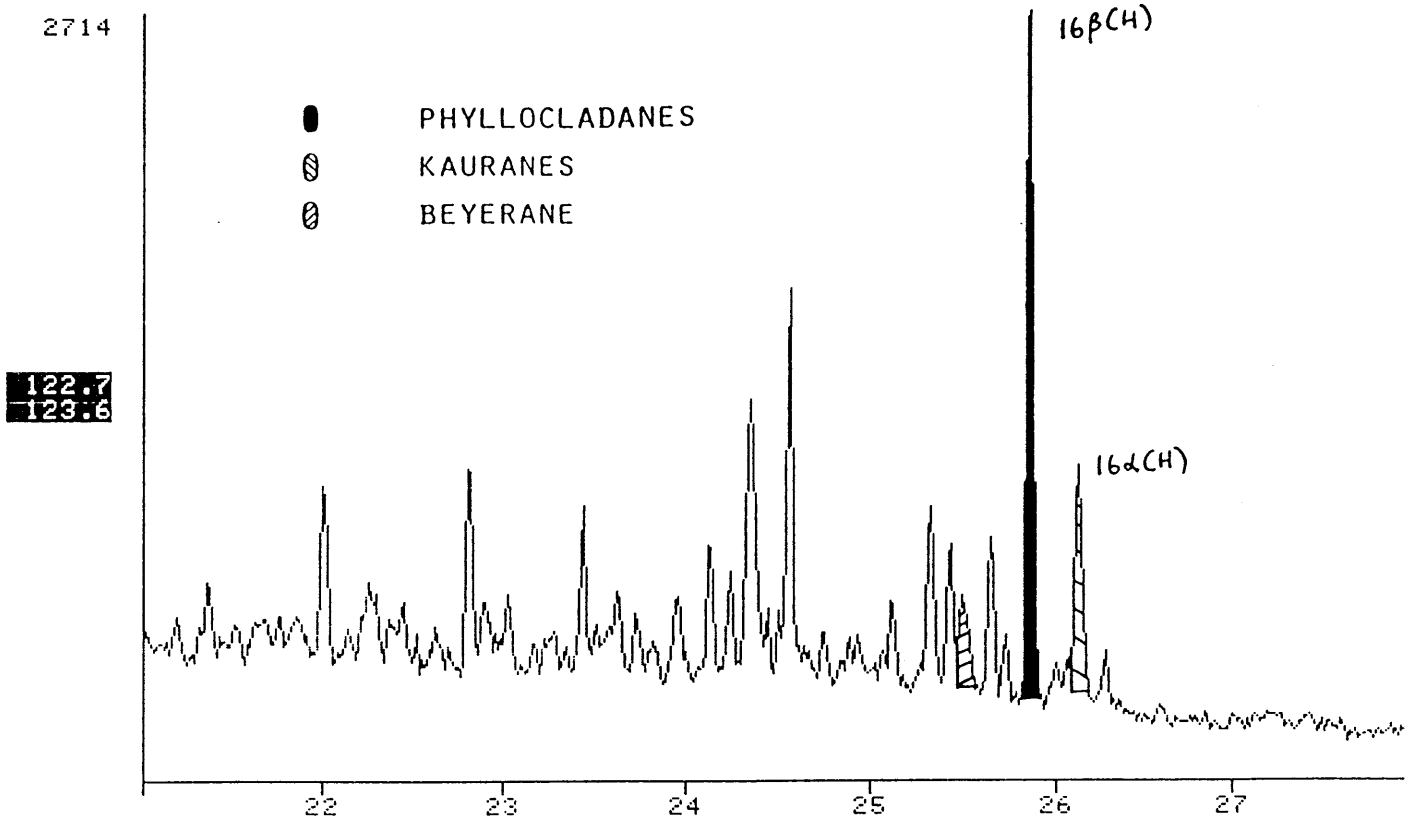


FIGURE 16-2

NAME DOLPHIN OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 4-6-86. GEC. 0.2ul/320ul. COL#56. P.CONN

FRN 6009



NAME DOLPHIN OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 4-6-86. GEC. 0.2ul/320ul. COL#56. P.CONN

FRN 6009

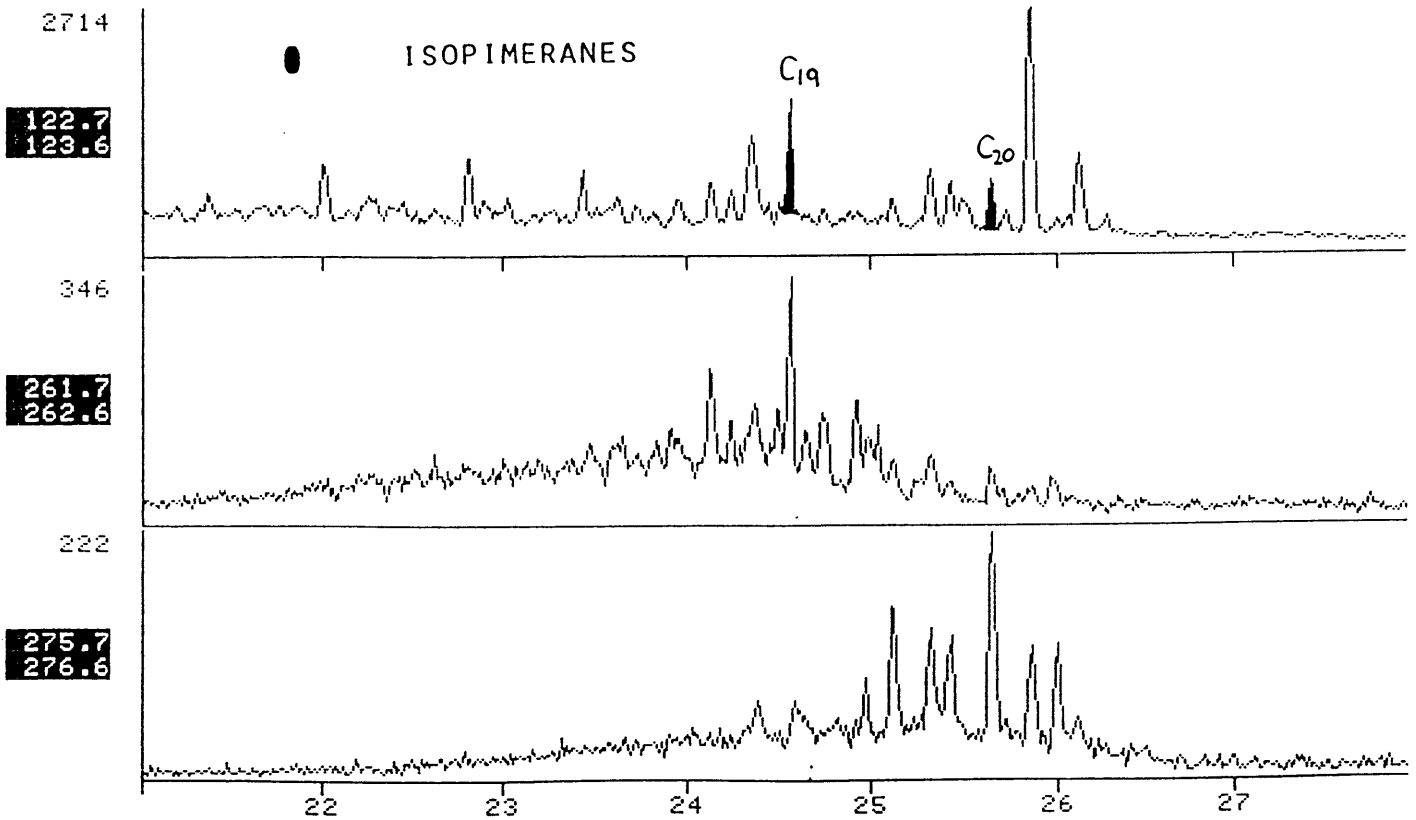


FIGURE 16-3

NAME DOLPHIN OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 4-6-86. GEC. 0.2ul/320ul. COL#56. P.CONN

FRN 6009

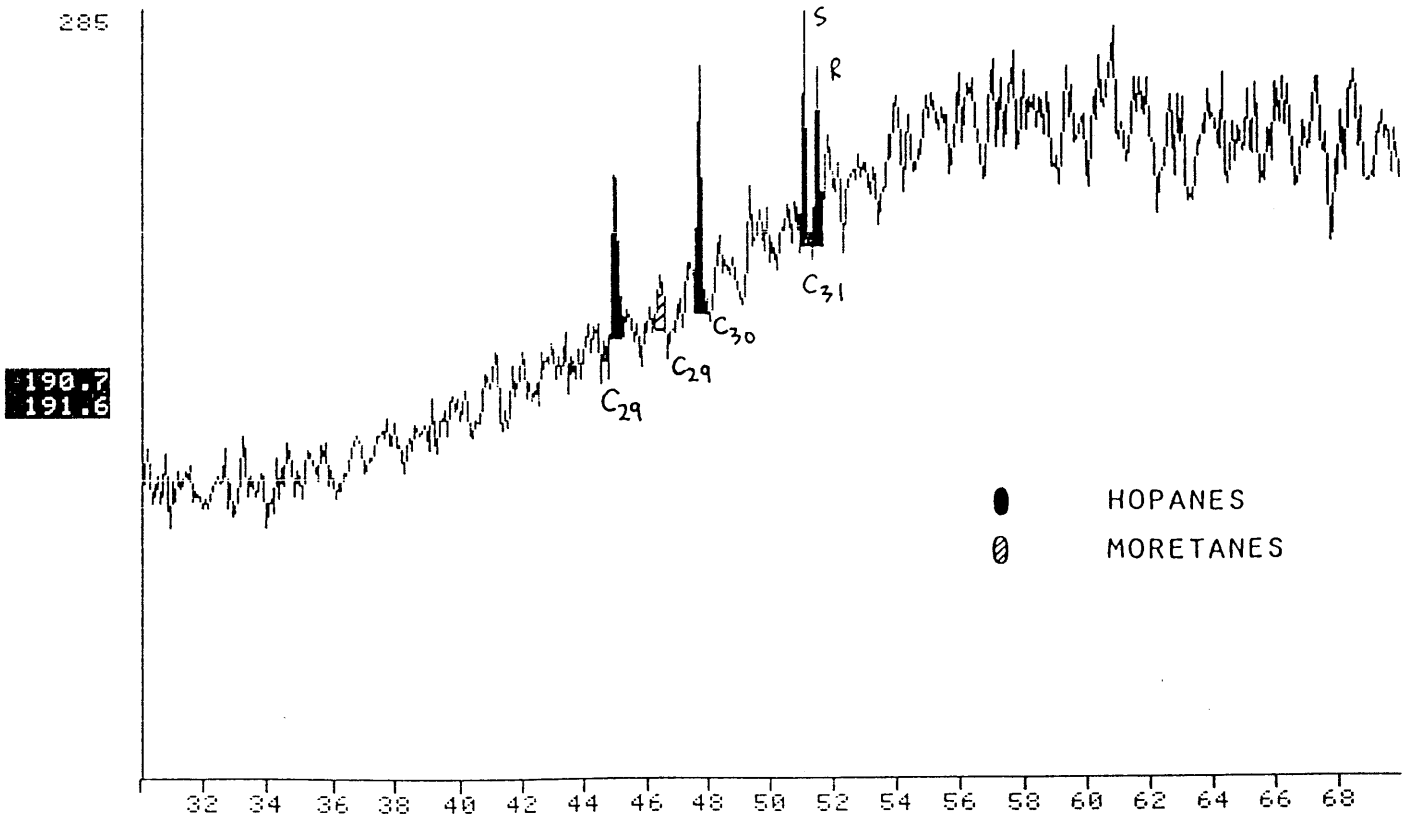
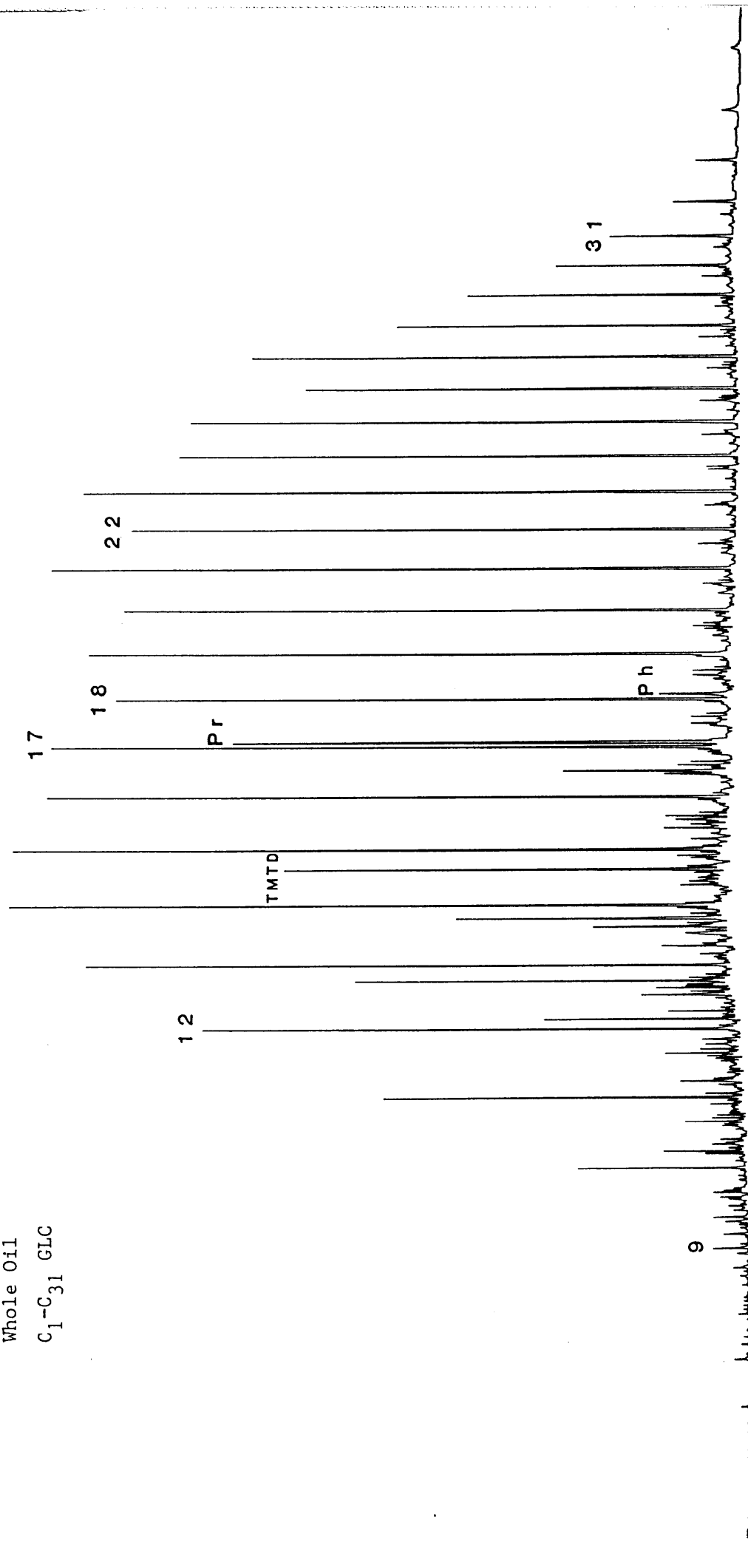


FIGURE 17-1
HALIBUT A - 1, 7500ft
Whole Oil
C₁-C₃₁ GLC



C4-7 COMPOUNDS

- A isobutane
- B n-butane
- C isopentane
- D n-pentane
- E 2,2-dimethylbutane
- F cyclopentane
- G 2,3-dimethylbutane
- H 2-methylpentane
- I 3-methylpentane
- J n-hexane
- K methylcyclopentane
- L 2,4-dimethylpentane
- M benzene
- N cyclohexane
- O 1,1-dimethylcyclopentane
- P 2-methylhexane
- Q 3-methylhexane
- R 1 cis-3-dimethylcyclopentane
- S 1 trans-3-dimethylcyclopentane
- T 1 trans-2-dimethylcyclopentane
- U n-heptane
- V methylcyclohexane
- W 1 cis-2-dimethylcyclopentane
- X toluene

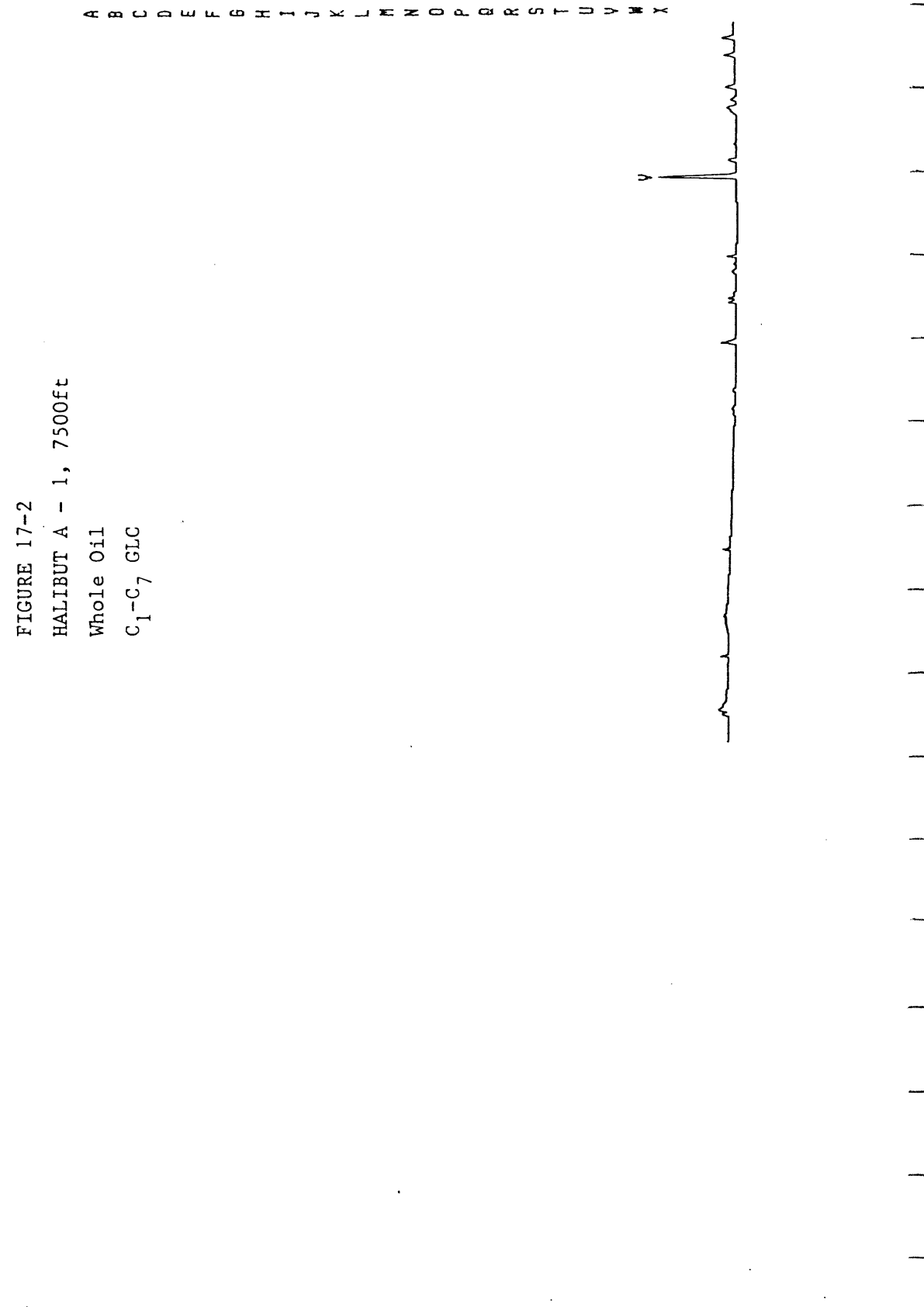
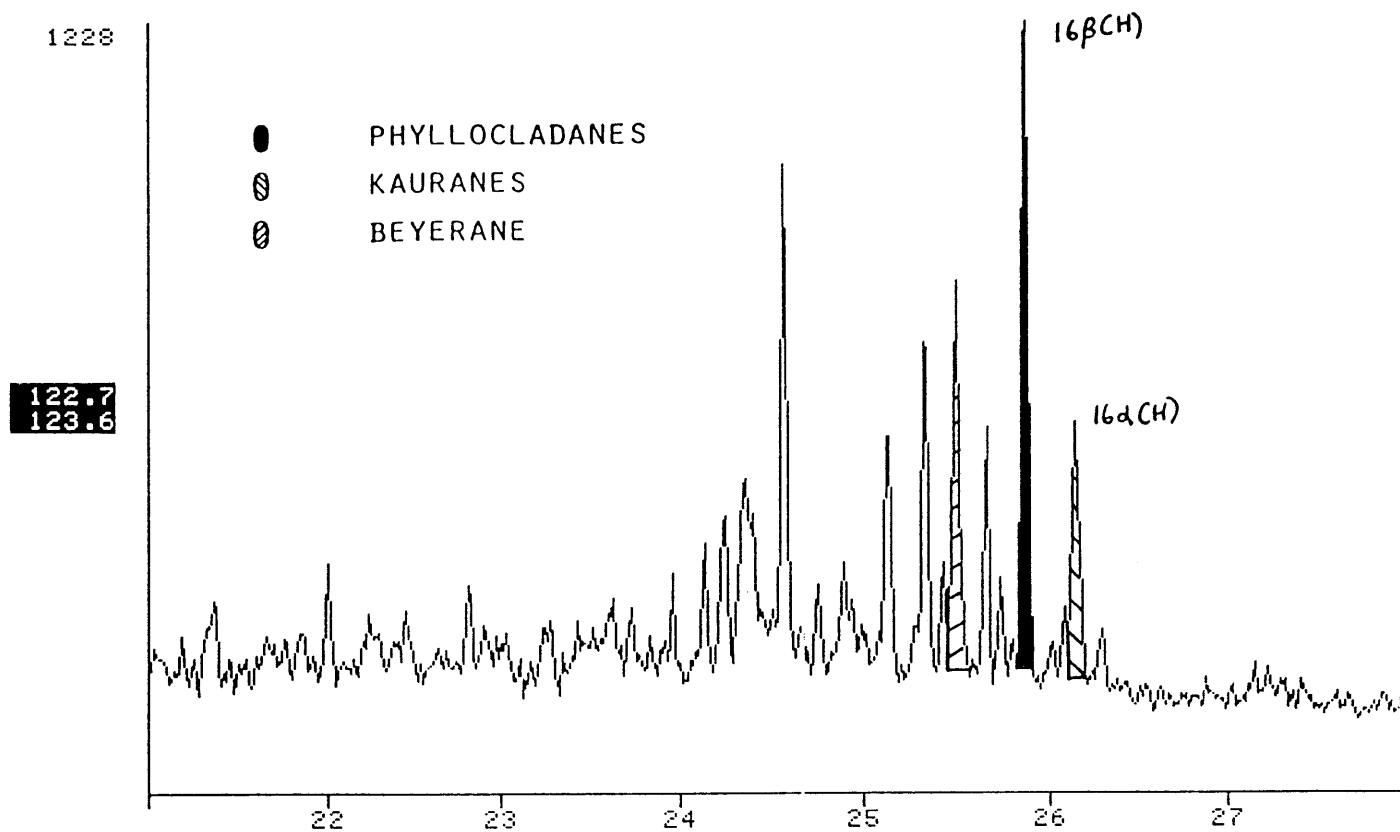


FIGURE 17-2
 HALIBUT A - 1, 7500ft
 Whole Oil
 C₁-C₇ GLC

FIGURE 18-2

NAME HALIBUT, A-1. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 9-6-86. GEC. 0.2ul/350ul. COL#56. P.CONN

FRN 6014



NAME HALIBUT, A-1. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 9-6-86. GEC. 0.2ul/350ul. COL#56. P.CONN

FRN 6014

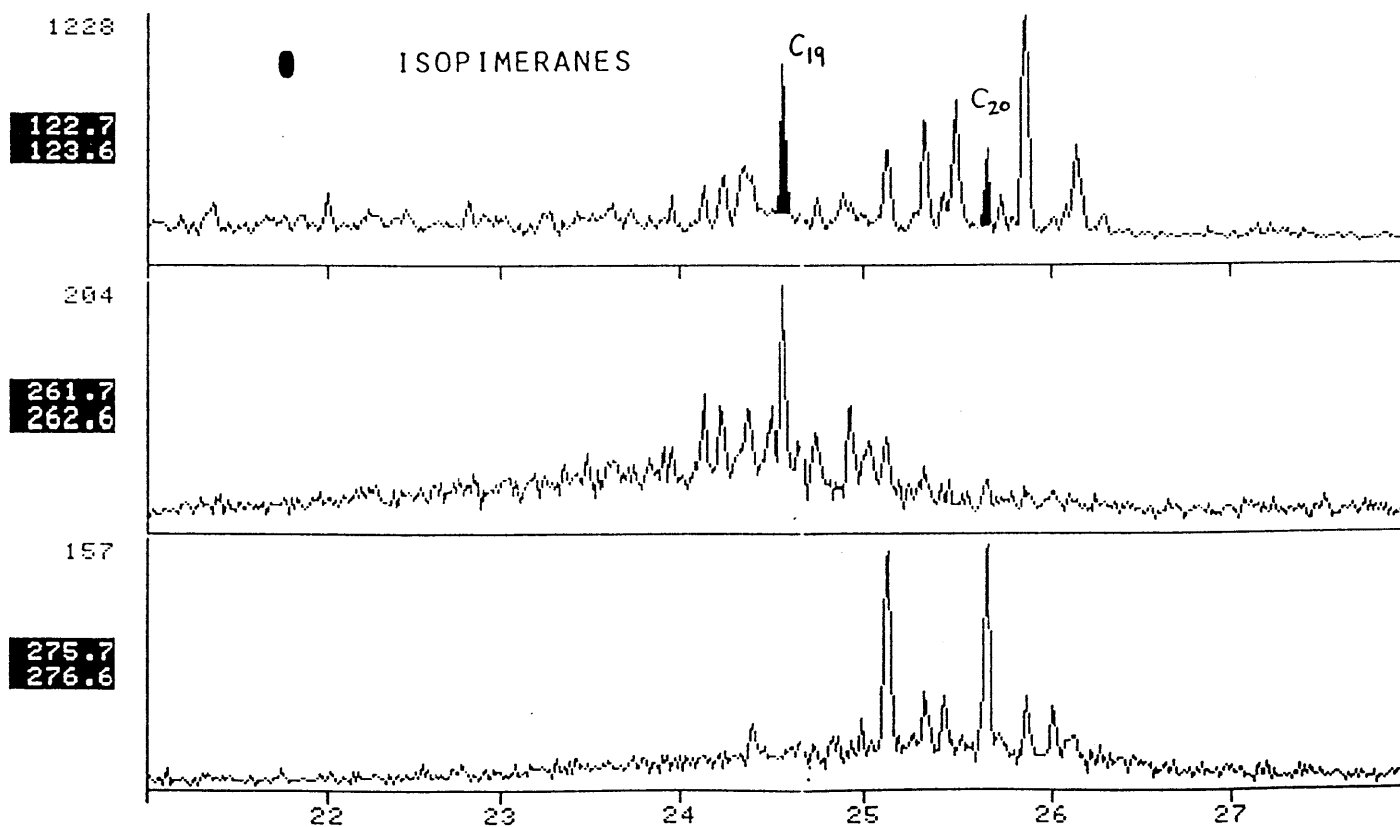


FIGURE 18-3

NAME HALIBUT, A-1. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 9-6-86. GEC. 0.2ul/350ul. COL#56. P.COMN

FRN 6014

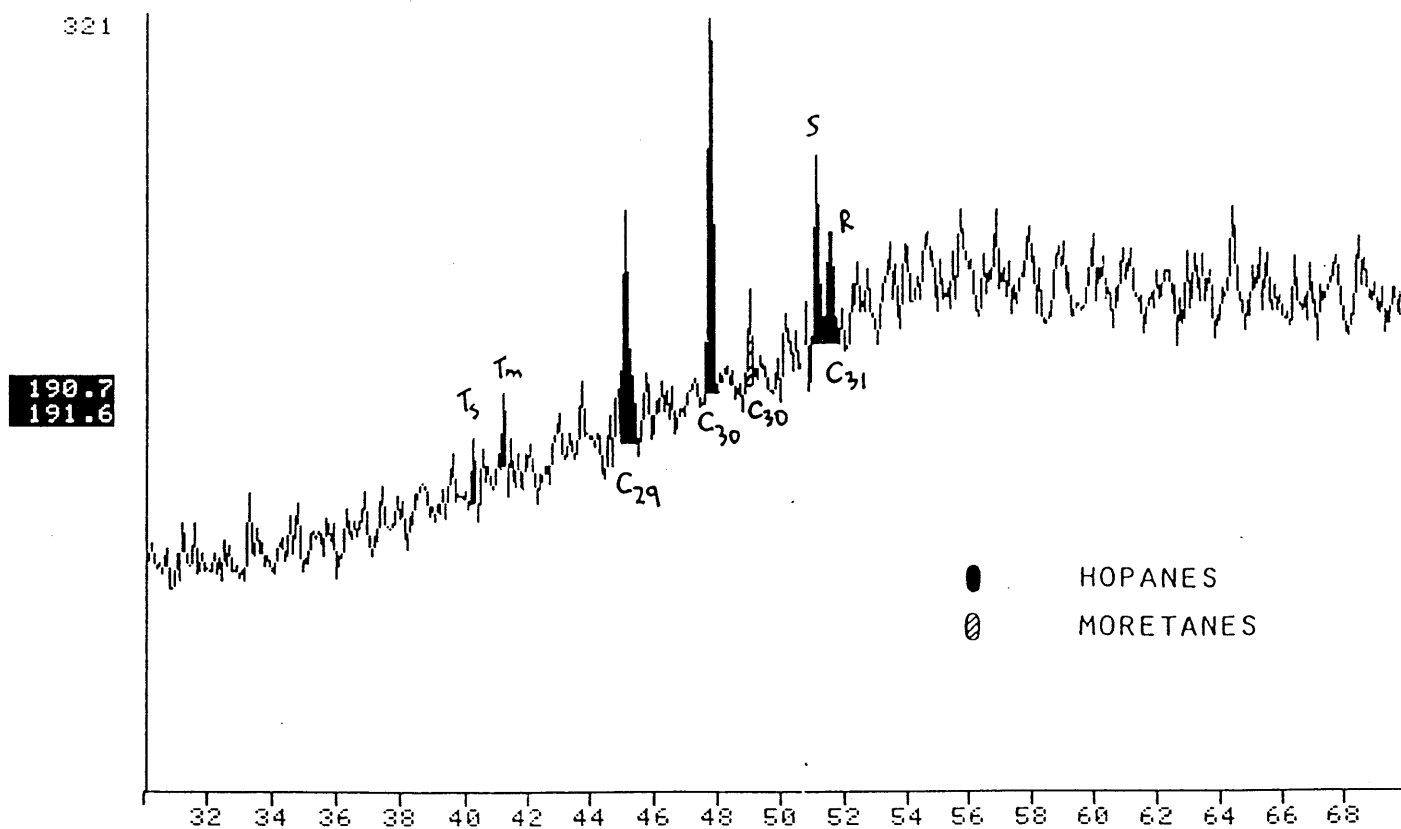


FIGURE 19-1

MARLIN A-24, FIT-14, 3183m

Whole Oil

C₁-C₃₁ GLC

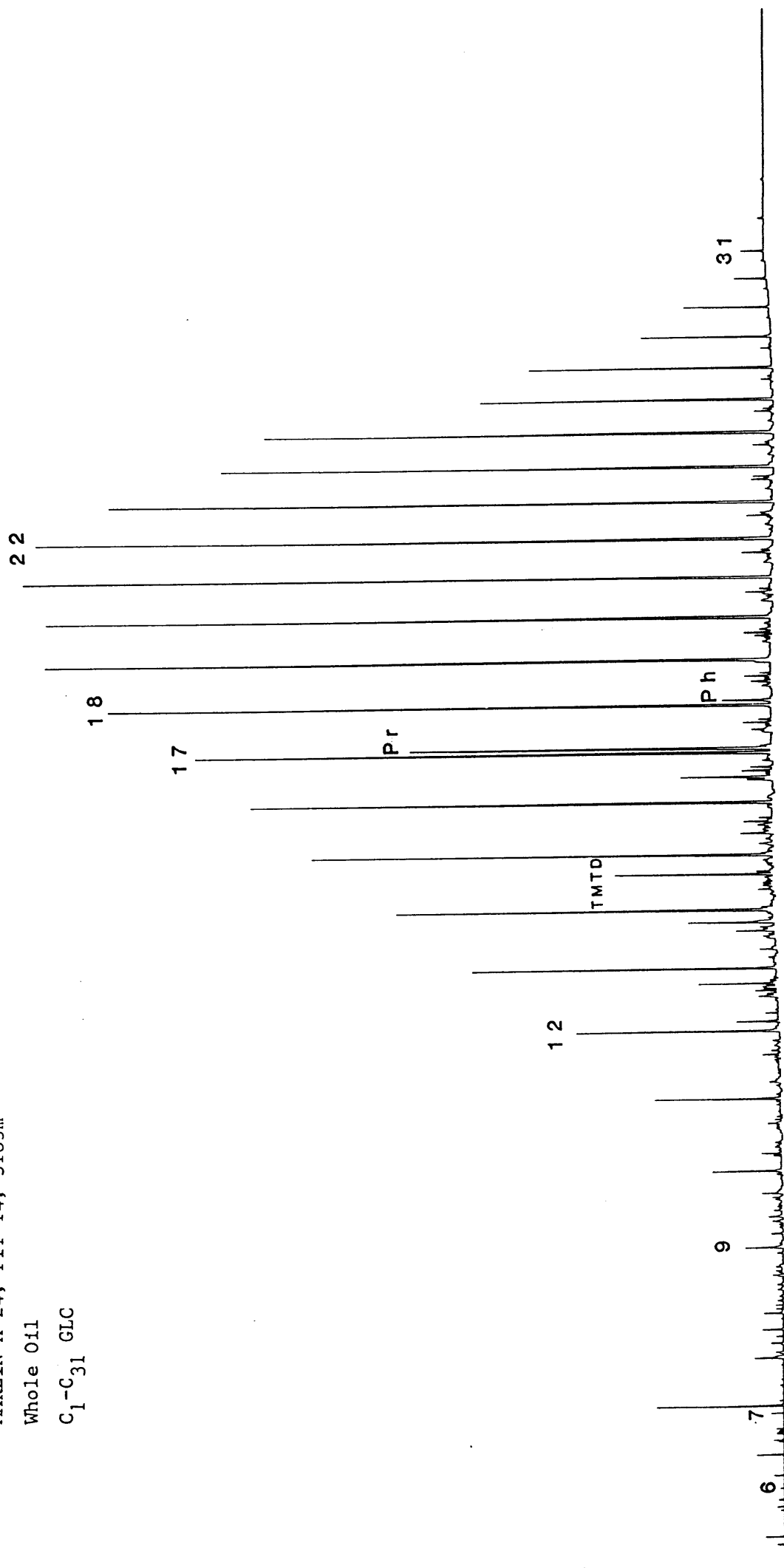


FIGURE 19-2
 MARLIN A-24, FIT-14, 3183m
 Whole Oil
 C₁-C₇ GLC

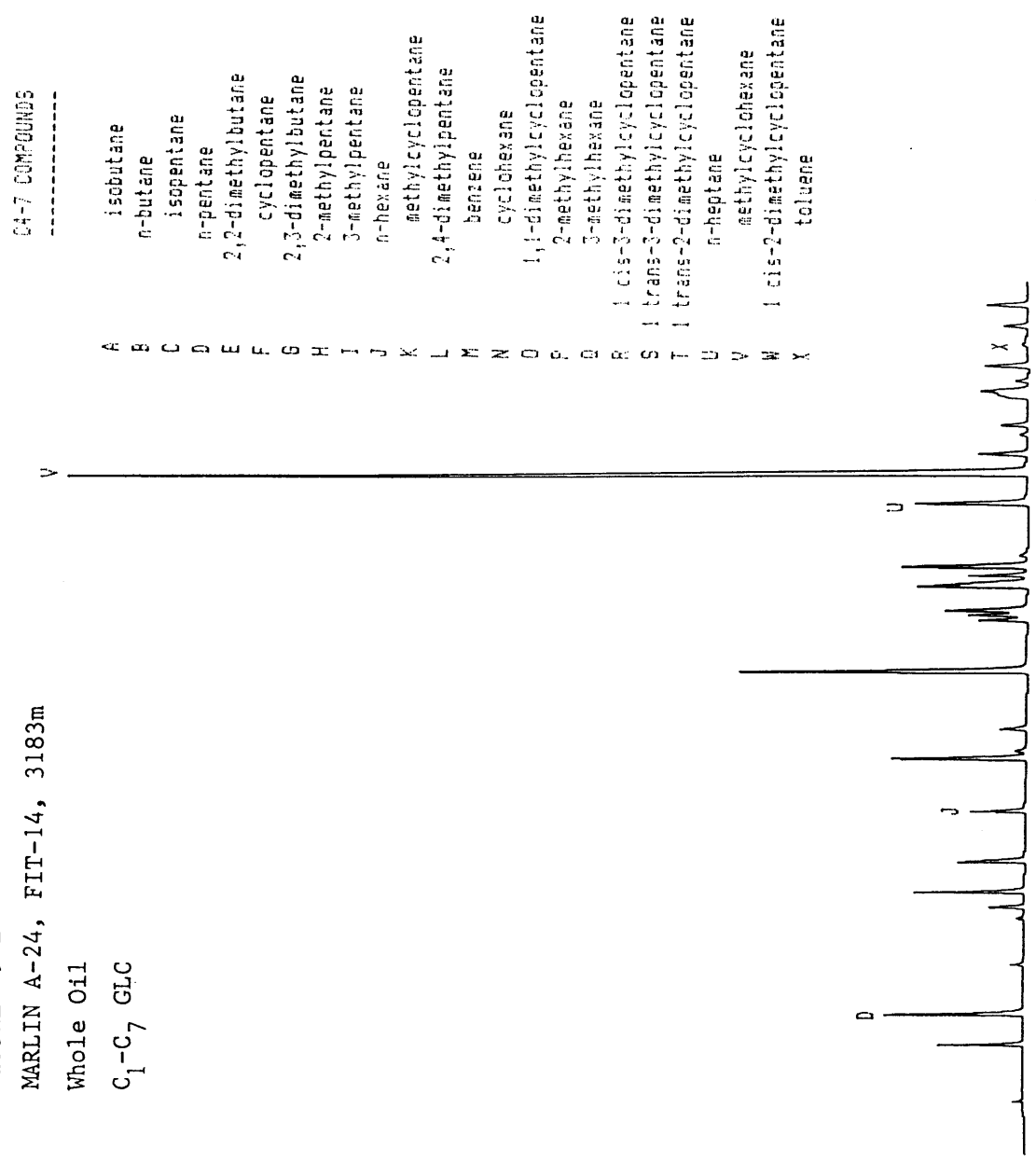
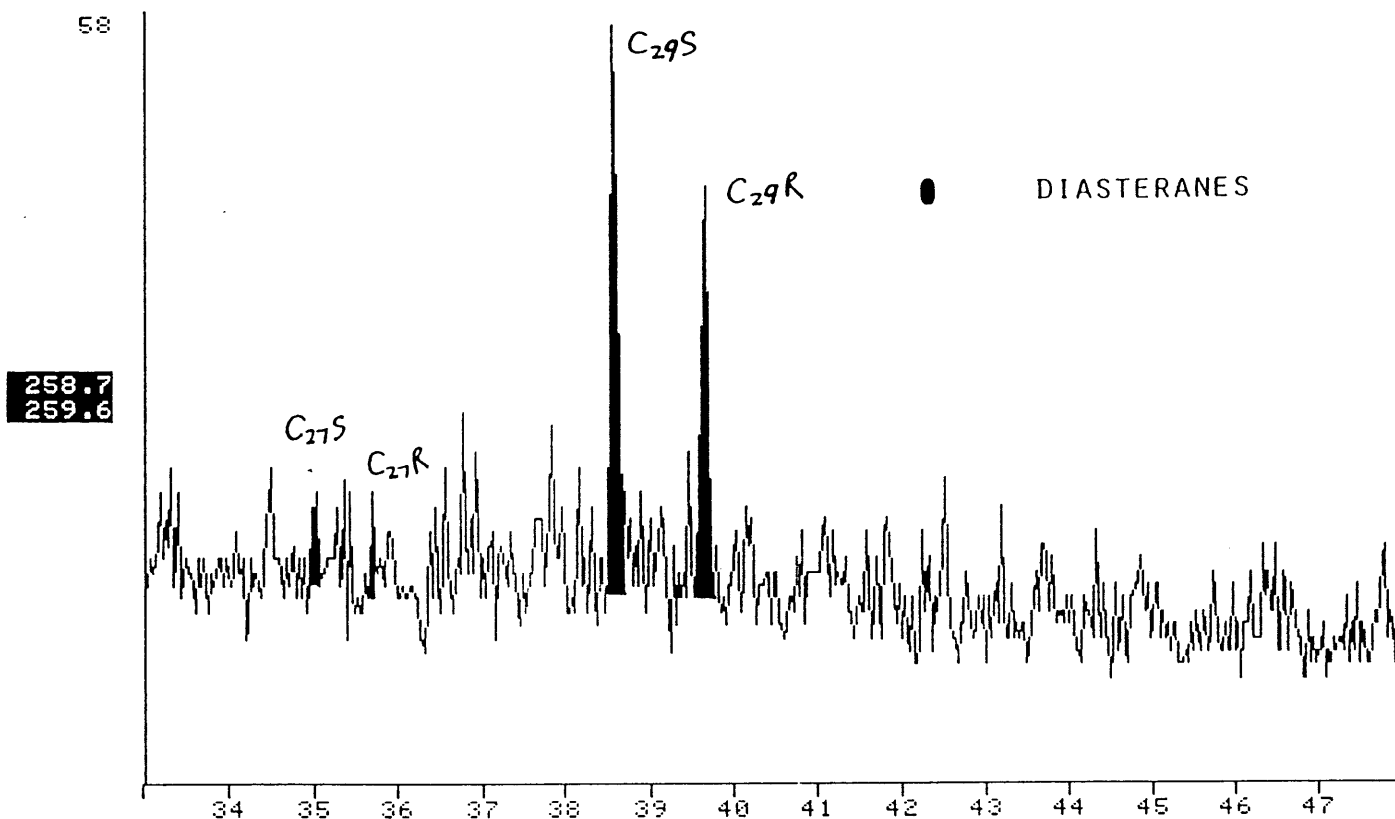


FIGURE 20-1

NAME MARLIN, A-24. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 9-6-86. GEC. 0.2ul/450ul. COL#56. P.CONN

FRN 6013



NAME MARLIN, A-24. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 9-6-86. GEC. 0.2ul/450ul. COL#56. P.CONN

FRN 6013

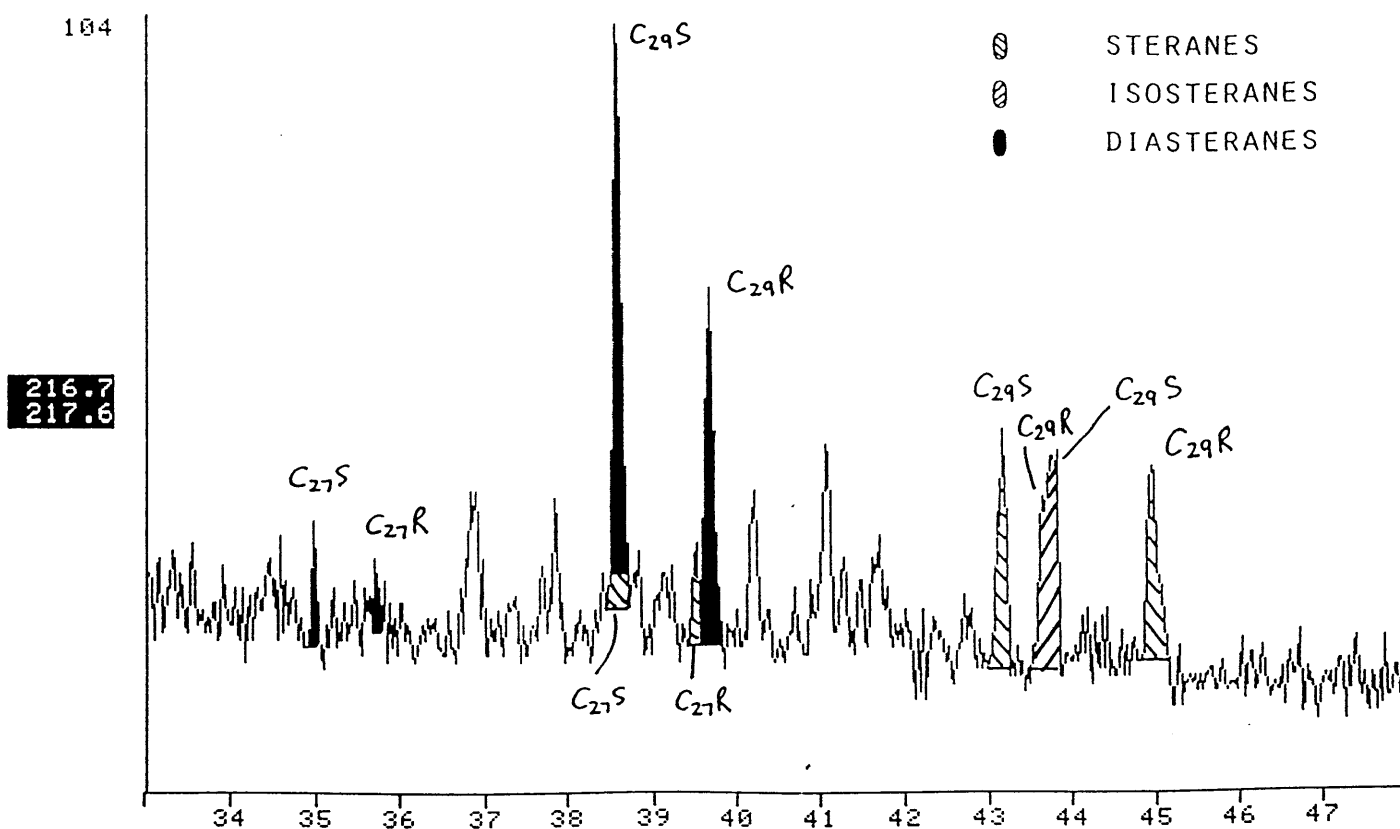
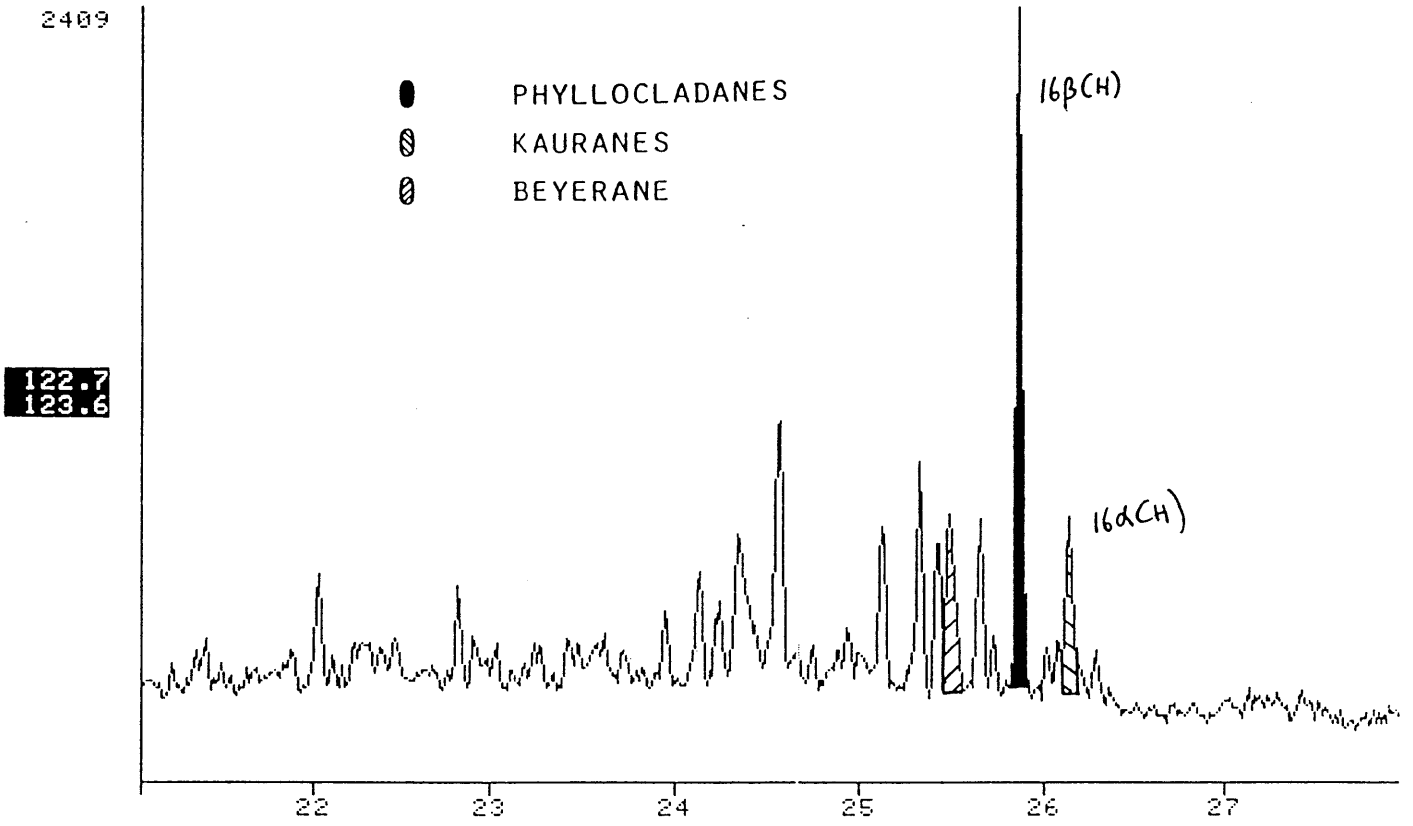


FIGURE 20-2

NAME MARLIN, A-24. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 9-6-86. GEC. 0.2ul/450ul. COL#56. P.CONN

FRN 6013



NAME MARLIN, A-24. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 9-6-86. GEC. 0.2ul/450ul. COL#56. P.CONN

FRN 6013

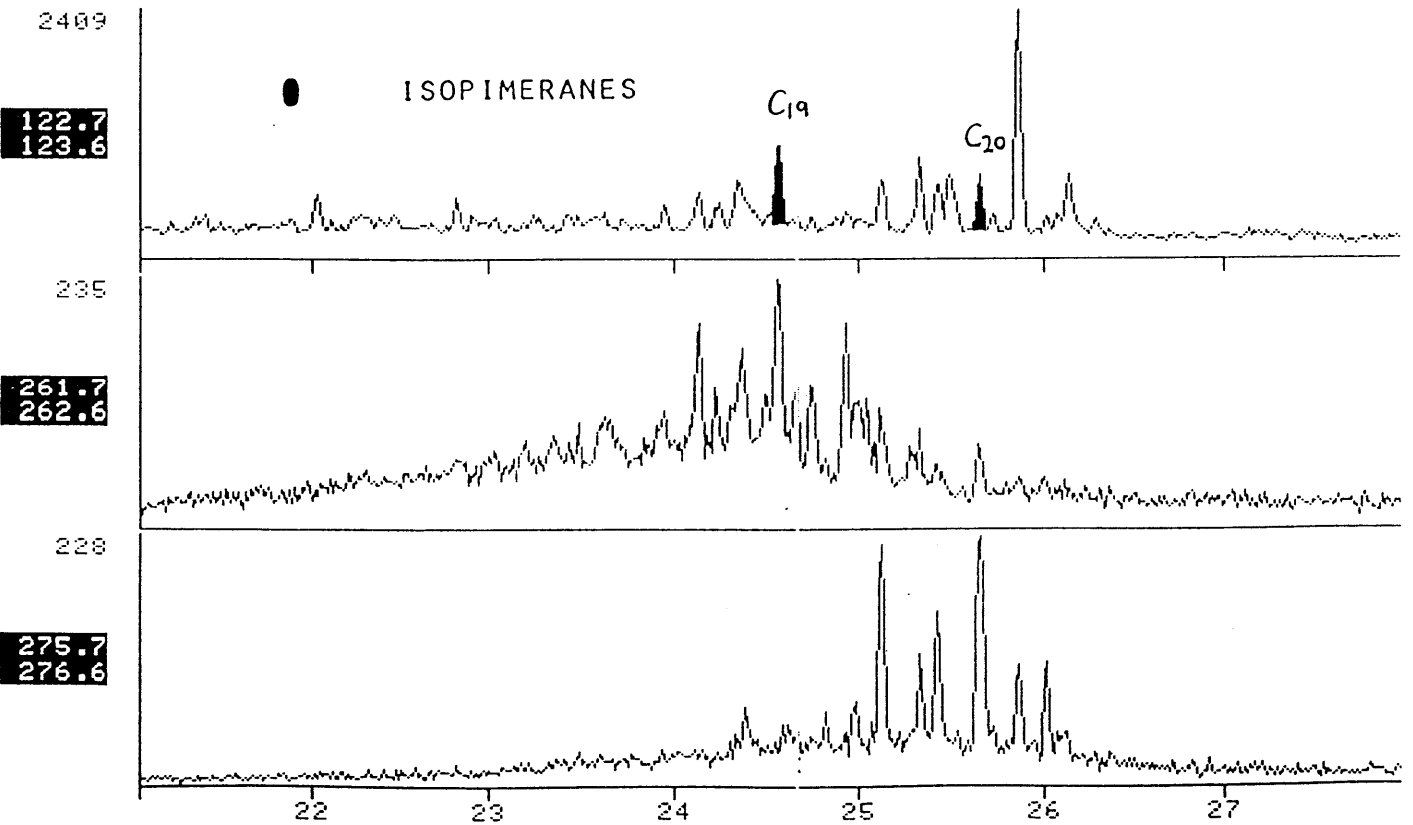


FIGURE 20-3

NAME MARLIN, A-24. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 9-6-86. GEC. 0.201/450ul. COL#56. P.CONN

FRN 6013

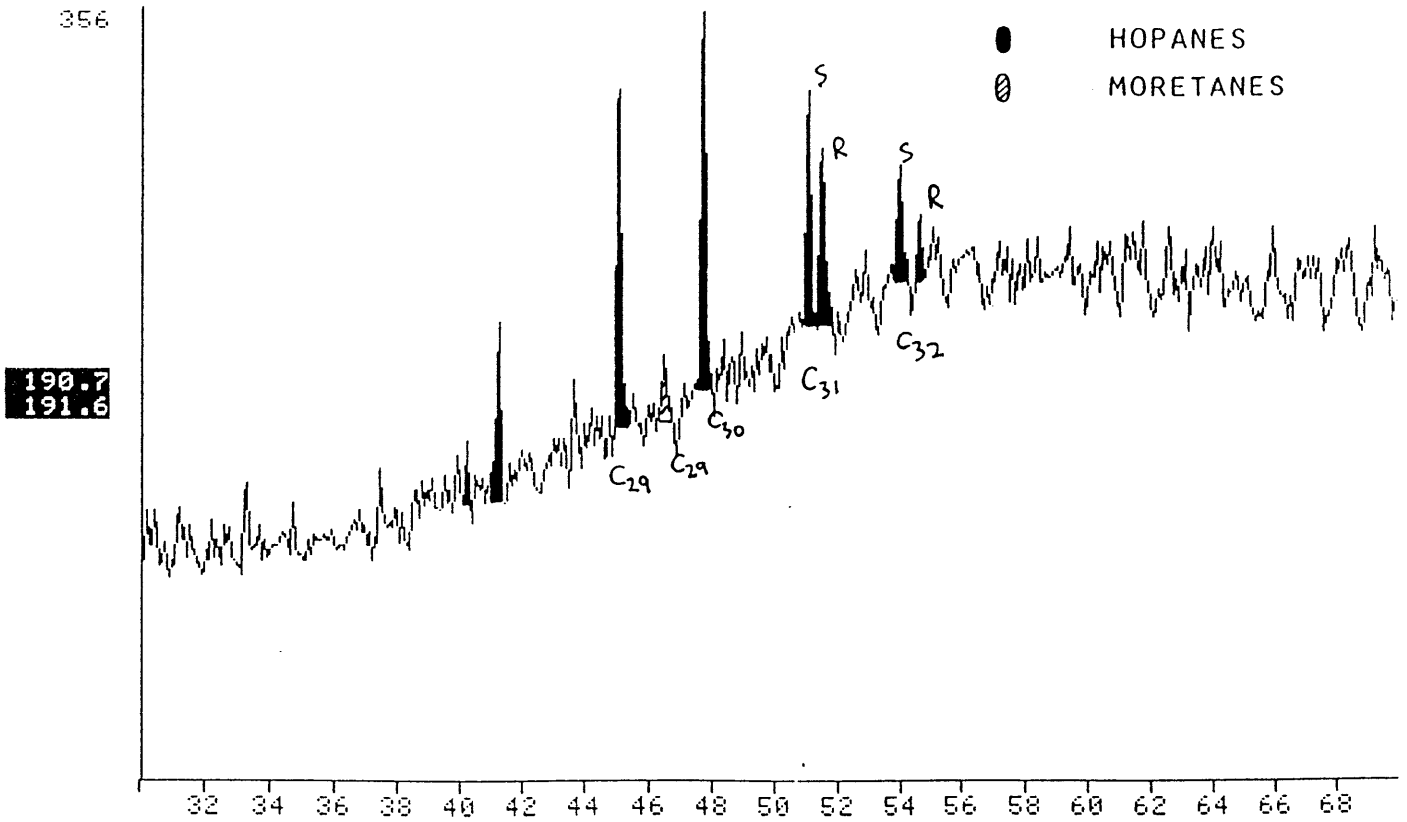


FIGURE 21-1
TUNA A - 2, 1996-2005m
Whole Oil
C₁-C₃₁ GLC

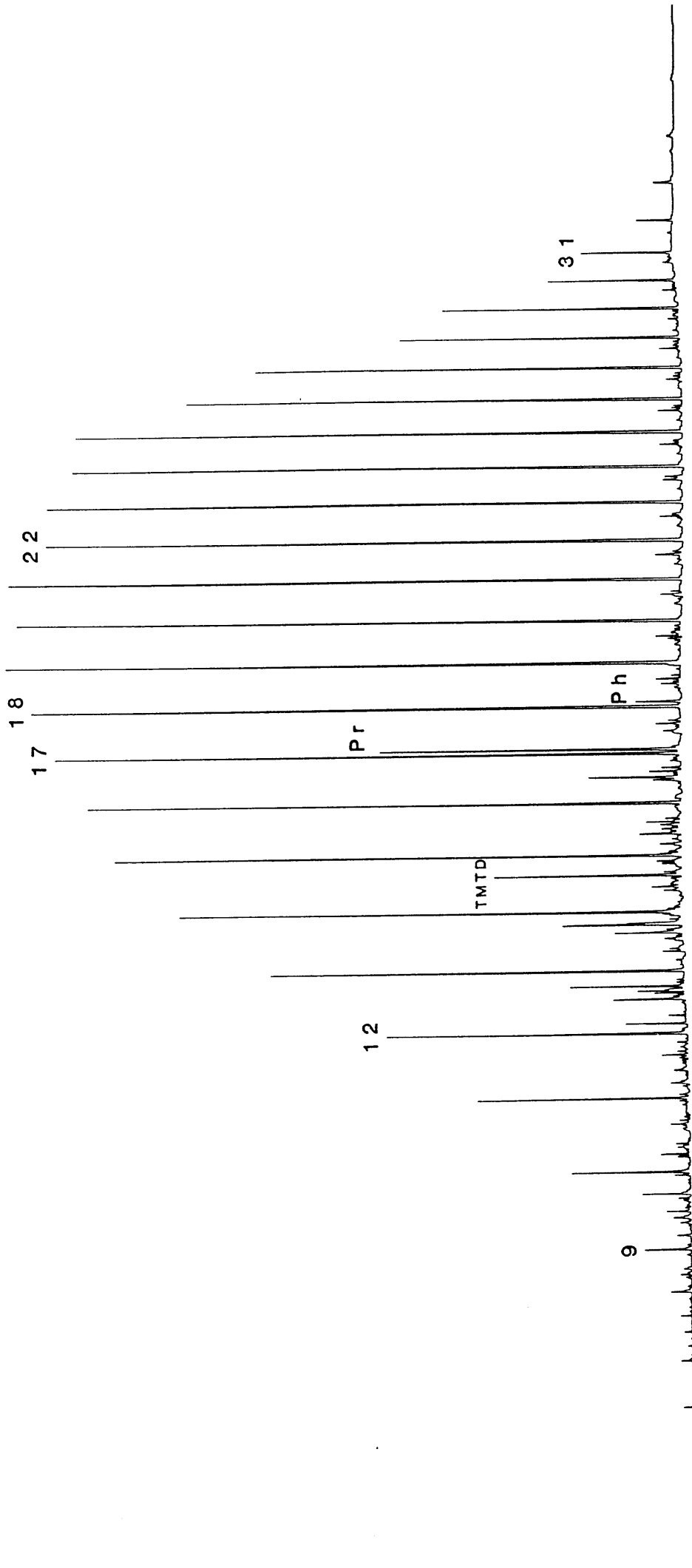


FIGURE 21-2

TUNA A - 2, 1996-2005m

Whole Oil

C₁-C₇ GLC

C4-7 COMPOUNDS

- A isobutane
- B n-butane
- C isopentane
- D n-pentane
- E 2,2-dimethylbutane
- F cyclopentane
- G 2,3-dimethylbutane
- H 2-methylpentane
- I 3-methylpentane
- J n-hexane
- K methylcyclopentane
- L 2,4-dimethylpentane
- M benzene
- N cyclohexane
- O 1,1-dimethylcyclopentane
- P 2-methylhexane
- Q 3-methylhexane
- R 1 cis-3-dimethylcyclopentane
- S 1 trans-3-dimethylcyclopentane
- T 1 trans-2-dimethylcyclopentane
- U n-heptane
- V methylcyclohexane
- W 1 cis-2-dimethylcyclopentane
- X toluene

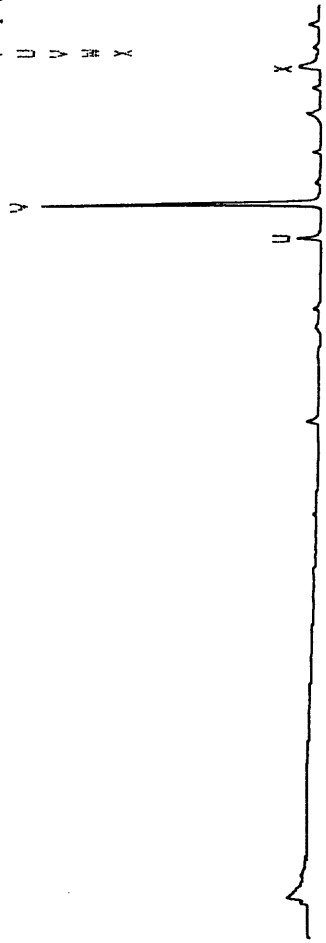
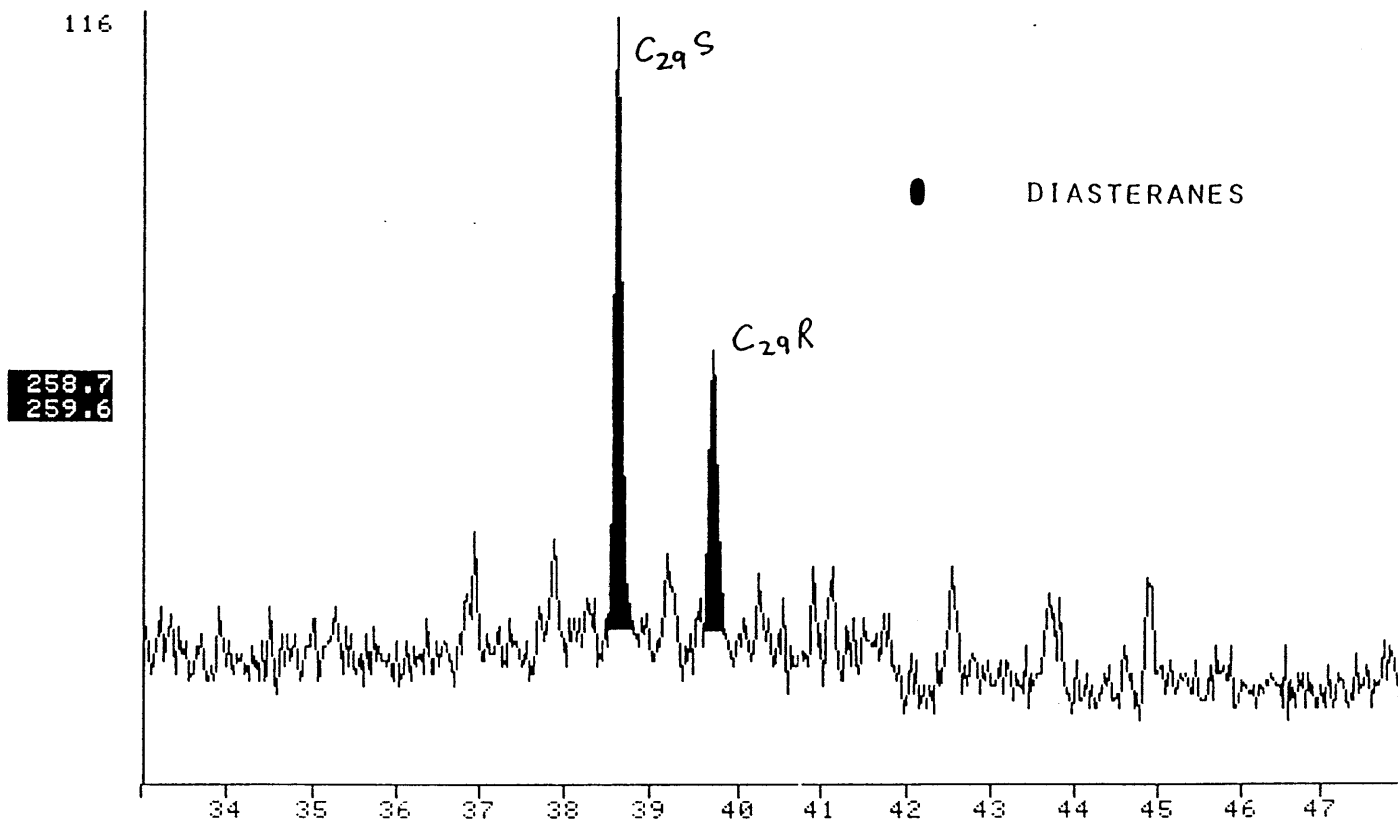


FIGURE 22-1

NAME TUNA, A-2. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 10-6-86. GEC. 0.2ul/150ul. COL#56. P.COM

FRN 6015



NAME TUNA, A-2. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 10-6-86. GEC. 0.2ul/150ul. COL#56. P.COM

FRN 6015

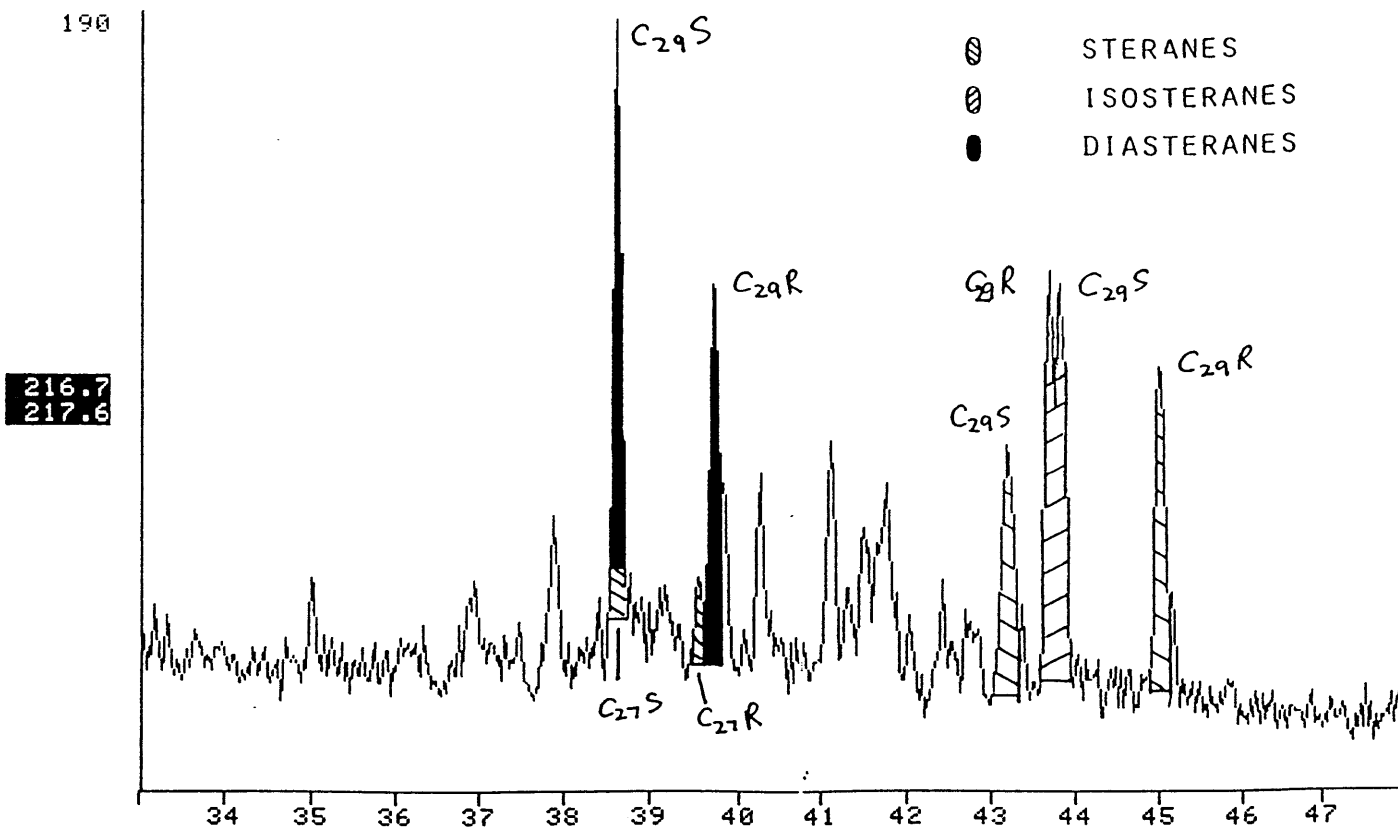
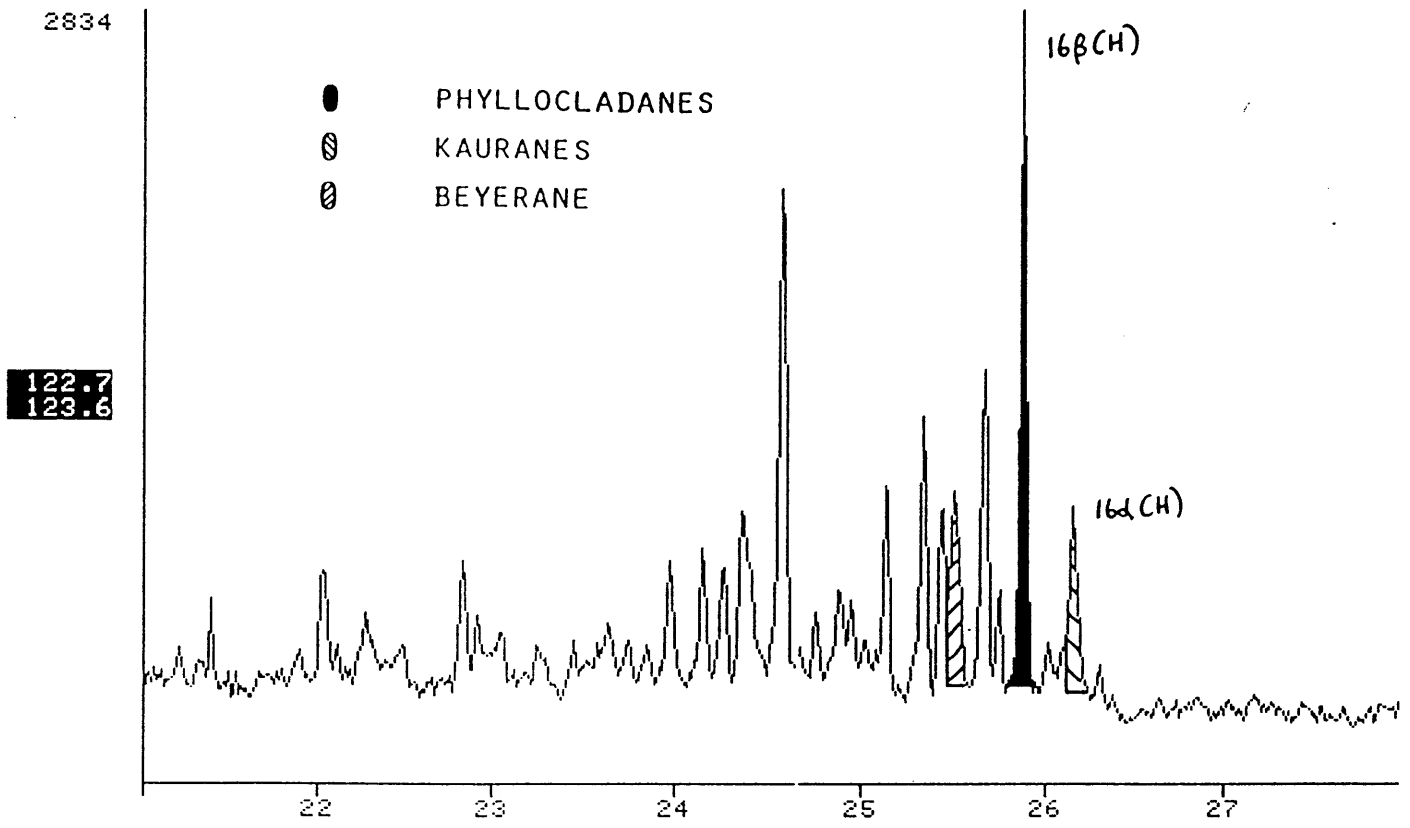


FIGURE 22-2

NAME TUNA, A-2. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 10-6-86. GEC. 0.2ul/150ul. COL#56. P.CON

FRN 6015



NAME TUNA, A-2. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 10-6-86. GEC. 0.2ul/150ul. COL#56. P.CON

FRN 6015

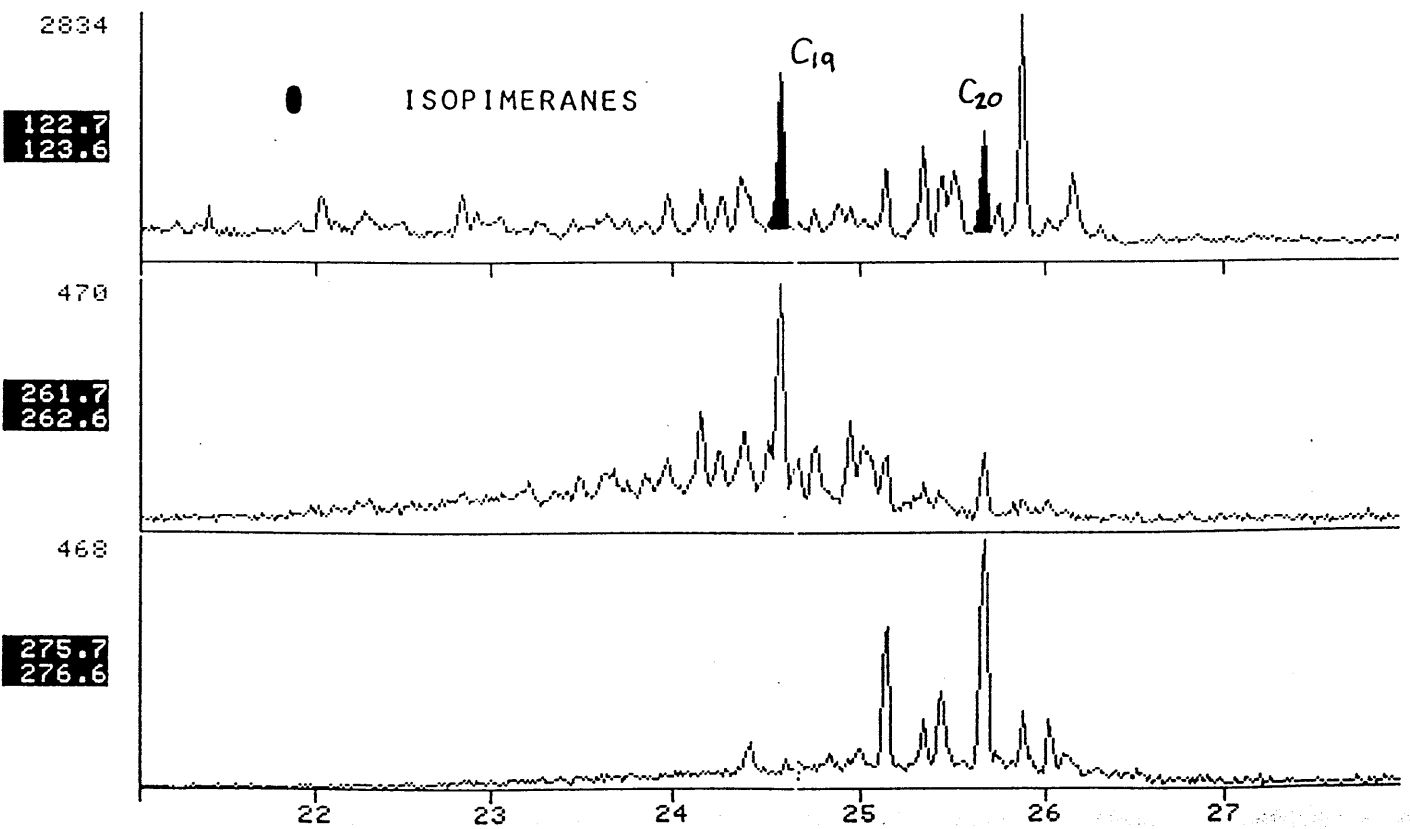


FIGURE 22-3

NAME TUNA, A-2. BRANCHED CYCLIC FRAGMENTOGRAM.
 MISC 10-6-86. GEC. 0.2ul/150ul. COL#56. P.CON

FRN 6015

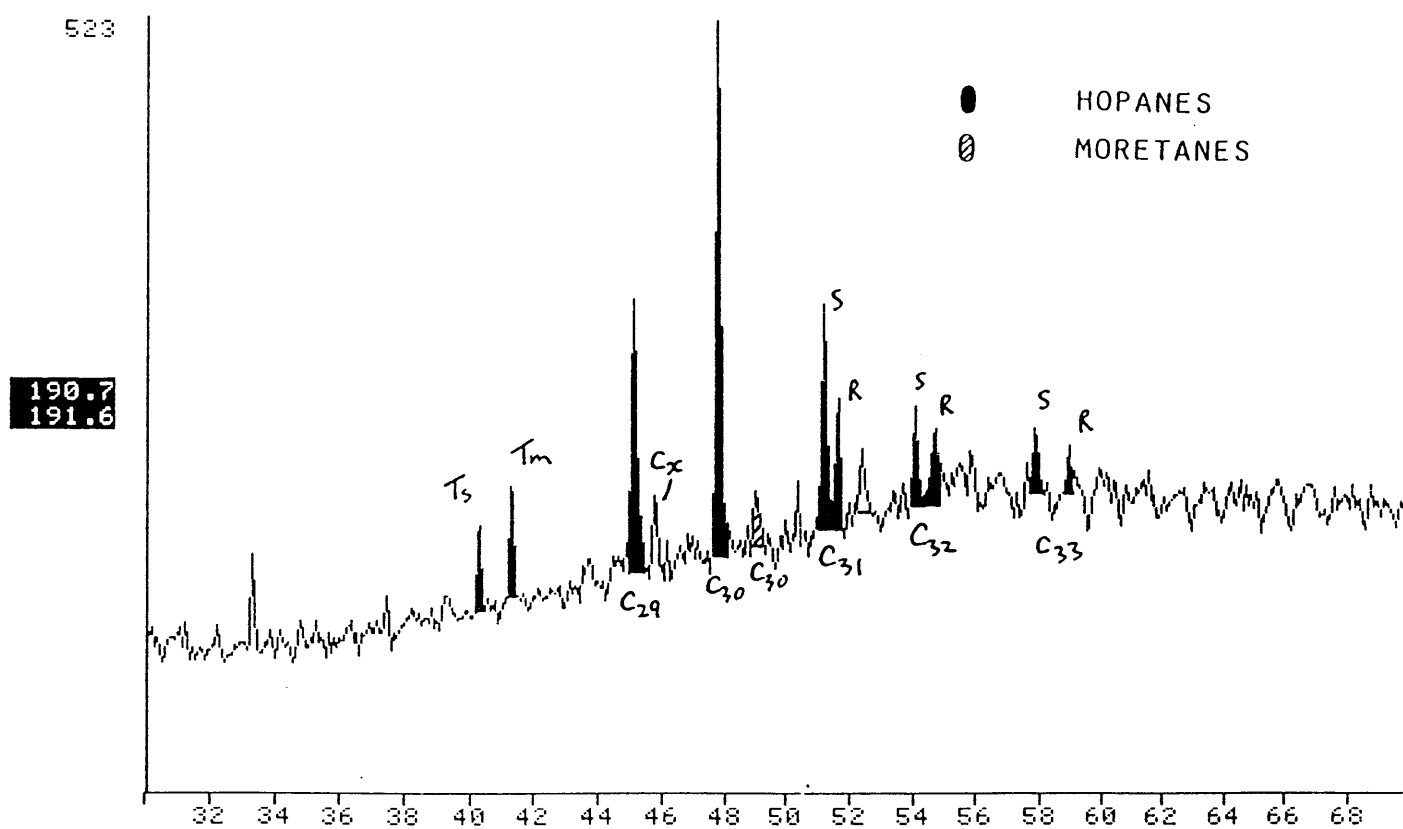


FIGURE 23-1
WEST SEAHORSE 1, 1417m
Whole Oil
C₁-C₃₁ GLC

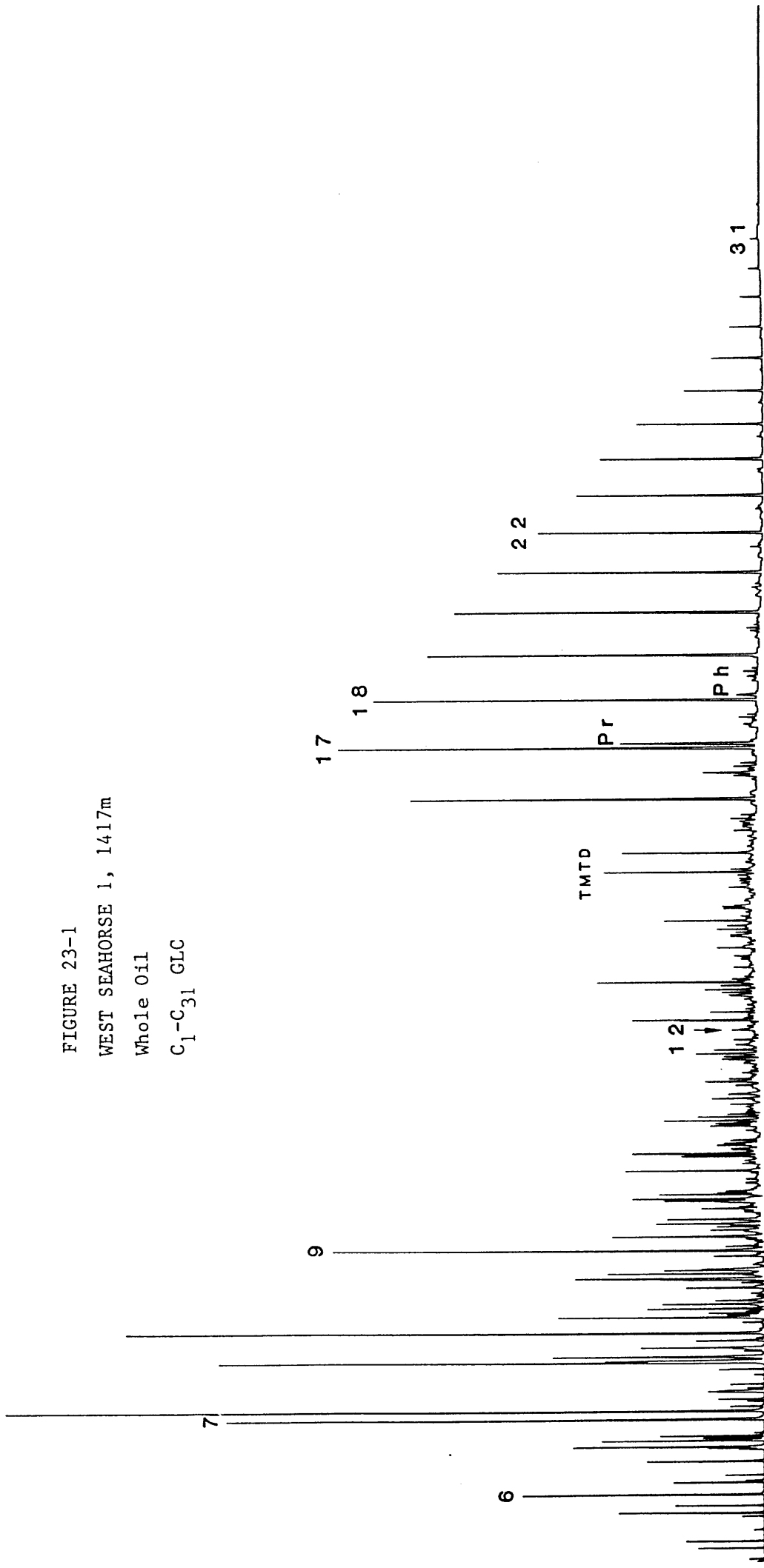
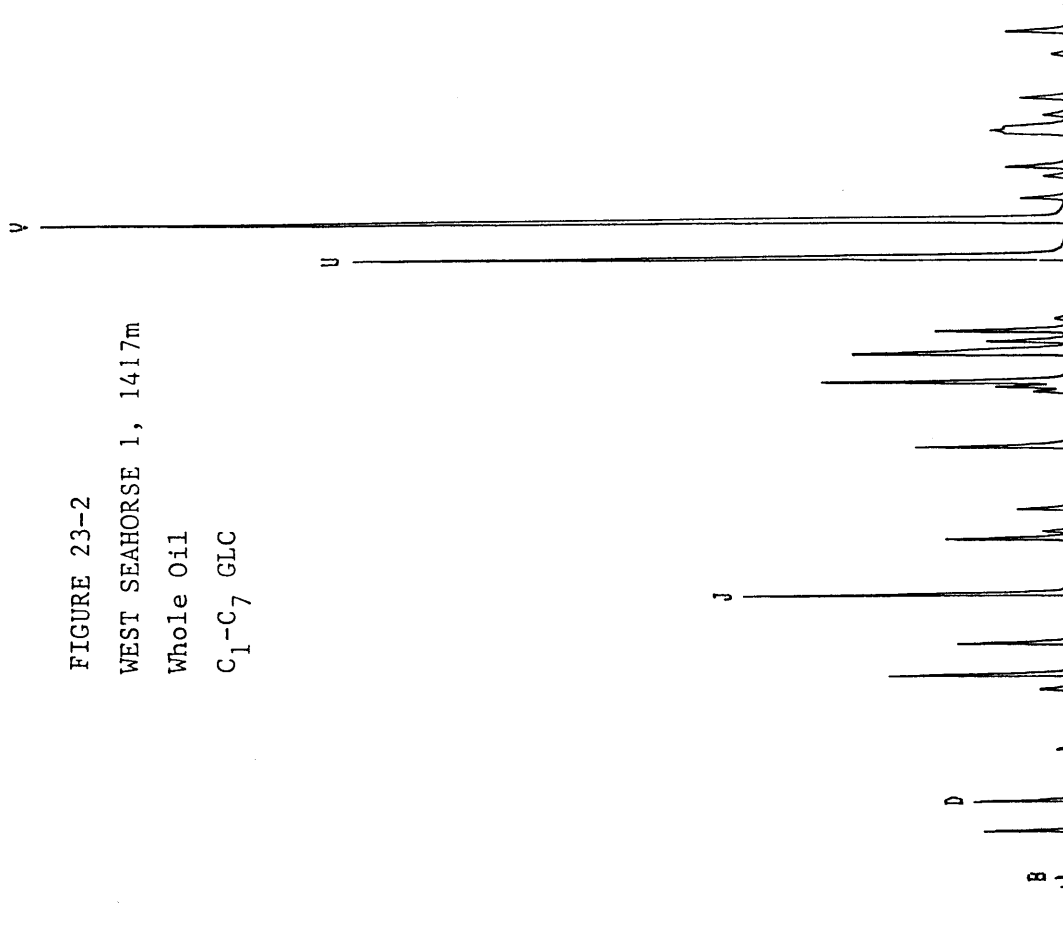


FIGURE 23-2

WEST SEAHORSE 1, 1417m

Whole Oil

C₁-C₇ GLC



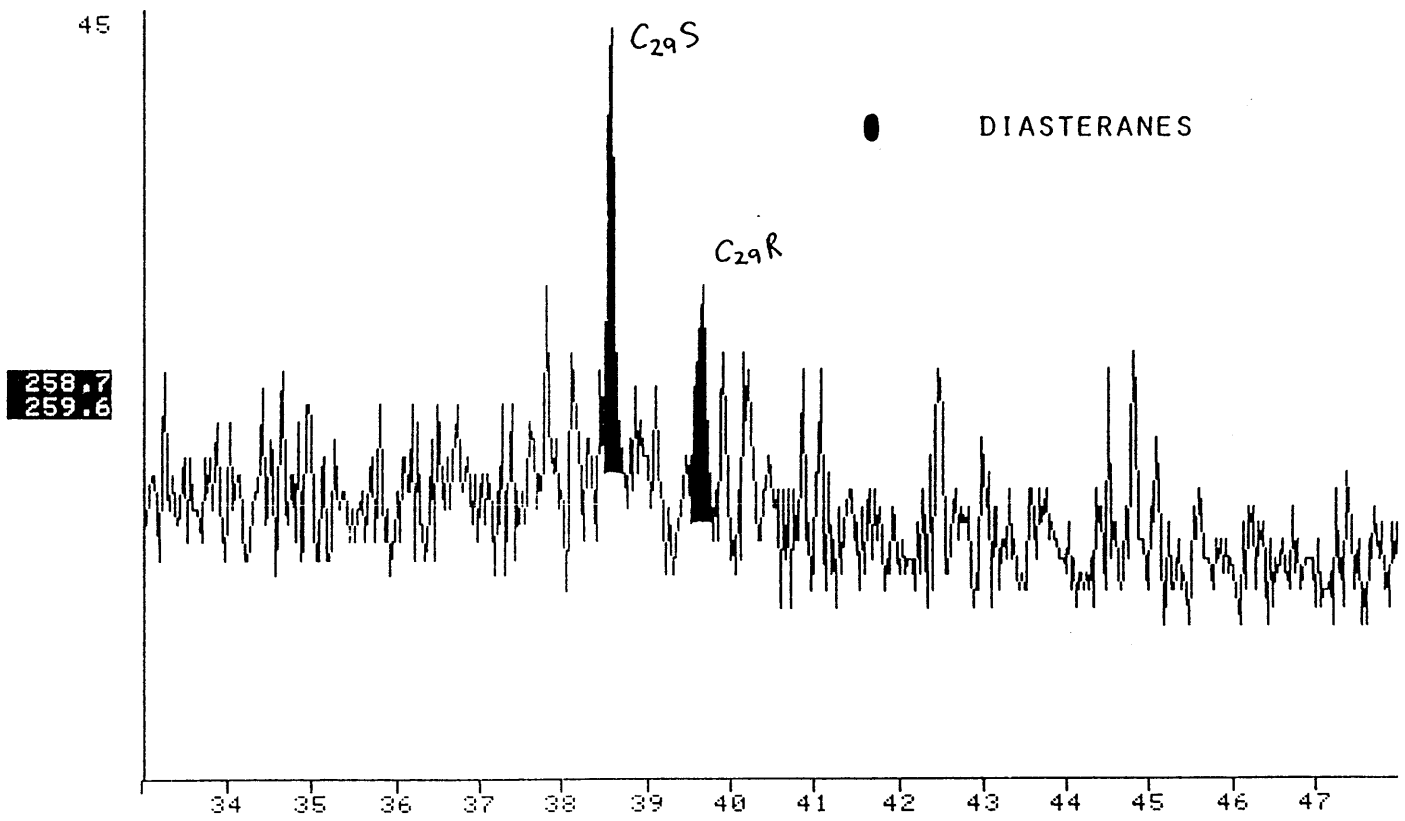
C4-7 COMPOUNDS

- | | |
|---|--------------------------------|
| A | isobutane |
| B | n-butane |
| C | isopentane |
| D | n-pentane |
| E | 2,2-dimethylbutane |
| F | cyclopentane |
| G | 2,3-dimethylbutane |
| H | 2-methylpentane |
| I | 3-methylpentane |
| J | n-hexane |
| K | methylcyclopentane |
| L | 2,4-dimethylpentane |
| M | benzene |
| N | cyclohexane |
| O | 1,1-dimethylcyclopentane |
| P | 2-methylhexane |
| Q | 3-methylhexane |
| R | 1 cis-3-dimethylcyclopentane |
| S | 1 trans-3-dimethylcyclopentane |
| T | 1 trans-2-dimethylcyclopentane |
| U | n-heptane |
| V | methylcyclohexane |
| W | 1 cis-2-dimethylcyclopentane |
| X | toluene |

FIGURE 24-1

NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2u00ul. COL#56. P.CONNARD

FRN 6008



NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2u00ul. COL#56. P.CONNARD

FRN 6008

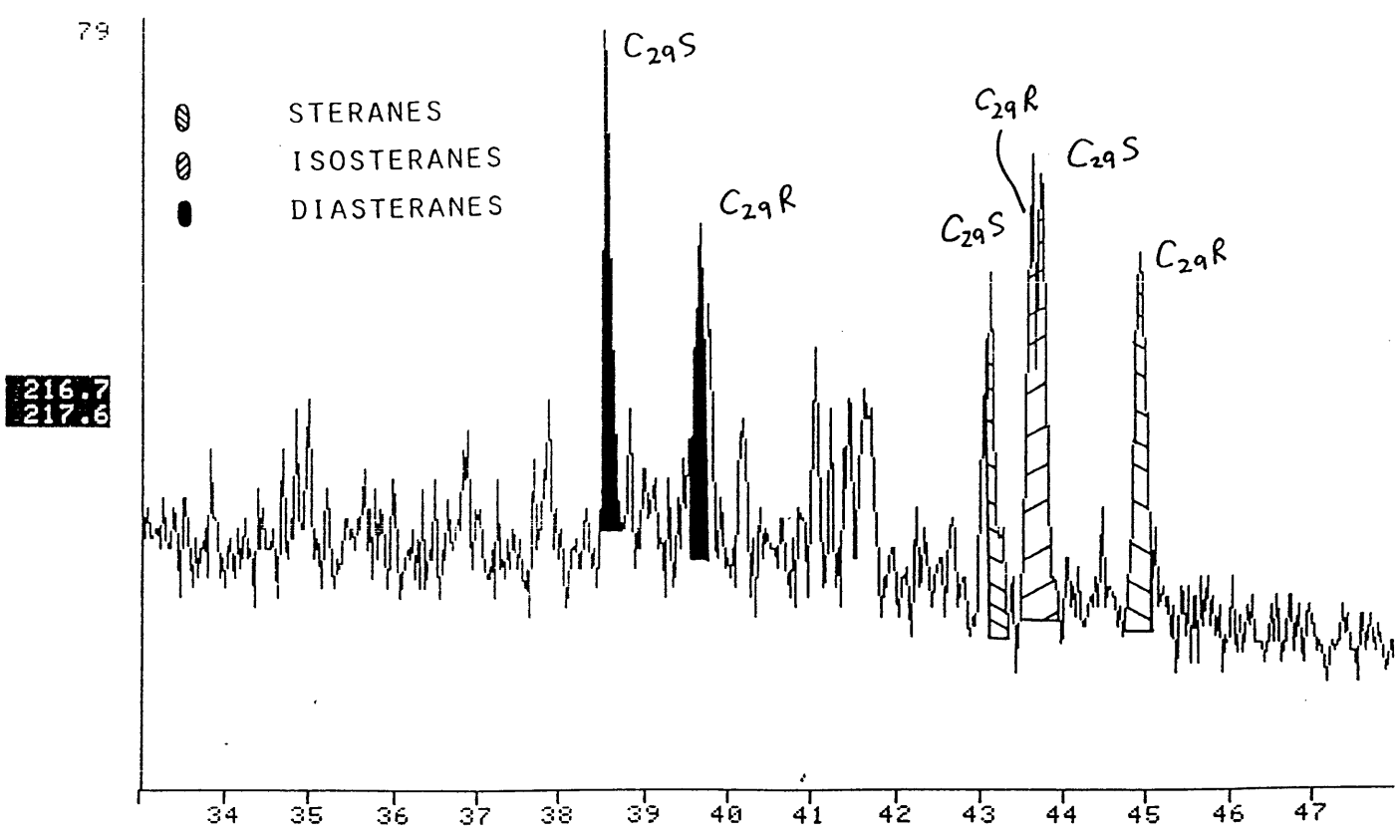
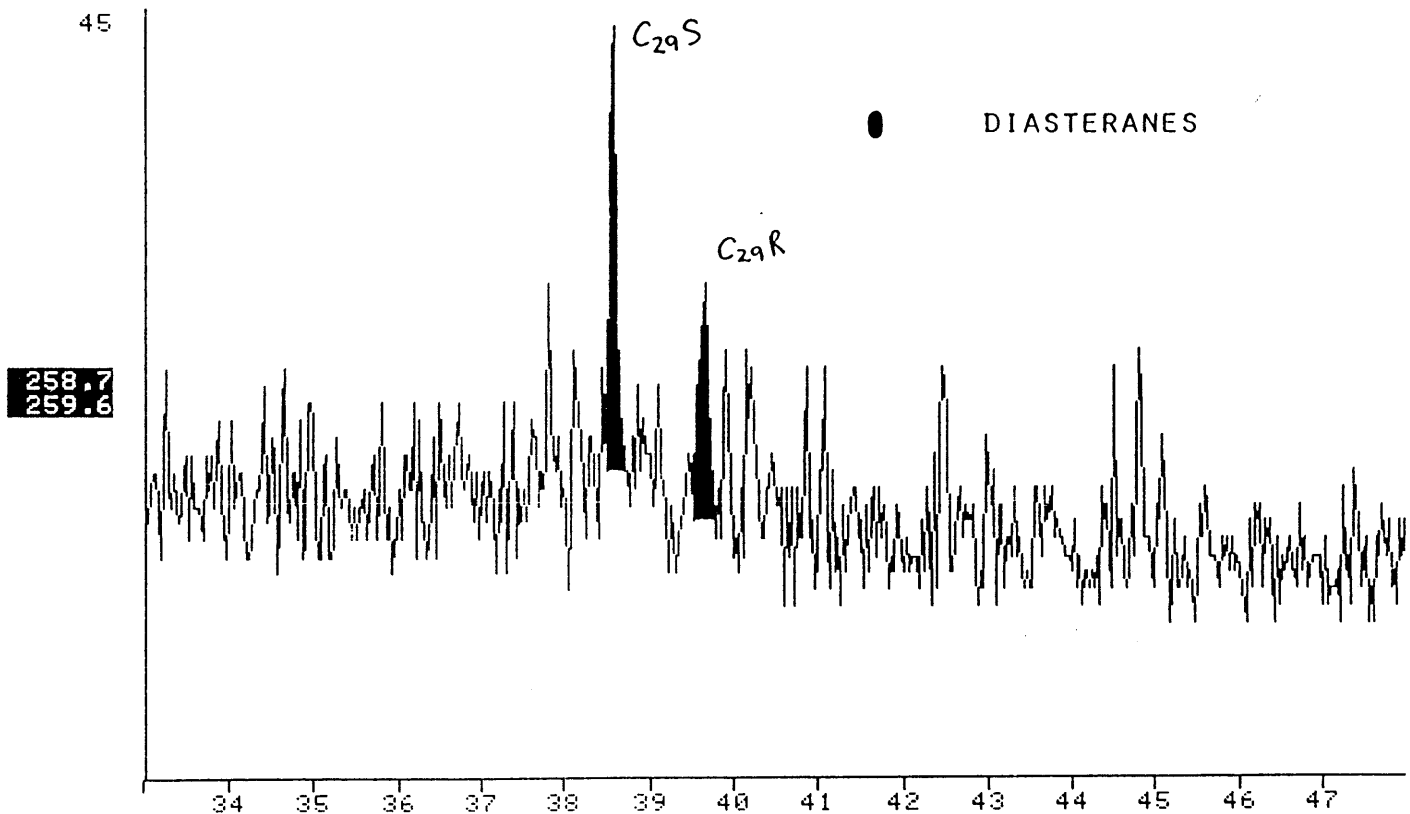


FIGURE 24-1

NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2u000ul. COL#56. P.CONNARD

FRN 6008



NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2u000ul. COL#56. P.CONNARD

FRN 6008

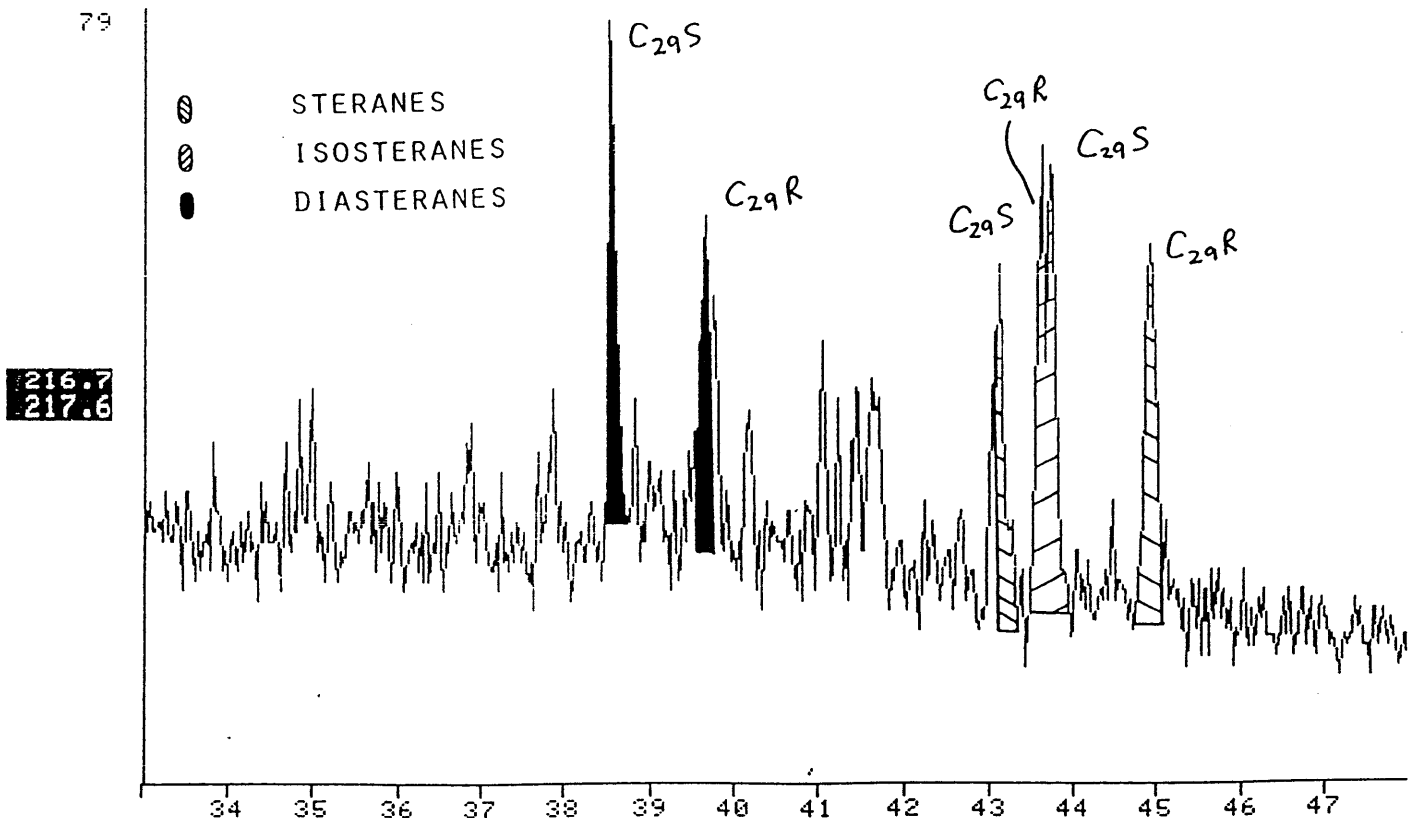
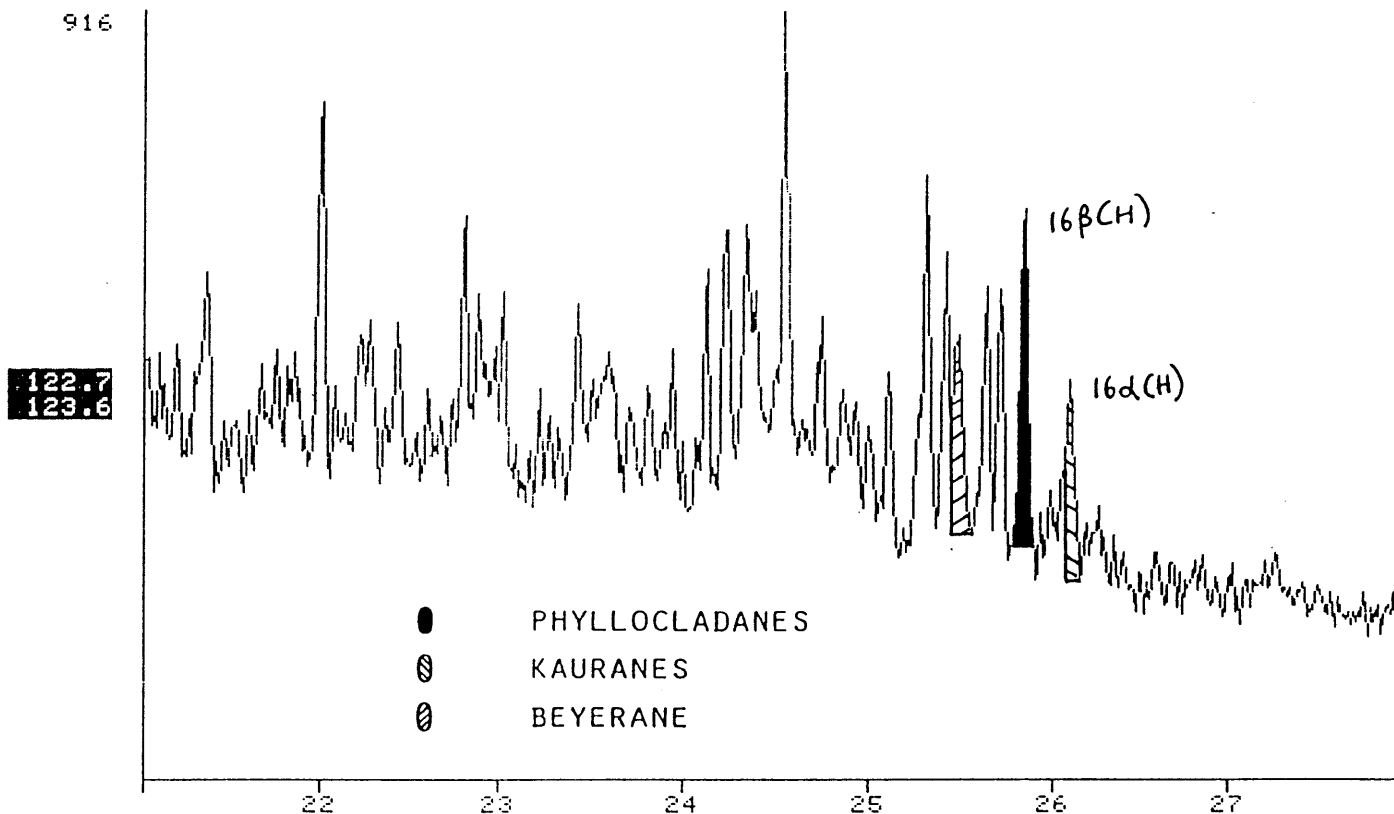


FIGURE 24-2

NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2u00u1. COL#56. P.CONNARD

FRN 6008



NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.2u00u1. COL#56. P.CONNARD

FRN 6008

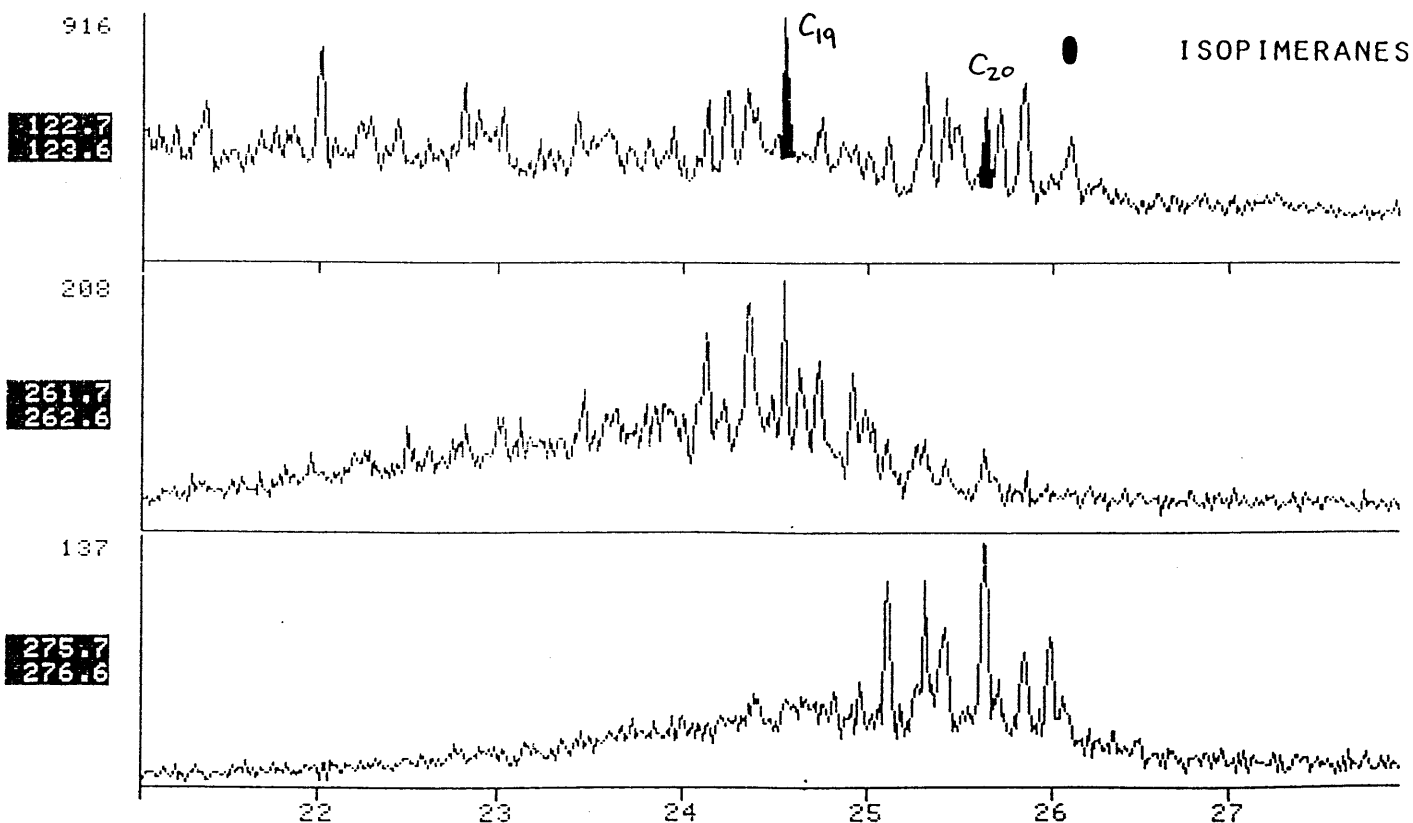


FIGURE 24-3

NAME WEST SEAHORSE#1, OIL. BRANCHED CYCLIC FRAGMENTOGRAM.
MISC 3-6-86. GEC. 0.200001. COL#56. P.CONNARD

FRN 6008

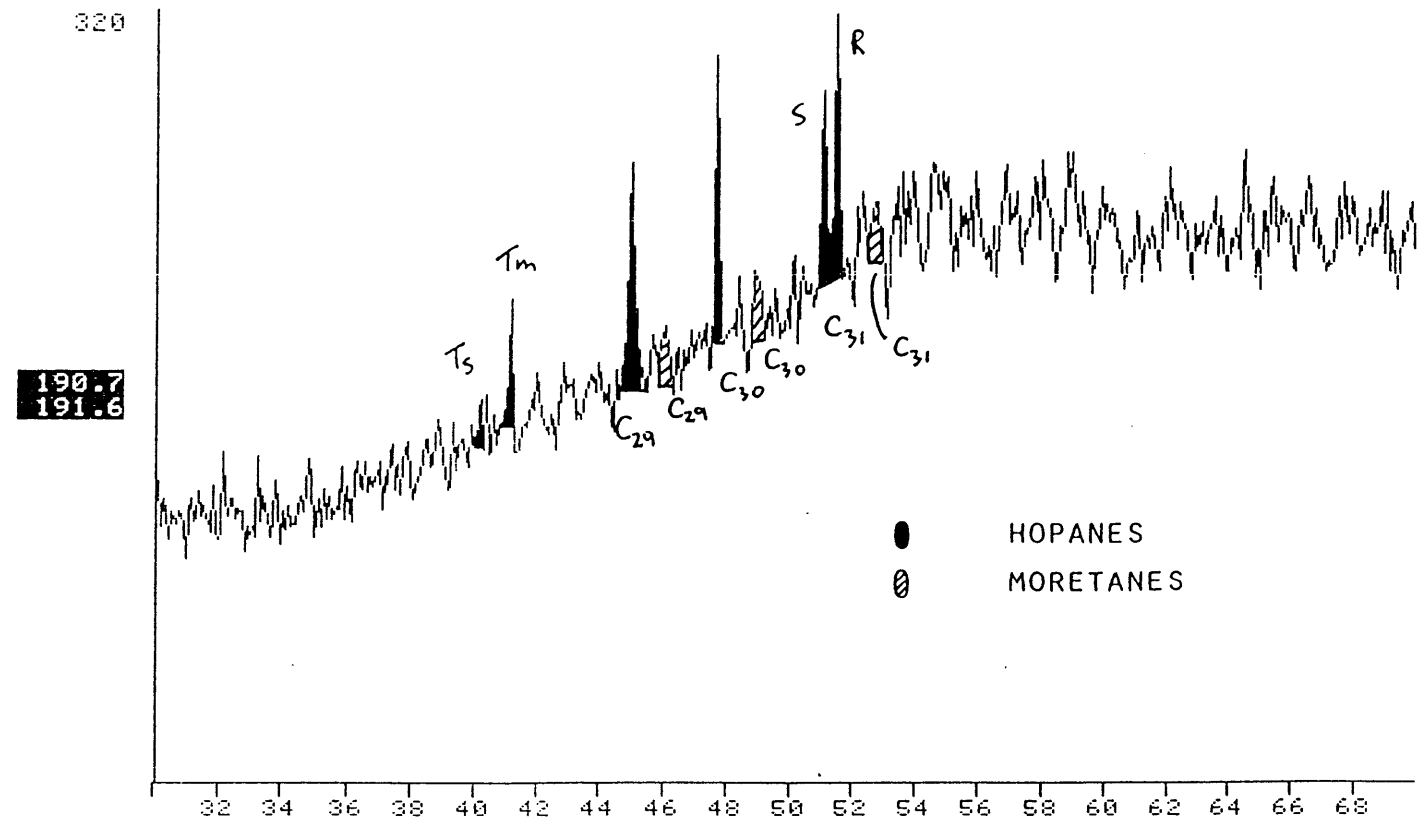
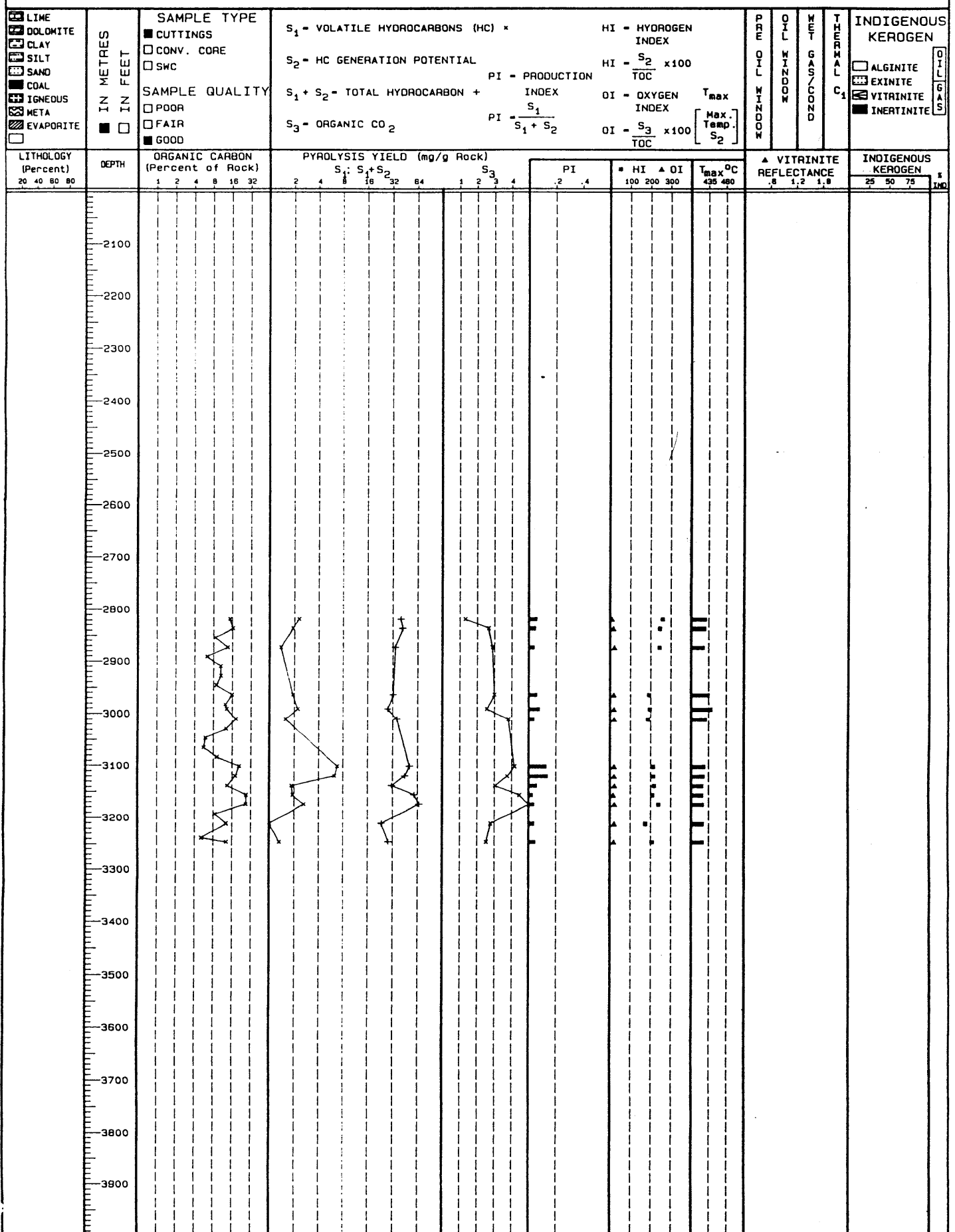


FIGURE 25
JUNE 1988

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY
BREAM 2



ANALABS OIL AND GAS DIVISION, 52 Murray Road, Welshpool, W.A. 8106.
TEL: (09) 458 7898 Telex: Analab AA82560.

FIGURE 26
JUNE 1988

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY
HERMES 1

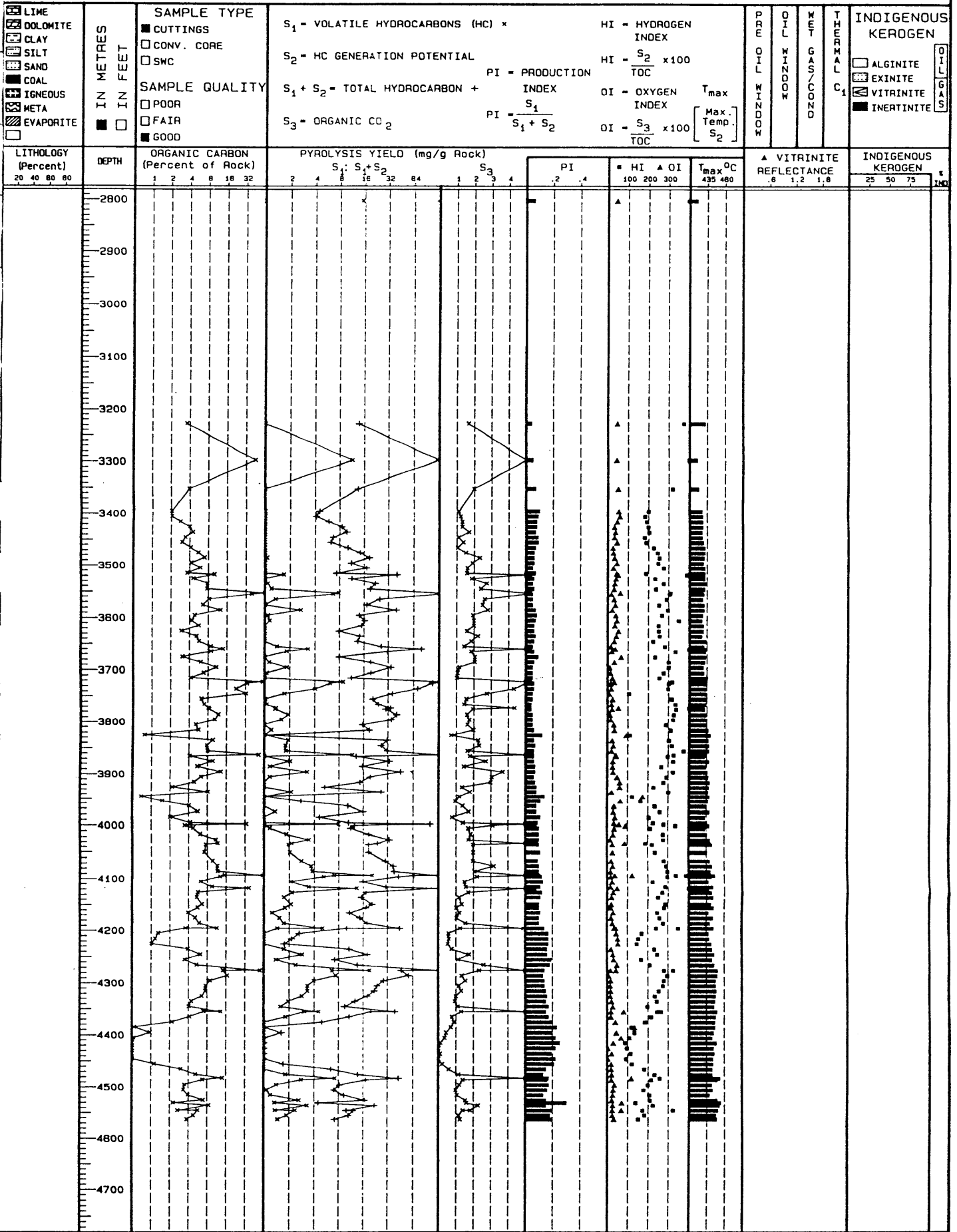


FIGURE 27

JUNE 1986

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY

MARLIN A-8

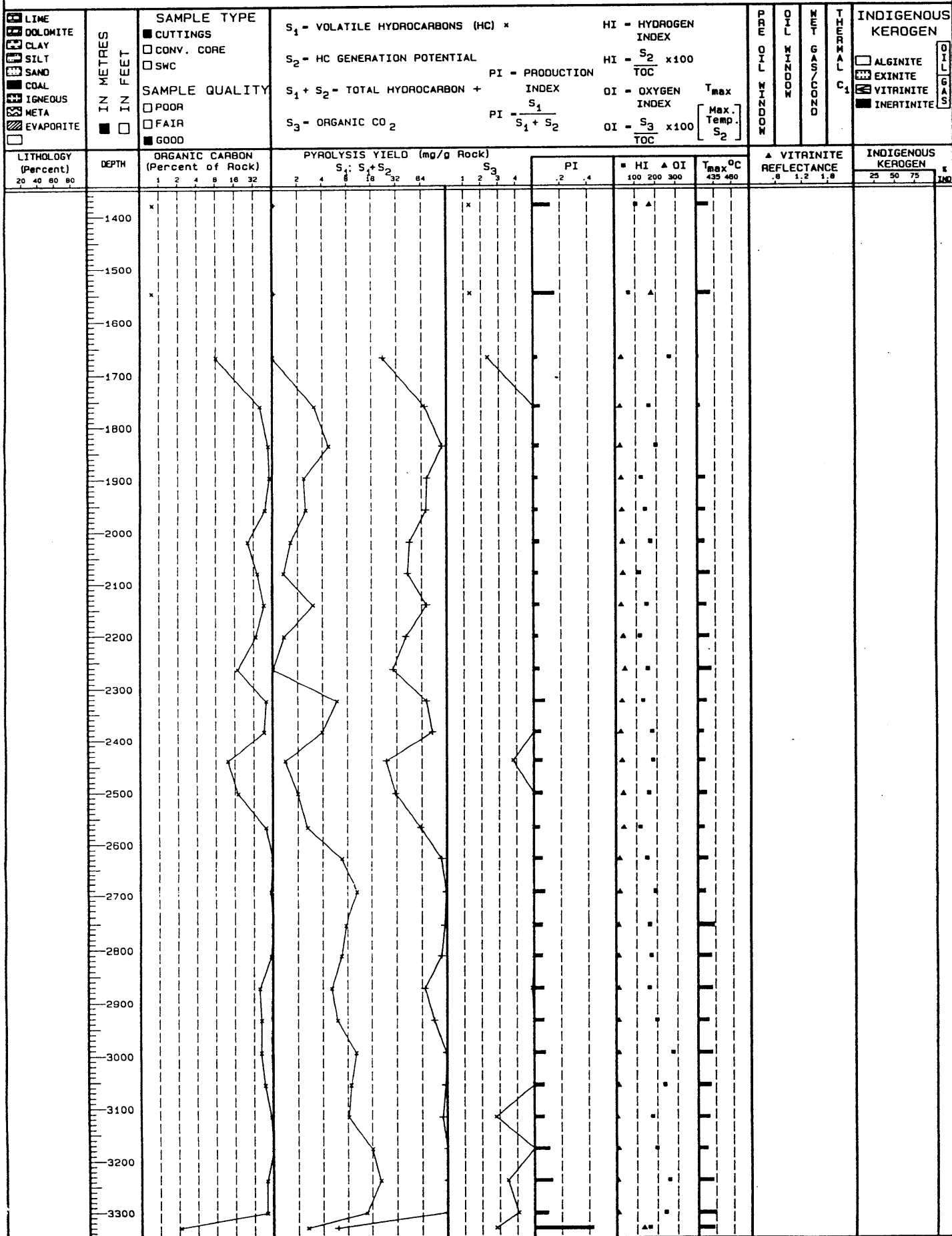


FIGURE 28
JUNE 1988

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY
SELENE 1

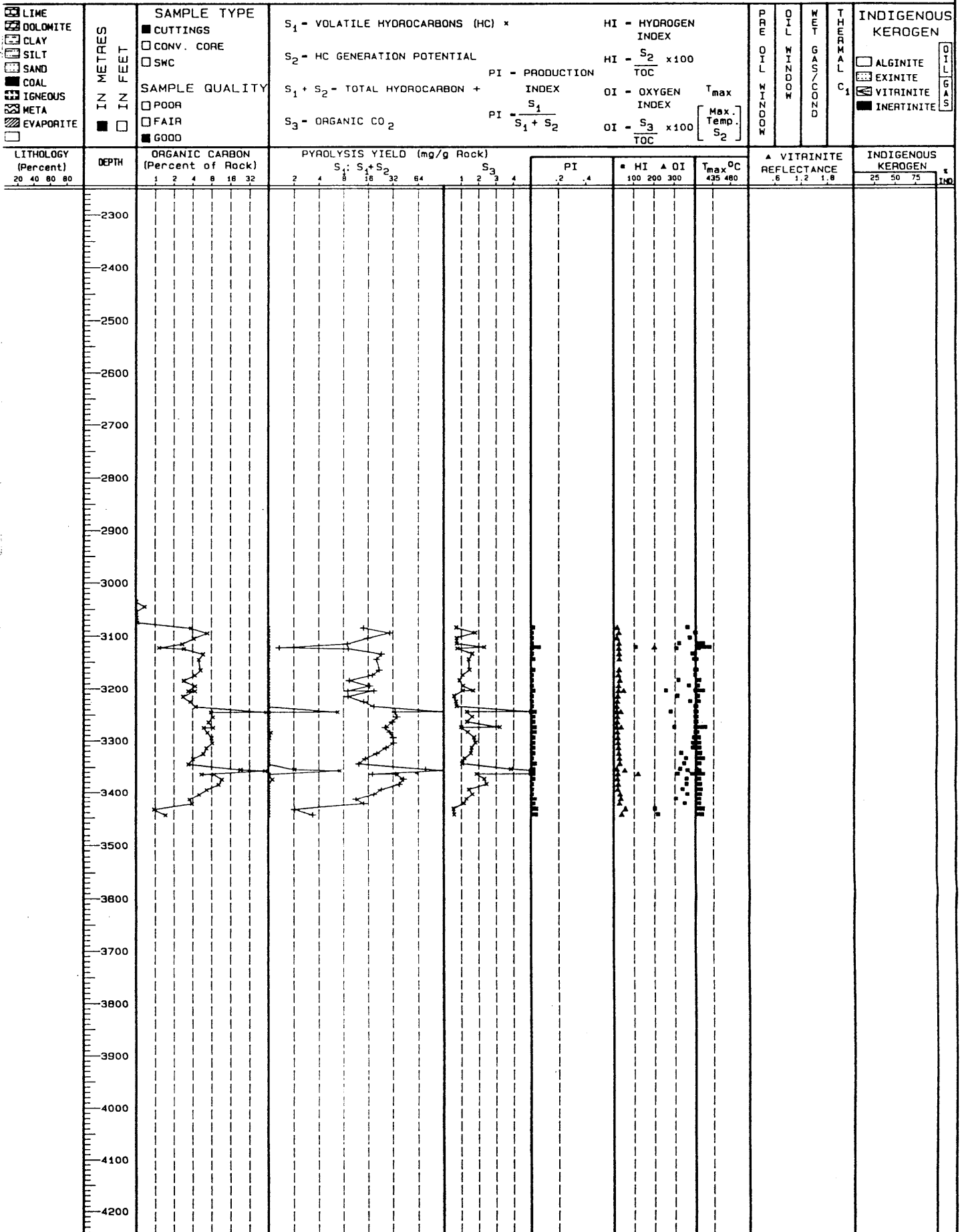


FIGURE 29
JUNE 1988

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY
SNAPPER 1

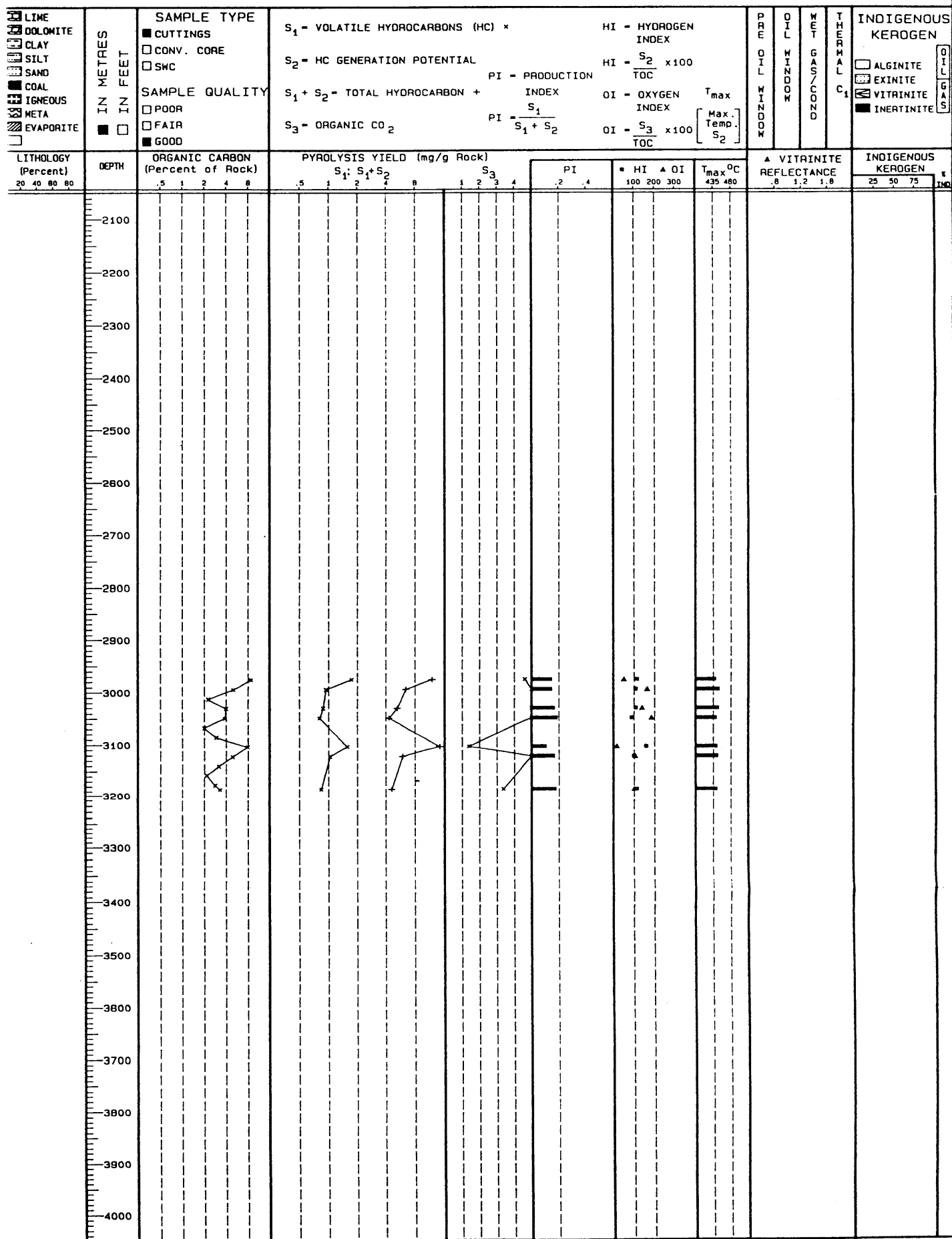


FIGURE 30
JUNE 1988

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY
TARWHINE 1

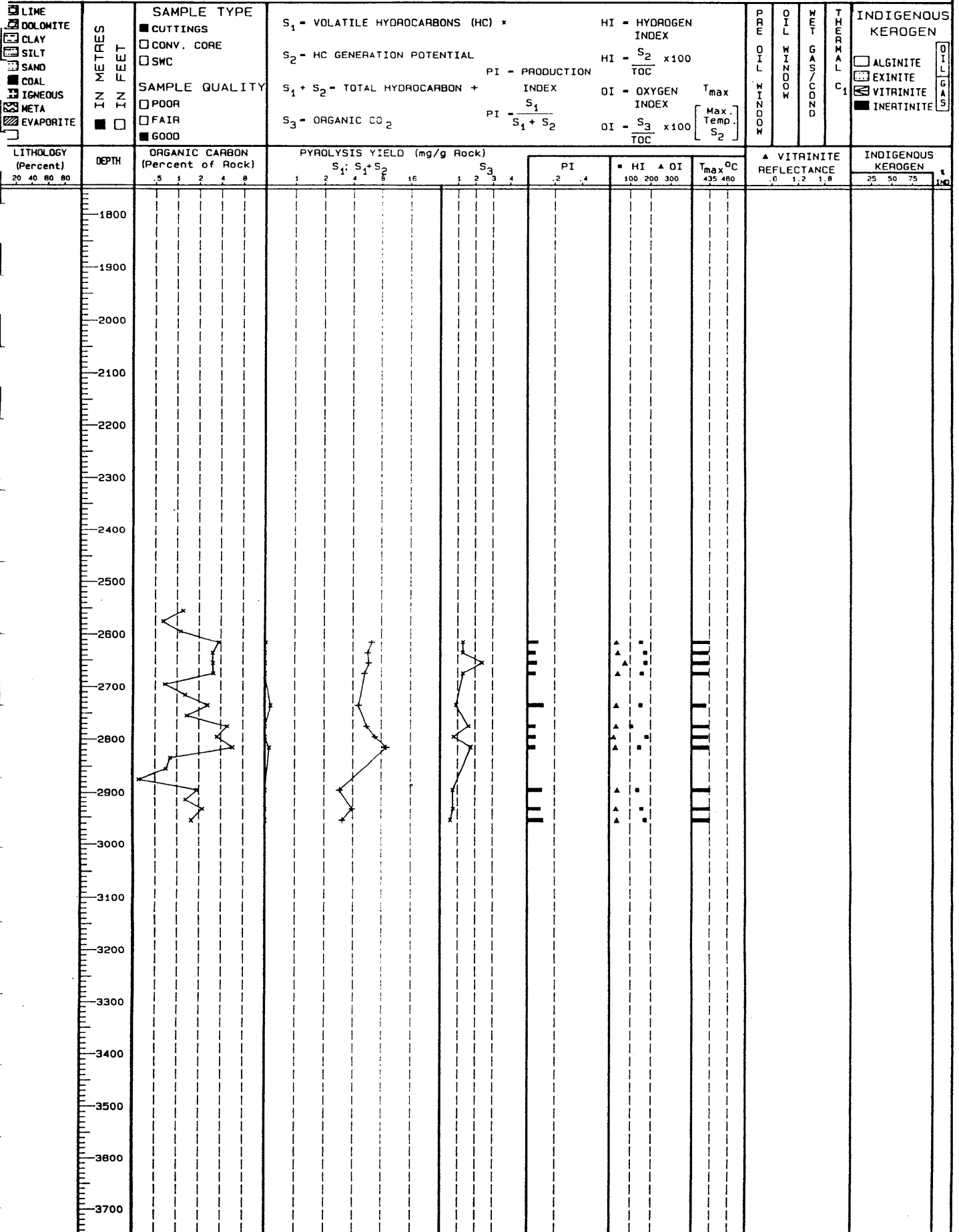


FIGURE 31
JUNE 1988

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

GIPPSLAND BASIN STUDY
VEILFIN 1

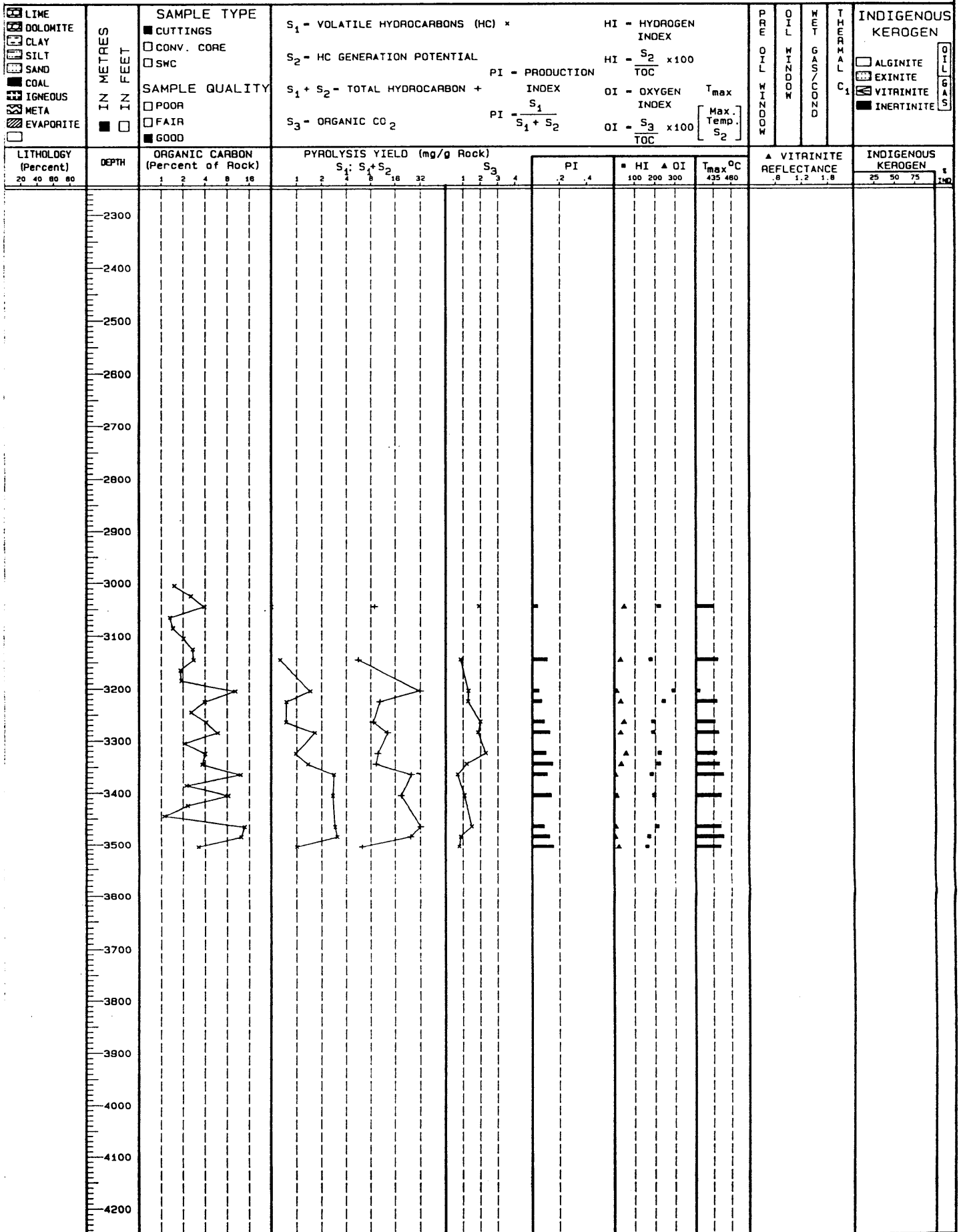


FIGURE 32

ANA-LOG

GIPPSLAND BASIN STUDY

JUNE 1986

HYDROCARBON SOURCE ROCK EVALUATION

VOLADOR 1

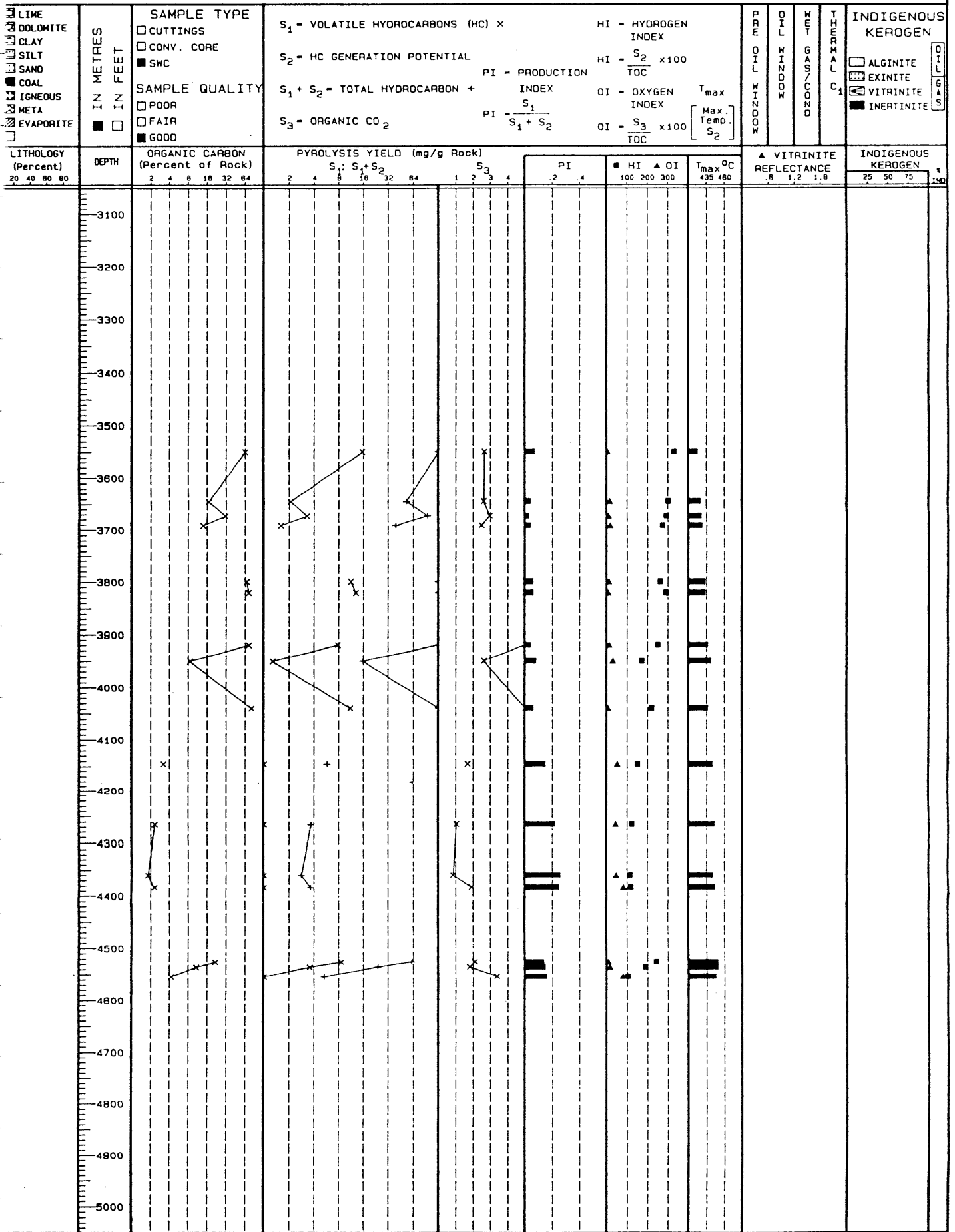


TABLE 1

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = BREAM 2

DATE OF JOB = JUNE 1986

DEPTH(ft)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
9230.0- 9260.0	432	2.28	38.04	1.32	40.32	28.82	0.06	3.35	14.60	260	9
9290.0- 9320.0	431	1.92	40.43	2.66	42.35	15.20	0.05	3.52	16.43	246	16
9350.0- 9380.0	nd	nd	nd	nd	nd	nd	nd	nd	8.53	nd	nd
9410.0- 9440.0	429	1.37	33.06	2.88	34.43	11.48	0.04	2.86	13.50	244	21
9470.0- 9500.0	nd	nd	nd	nd	nd	nd	nd	nd	6.34	nd	nd
9530.0- 9560.0	nd	nd	nd	nd	nd	nd	nd	nd	10.48	nd	nd
9590.0- 9620.0	nd	nd	nd	nd	nd	nd	nd	nd	10.55	nd	nd
9650.0- 9680.0	nd	nd	nd	nd	nd	nd	nd	nd	8.98	nd	nd
9710.0- 9740.0	436	1.93	30.66	3.01	32.59	10.19	0.06	2.70	15.95	192	18
9770.0- 9800.0	nd	nd	nd	nd	nd	nd	nd	nd	12.41	nd	nd
9800.0- 9830.0	440	2.22	25.72	2.56	27.94	10.05	0.08	2.32	13.09	196	19
9860.0- 9890.0	432	1.57	34.55	3.82	36.12	9.04	0.04	3.00	18.39	187	20
9920.0- 9950.0	nd	nd	nd	nd	nd	nd	nd	nd	12.82	nd	nd
9980.0-10010.0	nd	nd	nd	nd	nd	nd	nd	nd	5.97	nd	nd
10040.0-10070.0	nd	nd	nd	nd	nd	nd	nd	nd	5.58	nd	nd
10100.0-10130.0	nd	nd	nd	nd	nd	nd	nd	nd	9.14	nd	nd
10160.0-10190.0	430	6.85	44.57	4.17	51.42	10.69	0.13	4.27	20.83	213	20
10220.0-10250.0	429	6.29	38.72	3.75	45.01	10.33	0.14	3.74	18.05	214	20
10280.0-10310.0	427	1.86	29.38	3.05	31.24	9.63	0.06	2.59	13.43	218	22
10340.0-10370.0	427	1.92	56.69	4.46	58.61	12.71	0.03	4.86	27.08	209	16
10400.0-10430.0	428	2.63	64.21	6.05	66.84	10.61	0.04	5.55	26.70	240	22
10460.0-10490.0	nd	nd	nd	nd	nd	nd	nd	nd	8.49	nd	nd
10520.0-10550.0	428	0.91	22.68	2.78	23.59	8.16	0.04	1.96	12.96	175	21
10610.0-10640.0	nd	nd	nd	nd	nd	nd	nd	nd	5.14	nd	nd
10640.0-10657.0	428	1.32	27.05	2.53	28.37	10.69	0.05	2.35	12.99	208	19

TMAX = Max. temperature
 S1+S2 = Potential yield
 PC = Pyrolysable carbon
 OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)
 S3 = Organic carbon dioxide
 TOC = Total organic carbon
 nd = no data

S2 = HC generating potential
 PI = Production index
 HI = Hydrogen index

TABLE 2

Summary of Extraction and Liquid Chromatography

Wellname: BREAM 2

Date of Job: JUNE 1986

A. Concentrations of Extracted Material

Depth(ft)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
10340.0-10430.0	24.8	8322.6	1698.9	1097.4	1900.9	2998.3	3625.4	nd	3625.4

TABLE 2

Summary of Extraction and Liquid Chromatography

Wellname: BREAM 2

Date of Job: JUNE 1986

B. Compositional Data

Depth(ft)	-----Hydrocarbons-----			-----Nonhydrocarbons-----			<u>EOM(mg)</u>	<u>SAT(mg)</u>	<u>SAT</u>	<u>ASPH</u>	<u>HC</u>
	ZSAT.	ZAROM.	ZHC's	ZNSO's	ZASPH.	ZNon HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
10340.0-10430.0	16.6	28.7	45.3	54.7	nd	54.7	31.0	4.1	.58	nd	.8

na = not applicable nd = no data

TABLE 3

Summary of Gas Chromatography Data

Wellname: BREAM 2

Date of Job: JUNE 1986

A. Alkane Compositional Data

Depth(ft)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
10340.0-10430.0	7.00	1.88	.41	1.17	1.17	.48

TABLE 3

Summary of Gas Chromatography Data

Wellname: BREAM 2

Date of Job: JUNE 1986

B. n-Alkane Distributions

DEPTH(ft)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
10340.0-10430.0	3.1	3.7	3.4	4.1	3.0	4.1	7.7	2.7	1.1	3.0	2.5	3.0	3.7	4.6	5.8	7.3	6.7	8.3	6.3	7.9	4.7	3.3

na = not applicable nd = no data

TABLE 4

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: BREAM 2, 10340-10430ft

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.03
2.	C ₃₀ hopane/C ₃₀ moretane	191	5.15
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.42
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.16
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.99
6.	$\frac{C_{29} \alpha\beta\beta \text{ steranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.35
7.	C ₂₇ /C ₂₉ diasteranes	259	0.21
8.	C ₂₇ /C ₂₉ steranes	217	0.82
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.53
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	4.00
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.28
13.	Rearranged drimanes/normal drimanes	123	0.16
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	0.33

nd = no data

TABLE 5

ROCK-EVAL PYROLYSIS DATA (two run)

WELLNAME = HERMES 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
2800.0-2805.0	421	15.00	251.02	27.73	266.02	9.05	0.06	22.08	63.38	396	43
3225.0-3230.0	432	0.49	13.23	1.66	13.72	7.97	0.04	1.14	3.54	373	46
3295.0-3300.0	421	11.42	218.36	19.45	229.78	11.23	0.05	19.07	44.71	488	43
3345.0-3360.0	423	0.97	12.42	1.97	13.39	6.30	0.07	1.11	3.90	318	50
3390.0-3400.0	428	0.45	4.06	1.10	4.51	3.69	0.10	0.37	2.02	200	54
3400.0-3410.0	429	0.38	3.72	1.21	4.10	3.07	0.09	0.34	2.04	182	59
3410.0-3420.0	429	0.47	5.37	1.30	5.84	4.13	0.08	0.48	2.80	191	46
3420.0-3430.0	429	0.65	7.87	1.30	8.52	6.05	0.08	0.71	3.97	198	32
3430.0-3440.0	428	0.72	9.08	1.69	9.80	5.37	0.07	0.81	4.48	202	37
3440.0-3450.0	428	0.58	6.07	1.09	6.65	5.57	0.09	0.55	3.38	179	32
3450.0-3460.0	430	0.55	5.64	1.36	6.19	4.15	0.09	0.51	3.00	188	45
3460.0-3470.0	432	0.72	9.38	1.04	10.10	9.02	0.07	0.84	4.14	226	25
3470.0-3480.0	432	0.87	13.46	1.51	14.33	8.91	0.06	1.19	5.49	245	27
3480.0-3490.0	431	1.06	17.64	2.32	18.70	7.60	0.06	1.55	6.92	254	33
3490.0-3500.0	430	0.63	10.47	1.90	11.10	5.51	0.06	0.92	4.21	248	45
3500.0-3510.0	432	0.86	16.40	1.61	17.26	10.19	0.05	1.43	5.91	277	27
3510.0-3520.0	432	0.51	6.80	1.58	7.31	4.30	0.07	0.61	3.63	187	43
3515.0-3520.0	432	1.68	38.99	5.19	40.67	7.51	0.04	3.38	10.00	389	51
3520.0-3530.0	432	0.69	10.58	1.85	11.27	5.72	0.06	0.94	4.53	233	40
3530.0-3540.0	434	1.08	21.15	2.73	22.23	7.75	0.05	1.85	7.66	276	35
3540.0-3550.0	432	1.19	17.93	2.38	19.12	7.53	0.06	1.59	7.54	237	31
3550.0-3555.0	429	7.76	202.98	40.76	210.74	4.98	0.04	17.49	65.32	310	62
3550.0-3560.0	431	6.64	121.34	7.43	127.98	16.33	0.05	10.62	39.60	306	18
3560.0-3570.0	429	1.33	23.70	2.60	25.03	9.12	0.05	2.08	8.17	290	31
3570.0-3580.0	431	0.92	16.38	2.48	17.30	6.60	0.05	1.44	6.48	252	38
3580.0-3590.0	431	2.68	37.25	2.79	39.93	13.35	0.07	3.31	12.51	297	22
3590.0-3600.0	429	1.08	12.90	1.92	13.98	6.72	0.08	1.16	4.80	268	40
3600.0-3610.0	428	1.14	15.26	1.98	16.40	7.71	0.07	1.36	4.36	350	45
3610.0-3620.0	430	0.94	13.99	1.98	14.93	7.07	0.06	1.24	5.59	250	35
3620.0-3630.0	430	0.49	7.39	1.58	7.88	4.68	0.06	0.65	2.94	251	53
3630.0-3640.0	428	0.97	13.24	2.22	14.21	5.96	0.07	1.18	5.17	256	42
3640.0-3650.0	434	0.76	12.66	1.83	13.42	6.92	0.06	1.11	5.67	223	32
3650.0-3660.0	431	1.39	24.88	1.42	26.27	17.52	0.05	2.18	8.80	282	16
3655.0-3665.0	434	3.30	75.87	5.12	79.17	14.82	0.04	6.57	13.82	548	37
3660.0-3670.0	433	1.82	29.67	1.83	31.49	16.21	0.06	2.61	8.88	334	20
3670.0-3680.0	433	0.74	7.16	2.05	7.90	3.49	0.09	0.66	3.06	233	66
3680.0-3690.0	432	1.13	18.28	2.05	19.41	8.92	0.06	1.61	6.06	301	33
3690.0-3700.0	430	1.84	32.79	1.16	34.63	28.27	0.05	2.87	10.87	301	10
3700.0-3710.0	431	1.05	18.58	1.06	19.63	17.53	0.05	1.63	6.73	276	15
3710.0-3720.0	436	0.52	10.68	1.02	11.20	10.47	0.05	0.93	4.18	255	24
3720.0-3725.0	433	8.90	190.31	19.77	199.21	9.63	0.04	16.53	59.48	319	33
3720.0-3730.0	435	6.16	101.39	5.49	107.55	18.47	0.06	8.93	33.47	302	16
3730.0-3740.0	434	4.03	67.42	4.31	71.45	15.64	0.06	5.93	22.49	299	19
3740.0-3750.0	434	1.72	34.30	2.75	36.02	12.47	0.05	2.99	32.39	105	8
3750.0-3760.0	435	1.02	19.74	1.56	20.76	12.65	0.05	1.72	6.22	317	25
3760.0-3770.0	434	1.06	23.36	1.44	24.42	16.22	0.04	2.03	6.97	335	20
3770.0-3775.0	431	1.37	33.09	4.35	34.46	7.61	0.04	2.86	8.16	405	53

TMAX = Max. temperature S2

S1+S2 = Potential yield

PC = Pyrolysable carbon

OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)

S3 = Organic carbon dioxide

TOC = Total organic carbon

nd = no data

S2 = HC generating potential

PI = Production index

HI = Hydrogen index

TABLE 5(cont)

ROCK-EVAL PYROLYSIS DATA (two run)

WELLNAME = HERMES 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
3770.0-3780.0	432	1.33	28.71	1.94	30.04	14.80	0.04	2.49	8.47	338	22
3780.0-3790.0	434	1.92	38.80	1.61	40.72	24.10	0.05	3.38	11.83	327	13
3790.0-3800.0	434	1.59	33.40	1.74	34.99	19.20	0.05	2.90	10.32	323	16
3800.0-3810.0	434	0.83	14.75	1.63	15.58	9.05	0.05	1.29	5.10	289	31
3810.0-3820.0	437	1.21	17.73	1.98	18.94	8.95	0.06	1.57	5.68	312	34
3820.0-3830.0	440	0.11	0.84	0.70	0.95	1.20	0.12	0.08	0.76	110	92
3830.0-3840.0	437	1.93	29.49	2.25	31.42	13.11	0.06	2.61	9.68	304	23
3840.0-3850.0	438	1.79	24.76	2.31	26.55	10.72	0.07	2.20	7.75	319	29
3850.0-3860.0	438	1.80	29.64	1.63	31.44	18.18	0.06	2.61	7.90	375	20
3860.0-3865.0	435	11.61	169.51	21.60	181.12	7.85	0.06	15.03	51.81	327	41
3860.0-3870.0	432	0.81	12.15	1.77	12.96	6.86	0.06	1.08	4.07	298	43
3870.0-3880.0	438	2.04	31.42	2.70	33.46	11.64	0.06	2.78	9.65	325	27
3880.0-3890.0	434	1.16	14.44	1.42	15.60	10.17	0.07	1.29	5.41	266	26
3890.0-3900.0	436	3.25	42.20	3.68	45.45	11.47	0.07	3.77	13.01	324	28
3900.0-3910.0	437	1.16	18.32	3.04	19.48	6.03	0.06	1.62	6.27	292	48
3910.0-3920.0	439	0.97	13.51	2.98	14.48	4.53	0.07	1.20	4.86	277	61
3920.0-3930.0	438	0.43	4.89	1.32	5.32	3.70	0.08	0.44	2.15	227	61
3930.0-3940.0	437	2.09	24.53	1.78	26.62	13.78	0.08	2.21	8.10	302	21
3940.0-3950.0	439	0.13	0.83	1.18	0.96	0.70	0.14	0.08	0.68	122	173
3950.0-3960.0	437	0.29	2.46	0.96	2.75	2.56	0.11	0.23	1.50	164	64
3960.0-3970.0	435	0.86	9.46	1.37	10.32	6.91	0.08	0.86	4.04	234	33
3970.0-3980.0	439	1.35	14.62	1.72	15.97	8.50	0.08	1.33	5.61	260	30
3980.0-3990.0	433	0.49	4.10	0.76	4.59	5.39	0.11	0.38	2.00	205	38
3990.0-4000.0	436	1.00	9.53	1.39	10.53	6.86	0.09	0.87	4.21	226	33
3995.0-4000.0	433	7.93	93.96	19.57	101.89	4.80	0.08	8.46	33.62	279	58
3995.0-4005.0	439	0.91	11.57	3.11	12.48	3.72	0.07	1.04	3.43	337	90
4000.0-4010.0	433	1.17	10.00	1.69	11.17	5.92	0.10	0.93	4.70	212	35
4010.0-4020.0	436	1.84	16.94	1.83	18.78	9.26	0.10	1.56	6.12	276	29
4020.0-4030.0	440	3.42	30.08	1.71	33.50	17.59	0.10	2.78	10.83	277	15
4030.0-4035.0	441	2.12	21.88	9.93	24.00	2.20	0.09	1.99	11.67	187	85
4030.0-4040.0	443	1.94	16.62	1.97	18.56	8.44	0.10	1.54	7.52	221	26
4040.0-4060.0	436	2.03	16.64	1.98	18.67	8.40	0.11	1.55	7.08	235	27
4060.0-4070.0	440	2.78	27.15	1.96	29.93	13.85	0.09	2.48	9.67	280	20
4070.0-4080.0	443	3.65	33.54	3.17	37.19	10.58	0.10	3.09	11.47	292	27
4080.0-4090.0	441	3.76	34.63	2.05	38.39	16.89	0.10	3.19	11.59	298	17
4090.0-4095.0	441	20.75	205.60	23.38	226.35	8.79	0.09	18.79	60.55	339	38
4090.0-4095.0	447	7.02	58.49	18.46	65.51	3.17	0.11	5.44	15.01	389	122
4090.0-4100.0	442	5.20	37.84	2.20	43.04	17.20	0.12	3.57	12.74	297	17
4100.0-4110.0	438	2.08	13.72	1.48	15.80	9.27	0.13	1.31	6.14	223	24
4110.0-4120.0	444	3.41	27.10	1.54	30.51	17.60	0.11	2.53	9.46	286	16
4115.0-4120.0	438	13.33	163.75	17.91	177.08	9.14	0.08	14.70	36.85	444	48
4120.0-4130.0	442	2.16	15.22	1.68	17.38	9.06	0.12	1.44	5.61	271	29
4130.0-4140.0	444	1.73	13.52	1.17	15.25	11.56	0.11	1.27	5.39	250	21
4147.0-4150.0	441	2.09	18.68	1.32	20.77	14.15	0.10	1.72	6.52	286	20
4150.0-4160.0	445	1.78	15.61	1.01	17.39	15.46	0.10	1.44	5.55	281	18
4160.0-4170.0	438	1.24	9.58	1.19	10.82	8.05	0.11	0.90	3.89	246	30
4170.0-4180.0	444	1.53	13.07	1.03	14.60	12.69	0.10	1.21	5.06	258	20

TMAX = Max. temperature S2

S1+S2 = Potential yield

PC = Pyrolysable carbon

OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)

S3 = Organic carbon dioxide

TOC = Total organic carbon

nd = no data

S2 = HC generating potential

PI = Production index

HI = Hydrogen index

TABLE 5(cont)

ROCK-EVAL PYROLYSIS DATA (two run)

WELLNAME = HERMES 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
4180.0-4190.0	440	1.71	16.26	1.53	17.97	10.63	0.10	1.49	5.85	277	26
4190.0-4200.0	445	5.04	39.56	4.89	44.60	8.09	0.11	3.70	11.30	350	43
4190.0-4200.0	440	1.43	8.55	1.23	9.98	6.95	0.14	0.83	3.54	241	34
4200.0-4210.0	438	0.45	2.17	0.58	2.62	3.74	0.17	0.22	1.28	169	45
4210.0-4220.0	439	0.37	1.76	0.60	2.13	2.93	0.17	0.18	1.15	153	52
4220.0-4230.0	442	0.29	1.45	0.53	1.74	2.74	0.17	0.14	1.00	145	53
4230.0-4240.0	443	1.72	9.01	0.75	10.73	12.01	0.16	0.89	3.88	232	19
4240.0-4250.0	446	2.86	15.26	1.75	18.12	8.72	0.16	1.50	6.18	246	28
4250.0-4260.0	443	1.38	5.72	1.11	7.10	5.15	0.19	0.59	3.44	166	32
4260.0-4270.0	446	2.38	11.22	2.58	13.60	4.35	0.18	1.13	5.36	209	48
4270.0-4280.0	444	19.31	179.31	23.72	198.62	7.56	0.10	16.49	55.13	325	43
4270.0-4280.0	451	6.56	40.03	2.32	46.59	17.25	0.14	3.87	14.27	280	16
4280.0-4290.0	450	7.38	49.50	1.32	56.88	37.50	0.13	4.72	16.68	296	7
4290.0-4300.0	448	3.95	24.69	1.54	28.64	16.03	0.14	2.38	8.84	279	17
4300.0-4310.0	448	3.31	20.55	1.16	23.86	17.72	0.14	1.98	7.48	274	15
4310.0-4320.0	449	3.31	18.79	1.29	22.10	14.57	0.15	1.83	7.41	253	17
4320.0-4330.0	448	2.83	15.25	0.99	18.08	15.40	0.16	1.50	6.50	234	15
4330.0-4340.0	447	1.95	10.73	0.94	12.68	11.41	0.15	1.05	4.40	243	21
4340.0-4350.0	446	1.57	7.94	1.09	9.51	7.28	0.17	0.79	4.02	197	27
4350.0-4360.0	450	4.53	34.70	10.54	39.23	3.29	0.12	3.26	13.09	265	80
4350.0-4360.0	449	3.03	17.04	1.29	20.07	13.21	0.15	1.67	6.97	244	18
4360.0-4370.0	448	1.80	8.94	0.76	10.74	11.76	0.17	0.89	4.12	216	18
4370.0-4380.0	447	0.95	4.00	0.88	4.95	4.55	0.19	0.41	2.17	184	40
4380.0-4390.0	447	0.19	0.63	0.71	0.82	0.89	0.23	0.07	0.53	118	133
4390.0-4400.0	445	0.33	1.28	0.43	1.61	2.98	0.20	0.13	0.96	133	44
4400.0-4410.0	443	0.16	0.56	0.35	0.72	1.60	0.22	0.06	0.52	107	67
4410.0-4420.0	449	0.12	0.36	0.12	0.48	3.00	0.25	0.04	0.41	87	29
4420.0-4430.0	445	0.09	0.31	0.01	0.40	31.00	0.22	0.03	0.32	96	3
4430.0-4440.0	446	0.13	0.54	0.10	0.67	5.40	0.19	0.06	0.47	114	21
4440.0-4450.0	444	0.10	0.35	0.01	0.45	35.00	0.22	0.04	0.38	92	2
4450.0-4460.0	444	0.35	1.35	0.22	1.70	6.14	0.21	0.14	1.12	120	19
4460.0-4470.0	443	0.96	5.46	0.59	6.42	9.25	0.15	0.53	3.01	181	19
4470.0-4480.0	443	1.80	11.98	1.13	13.78	10.60	0.13	1.14	5.16	232	21
4482.0	454	7.18	36.09	16.45	43.27	2.19	0.17	3.59	13.99	257	117
4480.0-4490.0	450	2.77	14.45	1.38	17.22	10.47	0.16	1.43	6.71	215	20
4490.0-4500.0	442	1.40	6.80	1.19	8.20	5.71	0.17	0.68	3.43	198	34
4500.0-4510.0	443	1.08	5.86	0.98	6.94	5.98	0.16	0.58	3.31	177	29
4510.0-4520.0	439	1.19	8.10	1.05	9.29	7.71	0.13	0.77	3.93	206	26
4520.0-4530.0	450	2.61	14.28	1.53	16.89	9.33	0.15	1.40	6.84	208	22
4530.0	455	1.33	3.14	1.59	4.47	1.97	0.30	0.37	2.26	138	70
4530.0-4540.0	453	3.27	18.97	2.27	22.24	8.36	0.15	1.85	8.48	223	26
4540.0-4550.0	448	1.35	8.60	1.81	9.95	4.75	0.14	0.83	2.66	323	68
4540.0-4550.0	451	2.35	9.72	1.38	12.07	7.04	0.19	1.00	5.63	172	24
4550.0-4560.0	448	1.85	8.67	1.15	10.52	7.54	0.18	0.87	4.78	181	24
4560.0-4565.0	449	1.45	5.68	1.23	7.13	4.62	0.20	0.59	3.75	151	32

TMAX = Max. temperature
S1+S2 = Potential yield
PC = Pyrolysable carbon
OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)
S3 = Organic carbon dioxide
TOC = Total organic carbon
nd = no data

S2 = HC generating potential
PI = Production index
HI = Hydrogen index

TABLE 6

Summary of Extraction and Liquid Chromatography

Wellname: HERMES 1

Date of Job: JUNE 1986

A. Concentrations of Extracted Material

Depth(m)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
4270.0-4300.0	36.5	5465.8	737.8	2216.0	1416.0	3632.0	1096.0	nd	1096.0

TABLE 6

Summary of Extraction and Liquid Chromatography

Wellname: HERMES 1

Date of Job: JUNE 1986

B. Compositional Data

Depth(m)	-----Hydrocarbons-----			-----Nonhydrocarbons-----			<u>EOM(mg)</u>	<u>SAT(mg)</u>	<u>SAT</u>	<u>ASPH</u>	<u>HC</u>
	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
4270.0-4300.0	46.9	29.9	76.8	23.2	nd	23.2	nd	nd	1.56	nd	3.3

na = not applicable nd = no data

TABLE 7

Summary of Gas Chromatography Data

Wellname: HERMES 1

Date of Job: JUNE 1986

A. Alkane Compositional Data

Depth(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
4270.0-4300.0	6.44	1.02	.15	1.10	1.08	1.88

TABLE 7

Summary of Gas Chromatography Data

Wellname: HERMES 1

Date of Job: JUNE 1986

B. n-Alkane Distributions

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
4270.0-4300.0	3.7	4.1	4.4	4.2	4.4	4.6	4.7	4.8	.7	5.2	5.5	5.9	6.4	6.8	6.7	7.0	5.8	5.6	3.7	2.8	1.6	1.4

na = not applicable nd = no data

TABLE 8

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: HERMES 1, 4270-4300m

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.38
2.	C ₃₀ hopane/C ₃₀ moretane	191	>11.20
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.09
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.50
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.85
6.	$\frac{C_{29} \text{ } \alpha\beta\beta \text{ steranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.52
7.	C ₂₇ /C ₂₉ diasteranes	259	0.12
8.	C ₂₇ /C ₂₉ steranes	217	0.32
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.65
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	0.54
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.40
13.	Rearranged drimanes/normal drimanes	123	0.38
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	9.37

nd = no data

TABLE 9

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = MARLIN A-6

DATE OF JOB = JUNE 1986

DEPTH(ft)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
4500.0- 4550.0	427	0.12	0.82	1.33	0.94	0.62	0.13	0.08	0.78	105	170
5050.0- 5100.0	429	0.10	0.51	1.35	0.61	0.38	0.16	0.05	0.76	67	177
5450.0- 5500.0	412	0.76	21.29	2.36	22.05	9.02	0.03	1.83	8.03	265	29
5750.0- 5800.0	414	3.16	66.57	9.54	69.73	6.98	0.05	5.79	40.40	164	23
6000.0- 6050.0	410	4.75	108.60	12.83	113.35	8.46	0.04	9.41	54.65	198	23
6200.0- 6250.0	421	2.39	71.94	16.52	74.33	4.35	0.03	6.17	57.14	125	28
6400.0- 6450.0	421	2.49	69.37	15.72	71.86	4.41	0.03	5.96	47.67	145	32
6600.0- 6650.0	420	1.64	44.02	8.57	45.66	5.14	0.04	3.79	25.80	170	33
6800.0- 6850.0	427	1.35	41.94	13.09	43.29	3.20	0.03	3.59	36.76	114	35
7000.0- 7050.0	422	3.05	70.12	12.47	73.17	5.62	0.04	6.07	46.36	151	26
7200.0- 7250.0	426	1.36	39.93	12.31	41.29	3.24	0.03	3.43	34.08	117	36
7400.0- 7450.0	429	1.01	27.77	7.82	28.78	3.55	0.04	2.39	17.75	156	44
7600.0- 7650.0	422	5.94	66.88	15.53	72.82	4.31	0.08	6.04	50.12	133	30
7800.0- 7850.0	418	3.89	81.74	11.06	85.63	7.39	0.05	7.11	46.16	177	23
8000.0- 8010.0	420	1.40	22.49	3.80	23.89	5.92	0.06	1.98	12.38	181	30
8200.0- 8220.0	422	1.98	28.87	6.54	30.85	4.41	0.06	2.56	17.93	161	36
8400.0- 8450.0	419	2.60	59.07	18.92	61.67	3.12	0.04	5.12	49.34	119	38
8600.0- 8650.0	424	6.81	103.19	11.70	110.00	8.82	0.06	9.13	67.67	152	17
8830.0- 8850.0	421	10.48	114.40	11.07	124.88	10.33	0.08	10.37	59.14	193	18
9020.0- 9050.0	433	7.64	112.21	8.43	119.85	13.31	0.06	9.95	68.23	164	12
9200.0- 9250.0	429	6.73	103.00	7.54	109.73	13.66	0.06	9.11	59.93	171	12
9400.0- 9450.0	430	5.09	63.79	4.87	68.88	13.10	0.07	5.72	39.18	162	12
9600.0- 9650.0	425	6.01	83.77	5.18	89.78	16.17	0.07	7.45	41.90	199	12
9800.0- 9850.0	430	10.20	115.04	5.29	125.24	21.75	0.08	10.39	41.33	278	12
10000.0-10050.0	428	8.80	113.16	5.02	121.96	22.54	0.07	10.12	47.70	237	10
10200.0-10250.0	426	8.21	104.82	2.80	113.03	37.44	0.07	9.38	59.39	176	4
10420.0-10430.0	423	16.05	130.73	6.97	146.78	18.76	0.11	12.18	66.27	197	10
10600.0-10650.0	431	20.23	130.72	3.47	150.95	37.67	0.13	12.53	50.38	259	6
10810.0-10850.0	435	13.70	122.20	4.08	135.90	29.95	0.10	11.28	50.56	241	8
10900.0-10950.0	432	2.60	3.43	2.82	6.03	1.22	0.43	0.50	2.10	163	134

TMAX = Max. temperature S2

S1+S2 = Potential yield

PC = Pyrolysable carbon

OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)

S3 = Organic carbon dioxide

TOC = Total organic carbon

nd = no data

S2 = HC generating potential

PI = Production index

HI = Hydrogen index

TABLE 10

Summary of Extraction and Liquid Chromatography

Wellname: MARLIN A-6

Date of Job: JUNE 1986

A. Concentrations of Extracted Material

Depth(ft)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
9620.0- 9710.0	26.5	20441.5	3650.4	8142.4	3543.8	11686.3	5104.8	nd	5104.8

TABLE 10

Summary of Extraction and Liquid Chromatography

Wellname: MARLIN A-6

Date of Job: JUNE 1986

B. Compositional Data

Depth(ft)	-----Hydrocarbons-----			-----Nonhydrocarbons-----			<u>EOM(mg)</u>	<u>SAT(mg)</u>	<u>SAT</u>	<u>ASPH</u>	<u>HC</u>
	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
9620.0- 9710.0	48.5	21.1	69.6	30.4	nd	30.4	nd	nd	2.30	nd	2.3

na = not applicable nd = no data

TABLE 11

Summary of Gas Chromatography Data

Wellname: MARLIN A-6

Date of Job: JUNE 1986

A. Alkane Compositional Data

Depth(ft)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
9620.0- 9710.0	2.28	.78	.36	1.40	1.40	2.33

TABLE 11

Summary of Gas Chromatography Data

Wellname: MARLIN A-6

Date of Job: JUNE 1986

B. n-Alkane Distributions

DEPTH(ft)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
9620.0- 9710.0	2.9	4.5	6.3	7.1	8.3	9.0	7.0	8.5	3.1	7.5	5.9	4.8	3.9	3.6	2.8	3.5	2.5	3.2	1.6	2.1	1.0	.9

na = not applicable nd = no data

TABLE 12

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: MARLIN A-6, 9620-9710ft

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.39
2.	C ₃₀ hopane/C ₃₀ moretane	191	4.08
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.54
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.36
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.81
6.	$\frac{C_{29} \text{ } \alpha\beta\beta \text{ steranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.41
7.	C ₂₇ /C ₂₉ diasteranes	259	0.52
8.	C ₂₇ /C ₂₉ steranes	217	1.34
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.37
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	1.54
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.42
13.	Rearranged drimanes/normal drimanes	123	0.39
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	1.66

nd = no data

TABLE 13

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = SNAPPER 1

DATE OF JOB = JUNE 1986

DEPTH(ft)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
9750.0- 9780.0	439	1.74	10.25	4.62	11.99	2.22	0.15	1.00	8.81	116	52
9810.0- 9840.0	444	0.94	5.53	8.36	6.47	0.66	0.15	0.54	5.04	109	165
9870.0- 9900.0	nd	nd	nd	nd	nd	nd	nd	nd	2.27	nd	nd
9930.0- 9960.0	443	0.88	4.41	5.66	5.29	0.78	0.17	0.44	4.02	109	140
9990.0-10020.0	440	0.81	3.51	7.16	4.32	0.49	0.19	0.36	3.87	90	185
10050.0-10080.0	nd	nd	nd	nd	nd	nd	nd	nd	2.01	nd	nd
10110.0-10140.0	nd	nd	nd	nd	nd	nd	nd	nd	2.93	nd	nd
10170.0-10200.0	441	1.58	12.73	1.39	14.31	9.16	0.11	1.19	7.95	160	17
10230.0-10260.0	442	1.04	4.97	5.24	6.01	0.95	0.17	0.50	4.93	100	106
10290.0-10320.0	nd	nd	nd	nd	nd	nd	nd	nd	3.18	nd	nd
10350.0-10370.0	nd	nd	nd	nd	nd	nd	nd	nd	2.17	nd	nd
10410.0-10440.0	nd	nd	nd	nd	nd	nd	nd	nd	2.83	nd	nd
10440.0-10470.0	441	0.84	3.79	3.38	4.63	1.12	0.18	0.38	3.32	114	101

TMAX = Max. temperature S2

S1+S2 = Potential yield

PC = Pyrolysable carbon

OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)

S3 = Organic carbon dioxide

TOC = Total organic carbon

nd = no data

S2 = HC generating potential

PI = Production index

HI = Hydrogen index

TABLE 14

Summary of Extraction and Liquid Chromatography

Wellname: SNAPPER 1

Date of Job: JUNE 1986

A. Concentrations of Extracted Material

Depth(ft)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
10170.0-10260.0	27.5	2363.6	261.8	774.5	483.6	1258.2	843.6	nd	843.6

TABLE 14

Summary of Extraction and Liquid Chromatography

Wellname: SNAPPER 1

Date of Job: JUNE 1986

B. Compositional Data

Depth(ft)	-----Hydrocarbons-----			-----Nonhydrocarbons-----			<u>EOM(mg)</u>	<u>SAT(mg)</u>	<u>SAT</u>	<u>ASPH</u>	<u>HC</u>
	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
10170.0-10260.0	36.9	23.0	59.9	40.1	nd	40.1	36.7	12.0	1.60	nd	1.5

na = not applicable nd = no data

TABLE 15

Summary of Gas Chromatography Data

Wellname: SNAPPER 1

Date of Job: JUNE 1986

A. Alkane Compositional Data

Depth(ft)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
10170.0-10260.0	6.05	.89	.14	1.09	1.07	1.98

TABLE 15

Summary of Gas Chromatography Data

Wellname: SNAPPER 1

Date of Job: JUNE 1986

B. n-Alkane Distributions

DEPTH(ft)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
10170.0-10260.0	3.6	4.0	4.5	4.8	5.2	5.4	4.9	5.6	.8	5.7	5.8	6.0	6.2	6.4	6.1	6.0	4.8	4.7	3.3	2.9	1.8	1.7

na = not applicable nd = no data

TABLE 16

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: SNAPPER 1, 10170-10260ft

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.81
2.	C ₃₀ hopane/C ₃₀ moretane	191	6.97
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.32
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.54
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.71
6.	$\frac{C_{29} \alpha\beta\beta \text{ steranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.47
7.	C ₂₇ /C ₂₉ diasteranes	259	0.28
8.	C ₂₇ /C ₂₉ steranes	217	0.84
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.57
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	1.40
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.34
13.	Rearranged drimanes/normal drimanes	123	0.52
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	10.90

nd = no data

TABLE 17

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = TARWHINE 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
2550.0-2560.0	nd	nd	nd	nd	nd	nd	nd	nd	1.21	nd	nd
2570.0-2580.0	nd	nd	nd	nd	nd	nd	nd	nd	0.64	nd	nd
2590.0-2600.0	nd	nd	nd	nd	nd	nd	nd	nd	1.12	nd	nd
2610.0-2620.0	436	0.51	5.83	1.31	6.34	4.45	0.08	0.53	3.77	154	34
2630.0-2640.0	434	0.36	5.42	1.30	5.78	4.17	0.06	0.48	3.10	174	41
2650.0-2660.0	434	0.41	5.52	2.41	5.93	2.29	0.07	0.49	3.13	176	76
2670.0-2680.0	434	0.30	5.05	1.31	5.35	3.85	0.06	0.44	3.18	158	41
2690.0-2700.0	nd	nd	nd	nd	nd	nd	nd	nd	0.68	nd	nd
2710.0-2720.0	nd	nd	nd	nd	nd	nd	nd	nd	1.30	nd	nd
2730.0-2740.0	431	0.57	4.04	0.92	4.61	4.39	0.12	0.38	2.65	152	34
2750.0-2760.0	nd	nd	nd	nd	nd	nd	nd	nd	1.37	nd	nd
2770.0-2780.0	434	0.35	5.29	1.63	5.64	3.25	0.06	0.47	4.91	107	33
2790.0-2800.0	433	0.40	6.48	0.78	6.88	8.31	0.06	0.57	3.56	182	21
2810.0-2820.0	434	0.55	8.50	1.76	9.05	4.83	0.06	0.75	5.81	146	30
2830.0-2840.0	nd	nd	nd	nd	nd	nd	nd	nd	0.81	nd	nd
2850.0-2860.0	nd	nd	nd	nd	nd	nd	nd	nd	0.71	nd	nd
2870.0-2880.0	nd	nd	nd	nd	nd	nd	nd	nd	0.30	nd	nd
2890.0-2900.0	437	0.32	2.60	0.74	2.92	3.51	0.11	0.24	1.89	137	39
2910.0-2920.0	nd	nd	nd	nd	nd	nd	nd	nd	1.32	nd	nd
2930.0-2940.0	436	0.38	3.57	0.76	3.95	4.70	0.10	0.33	2.25	158	33
2950.0-2960.0	436	0.36	2.75	0.60	3.11	4.58	0.12	0.26	1.58	174	37

TMAX = Max. temperature S2
 S1+S2 = Potential yield
 PC = Pyrolysable carbon
 OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)
 S3 = Organic carbon dioxide
 TOC = Total organic carbon
 nd = no data

S2 = HC generating potential
 PI = Production index
 HI = Hydrogen index

TABLE 18

Summary of Extraction and Liquid Chromatography

Wellname: TARWHINE 1

Date of Job: JUNE 1986

A. Concentrations of Extracted Material

Depth(m)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
2610.0-2660.0	18.6	2166.7	279.6	392.5	779.6	1172.0	715.1	nd	715.1

TABLE 18

Summary of Extraction and Liquid Chromatography

Wellname: TARWHINE 1

Date of Job: JUNE 1986

B. Compositional Data

Depth(m)	-----Hydrocarbons-----			-----Nonhydrocarbons-----			EDM(mg)	SAT(mg)	SAT	ASPH	HC
	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
2610.0-2660.0	20.8	41.3	62.1	37.9	nd	37.9	65.1	11.8	.50	nd	1.6

na = not applicable nd = no data

TABLE 19

Summary of Gas Chromatography Data

Wellname: TARWHINE 1

Date of Job: JUNE 1986

A. Alkane Compositional Data

Depth(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
2610.0-2660.0	7.53	2.20	.29	1.42	1.42	.84

TABLE 19

Summary of Gas Chromatography Data

Wellname: TARWHINE 1

Date of Job: JUNE 1986

B. n-Alkane Distributions

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
2610.0-2660.0	2.4	3.6	4.4	4.0	3.2	3.2	7.1	3.2	.9	3.3	3.5	4.1	4.8	6.3	6.1	8.6	5.9	8.7	4.5	6.1	3.1	2.7

na = not applicable nd = no data

TABLE 20

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: TARWHINE 1, 2610-2660m

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.03
2.	C ₃₀ hopane/C ₃₀ moretane	191	4.08
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.28
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.40
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.90
6.	$\frac{C_{29} \alpha\beta\beta \text{ steranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.25
7.	C ₂₇ /C ₂₉ diasteranes	259	0.10
8.	C ₂₇ /C ₂₉ steranes	217	0.46
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.42
11.	$\frac{C_{30} (\text{hopane} + \text{moretane})}{C_{29} (\text{steranes} + \text{diasteranes})}$	191/217	2.61
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.37
13.	Rearranged drimanes/normal drimanes	123	0.19
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	0.75

nd = no data

TABLE 21

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = VEILFIN 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
3000.0-3010.0	nd	nd	nd	nd	nd	nd	nd	nd	1.52	nd	nd
3020.0-3030.0	nd	nd	nd	nd	nd	nd	nd	nd	2.57	nd	nd
3040.0-3050.0	434	0.36	8.65	1.93	9.01	4.48	0.04	0.75	3.94	219	48
3060.0-3070.0	nd	nd	nd	nd	nd	nd	nd	nd	1.32	nd	nd
3080.0-3090.0	nd	nd	nd	nd	nd	nd	nd	nd	1.46	nd	nd
3100.0-3110.0	nd	nd	nd	nd	nd	nd	nd	nd	2.04	nd	nd
3120.0-3130.0	nd	nd	nd	nd	nd	nd	nd	nd	2.73	nd	nd
3140.0-3150.0	441	0.64	5.01	0.87	5.65	5.76	0.11	0.47	2.81	178	30
3160.0-3170.0	nd	nd	nd	nd	nd	nd	nd	nd	1.85	nd	nd
3180.0-3190.0	nd	nd	nd	nd	nd	nd	nd	nd	1.91	nd	nd
3200.0-3210.0	416	1.47	30.54	1.32	32.01	23.14	0.05	2.66	10.41	293	12
3220.0-3230.0	440	0.76	9.71	1.30	10.47	7.47	0.07	0.87	3.98	243	32
3240.0-3250.0	nd	nd	nd	nd	nd	nd	nd	nd	2.60	nd	nd
3260.0-3270.0	437	0.75	7.92	2.01	8.67	3.94	0.09	0.72	4.16	190	48
3280.0-3290.0	442	1.66	11.39	1.88	13.05	6.06	0.13	1.08	5.98	190	31
3300.0-3310.0	nd	nd	nd	nd	nd	nd	nd	nd	2.09	nd	nd
3320.0-3330.0	439	0.98	8.91	2.31	9.89	3.86	0.10	0.82	4.01	222	57
3340.0-3350.0	443	1.37	7.98	1.21	9.35	6.60	0.15	0.78	3.66	218	33
3360.0-3370.0	449	2.83	22.33	0.69	25.16	32.36	0.11	2.09	12.25	182	5
3380.0-3390.0	nd	nd	nd	nd	nd	nd	nd	nd	2.23	nd	nd
3400.0-3410.0	446	2.76	16.39	1.09	19.15	15.04	0.14	1.59	8.35	196	13
3420.0-3430.0	nd	nd	nd	nd	nd	nd	nd	nd	2.34	nd	nd
3440.0-3450.0	nd	nd	nd	nd	nd	nd	nd	nd	1.12	nd	nd
3460.0-3470.0	446	2.93	29.53	1.51	32.46	19.56	0.09	2.69	13.89	212	10
3480.0-3490.0	450	3.12	21.59	0.88	24.71	24.53	0.13	2.05	12.49	172	7
3500.0-3510.0	446	1.01	5.30	0.79	6.31	6.71	0.16	0.52	3.25	163	24

TMAX = Max. temperature
S1+S2 = Potential yield
PC = Pyrolysable carbon
OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)
S3 = Organic carbon dioxide
TOC = Total organic carbon
nd = no data

S2 = HC generating potential
PI = Production index
HI = Hydrogen index

TABLE 22

Summary of Extraction and Liquid Chromatography

Wellname: VEILFIN 1

Date of Job: JUNE 1986

A. Concentrations of Extracted Material

Depth(m)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	-----Hydrocarbons-----			-----Nonhydrocarbons-----		
				Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
3460.0-3490.0	26.7	5614.2	149.8	1006.9	2580.7	3587.5	1876.9	nd	1876.9

TABLE 22

Summary of Extraction and Liquid Chromatography

Wellname: VEILFIN 1

Date of Job: JUNE 1986

B. Compositional Data

Depth(m)	-----Hydrocarbons-----			-----Nonhydrocarbons-----			<u>EOM(mg)</u>	<u>SAT(mg)</u>	<u>SAT</u>	<u>ASPH</u>	<u>HC</u>
	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
3460.0-3490.0	18.4	47.2	65.7	34.3	nd	34.3	42.6	7.6	.39	nd	1.9

na = not applicable nd = no data

TABLE 23

Summary of Gas Chromatography Data

Wellname: VEILFIN 1

Date of Job: JUNE 1986

A. Alkane Compositional Data

Depth(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
3460.0-3490.0	6.29	.70	.11	1.12	1.11	2.10

TABLE 23

Summary of Gas Chromatography Data

Wellname: VEILFIN 1

Date of Job: JUNE 1986

B. n-Alkane Distributions

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
3460.0-3490.0	3.4	4.0	4.5	5.0	5.3	6.0	4.2	6.0	.7	6.2	6.2	6.2	6.3	6.4	5.9	5.8	4.5	4.5	3.1	2.9	1.7	1.2

na = not applicable nd = no data

TABLE 24

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: VEILFIN 1, 3460-3490m

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.25
2.	C ₃₀ hopane/C ₃₀ moretane	191	11.30
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.33
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.12
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.94
6.	$\frac{C_{29} \text{ } \alpha\beta\beta \text{ steranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.42
7.	C ₂₇ /C ₂₉ diasteranes	259	0.42
8.	C ₂₇ /C ₂₉ steranes	217	0.73
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.34
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	2.00
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.23
13.	Rearranged drimanes/normal drimanes	123	0.22
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	3.49

nd = no data

TABLE 25

ROCK-EVAL PYROLYSIS DATA (two run)

WELLNAME = SELENE 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
3030.0-3040.0	nd	nd	nd	nd	nd	nd	nd	nd	0.28	nd	nd
3040.0-3050.0	nd	nd	nd	nd	nd	nd	nd	nd	0.68	nd	nd
3050.0-3060.0	nd	nd	nd	nd	nd	nd	nd	nd	0.33	nd	nd
3060.0-3070.0	nd	nd	nd	nd	nd	nd	nd	nd	0.51	nd	nd
3070.0-3080.0	nd	nd	nd	nd	nd	nd	nd	nd	0.52	nd	nd
3080.0-3090.0	412	0.41	13.79	0.72	14.20	19.15	0.03	1.18	3.79	363	18
3090.0-3100.0	413	0.58	29.09	1.80	29.67	16.16	0.02	2.46	6.92	420	26
3100.0-3110.0	412	0.25	15.67	0.74	15.92	21.18	0.02	1.32	4.19	373	17
3110.0-3120.0	423	0.14	8.83	0.74	8.97	11.93	0.02	0.74	2.74	322	27
3115.0-3130.0	432	0.09	1.26	2.32	1.35	0.54	0.07	0.11	1.16	108	200
3120.0-3130.0	417	0.19	9.03	0.78	9.22	11.58	0.02	0.77	2.92	309	26
3130.0-3140.0	412	0.53	22.89	1.64	23.42	13.96	0.02	1.94	5.92	386	27
3140.0-3150.0	414	0.57	19.88	1.44	20.45	13.81	0.03	1.70	5.04	394	28
3160.0-3170.0	414	0.63	21.43	1.48	22.06	14.48	0.03	1.83	5.37	399	27
3170.0-3180.0	412	0.41	17.72	1.09	18.13	16.26	0.02	1.50	4.39	403	24
3180.0-3190.0	418	0.21	9.23	0.91	9.44	10.14	0.02	0.78	2.89	319	31
3190.0-3200.0	416	0.40	16.39	1.11	16.79	14.77	0.02	1.39	4.43	369	25
3200.0-3210.0	423	0.25	8.83	1.69	9.08	5.22	0.03	0.75	3.43	257	49
3200.0-3210.0	413	0.53	18.41	1.09	18.94	16.89	0.03	1.57	4.40	418	24
3210.0-3220.0	416	0.21	8.91	0.60	9.12	14.85	0.02	0.76	2.83	314	21
3220.0-3230.0	417	0.35	13.82	0.71	14.17	19.46	0.02	1.18	3.68	375	19
3230.0-3240.0	414	0.44	18.43	0.74	18.87	24.91	0.02	1.57	4.49	410	16
3240.0-3250.0	410	6.83	166.16	20.75	172.99	8.01	0.04	14.36	59.28	280	35
3240.0-3250.0	414	1.01	33.24	1.32	34.25	25.18	0.03	2.84	7.83	424	16
3250.0-3260.0	414	1.01	35.34	1.63	36.35	21.68	0.03	3.02	8.49	416	19
3260.0-3270.0	414	0.96	30.57	1.33	31.53	22.98	0.03	2.62	7.19	425	18
3270.0-3280.0	426	0.80	25.54	3.22	26.34	7.93	0.03	2.19	8.56	298	37
3270.0-3280.0	409	0.97	24.95	0.99	25.92	25.20	0.04	2.15	6.03	413	16
3280.0-3290.0	415	1.07	28.62	1.38	29.69	20.74	0.04	2.46	6.92	413	19
3290.0-3300.0	417	1.03	31.47	1.74	32.50	18.09	0.03	2.70	8.02	392	21
3300.0-3310.0	418	0.84	32.09	1.82	32.93	17.63	0.03	2.73	8.25	388	22
3310.0-3320.0	418	0.76	25.76	1.60	26.52	16.10	0.03	2.20	6.64	387	24
3320.0-3330.0	419	0.55	19.78	1.55	20.33	12.76	0.03	1.69	5.94	332	26
3330.0-3340.0	423	0.34	14.45	1.20	14.79	12.04	0.02	1.23	4.06	355	29
3340.0-3350.0	418	0.52	11.80	1.05	12.32	11.24	0.04	1.02	3.41	346	30
3350.0-3360.0	414	2.03	76.19	3.86	78.22	19.74	0.03	6.49	23.24	327	16
3355.0-3360.0	418	7.20	205.33	31.38	212.53	6.54	0.03	17.64	56.46	363	55
3360.0-3370.0	423	0.58	17.50	6.66	18.08	2.63	0.03	1.50	5.53	316	120
3360.0-3370.0	419	0.63	34.01	1.88	34.64	18.09	0.02	2.88	8.82	385	21
3370.0-3380.0	418	1.11	41.97	2.33	43.08	18.01	0.03	3.58	11.70	358	19
3380.0-3390.0	419	0.79	37.36	2.46	38.15	15.19	0.02	3.17	10.41	358	23
3390.0-3400.0	420	0.46	22.72	1.44	23.18	15.78	0.02	1.92	6.69	339	21
3400.0-3410.0	419	0.42	18.39	1.64	18.81	11.21	0.02	1.56	5.07	362	32
3410.0-3420.0	418	0.42	10.90	1.30	11.32	8.38	0.04	0.94	3.55	307	36
3420.0-3430.0	418	0.42	13.73	1.15	14.15	11.94	0.03	1.17	3.92	350	29
3430.0-3440.0	423	0.10	1.95	0.56	2.05	3.48	0.05	0.17	0.96	203	58
3440.0-3450.0	422	0.16	3.22	0.60	3.38	5.37	0.05	0.28	1.47	219	40

TMAX = Max. temperature S2

S1+S2 = Potential yield

PC = Pyrolysable carbon

OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)

S3 = Organic carbon dioxide

TOC = Total organic carbon

nd = no data

S2 = HC generating potential

PI = Production index

HI = Hydrogen index

TABLE 38

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = VOLADOR 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
3549.9	423	15.64	213.26	2.67	228.90	79.87	0.07	19.00	64.30	331	4
3645.0	427	2.09	51.45	2.63	53.54	19.56	0.04	4.44	17.00	302	15
3673.5	428	3.29	91.95	2.98	95.24	30.86	0.03	7.90	31.30	293	9
3691.5	429	1.60	38.12	2.50	39.72	15.25	0.04	3.30	13.90	274	17
3799.0	433	11.28	180.76	7.94	192.04	22.77	0.06	15.94	68.80	262	11
3820.3	433	13.04	214.49	5.21	227.53	41.17	0.06	18.88	73.50	291	7
3920.0	437	7.85	184.76	9.52	192.61	19.41	0.04	15.99	73.90	250	12
3950.0	441	1.27	14.72	2.63	15.99	5.60	0.08	1.33	8.60	171	30
4039.0	437	11.11	178.47	5.55	189.58	32.16	0.06	15.74	80.90	220	6
4145.3	443	0.89	4.88	1.69	5.77	2.89	0.15	0.48	3.22	151	52
4265.0	446	0.80	2.98	1.04	3.68	2.77	0.22	0.31	2.34	123	44
4360.0	444	0.74	2.07	0.85	2.81	2.44	0.26	0.23	1.80	115	47
4383.0	447	0.90	2.76	1.91	3.66	1.45	0.25	0.30	2.31	119	82
4526.0	451	8.65	52.88	2.11	61.53	25.06	0.14	5.11	21.71	243	9
4536.0	451	3.56	20.68	1.81	24.24	11.43	0.15	2.01	10.83	190	16
4554.0	448	0.87	4.48	3.39	5.35	1.32	0.16	0.44	4.28	104	79

TMAX = Max. temperature
 S1+S2 = Potential yield
 PC = Pyrolysable carbon
 OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)
 S3 = Organic carbon dioxide
 TOC = Total organic carbon
 nd = no data

S2 = HC generating potential
 PI = Production index
 HI = Hydrogen index

TABLE 26

SUMMARY OF WHOLE OIL ANALYSIS

Date: 1986

Company: GIPPSLAND BASIN STUDY

Sample: BREAM 2, 6347ft (1943m)

PHYSICAL PROPERTY DATA

API Gravity	%Sulphur (w/w)	Viscosity (25°C)	Viscosity (60°C)	Pour Pt (°C)
nd	nd	nd	nd	nd

COMPOSITION BY CARBON NUMBER

COMPOSITION OF C4-C7 FRACTION

Carbon Number	Rel. Wt %	Compound	Rel. Wt %
1 - 3	nd	A isobutane	nd
4	nd	B n-butane	nd
5	nd	C isopentane	nd
6	nd	D n-pentane	nd
7	nd	E 2,2-dimethylbutane	nd
8	nd	F cyclopentane	nd
9	0.32	G 2,3-dimethylbutane	nd
10	2.11	H 2-methylpentane	nd
11	4.88	I 3-methylpentane	nd
12	7.21	J n-hexane	nd
13	10.33	K methylcyclopentane	nd
14	12.35	L 2,4-dimethylpentane	nd
15	11.69	M benzene	nd
16	8.92	N cyclohexane	nd
17	11.02	O 1,1-dimethylcyclopentane	nd
18	7.42	P 2-methylhexane	nd
19	6.20	Q 3-methylhexane	nd
20	5.03	R 1 cis-3-dimethylcyclopentane	nd
21	3.19	S 1 trans-3-dimethylcyclopentane	nd
22	2.55	T 1 trans-2-dimethylcyclopentane	nd
23	1.94	U n-heptane	nd
24	1.47	V methylcyclohexane	nd
25	1.24	W 1 cis-2-dimethylcyclopentane	nd
26	0.77	X toluene	nd
27	0.59		
28	0.33		
29	0.23		
30	0.13		
31	0.09		

CALCULATED DATA - C4-C7 FRACTION

CALCULATED DATA - C12+ FRACTION

Fristane/Phytane	4.30
Fristane/n-C17	0.67
Phytane/n-C18	0.16
TMTD/Fristane	0.59
(C21+C22)/(C28+C29)	8.46

Paraffin Index I	nd
Paraffin Index II	nd
N/K (Maturity)	nd
C/D (Maturity)	nd
J/K (Maturity)	nd
I/M (Water washing)	nd
I/J (Biodegradation)	nd

nd = no data
TMTD = Trimethyltridecane
is = Insufficient sample

Paraffin Index I = (P+Q)/(R+S+T)
Paraffin Index II = %U in all compounds N-
bd1 = Below detection limit

TABLE 27

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: BREAM 2

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.48
2.	C ₃₀ hopane/C ₃₀ moretane	191	3.78
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.62
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	nd
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.65
6.	$\frac{C_{29} \alpha\beta\beta \text{ steranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.41
7.	C ₂₇ /C ₂₉ diasteranes	259	0.32
8.	C ₂₇ /C ₂₉ steranes	217	nd
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	1.12
11.	$\frac{C_{30} (\text{hopane} + \text{moretane})}{C_{29} (\text{steranes} + \text{diasteranes})}$	191/217	0.96
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.54
13.	Rearranged drimanes/normal drimanes	123	0.48
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	38.20

nd = no data

TABLE 28

SUMMARY OF WHOLE OIL ANALYSIS

Date: 1986

Company: GIFFSLAND BASIN STUDY

Sample: DOLPHIN 1, 4000ft (1219m)

PHYSICAL PROPERTY DATA

API Gravity	%Sulphur (w/w)	Viscosity(25°C)	Viscosity(60°C)	Four Pt(°C)
nd	nd	nd	nd	nd

COMPOSITION BY CARBON NUMBER

COMPOSITION OF C4-C7 FRACTION

Carbon Number	Rel. Wt %	Compound	Rel. Wt %
1 - 3	nd	A isobutane	nd
4	nd	B n-butane	nd
5	nd	C isopentane	nd
6	nd	D n-pentane	nd
7	nd	E 2,2-dimethylbutane	nd
8	0.38	F cyclopentane	nd
9	2.98	G 2,3-dimethylbutane	nd
10	6.32	H 2-methylpentane	nd
11	7.30	I 3-methylpentane	nd
12	9.16	J n-hexane	nd
13	10.24	K methylcyclopentane	nd
14	12.83	L 2,4-dimethylpentane	nd
15	11.37	M benzene	nd
16	7.66	N cyclohexane	nd
17	10.87	O 1,1-dimethylcyclopentane	nd
18	5.76	P 2-methylhexane	nd
19	4.13	Q 3-methylhexane	nd
20	3.03	R 1 cis-3-dimethylcyclopentane	nd
21	2.01	S 1 trans-3-dimethylcyclopentane	nd
22	1.39	T 1 trans-2-dimethylcyclopentane	nd
23	1.03	U n-heptane	nd
24	0.78	V methylcyclohexane	nd
25	0.66	W 1 cis-2-dimethylcyclopentane	nd
26	0.49	X toluene	nd
27	0.41		
28	0.35		
29	0.31		
30	0.30		
31	0.25		

CALCULATED DATA - C4-C7 FRACTION

CALCULATED DATA - C12+ FRACTION

Pristane/Phytane	3.74
Pristane/n-C17	29.17
Phytane/n-C18	6.95
TMTD/Pristane	0.49
(C21+C22)/(C28+C29)	0.61

Paraffin Index I	nd
Paraffin Index II	nd
N/K (Maturity)	nd
C/D (Maturity)	nd
J/K (Maturity)	nd
I/M (Water washing)	nd
I/J (Biodegradation)	nd

nd = no data
TMTD = Trimethyltridecane
is = Insufficient sample

Paraffin Index I = (P+Q)/(R+S+T)
Paraffin Index II = %U in all compounds N-U
bdl = Below detection limit

TABLE 29

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: DOLPHIN 1

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	nd
2.	C ₃₀ hopane/C ₃₀ moretane	191	nd
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.23
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	nd
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.61
6.	$\frac{C_{29} \text{ } \alpha\beta\beta \text{ steranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.45
7.	C ₂₇ /C ₂₉ diasteranes	259	nd
8.	C ₂₇ /C ₂₉ steranes	217	nd
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.76
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	0.45
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.66
13.	Rearranged drimanes/normal drimanes	123	0.63
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	83.60

nd = no data

TABLE 30

SUMMARY OF WHOLE OIL ANALYSIS

Date: 1986

Company: GIFFSLAND BASIN STUDY

Sample: HALIBUT A-1, 7500 ft

PHYSICAL PROPERTY DATA

API Gravity	%Sulphur (w/w)	Viscosity (25°C)	Viscosity (60°C)	Pour Pt (°C)
nd	nd	nd	nd	nd

COMPOSITION BY CARBON NUMBER

COMPOSITION OF C4-C7 FRACTION

Carbon Number	Rel. Wt %		Compound	Rel. Wt %
1 - 3	nd	A	isobutane	nd
4	nd	B	n-butane	nd
5	nd	C	isopentane	nd
6	nd	D	n-pentane	nd
7	nd	E	2,2-dimethylbutane	nd
8	0.19	F	cyclopentane	nd
9	0.91	G	2,3-dimethylbutane	nd
10	2.59	H	2-methylpentane	nd
11	4.21	I	3-methylpentane	nd
12	5.98	J	n-hexane	nd
13	8.39	K	methylcyclopentane	nd
14	9.93	L	2,4-dimethylpentane	nd
15	9.33	M	benzene	nd
16	6.56	N	cyclohexane	nd
17	9.06	O	1,1-dimethylcyclopentane	nd
18	5.36	P	2-methylhexane	nd
19	5.04	Q	3-methylhexane	nd
20	4.50	R	1 cis-3-dimethylcyclopentane	nd
21	3.79	S	1 trans-3-dimethylcyclopentane	nd
22	3.51	T	1 trans-2-dimethylcyclopentane	nd
23	3.12	U	n-heptane	nd
24	2.92	V	methylcyclohexane	nd
25	2.86	W	1 cis-2-dimethylcyclopentane	nd
26	2.52	X	toluene	nd
27	2.39			
28	2.04			
29	1.86			
30	1.64			
31	1.29			

CALCULATED DATA - C4-C7 FRACTION

CALCULATED DATA - C12+ FRACTION

Fristane/Phytane	4.61
Fristane/n-C17	1.04
Phytane/n-C18	0.23
TMTD/Fristane	0.67
(C21+C22)/(C28+C29)	1.78

Paraffin Index I	nd
Paraffin Index II	nd
N/K (Maturity)	nd
C/D (Maturity)	nd
J/K (Maturity)	nd
I/M (Water washing)	nd
I/J (Biodegradation)	nd

nd = no data
TMTD = Trimethyltridecane
is = Insufficient sample

Paraffin Index I = (F+O)/(R+S+T)
Paraffin Index II = %U in all compounds
bdl = Below detection limit

TABLE 31

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: HALIBUT A-1

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.88
2.	C ₃₀ hopane/C ₃₀ moretane	191	3.81
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.58
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	nd
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.73
6.	$\frac{C_{29} \alpha\beta\beta \text{ steranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.53
7.	C ₂₇ /C ₂₉ diasteranes	259	0.21
8.	C ₂₇ /C ₂₉ steranes	217	0.33
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.70
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	0.29
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.77
13.	Rearranged drimanes/normal drimanes	123	0.80
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	20.30

nd = no data

TABLE 32

SUMMARY OF WHOLE OIL ANALYSIS

Date: 1986

Company: GIPPSLAND BASIN STUDY

Sample: MARLIN A-24, FIT-14, 3183m

PHYSICAL PROPERTY DATA

API Gravity	%Sulphur (w/w)	Viscosity (25°C)	Viscosity (60°C)	Pour Pt (°C)
nd	nd	nd	nd	nd

COMPOSITION BY CARBON NUMBER

COMPOSITION OF C4-C7 FRACTION

Carbon Number	Rel. Wt %	Compound	Rel. Wt %
1 - 3	nd	A isobutane	nd
4	nd	B n-butane	nd
5	0.09	C isopentane	2.98
6	0.25	D n-pentane	4.84
7	0.79	E 2,2-dimethylbutane	0.41
8	0.90	F cyclopentane	0.20
9	1.20	G 2,3-dimethylbutane	1.01
10	1.58	H 2-methylpentane	3.14
11	1.88	I 3-methylpentane	2.44
12	2.92	J n-hexane	1.43
13	4.76	K methylcyclopentane	3.28
14	6.54	L 2,4-dimethylpentane	0.67
15	7.60	M benzene	nd
16	6.35	N cyclohexane	10.52
17	10.57	O 1,1-dimethylcyclopentane	2.94
18	7.30	P 2-methylhexane	3.75
19	7.23	Q 3-methylhexane	3.16
20	7.04	R 1 cis-3-dimethylcyclopentane	2.15
21	6.73	S 1 trans-3-dimethylcyclopentane	4.83
22	6.37	T 1 trans-2-dimethylcyclopentane	nd
23	5.70	U n-heptane	4.91
24	4.53	V methylcyclohexane	45.19
25	3.74	W 1 cis-2-dimethylcyclopentane	2.15
26	2.35	X toluene	nd
27	1.73		
28	0.88		
29	0.52		
30	0.24		
31	0.19		

CALCULATED DATA - C4-C7 FRACTION

CALCULATED DATA - C12+ FRACTION

Pristane/Phytane	5.55
Pristane/n-C17	0.86
Phytane/n-C18	0.14
TMTD/Pristane	0.34
(C21+C22)/(C28+C29)	8.38

Paraffin Index I	0.99
Paraffin Index II	6.34
N/K (Maturity)	3.21
C/D (Maturity)	0.62
J/K (Maturity)	0.44
I/M (Water washing)	nd
I/J (Biodegradation)	1.71

nd = no data
TMTD = Trimethyltridecane
is = Insufficient sample

Paraffin Index I = (P+Q)/(R+S+T)
Paraffin Index II = %U in all compounds N-V
bd1 = Below detection limit

TABLE 33

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: MARLIN A-24

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.22
2.	C ₃₀ hopane/C ₃₀ moretane	191	> 20.00
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.47
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.14
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.86
6.	$\frac{C_{29} \text{ } \alpha\beta\beta \text{ steranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.46
7.	C ₂₇ /C ₂₉ diasteranes	259	0.21
8.	C ₂₇ /C ₂₉ steranes	217	nd
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	1.18
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	0.69
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.48
13.	Rearranged drimanes/normal drimanes	123	0.61
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	37.30

nd = no data

TABLE 34

SUMMARY OF WHOLE OIL ANALYSIS

Date: 1986

Company: GIPPSLAND BASIN STUDY

Sample: TUNA A-2, 1996-2005m

PHYSICAL PROPERTY DATA

API Gravity	%Sulphur (w/w)	Viscosity(25°C)	Viscosity(60°C)	Four Pt(°C)
nd	nd	nd	nd	nd

COMPOSITION BY CARBON NUMBER

COMPOSITION OF C4-C7 FRACTION

Carbon Number	Rel. Wt %	Compound	Rel. Wt %
1 - 3	nd	A isobutane	nd
4	nd	B n-butane	nd
5	nd	C isopentane	nd
6	nd	D n-pentane	nd
7	0.07	E 2,2-dimethylbutane	nd
8	0.27	F cyclopentane	nd
9	1.49	G 2,3-dimethylbutane	nd
10	2.25	H 2-methylpentane	nd
11	2.82	I 3-methylpentane	nd
12	3.69	J n-hexane	nd
13	6.09	K methylcyclopentane	nd
14	7.97	L 2,4-dimethylpentane	nd
15	7.93	M benzene	nd
16	7.12	N cyclohexane	nd
17	8.42	O 1,1-dimethylcyclopentane	nd
18	6.06	P 2-methylhexane	nd
19	5.66	Q 3-methylhexane	nd
20	5.39	R 1 cis-3-dimethylcyclopentane	nd
21	4.96	S 1 trans-3-dimethylcyclopentane	nd
22	4.72	T 1 trans-2-dimethylcyclopentane	nd
23	4.65	U n-heptane	6.92
24	4.41	V methylcyclohexane	85.01
25	4.10	W 1 cis-2-dimethylcyclopentane	2.31
26	3.26	X toluene	5.76
27	2.90		
28	2.14		
29	1.60		
30	1.03		
31	0.98		

CALCULATED DATA - C4-C7 FRACTION

CALCULATED DATA - C12+ FRACTION

Fristane/Phytane	5.22
Fristane/n-C17	0.67
Phytane/n-C18	0.12
TMTD/Fristane	0.48
(C21+C22)/(C28+C29)	2.78

Paraffin Index I	nd
Paraffin Index II	7.52
N/K (Maturity)	nd
C/D (Maturity)	nd
J/K (Maturity)	nd
I/M (Water washing)	nd
I/J (Biodegradation)	nd

nd = no data
TMTD = Trimethyltridecane
is = Insufficient sample

Paraffin Index I = (P+Q)/(R+S+T)
Paraffin Index II = %U in all compounds
bdl = Below detection limit

TABLE 35

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: TUNA A-2

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.80
2.	C ₃₀ hopane/C ₃₀ moretane	191	8.00
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	1.53
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	1.21
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.88
6.	$\frac{C_{29} \text{ } \alpha\beta\beta \text{ steranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.54
7.	C ₂₇ /C ₂₉ diasteranes	259	nd
8.	C ₂₇ /C ₂₉ steranes	217	nd
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \text{ } \alpha\alpha\alpha \text{ steranes} + C_{29} \text{ } \alpha\beta\beta \text{ steranes}}$	217	0.78
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	0.52
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.54
13.	Rearranged drimanes/normal drimanes	123	0.58
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	22.20

nd = no data

TABLE 36 .

SUMMARY OF WHOLE OIL ANALYSIS

Date: 1986

Company: GIFFSLAND BASIN STUDY

Sample: WEST SEAHORSE 1, 1417m

PHYSICAL PROPERTY DATA

API Gravity	%Sulphur (w/w)	Viscosity (25°C)	Viscosity (60°C)	Four Pt (°C)
nd	nd	nd	nd	nd

COMPOSITION BY CARBON NUMBER

COMPOSITION OF C4-C7 FRACTION

Carbon Number	Rel. Wt %	Compound	Rel. Wt
1 - 3	nd	A isobutane	0.14
4	0.04	B n-butane	0.23
5	0.31	C isopentane	1.28
6	2.21	D n-pentane	1.42
7	8.94	E 2,2-dimethylbutane	0.28
8	12.82	F cyclopentane	nd
9	10.35	G 2,3-dimethylbutane	0.65
10	8.17	H 2-methylpentane	3.64
11	5.80	I 3-methylpentane	2.08
12	5.63	J n-hexane	6.39
13	6.05	K methylcyclopentane	2.50
14	5.58	L 2,4-dimethylpentane	1.13
15	5.33	M benzene	nd
16	4.71	N cyclohexane	3.66
17	6.09	O 1,1-dimethylcyclopentane	1.69
18	4.26	P 2-methylhexane	6.25
19	3.69	Q 3-methylhexane	7.98
20	2.41	R 1 cis-3-dimethylcyclopentane	2.13
21	1.83	S 1 trans-3-dimethylcyclopentane	3.25
22	1.57	T 1 trans-2-dimethylcyclopentane	0.41
23	1.22	U n-heptane	19.46
24	0.89	V methylcyclohexane	34.18
25	0.76	W 1 cis-2-dimethylcyclopentane	1.16
26	0.50	X toluene	0.10
27	0.37		
28	0.21		
29	0.14		
30	0.06		
31	0.05		

CALCULATED DATA - C4-C7 FRACTION

CALCULATED DATA - C12+ FRACTION

Fristane/Phytane	4.10
Fristane/n-C17	0.43
Phytane/n-C18	0.11
TMTD/Pristane	0.83
(C21+C22)/(C28+C29)	8.60

Paraffin Index I	2.46
Paraffin Index II	24.63
N/K (Maturity)	1.47
C/D (Maturity)	0.90
J/K (Maturity)	2.56
I/M (Water washing)	nd
I/J (Biodegradation)	0.33

nd = no data
TMTD = Trimethyltridecane
is = Insufficient sample

Paraffin Index I = (P+Q)/(R+S+T)
Paraffin Index II = %U in all compounds N-
bdl = Below detection limit

TABLE 37

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: WEST SEAHORSE 1

	<u>Parameter</u>	<u>Ion(s)</u>	<u>Value</u>
1.	18 α (H)-hopane/17 α (H)-hopane (Ts/Tm)	191	0.65
2.	C ₃₀ hopane/C ₃₀ moretane	191	4.75
3.	C ₃₁ 22S hopane/C ₃₁ 22R hopane	191	0.88
4.	C ₃₂ 22S hopane/C ₃₂ 22R hopane	191	nd
5.	C ₂₉ 20S $\alpha\alpha\alpha$ sterane/C ₂₉ 20R $\alpha\alpha\alpha$ sterane	217	0.78
6.	$\frac{C_{29} \alpha\beta\beta \text{ steranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.50
7.	C ₂₇ /C ₂₉ diasteranes	259	nd
8.	C ₂₇ /C ₂₉ steranes	217	nd
9.	18 α (H)-oleanane/C ₃₀ hopane	191	nd
10.	$\frac{C_{29} \text{ diasteranes}}{C_{29} \alpha\alpha\alpha \text{ steranes} + C_{29} \alpha\beta\beta \text{ steranes}}$	217	0.46
11.	$\frac{C_{30} \text{ (hopane + moretane)}}{C_{29} \text{ (steranes + diasteranes)}}$	191/217	0.66
12.	C ₁₅ drimane/C ₁₆ homodrimane	123	0.74
13.	Rearranged drimanes/normal drimanes	123	1.01
14.	C ₁₅ alkyl cyclohexane/C ₃₀ hopane	83/191	42.80

nd = no data

TABLE 38

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = VOLADOR 1

DATE OF JOB = JUNE 1986

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
3549.9	423	15.64	213.26	2.67	228.90	79.87	0.07	19.00	64.30	331	4
3645.0	427	2.09	51.45	2.63	53.54	19.56	0.04	4.44	17.00	302	15
3673.5	428	3.29	91.95	2.98	95.24	30.86	0.03	7.90	31.30	293	9
3691.5	429	1.60	38.12	2.50	39.72	15.25	0.04	3.30	13.90	274	17
3799.0	433	11.28	180.76	7.94	192.04	22.77	0.06	15.94	68.80	262	11
3820.3	433	13.04	214.49	5.21	227.53	41.17	0.06	18.88	73.50	291	7
3920.0	437	7.85	184.76	9.52	192.61	19.41	0.04	15.99	73.90	250	12
3950.0	441	1.27	14.72	2.63	15.99	5.60	0.08	1.33	8.60	171	30
4039.0	437	11.11	178.47	5.55	189.58	32.16	0.06	15.74	80.90	220	6
4145.3	443	0.89	4.88	1.69	5.77	2.89	0.15	0.48	3.22	151	52
4265.0	446	0.80	2.88	1.04	3.68	2.77	0.22	0.31	2.34	123	44
4360.0	444	0.74	2.07	0.85	2.81	2.44	0.26	0.23	1.80	115	47
4383.0	447	0.90	2.76	1.91	3.66	1.45	0.25	0.30	2.31	119	82
4526.0	451	8.65	52.88	2.11	61.53	25.06	0.14	5.11	21.71	243	9
4536.0	451	3.56	20.68	1.81	24.24	11.43	0.15	2.01	10.83	190	16
4554.0	448	0.87	4.48	3.39	5.35	1.32	0.16	0.44	4.28	104	79

TMAX = Max. temperature S2
 S1+S2 = Potential yield
 PC = Pyrolysable carbon
 OI = Oxygen Index

S1 = Volatile hydrocarbons (HC)
 S3 = Organic carbon dioxide
 TOC = Total organic carbon
 nd = no data

S2 = HC generating potential
 PI = Production index
 HI = Hydrogen index

GIPPSLAND BASIN CRUDE OILS AND SOURCE ROCKS:

Biomarker correlation of crude oils and source rocks
based on diterpanes

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12-6-86.

Correlation of crude oils and source rocks

Crude oils and sediment extracts were analysed for biological marker compounds using GC-MS techniques. The data obtained from these analyses indicated that all samples contained biological marker compounds characteristic of higher plants. In particular, the diterpanes, whose precursors are often associated with plant resins, were abundant and their distributions showed considerable variation between samples. For these reasons a detailed correlation between oils and source rocks was carried out on the basis of diterpane composition.

Table 1 contains a list of the diterpanes which have been identified in the various petroleum samples together with the methods of identification. Figure 1 shows a series of partial m/z 123 mass fragmentograms obtained from the crude oil samples. Two features which are common to all of the crude oils are:

- (a) they contain complex mixtures of diterpanes;
- (b) $16\alpha(H)$ -phyllocladane (peak F) is a major diterpane component.

Figure 2 contains the corresponding mass fragmentograms for sediment extracts. It is apparent that the distributions of diterpanes are more varied in the sediments than in the crude oils. Three samples have similar features to the crude oils. (i) Tarwhine 2610-2660 sample has a distribution of diterpanes which best matches that of the crude oils. (ii) Veilfin 3460-3490 also contains a complex mixture of diterpanes similar to the crude oils although isopimarane (peak D) is more abundant than in the crude oils. (iii) Hermes 4270-4300 contains most of the diterpanes present in the crude oils and has abundant $16\alpha(H)$ -phyllocladane. The remaining samples contain either a restricted range of diterpanes (Marlin A-6

9620-9710 and Bream 10340-10430), or a distribution quite unlike the crude oils (Snapper 10170-10260).

Correlation of crude oil and source rocks from the Volador #1 exploration well.

The following material is adapted from a PhD Thesis by R. Noble entitled 'A geochemical study of bicyclic alkanes and diterpenoid hydrocarbons in crude oils, sediments and coals' (Submitted to University of Western Australia 1986).

Figure 3 contains a series of partial m/z 123 mass fragmentograms obtained from extracts of sediment samples and the crude oil recovered from the Volador #1 well. It is apparent from the mass fragmentogram of the oil sample that Volador #1 crude oil has a similar distribution of diterpanes to the other crude oils (Figure 1). Again in this case, the distributions of diterpanes in the sediment samples show considerable variation. Only the distribution from the 4536 m sample matches that of the crude oil.

Table 1. Summary of structural assignments and Kovats indices for diterpanes identified in crude oils and sediments.

Elution Order ^a	Compound Name	Peak Label ^b	Method of Identification ^c
1	8B(H)-Labdane	K	Lit
2	4B(H)-19-Norisopimarane	A	Std
3	Fichtelite	B	Lit
4	Rimuane	C	Lit
5	17-Nortetracyclane	L	MS
6	Pimarane	J	MS
7	<u>ent</u> -Beyerane	E	Std
8	Isopimarane	D	Std
	UNKNOWN	U	—
9	16B(H)-Phyllocladane	F	Std
10	<u>ent</u> -16a(H)-Kaurane	G	Std
11	15a(H)-Phyllocladane	H	Std
12	<u>ent</u> -16B(H)-Kaurane	I	Std

a : Relative GC elution order for methylsilicone capillary columns.

b : Peak labels refer to Figures 1, 2 and 3 ;

c : Methods used for compound identification : Lit = comparison of mass spectrum with cited literature; MS = interpretation of mass spectrum; Std = comparison with authentic compound.

Figure 1. Partial m/z 123 mass fragmentograms showing diterpanes from crude oils. Peak assignments are shown in Table 1.

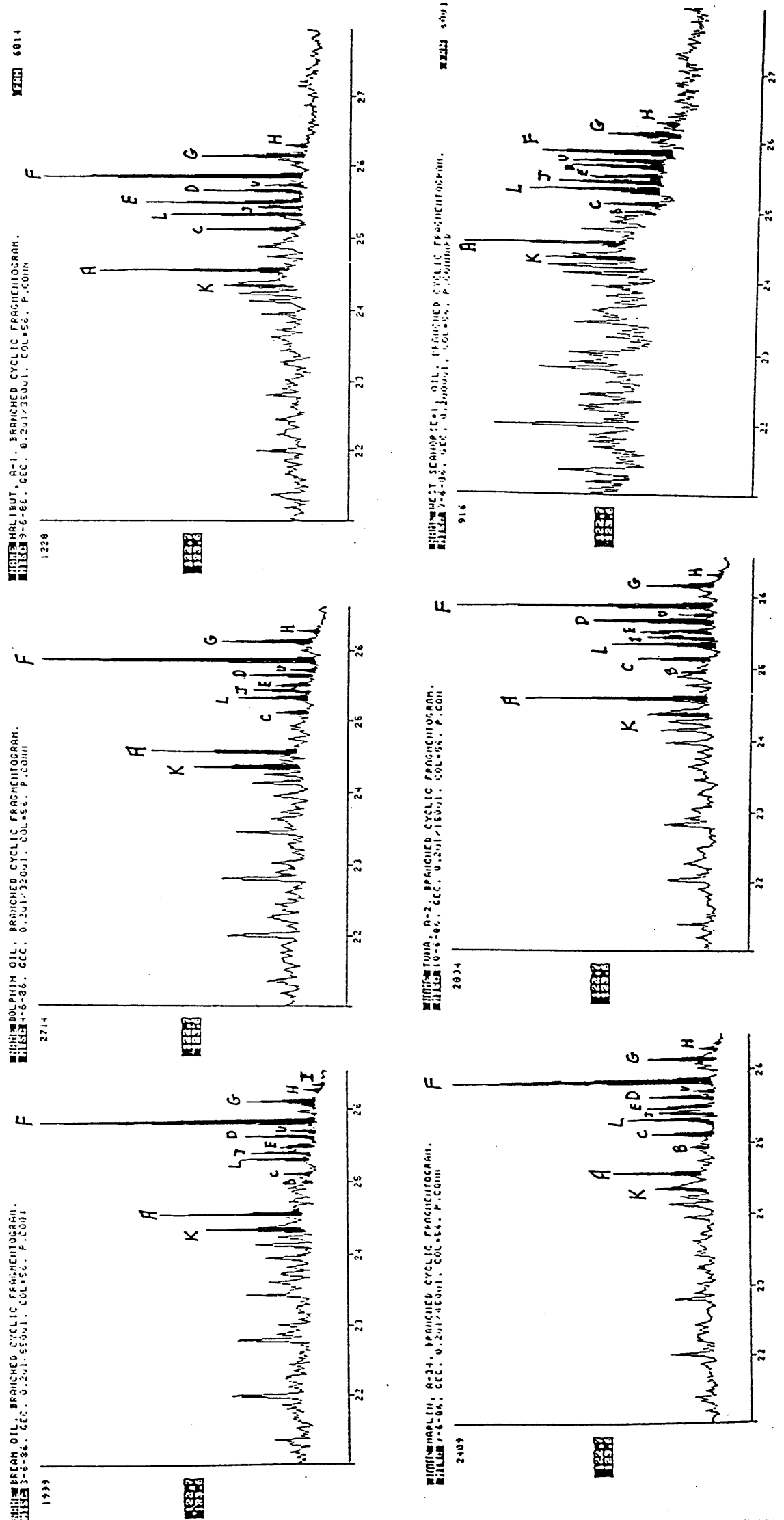


Figure 2. Partial m/z mass fragmentograms showing diterpanes from sediment samples. Peak assignments are given in Table 1.

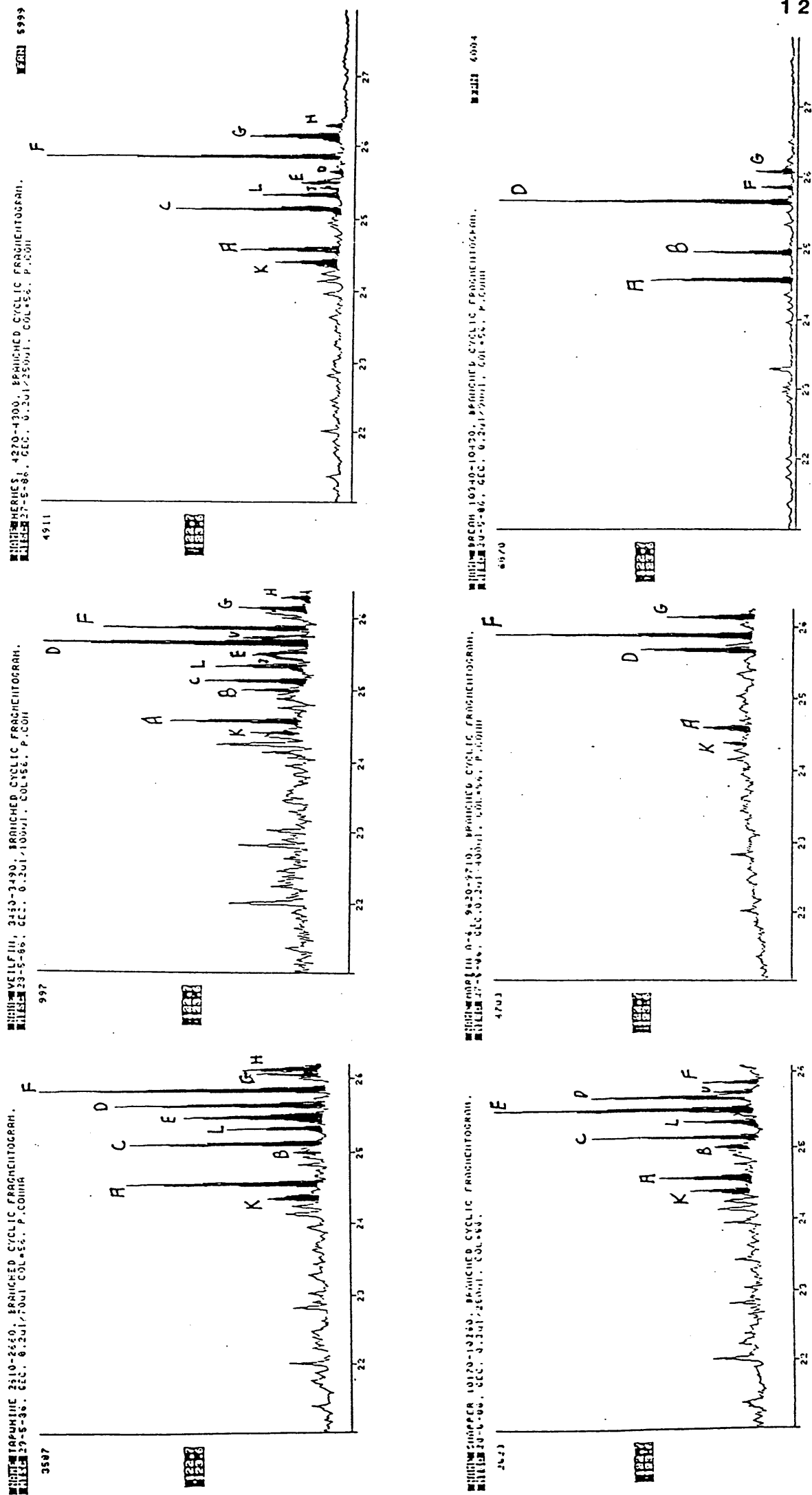
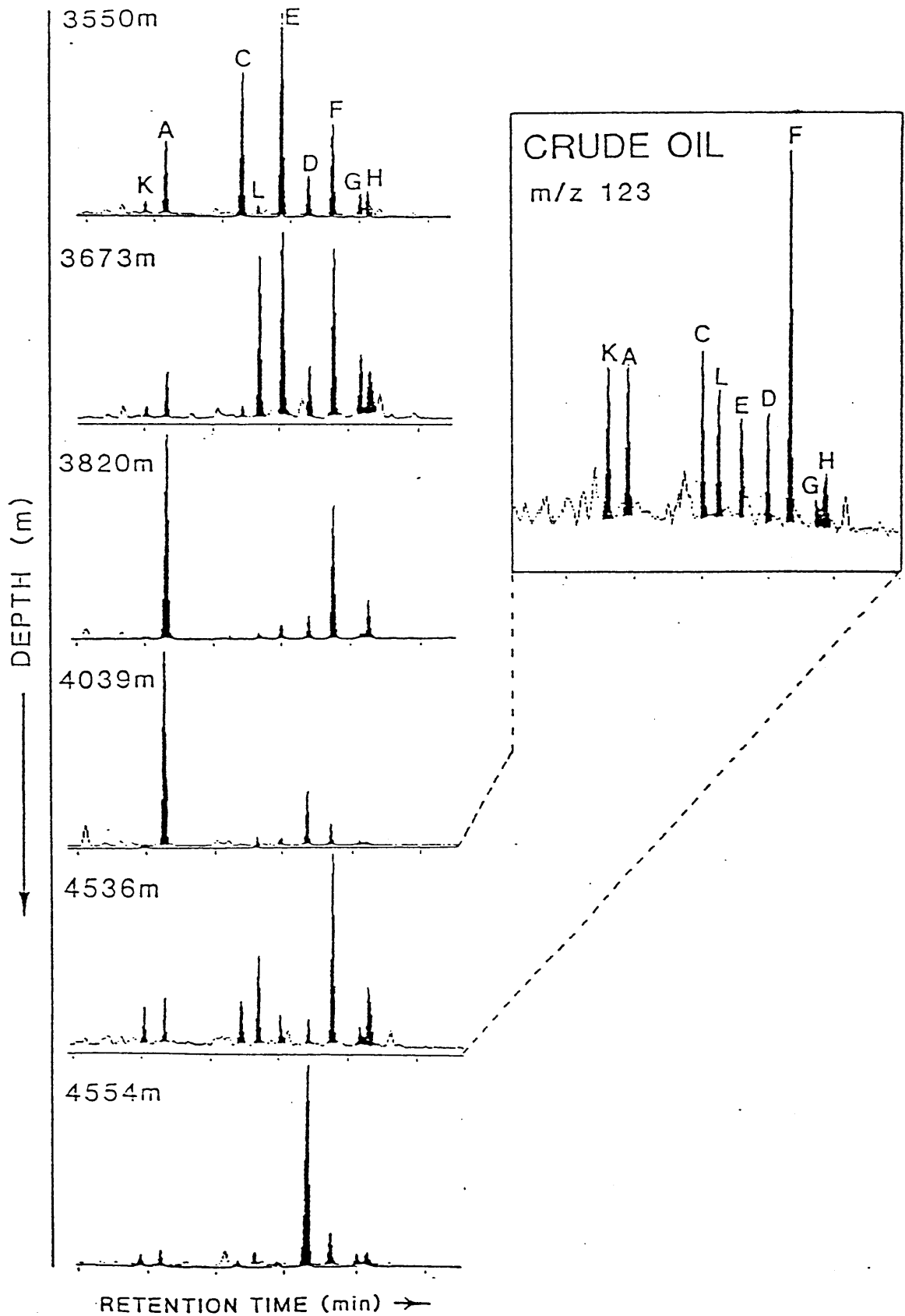


Figure 3. Partial m/z 123 mass fragmentograms showing a comparison of the distributions of diterpanes in the extracts of some Volador #1 sediments, and the Volador crude oil. Peak assignments are given in Table 1.



THEORY AND METHODS

This section details a series of geochemical methods which are commonly used in our laboratory, including those used to obtain the data presented in this report. Where applicable, the discussion is accompanied by a summary of the general theory used to interpret the data generated by each method.

1. SEDIMENTARY GAS ANALYSIS

a) Headspace Analysis

Headspace analysis is carried out using sealed containers (usually tinned cans) of wet cuttings. The containers are approximately three quarters filled with the cuttings and water to leave an appreciable headspace into which volatile hydrocarbons contained in the cuttings diffuse.

After covering about 1cm² of the container lid with silicone and allowing the silicone to dry, the procedure involves placing a small hole in the lid through the silicone, then sampling an aliquot of the headspace gas with a gas injection syringe, and finally gas chromatographing this sample of gas under the following conditions: instrument = Shimadzu GC-8APF; column = 6' x 1/8" Chromosorb 102; column temperature = 110 Deg. C; carrier gas = nitrogen at 23mls/min; injector temperature = 120 Deg. C.; analysis cycle = C1-C4 components are flushed from the column in the forward direction and then the C5-C7 compounds are removed from the column by backflushing.

The integrated areas of peaks representing each of the C1-C7 components of the headspace gas are compared to the areas of corresponding components of a standard gas of known composition. The calculated amount of each component in the sample gas is adjusted for the total headspace volume and reported as ppm (parts of gas per million parts of sediment by volume).

Data from headspace analysis is commonly used to identify the zone of oil generation by plotting gas wetness (C2-C4/C1-C4) expressed as a % against sediment burial depth. Gas containing appreciable quantities of C2-C4 components, termed wet gas (Fuex, 1977), is generally considered to be gas associated with oil generation. In addition, the ratio of isomeric butanes can sometimes be used for assessment of sediment maturity (Alexander et. al., 1981). The amount of gas in sediments can be used to identify zones of significant gas generation and out-of-place gas (LeTran et. al., 1975).

b) Cuttings Gas Analysis

This analysis is the same as Headspace Analysis with the exception that instead of analysing the gas in the container headspace, a known volume of the wet cuttings are transferred to the blender bowl of a Kenwood electronic blender with the lid modified to incorporate a septum, water at 75 Deg. C is added to leave a headspace of 160ml, and the mixture is blended at maximum speed for 2 minutes. Following a 2 minute settling period 1ml of the blending bowl headspace gas is analysed as described in section 1a.

It is recommended that for the most meaningful gas data both headspace and cuttings gas analysis are carried out. In such cases we provide tabulations of the headspace, gas, and combined headspace/cuttings.gas data. Normally, the combined data is used for plotting purposes.

2. SAMPLE PREPARATION

a) Cuttings

Cuttings samples are inspected by our qualified geological staff and then water washed according to the drilling mud content and lithology. In special cases (e.g. diesel contamination) it is necessary to lightly solvent wash samples. After washing, the samples are air dried, either sieved or picked free of cavings, and crushed to 0.1mm using a ring pulveriser.

b) Sidewall Cores

Sidewall samples are freed of mud cake and any other visible contaminants, and are also inspected for lithologic homogeneity. For homogeneous samples, the minimum amount of material required for the requested analyses is air dried and handcrushed to 0.1mm. For non-homogeneous samples, the whole sample is air dried and handcrushed to 0.1mm.

c) Conventional Core and Outcrop Samples

These sample types are firstly inspected for visible contaminants, and where applicable, are freed of these contaminants to the best of our ability. Commonly the surface of conventional core and outcrop samples are lightly solvent washed. The samples are then crushed to approximately 1/8" chips using a jaw crusher, air dried and finally further crushed to 0.1mm using a ring pulveriser.

d) Petroleum/Aqueous Mixtures

The most common sample type in this category are RFT tests containing oil, water and mud. The mixture is placed in a separation funnel and allowed to stand for several hours which enables the petroleum and water/mud fractions to separate. The neat petroleum is isolated by removal of the lower layer (water/mud) from the funnel. To remove the last traces of water and mud, the neat petroleum is centrifuged at a moderate speed.

When the volume of petroleum accounts for only a very small part of the sample the method above is unsatisfactory and the petroleum is solvent extracted from the mixture with dichloromethane. The petroleum is recovered by careful evaporation of the solvent from the organic layer.

3. TOTAL ORGANIC CARBON DETERMINATION

The total organic carbon value (TOC) is determined on the unextracted sediment sample. The value is determined by treating a known weight of sediment with hot dilute HCl for 1 hour to remove carbonate minerals, and then heating the residue to 1700 Deg. C (Leco Induction Furnace CS-044) in an atmosphere of pure oxygen. The carbon dioxide produced is transferred to an infra-red detector which has been calibrated with a series of standards, and the microprocessor of the Leco unit then automatically calculates the % TOC in the sample. To ensure reliable data a standard is run after every 10 samples, regular sample repeats are carried out, and at least one blank determination is carried out for each batch of samples.

The following scales are normally used for source rock classification based on % TOC data:

<u>Classification</u>	<u>Clastics</u>	<u>Carbonates</u>
Poor	0.00 - 0.50	0.00 - 0.25
Fair	0.50 - 1.00	0.25 - 0.50
Good	1.00 - 2.00	0.50 - 1.00
Very Good	2.00 - 4.00	1.00 - 2.00
Excellent	> 4.00	> 2.00

4. ROCK-EVAL PYROLYSIS

Although a preliminary source rock classification is made using TOC data a more accurate assessment accounting for organic source type and maturity is made by pyrolysis analysis. Two types of Rock-Eval pyrolysis services are offered: "one run" which involves pyrolysis of the crushed but otherwise untreated sediment and "two run" which involves pyrolysis of both the crushed, untreated sediment and sediment which has been rendered free of carbonate minerals by treatment with hot dilute HCl. The two run service offers considerably more reliable S3 data.

The method involves accurately weighing approximately 100mg of the sample into a sintered steel crucible and subjecting it to the following pyrolysis cycle:

- Stage (i) - Sample purged with helium for 3.5 minutes in unheated part of pyrolysis furnace;
- Stage (ii) - Sample heated at 300 Deg. C for 3 minutes to liberate free petroleum (S1 peak);
- Stage (iii) - Sample heated from 300 Deg. C to 550 Deg. C at 25 Deg. C/minute to produce petroleum from kerogen (S2 peak). The furnace is maintained at 550 Deg. C for one minute. Carbon dioxide produced during this pyrolysis up to 390 Deg. C in the case of "one run" and 550 Deg. C for "two run" is absorbed on a molecular sieve trap;
- Stage (iv) - During the cool down period the carbon dioxide produced during pyrolysis is measured (S3 peak).

The units used for Rock-Eval data are as follows:

S1, S2, S3 = kg/tonne or mg/g of rock

Tmax = Deg. C

Hydrogen Index = $\frac{S2}{TOC} \times \frac{100}{I}$

Oxygen Index = $\frac{S3}{TOC} \times \frac{100}{I}$

Rock-Eval data is most commonly used in the following manner:

- (i) S1 - indicates the level of oil and or/gas already generated by the sample according to the following scale:

<u>S1 (mg/g or kg/tonne)</u>	<u>Classification</u>
0.00 - 0.20	Poor
0.20 - 0.40	Fair
0.40 - 0.80	Good
0.80 - 1.60	Very Good
> 1.60	Excellent

- (ii) S1+S2 - referred to as the genetic potential this parameter is used for source rock classification according to the following criteria:

<u>S1+S2 (mg/g or kg/tonne)</u>	<u>Classification</u>
0.00 - 1.00	Poor
1.00 - 2.00	Marginal
2.00 - 6.00	Moderate
6.00 - 10.00	Good
10.00 - 20.00	Very Good
> 20.00	Excellent

- (iii) S1/(S1+S2)- this parameter is the production index (PI) which is a measure of the level of maturity of the sample. For oil prone sediments, values less than 0.1 are indicative of immaturity, the values increase from 0.1 to 0.4 over the oil window and values greater than 0.4 represent over maturity. For gas prone sediments, the PI data shows a relatively smaller change with increasing maturity.

- (iv) Tmax - the temperature corresponding to the S2 maxima. This temperature increases with increasingly mature sediments. Values less than 430 Deg. C are indicative of immaturity while values from 430/435 to 460 Deg. C represent the maturity range of the oil window. Tmax values greater than 460 Deg. C are indicative of over maturity.

- (v) HI, OI - the hydrogen ((S2 x 100)/TOC) and oxygen ((S3 x 100)/TOC) indices when plotted against one another provide information about the type of kerogen contained in the sample and the maturity of the sample. Both parameters decrease in value with increasing maturity. Samples with large HI and low OI are dominantly oil prone and conversely samples with low HI and large OI are at best gas prone.

5. EXTRACTION OF SEDIMENT SAMPLES

Crushed sediment (maximum of 250g) and 300mls of purified dichloromethane are placed in a 500ml conical flask and are then blended for ten minutes with a Janke and Kunkel Ultra-Turrax T45/2G high efficiency disperser. After a ten minute settling period the solvent is separated from the sediment using a large Buchner filtration system. The extract is recovered by careful evaporation of the solvent on a steam bath and weighed. The weight of extract is used to calculate % EOM and ppm EOM using the following formulae:

$$\% \text{ EOM} = \frac{\text{Wt EOM}}{\text{Wt Sediment Extracted (g)}} \times \frac{100}{1}$$

$$\text{ppm EOM} = \frac{\text{Wt EOM (mg)}}{\text{Wt Sediment Extracted (kg)}}$$

The following scale is used to classify the source rock richness of samples based on C12+ extractables:

<u>Classification</u>	<u>ppm Total Extract</u>
Poor	0 - 500
Fair	500 - 1000
Good	1000 - 2000
Very Good	2000 - 4000
Excellent	> 4000

6. SEPARATION OF PETROLEUM INTO CONSTITUENT FRACTIONS

Sediment extracts and crude oil or condensate samples are separated into saturate, aromatic and NSO (asphaltenes plus resins) fractions by medium pressure liquid chromatography (MPLC). That part of the petroleum which is soluble in pentane is applied to the MPLC system via a sample loop and is then pumped using pentane to a partially activated silicic acid pre-column which prevents further movement of the non-hydrocarbon compounds. The hydrocarbon components are pumped further to a Merck Si60 column where the saturate fraction is obtained by forward flushing and the aromatic fraction is recovered by reverse flushing. This separation procedure is monitored using a refractive index detector. To complete the separation the pre-column is removed from the MPLC system and flushed with dichloromethane: methanol (1:10). This non-hydrocarbon fraction is combined with the pentane insoluble material which is not applied to the MPLC system, and is labelled as the NSO fraction. The neat fractions are recovered by careful removal of the solvent by distillation and are weighed.

The weight of each fraction is used to calculate the % of each fraction in the sediment according to the following formulas:

$$\% \text{ Fraction} = \frac{\text{Wt Fraction}}{\text{Wt all Fractions}} \times \frac{100}{1}$$

$$\text{ppm Fraction} = \frac{\text{Wt Fraction (mg)}}{\text{Wt Sediment Extracted (kg)}}$$

The ppm hydrocarbon (saturates and aromatics) and ppm saturate values can be used to classify source rock richness and oil source potential respectively according to the following criteria:

<u>Classification</u>	<u>ppm Hydrocarbon</u>	<u>ppm Saturates</u>
Poor	0 - 300	0 - 200
Fair	300 - 600	200 - 400
Good	600 - 1200	400 - 800
Very Good	1200 - 2400	800 - 1600
Excellent	> 2400	> 1600

The composition of the extracts can also provide information about their levels of maturity and/or source type (LeTran et. al., 1974; Philippi, 1974). Generally, marine extracts have relatively low concentrations of saturated and NSO compounds at low levels of maturity, but these concentrations increase with increased maturation. Terrestrially derived organic matter often has a low level of saturates and large amount of aromatic and NSO compounds irrespective of the level of maturity.

N.B. If requested by a client the NSO fraction is separated into asphaltenes and resins by conventional methods.

7. EXTRACTABLE/TOTAL ORGANIC CARBON RATIOS

The ratios of EOM(mg)/TOC(g) and SAT(mg)/TOC(g) are determined from the appropriate data. The EOM(mg)/TOC(g) ratio can be used as a maturation indicator, especially if the parameter is plotted against depth for a given sedimentary sequence. In an absolute sense it is less reliable as a maturation indicator, although previous work (Tissot et. al., 1971; LeTran et. al., 1974) suggests that the following criteria can be used to determine maturity with this parameter.

< 50	Low maturity
50 - 100	Moderate maturity
> 100	High maturity

The ratios of EOM(mg)/TOC(g) and SAT(mg)/TOC(g) can be used collectively to provide information about source type. For example, if SOM(mg)/TOC(g) is > 100, suggesting high level of maturity, but the SAT(mg)/TOC(g) < 20 it is very likely that the organic matter is gas prone. Conversely, the same EOM(mg)/TOC(g) value with a SAT(mg)/TOC(g) value > 40 suggests oil prone source type.

8. PYROLYSIS GAS CHROMATOGRAPHY

Pyrolysis-gas chromatography (PGC) incorporates a Chemical Data System Pyroprobe 15 flash pyrolysis unit interfaced with a capillary gas chromatograph. A sample (5-10mg) of extracted sediment is placed in a quartz tube inside the element coil of the pyrolysis probe and is then heated to 610 Deg. C in a few milliseconds, and is maintained at this temperature for 20 seconds. Products generated from the pyrolysis are swept onto the bonded phase capillary column of the gas chromatograph and are chromatographed from -20 Deg. C (isothermal for two minutes) to 280 Deg. C at 4 Deg. C/minute. The product distribution is dominated by the nature of the kerogen from which it is derived.

9. C12+ GAS CHROMATOGRAPHY

C12+ gas chromatography is commonly carried out on the saturate fraction but in certain instances is carried out on neat oil, condensate or extract. The analysis is carried out under the following conditions: instrument = Shimadzu GC-9A; column = 50m x 0.2mm ID OV101 vitreous silica; column temperature = programmed from 60 Deg. C

to 280 Deg. C at 4 Deg. C/min; injection system = Grob splitless using a 30 second dump time and split ratio of 25:1, carrier gas = hydrogen at 2mls/min; sample = 1 μ l of 0.5% soln in pentane.

The following information is commonly obtained from C12+ gas chromatographic analysis:

(a) n-Alkane Distribution - The C12-C31 n-alkane distribution is determined from the area under peaks representing each of these n-alkanes. This distribution can yield information about both the level of maturity and the source type (LeTran et. al., 1974).

(b) Carbon Preference Index - Two values are determined:

$$\text{CPI (1)} = \frac{(\text{C23} + \text{C25} + \text{C27} + \text{C29}) \text{ Wt\%} + (\text{C25} + \text{C27} + \text{C29} + \text{C31}) \text{ Wt\%}}{2 \times (\text{C24} + \text{C26} + \text{C28} + \text{C30}) \text{ Wt\%}}$$

$$\text{CPI (2)} = \frac{(\text{C23} + \text{C25} + \text{C27}) \text{ Wt\%} + (\text{C25} + \text{C27} + \text{C29}) \text{ Wt\%}}{2 \times (\text{C24} + \text{C26} + \text{C28}) \text{ Wt\%}}$$

The CPI is believed to be a function of both the level of maturity (Cooper and Bray, 1963; Scalan and Smith, 1970) and the source type (Tissot and Welte, 1978). Marine extracts tend to have values close to 1.0 irrespective of maturity whereas values for terrestrial extracts decrease with maturity from values as high as 20 but do not usually reach a value of 1.0

(c) (C21+C22)/(C28+C29) - This parameter provides information about the source of the organic matter (Philippi, 1974). Generally, terrestrial source material gives values <1.2 whereas a aquatic source material results in values >1.5.

(d) Pristane/Phytane Ratio - This value was determined from the areas of peaks representing these compounds. The ratio renders information about the depositional environment according to the following scale (Powell and McKirdy, 1975):

< 3.0	Relatively reducing depositional environment
3.0-4.5	Reducing/oxidizing depositional environment
>4.5	Relatively oxidizing depositional environment

(e) Pristane/n-C17 Ratio - This ratio was determined from the areas of peaks representing these compounds. The value can provide information about both the depositional environment and the level of maturation (Lijmbach, 1975). Very immature crude oil has a pristane/n-C17 ratio >1.0, irrespective of the depositional environment. However, the following classification can be applied to mature crude oil:

<0.5	Open water depositional environment
0.5-1.0	Mixed depositional environment
>1.0	Peat-swamp depositional environment

In the case of sediment extracts these values are significantly higher and the following classification is used:

<1.0	Open water depositional environment
1.0-1.5	Mixed depositional environment
>1.5	Peat-swamp depositional environment

- (f) Phytane/n-C18 Ratio - This ratio was determined from the areas of peak representing these compounds. The value usually only provides information about the level of maturity of petroleum. The value decreases with increased maturation.
- (g) Relative Amounts of n-Alkanes and Naphthenes - Since n-alkanes and naphthenes are the two dominant classes of compounds in the saturate fraction, a semi-quantitative estimate of the relative amounts of these compounds can be made from saturate GLC's. This information can be used to assess the degree of maturation and/or the source type of the petroleum (Philippi, 1974; Tissot and Welte, 1978). Very immature petroleum has only small proportions of n-alkanes but as maturity increases the relative amount of n-alkanes increases. In addition, terrestrial petroleum has a greater proportion of high molecular weight naphthenes than petroleum comprising aquatic source material.

10. API/SPECIFIC GRAVITY

A specific gravity (SG) bottle was accurately weighed, then filled with crude oil at 60 Deg. F and finally reweighed. The weight difference was divided by the weight of an equal volume of water at 60 Deg. F to obtain the specific gravity. The following formula was then used to calculate the API gravity:

$$\text{API Gravity} = \left[\frac{141.5}{\text{SG (60 Deg. F)}} \right] - 131.5$$

The reported gravity value is the average of duplicate determinations.

11. SULPHUR DETERMINATION

The % sulphur by weight is determined by dissolving 0.5g of the petroleum in 50ml kerosene and then analysing this mixture with an inductively coupled plasma (ICP) instrument which has been calibrated with a series of sulphur standards.

This parameter is influenced by the nature of the source material from which a crude is derived, the depositional environment of the source rocks, and reservoir alteration processes such as bacterial alteration.

12. C1-C31 WHOLE SAMPLE GAS CHROMATOGRAPHY

This method of analysis is normally only applied to oil or condensate samples. The technique provides a "picture" of the sample which shows good resolution of the low, medium and high molecular weight components. Whole sample GC data is considered to be more useful than C12+ saturate fraction GC data for oil or condensate samples.

The analysis is carried out under the same conditions as for the C12+ GC analysis with the following exceptions: column temperature = programmed from -20 Deg. C to 28 Deg. C at 4 Deg. C/min (uses cryogenic mode); injection is carried out in split mode sample = 0.1 µl of neat petroleum.

C1-C31 analysis data can be used to obtain the same information as that obtained from C12+ GC but further provides detailed compositional data on the C1-C11 fraction and enables calculation of the distillation range of the sample.

13. MOLECULAR SIEVE EXTRACTION

This technique is used to isolate the branched/cyclic alkanes from the saturate fraction for gas chromatography/mass spectrometry analysis. A mixture of saturates: 5A molecular sieves: purified benzene in the proportions 1:5:12 by weight is placed in a 100ml round bottom flask and refluxed for 24 hours. After cooling, the sieves are filtered from the liquid phase and are washed with 4 x 10ml aliquots of benzene. The liquid phase plus washing are freed of benzene by distillation yielding the branched/cyclic compounds.

14. COMPUTERIZED GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS)

Gas chromatography/mass spectrometry employs a capillary column gas chromatograph linked in series with a mass spectrometer and data system (GC/MS/DS). As molecules are eluted from the capillary column they are bled into the analyser tube of the mass spectrometer where they are bombarded with high energy electrons and consequently fragment to form several ions each with molecular weights less than that of the parent molecule. The fragmentation pattern is characteristic of the particular molecular type. The spectrum of these ions (referred to as a mass spectrum) is recorded approximately once every second and all of the mass spectra recorded during a GC/MS/DS analysis are memorised by the data system. Since any given class of molecules will breakdown in the analyser type to give one or more characteristic ion fragments of known molecular weight, after a GC/MS/DS analysis it is possible to examine the distribution of compounds within a given class by having the data system reproduce a mass fragmentogram (plot of ion concentration against gas chromatography retention time) representative of the particular class.

GC/MS/DS analyses can be carried out using one of the two following modes of operation:

- (i) Acquire mode - in which all ions in each mass spectrum are memorised by the data system;
- (ii) Selective ion monitoring (SIM) mode - in which only selected ions of interest are memorised by the data system.

At present the sterane/triterpane/bicyclane fraction of petroleum is considered most useful for GC/MS/DS analysis and therefore we commonly use the second of the above mentioned modes of operation and run the following twenty-two ions which are pertinent to the sterane/triterpane/bicuclane fraction.

<u>Ion</u>	<u>Molecular Type</u>
177	Demethylated triterpanes
191	Normal triterpanes
205	Methyl triterpanes
163	Specific dethylated triterpanes
356	Parent ion - C26 triterpanes
370	Parent ion - C27 triterpanes
384	Parent ion - C28 triterpanes
398	Parent ion - C29 triterpanes

412	Parent ion - C30 triterpanes
426	Parent ion - C31 triterpanes
183	Isoprenoids
217	Normal steranes
218	Normal steranes
231	4-methylsteranes
259	Diasteranes
358	Parent ion - C26 steranes
372	Parent ion - C27 steranes
386	Parent ion - C28 steranes
400	Parent ion - C29 steranes
414	Parent ion - C30 steranes

GC/MS/DS analysis of the sterane/triterpane/bicyclane fraction can often provide information about the maturity and source type of petroleum and whether it has been affected by micro-organisms. This technique is also often useful for oil:oil and oil:source rock correlation. The following sections indicate which parameters are used to obtain this information and summarize the theory behind their use.

Maturity

(i) Based on Steranes

- (a) The biologically produced $\alpha\alpha\alpha$ (20R) stereoisomer is converted in sediment to a mixture of the $\alpha\alpha\alpha$ (20R) and $\alpha\alpha\alpha$ (20S) compounds. The ratio of $\alpha\alpha\alpha$ (20S) C29 ----- expressed as a percentage is about 25% at the $\alpha\alpha\alpha$ (20R) + $\alpha\alpha\alpha$ (20S) onset of oil generation and increases almost linearly to a value of about 50% at the peak of oil generation.

(ii) Based on Triterpanes

- (a) The C31, C32, C33, C34 and C35 hopanes have the biological configuration at C22. On mild thermal maturation equilibration occurs to produce a 60/40 mixture of S/R. This equilibration occurs before the onset of oil generation.
- (b) The conversion of the biological $17\beta,21\beta$ hopanes to the corresponding $17\alpha,21\beta$ and $17\beta,21\alpha$ compounds is also maturation dependant. For C30 triterpanes the ratio of $\frac{17\beta,21\alpha}{17\alpha,21\beta}$ ----- decreases steadily from a value of about 0.4 at the onset of oil generation to a value of about 0.1 at peak oil generation.
- (c) Two of the C27 triterpanes can also be used as maturity indicators. The ratio of 18α (H) trisnorhopane to 17α (H) trisnorhopane increase exponentially with increasing maturity from a value of approximately 0.2 at the onset of oil generation to approximately 1.0 at peak oil generation.
- (d) It is our experience that the ratio of the C27 18α (H) + C27 17α (H) triterpanes to C30 $17\alpha,21\beta$ triterpane is maturity dependent. The ratio decreased from values around 1.0 at the onset of oil generation to a value of approximately 0.4 at peak oil generation. With increasing maturity at levels greater than that equivalent to peak oil generation the ratio

increases steadily to values greater than 3.0.

Source Type

(i) Based on Steranes

Algal organic matter contains steranes in which the C27 compounds are more abundant than the C29 compounds. General aquatic organic matter has approximately equivalent amounts of the C27 and C29 compounds while organic matter rich in land-plants usually has a lot more of the C29 steranes.

(ii) Based on Triterpanes

The triterpane components in petroleum can be derived from both bacteria and higher plants. The common bacterial products are the C27-C35 hopanes and moretanes whereas the higher plant triterpanes are compounds other than hopanes or moretanes and are commonly C30 compounds.

(iii) Based on Diasteranes

The diasteranes are not produced biologically but are formed during early diagenesis from sterane precursors. The diasterane ratios

$$\frac{C27(20R)}{C29(20R)} \quad \text{and} \quad \frac{C27(20R+20S)}{C29(20R+20S)}$$

should reflect the nature of the organic matter in the same manner as that outlined above for the steranes.

Biodegradation

It has been observed that in severely biodegraded petroleum the series of normal hopanes are converted to a series of A ring demethylated hopanes and the C29 (20R) sterane is selectively removed. For altered crudes which have not been degraded to this extent the severity of biodegradation can often be gauged by studying the isoprenoid and aromatic fractions. However, this type of investigation extends beyond a standard GC/MS/DS analysis.

Correlation

Our present approach to oil:oil or oil:source rock correlation problems is as follows:

(i) Compare the distribution of compounds in the 123, 177, 191, 205, 217, 218, 231 and 259 mass fragmentograms for an oil or sediment extract to the distribution of compounds in the respective fragmentograms for the other oil(s) or sediment extract(s). It is necessary in this type of comparison to make allowance for small variations due to possible maturity differences.

(ii) Examine the fragmentograms for peaks or sets of peaks which may represent compounds that are specific to the geological system under investigation. Normal steranes, diasteranes and bacterial hopanes cannot be used for this purpose because they are present in virtually all crude oils and sediment extracts. However, compounds like higher plant triterpanes, bisnorhopane and botryococcane can often prove very useful for this purpose.

15. CARBON ISOTOPE ANALYSIS

The measurement is carried out on one or more of the following mixtures; topped oil; saturate fraction; aromatic fraction; NSO fraction. The organic matter is combusted at 860 Deg. C in oxygen and the carbon dioxide formed is purified and transferred to an isotope mass spectrometer. The carbon isotope ratio is measured relative to a standard gas of known isotopic composition. In our case the standard gas is prepared from the NBS No. 22 oil. However, since the isotopic relationship between NBS No. 22 oil and the international reference PDB limestone are known, the values are adjusted to be relative to PDB limestone.

Although carbon isotope data has been commonly used for oil:oil and oil:source rock correlation its most significant application is the identification of the source of gas according to the following criteria (Fuex, 1977):

<u>$\delta^{13}C$ (PDB)</u>	<u>Gas Type</u>
-85 to -58	Biogenic methane
-58 to -40	Wet gas/associated with oil
-40 to -25	Thermal methane

16. VITRINITE REFLECTANCE MEASUREMENT

Vitrinite is a coal maceral which responds to increasing levels of thermal maturity. This response can be measured by the percent of light reflected off a polished surface of a vitrinite particle immersed in oil. Reflectance measurements are made on a number (40 if possible) of vitrinite particles in each sample, in order to establish a range and mean for reflectance values. Immature rocks have low reflectance values (0.2% Ro to 0.6% Ro), with mature values ranging from 0.6% Ro to 1.2% Ro. Very mature values are between 1.2% Ro and 1.8% Ro, while severely altered rocks have reflectances above 1.8% Ro.

Vitrinite reflectance results are best obtained from coals or rocks deposited in environments receiving large influxes of terrestrially-derived organic matter. Unfortunately, these environments are not conducive to the accumulation of large quantities of oil-prone organic matter. Also vitrinite reflectance cannot be performed on rocks older than Devonian Age, due to the absence of land plants in the older geological time periods.

17. VISUAL KEROGEN

Visual kerogen assessment is carried out by the coal petrologist and/or the palynologist. In the case of the petrologist the assessment is made in reflected light using the plug prepared for vitrinite reflectance measurement, and reports the relative amounts of alginite, exinite, vitrinite and inertinite particles.

Visual study of kerogen by the palynologist is carried out in transmitted light and can indicate the relative abundance, size and state of preservation of the various recognizable kerogen types and hence indicates the source character of a sedimentary rock. In addition, the colour of the kerogen is related to the thermal maturity of the sediments and is often used as a maturation indicator.

The preparation of slides for visual kerogen assessment by the palynologist firstly involves concentration of the organic matter by removal of the rock matrix using hydrochloric and hydrofluoric acid treatment and heavy liquid separation. The organic concentrate is then mounted on a glass slide using Petropoxy.

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