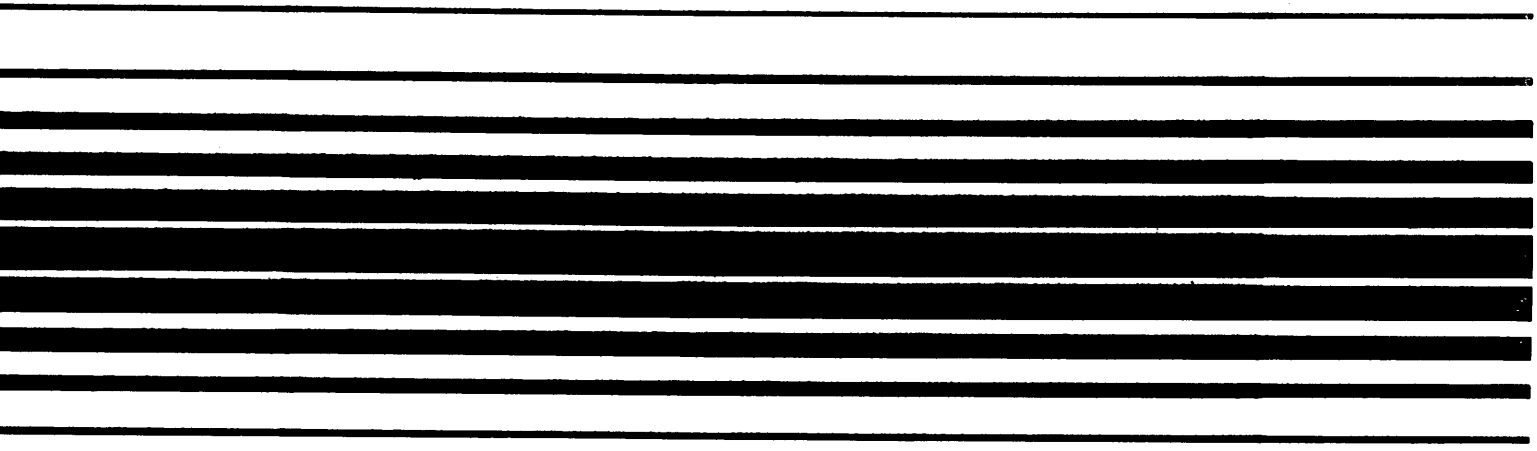


W956.



PEP 111
OTWAY BASIN
VICTORIA

WINDERMERE - 1

WELL COMPLETION REPORT

WINDERMERE-1. W.C.R. Vol 2 of 2.

Volume II of II

Appendix K

Geochem Report & Water
Analyses

GEOCHEMICAL ANALYSIS OF OIL, WATERS
AND CUTTINGS FROM WINDERMERE-1,
PEP-111, OTWAY BASIN

Minora Resources NL

F3/0/0-F6771/87

July 1987



technology and enterprise

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15 July 1987

F 3/0/0
F 6771/87 - Part 2 (Final)

Minora Resources NL
7th Floor
Colonial Mutual Building
55 St Georges Terrace
PERTH WA 6000

Attention: Ed Kopsen

REPORT F 6771/87 - Part 2 (Final)

YOUR REFERENCE: Phone call from E. Kopsen 1/4/87 and Data Transmittal No. 234

TITLE: Geochemical analysis of oil, waters and cuttings from Windermere-1, PEP-111, Otway Basin

MATERIAL: Oil (1 sample). Water (3 samples). Cuttings (1 sample).

LOCALITY: WINDERMERE-1

IDENTIFICATION: As in Section 1 of report

DATE RECEIVED: 6 and 29 April 1987

WORK REQUIRED: Water: Water analysis (W2/1). Oil: Whole-oil GC (R2.1). Physical tests (R2.3) - specific gravity, pour point, kinematic viscosity. Sulphur content (R2.4). Gasoline-range analysis (R3.18). Topping of oil to 210°C (R3.7). Liquid chromatography with prior deasphalting (R3.8). GC of saturates (R3.9). Isolation and GC-MS of naphthenes (R3.13). Isolation (by TLC) and GC-MS of aromatics (R3.14). Cuttings: TOC content. Rock-Eval pyrolysis. Vitrinite reflectance. Organic petrology. Interpretation.

Investigation and Report by: David M. McKirdy

Manager, Petroleum Services Section: Dr Brian G. Steveson

for Dr William G. Spencer
General Manager
Applied Sciences Group

1. INTRODUCTION

The following samples from Windermere-1 were submitted for geochemical analysis:

<u>Sample Type</u>	<u>Test</u>	<u>Depth</u>	<u>Formation</u>
Water	SFT	435	Dilwyn
Water	SFT	535	Dilwyn
Water	DST 1	1791-1838	Eumeralla
Oil	DST 1	1791-1838	Eumeralla
Cuttings	-	1830-1840	Eumeralla

The objectives of the analytical program were threefold:

- 1) to determine the physical properties, sulphur content, type, maturity, source affinity and degree of post-pooling alteration (water washing, biodegradation) of the oil;
- 2) to ascertain whether the oil has migrated from a distant source kitchen or, alternatively, is of local origin; and
- 3) to characterise the chemical composition, total dissolved solids, hardness, alkalinity and resistivity/conductivity of waters obtained from tests of the Dilwyn and Eumeralla Formations.

Preliminary results were facsimiled to Minora Resources' Perth office in seven progress reports dated 7 and 16 April, 1, 8, 11 and 25 May, and 30 June, 1987. Progress report 3 contained interpretative comments on the geochemistry of the Windermere-1 (DST 1) oil.

Analytical data on the fluids (oil, water) recovered during DST 1 of the Eumeralla Formation were formally presented in Part 1 of this report on 23 April 1987.

2. ANALYTICAL METHODS

Details of the analytical procedure are given in Appendix 1.

3. RESULTS

Analytical data are summarised and presented herein as follows:

	<u>Table</u>	<u>Figure</u>	<u>Appendix</u>
<u>Oil Analysis</u>			
Physical properties, gasoline & sulphur contents	1	-	-
Whole-oil GC	-	1	2
Gasoline-range composition	2,3	2-4	-
C ₁₂₊ composition	4	5	-
GC of saturates	4,5	6	-
GC-MS of naphthenes	5,6	7-9,12	3
GC-MS of aromatics	7,8	10,11	-
Calculated vitrinite reflectance	7	-	-

Cuttings Analysis

TOC, Rock-Eval pyrolysis	9	13	-
Vitrinite reflectance	10	-	4
Organic petrology	11-13	-	-
<u>Water Analysis</u>	-	-	5

4. OIL GEOCHEMISTRY

4.1 General Characteristics

The Windermere-1 (Eumeralla) oil is a waxy, low sulphur, paraffinic crude (Fig. 5) with an intermediate gravity (41° API) and a high pour point (27°C).

Careful examination of its gasoline-range composition reveals that the oil probably has not been altered in the reservoir by water washing or biodegradation.

The values of gasoline-range parameters 3-5 in this oil (Table 3) are much lower than in water-washed oils of similar maturity and non-marine origin from certain Jurassic reservoirs in the Eromanga Basin (McKirdy, 1985).

Moreover, the low values of parameters 1 and 2, and high value of parameter 6 in the Windermere-1 crude (Table 3) are a reflection of its immaturity, rather than a result of slight biodegradation.

The immaturity of the Windermere-1 (Eumeralla) oil also accounts for its relative lack of light ends (C₅-C₁₀ hydrocarbons comprise less than 25% of the total crude: Fig. 1; Appendix 2). Thus, the high wax content (and pour point) of the oil is a primary compositional feature. This contrasts with the situation in the Pebble Point Formation at Lindon-1 where a mature oil or condensate has been stripped of its light ends by water washing and biodegradation, resulting in a heavy, waxy, residual crude (28° API gravity, 33°C pour point).

4.2 Maturity

Maturity measurements based on gasoline-range hydrocarbons (parameters 8 & 9, Table 3; Fig. 4), sterane, triterpane and isoprenoid alkane biomarkers (parameters 4, 6, 9, 10 & 16, Table 5), and triaromatic hydrocarbons (Tables 7, 8) all concur in highlighting the low maturity of the Windermere-1 crude ($VR_{calc} = 0.57\%$). Of particular significance is the high concentration of the thermally labile 1,8-DMN isomer in the dimethylnaphthalene distribution of the Windermere-1 oil (Table 8, Fig. 10).

The lack of evidence for long-distance migration (parameters 6 & 7, Table 5) is consistent with its probably origin in a nearby, marginally mature source rock, probably within the Early Cretaceous Eumeralla Formation.

4.3 Source Affinity

The terrestrial source affinity of the Windermere-1 oil is clearly evident from both its C₅-C₇ alkanes (Fig. 3) and aspects of its C₁₂₊ alkane composition (Fig. 12). The oil originated from higher plant remains (C₂₉/C₂₇ sterane > 1.5) which were deposited in a partly oxic aquatic environment (pr/ph > 2). This primary land plant detritus was reworked (degraded) by aerobic bacteria (and ?fungi) during early diagenesis. Bacteria were the precursors of the C₂₇-C₃₅ hopanes found in the oil (m/z 191, Fig. 8). A major input of bacterial lipids to its source material accounts for the oil's high hopane/sterane ratio (parameter 18, Table 6).

The C₂₇-C₂₉ sterane and diasterane distributions of the Windermere-1 oil are dominated by C₂₉ homologues of higher plant origin (Fig. 9). This is a characteristic feature of most Australian non-marine crude oils (see e.g. Vincent *et al.*, 1985; Philp and Gilbert, 1986).

Regular (head-to-tail) acyclic isoprenoids up to C₄₀ have been tentatively identified in the Windermere-1 oil (m/z 183, Fig. 8). This isoprenoid distribution differs in detail from those found in oils like the Otway Basin coastal bitumens which were generated from source rocks deposited under stable anoxic conditions (McKirdy *et al.*, 1984, 1986; see also Fig. 12). The higher isoprenoids (C₂₁₊) in the Windermere-1 crude are likely to be derived from long-chain oligoterpenyl alcohols which occur in higher plants (Philp and Gilbert, 1986), rather than from methanogenic archaeobacteria.

The m/z 123 mass fragmentogram (retention time 25-30 mins.: Fig. 7) is dominated by the tricyclic diterpanes, 19-norisopimarane and isopimarane. These particular C₁₉ and C₂₀ hydrocarbons are biological markers of conifer leaf resins (Noble *et al.*, 1986).

5. SOURCE ROCK ANALYSIS

Cuttings from 1830-1838 metres depth in the Eumeralla Formation were hand-picked to separate its dominant lithotypes (90% shale, 10% coal). These two rock types were analysed separately.

5.1 Maturity

Rock-Eval pyrolysis data (Fig. 13) are in good agreement with vitrinite reflectance measurements (VR = 0.50% : Table 10). The slightly higher apparent maturity of the shale in Figure 13 is attributable to the high inertinite content of its dispersed organic matter (I = 90% of DOM : Table 11).

5.2 Source Richness and Quality

The low genetic potential and poor source quality of the shale (S₁+S₂ < 1 kg hydrocarbons/tonne; HI = 100 : Table 9) is consistent with the highly inertinitic composition of its DOM, and the slightly oxidised condition of its exinite (Tables 11, 12). The shale contains gas-prone Type III-IV kerogen (Fig. 13).

The source richness and quality of the coal is very good ($S_1+S_2 = 210$ kg hydrocarbons/tonne; HI = 353 : Table 9). The better quality of its Type II-III organic matter (Fig. 13) is a direct result of its higher vitrinite content ($V = 50\%$ of DOM : Table 11). This coal is a marginally mature potential source of oil and gas.

6. OIL-SOURCE CORRELATION

The MPI-derived maturity of the Windermere-1 (Eumeralla) oil ($VR_{calc} = 0.57\%$) represents the maturation level of its source rock at the time of primary migration.

Comparison of VR_{calc} with the vitrinite reflectance of the host reservoir ($VR_{meas} = 0.50\%$) shows that the oil is only slightly out of place in terms of maturity.

Given the apparent oil-source potential of coal within the Eumeralla Formation (Section 5.2), it seems likely that the Windermere-1 crude originated within the same formation. Two possible scenarios exist for the origin of this oil from an intra-Eumeralla source:

- 1) migration up faults from deeper in the Eumeralla Formation at Windermere-1
- 2) up-dip migration from a source kitchen located basinward of the Windermere-1 well where coals of the upper Eumeralla Formation are more deeply buried.

7. CONCLUSIONS

1. Intermediate (41° API gravity), waxy (27°C pour point) oil recovered during drill-stem testing of sands within the upper Eumeralla Formation at Windermere-1 is an immature, unaltered, primary paraffinic crude of terrestrial origin.
2. On the basis of its maturity ($VR_{calc} = 0.57\%$) and composition, the oil can be correlated with coal-bearing sediments within the Early Cretaceous Eumeralla Formation.
3. The oil originated from a source kitchen in close proximity to the Windermere-1 well locality.

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TABLE 1

Job No.	:	F6771/87
Client	:	Minora Resources NL
Well	:	Windermere-1
Sample	:	DST 1, 1791-1838 m

Specific gravity (15°C)	0.8205
API gravity (60/60°F)	40.9
Pour point	27°C
Viscosity (40°C)	4.21 centistokes
Gasoline content (C ₅ -C ₁₀ by wt)	23.7%
Sulphur content (by ICP)	400 ppm

TABLE 2

AMDEL
GASOLINE-RANGE ANALYSIS

MINORA RESOURCES N.L.

GASOLINE-RANGE (C5-C7)

SAMPLE: WINDERMERE-1 DST 1 1791-1838M

COMPOUND	%			
	NORMAL	BRANCHED	CYCLIC	AROMATIC
2-METHYLBUTANE		7.61		
N-PENTANE	5.84			
2,2-DIMETHYLBUTANE		.67		
CYCLOPENTANE				.55
2,3-DIMETHYLBUTANE		1.59		
2-METHYLPENTANE		4.67		
3-METHYLPENTANE		2.78		
N-HEXANE	7.39			
2,2-DIMETHYLPENTANE		.43		
METHYLCYCLOPENTANE			5.84	
2,4-DIMETHYLPENTANE		.21		
2,2,3-TRIMETHYLBUTANE		.02		
BENZENE				.23
3,3-DIMETHYLPENTANE		.18		
CYCLOHEXANE			6.87	
2-METHYLHEXANE		3.00		
2,3-DIMETHYLPENTANE		1.38		
1,1-DIMETHYLCYCLOPENTANE				.82
3-METHYLHEXANE		2.68		
TRANS-1,3-DIMETHYLCYCLOPENTANE				1.50
CIS-1,3-DIMETHYLCYCLOPENTANE				1.45
3-ETHYLPENTANE		.00		
TRANS-1,2-DIMETHYLCYCLOPENTANE				2.46
N-HEPTANE	9.06			
METHYLCYCLOHEXANE			31.61	
ETHYLCYCLOPENTANE			.46	
TOLUENE				.73
TOTAL PERCENTAGES	22.29	25.22	51.53	.96

TABLE 5: BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION IN OIL FROM WINDERMERE-1

AMDEL Sample	Test & Formation	Depth m	Steranes					Terpanes					Acyclic Alkanes						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MS-369	DST 1	1791-1838	-	6.8	11.1	0.82	1.1	0.90	0.57	0.08	3.7	0.05	1.4	0.17	0.04	6.1	0.43	1.1	0.17
	Eumeralla																		

*See key (next page) for derivation and specificity of each parameter

KEY TO BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION

Parameter	* Derivation	Specificity
1	C ₂₇ : C ₂₈ : C ₂₉ 5α(H)14α(H)17α(H) 20R steranes	Source
2	C ₂₉ 5α(H)14α(H)17α(H) 20R sterane / C ₂₇ 5α(H)14α(H)17α(H) 20R sterane	Source
3	C ₂₉ 13β(H)17α(H) 20R diasterane / C ₂₇ 13β(H)17α(H) 20R diasterane	Source
4	C ₂₉ 5α(H)14α(H)17α(H) 20S sterane / C ₂₉ 5α(H)14α(H)17α(H) 20R sterane	Maturity, Biodegradation
5	C ₂₇ 13β(H)17α(H) 20S diasterane / C ₂₇ 13β(H)17α(H) 20R diasterane	Maturity
6	C ₂₉ 5α(H)14β(H)17β(H) 20R sterane / C ₂₉ 5α(H)14α(H)17α(H) 20R sterane	Maturity, Migration
7	C ₂₉ 13β(H)17α(H) 20R+20S diasteranes / C ₂₉ 5α(H) steranes	Migration, Source
8	C ₃₀ pentacyclic terpene/C ₃₀ 17α(H)21β(H) hopane	Source
9	C ₂₇ 17α(H)-22,29,30-trisnorhopane / C ₂₇ 18α(H)-22,29,30-trisnorhopane (T _m /T _s)	Maturity, Source
10	T _s / C ₃₀ 17α(H)21β(H) hopane	Maturity
11	C ₃₂ 17α(H)21β(H) 22S homohopane / C ₃₂ 17α(H)21β(H) 22R homohopane	Maturity
12	C ₃₀ 17β(H)21α(H) moretane / C ₃₀ 17α(H)21β(H) hopane	Maturity
13	C ₂₉ 17α(H)-25-norhopane / C ₂₉ 17α(H)-30-norhopane	Biodegradation
14	pristane / phytane	Source
15	2,6,10-trimethyltridecane / pristane	Maturity
16	pristane / n-heptadecane	Source, Biodegradation, Maturity
17	phytane / n-octadecane	Source, Biodegradation, Maturity

* Ratios calculated from peak areas as follows:

- Parameters 1-6 m/z = 217 mass fragmentogram
- Parameter 7 m/z = 217, 259 mass fragmentograms
- Parameters 8-13 m/z = 191 mass fragmentogram
- Parameters 14-17 capillary gas chromatogram of alkanes or whole oil/extract

TABLE 6: SUPPLEMENTARY SOURCE-DEPENDENT BIOMARKER RATIOS IN OIL FROM WINDERMERE-1

Test & Formation	C ₃₀ Hopane		C ₃₁ Me Hopane		C ₂₄ Tetracyclic		16 β H-Phyll		ent-Bey: 16 β H-Phyll:ent-16 β H-Kaur		Isopim 16 β H-Phyll
	C ₂₉ Steranes	C ₃₀ Hopane	C ₃₀ Hopane	C ₃₀ Hopane	C ₃₀ Hopane	C ₃₀ Hopane	C ₃₀ Hopane	C ₃₀ Hopane	C ₃₀ Hopane	49:51:0	
DST 1 Eumeralla	4.4	0.14	0.39	0.04	20	21	22	23	6.0		

*Measured from mass fragmentograms as follows:

- Parameter 18 m/z 191, 217
- Parameter 19 m/z 191, 205
- Parameter 20 m/z 191
- Parameter 21 m/z 123, 191
- Parameter 22 m/z 259
- Parameter 23 m/z 123

TABLE 7 : OIL MATURITY BASED ON AROMATIC HYDROCARBON DISTRIBUTIONS*,
WINDERMERE-1

AMDEL Sample No.	Well	Test & Depth (m)	MPI	MPR	DNR	VR _{calc}				
						(a)	(b)	(c)	(d)	(e)
MS-370	Windermere-1	DST 1 1791-1838	0.49	0.81	nd	0.70	N/A	0.85	N/A	0.57 ✓

*See key (next page) for derivation of listed parameters

nd = not determined

N/A = not applicable

✓ = preferred value

KEY TO AROMATIC MATURITY INDICATORS

Methylphenanthrene index (MPI), methylphenanthrene ratio (MPR), dimethylnaphthalene ratio (DNR) and calculated vitrinite reflectance (VR_{calc}) are derived from the following equations (after Radke and Welte, 1983; Radke et al., 1984):

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

$$VR_{calc} (a) = 0.6 MPI + 0.4 \text{ (for } VR < 1.35\%)$$

$$VR_{calc} (b) = -0.6 MPI + 2.3 \text{ (for } VR > 1.35\%)$$

$$MPR = \frac{2-MP}{1-MP}$$

$$VR_{calc} (c) = 0.99 \log_{10} MPR + 0.94 \text{ (for } VR = 0.5-1.7\%)$$

$$DNR-1 = \frac{2,6-DMN + 2,7-DMN}{1,5-DMN}$$

$$VR_{calc} (d) = 0.046 DNR + 0.89 \text{ (for } VR = 0.9-1.5\%)$$

Where P	=	phenanthrene
1-MP	=	1-methylphenanthrene
2-MP	=	2-methylphenanthrene
3-MP	=	3-methylphenanthrene
9-MP	=	9-methylphenanthrene
1,5-DMN	=	1,5-dimethylnaphthalene
2,6-DMN	=	2,6-dimethylnaphthalene
2,7-DMN	=	2,7-dimethylnaphthalene

Peak areas measured from m/z 155+156 (dimethylnaphthalene), m/z 178 (phenanthrene) and m/z 191+192 (methylphenanthrene) mass fragmentograms of diaromatic and triaromatic hydrocarbon fraction isolated by thin layer chromatography.

Recalibration of the methylphenanthrene index using data from a suite of Australian coals has given rise to another equation for calculated vitrinite reflectance (after Boreham and Powell, 1987):

$$VR_{calc} (e) = 0.7 MPI + 0.22 \text{ (for } VR < 1.7\%)$$

The following dimethylnaphthalene ratio (Alexander et al., 1985) has not been calibrated against vitrinite reflectance:

$$DNR-5 = \frac{1,6-DMN}{1,8-DMN}$$

TABLE 8: SUPPLEMENTARY AROMATIC MATURITY RATIOS* IN OIL FROM WINDERMERE-1

Well	Test & Depth (m)	DNR-5	TNR-1
Windermere-1	DST 1 1791-1838	4.2	0.54

*After Alexander et al. (1985)

$$\begin{aligned}
 \text{DNR-5} &= \frac{1,6\text{-Dimethylnaphthalene}}{1,8\text{-Dimethylnaphthalene}} \\
 \text{TNR-1} &= \frac{2,3,6\text{-Trimethylnaphthalene}}{1,4,6+1,3,5\text{-Trimethylnaphthalene}}
 \end{aligned}$$

4/10/85

TABLE 10: SUMMARY OF VITRINITE REFLECTANCE DATA, WINDERMERE-1

Depth (m)	Mean Maximum Reflectance (%)	Standard Deviation	Range	Number of Determinations
1830-1838*				
Coal	0.50	0.03	0.44-0.60	33
Shale	0.49	0.04	0.40-0.54	12

*Cuttings comprise 10% coal, 90% shale.

W. J. B. B. B.

TABLE 11: PERCENTAGE OF VITRINITE, INERTINITE AND EXINITE IN DISPERSED ORGANIC MATTER, WINDERMERE-1

Depth (m)	Percentage of		
	Vitrinite	Inertinite	Exinite
1830-1838 Coal	50	40	10
1830-1838 Shale	<5	90	5-10

PLS (P. 22.04)

TABLE 12: ORGANIC MATTER TYPE AND ABUNDANCE, WINDERMERE-1

Depth (m)	Relative Maceral Group Proportions	Estimated Volume of DDM	Estimated Volume of Exinites	Exinite Macerals
1830-1838 Coal	V>I>E	60-70%	Ab	lama, bmite, lipto, spo, res, cut
1830-1838 Shale	I>>E>V	0.5-1%	Ra	lama, lipto, spo, cut, bmite, tela

1/10/76

TABLE 13: EXINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS,
WINDERMERE-1

Depth (m)	Exinite Macerals	Lithology/Comments
1830-1838 Coal	lama (Ab; mO-dO), bmite (Co; dO), lipto (Sp; mO), spo (Ra; mY-dO), cut (Vr; mO-dO)	Coal; durite, duroclarite and clarodurite. Bituminite is slightly micrinitised. Most exinites appear to be slightly oxidised.
1830-1838 Shale	lama (Ra; mO-dO), lipto (Vr; mO), spo (Vr, mY-dO), cut (Vr; mO-dO), tela (Tr; iY)	Shale; most exinites appear to be slightly oxidised. Bituminite as above. Telalginite is <i>Botryococcus</i> - related.

11-18-79 5:11

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

	<u>PARAMETER</u>	<u>SPECIFICITY</u>
T max	position of S ₂ peak in temperature program (°C)	Maturity/Kerogen type
S ₁	kg hydrocarbons (extractable)/tonne rock	Kerogen type/Maturity/Migrated oil
S ₂	kg hydrocarbons (kerogen pyrolysate)/tonne rock	Kerogen type/Maturity
S ₃	kg CO ₂ (organic)/tonne rock	Kerogen type/Maturity*
S ₁ +S ₂	Potential Yield	Organic richness/Kerogen type
PI	Production Index (S ₁ /S ₁ + S ₂)	Maturity/Migrated oil
PC	Pyrolysable Carbon (wt. percent)	Organic richness/Kerogen type/Maturity
TOC	Total Organic Carbon (wt. percent)	Organic richness
HI	Hydrogen Index (mg h ^c (S ₂)/g TOC)	Kerogen type/Maturity
OI	Oxygen Index (mg CO ₂ (S ₃)/g TOC)	Kerogen type/Maturity*

*Also subject to interference by CO₂ from decomposition of carbonate minerals.

KEY TO DISPERSED ORGANIC MATTER DESCRIPTIONS

MACERAL GROUPS

V Vitrinite
I Inertinite
E Exinite

EXINITE MACERALS

spo Sporinite
cut Cutinite
res Resinite
sub Suberinite
lipto Liptodetrinite
fluor Fluorinite
terp Terpenite
exs Exsudatinite
phyto Phytoplankton
tela Telalginite
lama Lamalginite
bmite Bituminite
bmen Bitumen
thuc Thucholite

ABUNDANCE (by vol.)

Ma Major >15%
Ab Abundant 2-15%
Co Common 1-2%
Sp Sparse 0.5-1%
Ra Rare 0.1-0.5%
Vr Very Rare \approx 0.1%
Tr Trace <0.1

FLUORESCENCE COLOUR AND INTENSITY

G Green
Y Yellow
O Orange
B Brown
i Intense
m Moderate
d Dull
nofl No Visible Fluorescence

FIGURE 1

WHOLE-OIL CHROMATOGRAM
WINDERMERE-1, DST 1
Eumeralla Fm.

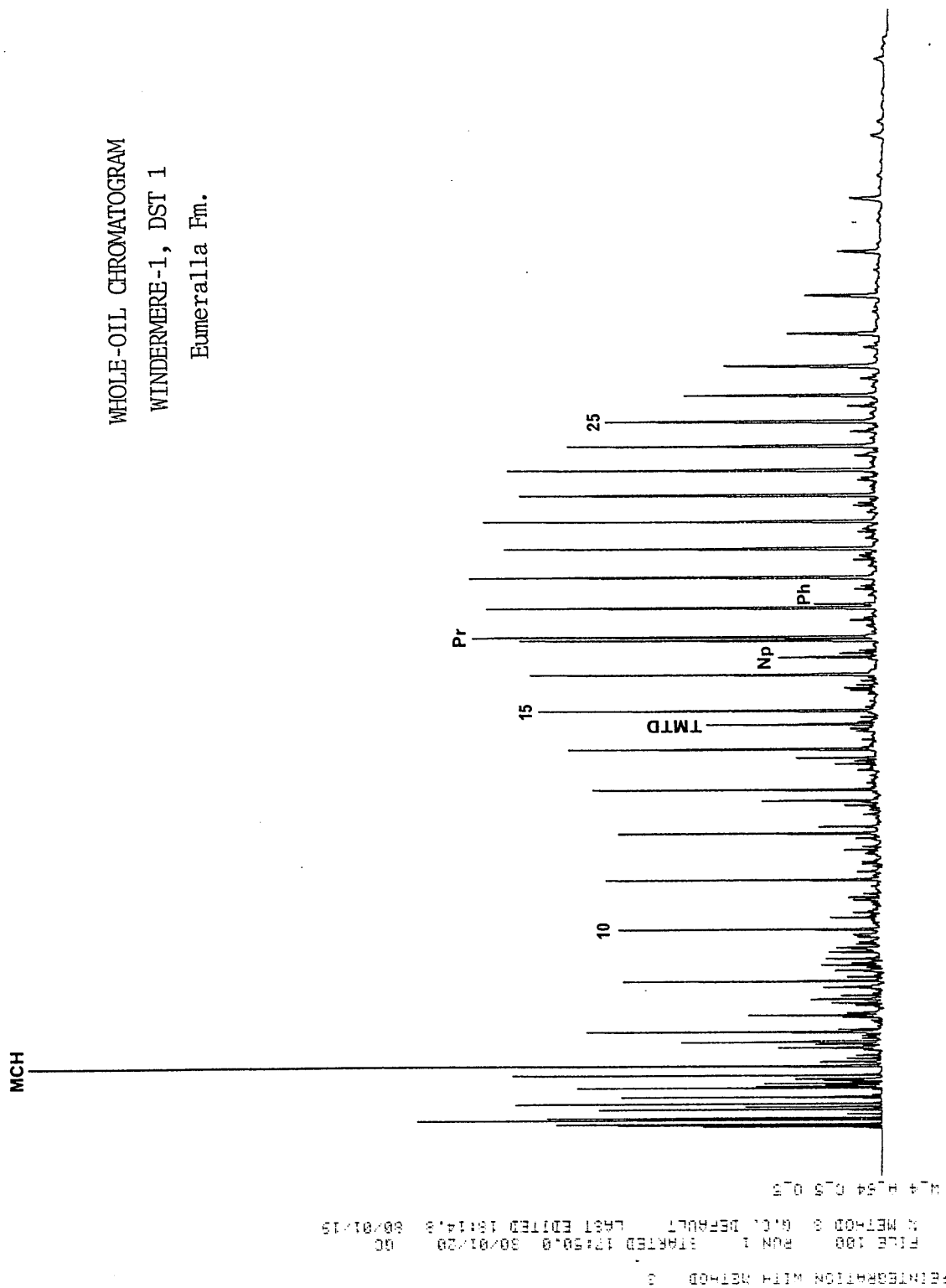
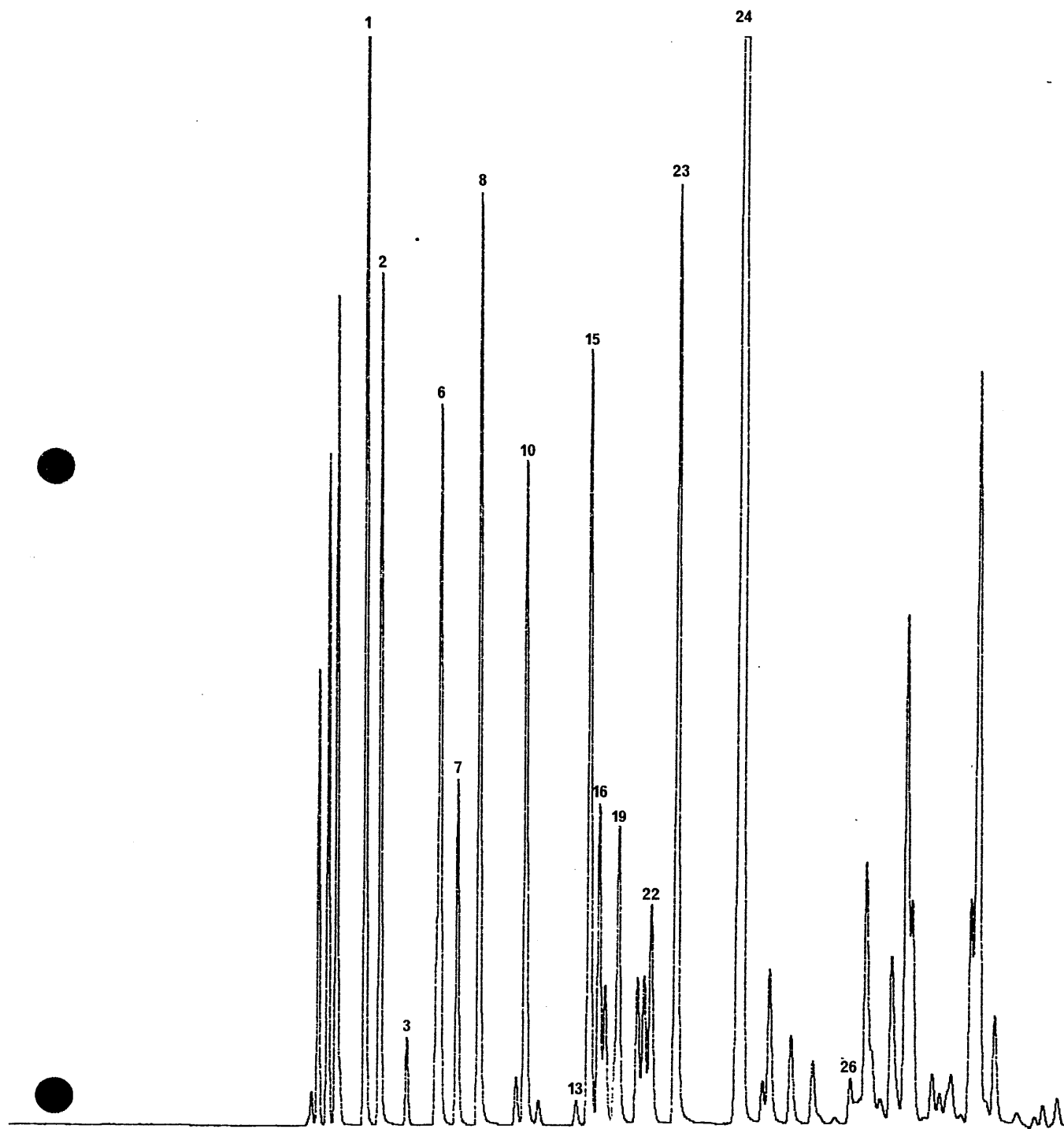


FIGURE 2

GASOLINE-RANGE CHROMATOGRAM

WINDERMERE-1, DST 1

Eumeralla Fm.

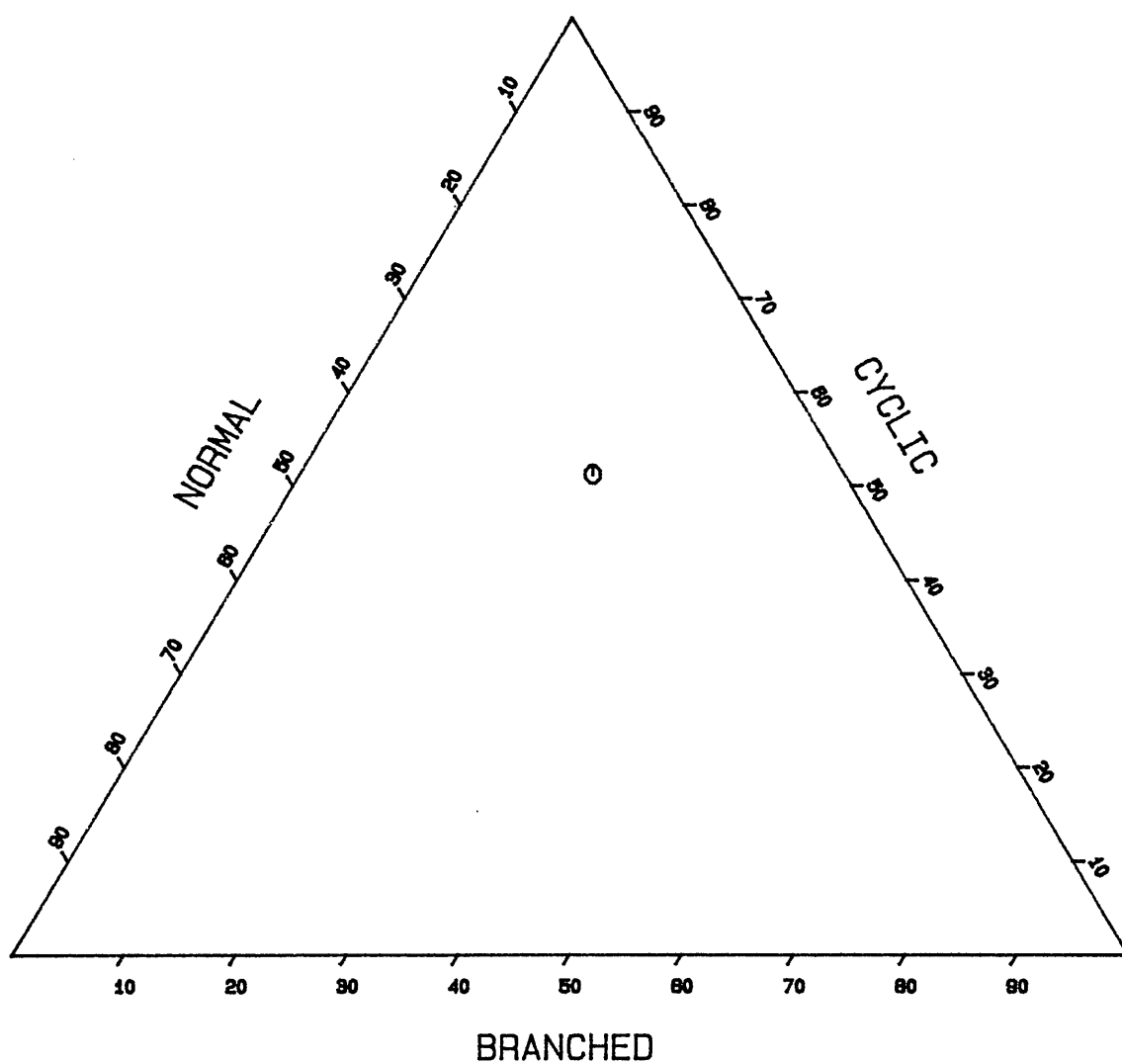


KEY TO GASOLINE-RANGE CHROMATOGRAM

1. 2-Methylbutane (Isopentane)
2. *n*-Pentane
3. 2,2-Dimethylbutane
4. Cyclopentane
5. 2,3-Dimethylbutane
6. 2-Methylpentane
7. 3-Methylpentane
8. *n*-Hexane
9. 2,2-Dimethylpentane
10. Methylcyclopentane
11. 2,4-Dimethylpentane
12. 2,2,3-Trimethylbutane
13. Benzene
14. 3,3-Dimethylpentane
15. Cyclohexane
16. 2-Methylhexane
17. 2,3-Dimethylpentane
18. 1,1-Dimethylcyclopentane
19. 3-Methylhexane
20. *cis*-1,3-Dimethylcyclopentane
21. *trans*-1,3-Dimethylcyclopentane
22. 3-Ethylpentane and *trans*-1,2-Dimethylcyclopentane
23. *n*-Heptane
24. Methylcyclohexane
25. Ethylcyclopentane
26. Toluene

FIGURE 3

SOURCE AFFINITY BASED ON C5-C7 ALKANES,
WINDERMERE-1



KEY TO C₅-C₇ TERNARY PLOT

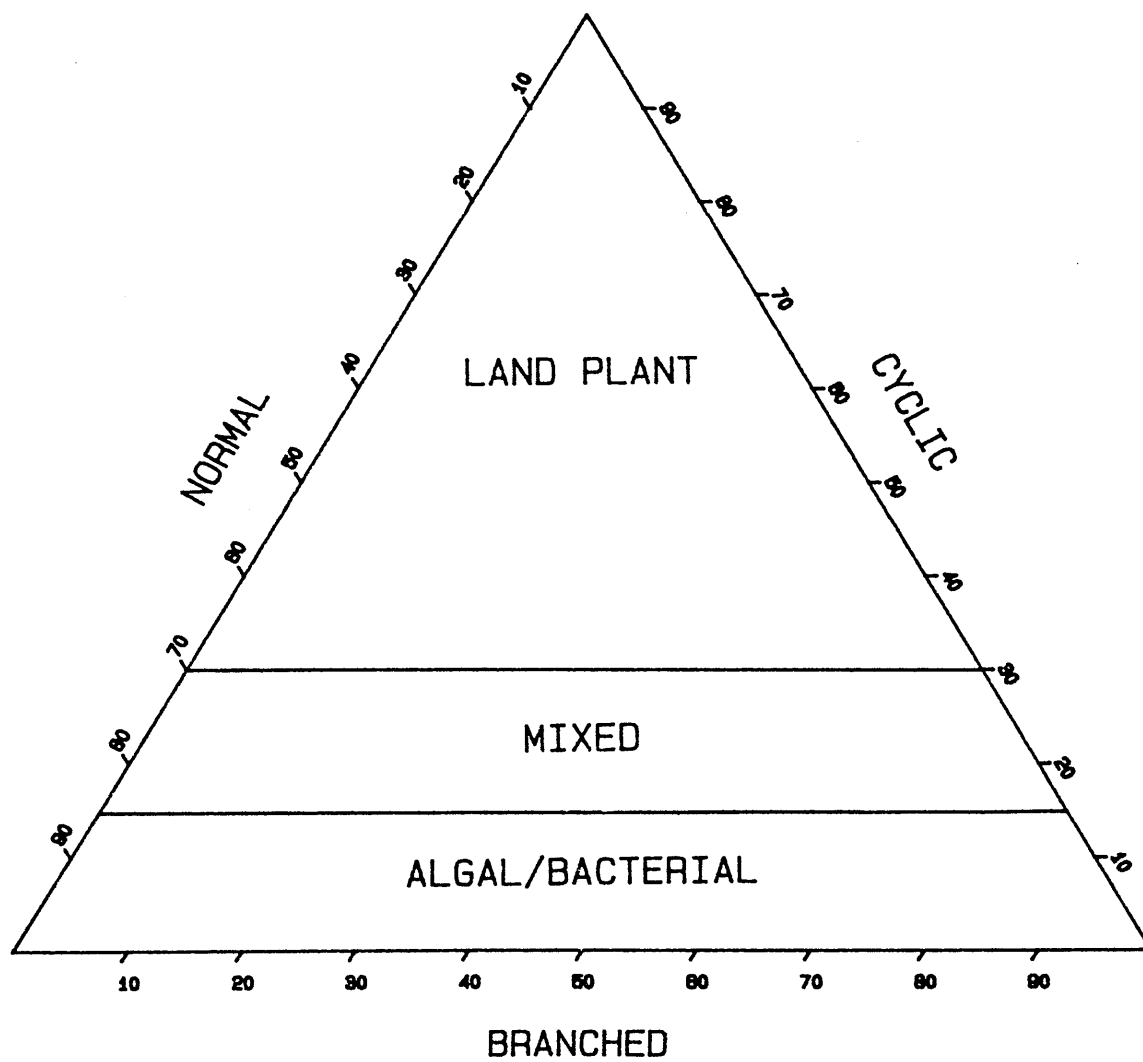


FIGURE 6

C₁₂₊ SATURATES
WINDERMERE-1, DST 1
Emeralla Fm.

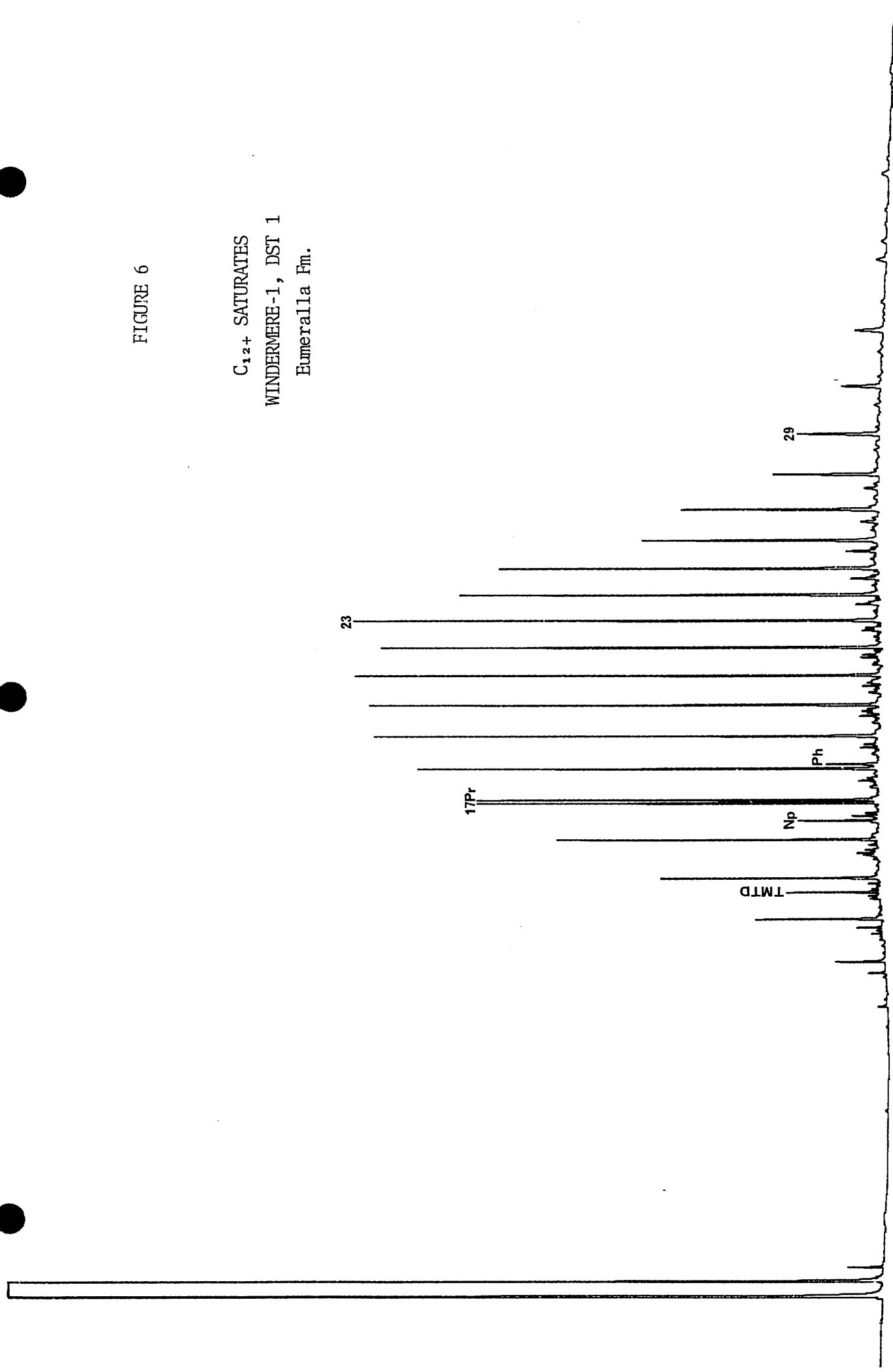
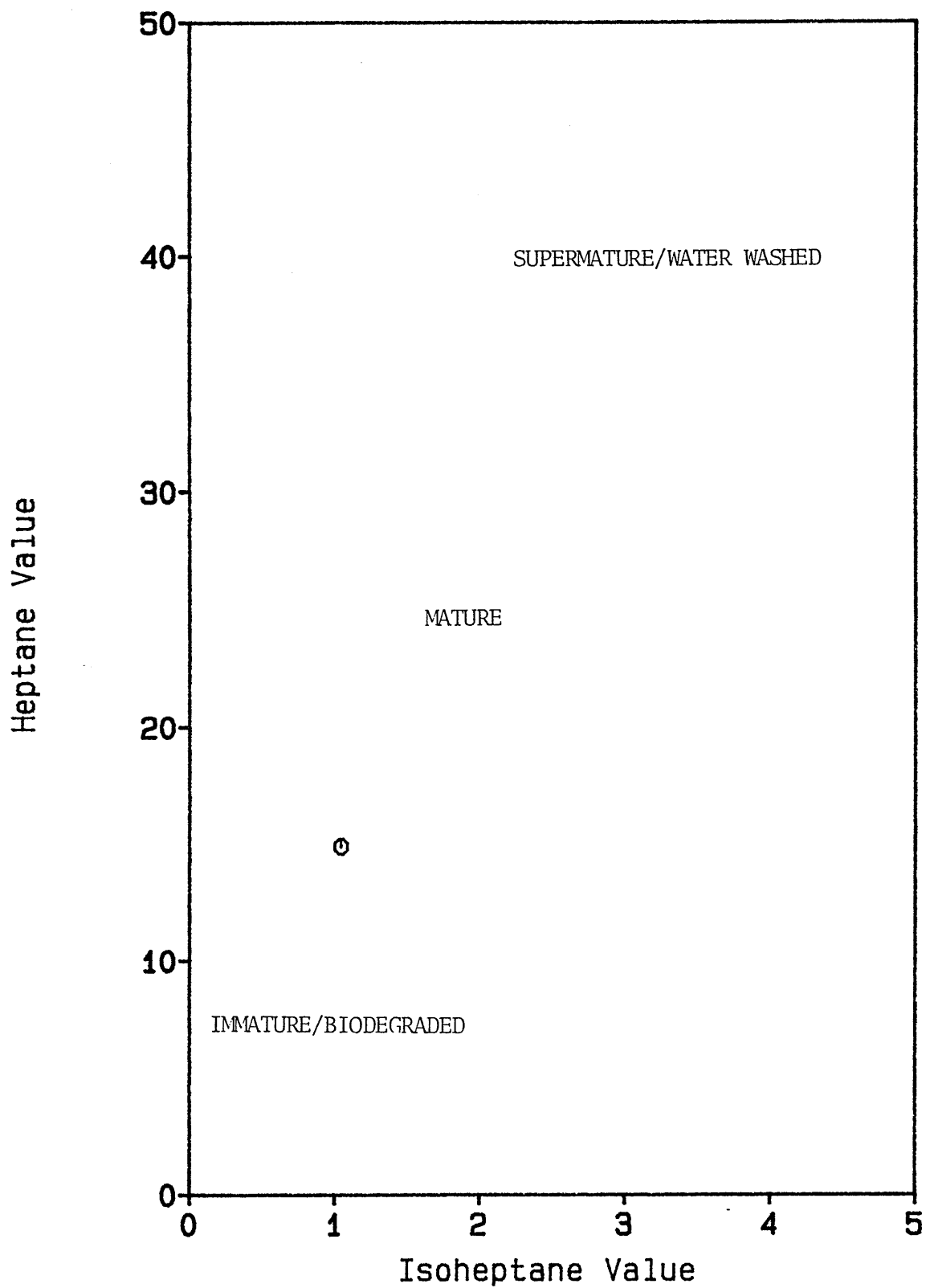


FIGURE 4

OIL MATURITY AND ALTERATION
WINDERMERE-1



dl-60, 30, 10

FIGURE 5

CRUDE OIL TYPE BASED ON
C₁₂₊ BULK COMPOSITION

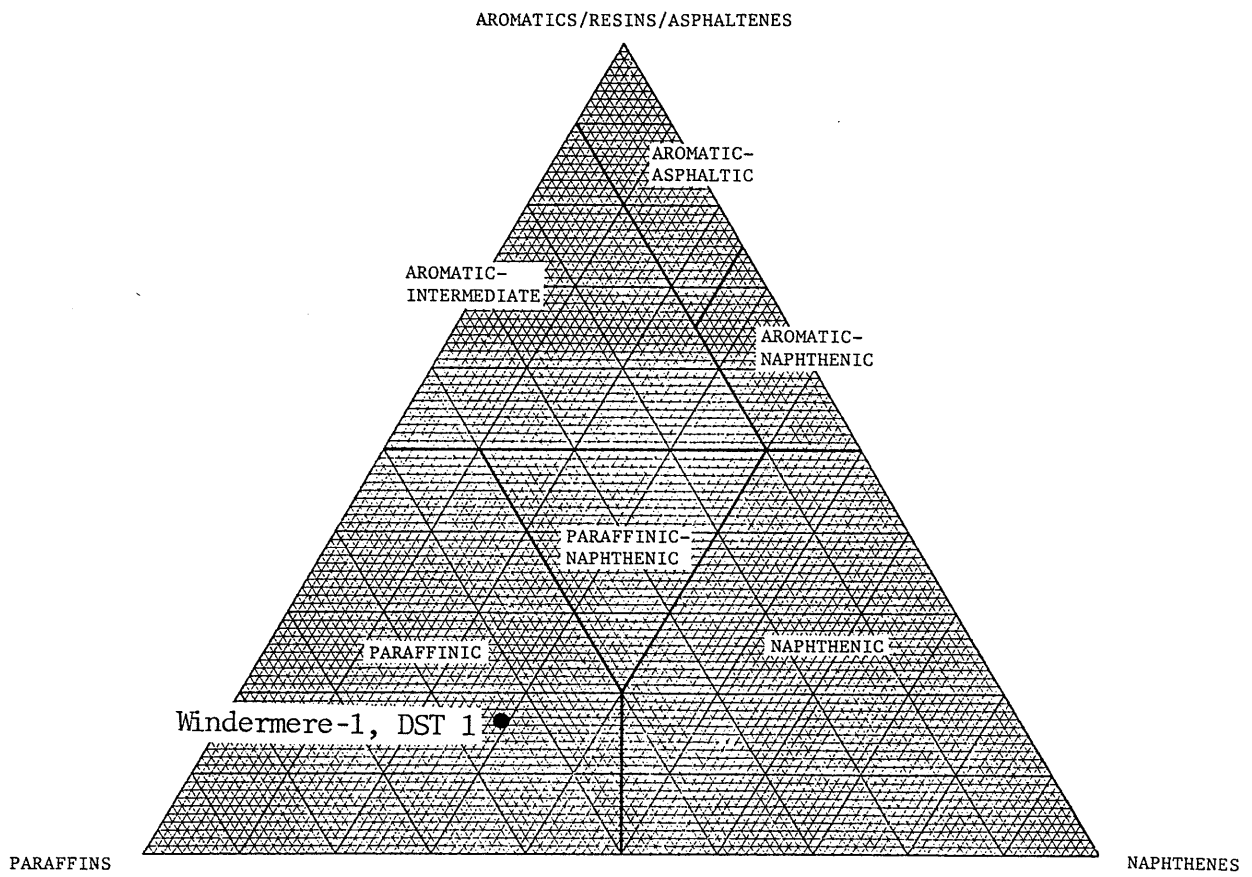


FIGURE 7-9

MASS FRAGMENTOGRAMS OF NAPHTHENES IN
OIL FROM WINDERMERE-1, DST 1

- Fig. 7 : m/z 123, 259 diterpanes
- Fig. 8 : m/z 183 acyclic isoprenoid alkanes
m/z 191 triterpanes (incl. hopanes,
moretanes)
- Fig. 9 : m/z 217, 218 steranes

KEY TO MASS FRAGMENTOGRAMS

m/z 123, 259 (diterpanes)

1	C ₁₉	isopimarane
2	C ₂₀	<u>ent</u> -beyerane
3	C ₂₀	isopimarane
4	C ₂₀	16 β (H)-phyllocladane
5	C ₂₀	<u>ent</u> -16 β (H)-kaurane
6	C ₂₀	16 α (H)-phyllocladane
7	C ₂₀	<u>ent</u> -16 α (H)-kaurane

m/z 183 (acyclic isoprenoid alkanes)

15-40 numbers indicate number of carbon atoms in compound
* irregular (head-to-head)

m/z 191 (terpanes)

1-6	C ₂₀ -C ₂₅	tricyclic terpanes
7	C ₂₄	tetracyclic terpane
8	C ₂₆	tricyclic terpane
9	C ₂₇	18 α (H)-22,29,30-trisnorhopane (Ts)
10	C ₂₇	17 α (H)-22,29,30-trisnorhopane (Tm)
11	C ₂₈	17 α (H)-28,30-bisnorhopane
12	C ₂₉	17 α (H)-25-norhopane
13	C ₂₉	17 α (H)21 β (H) norhopane
14	C ₃₀	pentacyclic terpane
15	C ₂₉	17 β (H)21 α (H) moretane
16	C ₃₀	17 α (H)21 β (H) hopane
17	C ₃₀	17 β (H)21 α (H) moretane
18-22	C ₃₁ -C ₃₅	17 α (H)21 β (H) 22S (left) and 22R (right) homohopanes

m/z 217, 218, 259 (steranes, diasteranes)

1	C ₂₁	sterane
2	C ₂₂	sterane
3&4	C ₂₇	20S and 20R diasteranes
5&8	C ₂₇	5 α (H)14 α (H)17 α (H) 20S and 20R steranes
6	C ₂₇	5 α (H)14 β (H)17 β (H) 20R sterane
7	C ₂₇	5 α (H)14 β (H)17 β (H) 20S sterane + C ₂₉ 20S diasterane
9	C ₂₉	20R diasterane
10&13	C ₂₈	5 α (H)14 α (H)17 α (H) 20S and 20R steranes
11&12	C ₂₈	5 α (H)14 β (H)17 β (H) 20R and 20S steranes
14&17	C ₂₉	5 α (H)14 α (H)17 α (H) 20S and 20R steranes
15&16	C ₂₉	5 α (H)14 β (H)17 β (H) 20R and 20S steranes

FIGURE 7

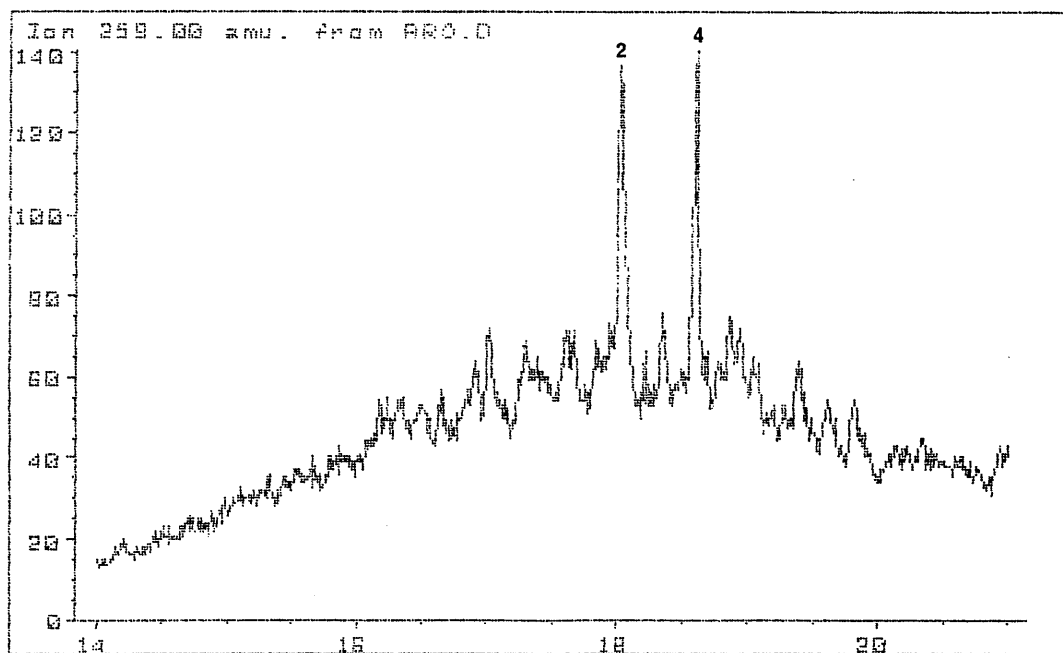
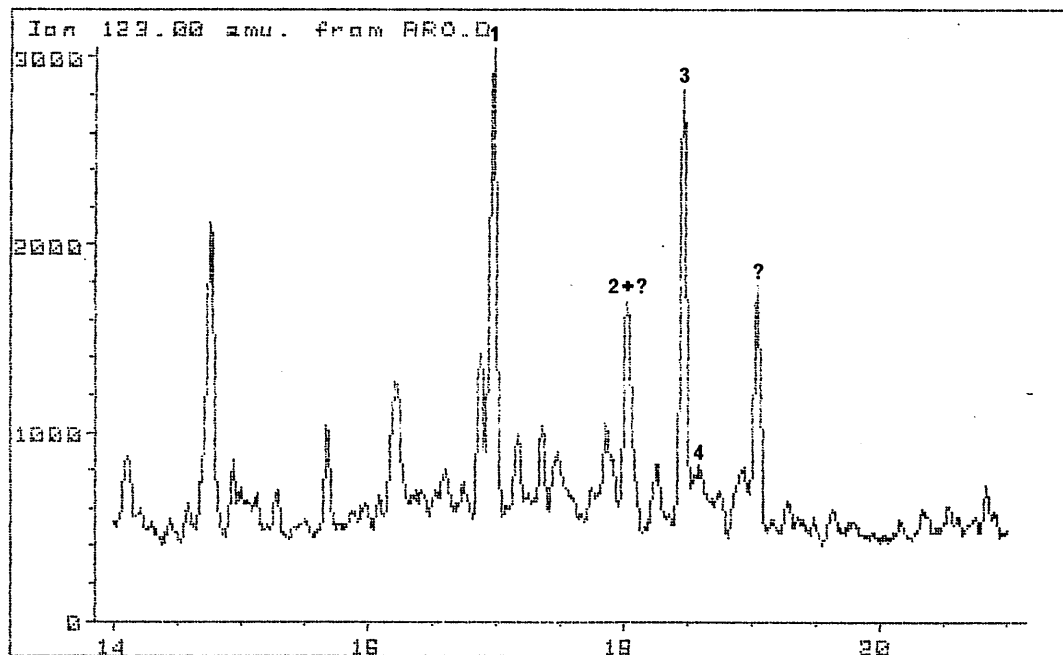


FIGURE 8

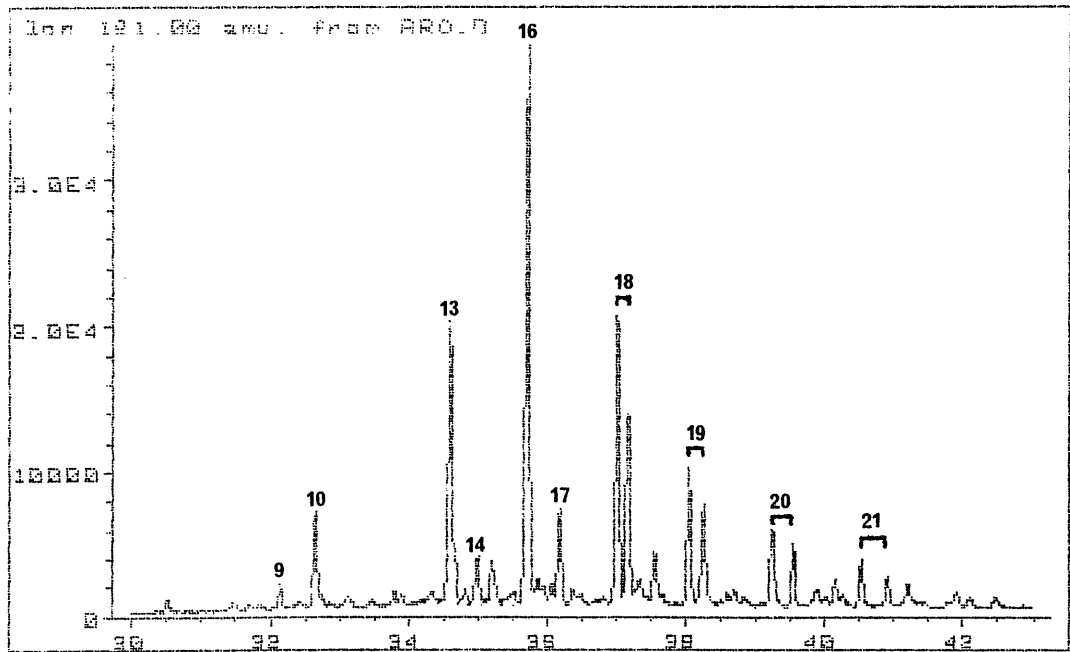
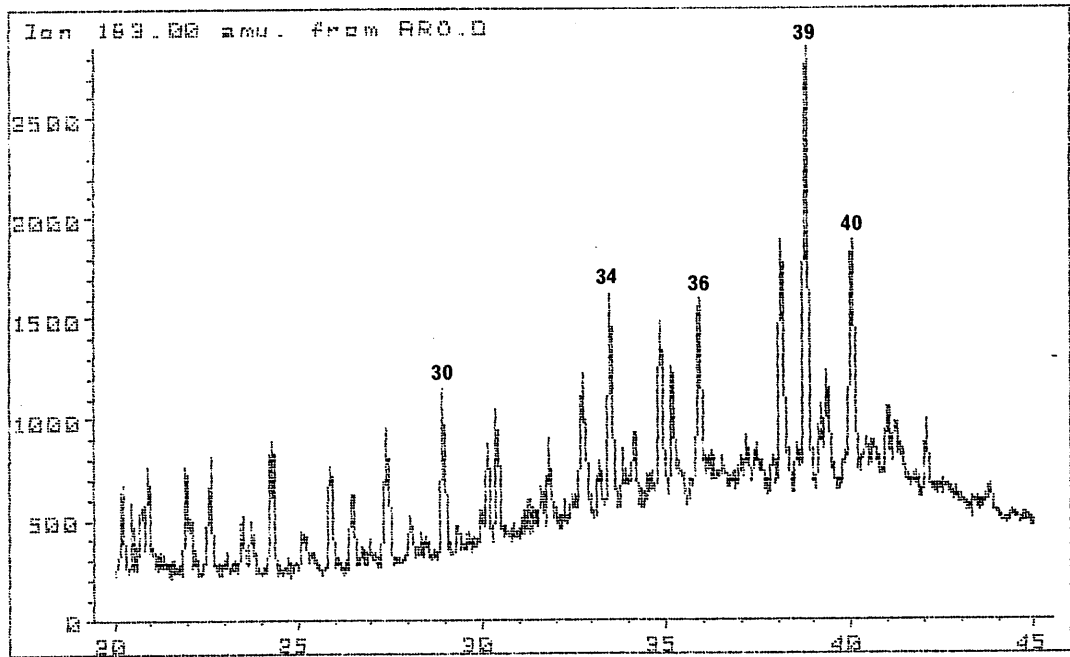
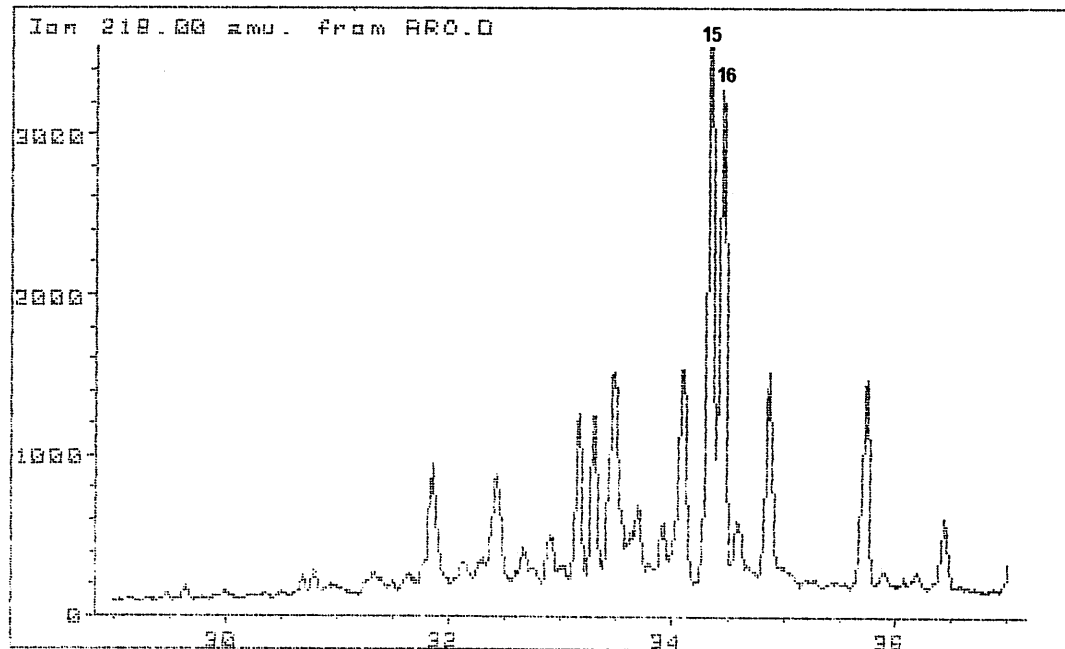
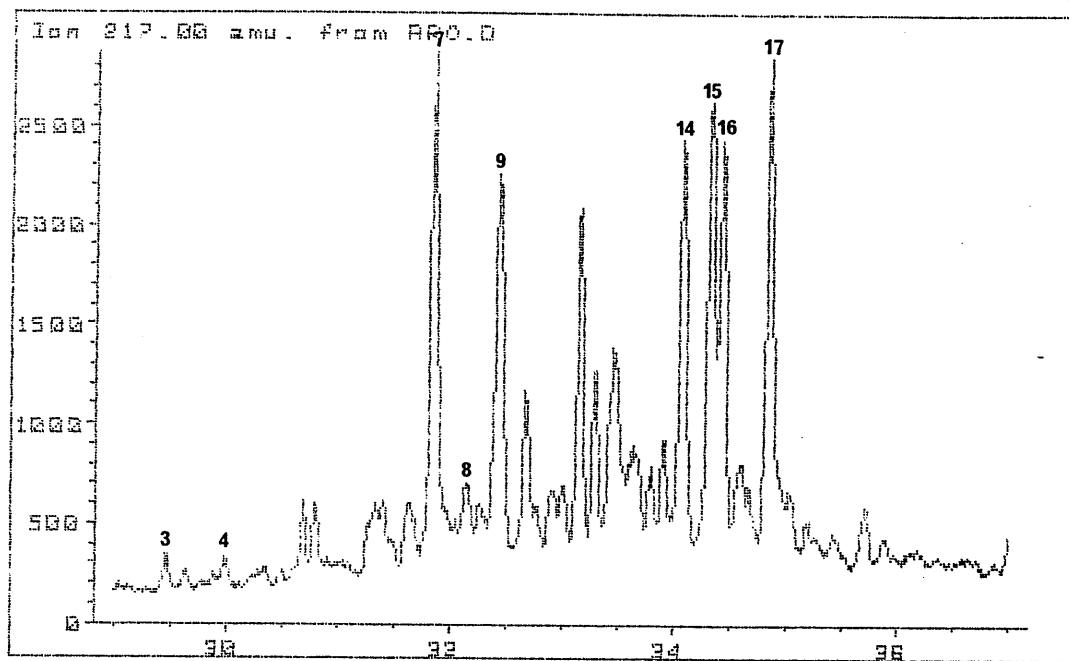


FIGURE 9



FIGURES 10-11

MASS FRAGMENTOGRAMS OF AROMATIC HYDROCARBONS -
IN OIL FROM WINDERMERE-1, DST 1

Fig. 10 : m/z 156 dimethylnaphthalenes
 m/z 169+170 trimethylnaphthalenes

Fig. 11 : m/z 178 phenanthrene
 m/z 191+192 methylphenanthrenes

4-10-1981

FIGURE 10

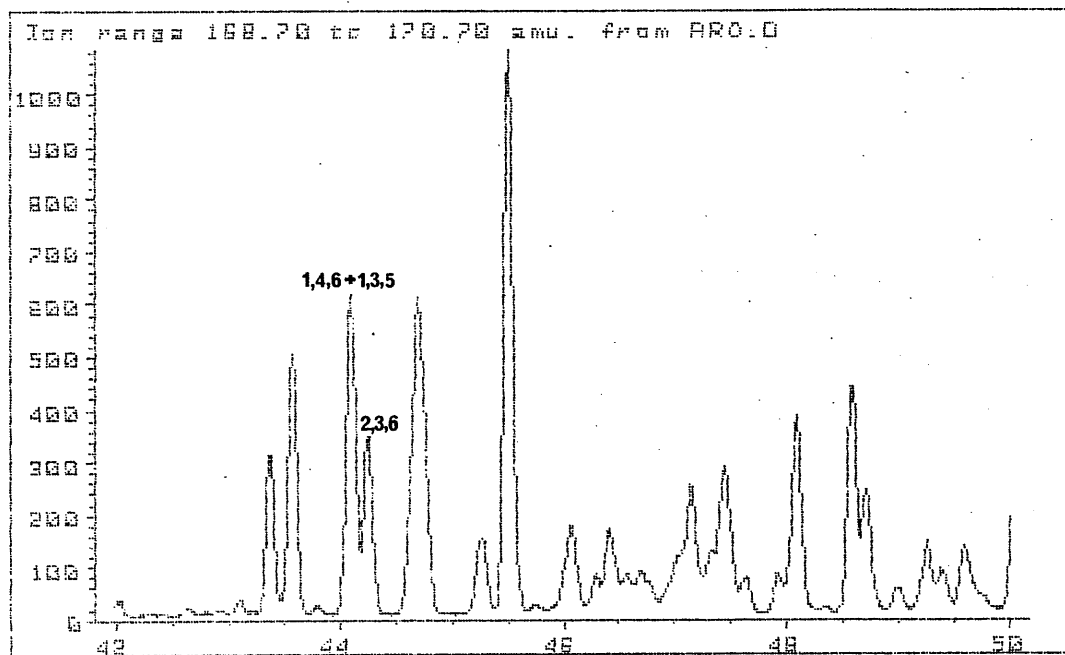
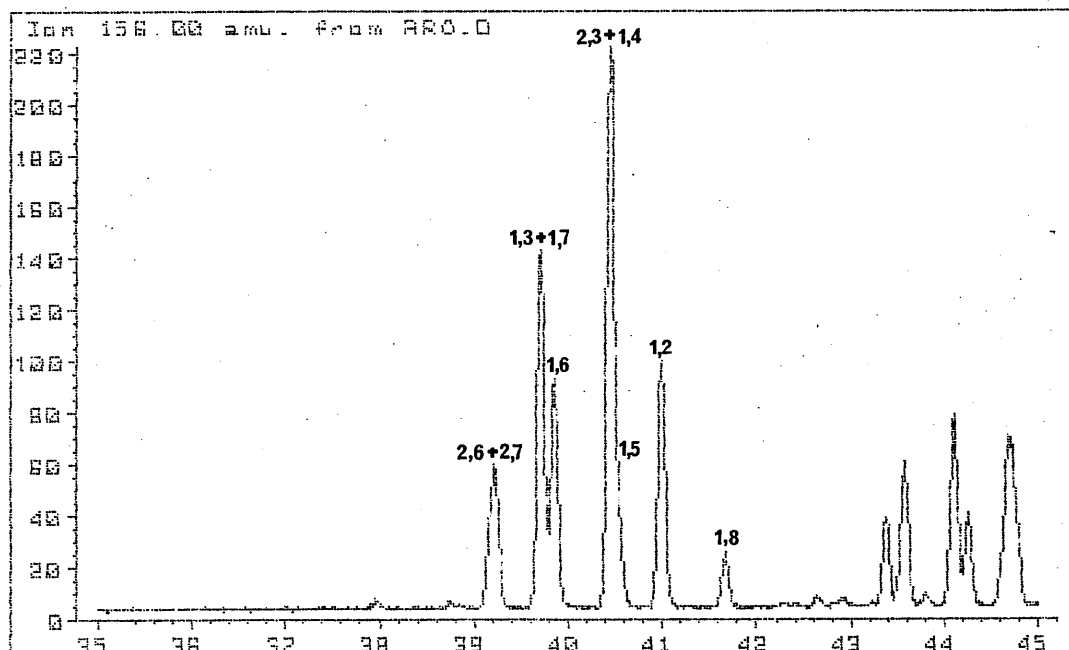
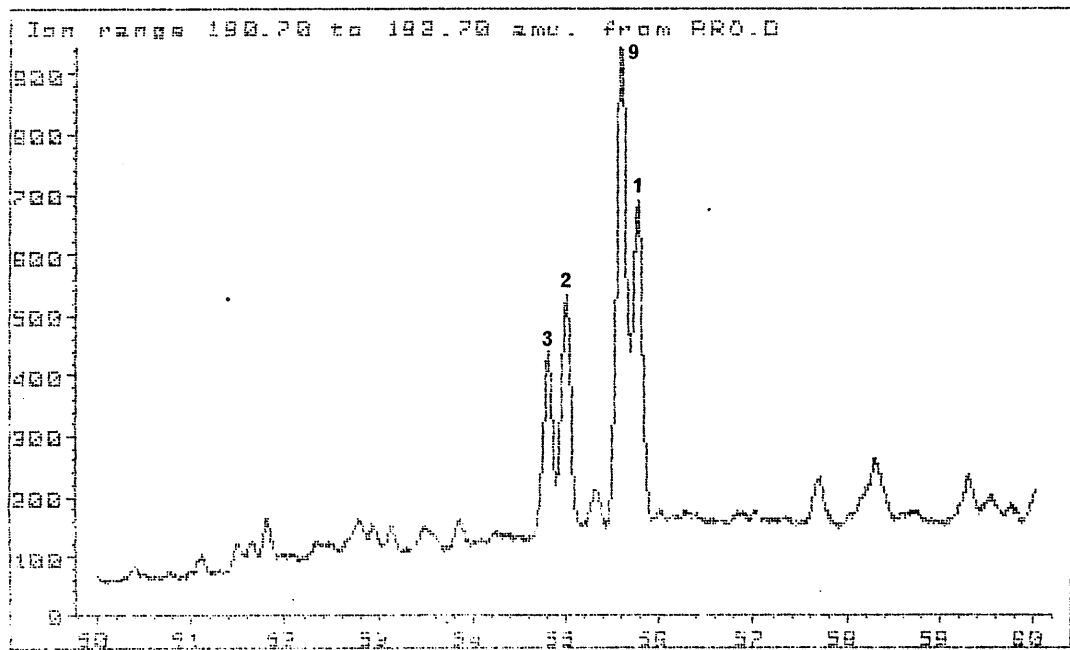
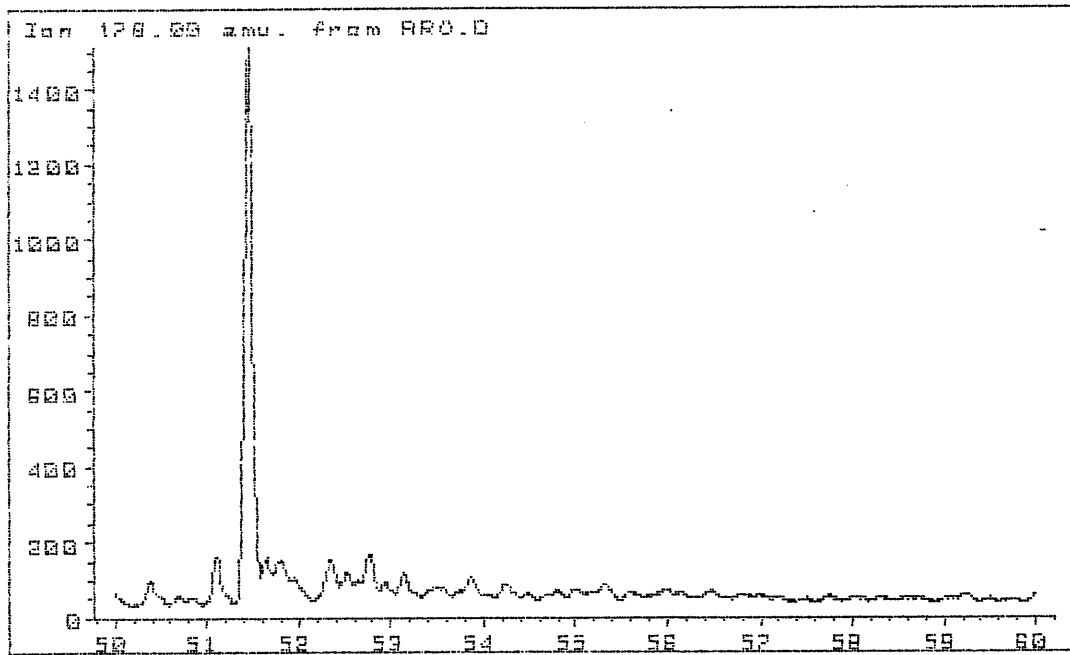
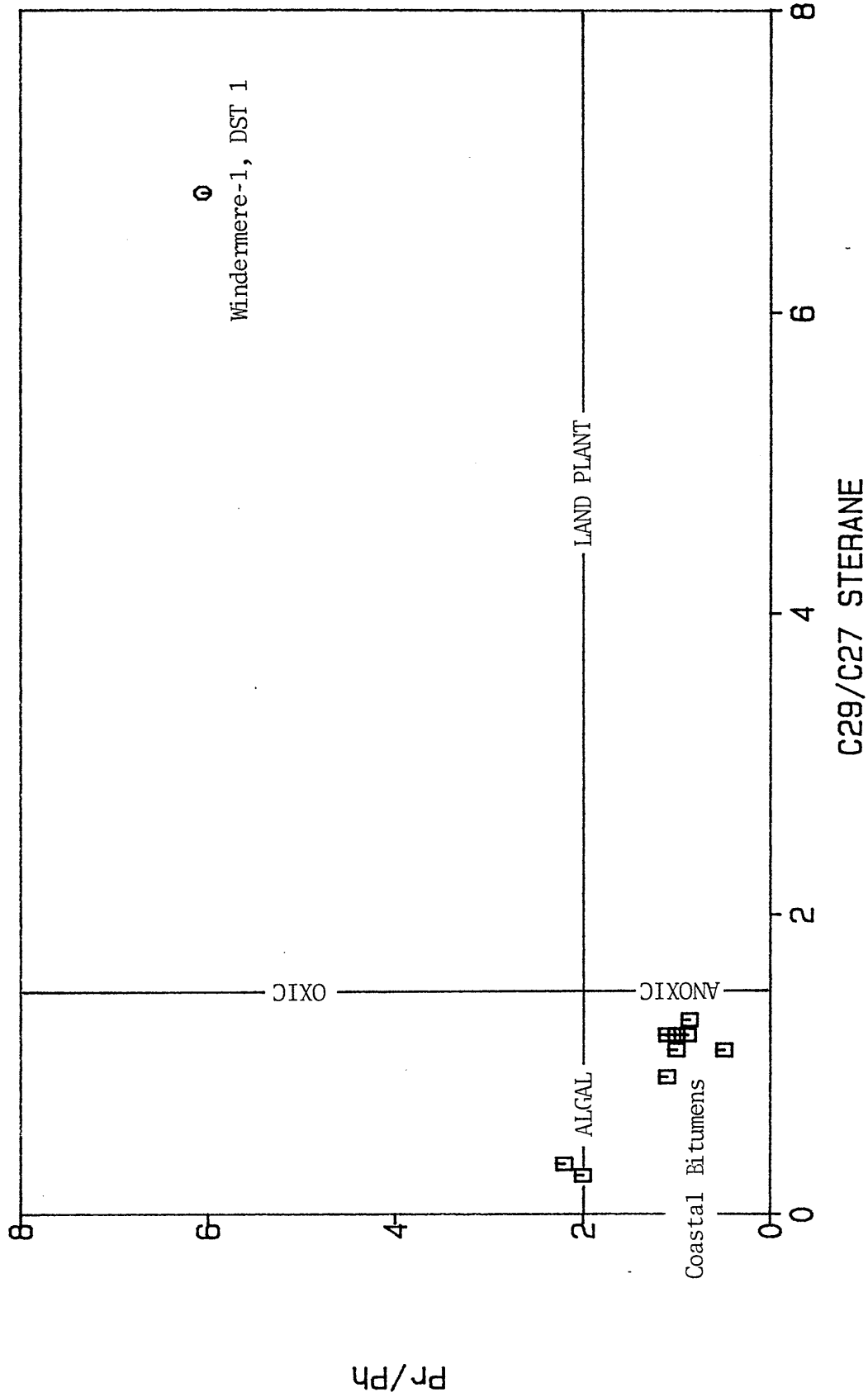


FIGURE 11

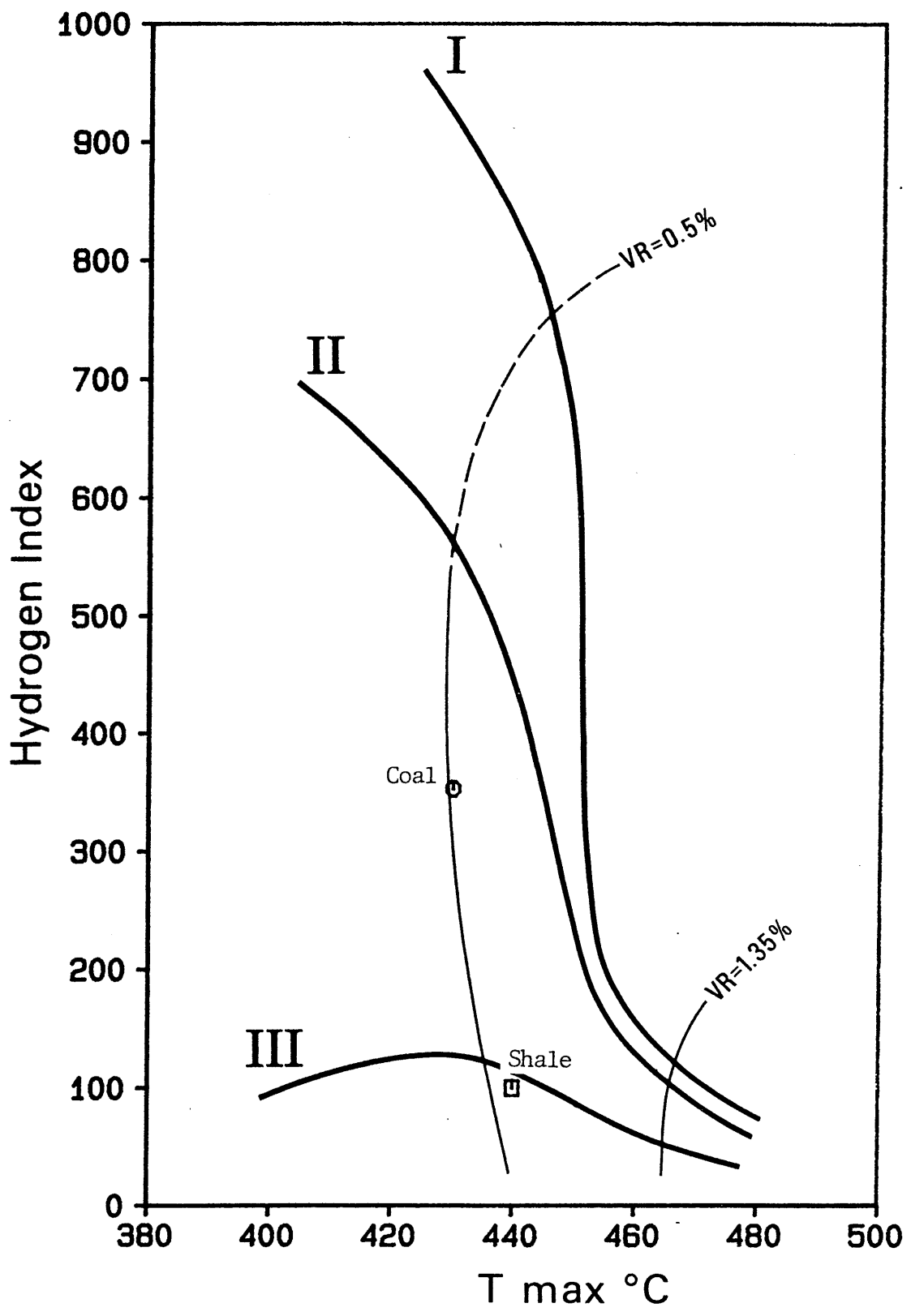


SOURCE AFFINITY OF WINDERMERE-1 OIL
& COASTAL BITUMENS, OTWAY BASIN

FIGURE 12



Client : MINORA RESOURCES N.L.
Well name : WINDERMERE-1
Interval : Eumeralla Formation



APPENDIX 1

ANALYTICAL METHODS

1. TOTAL ORGANIC CARBON (TOC)

Total organic carbon was determined by digestion of a known weight (20.2 g) of powdered rock in 50% HCl to remove carbonates, followed by combustion in oxygen in the induction furnace of a Leco IR-12 Carbon Determinator and measurement of the resultant CO₂ by infra-red detection.

2. ROCK-EVAL PYROLYSIS

A 100 mg portion of powdered rock was analysed by the Rock-Eval pyrolysis technique (Girdel IFP-Fina Mark 2 instrument; operating mode, Cycle 1).

3. ORGANIC PETROLOGY

Representative portions of the hand-picked cuttings (crushed to -14+35 BSS mesh) were obtained with a sample splitter and then mounted in cold setting Astic resin using a 2.5 cm diameter mould. Each block was ground flat using diamond impregnated laps and carborundum paper. The surface was then polished with aluminium oxide and finally magnesium oxide.

Reflectance measurements on vitrinite phytoclasts, were made with a Leitz MPV1.1 microphotometer fitted to a Leitz Ortholux microscope and calibrated against synthetic standards. All measurements were taken using oil immersion ($n = 1.518$) and incident monochromatic light (wavelength 546 nm) at a temperature at 24±1°C. Fluorescence observations were made on the same microscope utilising a 3 mm BG3 excitation filter, a TK400 dichroic mirror and a K510 suppression filter.

4. WHOLE-OIL AND GASOLINE-RANGE ANALYSIS

A sample of the whole-oil was analysed by gas chromatography using the same instrumental conditions described in Section 7.

5. ISOLATION OF C₁₂₊ FRACTION

The oil was topped to 210°C by distillation.

6. LIQUID CHROMATOGRAPHY

Asphaltenes were precipitated from the topped oil by refluxing with petroleum ether prior to liquid chromatography. The asphaltene-free fraction was separated into hydrocarbons (saturates and aromatics) and polar compounds (resins) by liquid chromatography on activated alumina (sample: adsorbent ratio = 1:100). Hydrocarbons were eluted with petroleum ether/dichloromethane (50:50) and resins with methanol/dichloromethane (65:35). The saturated and aromatic hydrocarbons were then separated by liquid chromatography on activated silica gel (sample: adsorbent ratio = 1:100) eluting in turn with petroleum ether and petroleum ether/dichloromethane (91:9).

7. GAS CHROMATOGRAPHY

The whole-oil and saturated hydrocarbons (alkanes) were examined by gas chromatography using the following instrumental parameters:

Gas chromatograph:	Perkin Elmer Sigma 2 operated in the split injection mode
Column:	25 m x 0.3 mm fused silica, SGE QC3/BP1
Detector temperature:	300°C
Column temperature:	40°C for 1 minute, then 8° per min. to 300°C and held isothermal at 300°C until all peaks eluted
Quantification:	Relative concentrations of individual hydrocarbons were obtained by measurement of peak areas with a Perkin Elmer LCI 100 integrator. The areas of peaks corresponding to aromatic hydrocarbons were multiplied by appropriate response factors.

8. THIN LAYER CHROMATOGRAPHY (TLC)

Aromatic hydrocarbons were isolated from an aliquot of the oil by preparative TLC using Merck GF₂₅₄ silica plates and distilled AR grade *n*-pentane as eluent. Naphthalene and anthracene were employed as reference standards for the diaromatic and triaromatic hydrocarbons, respectively. These two bands, visualised under UV light, were scraped from the plate and the aromatic hydrocarbons redissolved in dichloromethane.

9. GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS)

Naphthenes (branched/cyclic alkanes) were isolated from the oil by urea adduction of its saturated hydrocarbons.

GC-MS analysis of the naphthenes (urea non-adduct) was undertaken in the selected ion detection (SID) mode. The instrument and its operating parameters were as follows:

System:	Hewlett Packard (HP) 5790 GC coupled with a HP5970A mass selective detector and HP9816S data system
Column:	25 m x 0.3 mm i.d. HP Ultra Performance cross-linked methylsilicone phase fused silica, interfaced directly to source of mass spectrometer
Injector:	Split injection (60:1)
Carrier gas:	He at 0.2 kg/cm ² head pressure
Column temperature:	35-280°C at 5°/min
Mass spectrometer conditions:	70 eV; 9-ion selected ion monitoring, 50 millisec dwell time for each ion

The following mass fragmentograms were recorded:

<u>m/z</u>	<u>Compound Type</u>
123	sesquiterpanes (incl. drimanes), diterpanes
177	demethylated triterpanes
183	acyclic alkanes (incl. isoprenoids)
191	triterpanes (incl. hopanes, moretanes)
205	methyl triterpanes
217	steranes
218	steranes
231	4-methylsteranes
259	diasteranes, diterpanes

Integration of the m/z 123, 191, 205, 217 and 259 mass fragmentograms allowed calculation of the biomarker ratios in Tables 5 and 6.

The di- and triaromatic hydrocarbons isolated from the oil by thin layer chromatography were also analysed by GC-MS.

The same instrument as above was employed for the SID GC-MS of the aromatics. Its operating parameters were as follows:

Column:	50 m x 0.2 mm i.d. HP PDNA cross-linked methylsilicone phase fused silica, interfaced directly to source of mass spectrometer
Injector:	Split injection (40:1)
Carrier gas:	He at 1.2 kg/cm ² head pressure
Column temperature:	50-260°C @ 4°/min
Mass spectrometer conditions:	70 eV EI; 9-ion selected ion monitoring, 70 millisecc dwell time for each ion

The following mass fragmentograms were recorded:

<u>m/z</u>	<u>Compound Type</u>
156	dimethylnaphthalenes
169+170	trimethylnaphthalenes
178	phenanthrene
191+192	methylphenanthrenes

The area of the phenanthrene peak was multiplied by a response factor of 0.667 when calculating the methylphenanthrene index (MPI).

APPENDIX 2

WHOLE-OIL ANALYSIS, WINDERMERE-1



AMDEL LIQUID ANALYSIS SERVICE Method R2.1

Client: MINDRA RESOURCES N.L.

Report # F6771/87

Sample: WINDERMERE No.1
DST 1 (1791-1838m)

Boiling Point Range (Deg.C)	Component	Weight%	Mol%
-88.6	ETHANE	0.06	0.35
-42.1	PROPANE	0.56	2.21
-11.7	I-BUTANE	0.86	2.57
-0.5	N-BUTANE	1.17	3.50
27.9	I-PENTANE	1.59	3.83
36.1	N-PENTANE	1.22	2.94
36.1-68.9	C-6	3.55	7.16
80.0	BENZENE	0.05	0.11
68.9-98.3	C-7	3.11	5.39
100.9	METHYLCYCHX	6.61	11.69
110.6	TOLUENE	0.15	0.28
98.3-125.6	C-8	2.01	3.06
136.1-144.4	ETHYLBZ+XYL	0.99	1.62
125.6-150.6	C-9	1.95	2.65
150.6-173.9	C-10	2.45	2.99
173.9-196.1	C-11	2.51	2.79
196.1-215.0	C-12	2.70	2.75
215.0-235.0	C-13	4.51	4.25
235.0-252.2	C-14	3.64	3.19
252.2-270.6	C-15	4.43	3.62
270.6-287.8	C-16	4.47	3.43
287.8-302.8	C-17	4.11	2.97
302.8-317.2	C-18	4.57	3.12
317.2-330.0	C-19	5.80	3.75
330.0-344.4	C-20	5.05	3.10
344.4-357.2	C-21	5.35	3.13
357.2-369.4	C-22	5.22	2.92
369.4-380.0	C-23	5.54	2.96
380.0-391.1	C-24	4.66	2.39
391.1-401.7	C-25	4.70	2.31
401.7-412.2	C-26	3.15	1.49
412.2-422.2	C-27	2.94	1.34
>422.2	C-28+	0.32	0.14
	Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

The above boiling point ranges refer to the normal paraffin hydrocarbon boiling in that range. Aromatics, branched hydrocarbons, naphthenes and olefins may have higher or lower carbon numbers but are grouped and reported according to their boiling points.

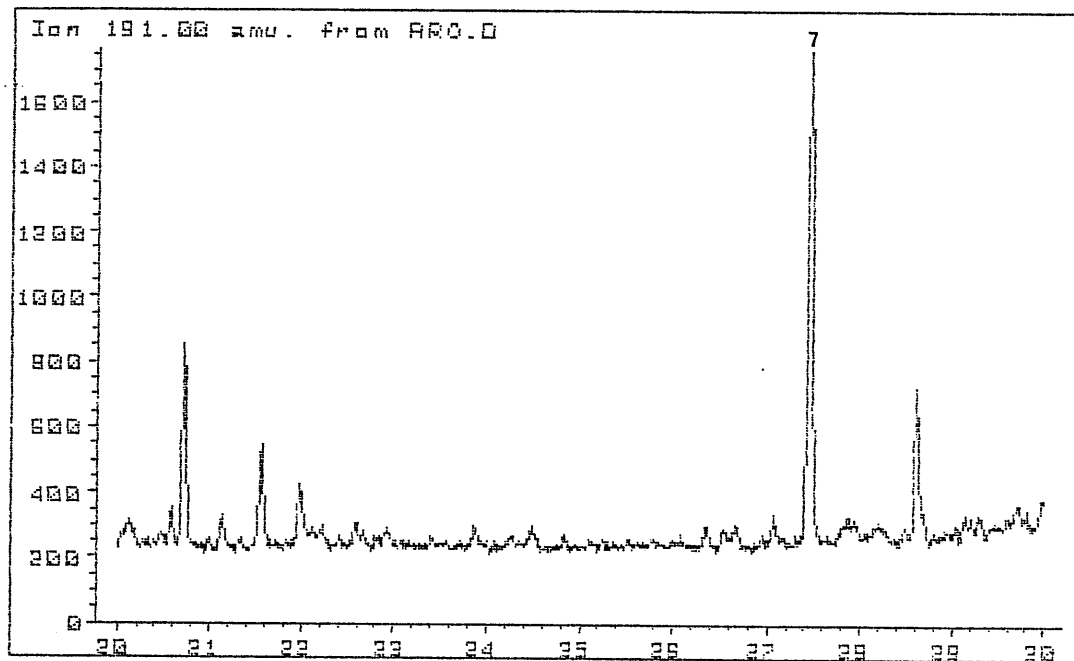
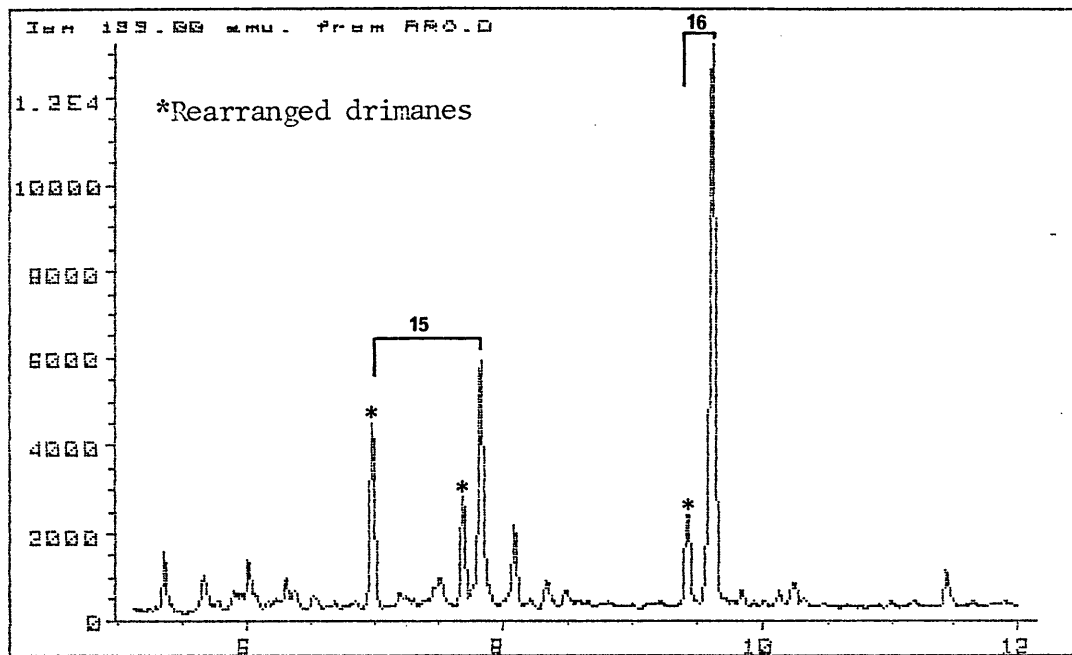
Average molecular weight of C-8 plus 234 g/mol

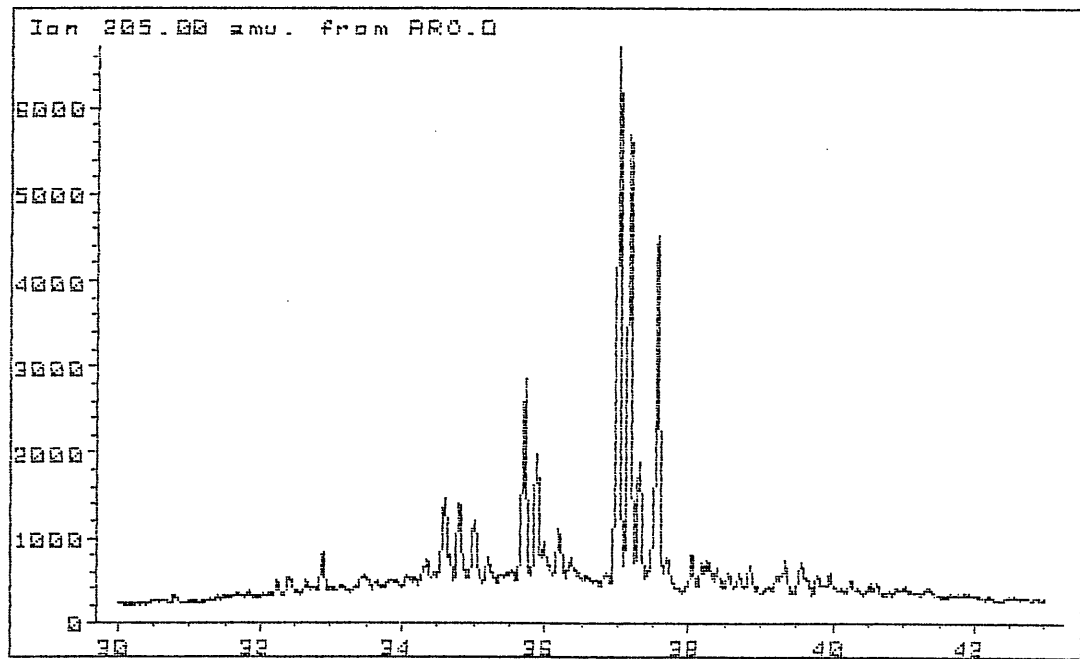
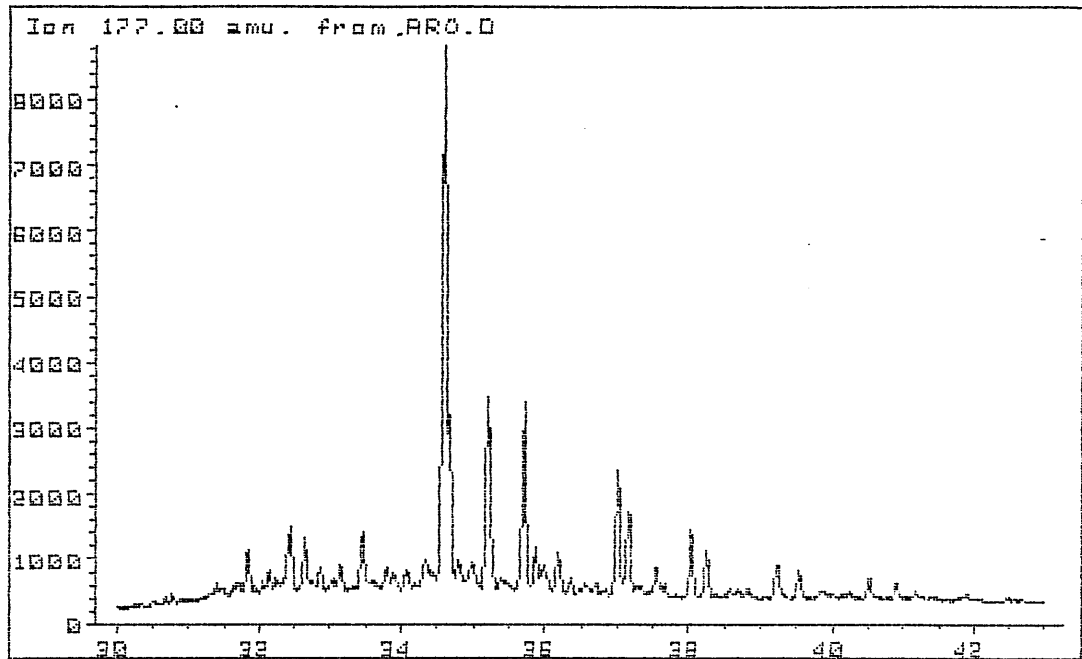
This report relates specifically to the sample tested; it also relates to the batch insofar as the sample is representative of the Batch.

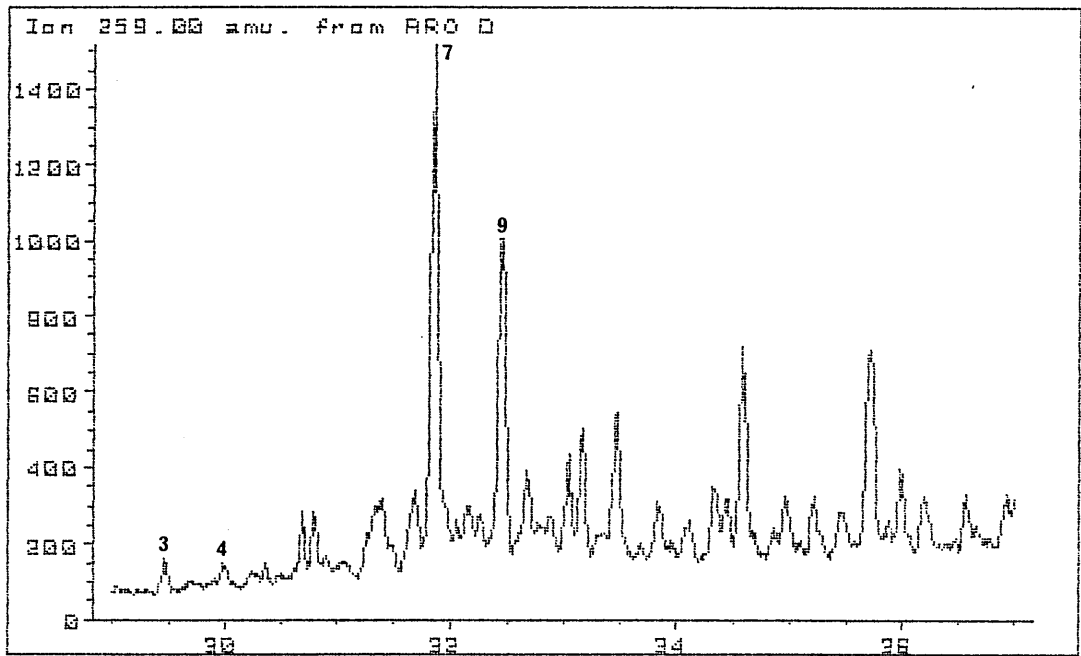
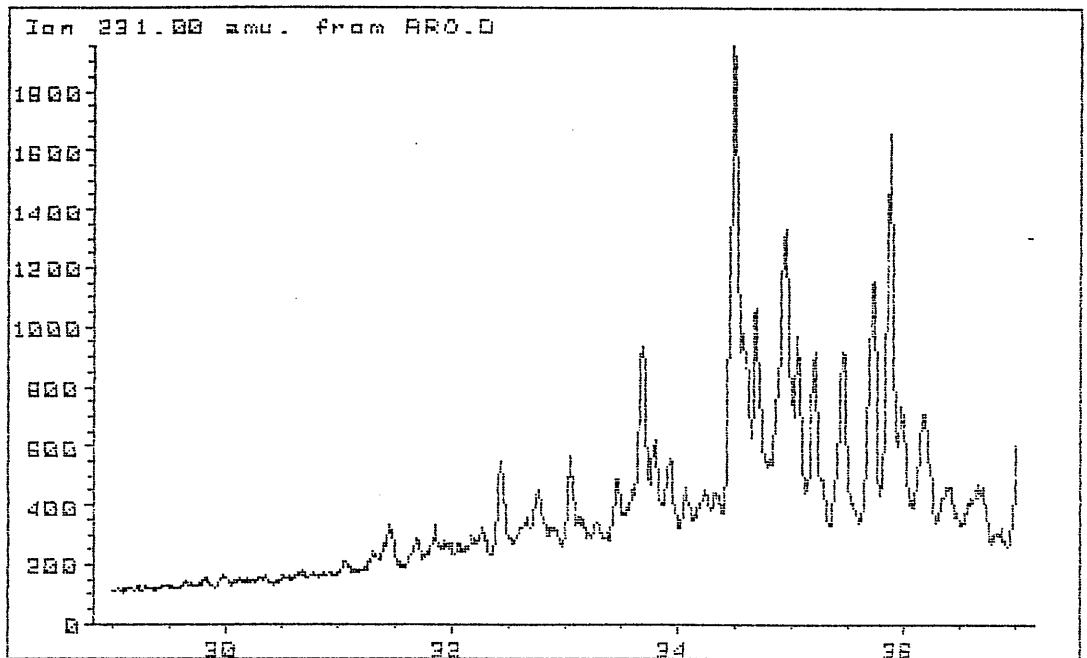
APPENDIX 3

OTHER MASS FRAGMENTOGRAMS OF NAPHTHENES
IN OIL FROM WINDERMERE-1 (DST 1)

m/z 123 drimanes
m/z 191 homologous tricyclic & tetracyclic terpanes
m/z 177 hopanes, demethylated hopanes
m/z 205 methylhopanes
m/z 231 4-methylsteranes
m/z 259 diasteranes







APPENDIX 4

HISTOGRAM PLOTS OF VITRINITE REFLECTANCE
MEASUREMENTS, WINDERMERE-1

WINDERMERE-1

1830-1838 M COAL

SORTED LIST

.44 .45 .46 .46 .47 .48 .48 .48 .49 .49
.49 .49 .49 .49 .49 .5 .5 .5 .5 .51
.51 .51 .51 .51 .52 .52 .53 .54 .54 .54
.55 .59 .6

Number of values= 33

MEAN OF VALUES .504

STD DEVIATION .034

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

44 - 46	██████████
47 - 49	████████████████████
50 - 52	████████████████████
53 - 55	██████████
56 - 58	
59 - 61	██████

WINDERMERE-1

1830-1838 M SHALE

SORTED LIST

.4 .45 .47 .47 .48 .48 .5 .52 .52 .52
.52 .54

Number of values= 12

MEAN OF VALUES .489

STD DEVIATION .038

HISTOGRAM OF RESULTS

Values are reflectance multiplied by 100

40 - 44	■
45 - 49	■■■■■
50 - 54	■■■■■■