WCR (VOL. 2)
DIGBY-1
W1130

GFE Resources Ltd

WELL COMPLETION REPORT

DIGBY-1

DIGBY JOINT VENTURE

OTWAY BASIN, VICTORIA

compiled by

Kevin Lanigan

November, 1995

VOLUME 2

APPENDICES 9 - 12

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APPENDIX 9

GFE RESOURCES LTD

APPENDIX 9

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DIGBY-1

APPENDIX 9A

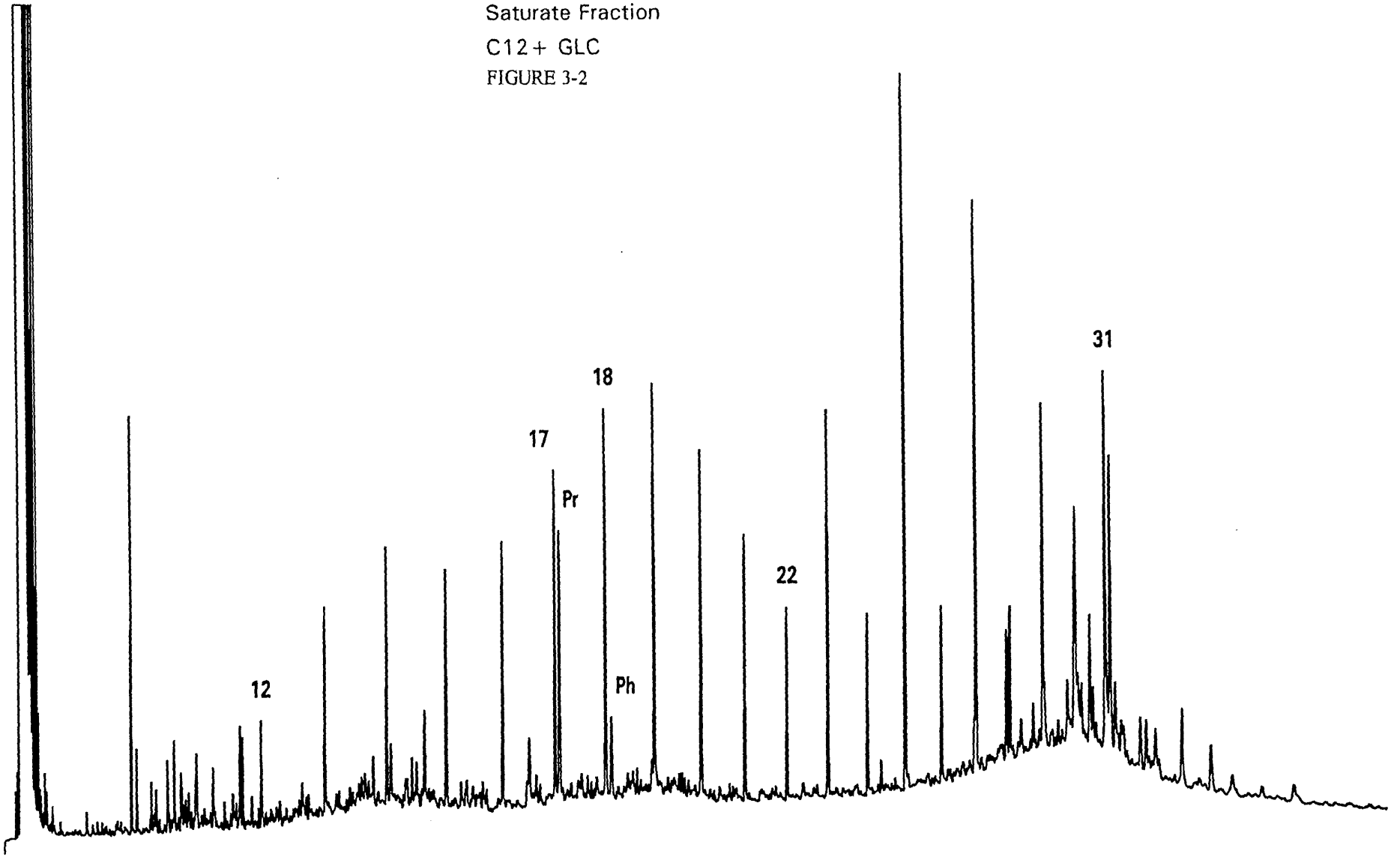
GAS CHROMATOGRAMS

FROM

CUTTINGS AND DST MUD

DIGBY-1

DIBGY 1, 450m, Cuttings
Saturate Fraction
C12+ GLC
FIGURE 3-2



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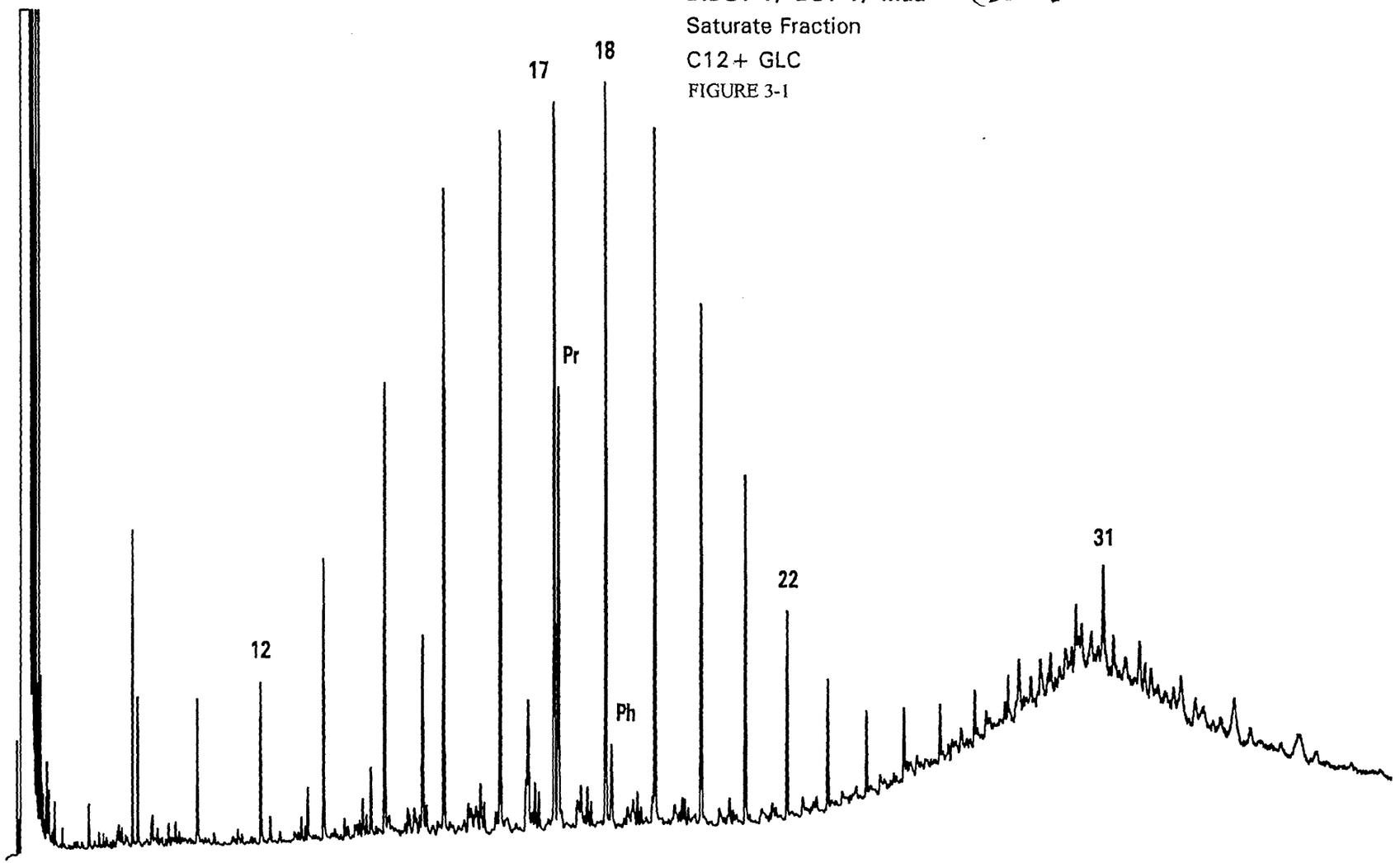
GEOTECHNICAL SERVICES PTY LTD

DIBGY 1, DST 1, Mud (DST-1 1460-1467.9 m KB)
Saturate Fraction
C12+ GLC
FIGURE 3-1



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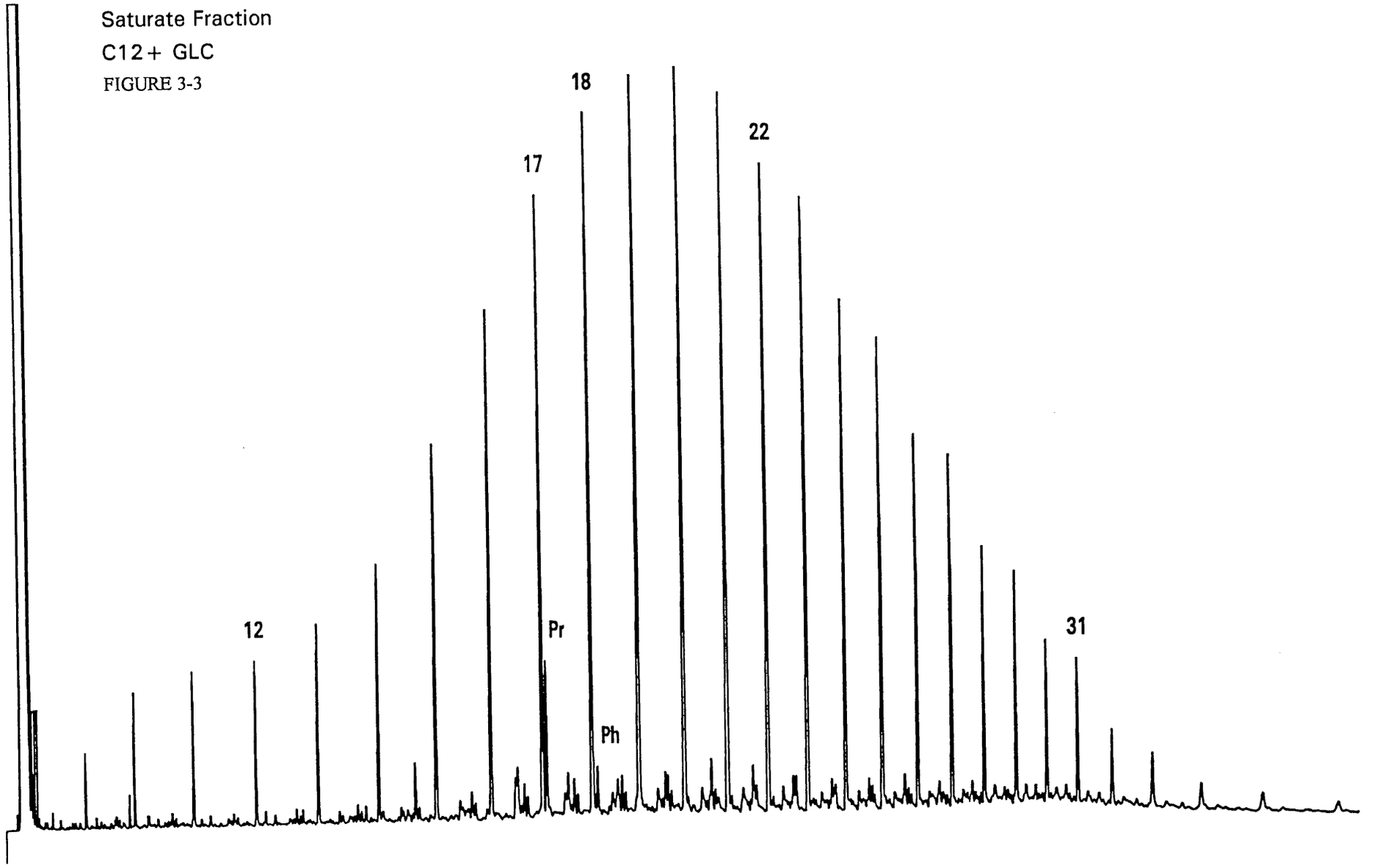
DIGBY 1, 1468m, Cuttings

Saturate Fraction

C12+ GLC

FIGURE 3-3



2176ED1

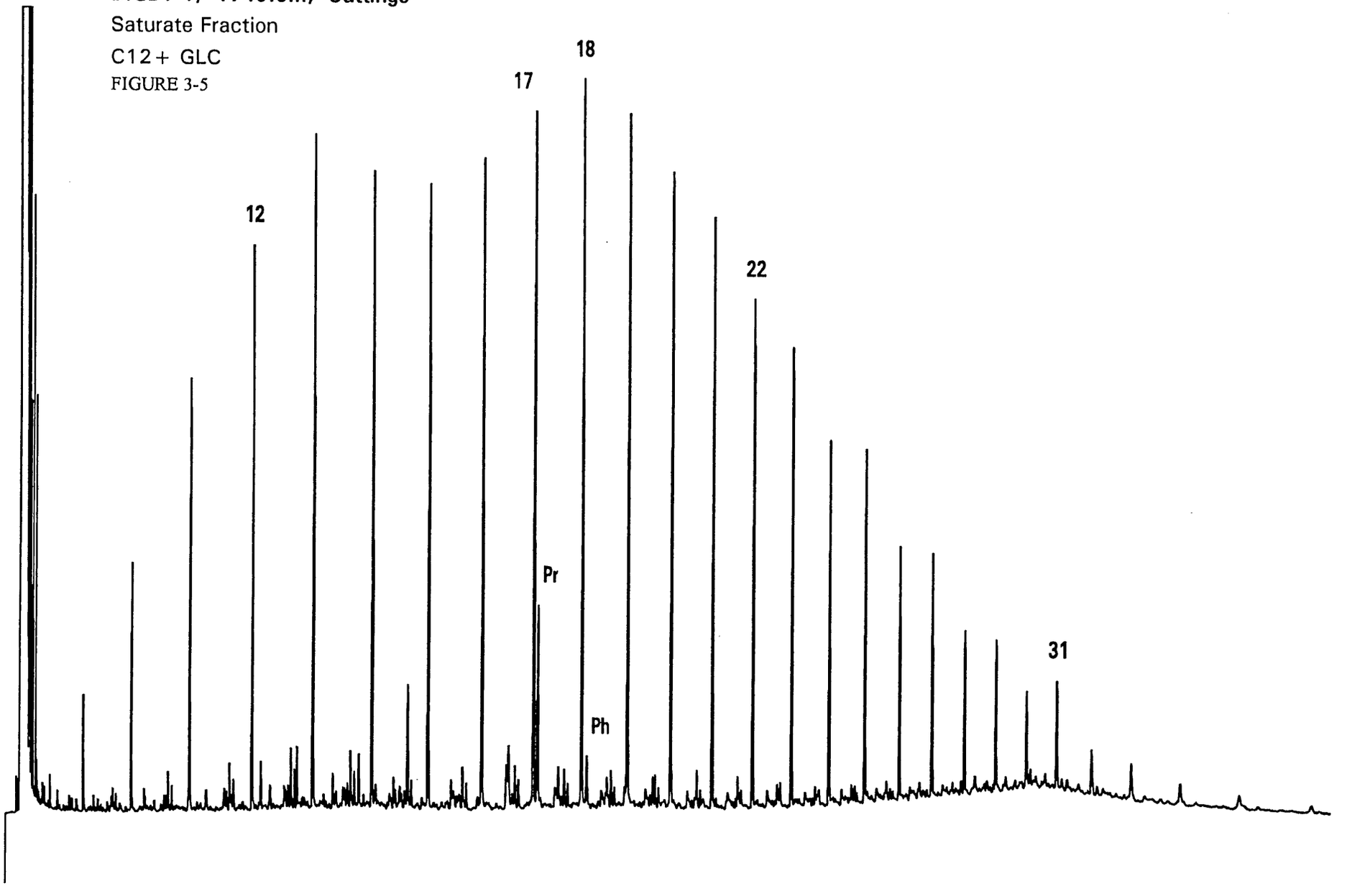
GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1740.0m, Cuttings

Saturate Fraction

C12+ GLC

FIGURE 3-5



2176ED5

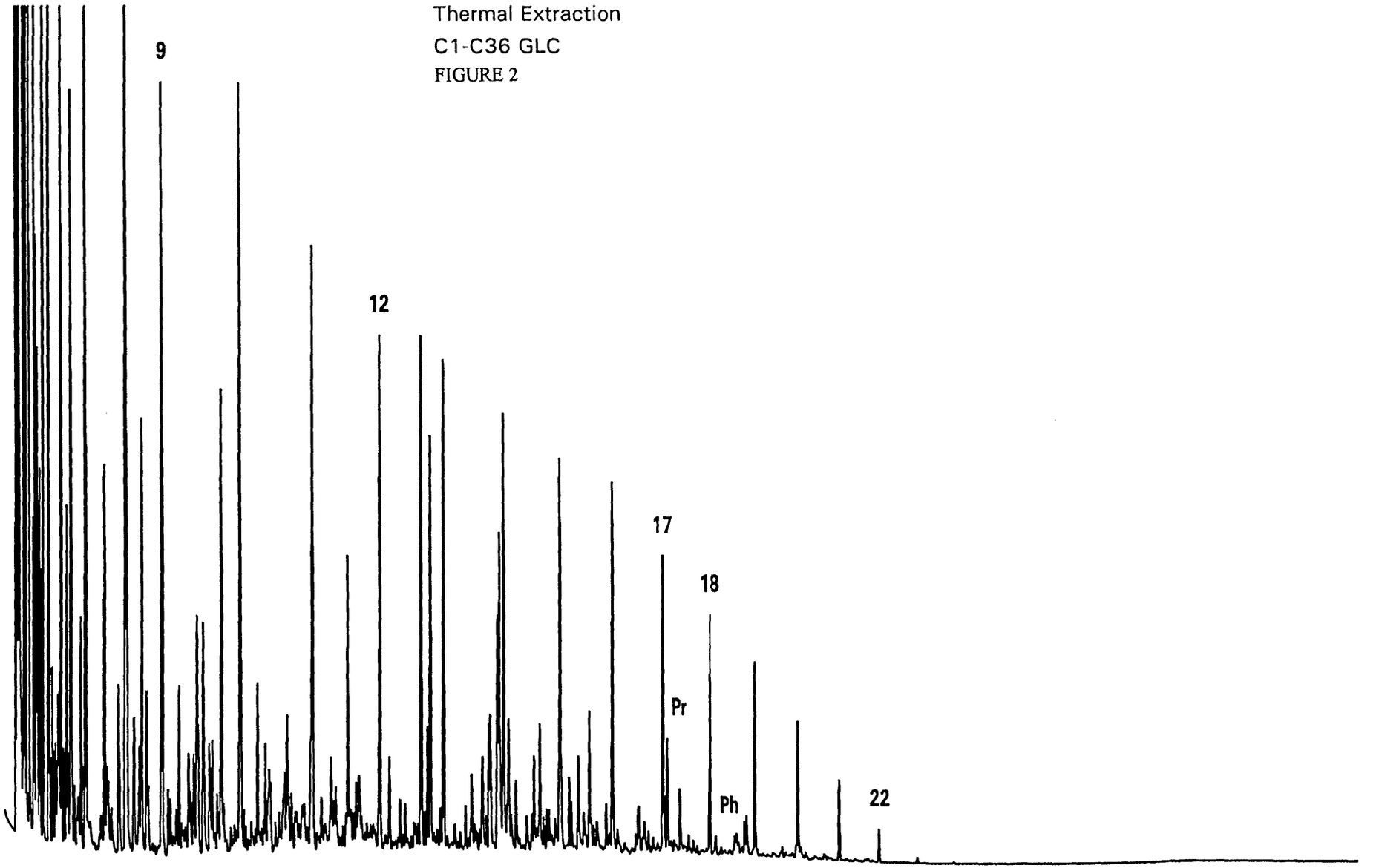
GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1930m, Cuttings

Thermal Extraction

C1-C36 GLC

FIGURE 2



C290

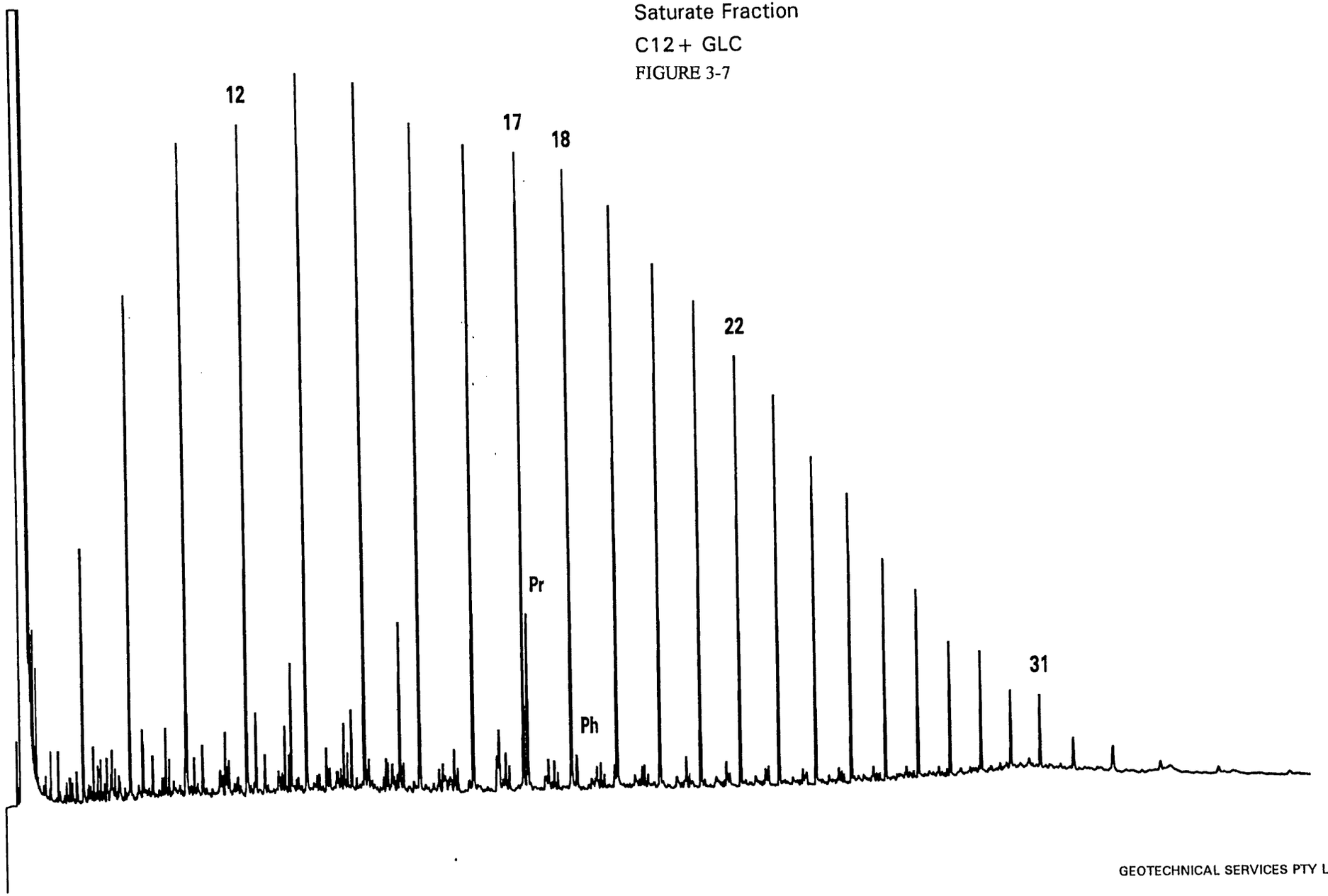
GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1930m, Cuttings

Saturate Fraction

C12+ GLC

FIGURE 3-7



GEOTECHNICAL SERVICES PTY LTD

2176ED2

TABLE 5-1

Summary of Extraction and Liquid Chromatography

DIGBY 1 Jun-95

A. Concentrations of Extracted Material

				-------Hydrocarbons-------			----Nonhydrocarbons----		
	Weight of Rock Extd	Total Extract	Loss on Column	Saturates	Aromatics	HC Total	NSO's	Asphalt	NonHC Total
DEPTH(m)	(grams)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
450.0	22.0	27.3	nd	nd	nd	nd	nd	nd	nd
DST 1	220.5	7.7	nd	nd	nd	nd	nd	nd	nd
450*	224.9	71.6	6.2	23.1	13.8	36.9	28.5	nd	28.5
1468.0	118.1	368.2	0.8	245.5	74.5	320.0	47.4	nd	47.4
1740.0	97.4	181.7	6.2	86.2	39.0	125.2	50.3	nd	50.3
1930.0	12.7	3252.2	133.5	1201.9	926.9	2128.8	989.8	nd	989.8

TABLE 5-1

Summary of Extraction and Liquid Chromatography

DIGBY 1 Jun-95

B. Compositional Data

	---Hydrocarbons----			---Nonhydrocarbons-----			EOM(mg)	SAT(mg)	SAT	ASPH	HC
							-------	-------	-------	-------	-------
DEPTH(m)	%SAT	%AROM	%HC's	%NSO	%ASPH	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
450.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
DST 1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
450*	35.4	21.1	56.5	43.5	nd	43.5	nd	nd	1.7	nd	1.3
1468.0	66.8	20.3	87.1	12.9	nd	12.9	nd	nd	3.3	nd	6.8
1740.0	49.1	22.2	71.3	28.7	nd	28.7	nd	nd	2.2	nd	2.5
1930.0	38.5	29.7	68.3	31.7	nd	31.7	nd	nd	1.3	nd	2.2

nd = no data * = total sample

TABLE 6-1

DIGBY 1 Summary of Gas Chromatography Data

A. Alkane Compositional Data SATURATE FRACTION

DEPTH(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21 + C22)/(C28 + C29)
450.0	nd	nd	nd	nd	nd	nd
DST 1	4.99	0.66	0.14	0.89	1.04	1.18
450*	2.99	0.92	0.28	2.20	3.26	0.86
1468.0	3.44	0.21	0.05	1.13	1.12	3.35
1740.0	4.03	0.34	0.08	1.20	1.19	3.36
1930.0	4.73	0.36	0.08	1.13	1.12	3.34

TABLE 6-1

DIGBY 1 Summary of Gas Chromatography Data

B, n-Alkane Distributions SATURATE FRACTION

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC3
450.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
DST 1	1.8	3.2	5.5	8.2	9.3	9.9	6.5	9.5	1.3	8.9	6.8	4.7	2.9	2.4	1.7	1.6	1.3	1.3	2.7	3.8	4.3	2.2
450*	1.4	3.1	3.3	3.2	3.7	4.9	4.5	5.3	1.5	5.9	4.9	3.6	2.6	5.4	2.6	10.7	2.7	9.2	2.3	4.9	6.6	7.7
1468.0	1.3	1.7	2.4	3.8	5.4	7.2	1.5	8.3	0.4	9.3	9.1	8.7	7.6	7.0	5.7	5.2	3.8	3.6	2.5	2.3	1.6	1.5
1740.0	5.1	6.3	6.2	6.4	6.9	7.6	2.6	7.7	0.6	7.8	7.1	6.2	5.3	4.9	4.0	3.9	2.7	2.7	1.7	1.7	1.1	1.3
1930.0	6.9	7.6	7.6	7.8	7.5	7.5	2.7	7.0	0.6	6.9	6.0	5.6	4.9	4.5	3.7	3.5	2.5	2.2	1.6	1.5	1.0	0.9

nd = no data * = total sample

AMDEL L93915

FIGURE 2

Digby-1
DST-2 (1920-1951mKB)
GC of Extractable Organic Matter

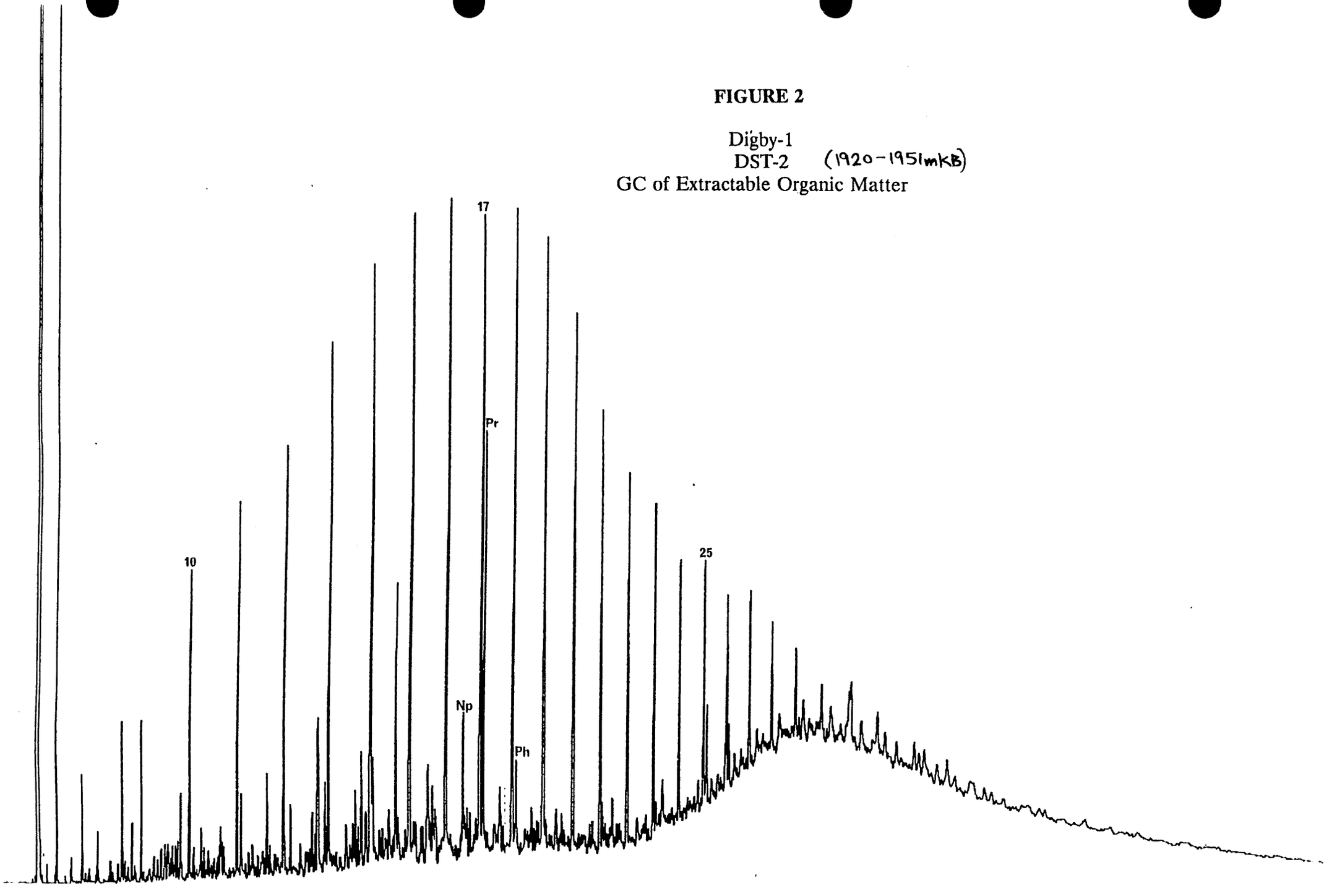
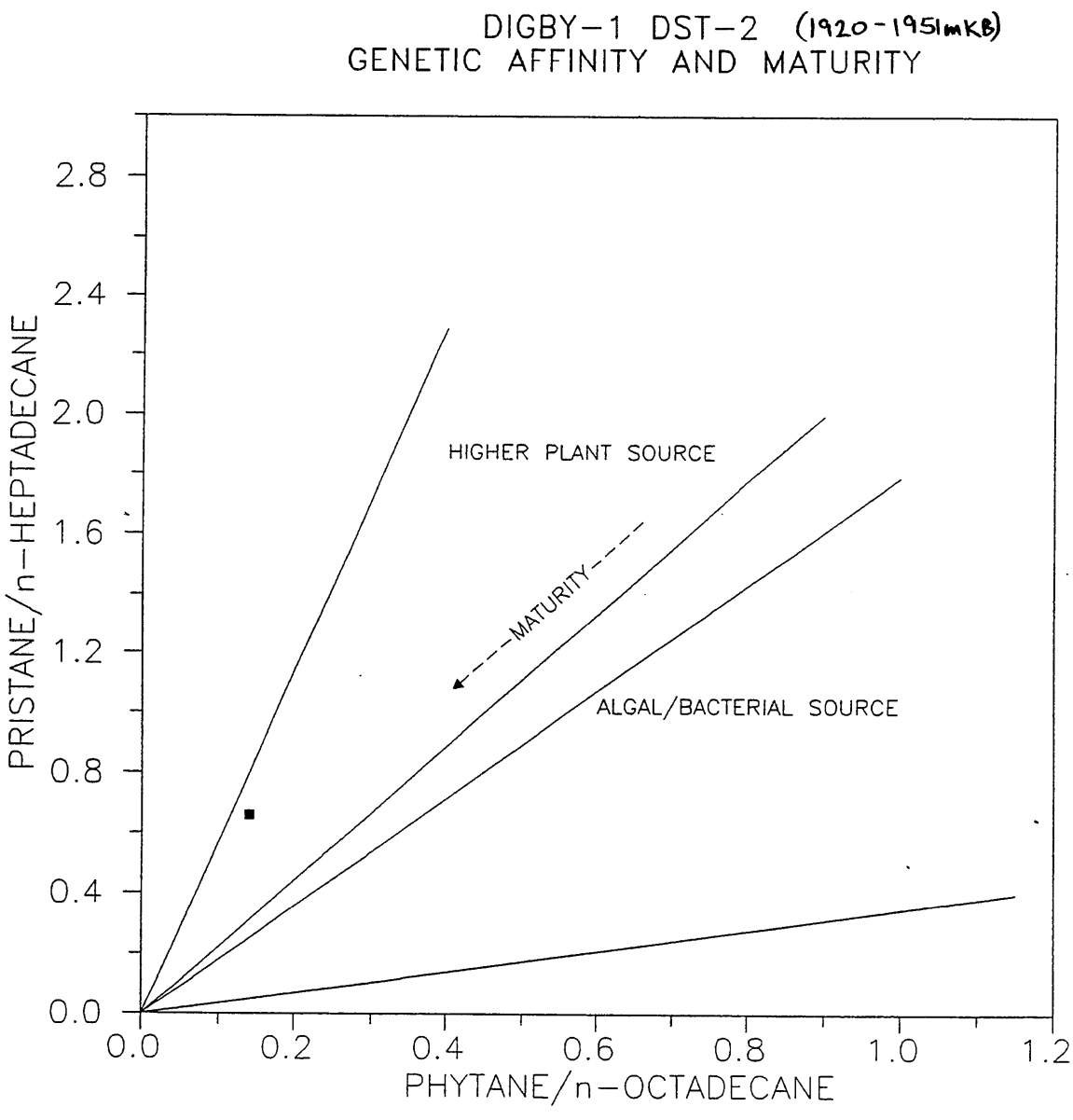


FIGURE 3



AMDEL LQ3915

APPENDIX 9B

GAS CHROMATOGRAMS

FROM

SIDEWALL CORES

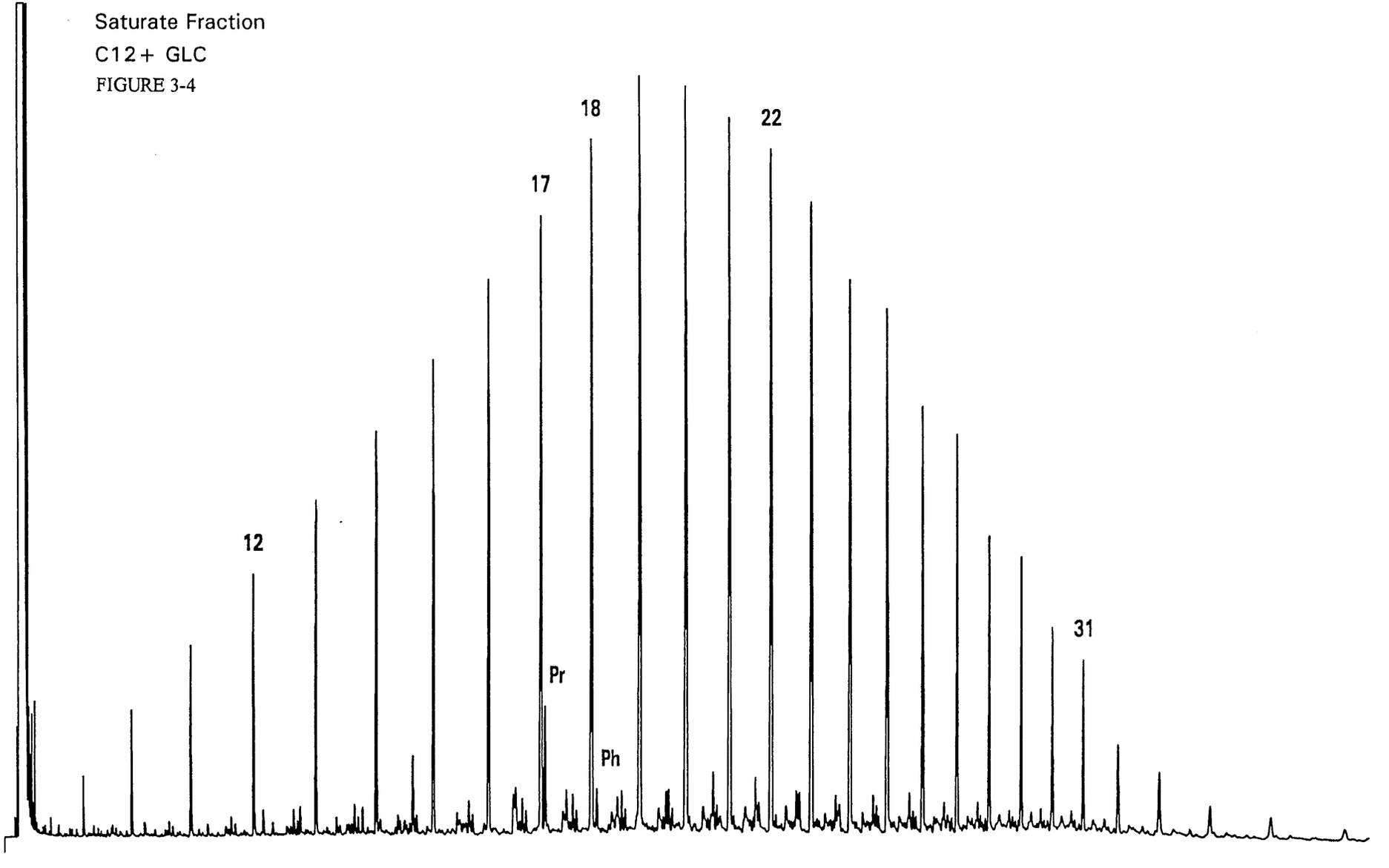
DIGBY-1

DIGBY 1, 1473.7m, SWC

Saturate Fraction

C12+ GLC

FIGURE 3-4



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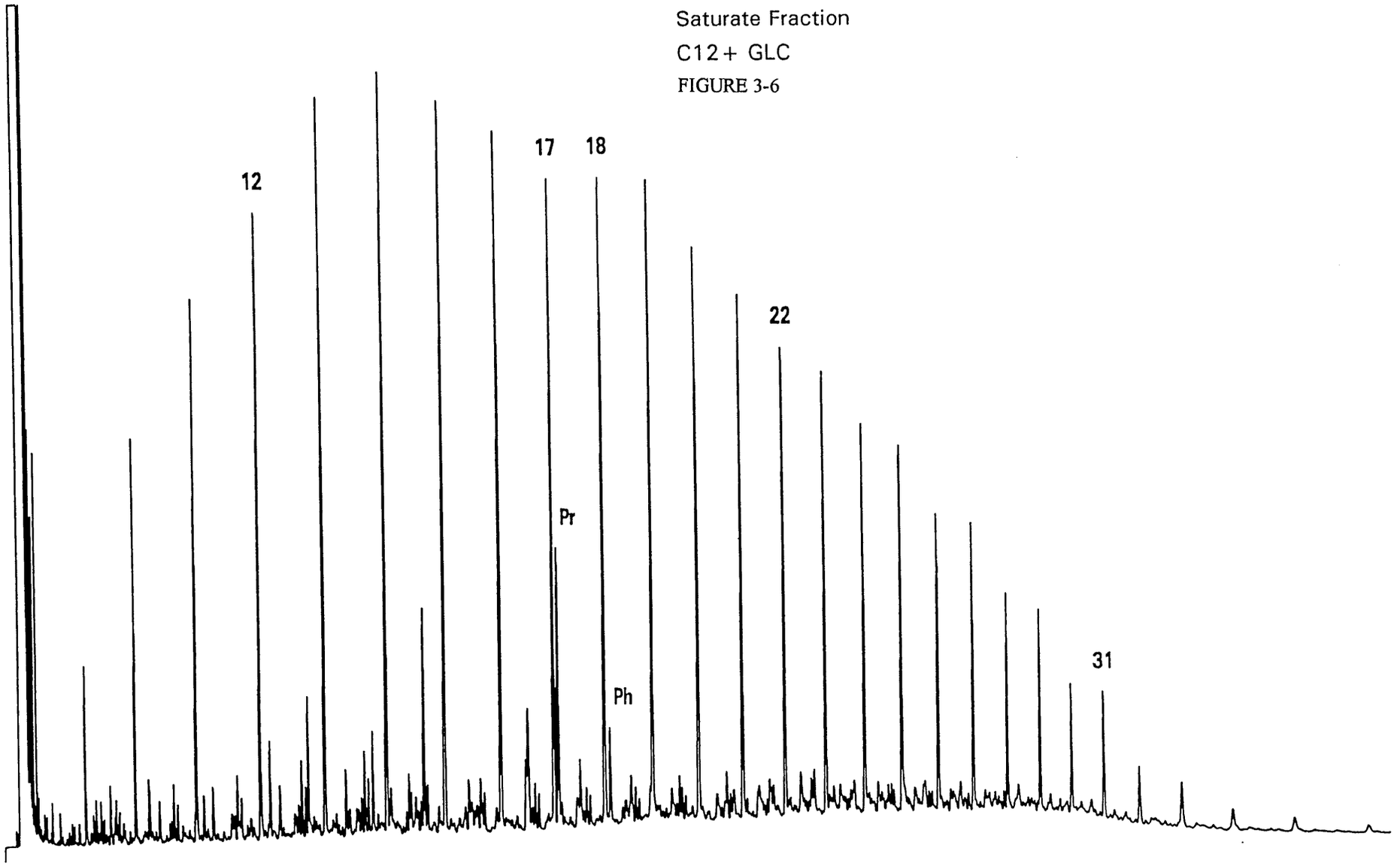
GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1903.2m, SWC

Saturate Fraction

C12+ GLC

FIGURE 3-6



2176ED8

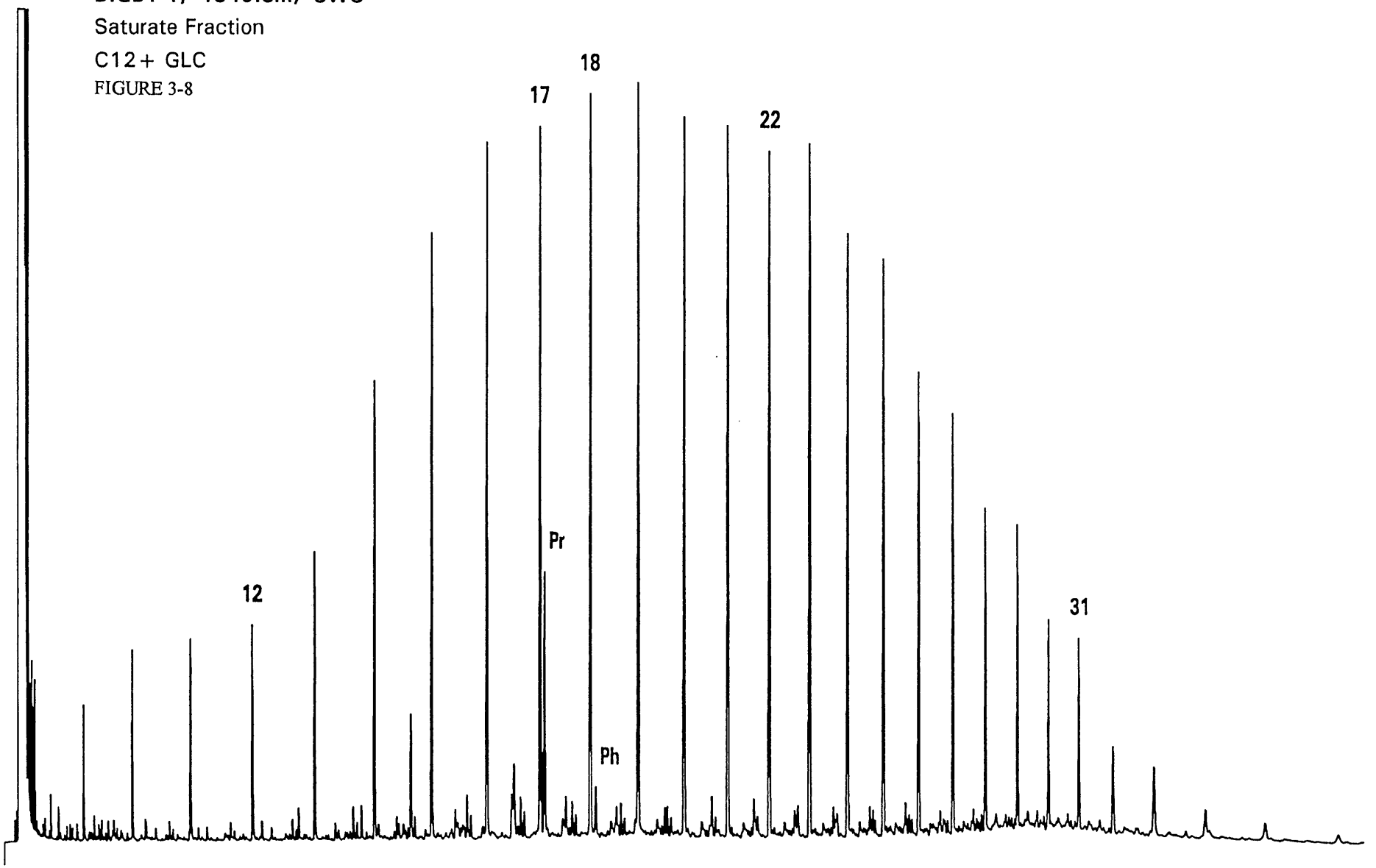
GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1940.8m, SWC

Saturate Fraction

C12+ GLC

FIGURE 3-8



2176ED7

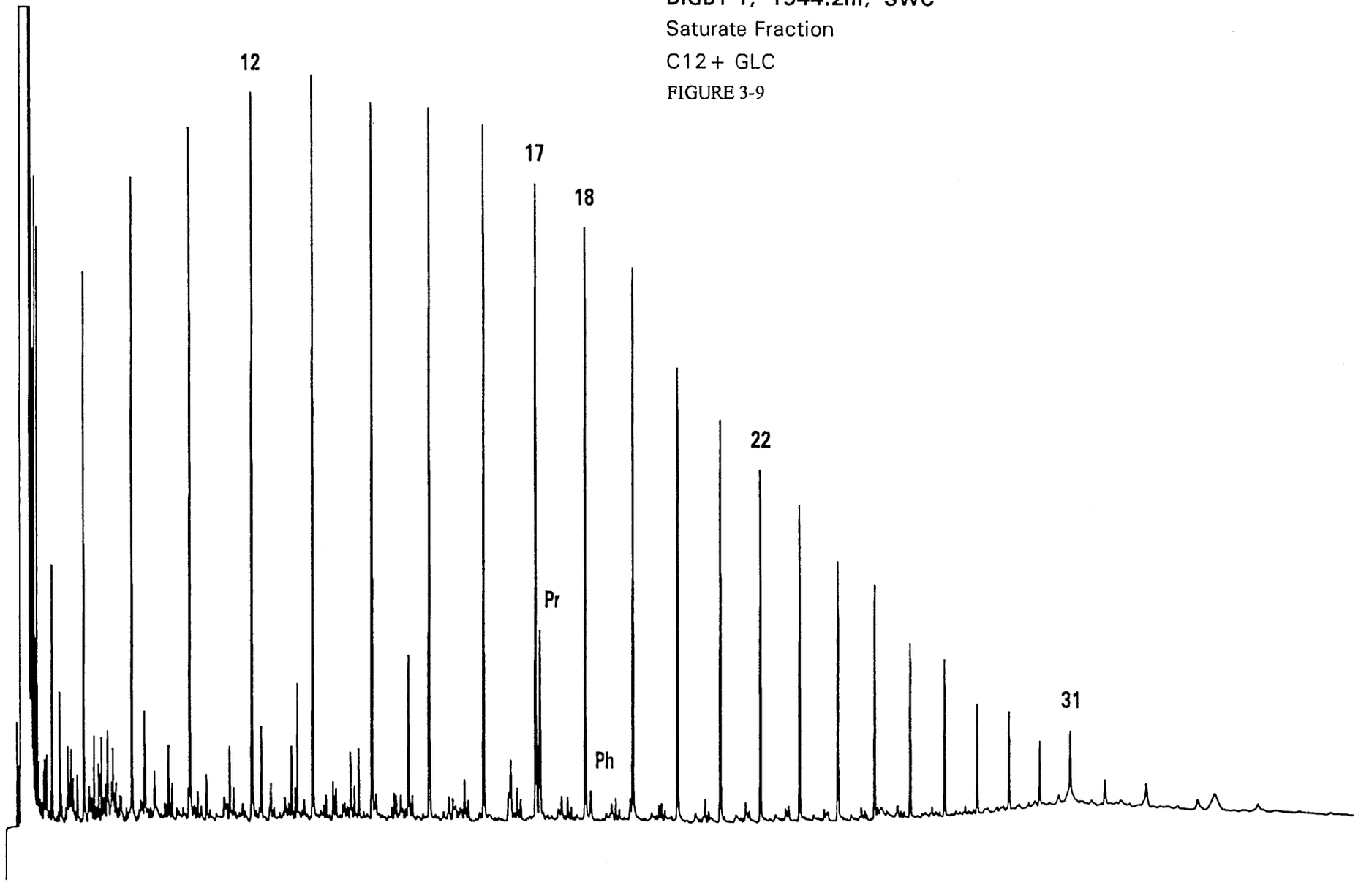
GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1944.2m, SWC

Saturate Fraction

C12+ GLC

FIGURE 3-9



2176ED9

TABLE 5-2

Summary of Extraction and Liquid Chromatography

DIGBY 1 Jul-95

A. Concentrations of Extracted Material

				-------Hydrocarbons-------			----Nonhydrocarbons----		
	Weight of Rock Extd	Total Extract	Loss on Column	Saturates	Aromatics	HC Total	NSO's	Asphalt	NonHC Total
DEPTH(m)	(grams)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1473.7	11.8	440.7	nd	nd	nd	nd	nd	nd	nd
1903.2	3.4	1858.4	nd	nd	nd	nd	nd	nd	nd
1940.8	9.7	569.4	nd	nd	nd	nd	nd	nd	nd
1944.2	5.5	4058.5	585.0	804.4	1316.3	2120.7	1352.8	nd	1352.8

TABLE 5-2

Summary of Extraction and Liquid Chromatography

DIGBY 1 Jul-95

B. Compositional Data

	---Hydrocarbons----			---Nonhydrocarbons-----			EOM(mg)	SAT(mg)	SAT	ASPH	HC
							-------	-------	-------	-------	-------
DEPTH(m)	%SAT	%AROM	%HC's	%NSO	%ASPH	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
1473.7	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1903.2	nd	nd	nd	nd	nd	nd	75.2	nd	nd	nd	nd
1940.8	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1944.2	23.2	37.9	61.1	38.9	nd	38.9	11.3	2.2	0.6	nd	1.6

nd = no data

TABLE 6-2

DIGBY 1 Summary of Gas Chromatography Data

A. Alkane Compositional Data SATURATE FRACTION

DEPTH(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21 + C22)/(C28 + C29)
1473.7	3.06	0.18	0.05	1.11	1.11	3.17
1903.2	3.13	0.43	0.14	1.18	1.16	2.50
1940.8	5.48	0.38	0.07	1.14	1.13	2.55
1944.2	5.78	0.36	0.07	1.16	1.10	3.50

TABLE 6-2

DIGBY 1 Summary of Gas Chromatography Data

B. n-Alkane Distributions SATURATE FRACTION

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
1473.7	1.8	2.5	3.1	4.0	5.0	6.3	1.1	7.4	0.4	8.5	8.7	8.6	7.8	7.2	5.9	5.5	4.0	3.8	2.7	2.4	1.7	1.5
1903.2	5.4	6.7	7.2	7.3	7.2	7.1	3.1	7.1	1.0	6.9	5.8	5.3	4.7	4.6	4.0	4.2	2.9	2.8	2.1	2.0	1.2	1.4
1940.8	1.6	2.1	3.5	5.2	6.3	6.9	2.6	7.2	0.5	7.6	7.1	7.1	6.9	6.9	5.6	5.6	4.2	3.9	2.8	2.7	1.8	1.8
1944.2	7.8	8.1	8.0	8.1	8.2	7.9	2.9	7.3	0.5	6.7	5.9	5.1	4.2	3.8	3.3	3.0	2.2	2.0	1.4	1.3	0.9	1.6

nd = no data

APPENDIX 9C

VITRINITE REFLECTANCE

AND ROCK-EVAL

(FROM CUTTINGS AND SIDEWALL CORES)

DIGBY-1

GEOTECH GEOTECHNICAL SERVICES PTY LTD
41-45 Furnace Road, Welshpool, Western Australia. 6106
Locked Bag 27, Cannington, Western Australia. 6107
Telephone: (09) 458 8877
Facsimile: (09) 458 8857

9 June, 1995

Mr. K. Lanigan
GFE Resources Ltd
Level 6
6 Riverside Quay
South Melbourne VIC 3205

Dear Kevin,

Please find enclosed extraction, GC and vitrinite reflectance results for samples from Digby-1, as well as an invoice for this work.

Although the interval covered by the Digby samples is only 920m, reflectance rises from below 0.4% at the top of the section to between 0.56 and 0.58% at the base. It is possible that the data from the deepest sample are biased by cavings, but the lower reflectances could also have been part of the indigenous population. Coals are present in the 4 deeper samples and abundant in the deepest two. The coal facies is typical of the Strzlecki facies. This is also present in the Otway Group, but the coals in some Otway sections are more rich in inertinite than the Digby coals. Data quality is good throughout.

If you have further queries or if we can be of any assistance to you, please do not hesitate to contact us.

Yours sincerely,

Dr. Birgitta Hartung-Kagi
Managing Director

JOB # 2176A, DIGBY-1, OTWAY BASIN

KK/Ref. No.	Depth(m) Type	$\bar{R}_v$ max	Range	N	Description Including Liptinite (Exinite) Fluorescence
T1392	130 Ctgs	0.37	0.29-0.53	26	Sparse lamalginite, bright yellow to orange, rare liptodetrinite, bright yellow to orange. (Silty claystone>> sandstone. Dom common, I>V>L. All three maceral groups sparse. Mineral fluorescence pervasive, weak yellow to orange. Iron oxides sparse. Pyrite sparse.)
T1393	260 Ctgs	0.40	0.32-0.53	26	Sparse lamalginite and liptodetrinite, bright yellow to orange, rare cutinite, yellow. (Silty claystone. Dom sparse, I>L>V. All three maceral groups sparse. Mineral fluorescence pervasive, weak yellow to orange. Iron oxides common. Pyrite sparse.)
T1394	440 Ctgs	0.42	0.31-0.61	25	Sparse lamalginite, bright yellow to orange, rare liptodetrinite, bright yellow to orange. (Claystone>>carbonate. Dom sparse, L>I=V. All three maceral groups sparse. Mineral fluorescence pervasive, yellow to orange. Iron oxides sparse. Pyrite sparse.)
T1395	480 Ctgs	0.43	0.32-0.67	25	Sparse lamalginite, yellow to orange, rare liptodetrinite, yellow to yellow. (Clayey siltstone>>carbonate>coal. Coal rare, I>>V. Vitrinertite. Dom sparse, V>I=L. All three maceral groups sparse. Mineral fluorescence faint green. Iron oxides sparse. Pyrite sparse.)
T1396	635 Ctgs	0.44	0.33-0.64	30	Sparse lamalginite and liptodetrinite, yellow to orange, rare cutinite orange to dull orange, rare resinite green to yellow. (Calcareous siltstone>claystone>coal. Coal sparse, V>>L. Vitrite>>clarite. Dom common, V>L>I. All three maceral groups sparse. Oil droplets rare, green. Mineral fluorescence pervasive weak green to orange. Iron oxides rare. Pyrite sparse.)
T1397	850 Ctgs	0.58	0.50-0.67	33	Sparse lamalginite, greenish yellow to orange, sparse sporinite, resinite and liptodetrinite yellow to orange. (Silty claystone>>carbonate>coal. Coal abundant, V=90%, L=6, I=4%. Vitrite>clarite>duroclarite. Dom common, L>V>I. All three maceral groups sparse. Mineral fluorescence pervasive, weak green to orange. Pyrite sparse.)
T1398	1050 Ctgs $\bar{R}_I$ max	0.56 0.79	0.44-0.71 -	31 1	Sparse sporinite, yellow to dull orange, sparse cutinite and suberinite orange to dull orange, sparse lamalginite, yellow to orange, rare resinite and liptodetrinite yellow to orange. (Silty claystone>carbonate>coal. Coal common, V=80%, L=8%, I=12%. Duroclarite>clarite>vitrite. Dom common, V>I>L. All three maceral groups sparse. Mineral fluorescence pervasive weak green to orange. Pyrite sparse.)

amdel

Amdel Limited
A.C.N. 008 127 802

Petroleum Services
PO Box 338
Torrensville Plaza SA 5031

Telephone: (08) 416 5240
Facsimile: (08) 234 2933

31 July, 1995

GFE Resources Ltd
PO Box 629
Market Street Post Office
MELBOURNE VIC 8007

Attention: Kevin Lanigan

REPORT LQ3915

CLIENT REFERENCE:

WELL NAME/RE: Digby-1

MATERIAL: Cuttings

WORK REQUIRED: Source Rock Geochemistry

Please direct technical enquiries regarding this work to the signatory below under whose supervision the work was carried out.

Brian L. Watson
Manager
Petroleum Services

1. INTRODUCTION

Five (5) unwashed cuttings samples from Digby-1 were received for TOC analysis and Rock-Eval pyrolysis and one (1) DST liquid sample was received for extraction and gas chromatographic analysis of any hydrocarbons present. This report is a formal presentation of results forwarded by facsimile as they became available.

2. ANALYTICAL PROCEDURES

2.1 Sample Preparation

The cuttings samples were first washed and dried and then ground in a Siebtechnik mill for 20-30 seconds. Liquid extraction was performed on the DST sample as no hydrocarbons could be easily separated. A low boiling point organic solvent was used and carefully dried to yield the extract which was subsequently analysed by gas chromatography.

2.2 Total Organic Carbon (TOC)

Total organic carbon was determined by digestion of a known weight (approximately 0.2g) of powdered rock in HCl to remove carbonates, followed by combustion in oxygen in the induction furnace of a Leco WR-12 Carbon Determinator and measurement of the resultant CO_2 by infra-red detection.

2.3 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. RESULTS

TOC and Rock-Eval data are listed in Table 1. Figure 1 is a plot of T_{max} versus Hydrogen Index illustrating kerogen type and maturity. Figure 2 is a gas chromatograph of the Digby-1, DST-2 extractable organic matter while Figure 3 is a plot of pristane/n-heptadecane versus phytane/n-octadecane illustrating genetic affinity and maturity.

4. INTERPRETATION

4.1 Maturity

Reliable Rock-Eval T_{max} values show only a slight variation over the narrow interval studied (generally 448-455°C). These values, in conjunction with the Hydrogen

Indices (Table 1; Figure 1), suggest that the sediments analysed are mature for the generation of liquid hydrocarbons (Vr_{equiv} ≈0.8-0.9%).

High Production Indices (>0.2) in samples from 1920, 1955 and 1985 metres depth suggest that migrated hydrocarbons may be present in these samples.

4.2 Source Richness

Organic richness ranges from fair to good in the samples studied (TOC = 2.30 - 8.90%; Table 1), with the richer samples occurring at the shallower depths.

Source richness for the generation of hydrocarbons ranges from poor to excellent in the samples studied ($S_1 + S_2$ = 0.91 - 36.75 kg of hydrocarbons/tonne: Table 1). The sample with best source richness occurs at 1920 metres depth.

4.3 Kerogen Type and Source Quality

Hydrogen Index and T_{max} values (Table 1: Figure 1) indicate that the sediments examined contain organic matter which have bulk compositions ranging from Type IV to Type II kerogen.

4.4 Gas Chromatography

Figures 2 and 3 indicate that the extracted hydrocarbons are likely to be a terrestrially derived oil. Odd/Even predominance can be seen in the C_{23}-C_{27} n-alkanes suggesting the oil is of low to moderate maturity. It should be noted that the boiling point range of the n-alkane portion of the oil is such that the possibility of diesel contamination cannot be ruled out.

amdel

TABLE 1

AMDEL PETROLEUM SERVICES

Rock–Eval Pyrolysis

28/07/95

Client: *GFE Resources Ltd*

Well: *Digby–1*

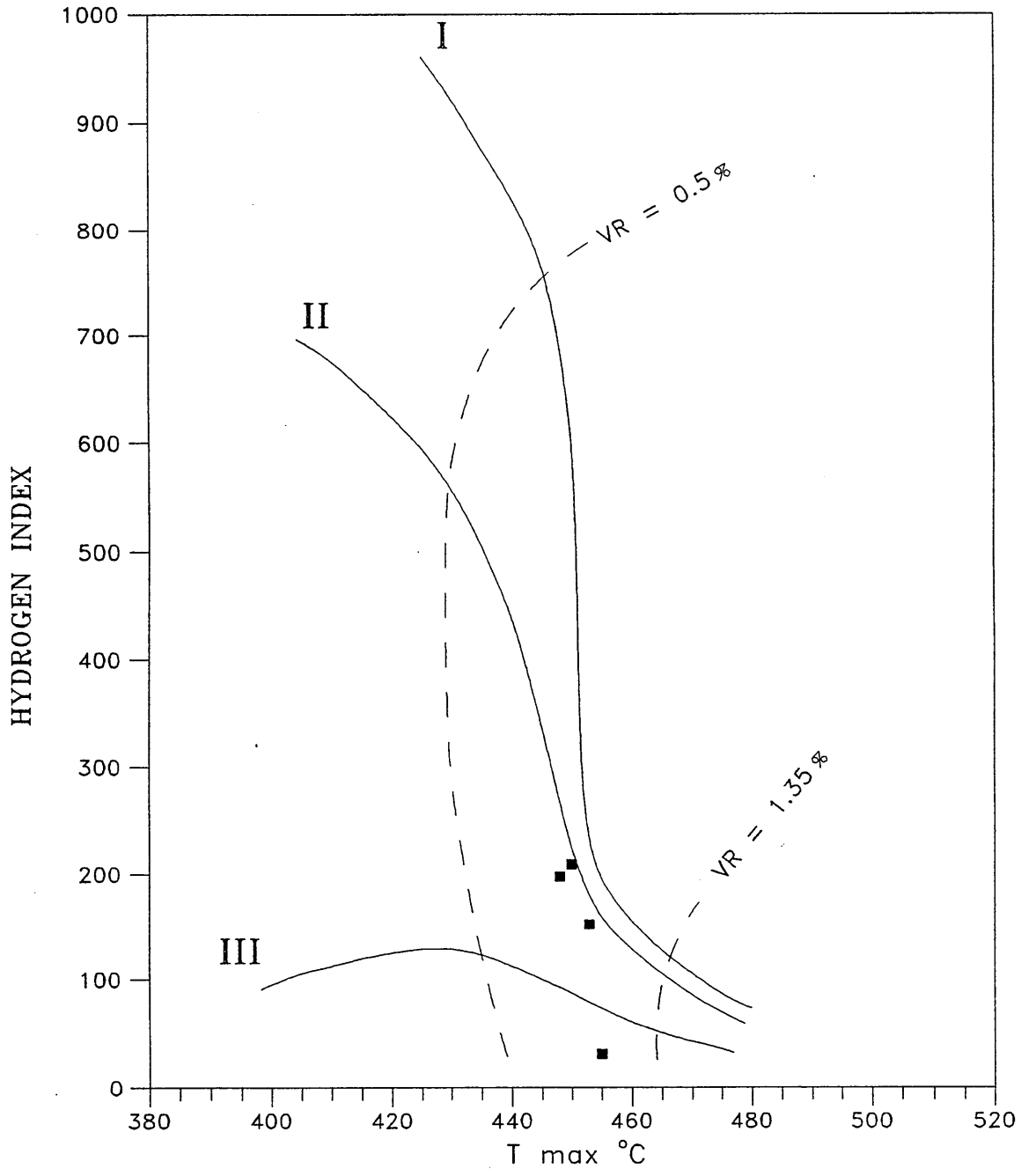
Depth (m)	Tmax	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
1920	322	15.05	21.70	8.24	36.75	0.41	2.63	3.06	8.90	244	93
1955	453	1.83	7.02	0.89	8.85	0.21	7.89	0.73	4.60	152	19
1985	448	1.60	4.95	1.97	6.55	0.24	2.51	0.54	2.50	198	78
2020	450	1.13	4.80	0.93	5.93	0.19	5.16	0.49	2.30	209	40
2040	455	0.15	0.76	4.64	0.91	0.17	0.16	0.07	2.40	31	193

amdel

FIGURE 1

HYDROGEN INDEX vs T max

Client: GFE Resources Ltd
Location: Digby-1



GEOTECH GEOTECHNICAL SERVICES PTY LTD
41-45 Furnace Road, Welshpool, Western Australia. 6106
Locked Bag 27, Cannington, Western Australia. 6107

Telephone: (09) 458 8877
Facsimile: (09) 458 8857

FILE COPY

12 July, 1995

Mr. K. Lanigan
GFE Resources Ltd
Level 6
6 Riverside Quay
South Melbourne VIC 3205

Dear Kevin,

Please find enclosed rock-eval pyrolysis results and vitrinite reflectance data for Digby-1, as well as an invoice for this work.

Please note that a 50% urgency surcharge has been charged for the vitrinite work.

The vitrinite reflectances found follow on from the trend found with the earlier batch of samples. However, the reflectances in the interval sampled with the SWC cores increase rapidly down-section, with reflectance of over 0.9% being found in the 1900m to 2000m interval. The organic facies is characterised by a dominance of inertinite over vitrinite with liptinite typically being present only in trace amounts. The vitrinite shows a relatively high reflectance range in individual samples. Where coals are absent, this could be due to the difficulty of distinguishing sclerophyll tissues preserved as low reflectance semifusinite from vitrinite. This is not, however, a problem where coals are present. Thus, two of the coaly samples provide excellent control over the discrimination of inertinite from vitrinite. The data from 2028.2m are probably the poorest of the suite but that for 2048.2m are good.

Reflectances found are unusually high for 2000m from the Otway Basin. The deeper samples have abundant carbonate. Some of this may be syngenetic and be associated with the conditions that favoured formation of inertinite over vitrinite. However, some of the mineralisation (including an unidentified fibrous phase) are clearly epigenetic in origin. It is possible that the deeper part of the section shows some effects caused by the circulation of hot fluids. These could be associated with igneous activity or they could be the product of deep basin dewatering.

If you have further queries or if we can be of any assistance to you, please do not hesitate to contact us.

Yours sincerely,

B. Hartung-Kagi

Dr. Birgitta Hartung-Kagi
Managing Director

JOB # 2176A, OTWAY BASIN, DIGBY-1

KK/Ref. No.	Depth(m) Type	$\bar{R}_v$ max	Range	N	Description Including Liptinite (Exinite) Fluorescence
T1507	1096.8 SWC-43	0.59	0.45-0.72	25	Sparse cutinite, yellow to orange, rare liptodetrinite and sporinite, yellow to orange. (Silty claystone. Dom common, I>V>L. All three maceral groups sparse. Mineral fluorescence pervasive, moderate green to yellow. Iron oxides rare. Pyrite sparse.)
T1508	1364.4	0.57	-	1	Rare cutinite, sporinite and liptodetrinite, yellow to orange.
	SWC-39 $\bar{R}_I$ max	1.24	1.02-1.79	7	(Claystone. Dom sparse, I>L>V. Inertinite sparse, liptinite and vitrinite rare. Mineral fluorescence pervasive, moderate yellow to orange. Iron oxides sparse. Pyrite sparse.)
T1509	1445.2 SWC-37	0.88	0.64-1.03	25	Rare resinite and lamalginite, dull orange. (Calcareous siltstone>>shaly coal>coal. Coal rare, I only. Inertite. Shaly coal sparse, V>I. Vitrite. Dom abundant, V>I>L. Vitrinite and inertinite common, liptinite absent. Mineral fluorescence pervasive, faint green. Iron oxides common. Pyrite rare.)
T1510	1536.4 SWC-29	0.72	0.61-0.84	6	Rare lamalginite, orange. (Siltstone. Dom common, I>V>L. Inertinite common, vitrinite and liptinite rare. Mineral fluorescence pervasive, moderate yellow to orange. Iron oxides common. Pyrite rare.)
T1511	1591.0 SWC-27	0.81	0.56-1.02	15	Fluorescing liptinite absent. (Calcareous silty claystone. Dom rare, V=I. Vitrinite and inertinite rare, liptinite absent. Mineral fluorescence pervasive, orange. Iron oxides sparse. Pyrite sparse.)
T1512	1926.4 SWC-18	0.91	0.83-0.99	26	Rare cutinite, sporinite and liptodetrinite, orange to dull orange. (Sandstone>siltstone>coal>claystone. Coal abundant, vitrite>inertite. Mineral-free maceral group composition of the coal: vitrinite - 70%, inertinite - 30%, liptinite - tr. Dom abundant, V>I>>L. Vitrinite abundant, inertinite common, liptinite rare. Oil drops rare, bright green to yellow. Iron oxides sparse. Pyrite sparse.)
T1513	1944.2 SWC-13	0.93	0.76-1.07	31	Rare cutinite, resinite and sporinite, orange to dull orange. (Coal>>carbonate>calcareous claystone. Coal dominant, inertite> vitrinertite>vitrite. Dom abundant, I>V>>L. Inertinite abundant, vitrinite common, liptinite rare. Mineral fluorescence pervasive, yellow to dull orange. Iron oxides rare. Pyrite rare.)
T1514	2028.2	0.74	0.65-0.81	3	Rare liptodetrinite, dull orange. (Carbonate. Dom rare, I>V>L.
	SWC-4 $\bar{R}_I$ max	1.50	1.34-1.73	4	Mineral fluorescence pervasive, orange. Iron oxides abundant. Pyrite sparse.)
T1515	2048.2 SWC-3	0.94	0.74-1.11	25	Fluorescing liptinite absent. (Carbonate>calcareous siltstone. Dom common, I>V. Inertinite and vitrinite sparse, liptinite absent. Mineral fluorescence pervasive, yellow to orange. Iron oxides sparse. Pyrite sparse.)

APPENDIX 9D

PYROLYSIS GC

FROM

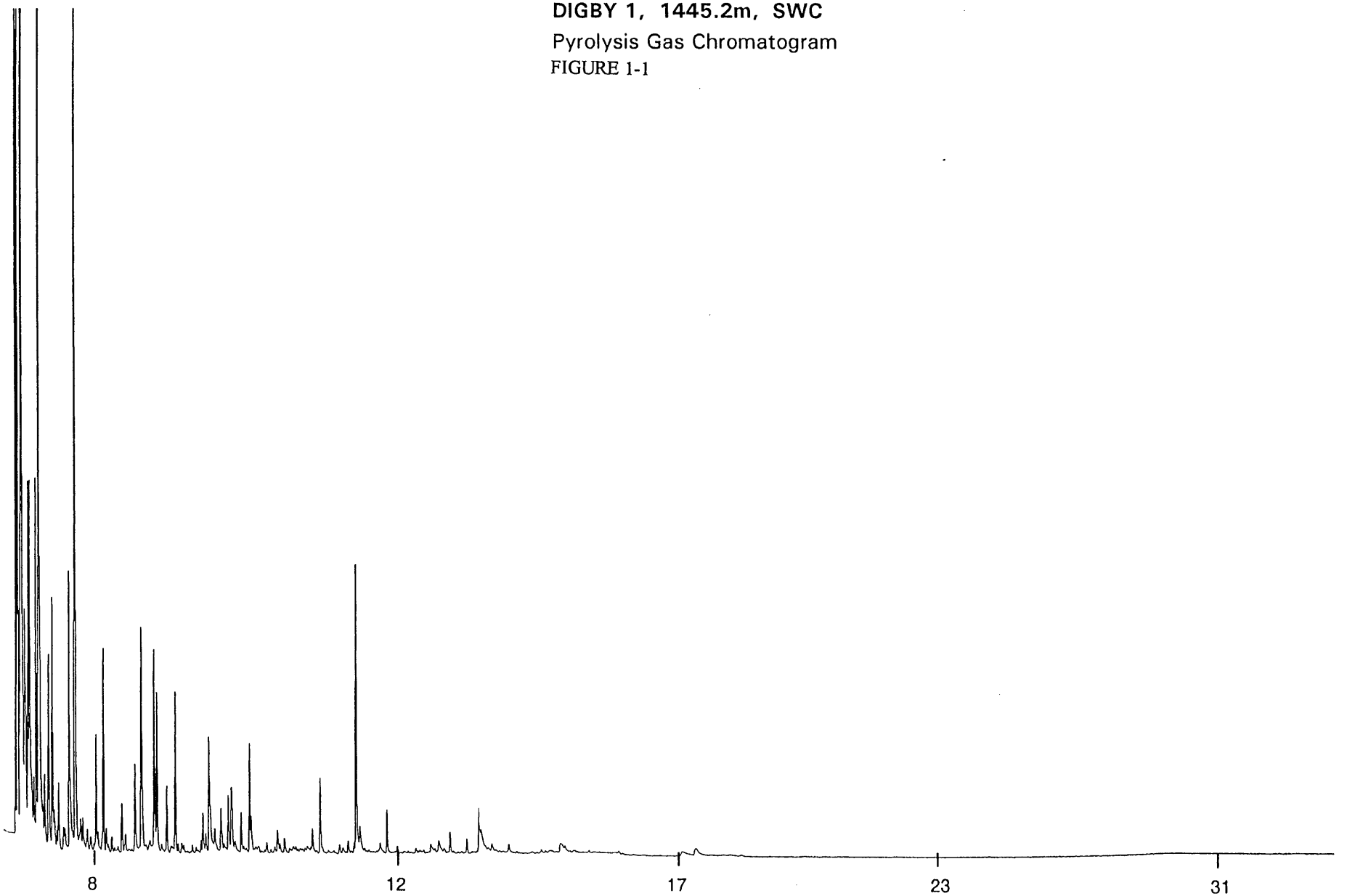
SIDEWALL CORES

DIGBY-1

DIGBY 1, 1445.2m, SWC

Pyrolysis Gas Chromatogram

FIGURE 1-1

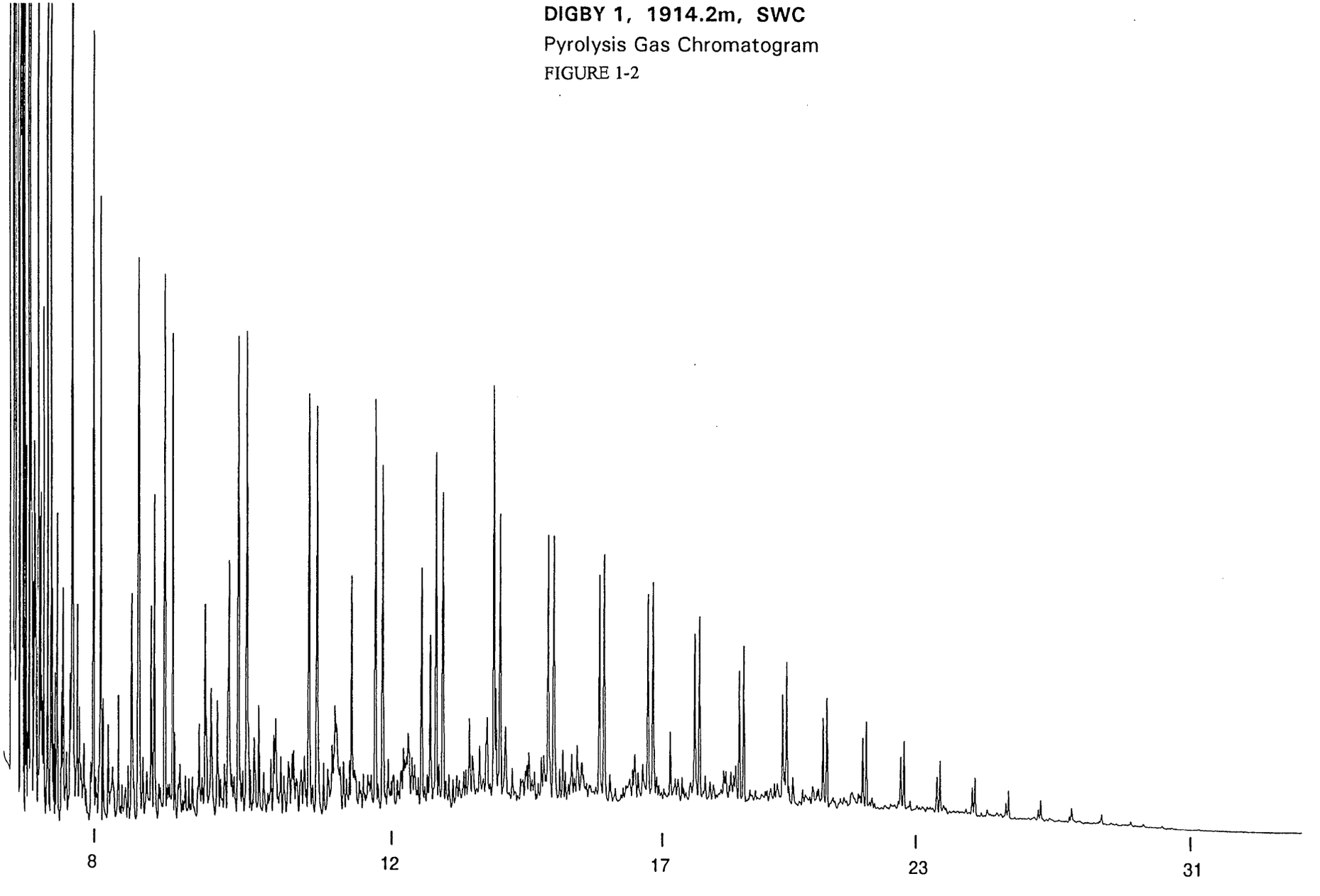


GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1914.2m, SWC

Pyrolysis Gas Chromatogram

FIGURE 1-2

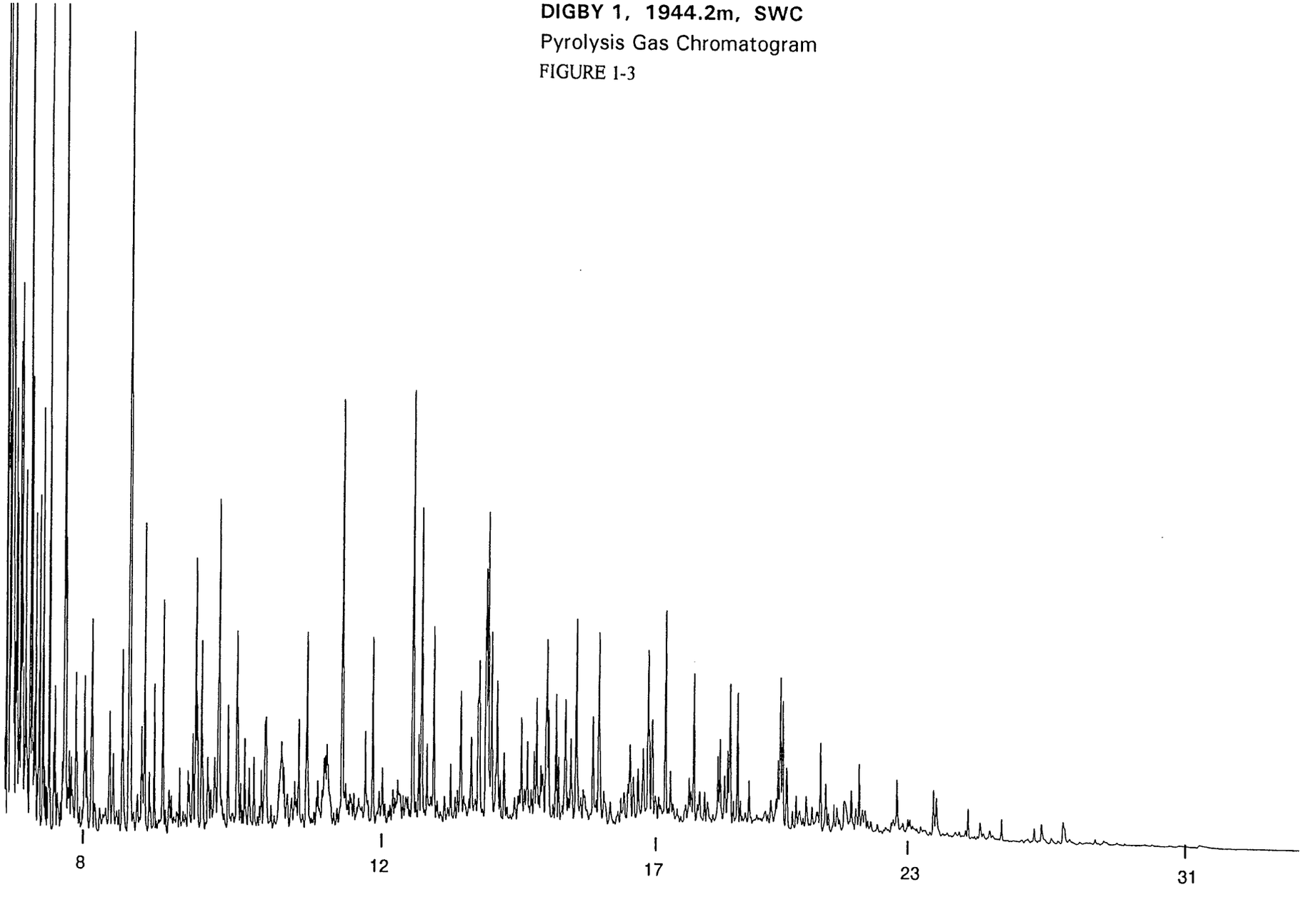


GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 1944.2m, SWC

Pyrolysis Gas Chromatogram

FIGURE 1-3

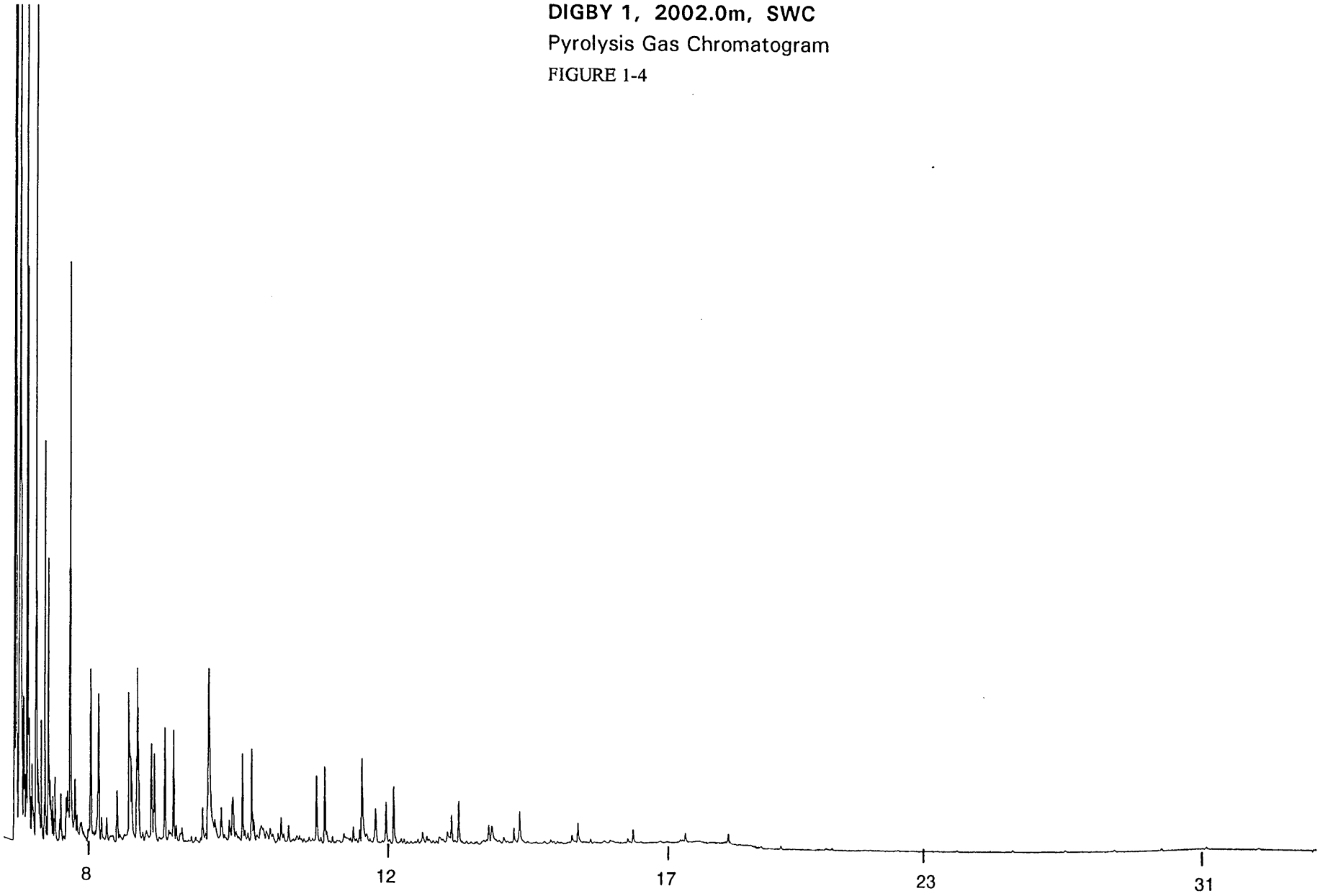


GEOTECHNICAL SERVICES PTY LTD

DIGBY 1, 2002.0m, SWC

Pyrolysis Gas Chromatogram

FIGURE 1-4



GEOTECHNICAL SERVICES PTY LTD

TABLE 2-1

ALKENE AND ALKANE COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 1445.2m, SWC 37 Jul-95

Carbon No.	----Alkane + Alkene----			-------Alkane-------			-------Alkene-------			Alkane/Alkene
	A	B	C	A	B	C	A	B	C	
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	4.104	0.062	0.057	2.320	0.035	0.032	1.784	0.027	0.025	1.30
6	2.896	0.044	0.040	1.583	0.024	0.022	1.313	0.020	0.018	1.21
7	1.746	0.026	0.024	0.899	0.014	0.013	0.847	0.013	0.012	1.06
8	1.126	0.017	0.016	0.720	0.011	0.010	0.406	0.006	0.006	1.77
9	0.824	0.012	0.012	0.572	0.009	0.008	0.252	0.004	0.004	2.27
10	0.526	0.008	0.007	0.371	0.006	0.005	0.155	0.002	0.002	2.39
11	0.397	0.006	0.006	0.288	0.004	0.004	0.109	0.002	0.002	2.64
12	0.235	0.004	0.003	0.160	0.002	0.002	0.075	0.001	0.001	2.13
13	0.123	0.002	0.002	0.090	0.001	0.001	0.033	0.000	0.000	2.73
14	0.033	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000	nd
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd

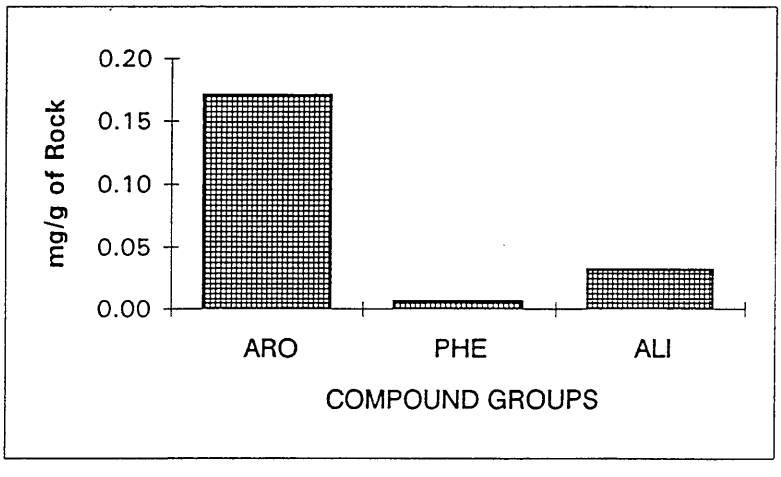
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC

TABLE 3-1

AROMATIC AND PHENOLIC COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 1445.2m, SWC 37 Jul-95

Key	Compound Name	Value A	Value B	Value C
A.	Benzene	4.405	0.067	0.062
B.	Toluene	3.801	0.057	0.053
C.	Ethylbenzene	0.388	0.006	0.005
D.	m- + p-xylene	1.171	0.018	0.016
E.	Styrene	0.864	0.013	0.012
F.	o-xylene	0.668	0.010	0.009
G.	Phenol	0.414	0.006	0.006
H.	o-cresol	0.000	0.000	0.000
I.	m- + p-cresol	0.000	0.000	0.000
J.	C2 phenol	0.000	0.000	0.000
K.	C2 phenol	0.000	0.000	0.000



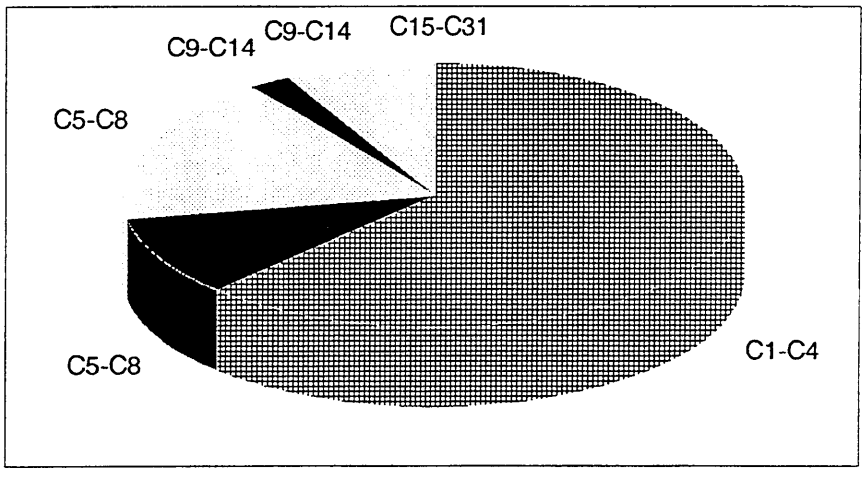
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
ARO = aromatic compounds (A to F)
PHE = phenolic compounds (G to K)
ALI = aliphatic compounds (C9 to C31 alkenes + alkanes)

TABLE 4-1

PARAMETER SUMMARY FOR PYROLYSIS GAS CHROMATOGRAPHY

DIGBY 1, 1445.2m, SWC 37 Jul-95

Parameter	Value A	Value B	Value C	Value D
C1-C4 abundance (all compounds)	62.27	0.94	0.87	
C5-C8 abundance (all resolved compounds)	27.70	0.42	0.39	
C5-C8 abundance (alkanes + alkenes)	9.87	0.15	0.14	
C9-C14 abundance (all resolved compounds)	9.95	0.15	0.14	
C9-C14 abundance (alkanes + alkenes)	2.14	0.03	0.03	
C15-C31 abundance (all resolved compounds)	0.08	0.00	0.00	
C15-C31 abundance (alkanes + alkenes)	0.00	0.00	0.00	
C9-C31 abundance (all resolved compounds)	10.03	0.15	0.14	
C9-C31 abundance (alkanes + alkenes)	2.14	0.03	0.03	
C5-C31 abundance (all resolved compounds)	37.73	0.57	0.53	
C5-C31 abundance (alkanes + alkenes)	12.01	0.18	0.17	
C5-C31 alkane abundance	7.04	0.11	0.10	
C5-C31 alkene abundance	4.97	0.08	0.07	
C5-C8 alkane/alkene				1.27
C9-C14 alkane/alkene				2.43
C15-C31 alkane/alkene				nd
C5-C31 alkane/alkene				1.41
(C1-C5)/C6+				2.21
R				2.88



nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
D = no units
R = m+p-xylene/n-octene

TABLE 2-2

ALKENE AND ALKANE COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 1914.2m, SWC 21 Jul-95

Carbon No.	----Alkane + Alkene----			-------Alkane-------			-------Alkene-------			Alkane/Alkene
	A	B	C	A	B	C	A	B	C	
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	3.887	0.324	0.076	2.169	0.181	0.042	1.718	0.143	0.033	1.26
6	2.953	0.246	0.057	1.271	0.106	0.025	1.682	0.140	0.033	0.76
7	2.757	0.230	0.054	1.277	0.107	0.025	1.480	0.123	0.029	0.86
8	2.260	0.188	0.044	0.995	0.083	0.019	1.265	0.106	0.025	0.79
9	1.881	0.157	0.037	0.881	0.073	0.017	1.000	0.083	0.019	0.88
10	1.794	0.150	0.035	0.885	0.074	0.017	0.909	0.076	0.018	0.97
11	1.726	0.144	0.034	0.881	0.073	0.017	0.845	0.070	0.016	1.04
12	1.507	0.126	0.029	0.720	0.060	0.014	0.787	0.066	0.015	0.91
13	1.357	0.113	0.026	0.654	0.055	0.013	0.703	0.059	0.014	0.93
14	1.145	0.095	0.022	0.503	0.042	0.010	0.642	0.054	0.012	0.78
15	0.980	0.082	0.019	0.598	0.050	0.012	0.382	0.032	0.007	1.57
16	0.918	0.077	0.018	0.475	0.040	0.009	0.443	0.037	0.009	1.07
17	0.756	0.063	0.015	0.394	0.033	0.008	0.362	0.030	0.007	1.09
18	0.621	0.052	0.012	0.306	0.026	0.006	0.315	0.026	0.006	0.97
19	0.489	0.041	0.010	0.270	0.023	0.005	0.219	0.018	0.004	1.23
20	0.348	0.029	0.007	0.205	0.017	0.004	0.143	0.012	0.003	1.43
21	0.322	0.027	0.006	0.181	0.015	0.004	0.141	0.012	0.003	1.28
22	0.239	0.020	0.005	0.133	0.011	0.003	0.106	0.009	0.002	1.25
23	0.182	0.015	0.004	0.102	0.009	0.002	0.080	0.007	0.002	1.28
24	0.144	0.012	0.003	0.080	0.007	0.002	0.064	0.005	0.001	1.25
25	0.102	0.009	0.002	0.060	0.005	0.001	0.042	0.004	0.001	1.43
26	0.062	0.005	0.001	0.042	0.004	0.001	0.020	0.002	0.000	2.10
27	0.043	0.004	0.001	0.029	0.002	0.001	0.014	0.001	0.000	2.07
28	0.026	0.002	0.001	0.020	0.002	0.000	0.006	0.001	0.000	3.33
29	0.014	0.001	0.000	0.014	0.001	0.000	0.000	0.000	0.000	nd
30	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	nd
31	0.003	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	nd

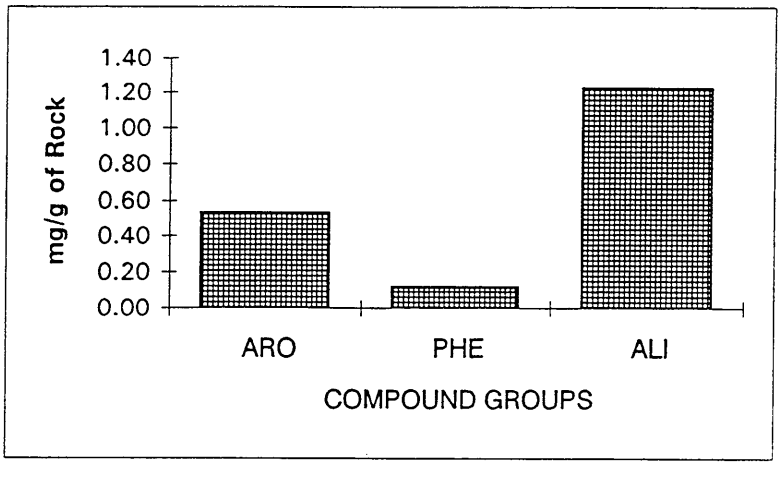
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC

TABLE 3-2

AROMATIC AND PHENOLIC COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 1914.2m, SWC 21 Jul-95

Key	Compound Name	Value A	Value B	Value C
A.	Benzene	1.700	0.142	0.033
B.	Toluene	2.014	0.168	0.039
C.	Ethylbenzene	0.443	0.037	0.009
D.	m- + p-xylene	1.326	0.111	0.026
E.	Styrene	0.379	0.032	0.007
F.	o-xylene	0.514	0.043	0.010
G.	Phenol	0.641	0.053	0.012
H.	o-cresol	0.000	0.000	0.000
I.	m- + p-cresol	0.000	0.000	0.000
J.	C2 phenol	0.328	0.027	0.006
K.	C2 phenol	0.435	0.036	0.008



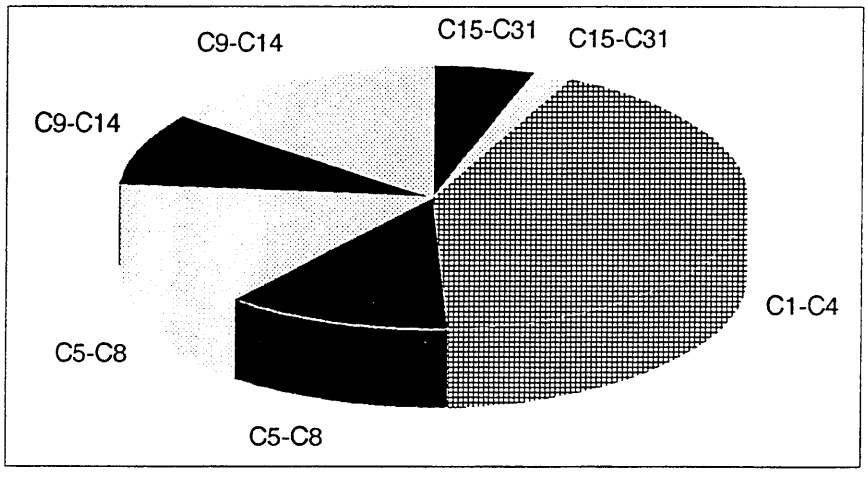
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
ARO = aromatic compounds (A to F)
PHE = phenolic compounds (G to K)
ALI = aliphatic compounds (C9 to C31 alkenes + alkanes)

TABLE 4-2

PARAMETER SUMMARY FOR PYROLYSIS GAS CHROMATOGRAPHY

DIGBY 1, 1914.2m, SWC 21 Jul-95

Parameter	Value A	B	C	D
C1-C4 abundance (all compounds)	42.37	3.53	0.82	
C5-C8 abundance (all resolved compounds)	27.54	2.30	0.54	
C5-C8 abundance (alkanes + alkenes)	11.86	0.99	0.23	
C9-C14 abundance (all resolved compounds)	24.08	2.01	0.47	
C9-C14 abundance (alkanes + alkenes)	9.41	0.78	0.18	
C15-C31 abundance (all resolved compounds)	7.46	0.62	0.14	
C15-C31 abundance (alkanes + alkenes)	5.25	0.44	0.10	
C9-C31 abundance (all resolved compounds)	31.54	2.63	0.61	
C9-C31 abundance (alkanes + alkenes)	14.66	1.22	0.29	
C5-C31 abundance (all resolved compounds)	59.08	4.93	1.15	
C5-C31 abundance (alkanes + alkenes)	26.52	2.21	0.52	
C5-C31 alkane abundance	13.15	1.10	0.26	
C5-C31 alkene abundance	13.37	1.11	0.26	
C5-C8 alkane/alkene				0.93
C9-C14 alkane/alkene				0.93
C15-C31 alkane/alkene				1.25
C5-C31 alkane/alkene				0.98
(C1-C5)/C6 + R				0.90 1.05



nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
D = no units
R = m + p-xylene/n-octene

TABLE 2-3

ALKENE AND ALKANE COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 1944.2m, SWC 13 Jul-95

Carbon No.	----Alkane + Alkene----			-------Alkane-------			-------Alkene-------			Alkane/Alkene
	A	B	C	A	B	C	A	B	C	
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	2.073	1.067	0.030	0.936	0.482	0.013	1.137	0.585	0.016	0.82
6	1.122	0.578	0.016	0.620	0.319	0.009	0.502	0.258	0.007	1.24
7	1.158	0.596	0.017	0.604	0.311	0.009	0.554	0.285	0.008	1.09
8	0.831	0.428	0.012	0.493	0.254	0.007	0.338	0.174	0.005	1.46
9	0.685	0.353	0.010	0.447	0.230	0.006	0.238	0.123	0.003	1.88
10	0.585	0.301	0.008	0.362	0.186	0.005	0.223	0.115	0.003	1.62
11	0.750	0.386	0.011	0.520	0.268	0.007	0.230	0.118	0.003	2.26
12	0.563	0.290	0.008	0.361	0.186	0.005	0.202	0.104	0.003	1.79
13	0.553	0.285	0.008	0.403	0.207	0.006	0.150	0.077	0.002	2.69
14	0.754	0.388	0.011	0.302	0.155	0.004	0.452	0.233	0.006	0.67
15	0.389	0.200	0.006	0.343	0.177	0.005	0.046	0.024	0.001	7.46
16	0.662	0.341	0.009	0.471	0.242	0.007	0.191	0.098	0.003	2.47
17	0.358	0.184	0.005	0.188	0.097	0.003	0.170	0.088	0.002	1.11
18	0.325	0.167	0.005	0.263	0.135	0.004	0.062	0.032	0.001	4.24
19	0.286	0.147	0.004	0.248	0.128	0.004	0.038	0.020	0.001	6.53
20	0.267	0.137	0.004	0.198	0.102	0.003	0.069	0.036	0.001	2.87
21	0.154	0.079	0.002	0.154	0.079	0.002	0.000	0.000	0.000	nd
22	0.105	0.054	0.002	0.105	0.054	0.002	0.000	0.000	0.000	nd
23	0.108	0.056	0.002	0.108	0.056	0.002	0.000	0.000	0.000	nd
24	0.082	0.042	0.001	0.082	0.042	0.001	0.000	0.000	0.000	nd
25	0.050	0.026	0.001	0.050	0.026	0.001	0.000	0.000	0.000	nd
26	0.042	0.022	0.001	0.042	0.022	0.001	0.000	0.000	0.000	nd
27	0.024	0.012	0.000	0.024	0.012	0.000	0.000	0.000	0.000	nd
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd

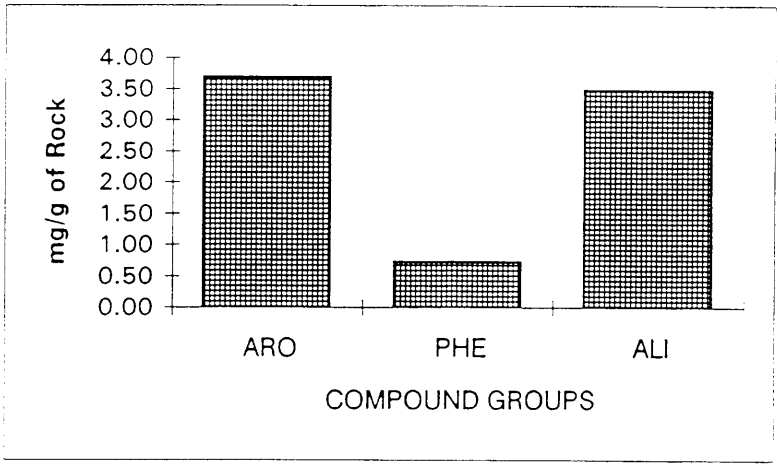
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC

TABLE 3-3

AROMATIC AND PHENOLIC COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 1944.2m, SWC 13 Jul-95

Key	Compound Name	Value A	Value B	Value C
A.	Benzene	1.473	0.758	0.021
B.	Toluene	2.236	1.151	0.032
C.	Ethylbenzene	0.449	0.231	0.006
D.	m- + p-xylene	2.209	1.137	0.032
E.	Styrene	0.245	0.126	0.004
F.	o-xylene	0.543	0.280	0.008
G.	Phenol	0.876	0.451	0.013
H.	o-cresol	0.232	0.119	0.003
I.	m- + p-cresol	0.285	0.147	0.004
J.	C2 phenol	0.000	0.000	0.000
K.	C2 phenol	0.000	0.000	0.000



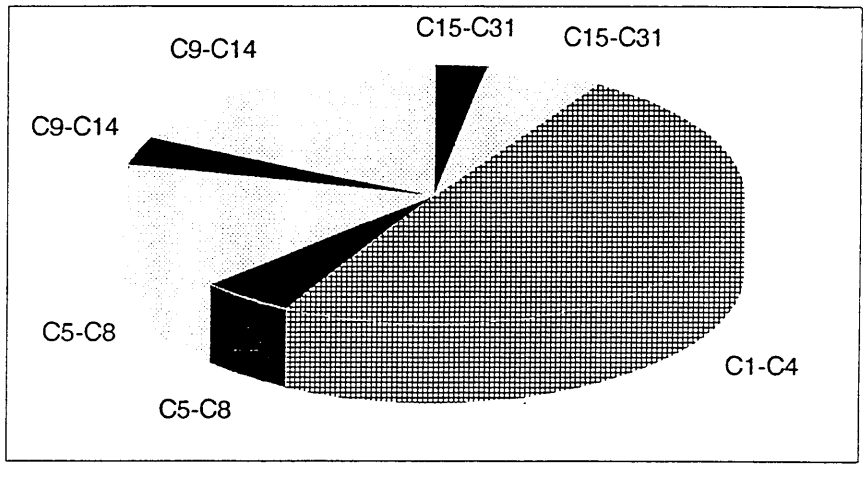
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
ARO = aromatic compounds (A to F)
PHE = phenolic compounds (G to K)
ALI = aliphatic compounds (C9 to C31 alkenes + alkanes)

TABLE 4-3

PARAMETER SUMMARY FOR PYROLYSIS GAS CHROMATOGRAPHY

DIGBY 1, 1944.2m, SWC 13 Jul-95

Parameter	Value A	Value B	Value C	Value D
C1-C4 abundance (all compounds)	50.01	25.74	0.72	
C5-C8 abundance (all resolved compounds)	21.19	10.91	0.30	
C5-C8 abundance (alkanes + alkenes)	5.18	2.67	0.07	
C9-C14 abundance (all resolved compounds)	21.92	11.29	0.31	
C9-C14 abundance (alkanes + alkenes)	3.89	2.00	0.06	
C15-C31 abundance (all resolved compounds)	9.01	4.64	0.13	
C15-C31 abundance (alkanes + alkenes)	2.85	1.47	0.04	
C9-C31 abundance (all resolved compounds)	30.94	15.93	0.44	
C9-C31 abundance (alkanes + alkenes)	6.74	3.47	0.10	
C5-C31 abundance (all resolved compounds)	52.12	26.83	0.75	
C5-C31 abundance (alkanes + alkenes)	11.93	6.14	0.17	
C5-C31 alkane abundance	7.32	3.77	0.11	
C5-C31 alkene abundance	4.60	2.37	0.07	
C5-C8 alkane/alkene				1.05
C9-C14 alkane/alkene				1.60
C15-C31 alkane/alkene				3.95
C5-C31 alkane/alkene				1.59
(C1-C5)/C6+				1.09
R				6.54



nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
D = no units
R = m + p-xylene/n-octene

TABLE 2-4

ALKENE AND ALKANE COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 2002m, SWC 6 Jul-95

Carbon No.	----Alkane + Alkene----			-------Alkane-------			-------Alkene-------			Alkane/Alkene
	A	B	C	A	B	C	A	B	C	
1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	5.567	0.057	0.084	4.878	0.050	0.073	0.689	0.007	0.010	7.08
6	3.928	0.040	0.059	1.539	0.016	0.023	2.389	0.024	0.036	0.64
7	3.121	0.032	0.047	1.490	0.015	0.022	1.631	0.017	0.024	0.91
8	2.314	0.024	0.035	1.098	0.011	0.016	1.216	0.012	0.018	0.90
9	1.701	0.017	0.026	0.837	0.009	0.013	0.864	0.009	0.013	0.97
10	1.283	0.013	0.019	0.647	0.007	0.010	0.636	0.006	0.010	1.02
11	1.053	0.011	0.016	0.536	0.005	0.008	0.517	0.005	0.008	1.04
12	0.768	0.008	0.012	0.403	0.004	0.006	0.365	0.004	0.005	1.10
13	0.580	0.006	0.009	0.349	0.004	0.005	0.231	0.002	0.003	1.51
14	0.367	0.004	0.006	0.264	0.003	0.004	0.103	0.001	0.002	2.56
15	0.192	0.002	0.003	0.132	0.001	0.002	0.060	0.001	0.001	2.20
16	0.119	0.001	0.002	0.097	0.001	0.001	0.022	0.000	0.000	4.41
17	0.067	0.001	0.001	0.067	0.001	0.001	0.000	0.000	0.000	nd
18	0.043	0.000	0.001	0.043	0.000	0.001	0.000	0.000	0.000	nd
19	0.013	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	nd
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd
31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	nd

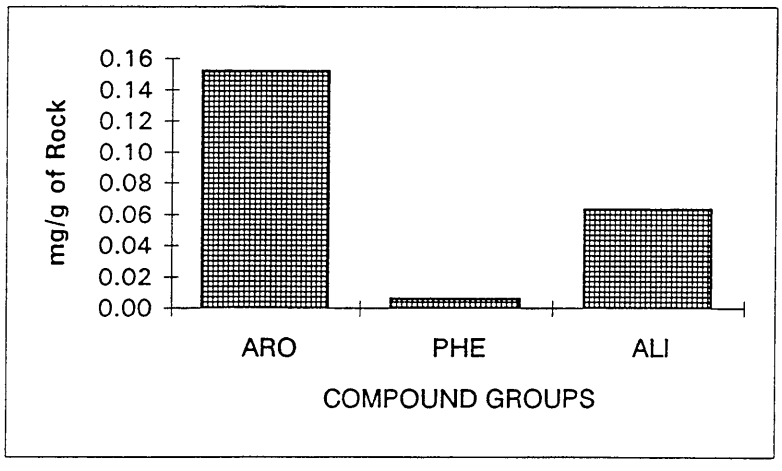
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC

TABLE 3-4

AROMATIC AND PHENOLIC COMPONENT ANALYSIS FROM PYROLYSIS-GC

DIGBY 1, 2002m, SWC 6 Jul-95

Key	Compound Name	Value A	Value B	Value C
A.	Benzene	7.615	0.078	0.114
B.	Toluene	3.915	0.040	0.059
C.	Ethylbenzene	0.701	0.007	0.011
D.	m- + p-xylene	1.054	0.011	0.016
E.	Styrene	0.834	0.009	0.013
F.	o-xylene	0.747	0.008	0.011
G.	Phenol	0.574	0.006	0.009
H.	o-cresol	0.000	0.000	0.000
I.	m- + p-cresol	0.000	0.000	0.000
J.	C2 phenol	0.000	0.000	0.000
K.	C2 phenol	0.000	0.000	0.000



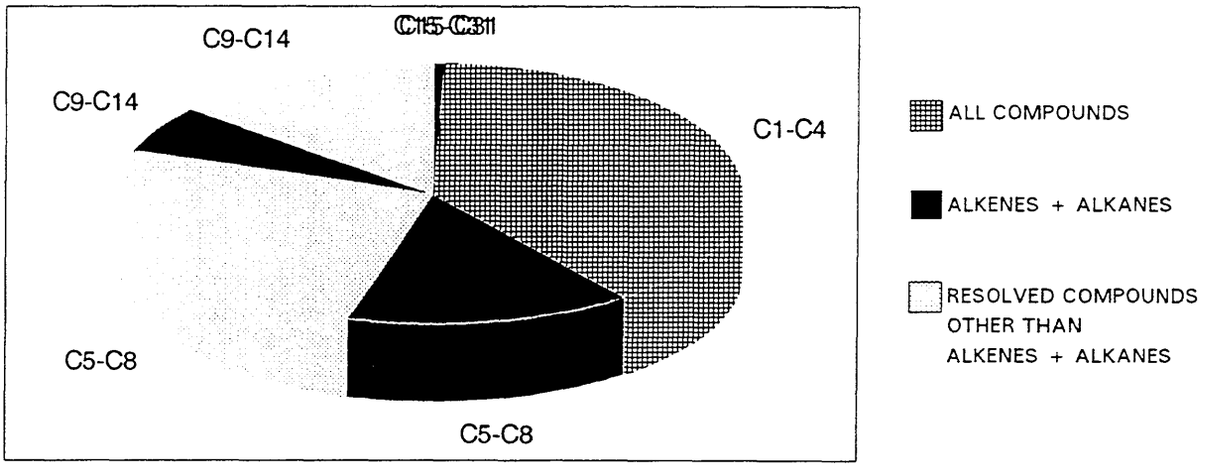
nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
ARO = aromatic compounds (A to F)
PHE = phenolic compounds (G to K)
ALI = aliphatic compounds (C9 to C31 alkenes + alkanes)

TABLE 4-4

PARAMETER SUMMARY FOR PYROLYSIS GAS CHROMATOGRAPHY

DIGBY 1, 2002m, SWC 6 Jul-95

Parameter	Value A	Value B	Value C	Value D
C1-C4 abundance (all compounds)	38.88	0.40	0.58	
C5-C8 abundance (all resolved compounds)	40.99	0.42	0.61	
C5-C8 abundance (alkanes + alkenes)	14.93	0.15	0.22	
C9-C14 abundance (all resolved compounds)	19.61	0.20	0.29	
C9-C14 abundance (alkanes + alkenes)	5.75	0.06	0.09	
C15-C31 abundance (all resolved compounds)	0.52	0.01	0.01	
C15-C31 abundance (alkanes + alkenes)	0.43	0.00	0.01	
C9-C31 abundance (all resolved compounds)	20.14	0.21	0.30	
C9-C31 abundance (alkanes + alkenes)	6.19	0.06	0.09	
C5-C31 abundance (all resolved compounds)	61.12	0.62	0.92	
C5-C31 abundance (alkanes + alkenes)	21.12	0.22	0.32	
C5-C31 alkane abundance	12.39	0.13	0.19	
C5-C31 alkene abundance	8.72	0.09	0.13	
C5-C8 alkane/alkene				1.52
C9-C14 alkane/alkene				1.12
C15-C31 alkane/alkene				4.29
C5-C31 alkane/alkene				1.42
(C1-C5)/C6+				0.93
R				0.87



nd = no data
A = % of resolved compounds in S2
B = mg/g Rock (Rock-Eval)
C = (mg/g Rock)/TOC
D = no units
R = m+p-xylene/n-octene

TABLE 1

ROCK-EVAL PYROLYSIS DATA (one run)

DIGBY 1 Jul-95

DEPTH (m)	TMAX	S1	S2	S3	S1 + S2	S2/S3	PI	PC	TOC	HI	OI
1096.8	nd	nd	nd	nd	nd	nd	nd	nd	0.32	nd	nd
1364.4	nd	nd	nd	nd	nd	nd	nd	nd	0.32	nd	nd
1414.6	nd	nd	nd	nd	nd	nd	nd	nd	0.41	nd	nd
1445.2	448	0.20	1.51	0.21	1.71	7.19	0.12	0.14	1.08	140	19
1536.4	447	0.16	0.69	0.20	0.85	3.45	0.19	0.07	0.53	130	38
1591.0	nd	nd	nd	nd	nd	nd	nd	nd	0.29	nd	nd
1903.2	446	0.73	3.97	1.09	4.70	3.64	0.16	0.39	2.47	161	44
1914.2	446	1.89	8.34	1.11	10.23	7.51	0.18	0.85	4.29	194	26
1926.4	449	1.68	6.31	0.30	7.99	21.03	0.21	0.66	3.27	193	9
1936.4	454	1.32	6.80	0.54	8.12	12.59	0.16	0.67	3.65	186	15
1944.2	458	12.87	51.48	1.20	64.35	42.90	0.20	5.34	35.90	143	3
2002.0	451	0.43	1.02	1.05	1.45	0.97	0.30	0.12	0.68	150	154
2028.2	nd	nd	nd	nd	nd	nd	nd	nd	0.42	nd	nd
2048.2	448	0.25	0.60	12.43	0.85	0.05	0.29	0.07	0.53	113	2345

TMAX = Max. temperature S2
S1 = Volatile hydrocarbons (HC)
S2 = HC generating potential
S1 + S2 = Potential yield
S3 = Organic carbon dioxide
PI = Production index
PC = Pyrolysable carbon
TOC = Total organic carbon
HI = Hydrogen index
OI = Oxygen Index
nd = no data

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APPENDIX 9E

GC-MS

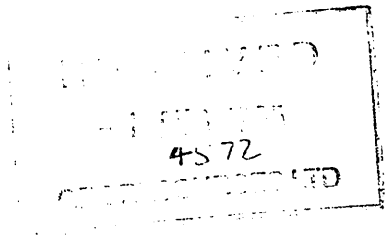
(BRANCHED / CYCLICS & AROMATICS)

DIGBY-1

GEOTECH GEOTECHNICAL SERVICES PTY LTD
41-45 Furnace Road, Welshpool, Western Australia. 6106
Locked Bag 27, Cannington, Western Australia. 6107
Telephone: (09) 458 8877
Facsimile: (09) 458 8857

FILE COPY

31 July, 1995



Mr. N. Newell
GFE Resources Ltd
Level 6
6 Riverside Quay
South Melbourne VIC 3205

Dear Noel,

Please find enclosed GC sat, GC-MS b/c and GC-MS arom results for two Digby-1 source rock samples from 1903.2m and 1944.2m depth as well as GC-MS data for SWCs 13, 14, 22 and 32.

Based on the data available, the following conclusions can be drawn:

- The oil shows at 1473.7m and 1940.8m are considerably different in terms of their organic source facies. The deeper oil is significantly more terrestrial than the shallower one, as reflected in C_{27}/C_{29} diasterane and sterane ratios of 0.09 and 0.29 at 1940.8m vs 0.58 and 0.83 at 1437.7m.

  Both oils were sourced from predominantly terrestrial organic matter, but the deeper one was generated from a coaly exclusively higher plant derived source, whereas the shallower one was generated from "normal" terrestrial organic matter with minor input from algae and bacteria.

  The depositional environment of the coaly source for the 1940.8m oil was much more oxic than the environment during deposition of the source for the 1473.7m oil, as characterised by a higher pristane/phytane ratio (5.48 vs 3.06) and less prominent dia- and neohopanes.

- The oil from 1473.7m correlates well with the source rock from 1903.2m, both in terms of its moderately terrestrial source character and the mixed oxic/anoxic depositional environment.

- The oil from 1940.8m is believed to be genetically related to the coaly source rock from 1944.2m: both samples show very terrestrial, coaly biomarker signatures and markers for quite oxic depositional environments.

  The higher proportion of light ends (up to about n-C_{15}) in the GC trace for 1944.2m is in agreement with the coaly nature of this organic matter (which is also reflected in its PGC trace).

  The lower proportions of n-alkanes up to C_{15} in the 1940.8m oil believed to be generated from this organic matter is likely to be due to migration effects.

- All four samples analysed are mature at present, with sterane ratios suggesting maturities of about 1.0 to 1.1% V_R equivalent and MPIs equivalent to approximately 0.8 to 0.9% V_R.

If you have further queries or if we can be of any assistance to you, please do not hesitate to contact us.

Yours sincerely,

Dr. Birgitta Hartung-Kagi
Managing Director

TABLE 10

SELECTED AROMATIC PARAMETERS

DIGBY 1 Jul-95

DEPTH	TYPE	DNR-1	DNR-5	DNR-6	TNR-1	TNR-5	TNR-6	MPR-1	MPI-1	MPI-2	Rc(a)	Rc(b)
1473.7m	SWC	3.39	nd	1.89	0.64	0.95	nd	1.67	0.76	0.81	0.85	1.85
1903.2m	SWC	4.22	nd	2.37	0.70	0.78	nd	1.48	0.63	0.69	0.78	1.92
1940.8m	SWC	4.58	nd	2.48	0.66	1.06	nd	1.17	0.69	0.81	0.82	1.88
1944.0m	SWC	4.55	nd	2.82	0.75	1.72	nd	1.02	0.65	0.80	0.79	1.91

response factors have been applied to DNR 6, TNR 1, TNR 5, MPI 1 and MPI 2

TABLE 10

SELECTED AROMATIC PARAMETERS CONT.

DIGBY 1 Jul-95

DEPTH	TYPE	1,7-DMP/X (m/z 206)	RETENE/9-MP (m/z 219,192)	1MP/9MP
1473.7m	SWC	0.92	0.36	0.94
1903.2m	SWC	0.81	0.04	1.03
1940.8m	SWC	1.55	0.31	1.62
1944.0m	SWC	2.70	0.64	2.27

nd = no data

TABLE 8

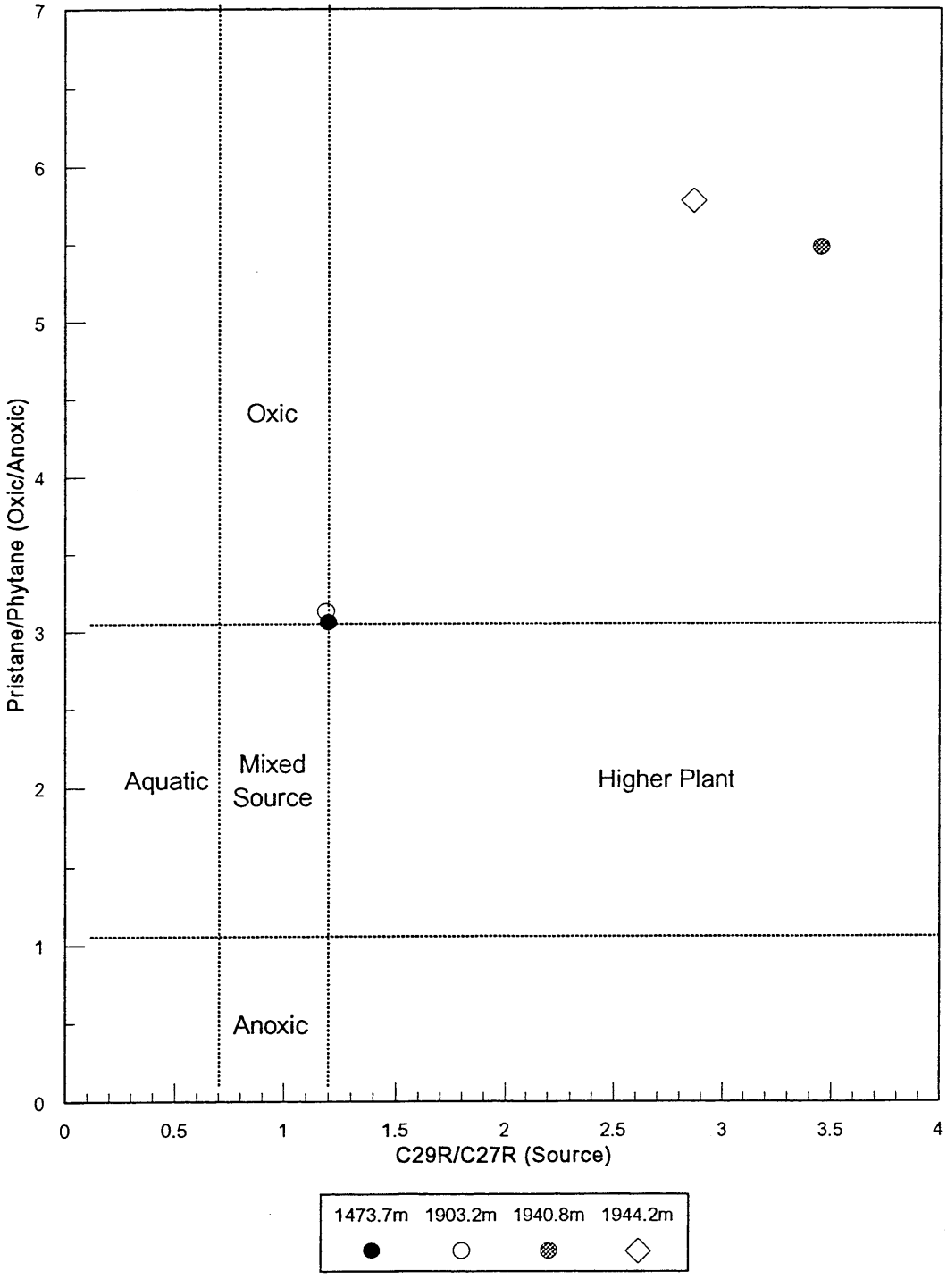
SUMMARY OF PARAMETERS FROM GC-MS ANALYSIS

DIGBY 1

		TRITERPANES					STERANES						BICYCLANES	
WELL	SAMPLE	Ts/Tm	C30H/C30M	C31 22S/22R	C32 22S/22R	HOPANES/ STERANES	C29 20S/20R	C29 20S/20S + 20R	C29 αBB/ααα+αBB	C29 DIAS/NORMAL	DIASTERANES C27/C29	NORMAL C27/C29	D/HD	R1 + R2/ D + HD
DIGBY 1	1473.7m	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.74	1.11
DIGBY 1	1473.7m, Topped	2.53	8.69	1.24	1.56	1.63	1.11	0.53	0.61	1.22	0.58	0.83	nd	nd
DIGBY 1	1903.2m	1.03	10.11	1.34	1.48	1.13	0.97	0.49	0.57	0.62	0.61	0.84	0.33	0.68
DIGBY 1	1940.8m	1.03	11.08	1.32	1.37	0.56	1.06	0.52	0.61	0.76	0.09	0.29	0.40	0.72
DIGBY 1	1944.2m	0.45	10.86	1.53	1.28	1.27	0.92	0.48	0.58	0.63	0.23	0.35	0.57	0.30

FIGURE 5-2

DIGBY 1
Pristane/Phytane vs C29R/C27R



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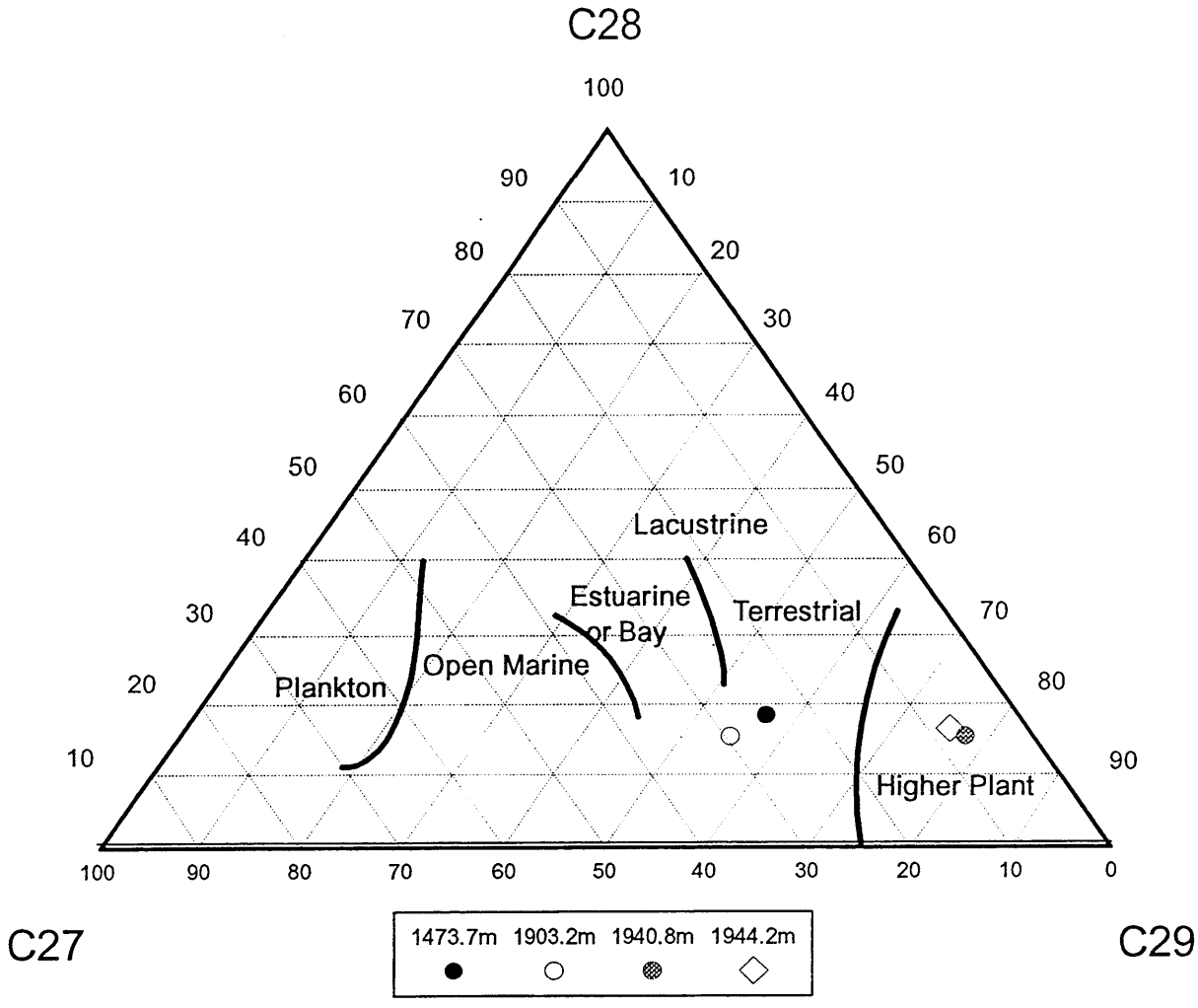
DIGBY 1 Comparison GC-MS (B/C) Data

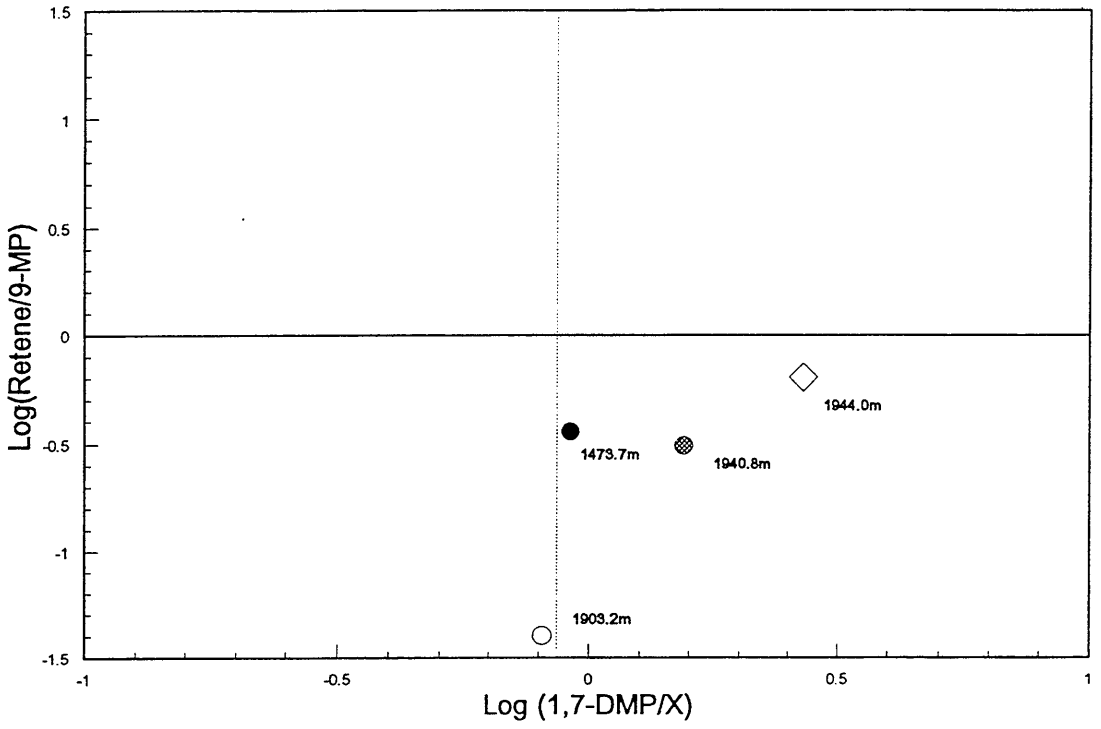
Facies Interpretation based on Steranes



m/z 218 Iso Steranes

DIGBY 1 GC-MS (AROMS) Data

Aromatic Source Input Parameters



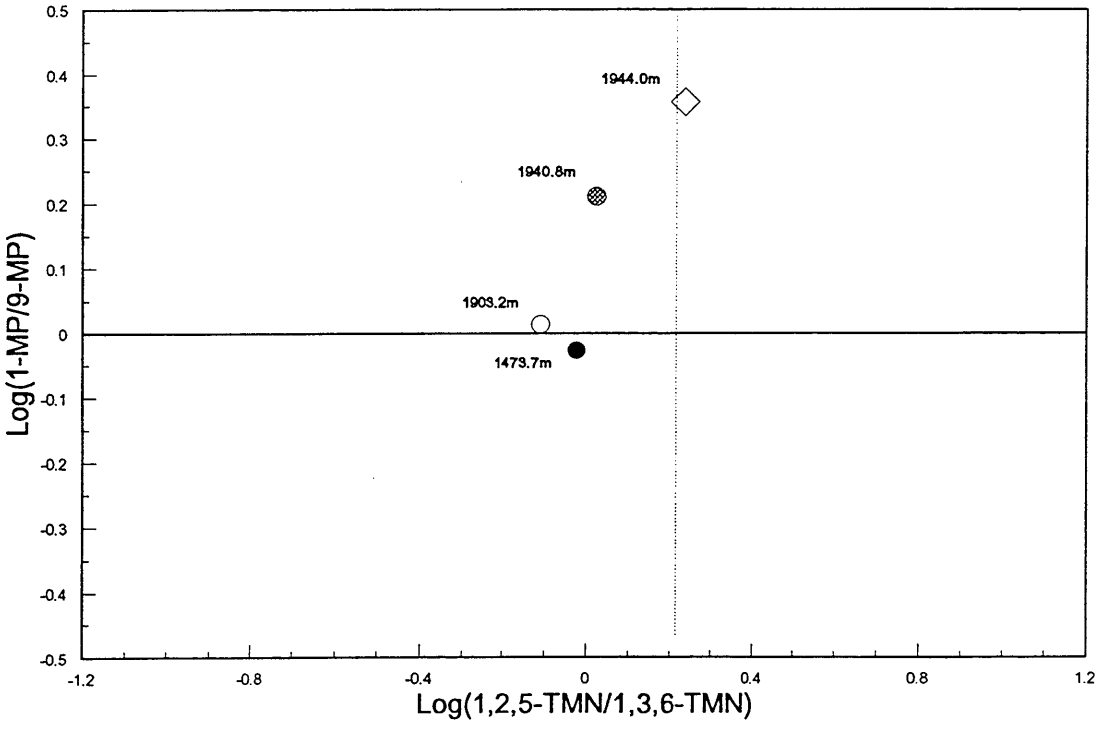


Figure 3

DIGBY 1 GC-MS (AROMS) Data

MPI-derived VR versus Depth

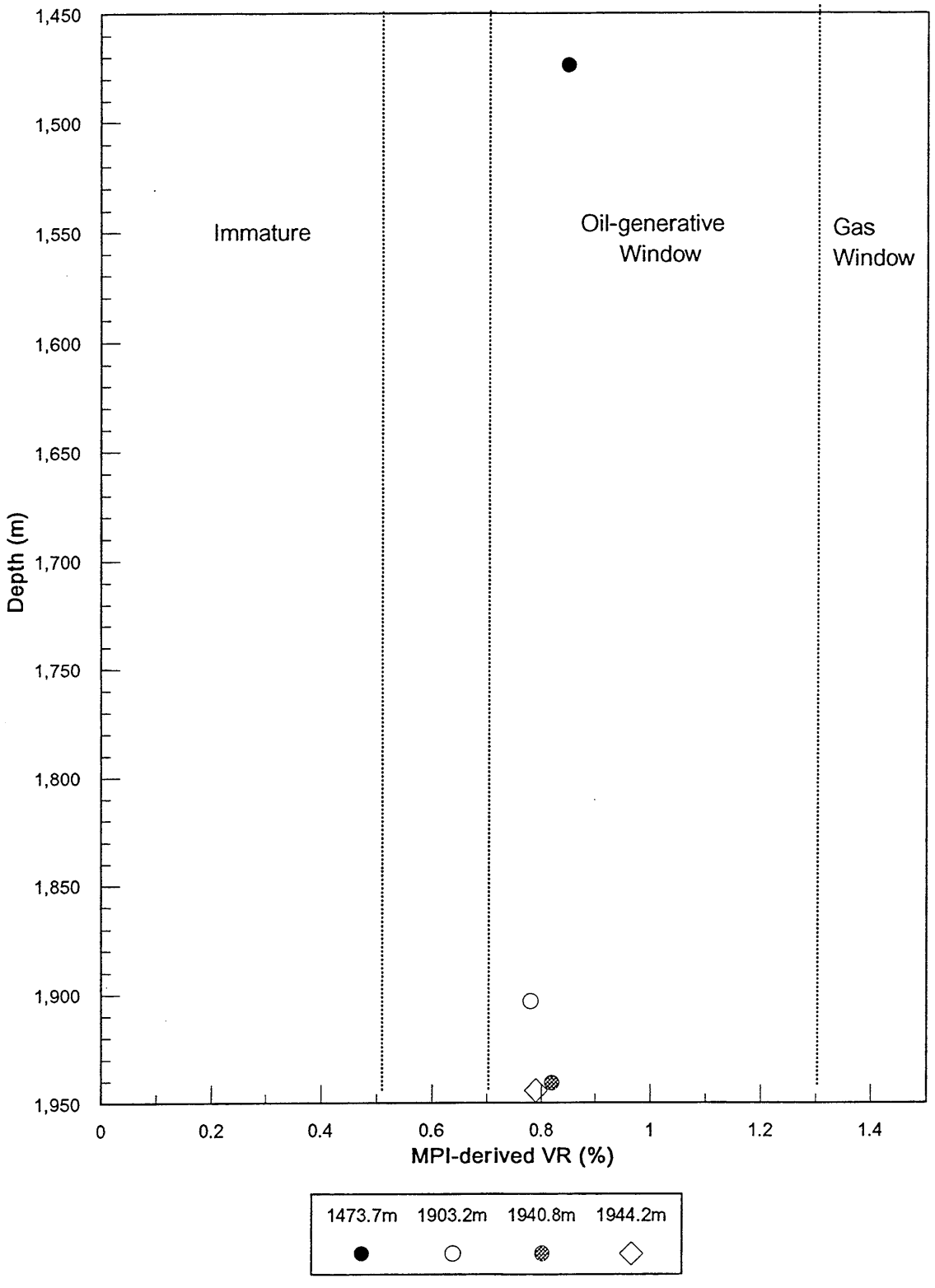


Figure 4

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TABLE 9-1

SELECTED PARAMETERS FROM GC/MS ANALYSIS

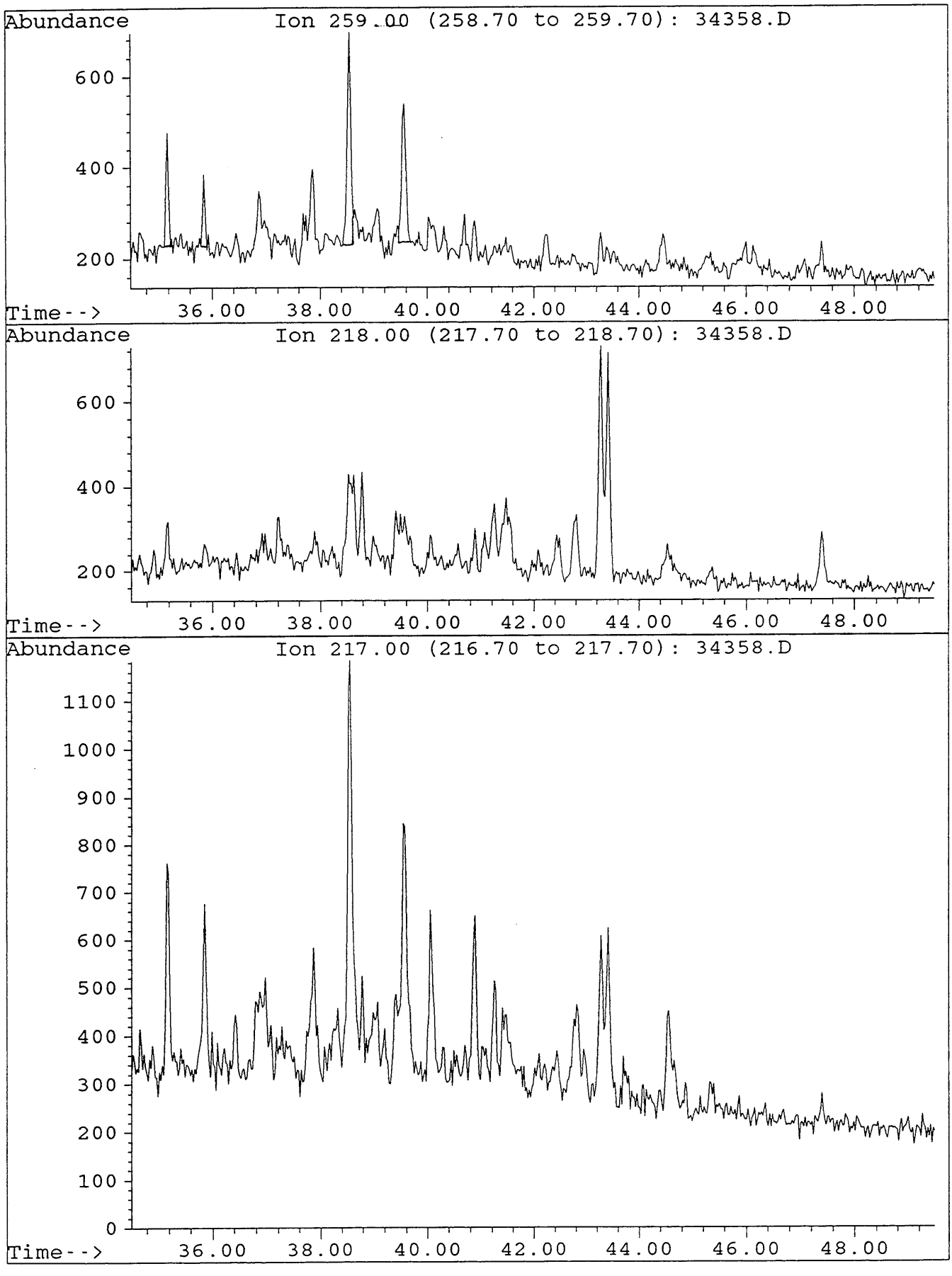
DIGBY 1, 1473.7m, SWC

	Parameter	Ion(s)	Value
1.	18 α (H)- hopane/17 α (H)-hopane (Ts/Tm)	191	nd
2.	C30 hopane/C30 moretane	191	nd
3.	C31 22S hopane/C31 22R hopane	191	nd
4.	C32 22S hopane/C32 22R hopane	191	nd
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ sterane	217	nd
6.	C29 $\alpha\alpha\alpha$ steranes (20S / 20S+20R)	217	nd
7.	$\frac{\text{C29 } \alpha\beta\beta \text{ steranes}}{\text{C29 } \alpha\alpha\alpha \text{ steranes + C29 } \alpha\beta\beta \text{ steranes}}$	217	nd
8.	C27/C29 diasteranes	259	nd
9.	C27/C29 steranes	217	nd
10.	18 α (H)-oleanane/C30 hopane	191	nd
11.	$\frac{\text{C29 diasteranes}}{\text{C29 } \alpha\alpha\alpha \text{ steranes + C29 } \alpha\beta\beta \text{ steranes}}$	217	nd
12.	$\frac{\text{C30 (hopane + moretane)}}{\text{C29 (steranes + diasteranes)}}$	191/217	nd
13.	C15 drimane/C16 homodrimane	123	0.74
14.	Rearranged drimanes/normal drimanes	123	1.11

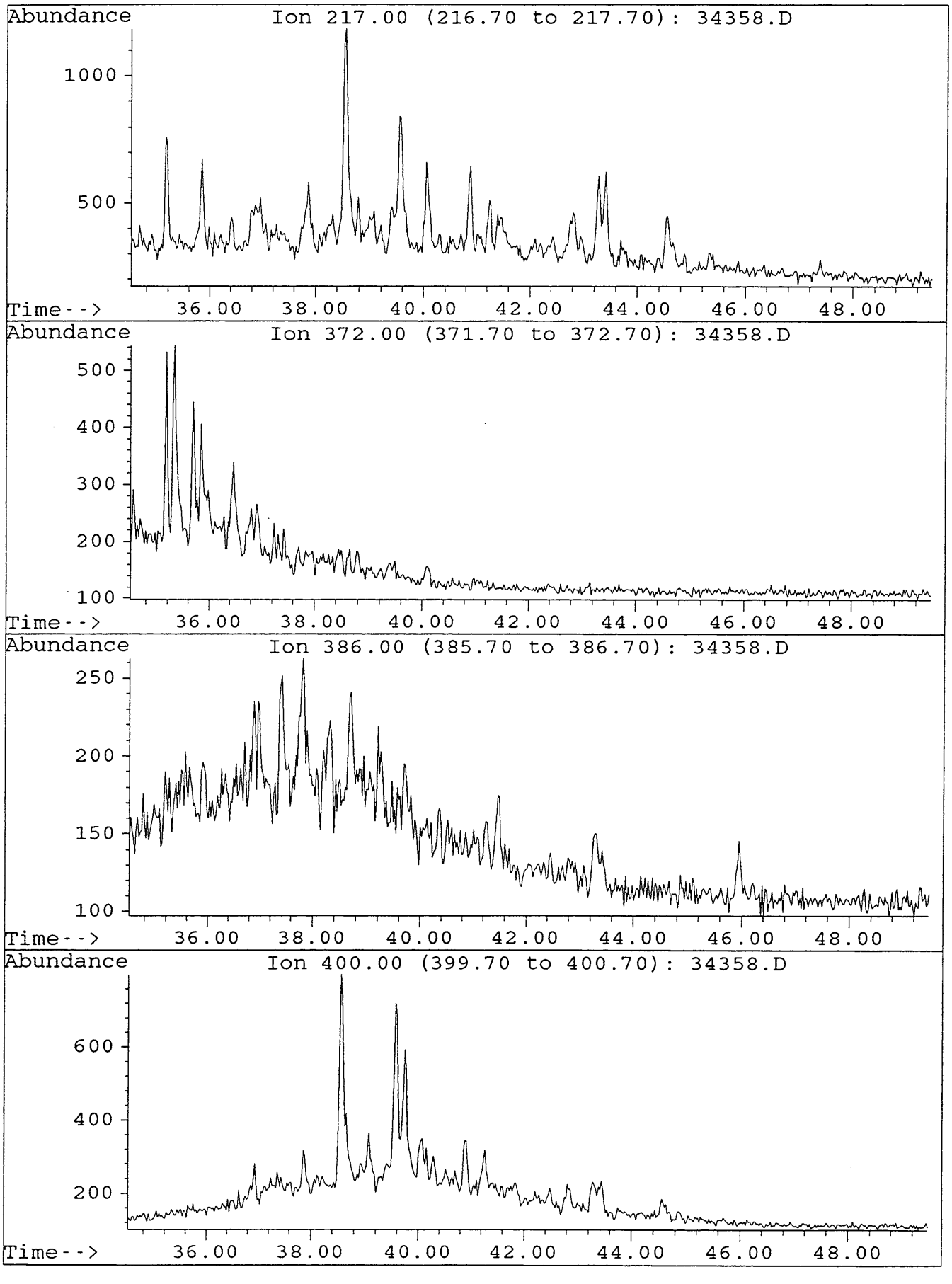
nd = not detectable

File : 34358.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 10-7-95

FIGURE 6-1



File : 34358.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 10-7-95



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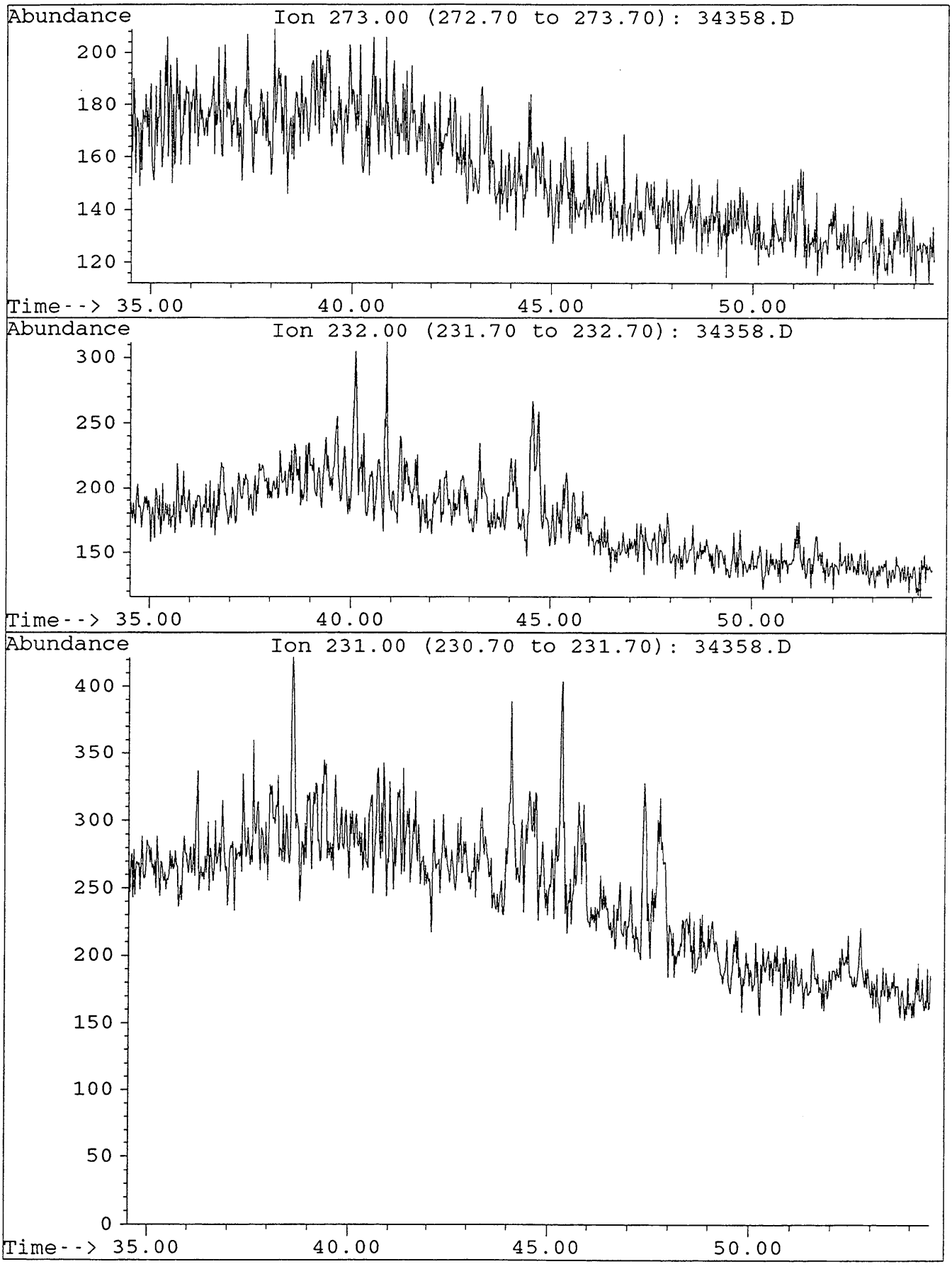
Misc. Info : COL#164. DJ. 10-7-95



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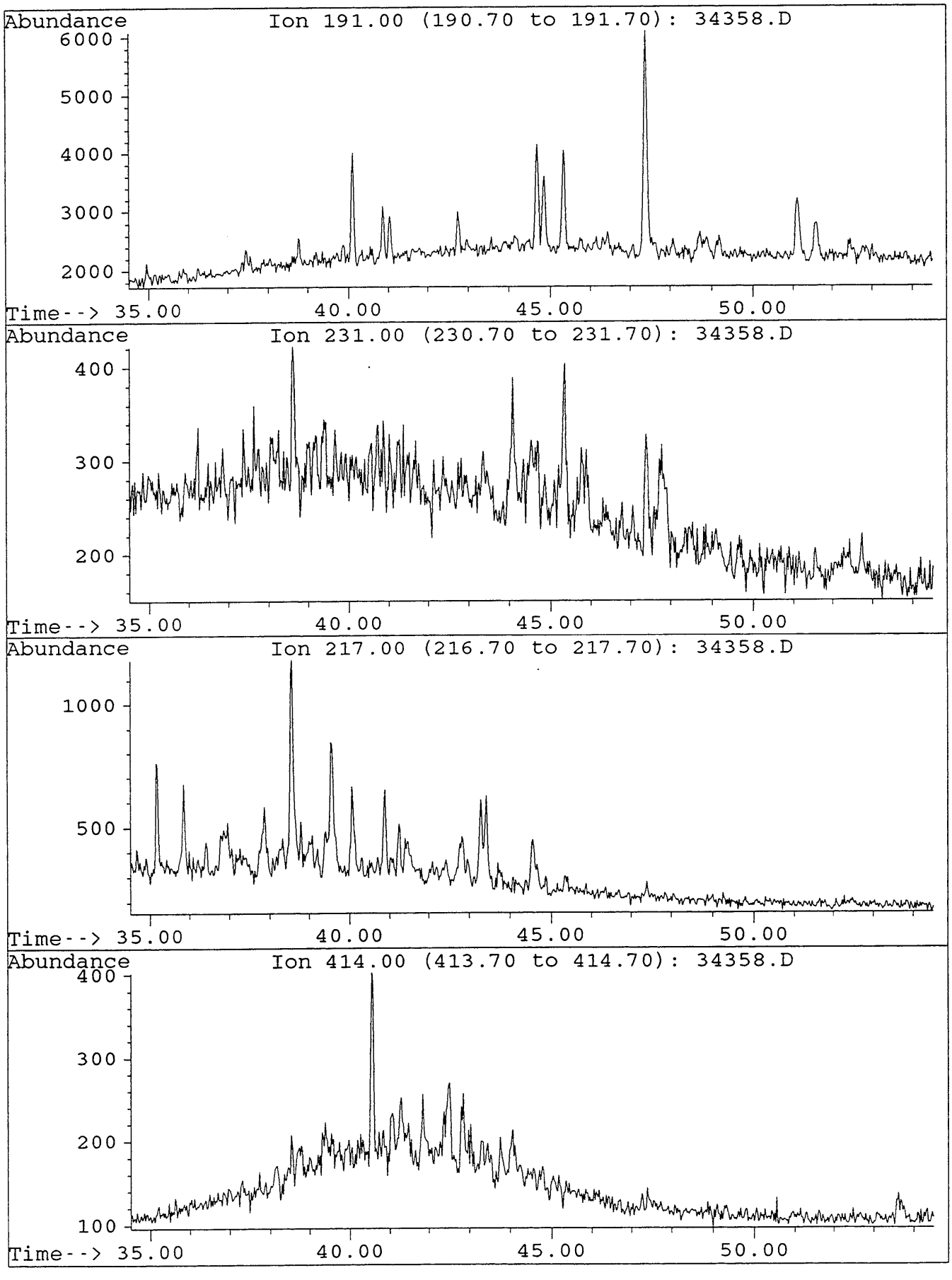
Misc. Info : COL#164. DJ. 10-7-95



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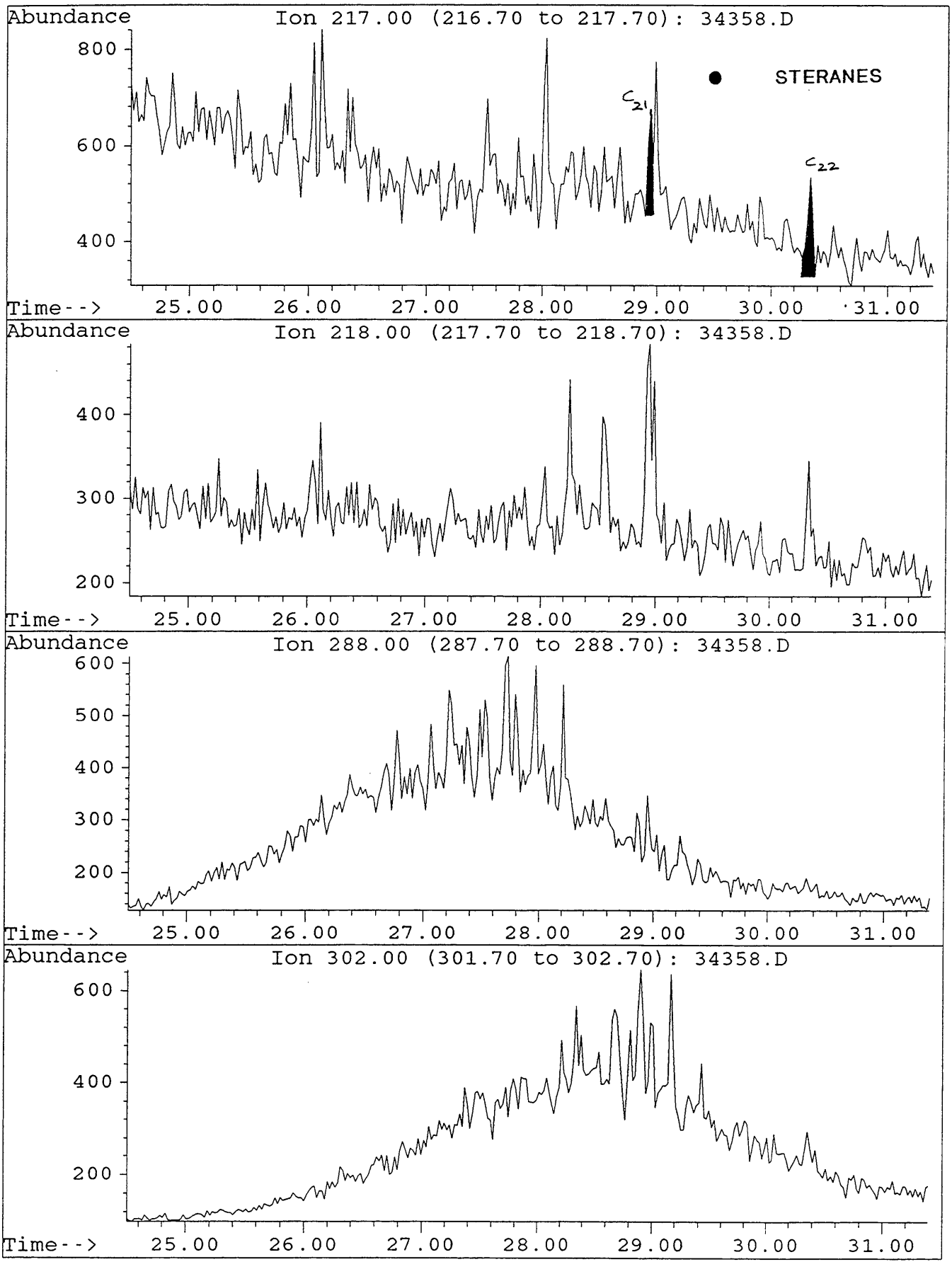
Misc. Info : COL#164. DJ. 10-7-95



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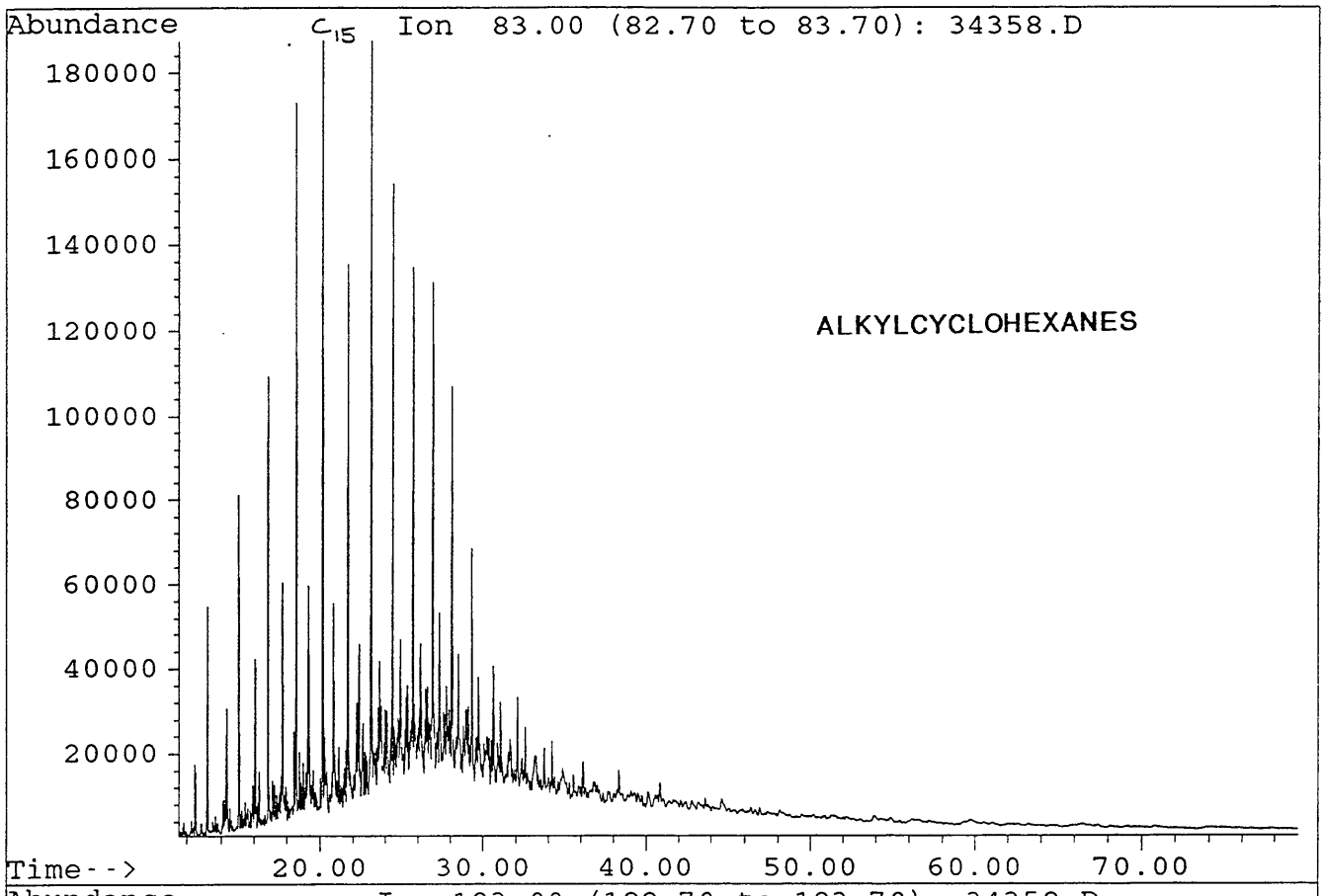
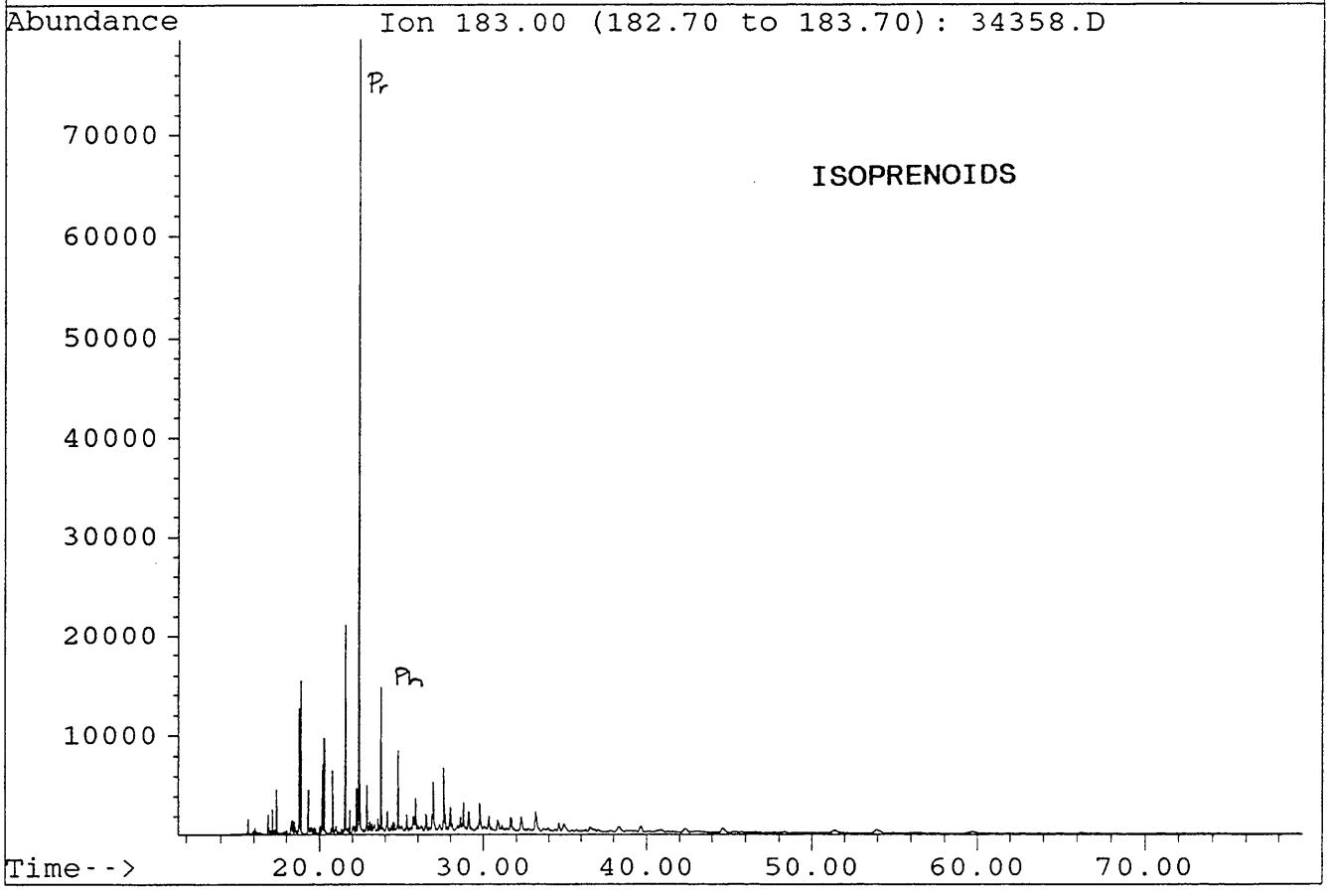
Misc. Info : COL#164. DJ. 10-7-95





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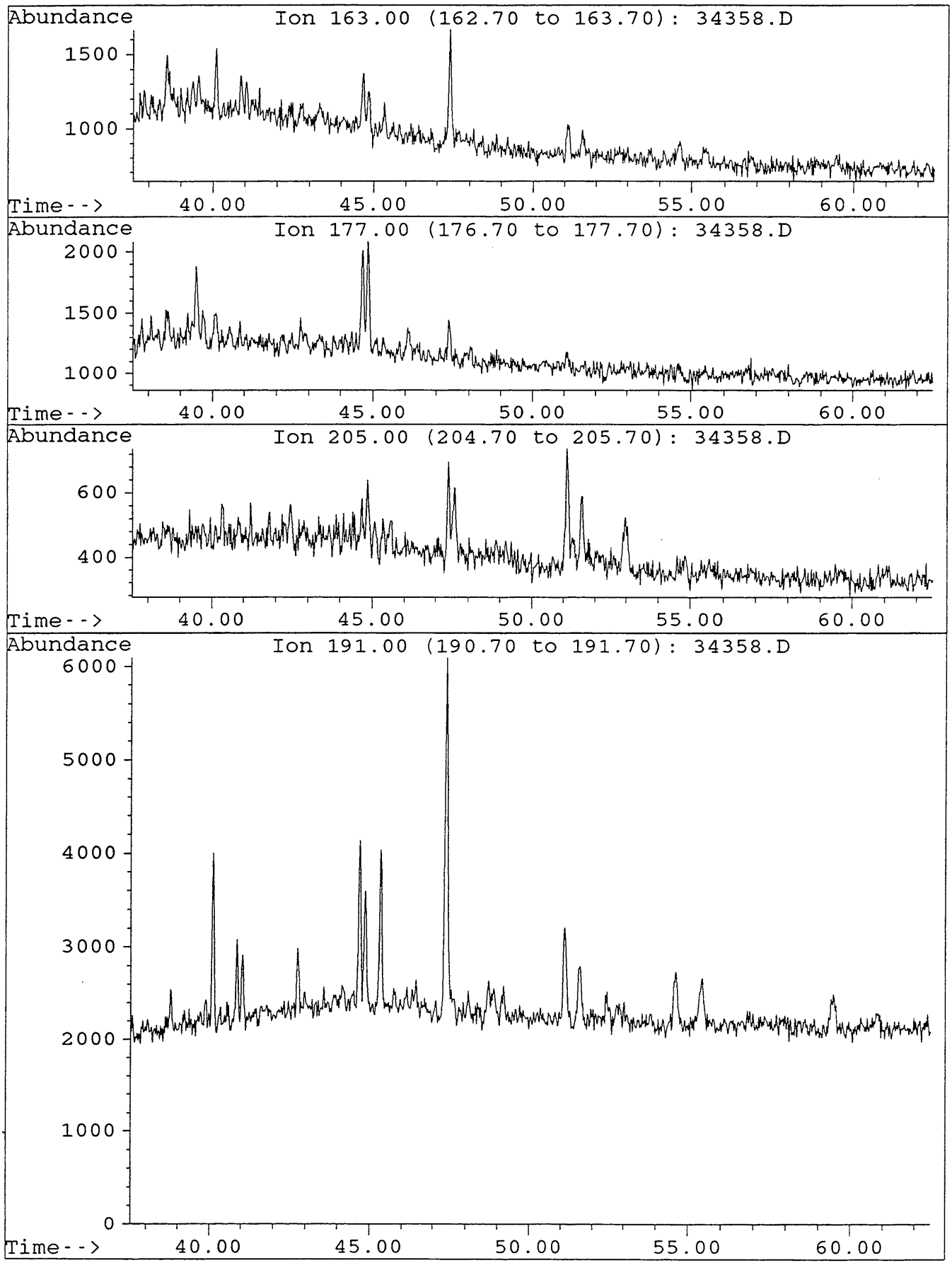

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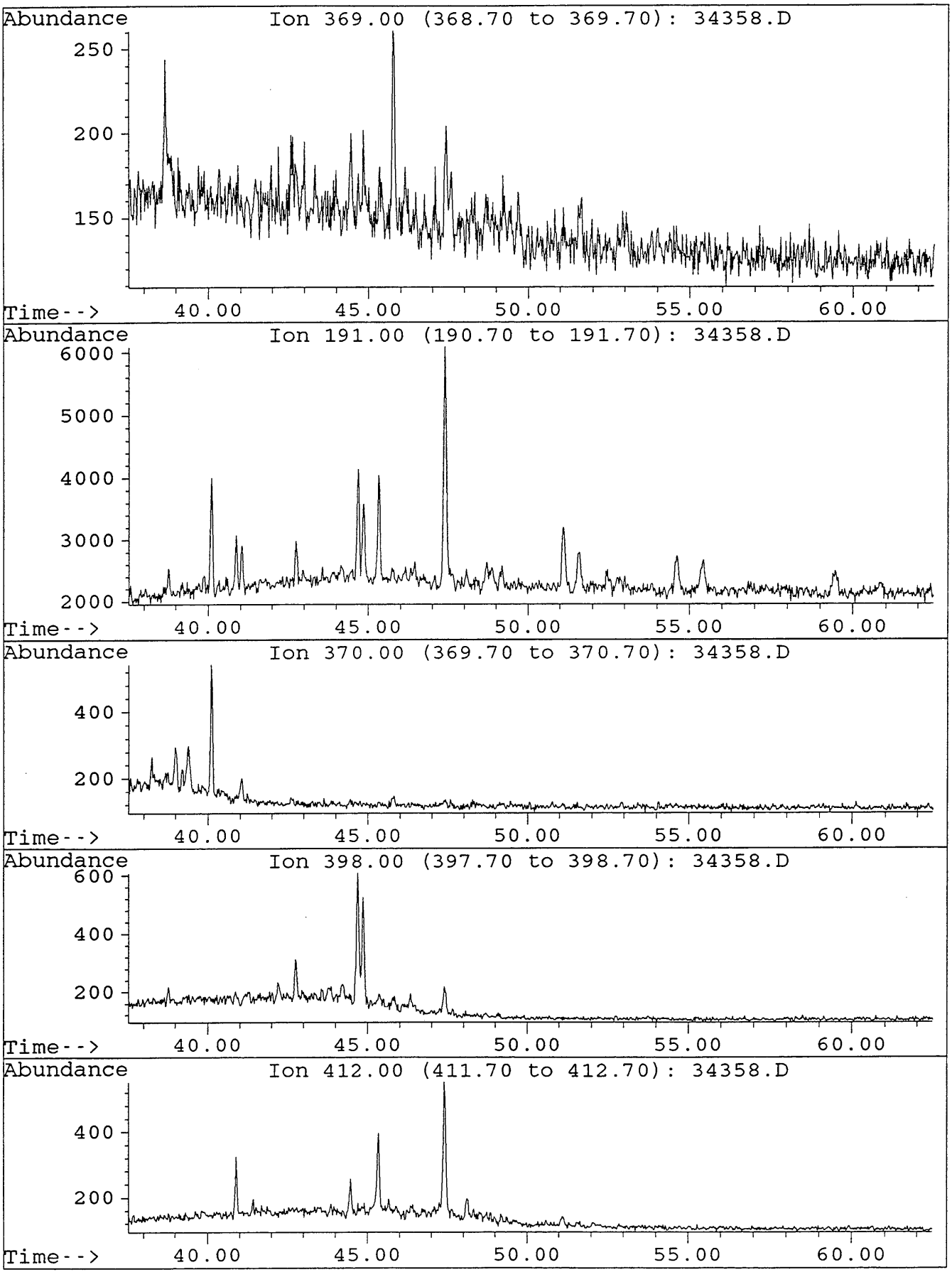
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 10-7-95



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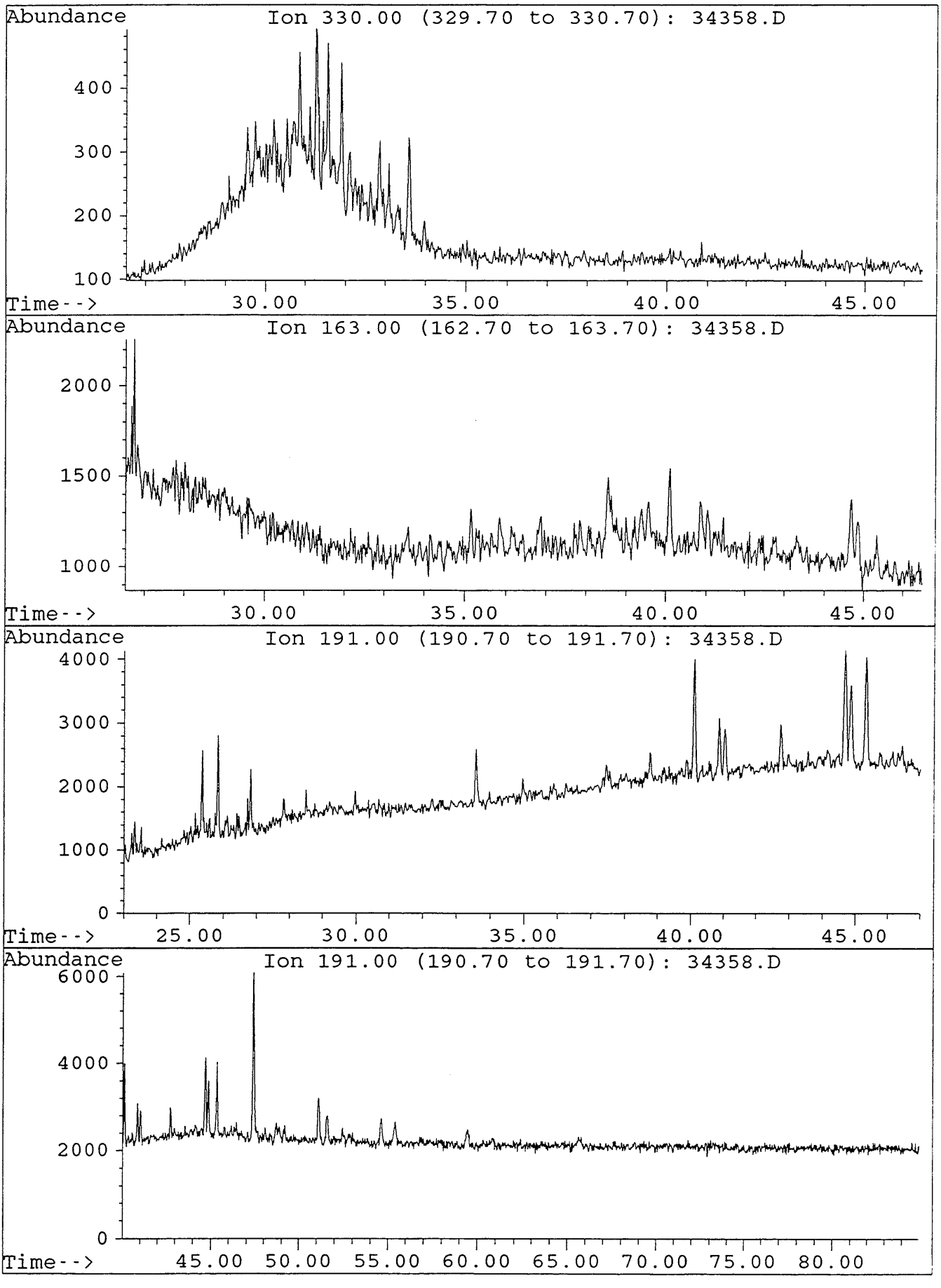
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 10-7-95



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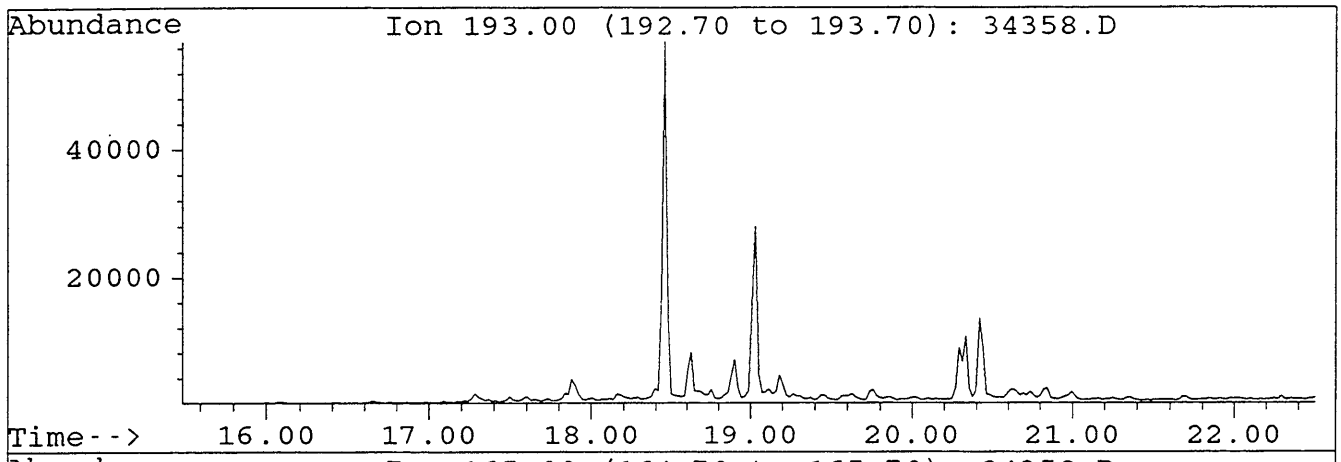

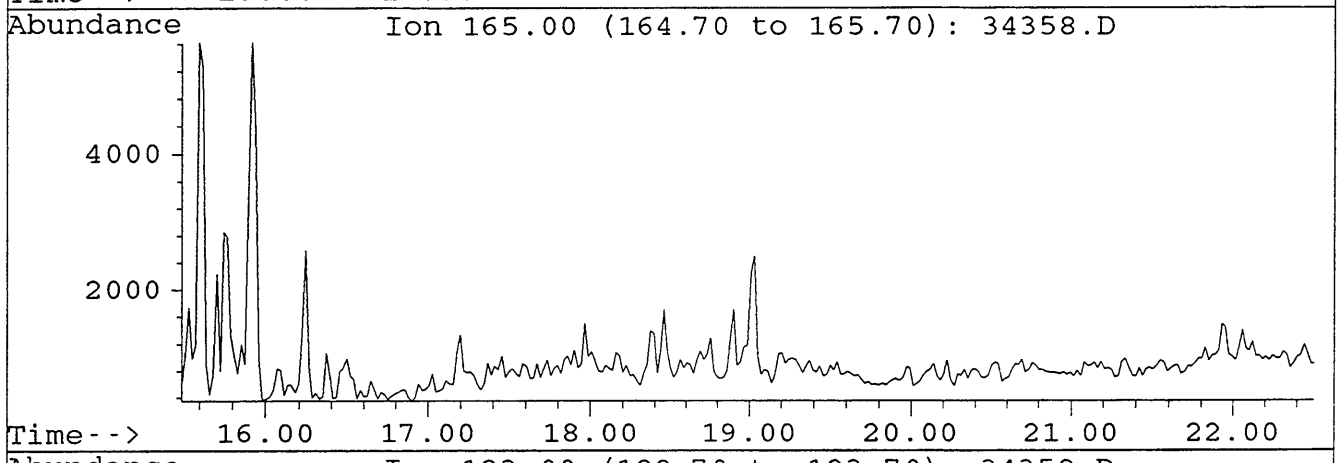

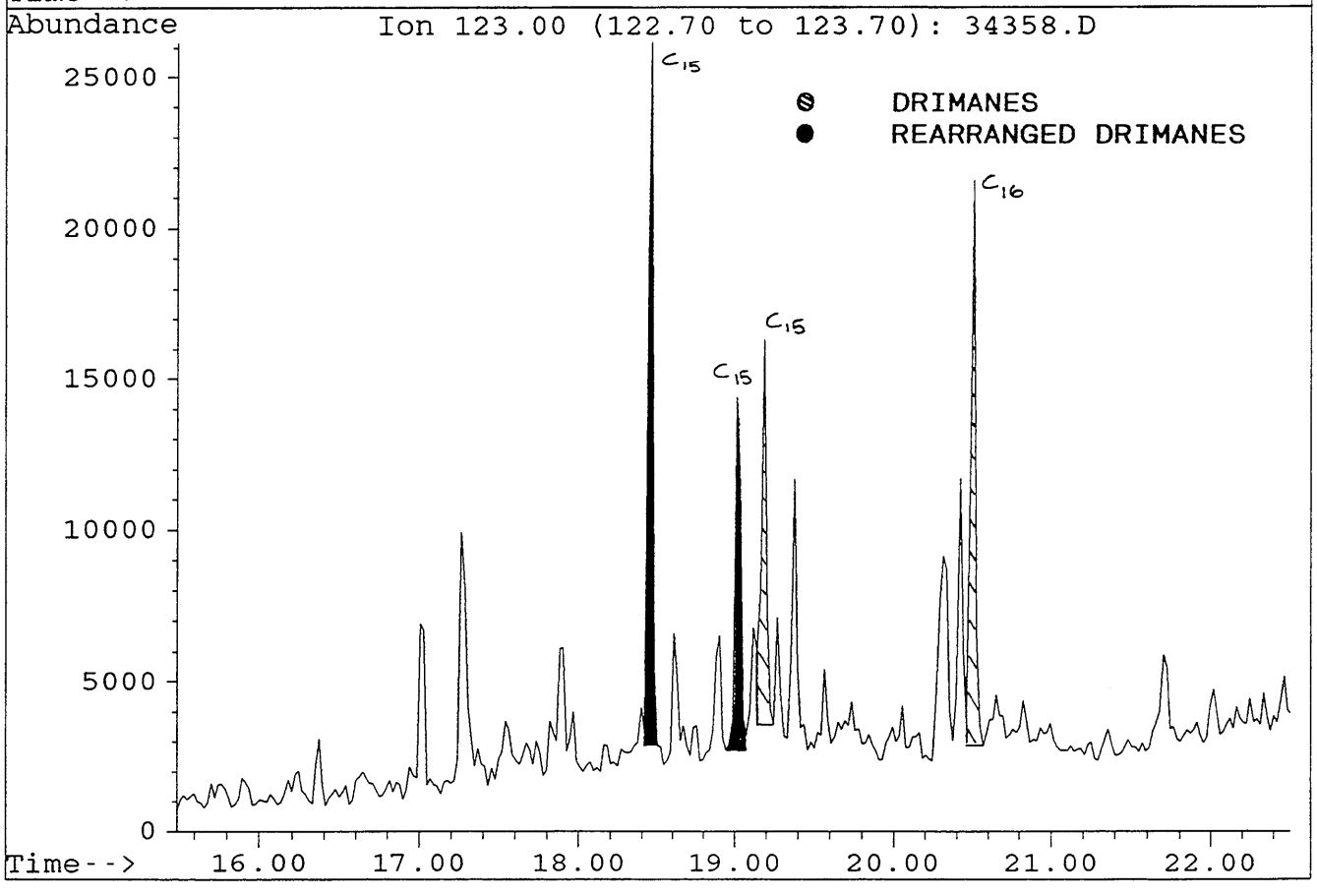

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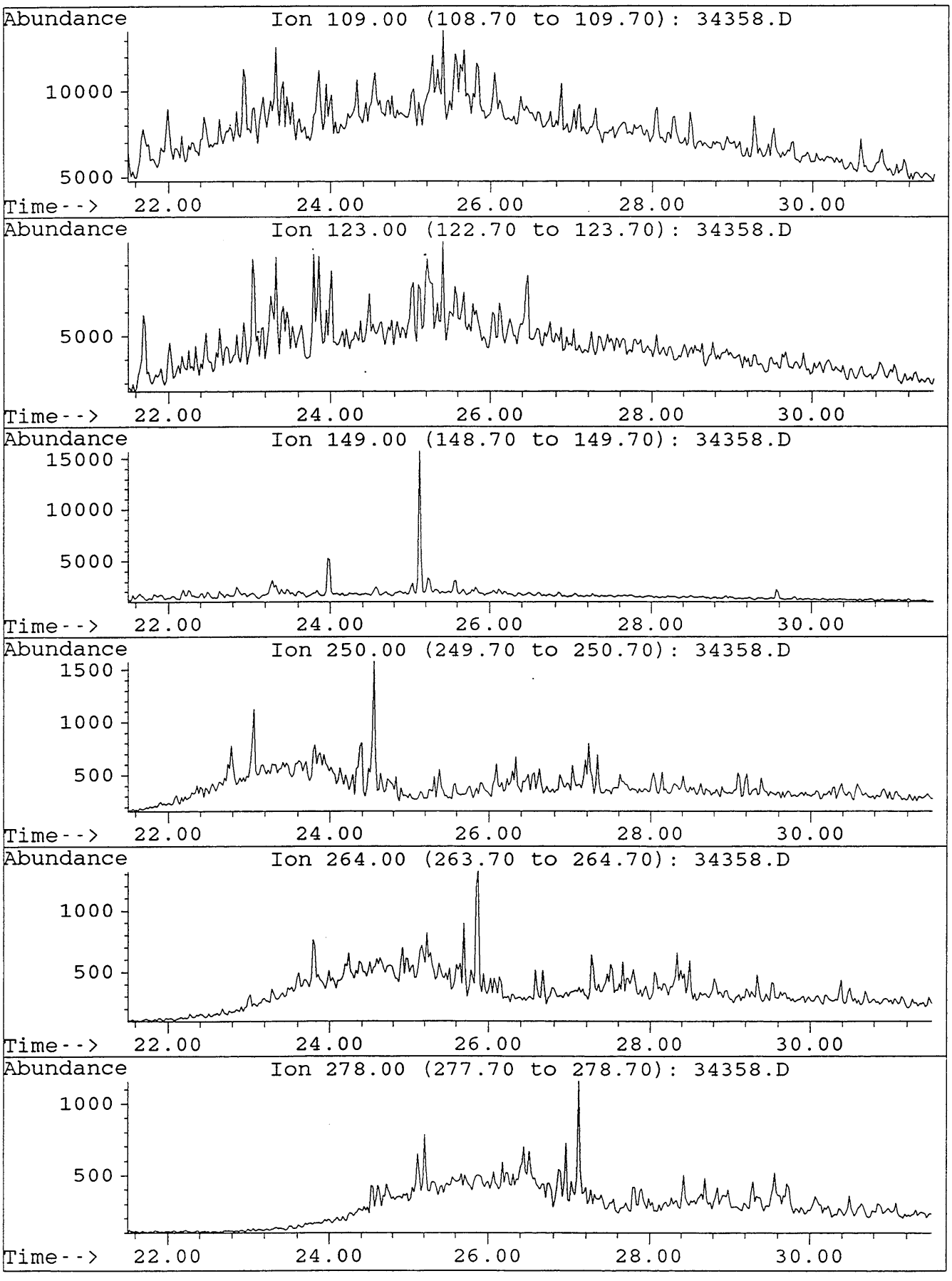

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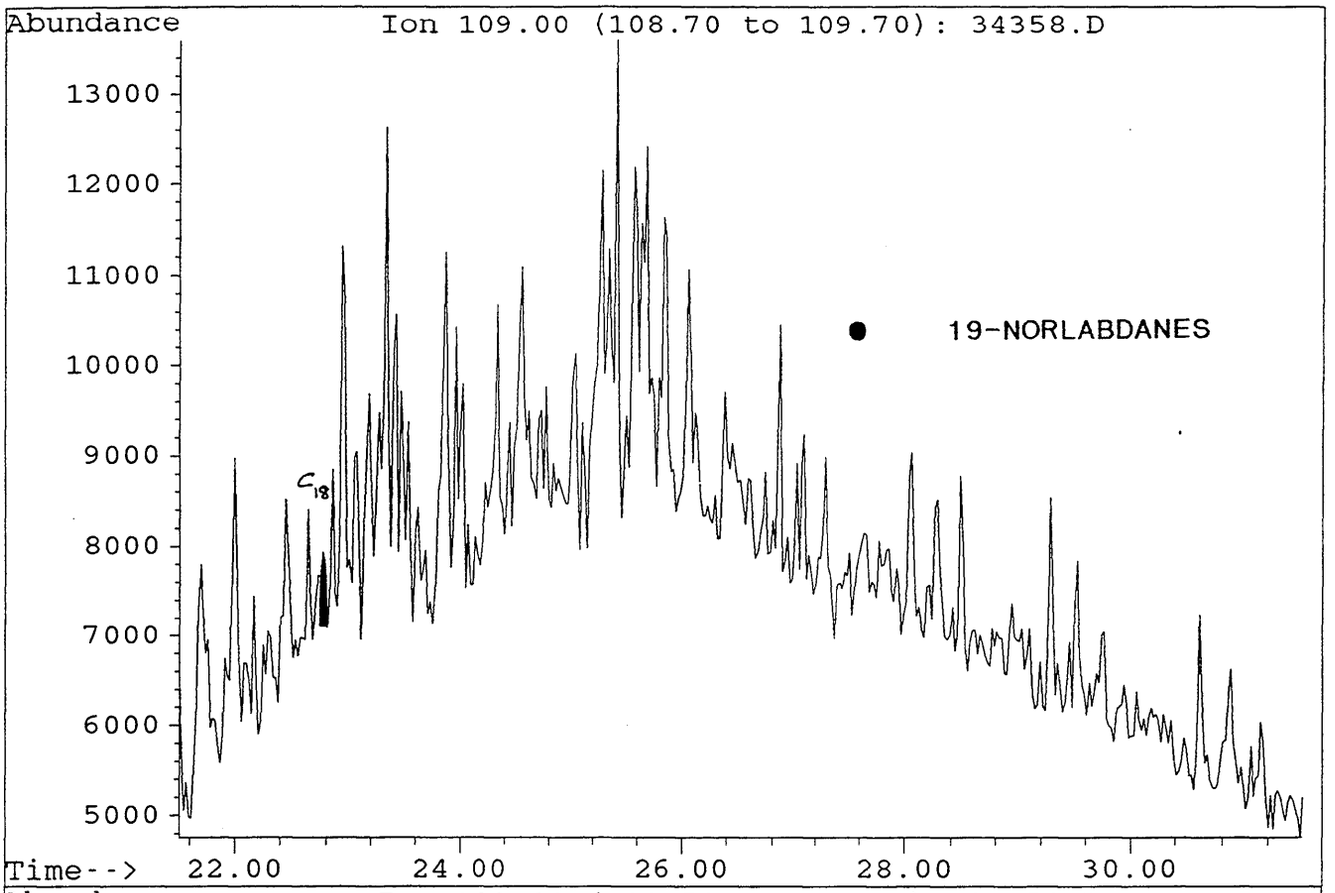

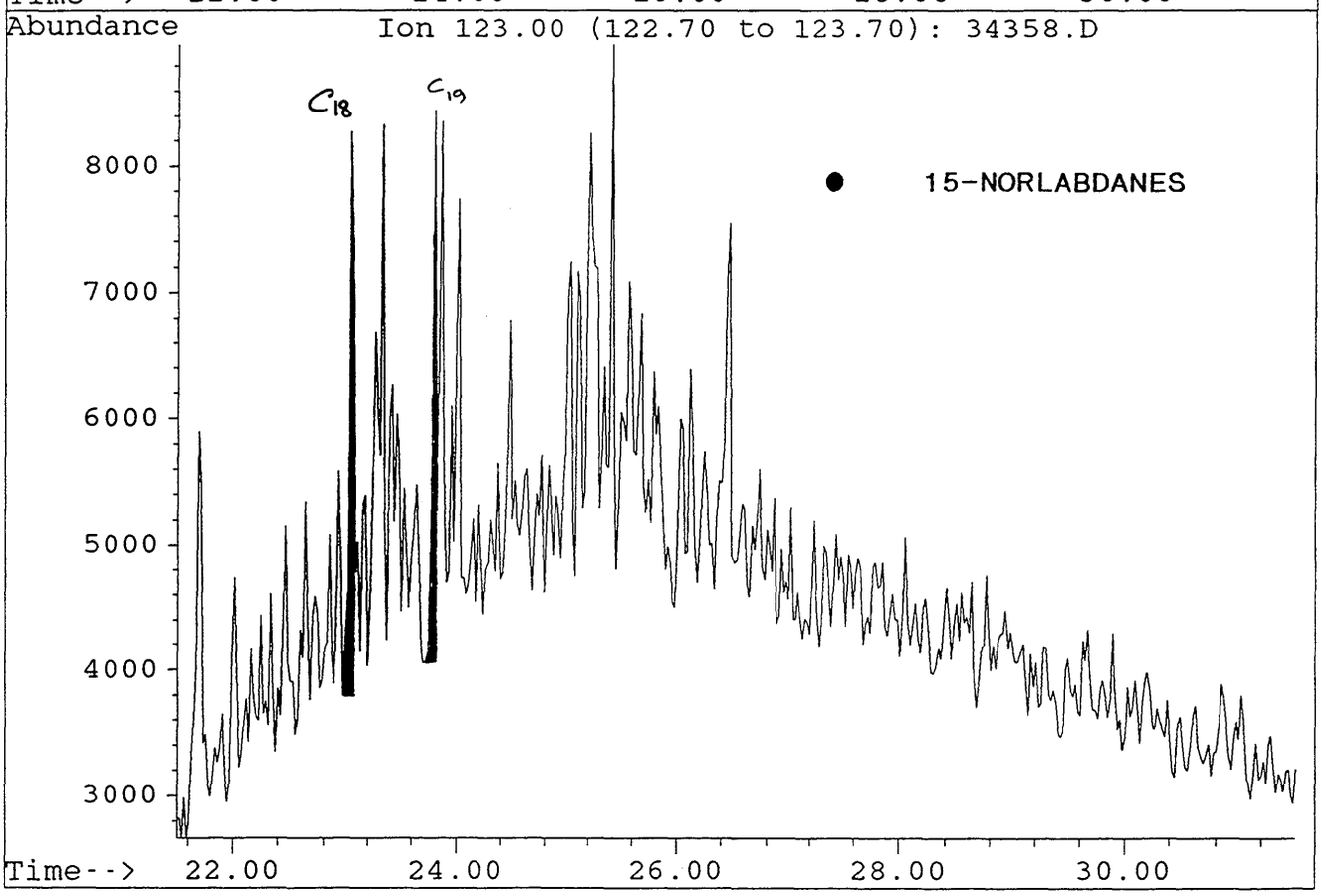

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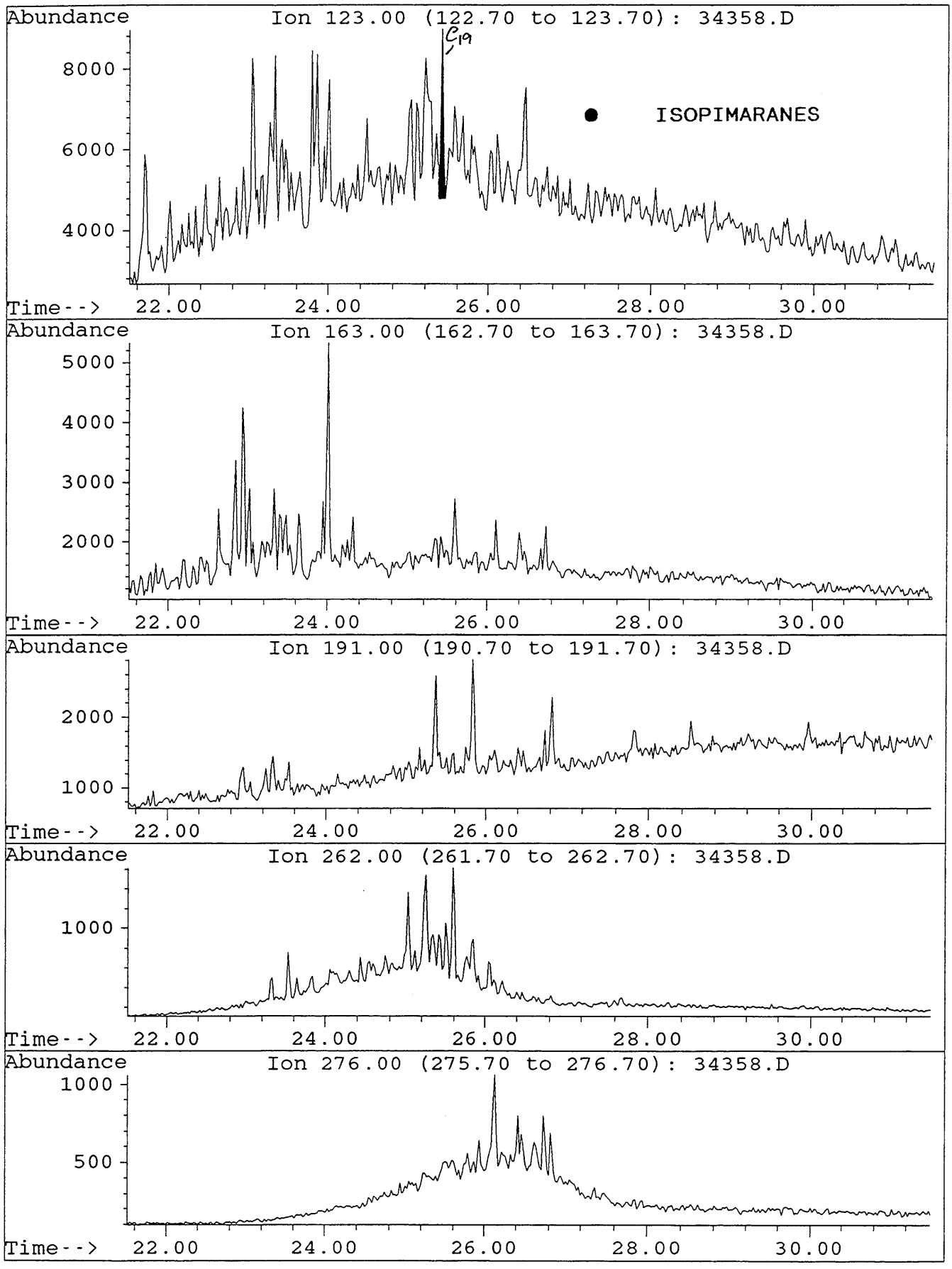

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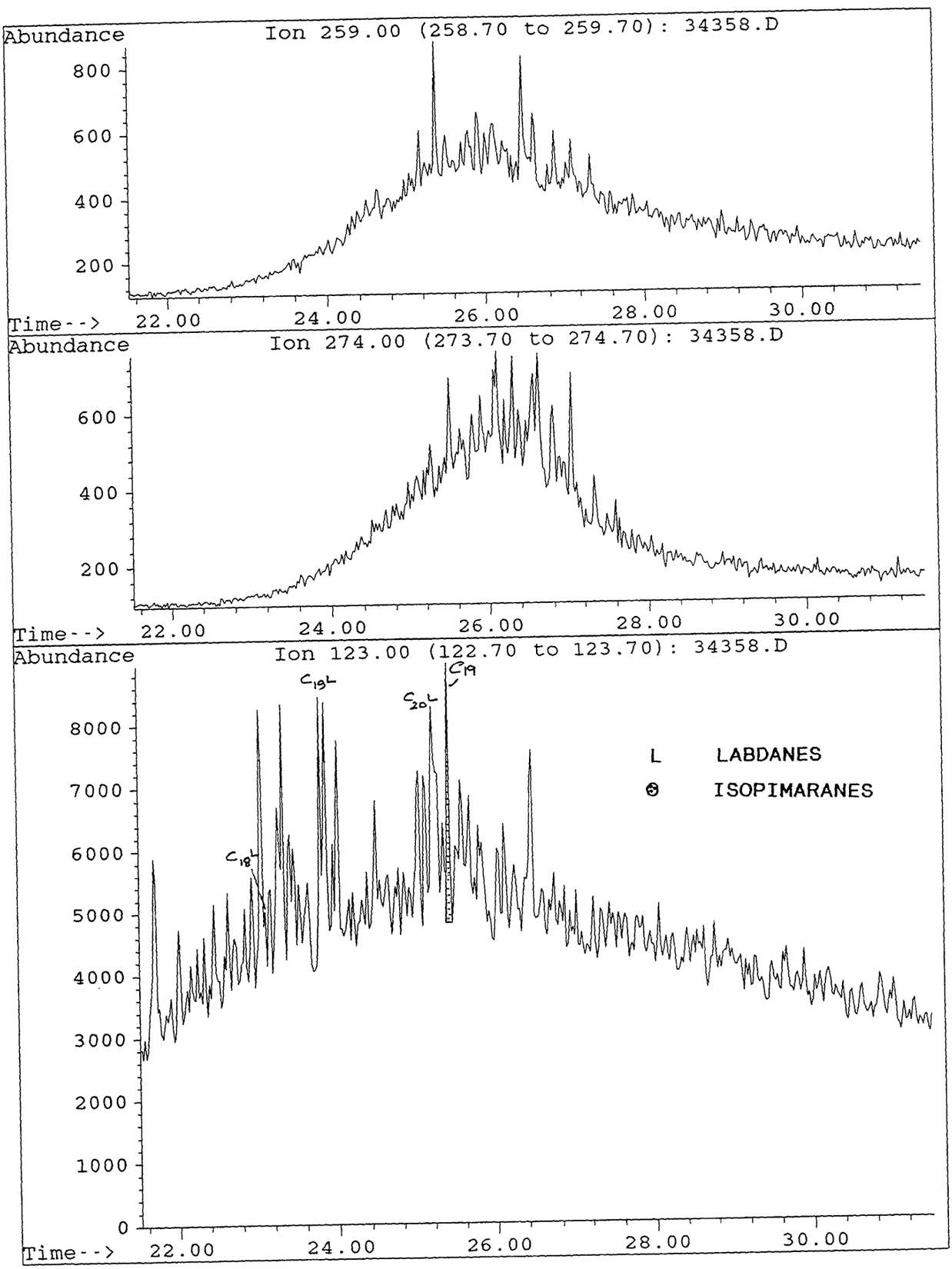

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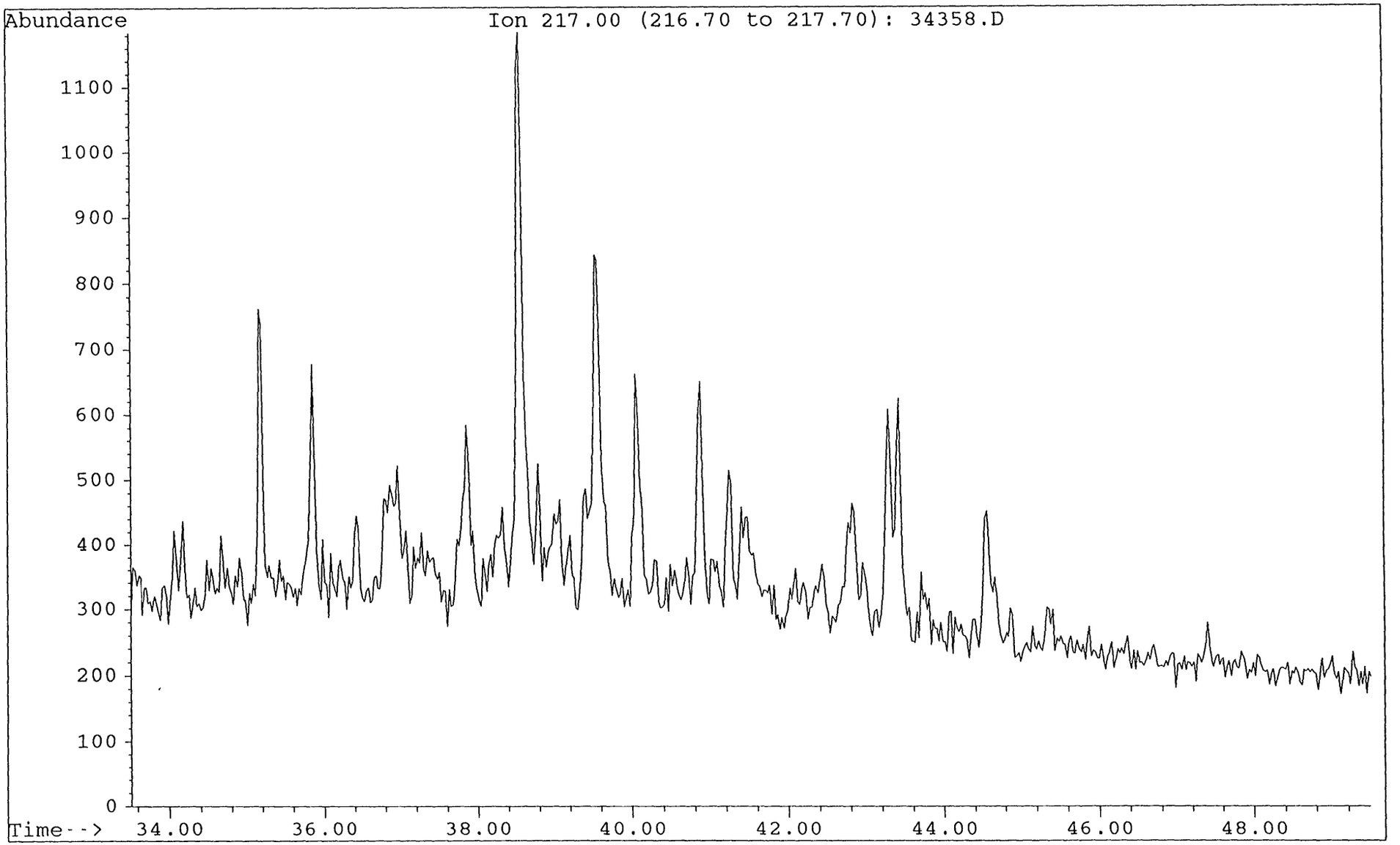

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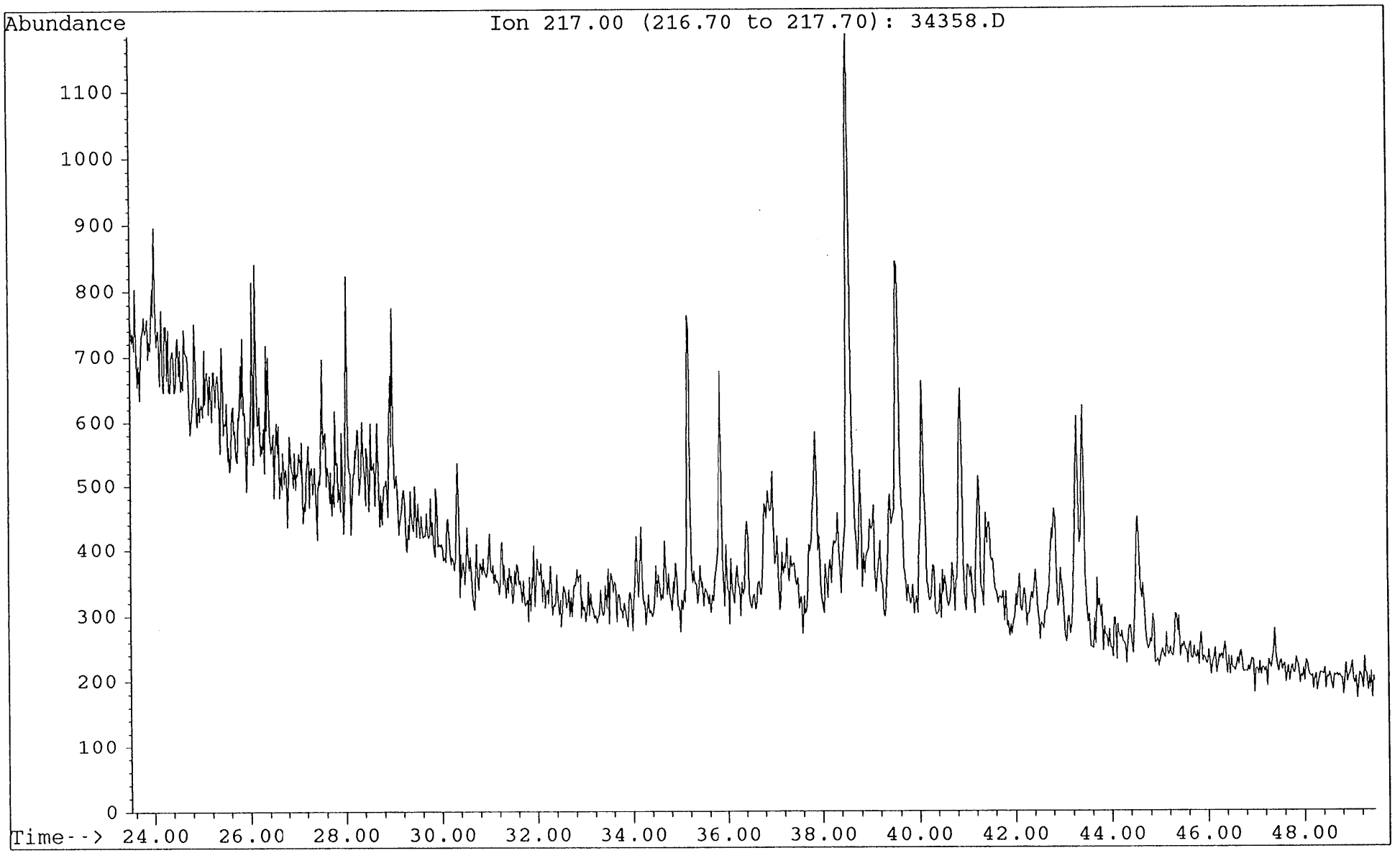

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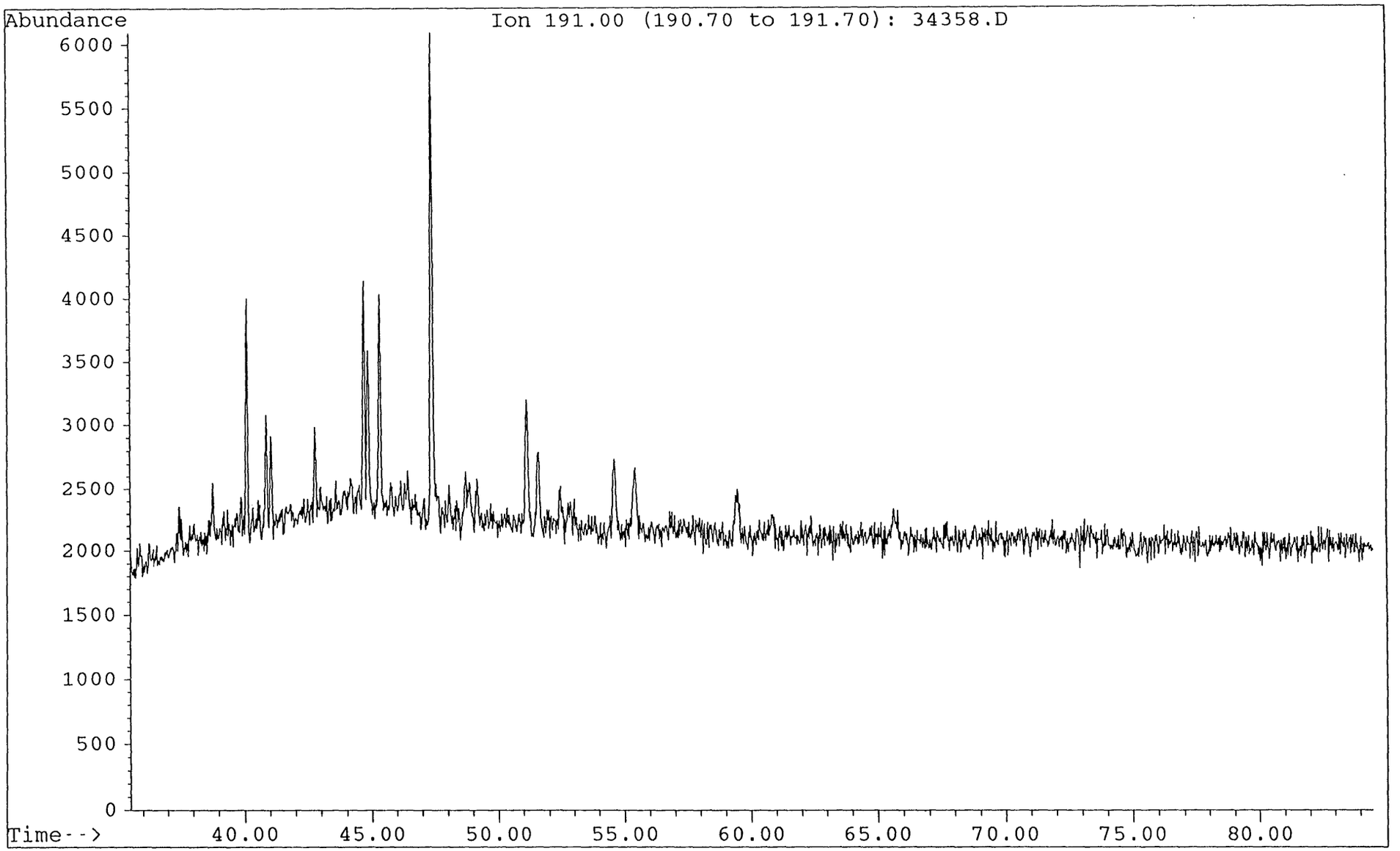

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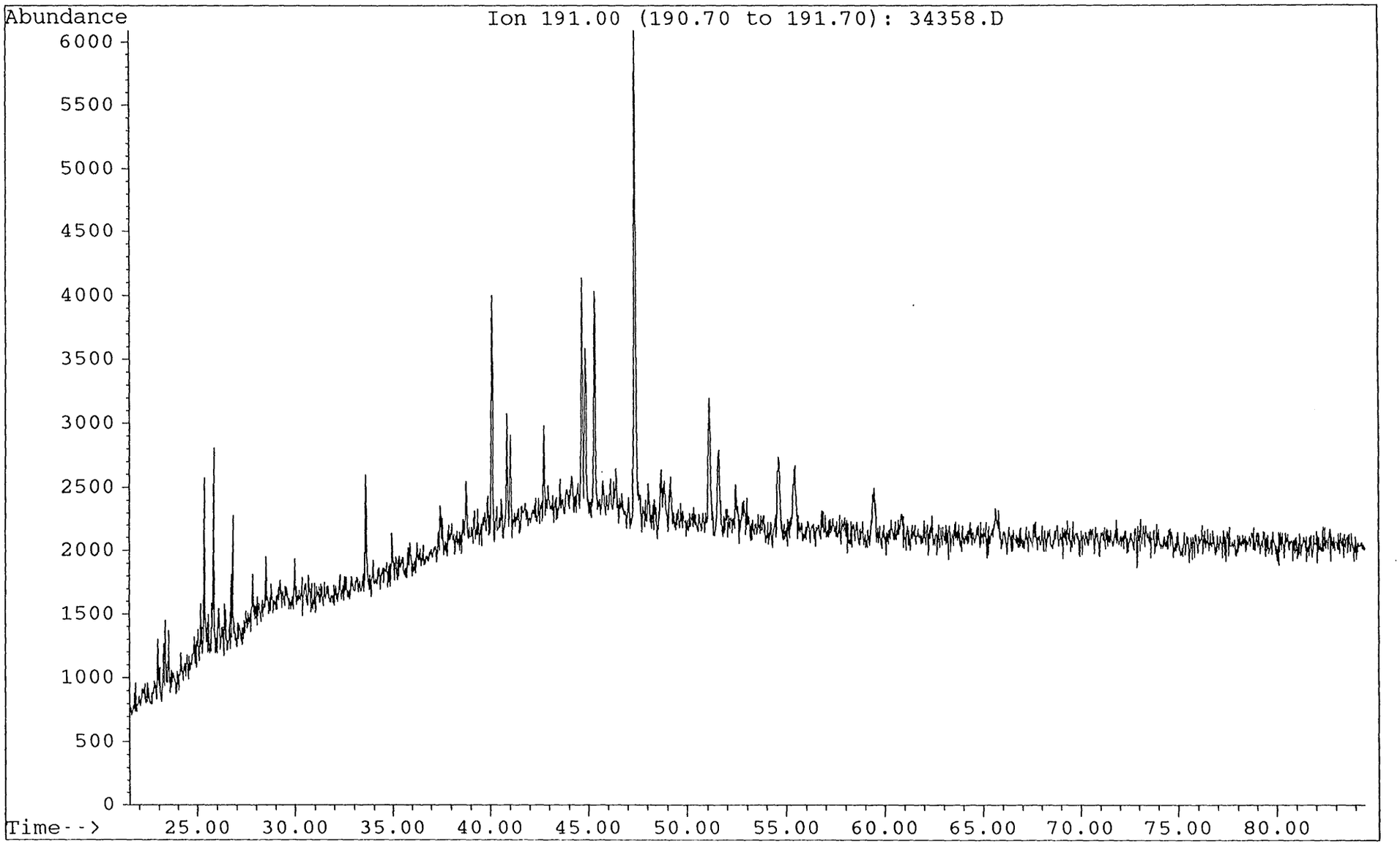


TABLE 9-1T

SELECTED PARAMETERS FROM GC/MS ANALYSIS

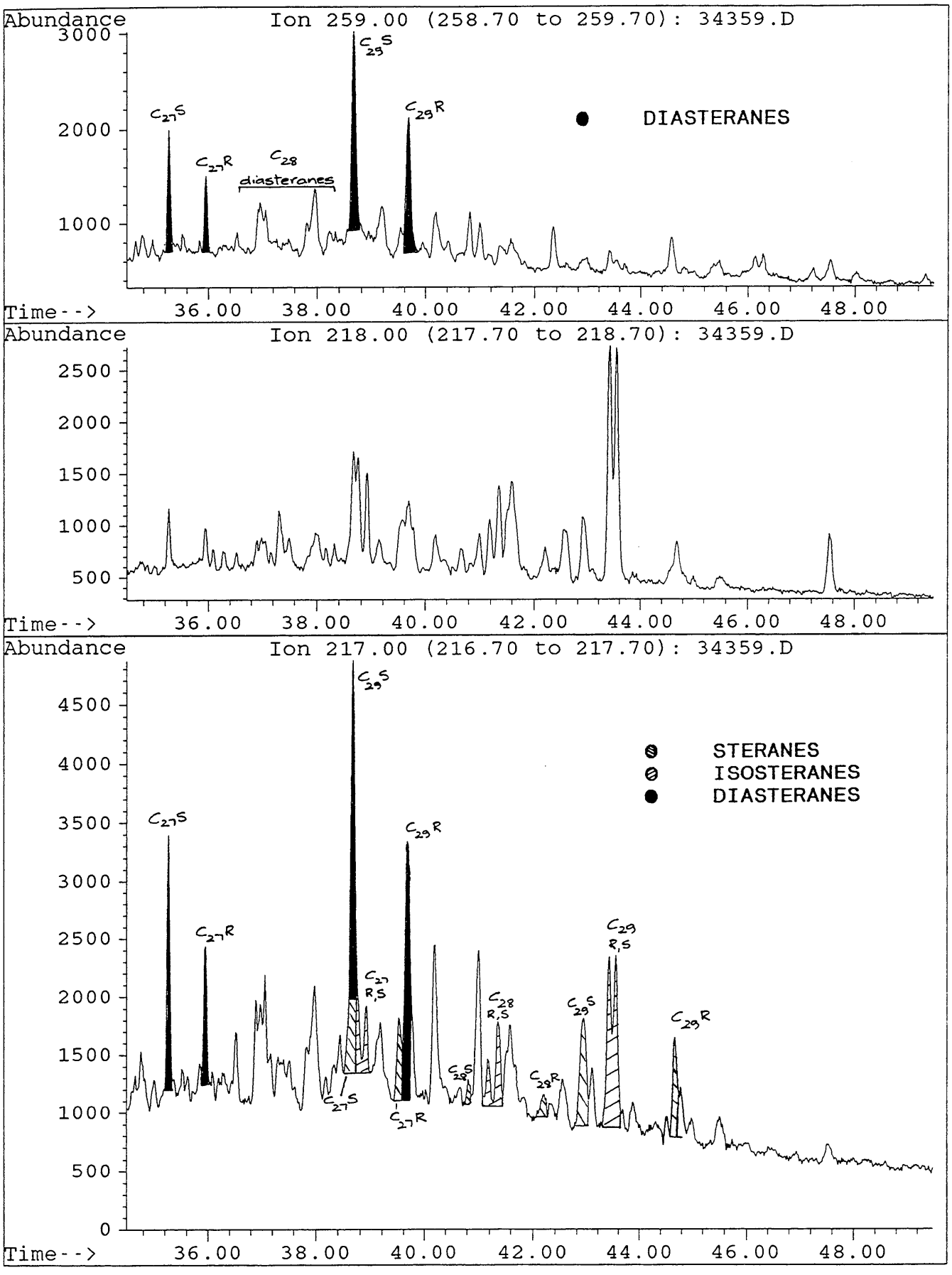
DIGBY 1, 1473.7m, Topped, SWC

	Parameter	Ion(s)	Value
1.	18 α (H)- hopane/17 α (H)-hopane (Ts/Tm)	191	2.53
2.	C30 hopane/C30 moretane	191	8.69
3.	C31 22S hopane/C31 22R hopane	191	1.24
4.	C32 22S hopane/C32 22R hopane	191	1.56
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ sterane	217	1.11
6.	C29 $\alpha\alpha\alpha$ steranes (20S / 20S+20R)	217	0.53
7.	C29 $\alpha\beta\beta$ steranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.61
8.	C27/C29 diasteranes	259	0.58
9.	C27/C29 steranes	217	0.83
10.	18 α (H)-oleanane/C30 hopane	191	nd
11.	C29 diasteranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	1.22
12.	C30 (hopane + moretane) / C29 (steranes + diasteranes)	191/217	1.63
13.	C15 drimane/C16 homodrimane	123	nd
14.	Rearranged drimanes/normal drimanes	123	nd

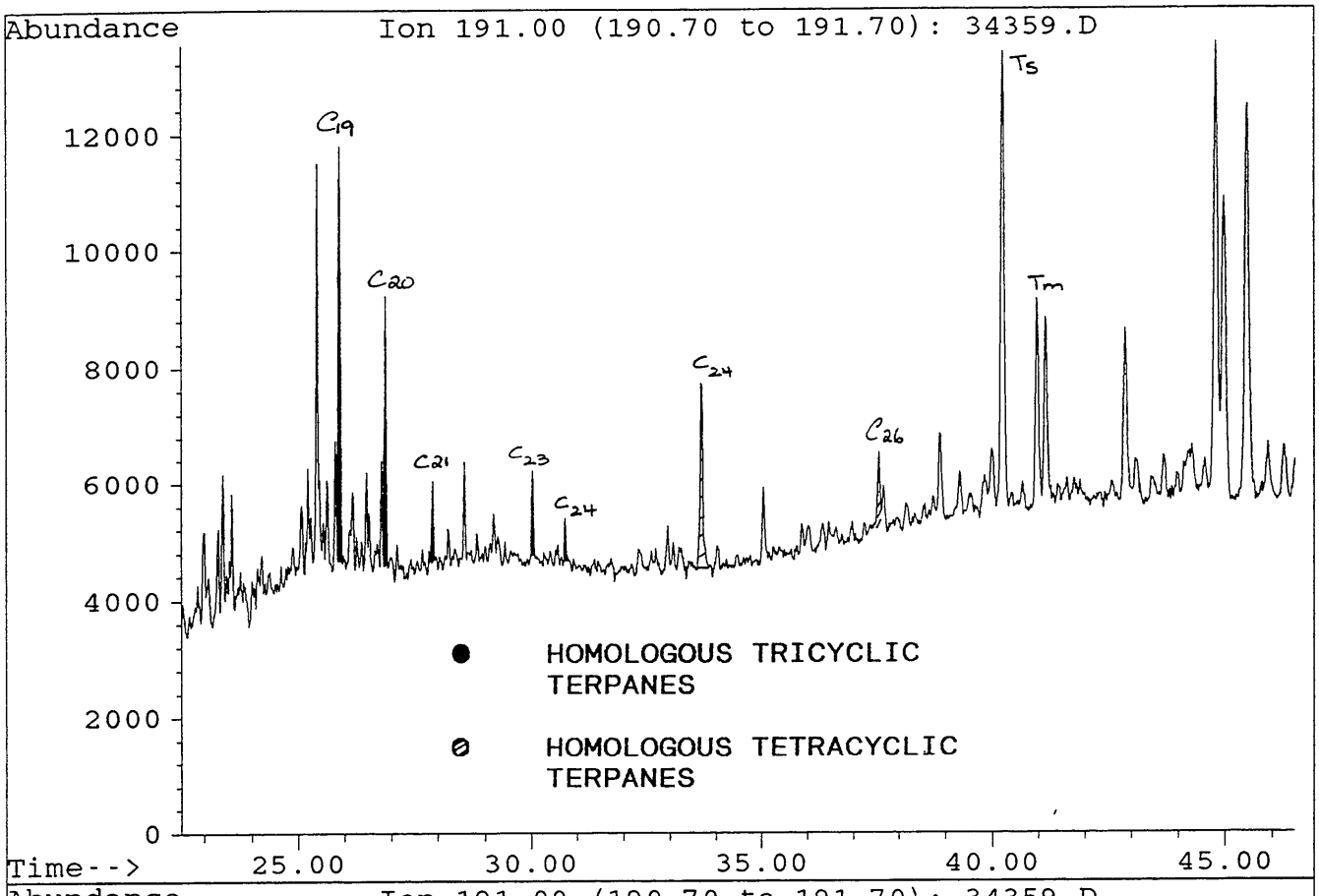
nd = not detectable

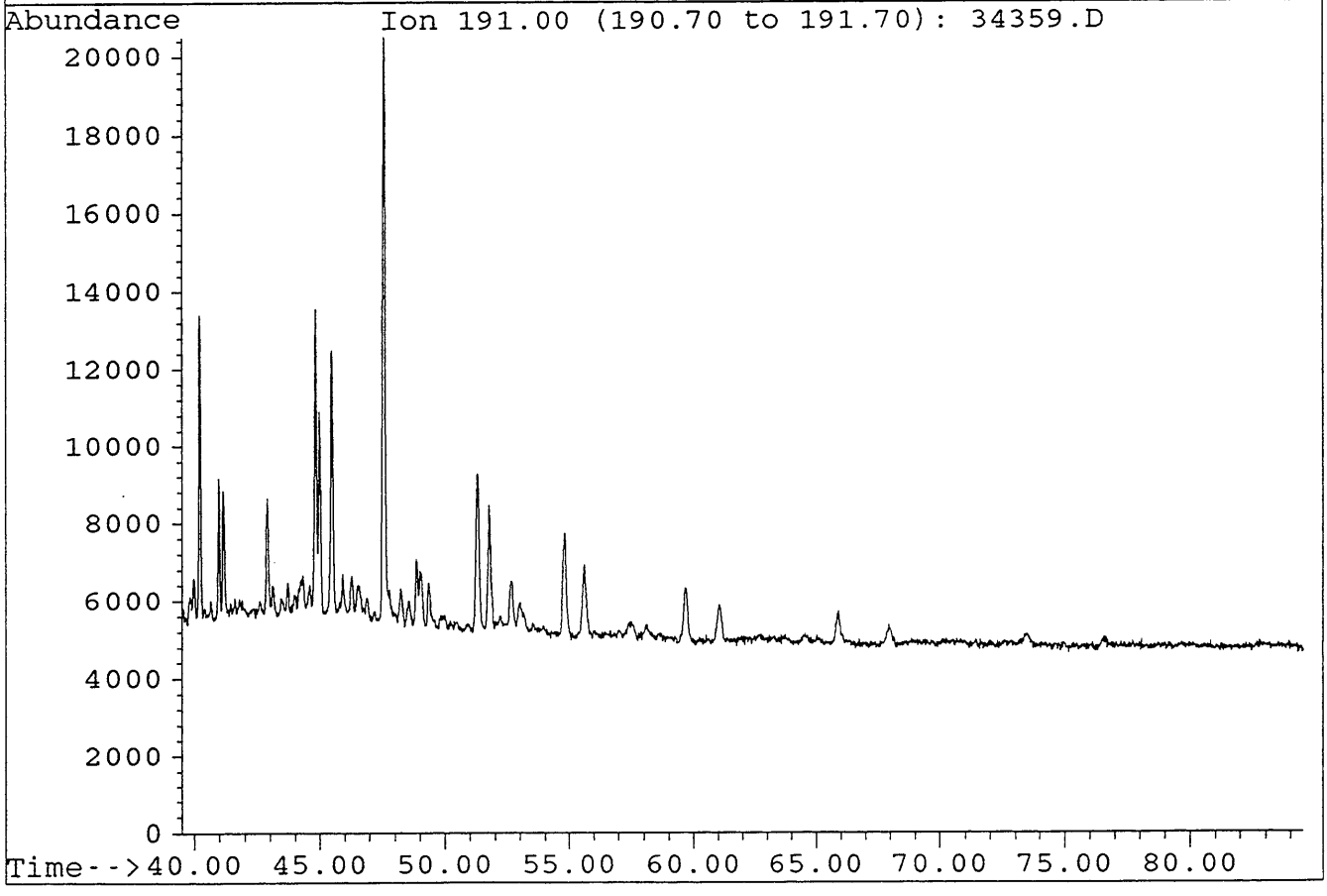
File : 34359.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 11-7-95

FIGURE 6-1T

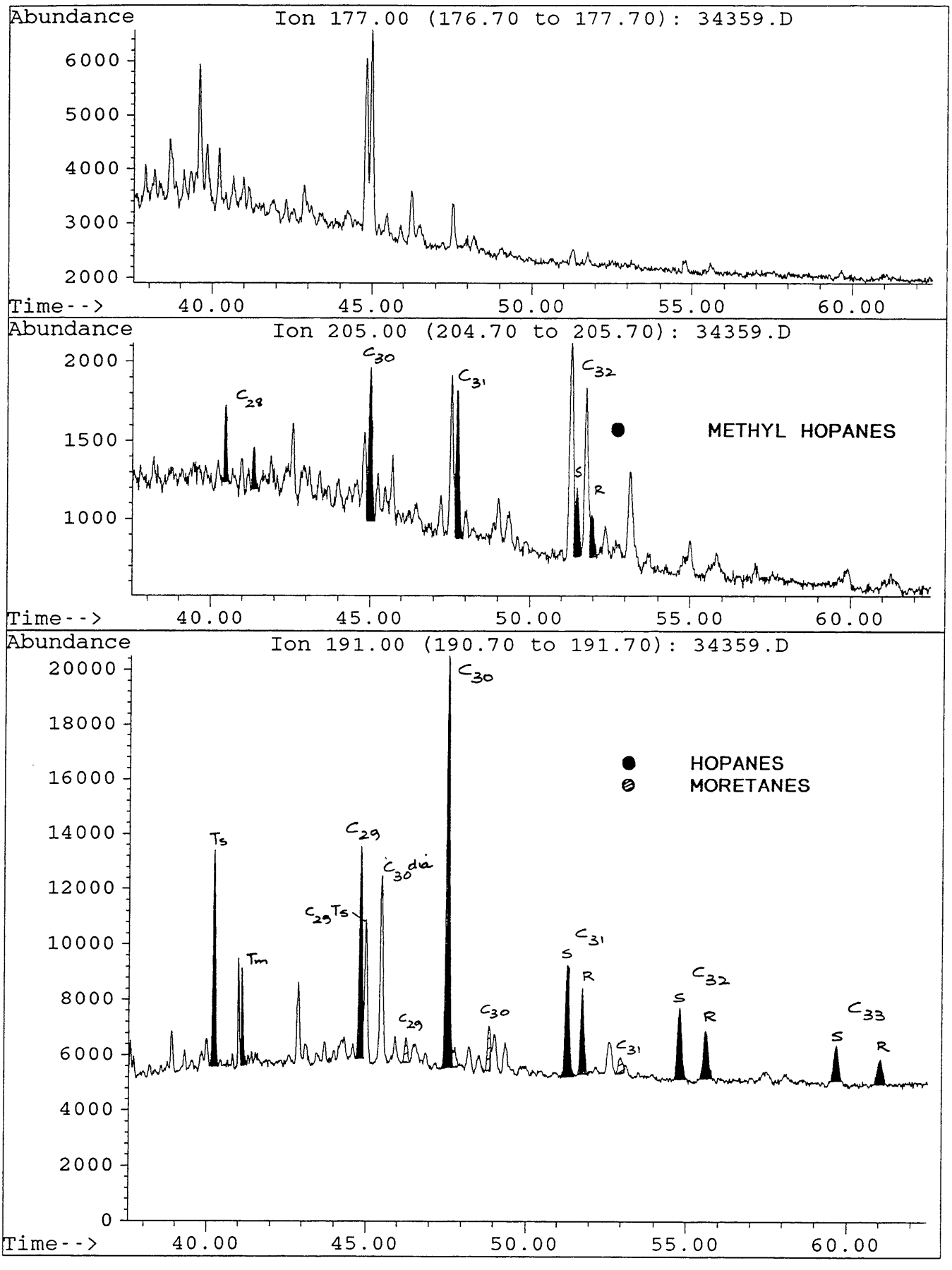


File : 34359.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 11-7-95

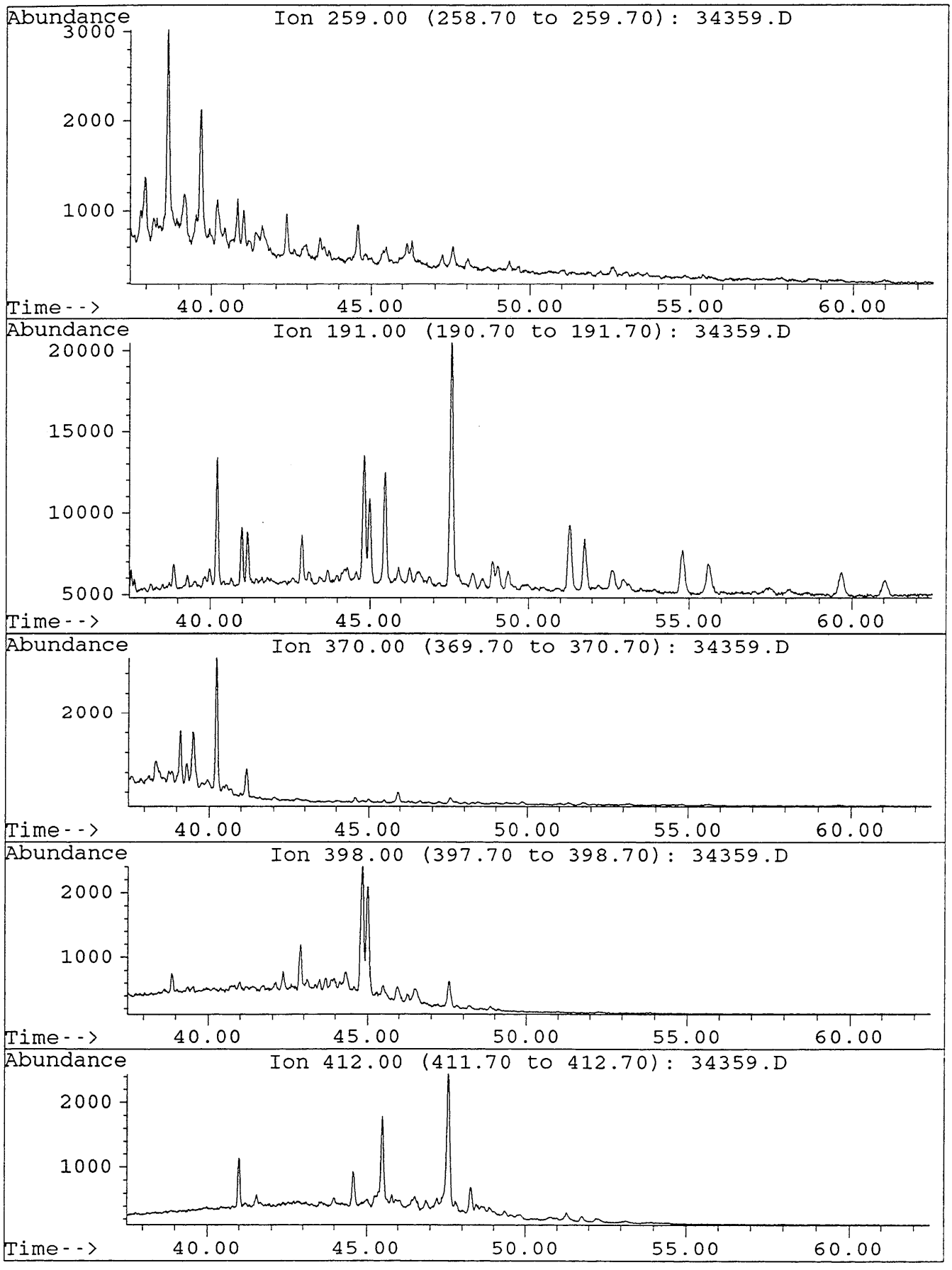




File : 34359.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 11-7-95



File : 34359.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 11-7-95



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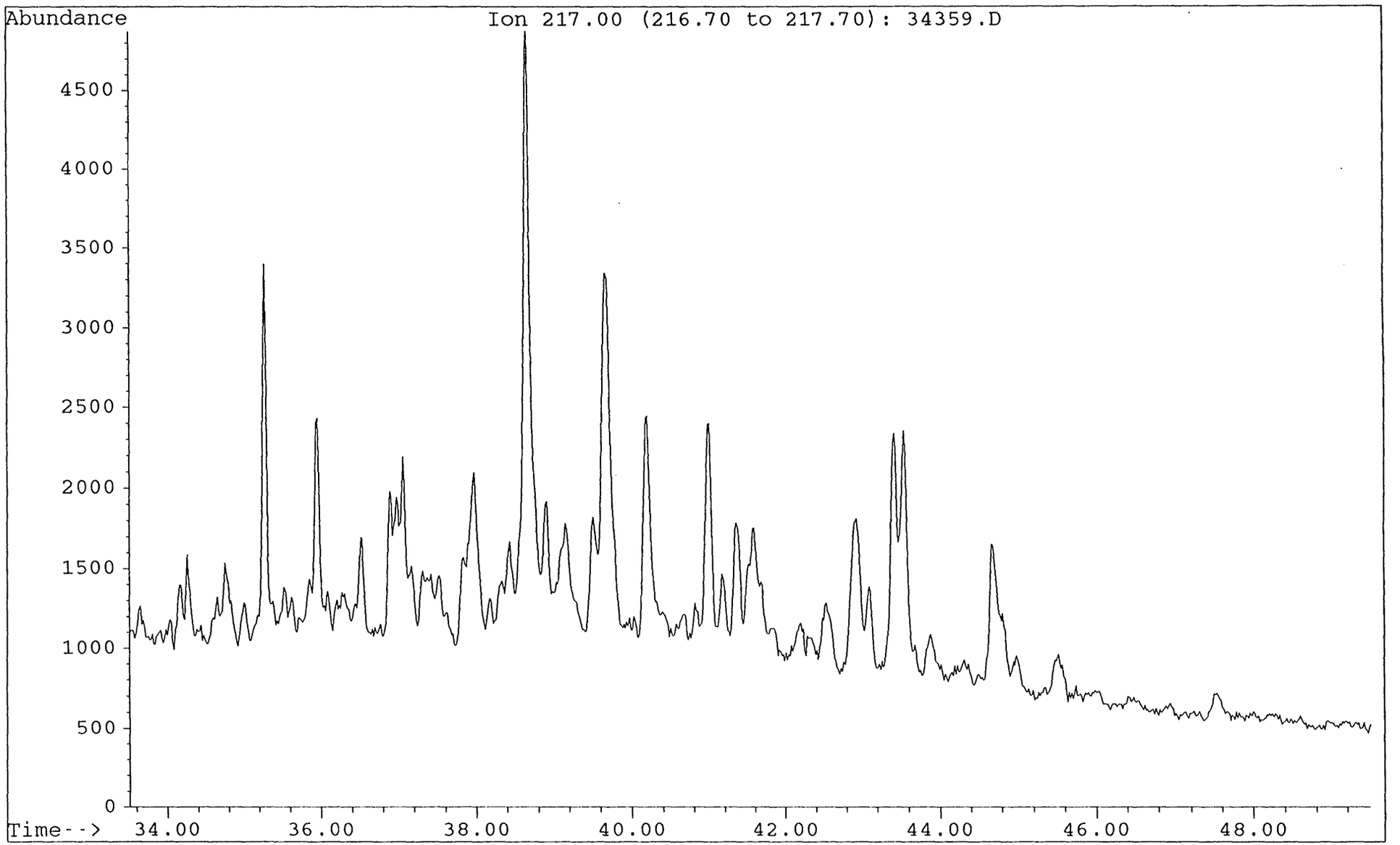
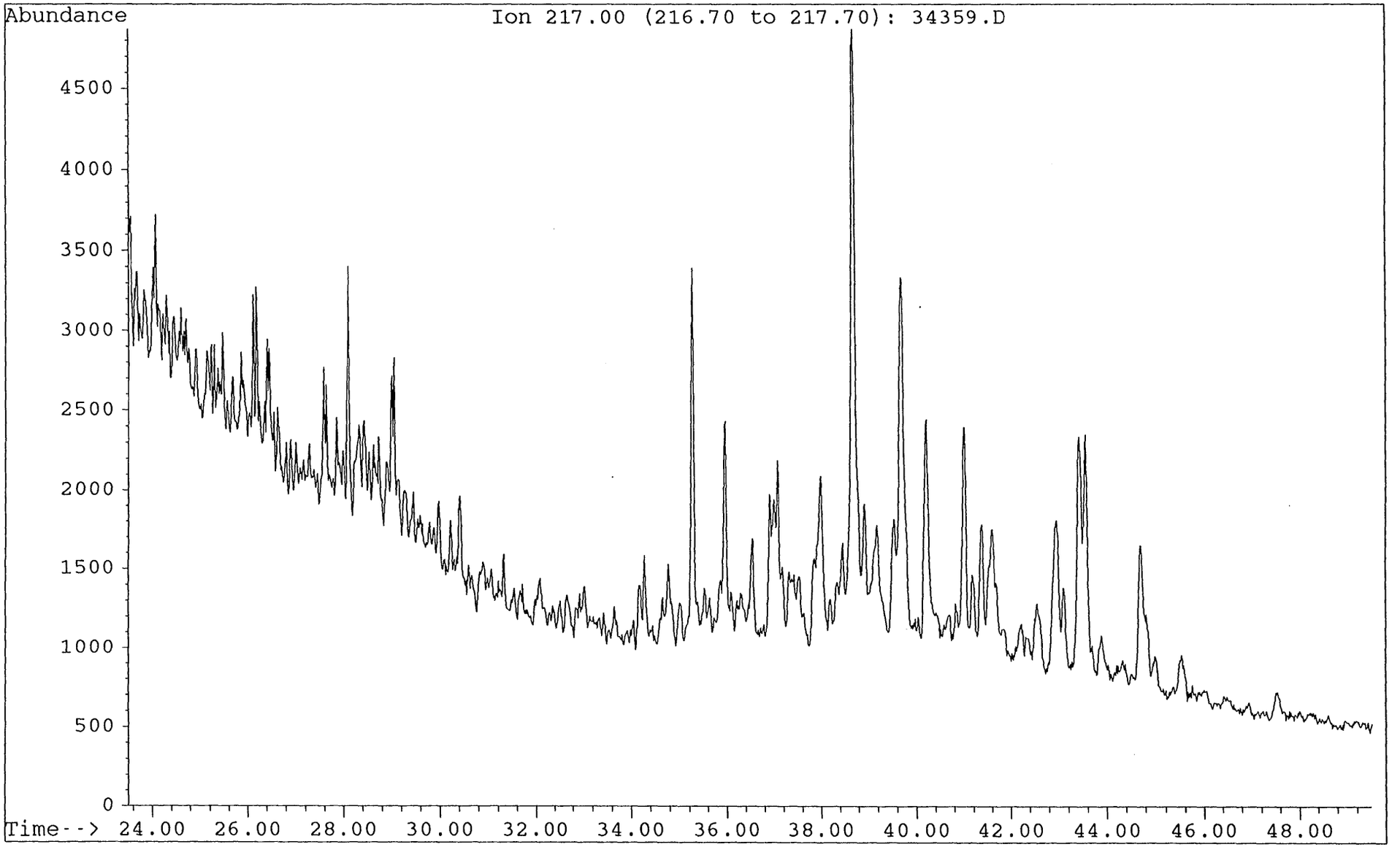


File : 34359.D
Sample : DIGBY-1 1473.7m B/C
Misc. Info : COL#164. DJ. 11-7-95



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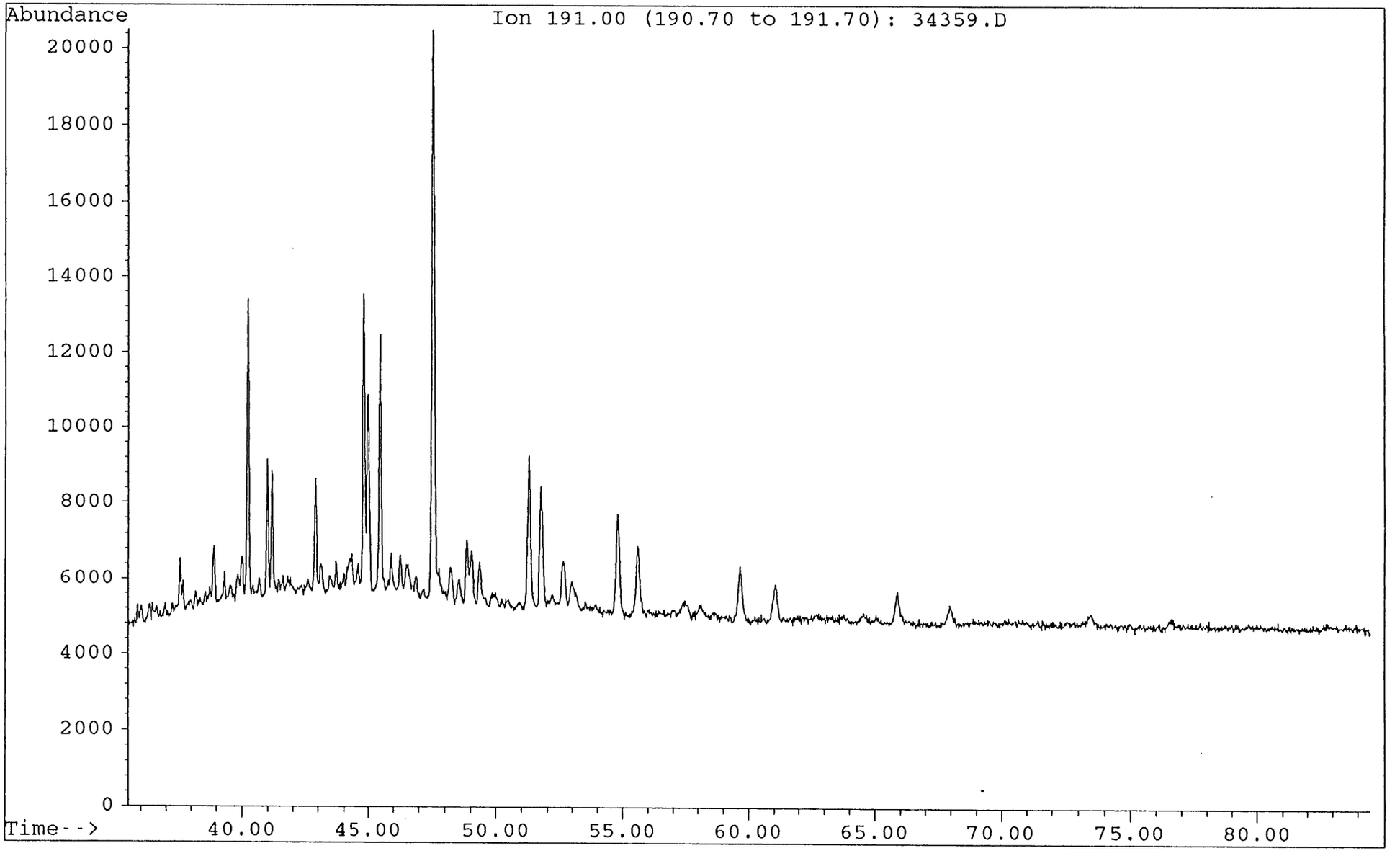

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Sample : DIGBY-1 1473.7m B/C
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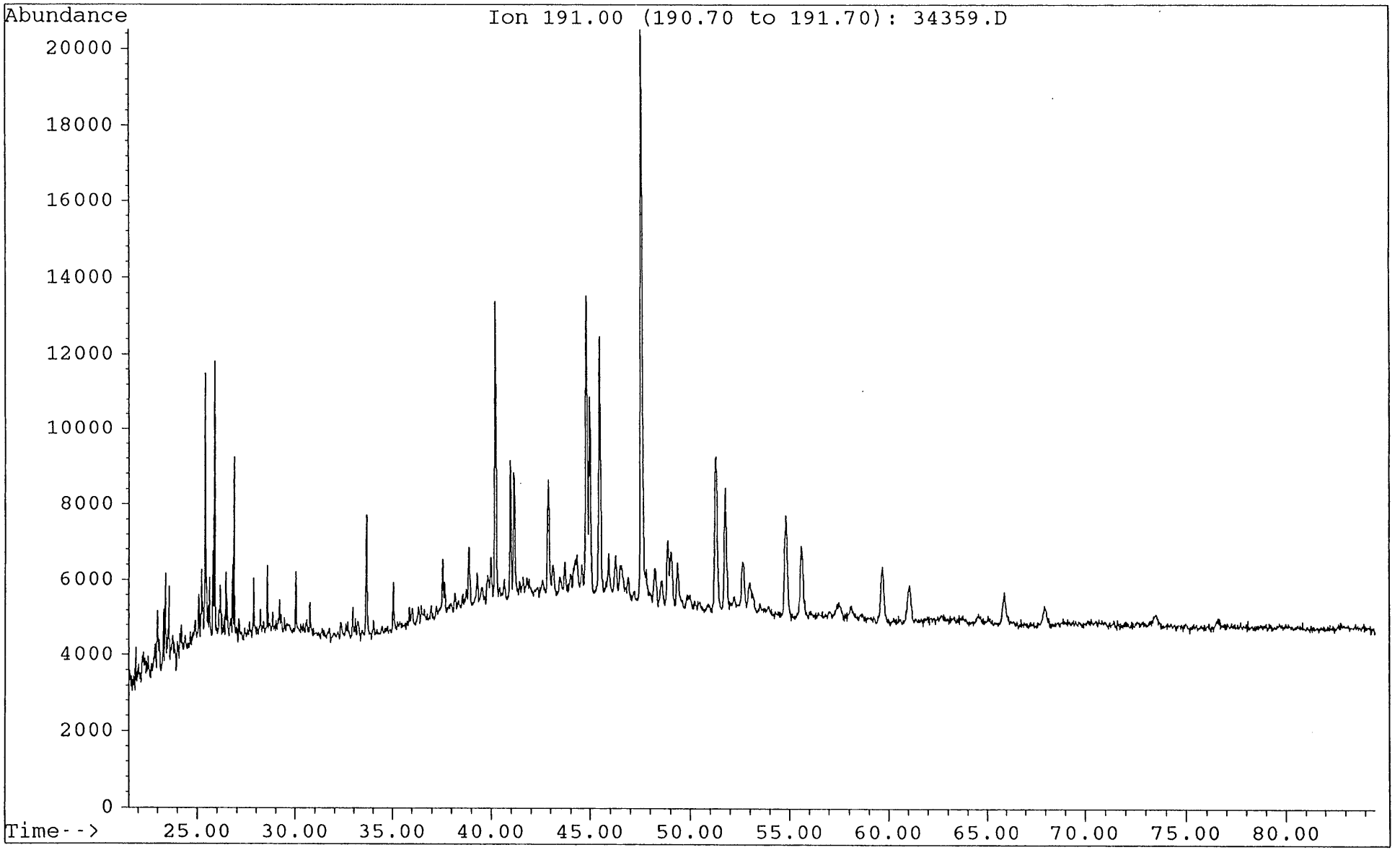
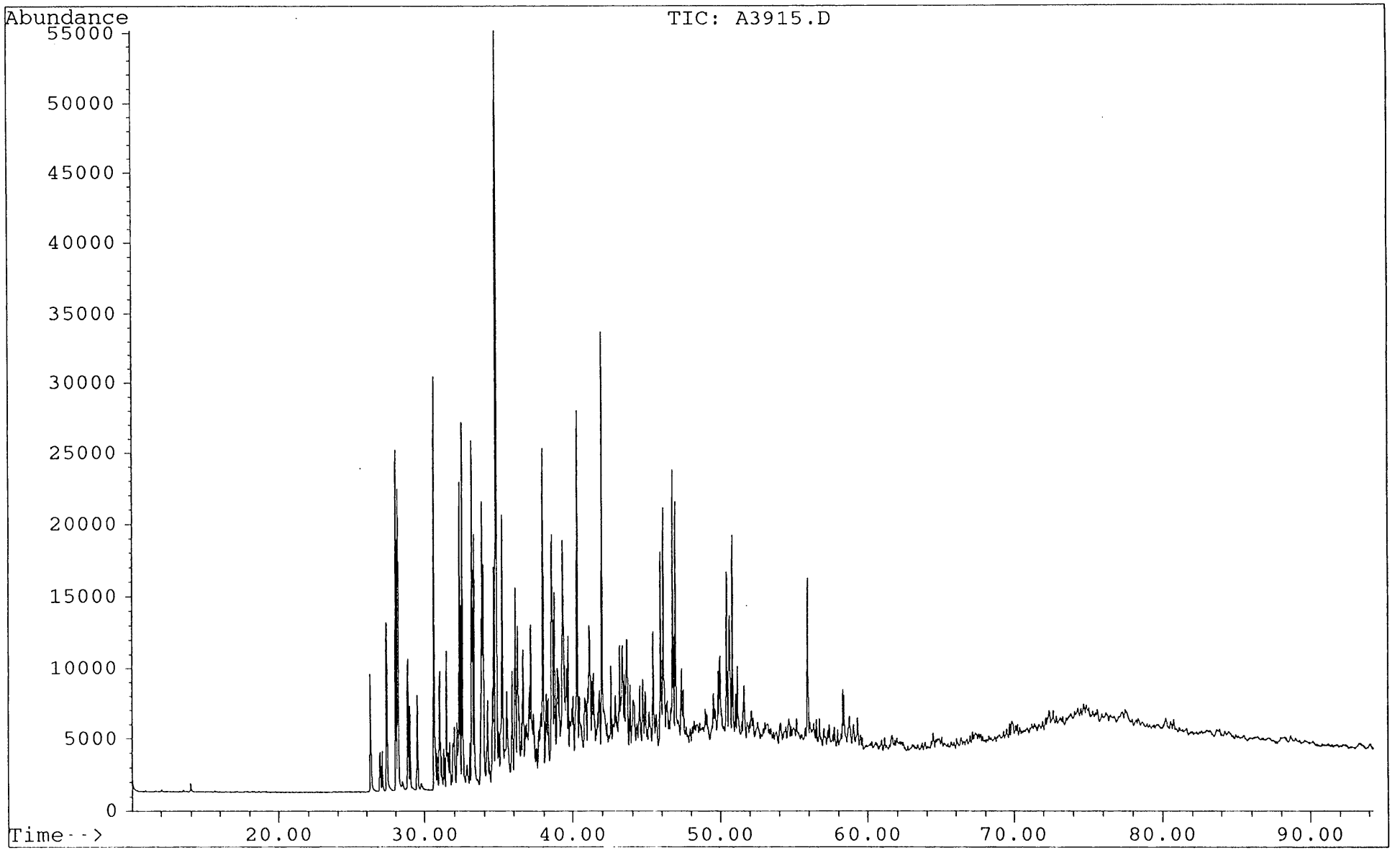
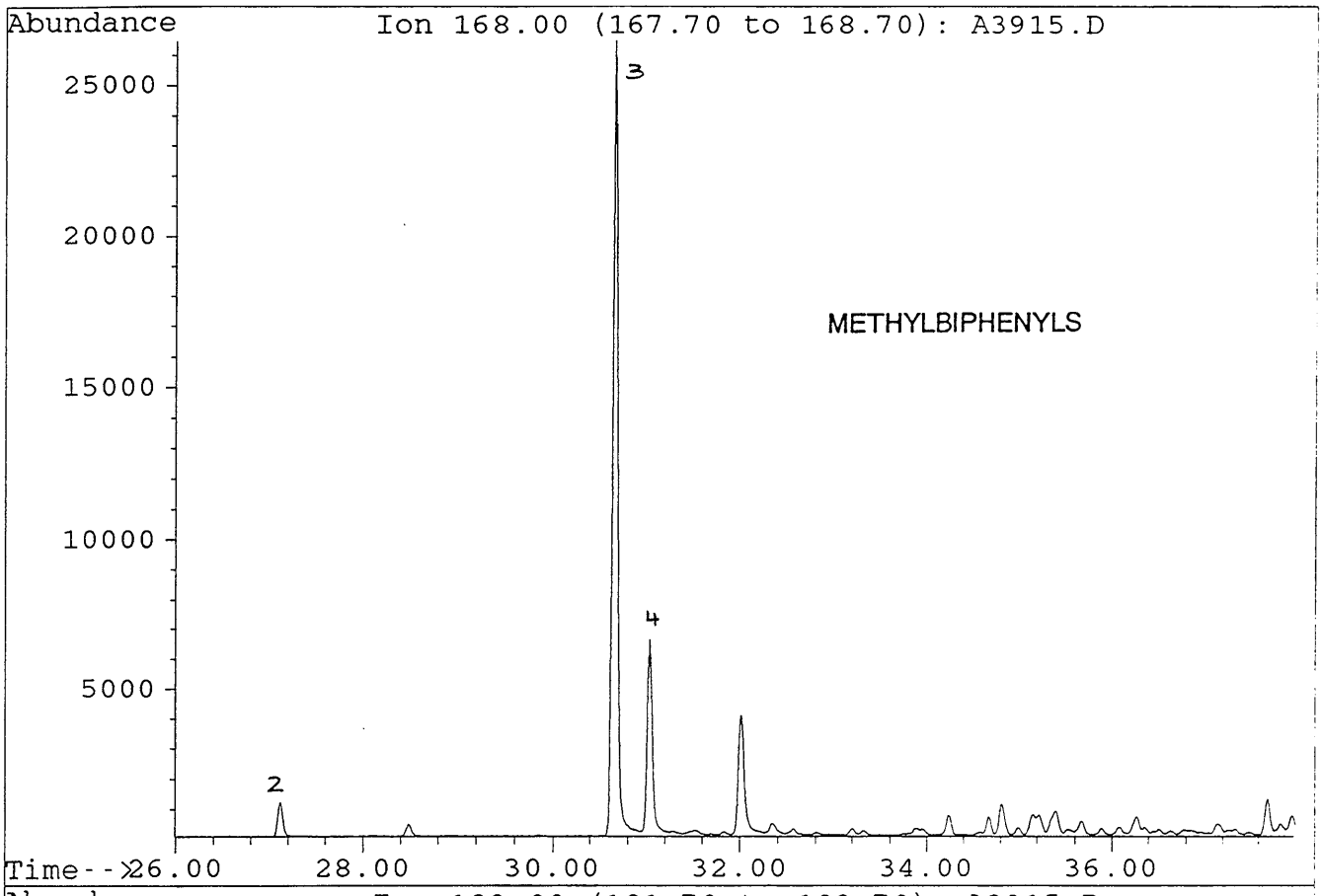


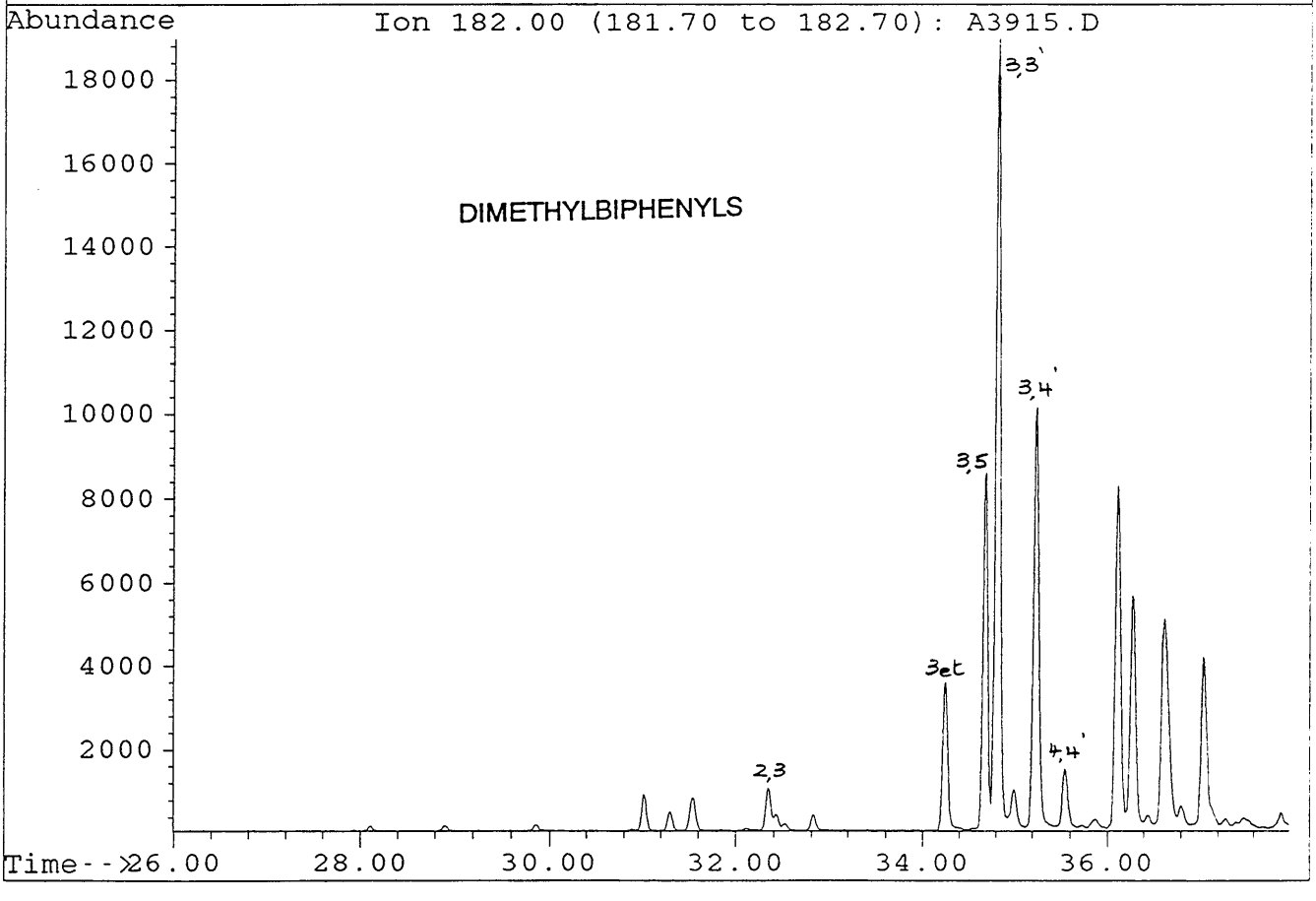
File : A3915.D
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.

FIGURE 8-1



File : A3915.D
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.





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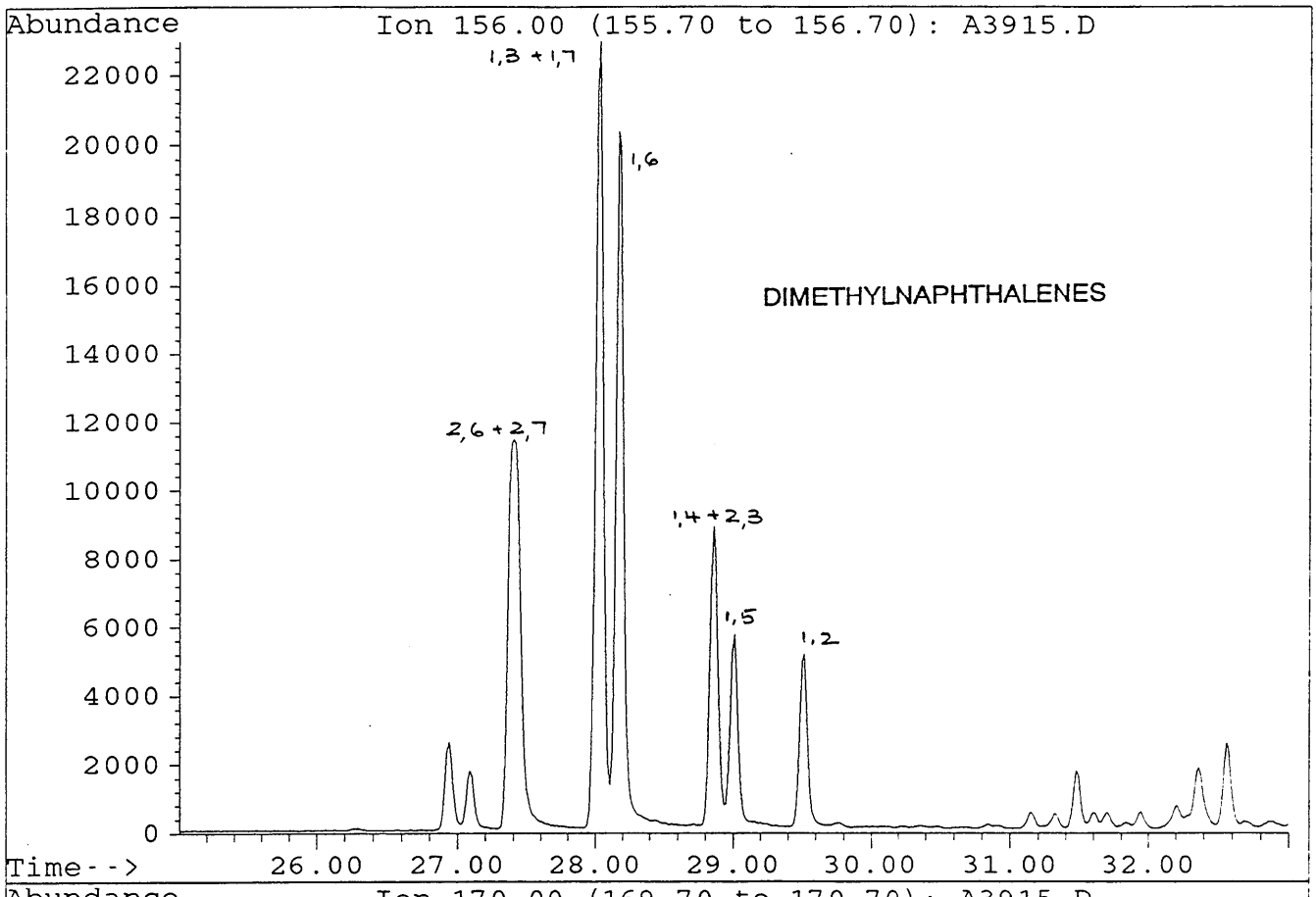
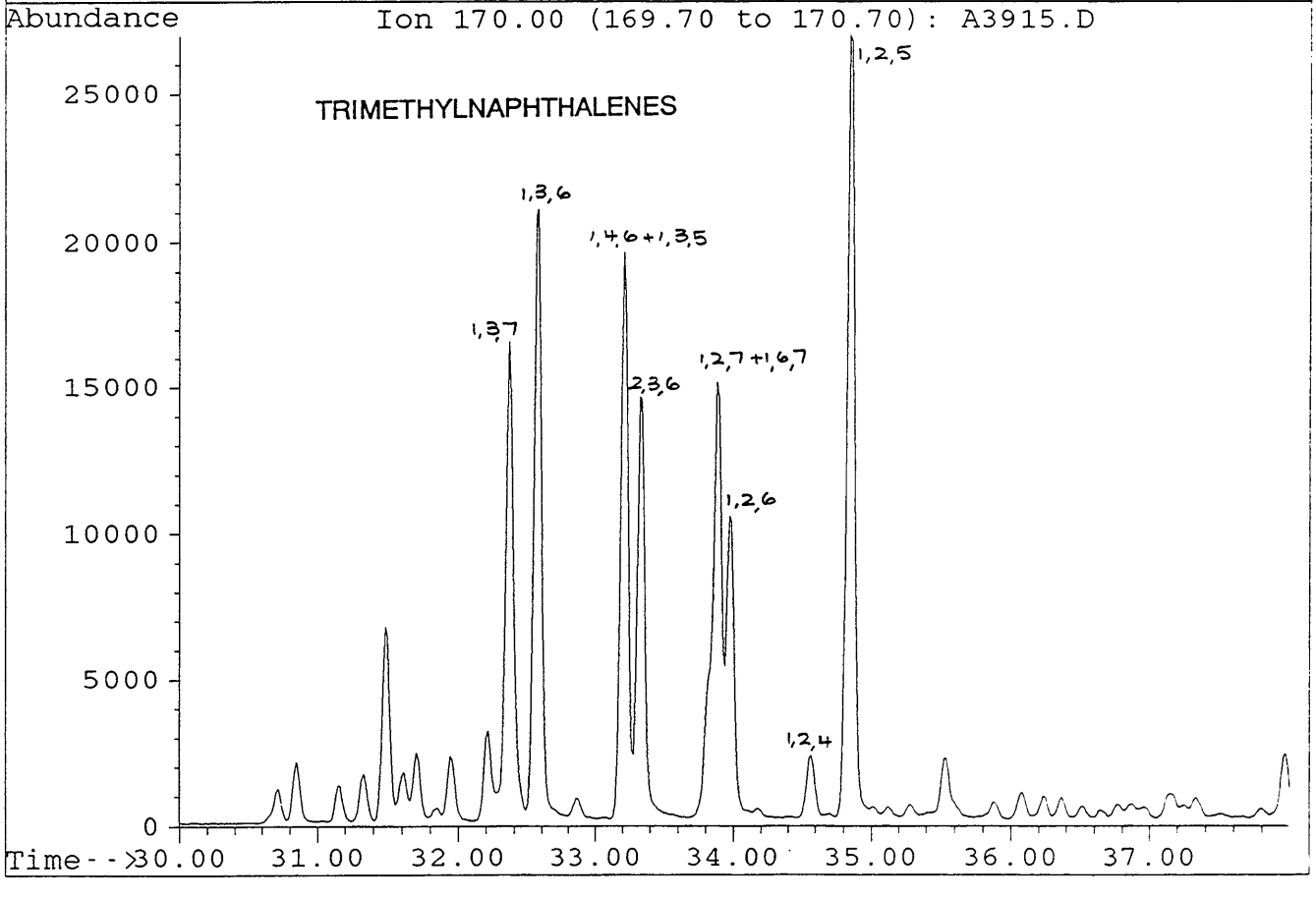
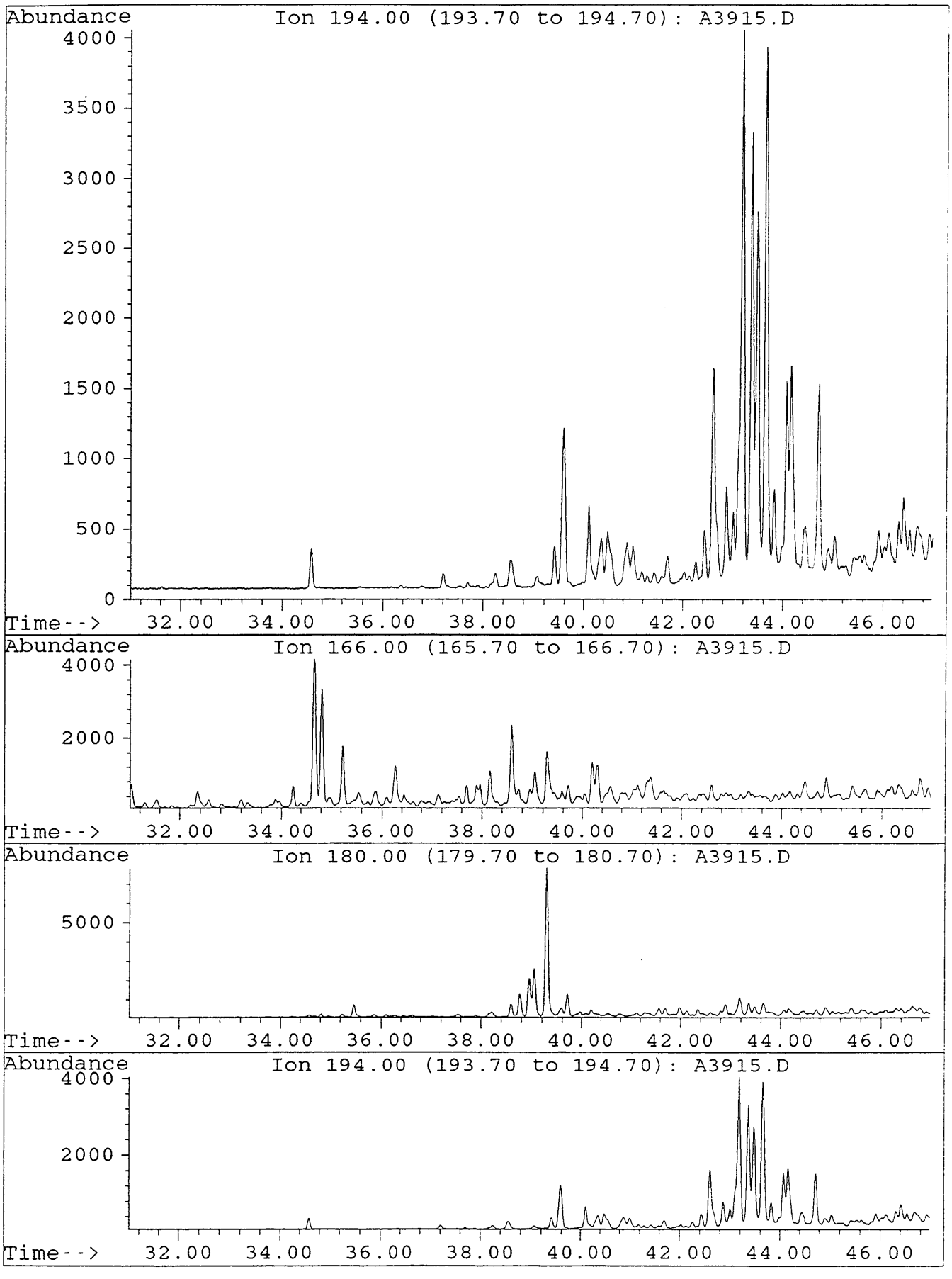
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.



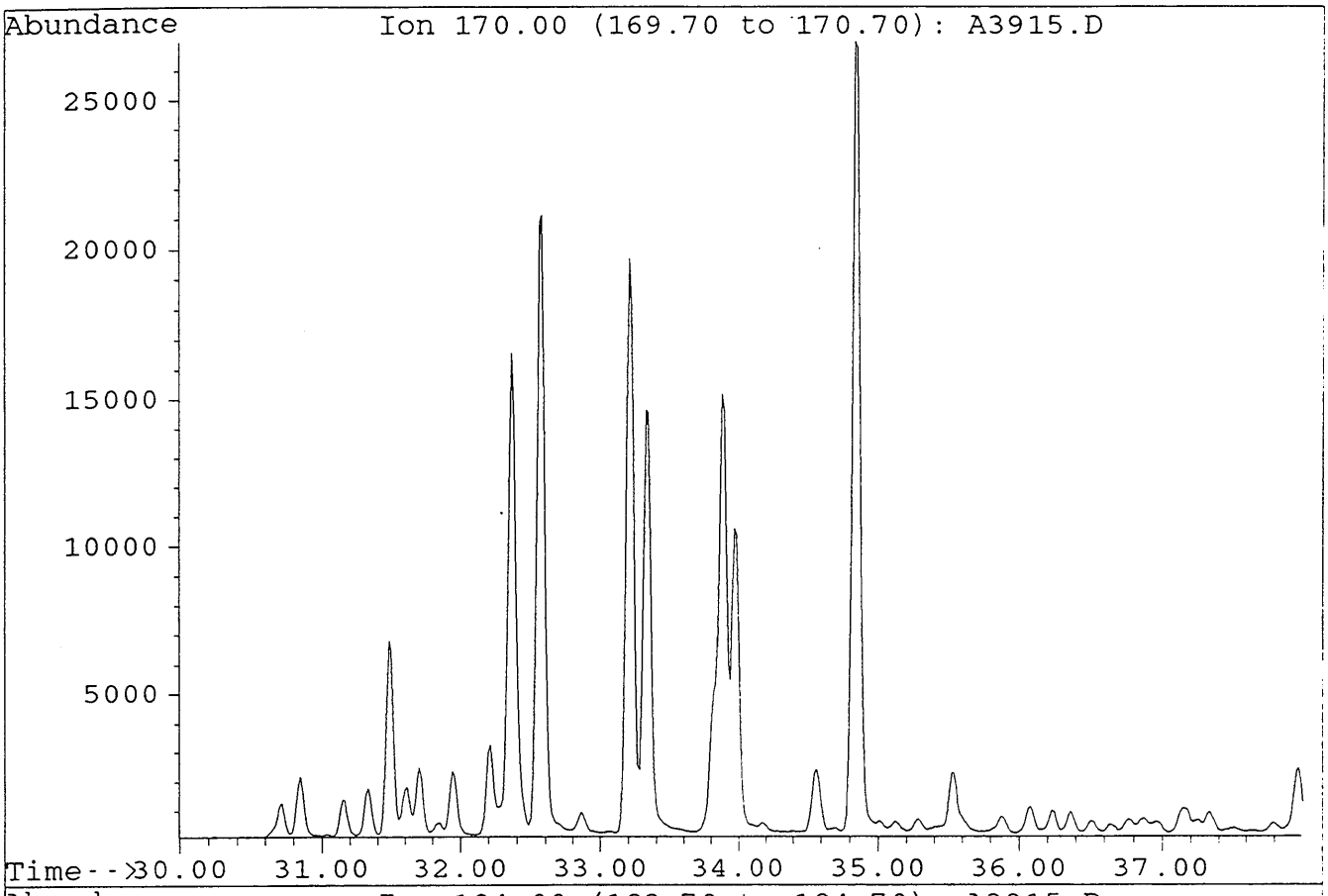


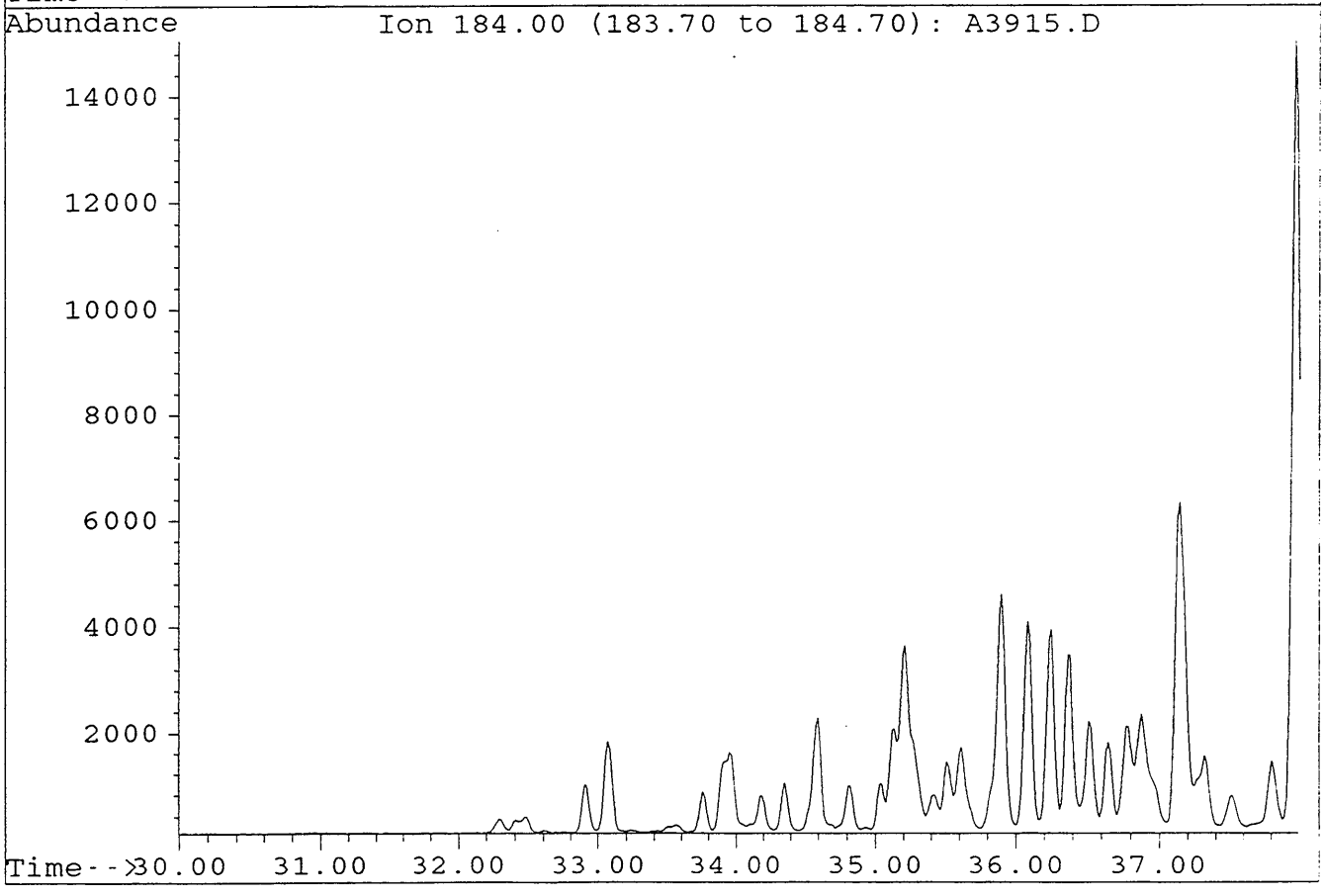
File : A3915.D
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.

FLUORENES



File : A3915.D
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.





File : A3915.D
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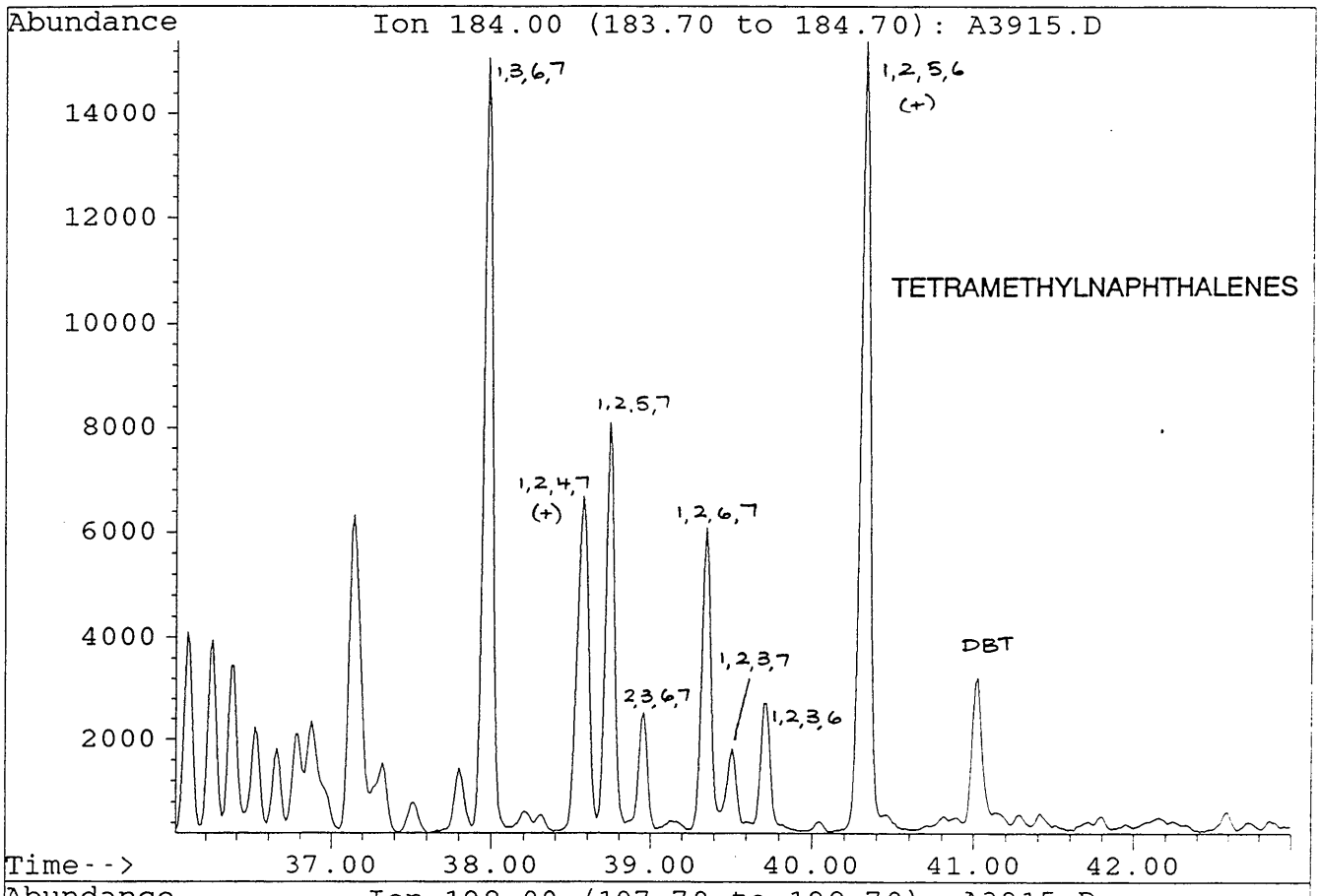
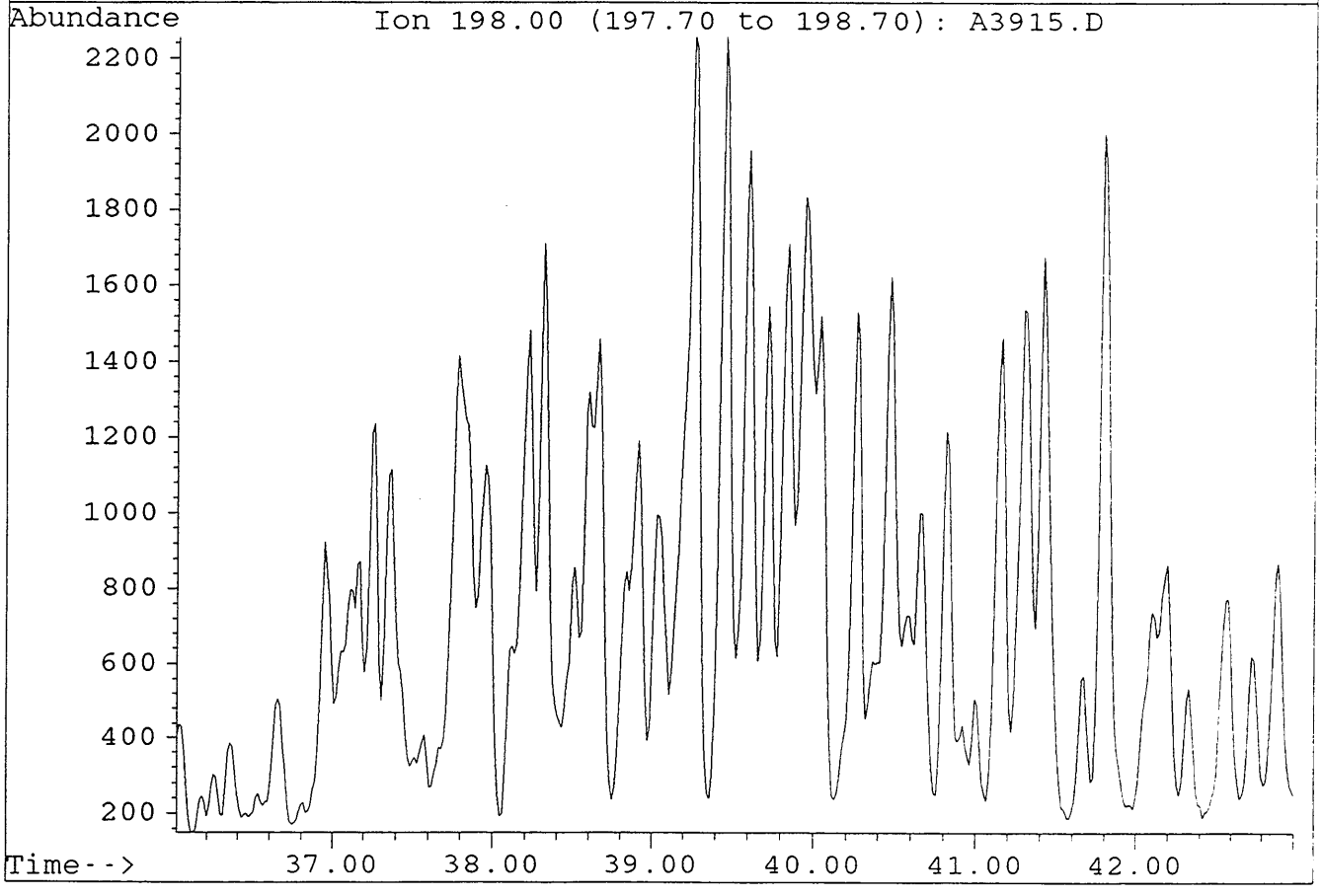
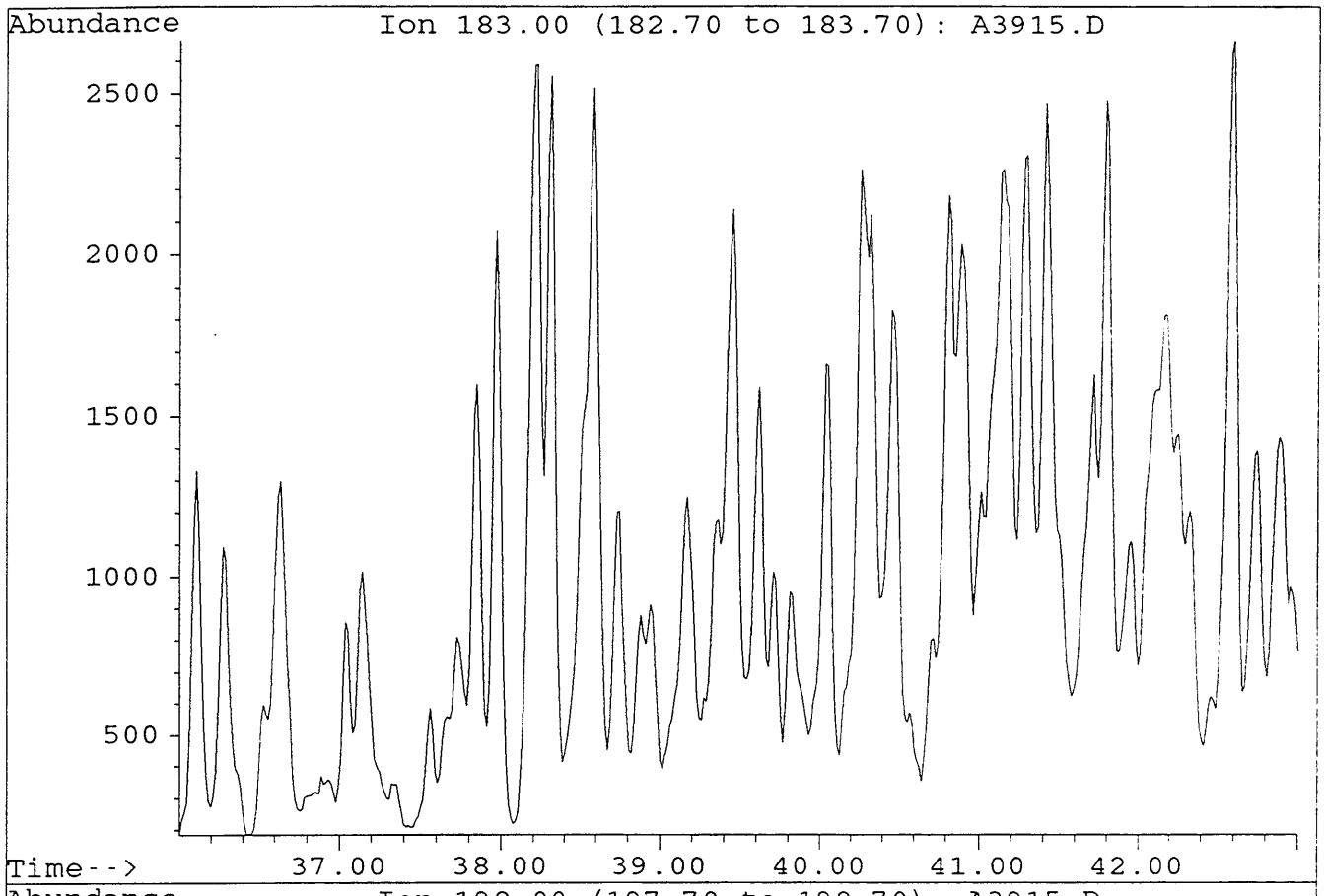
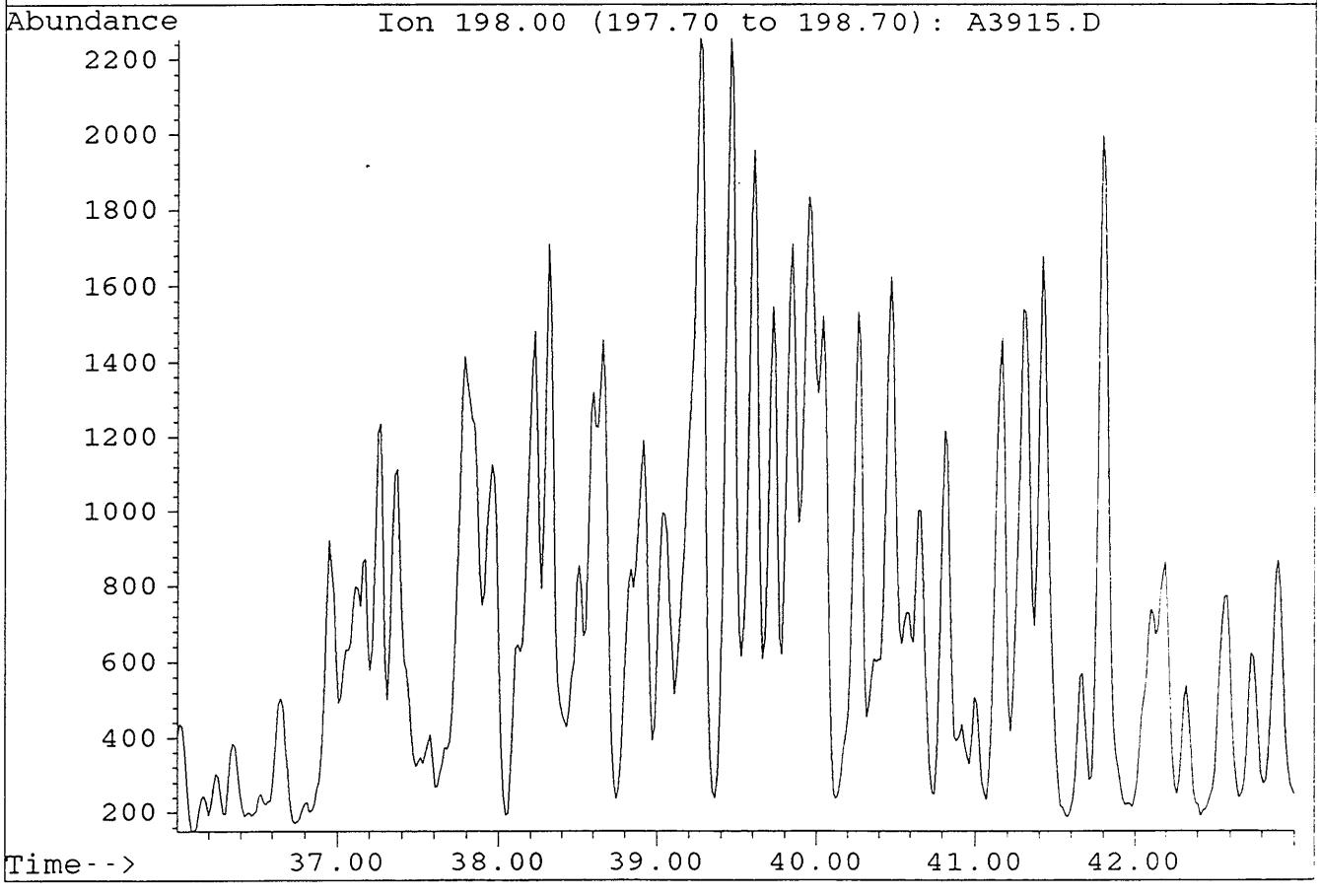
Misc. Info : COL#155. 28-7-95. GEC.





File : A3915.D
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.





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Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
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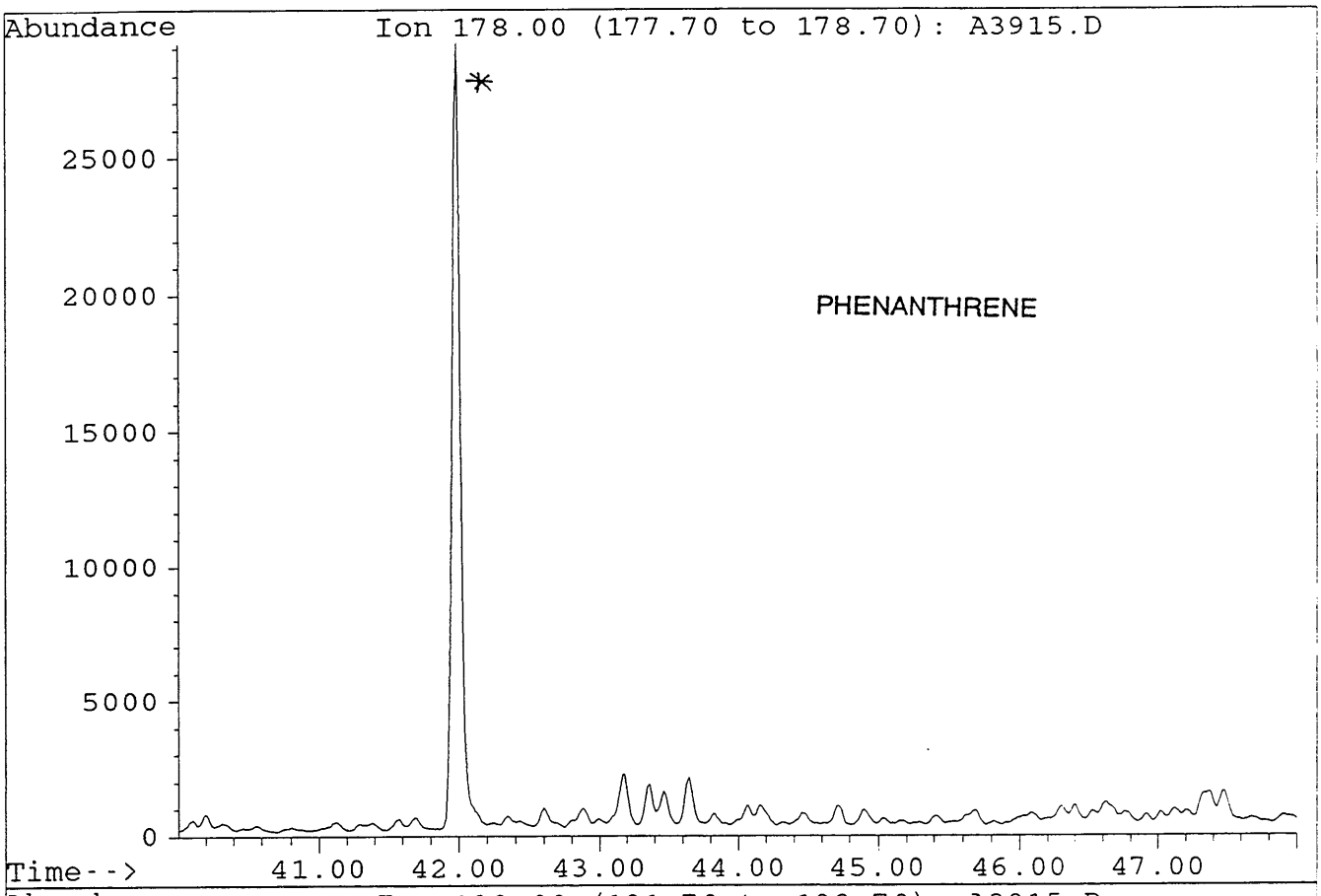

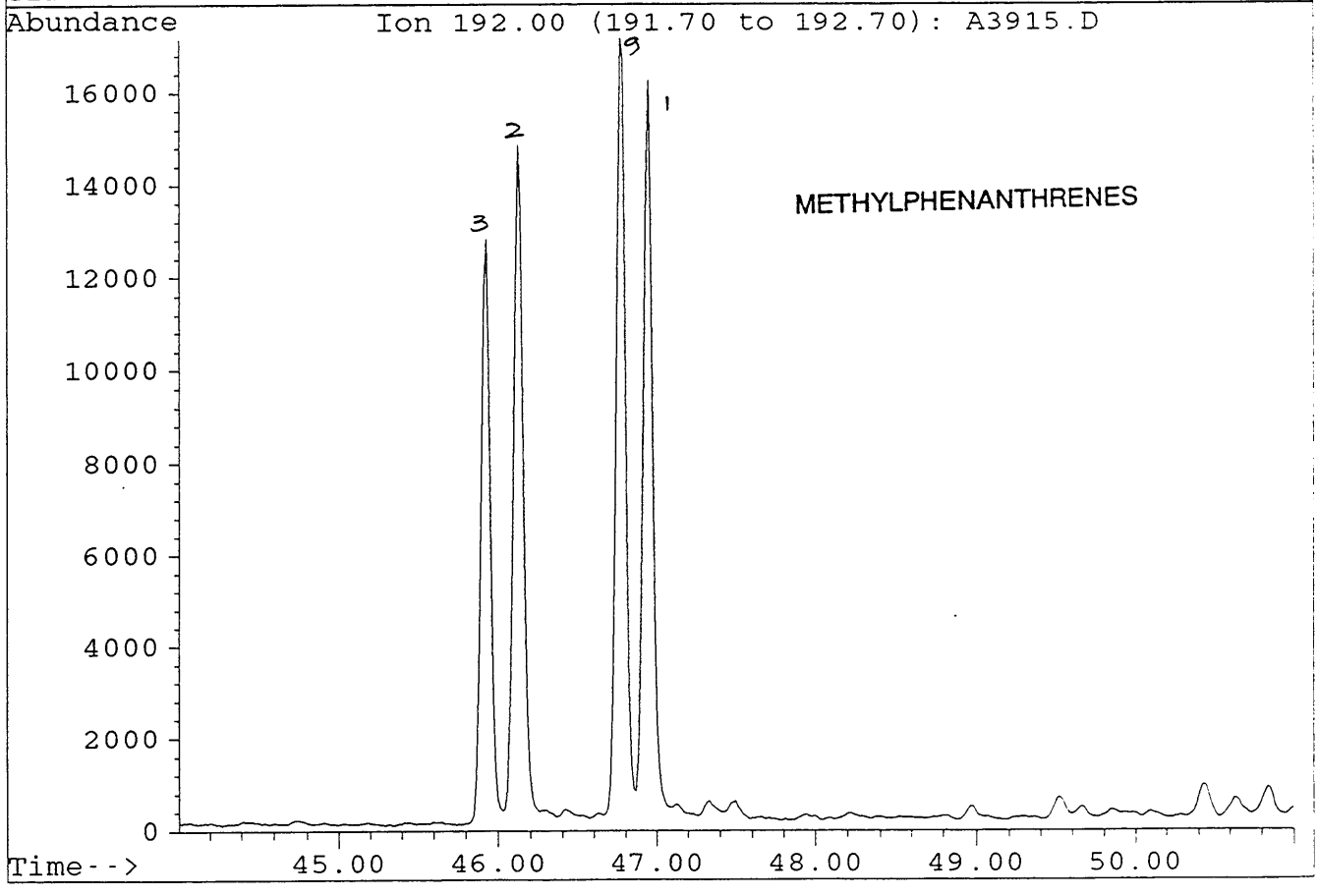

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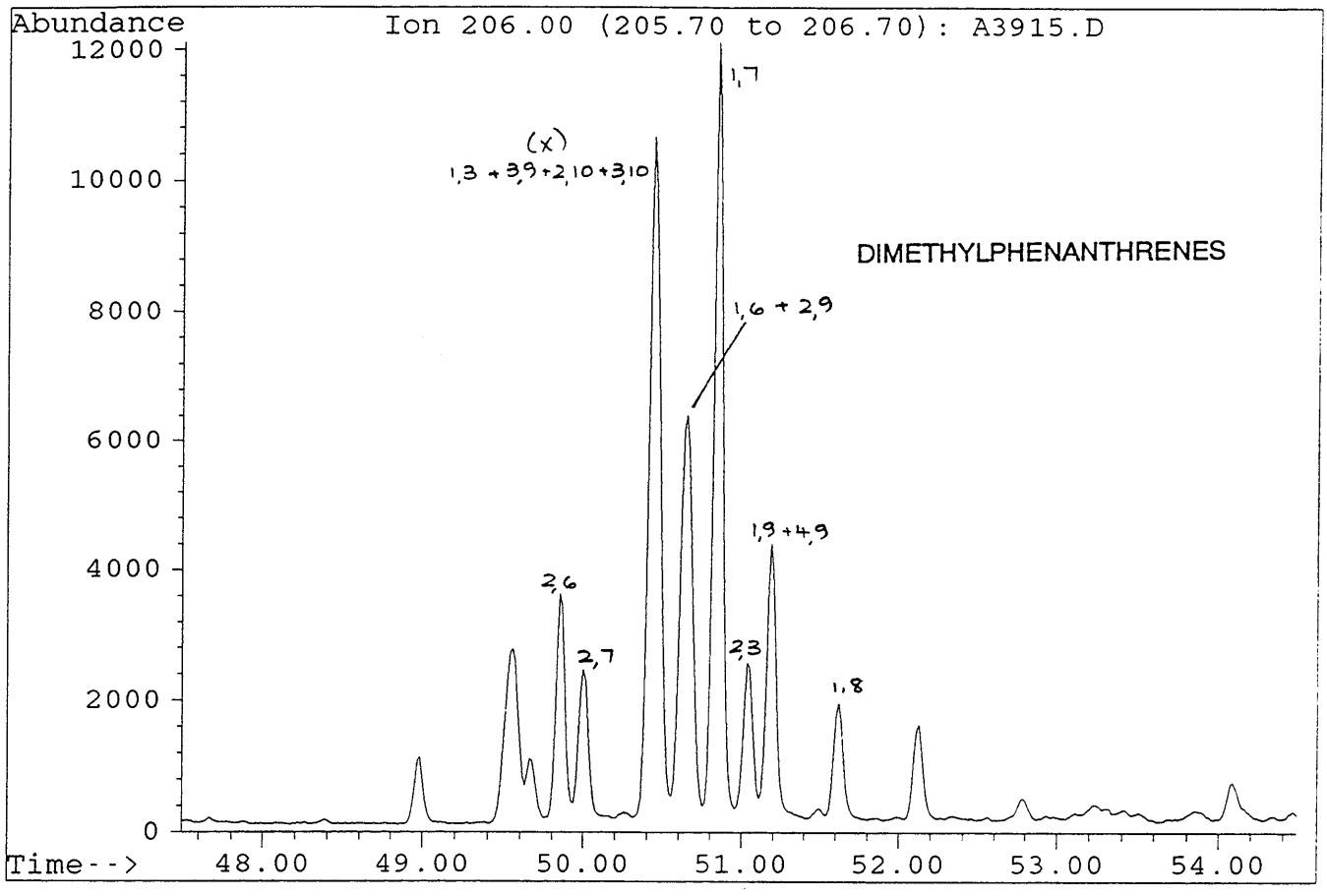
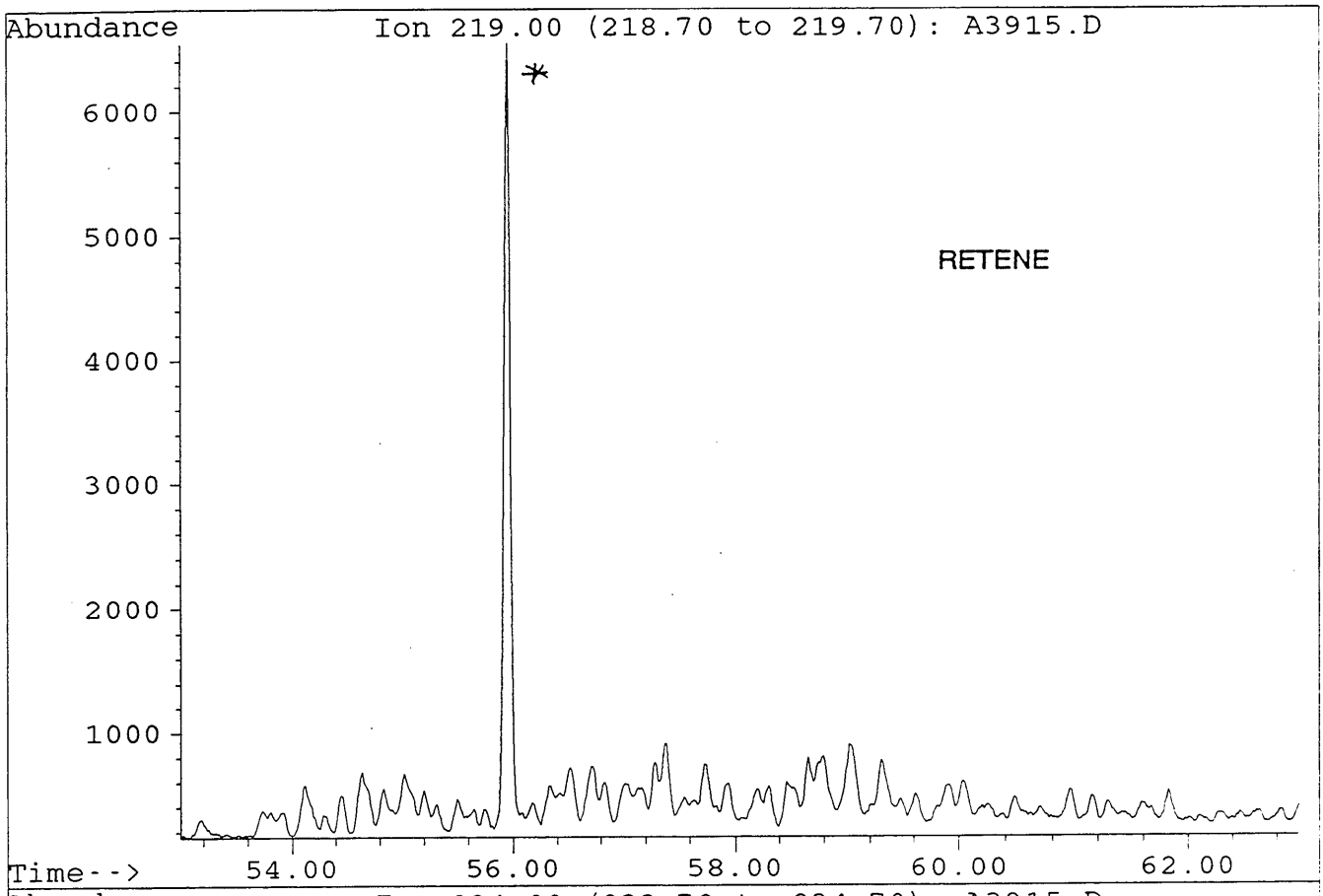


File : A3915.D
Sample : DIGBY#1, 1473.7m. AROS. (RE-SEPARATED)
Misc. Info : COL#155. 28-7-95. GEC.



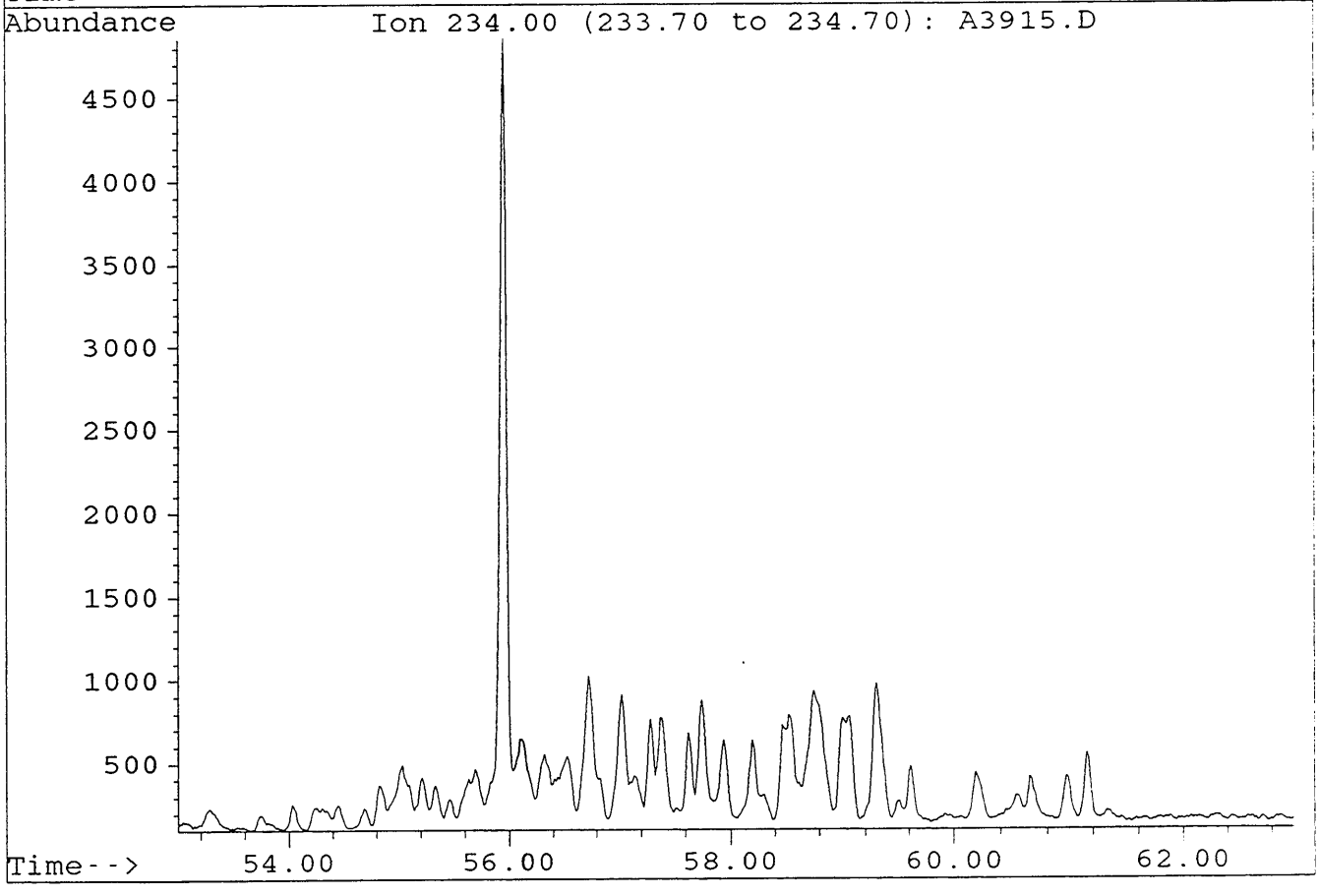


TABLE 9-2

SELECTED PARAMETERS FROM GC/MS ANALYSIS

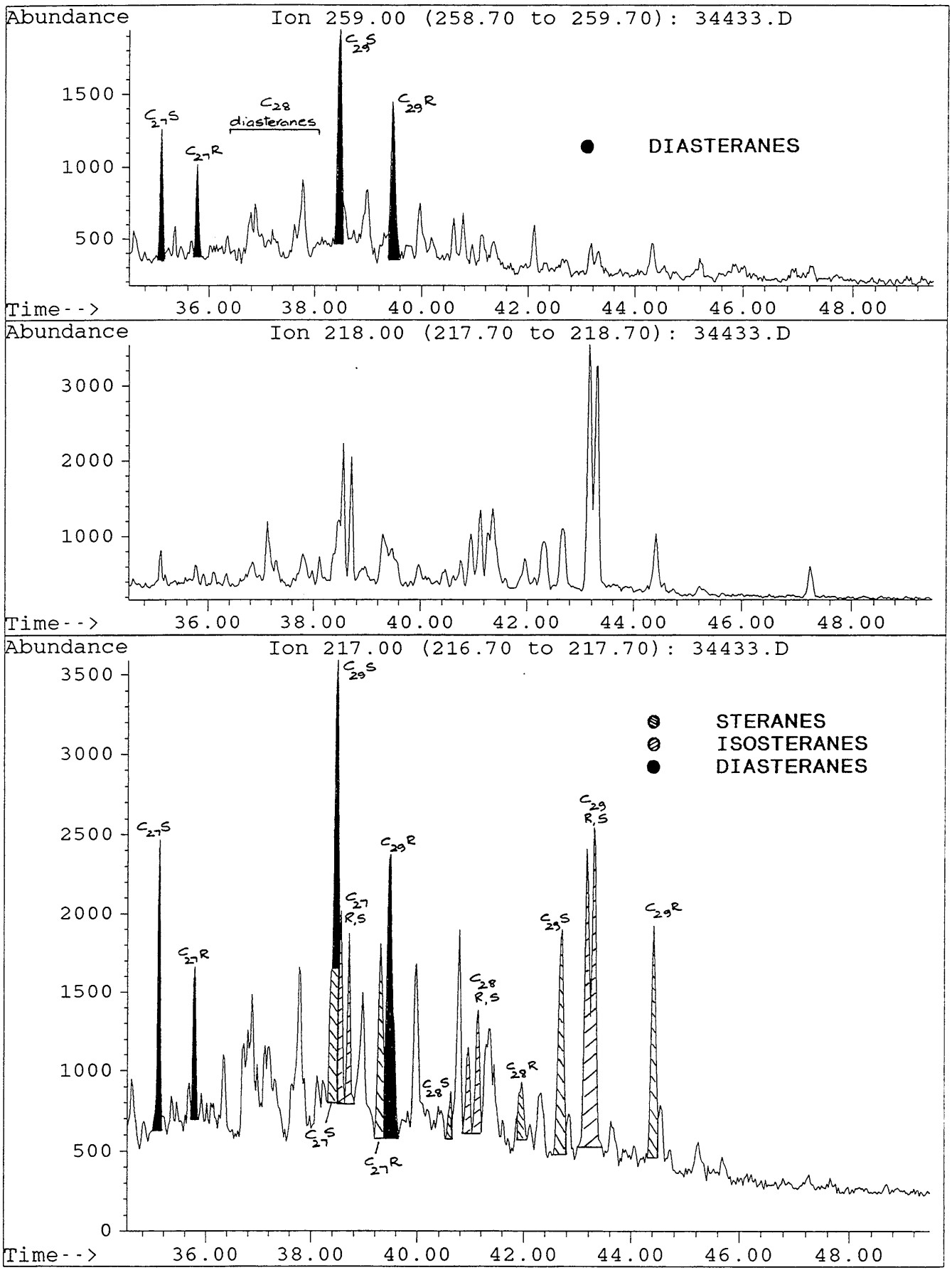
DIGBY 1, 1903.2m, SWC

	Parameter	Ion(s)	Value
1.	18 α (H)- hopane/17 α (H)-hopane (Ts/Tm)	191	1.03
2.	C30 hopane/C30 moretane	191	10.11
3.	C31 22S hopane/C31 22R hopane	191	1.34
4.	C32 22S hopane/C32 22R hopane	191	1.48
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ sterane	217	0.97
6.	C29 $\alpha\alpha\alpha$ steranes (20S / 20S+20R)	217	0.49
7.	C29 $\alpha\beta\beta$ steranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.57
8.	C27/C29 diasteranes	259	0.61
9.	C27/C29 steranes	217	0.84
10.	18 α (H)-oleanane/C30 hopane	191	nd
11.	C29 diasteranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.62
12.	C30 (hopane + moretane) / C29 (steranes + diasteranes)	191/217	1.13
13.	C15 drimane/C16 homodrimane	123	0.33
14.	Rearranged drimanes/normal drimanes	123	0.68

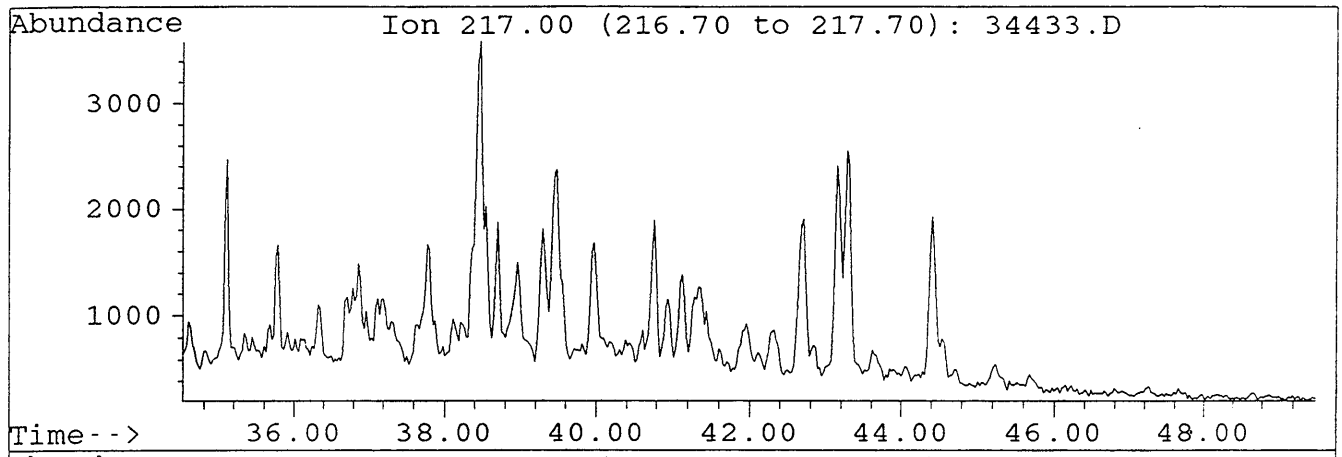
nd = not detectable

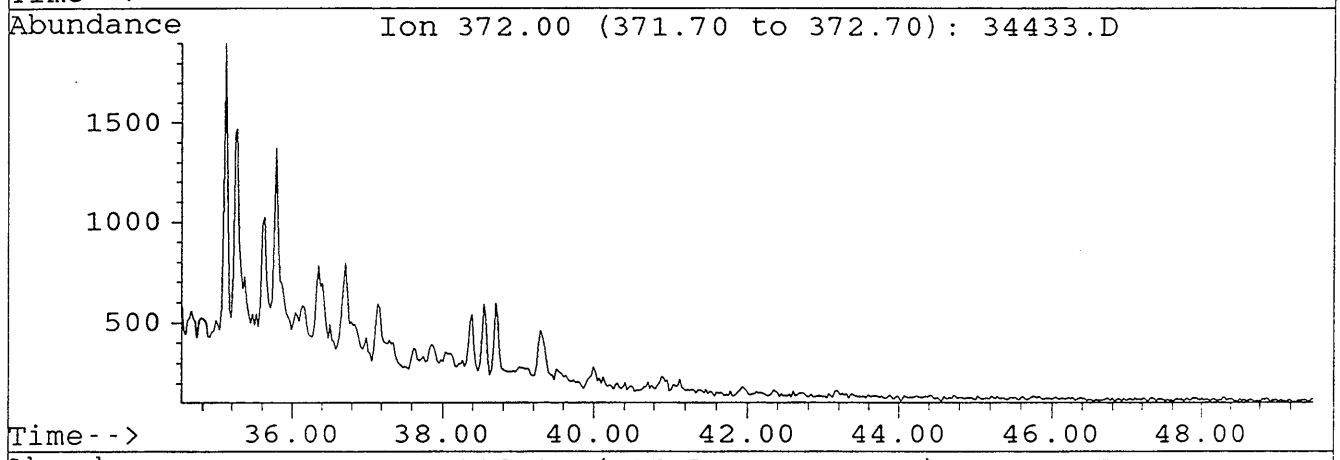
File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.

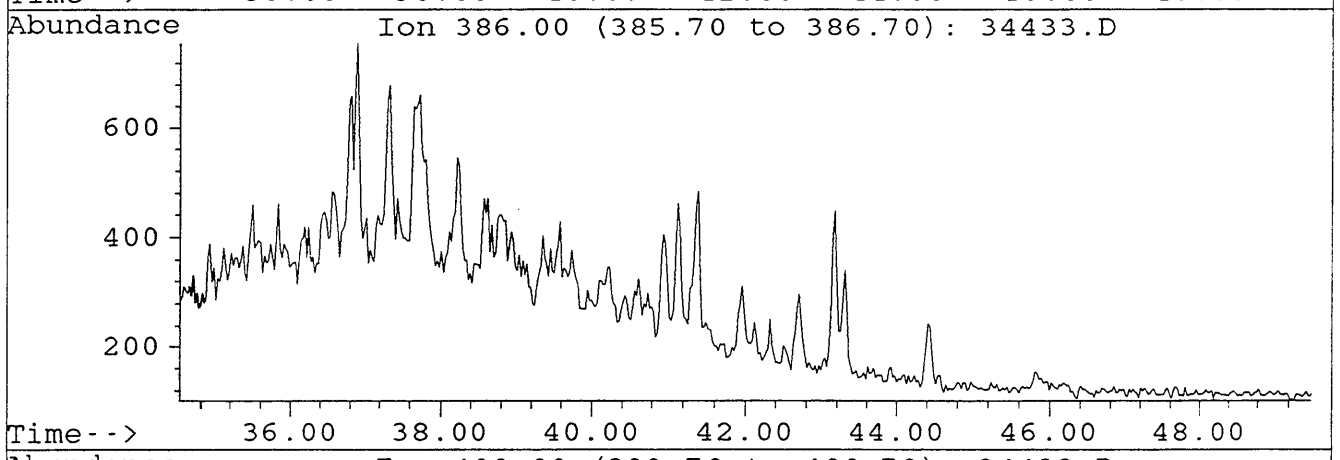
FIGURE 6-2

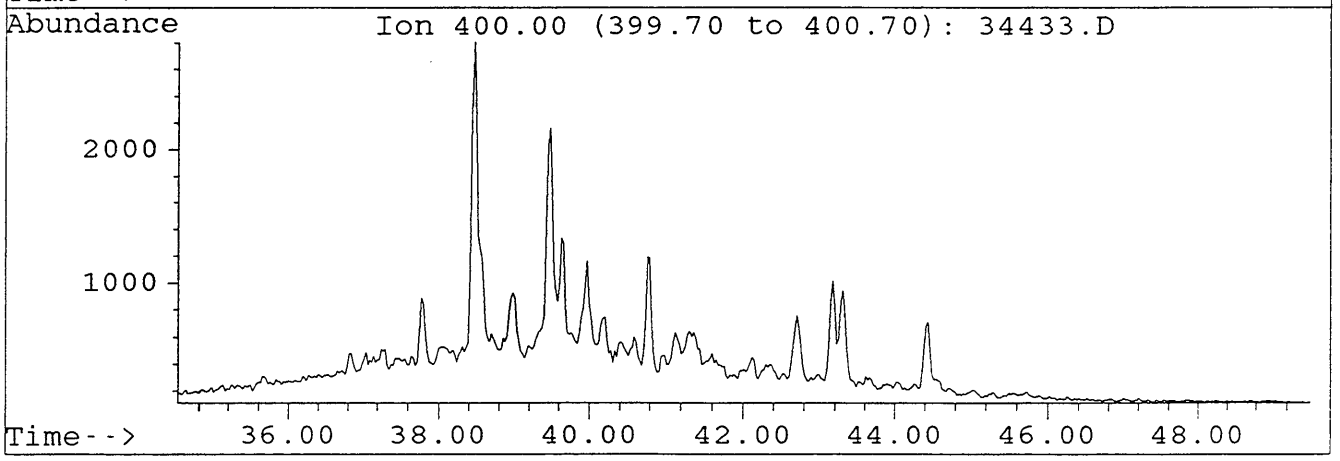


File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.

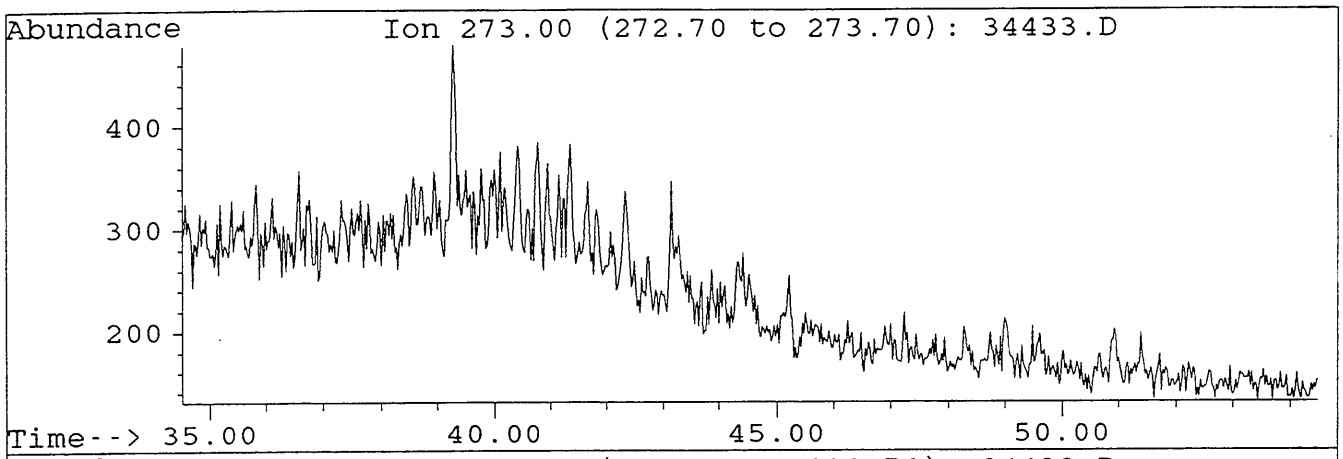


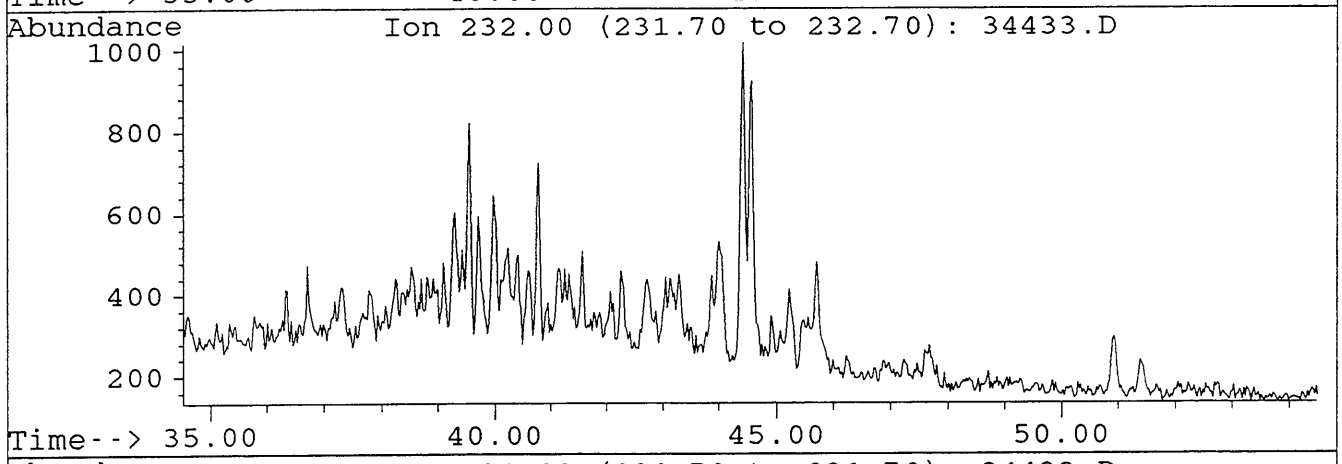


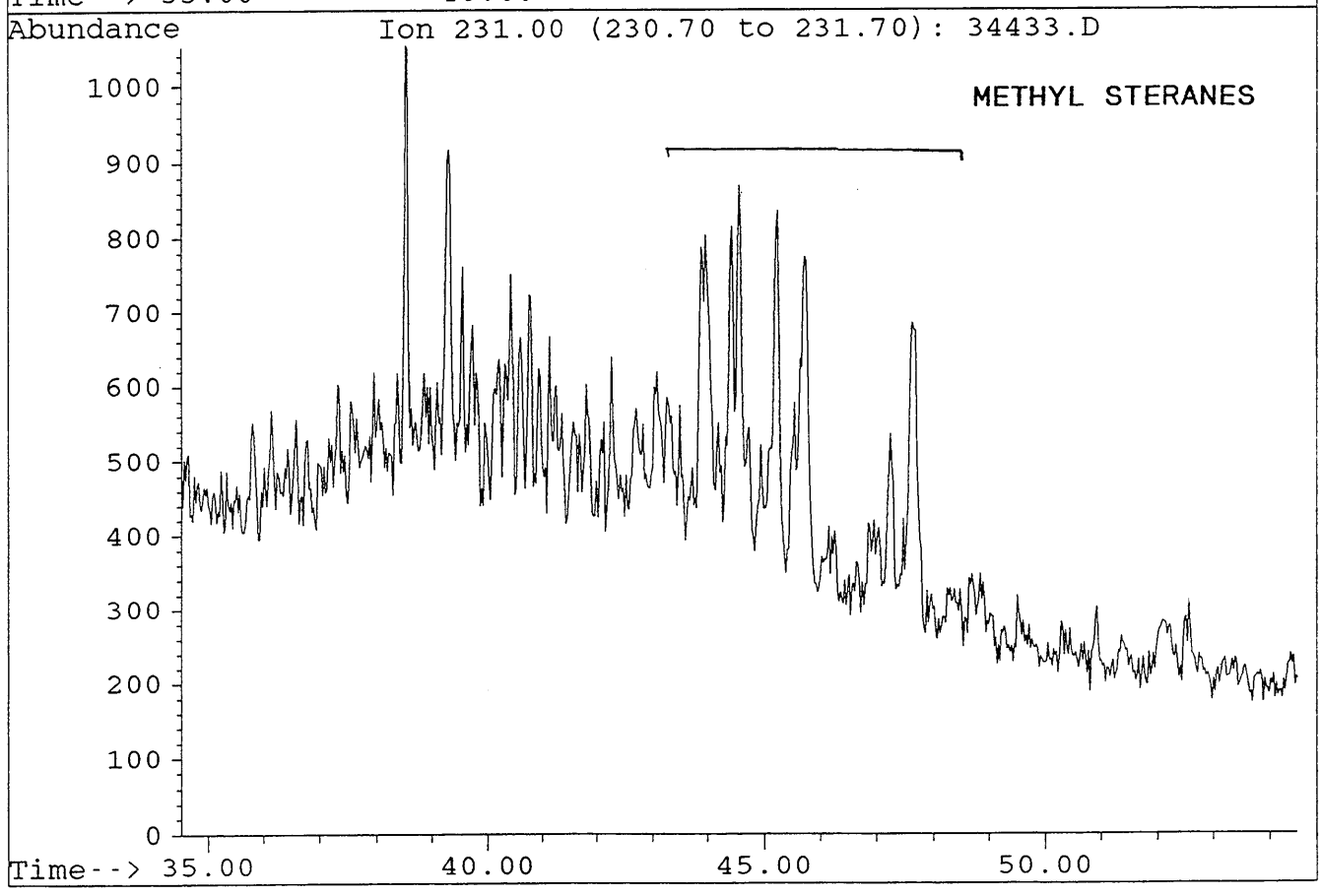




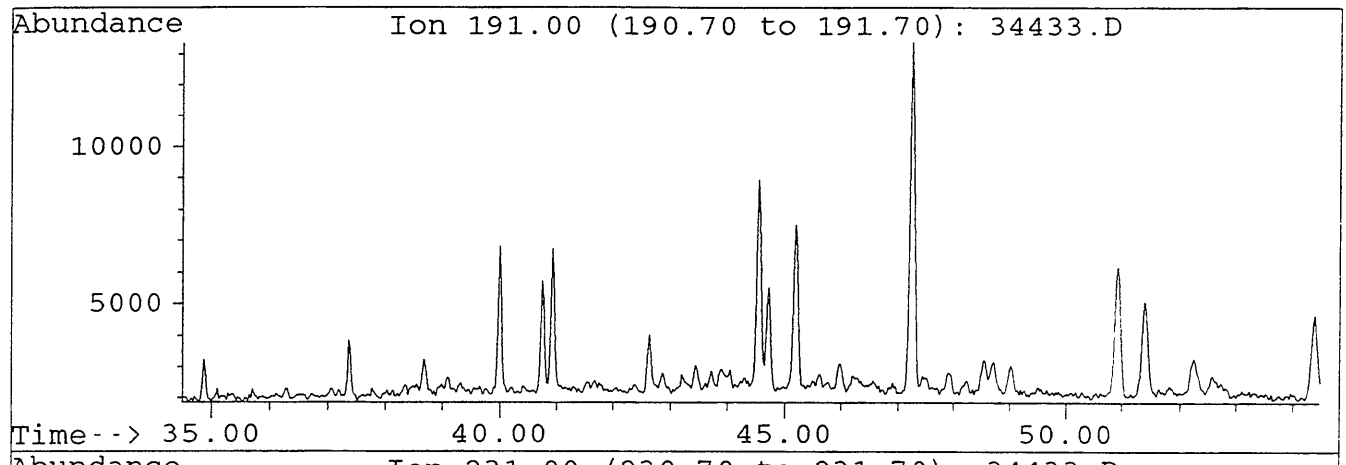
File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.

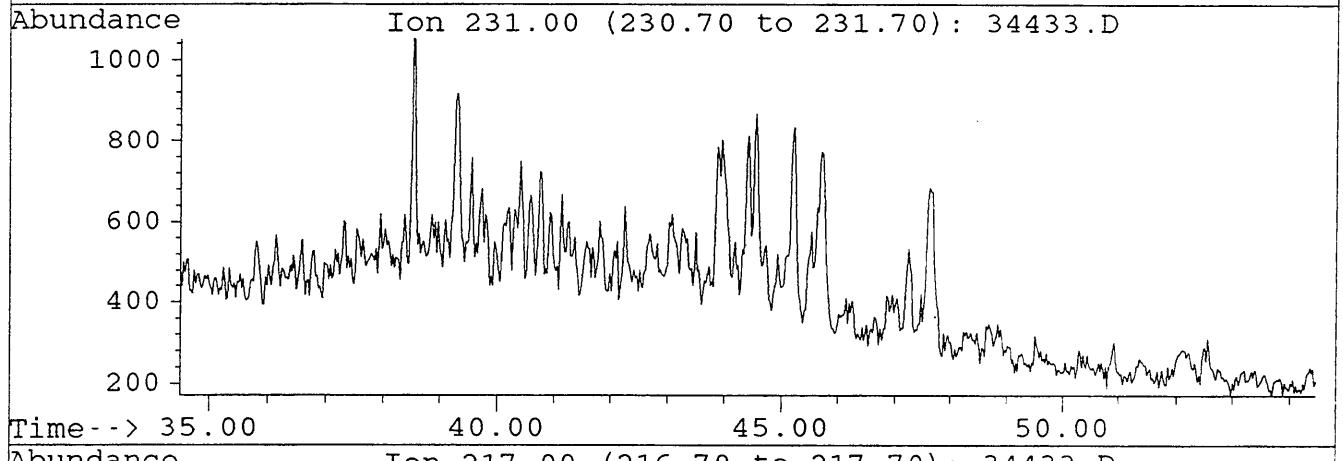


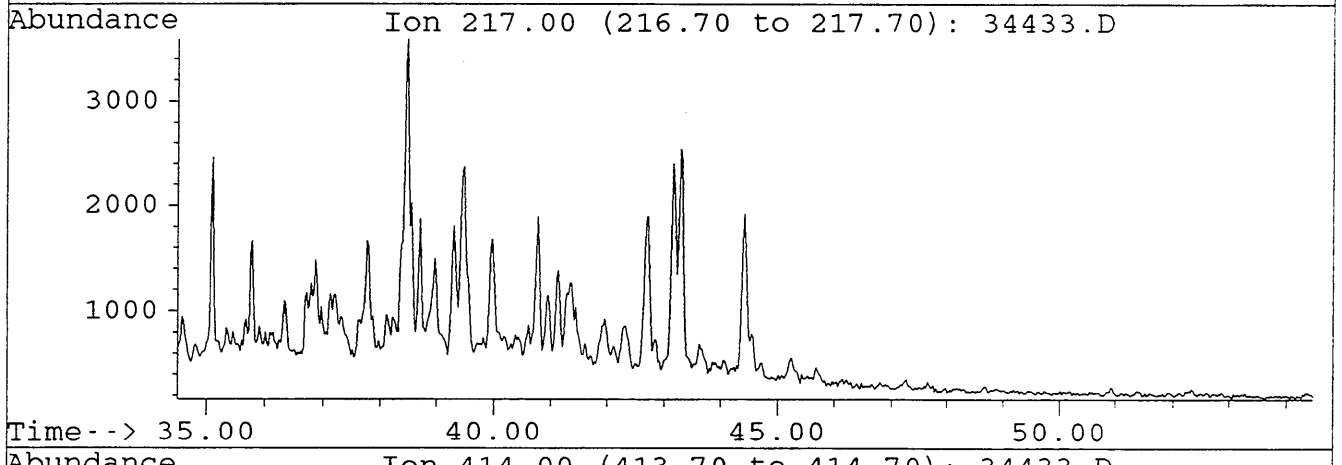


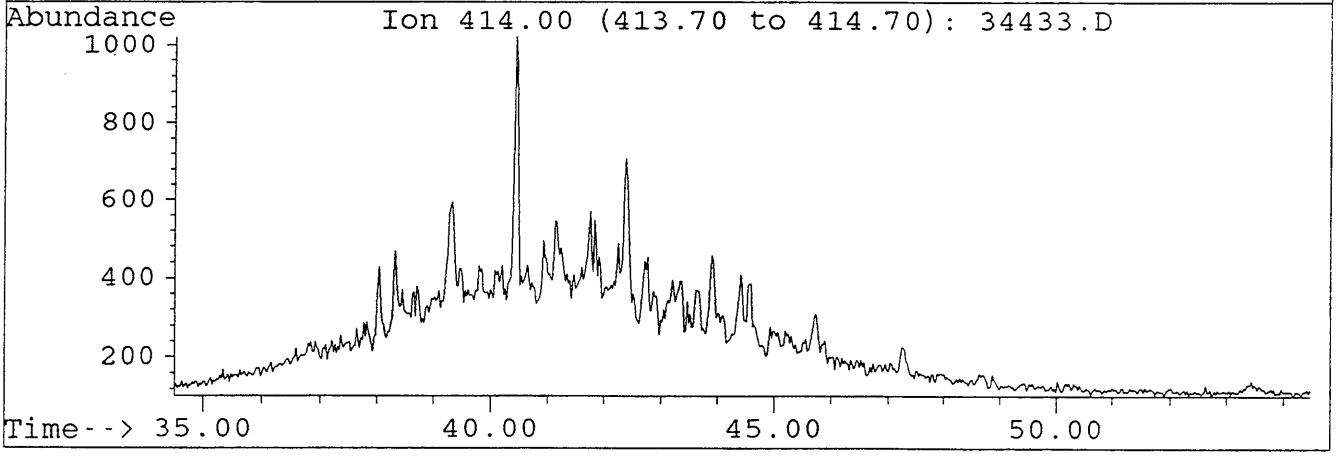


File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.

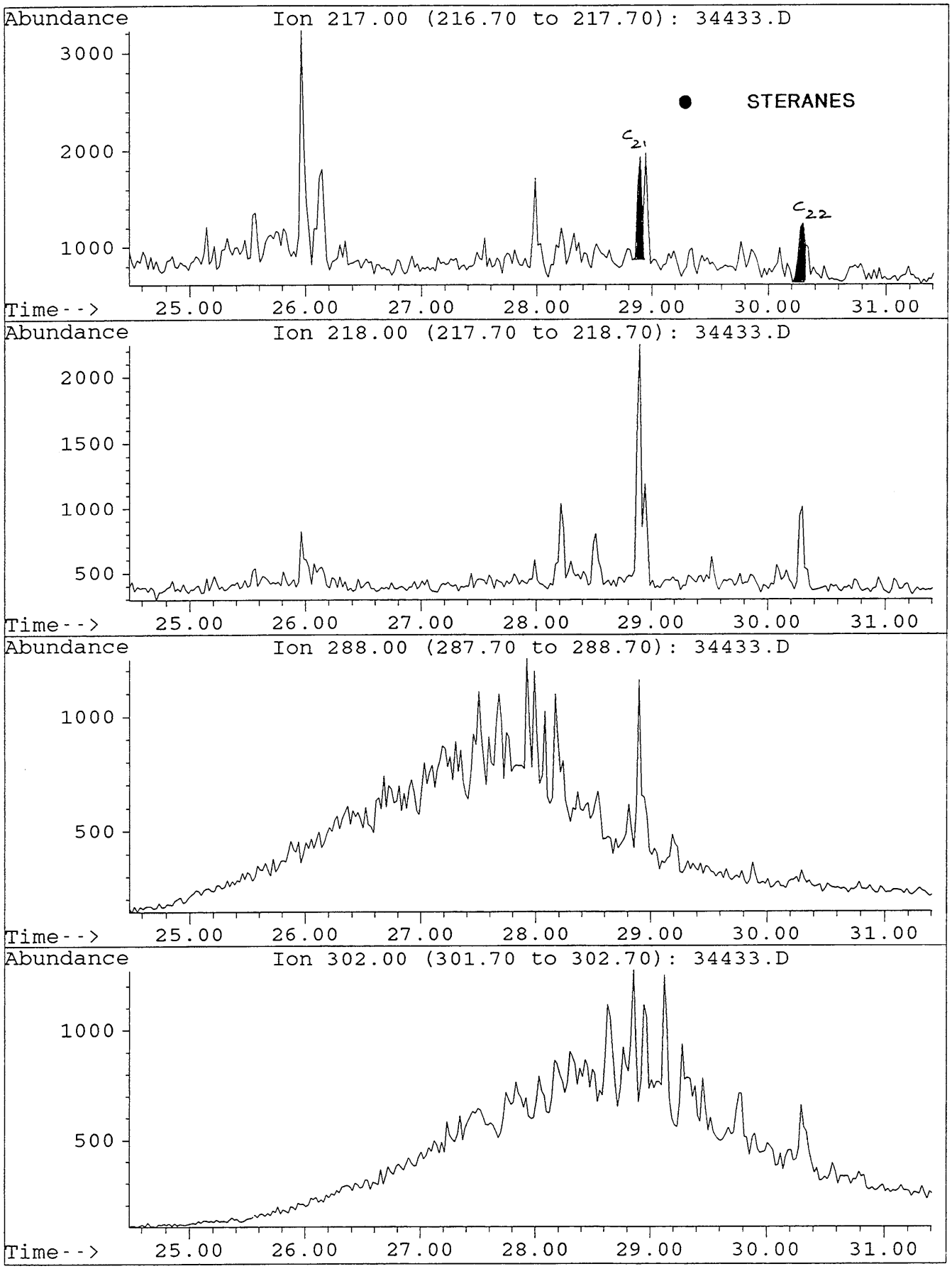








File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



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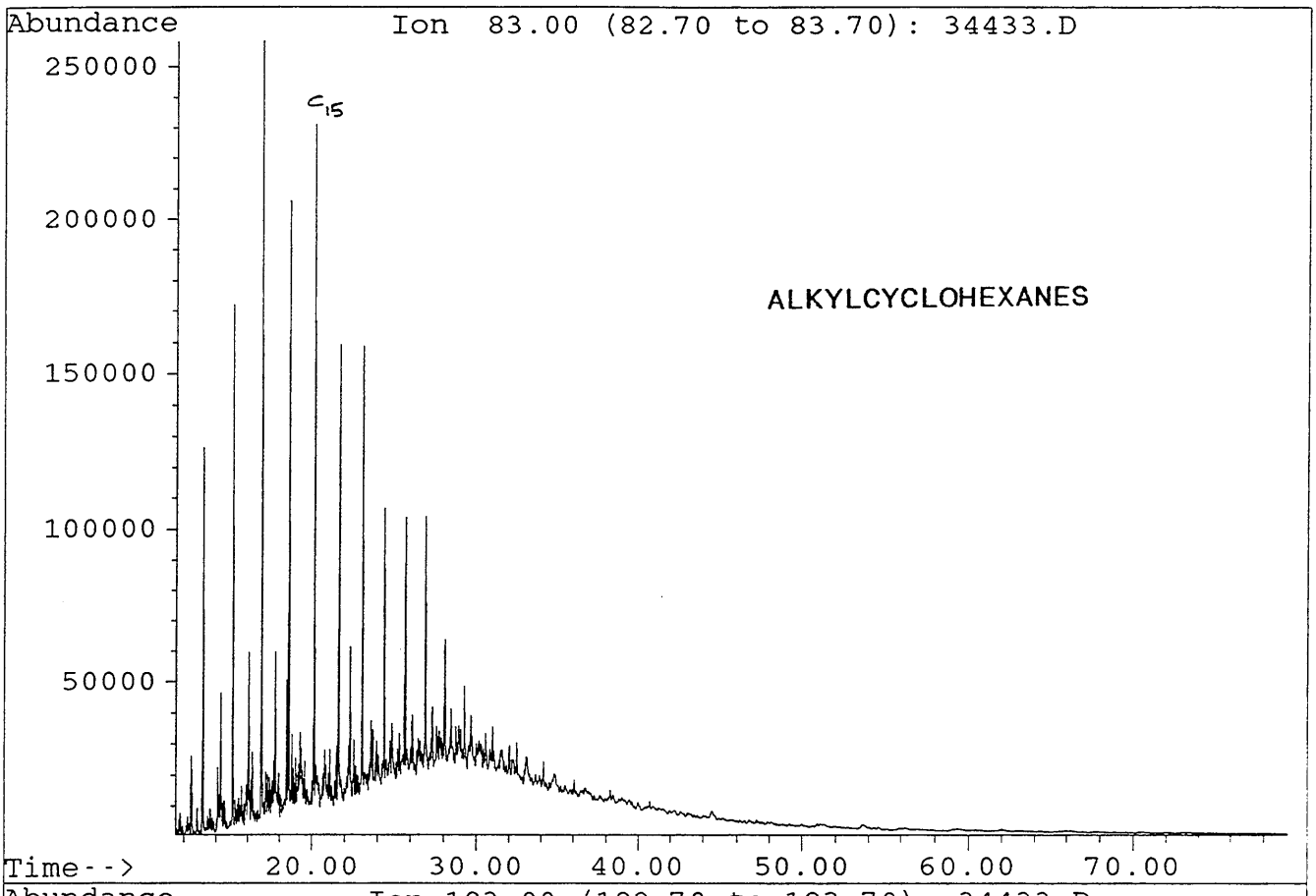

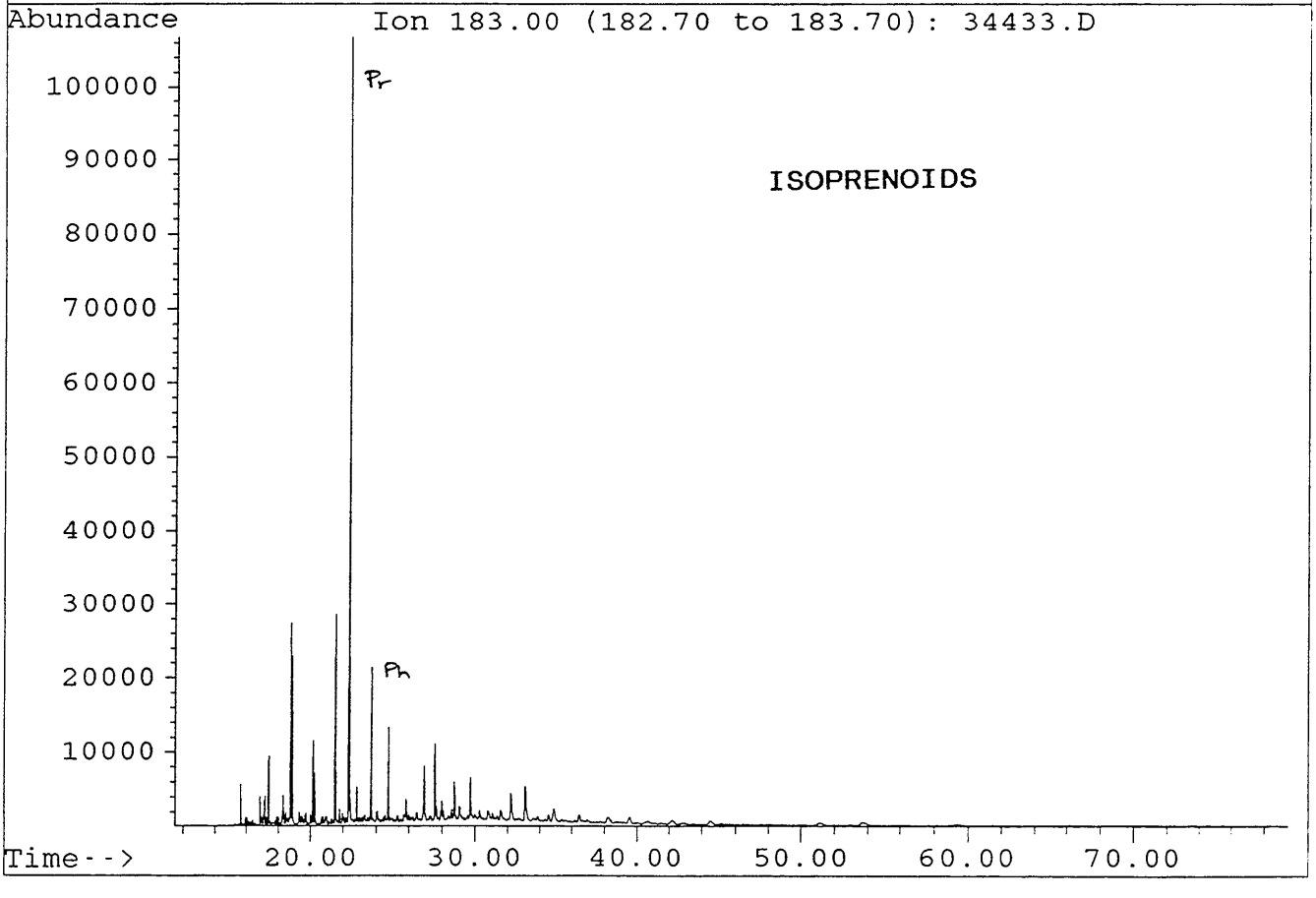

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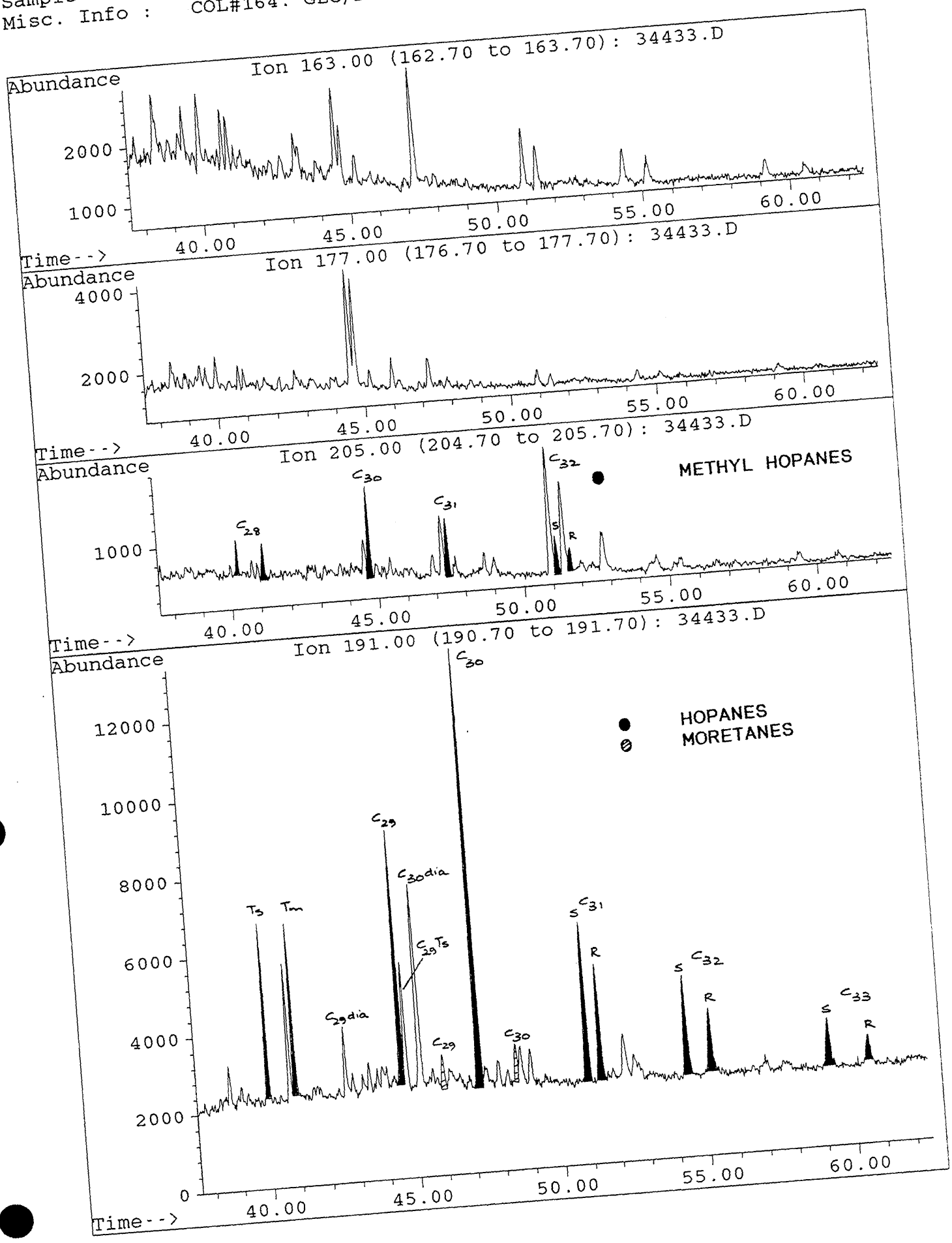
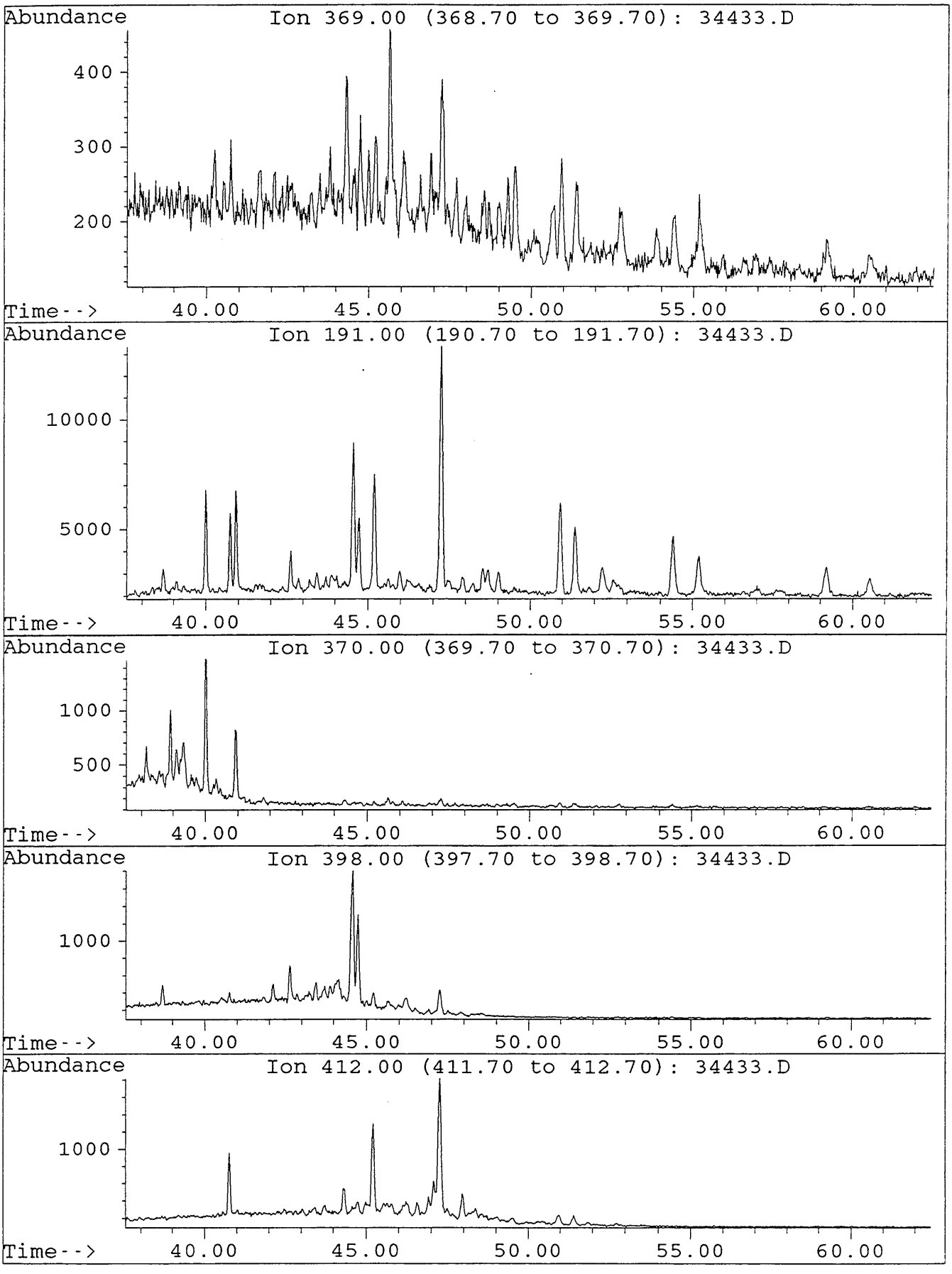


File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



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Sample : DIGBY#1, 1903.2m B/C
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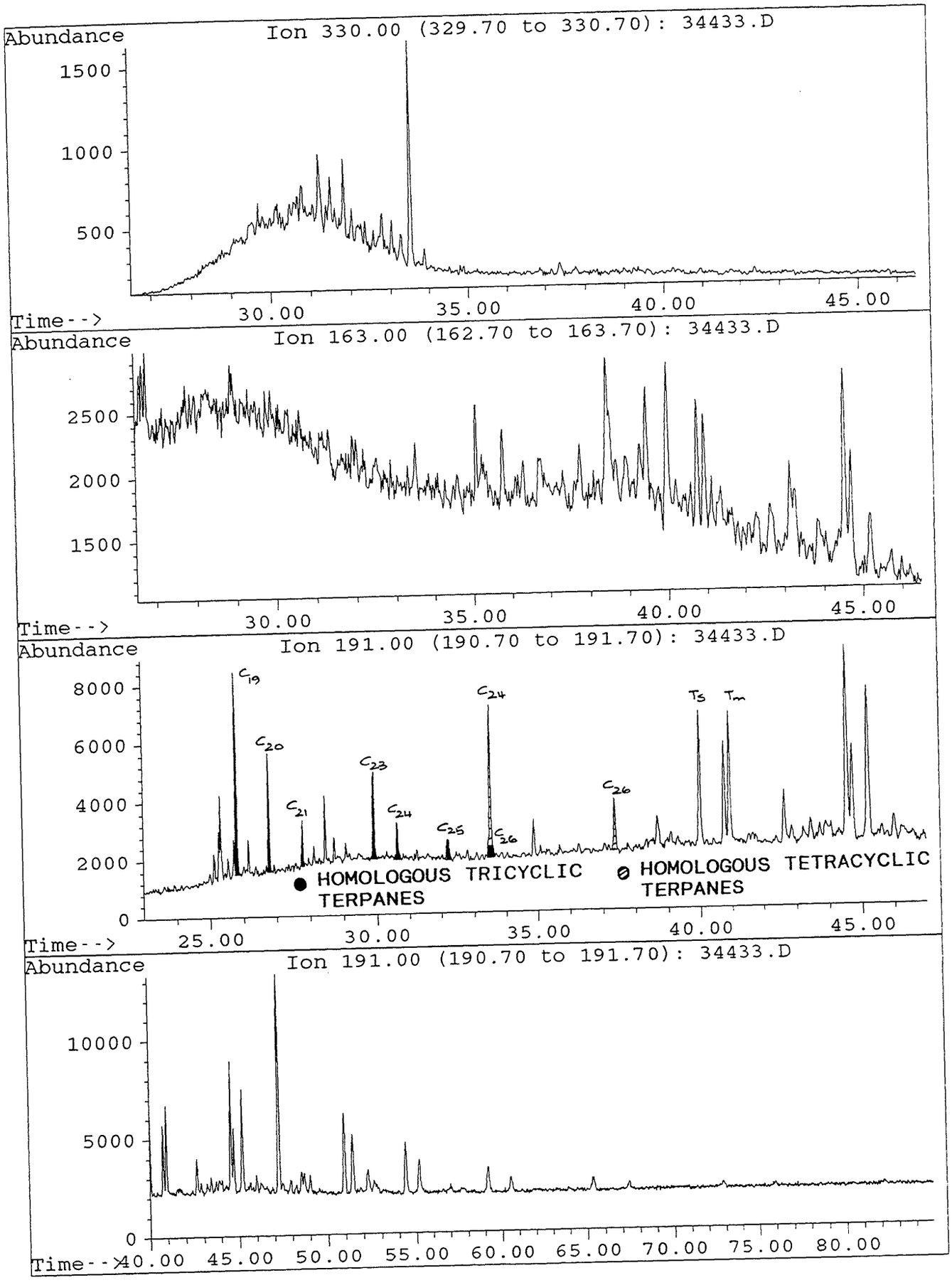

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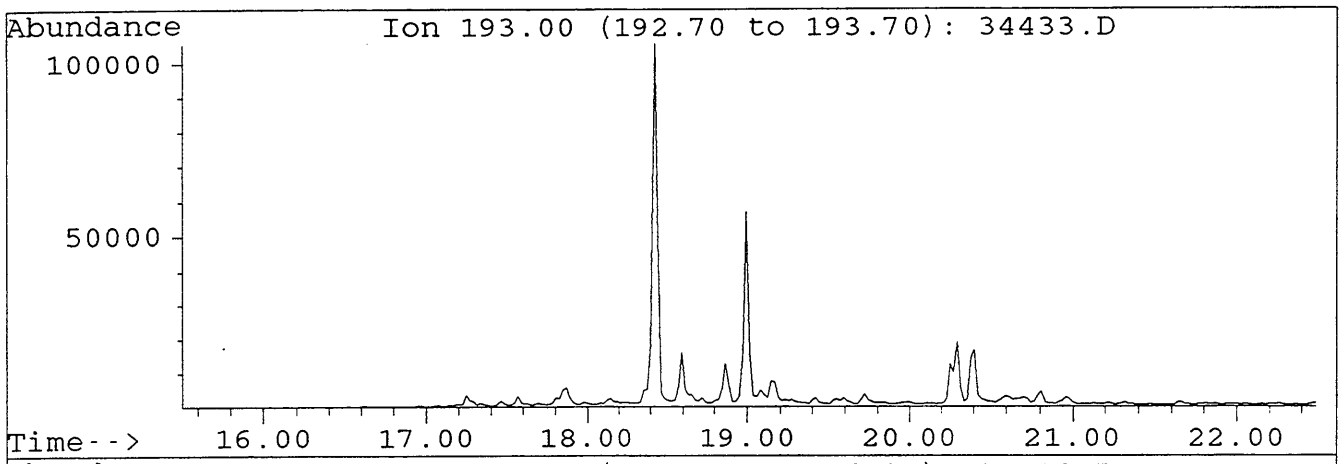

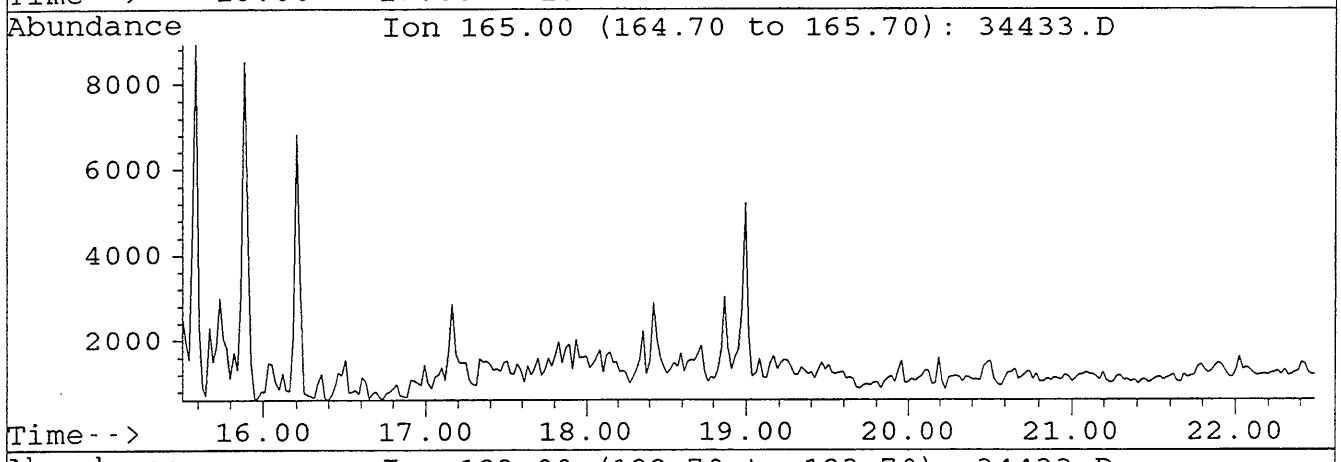

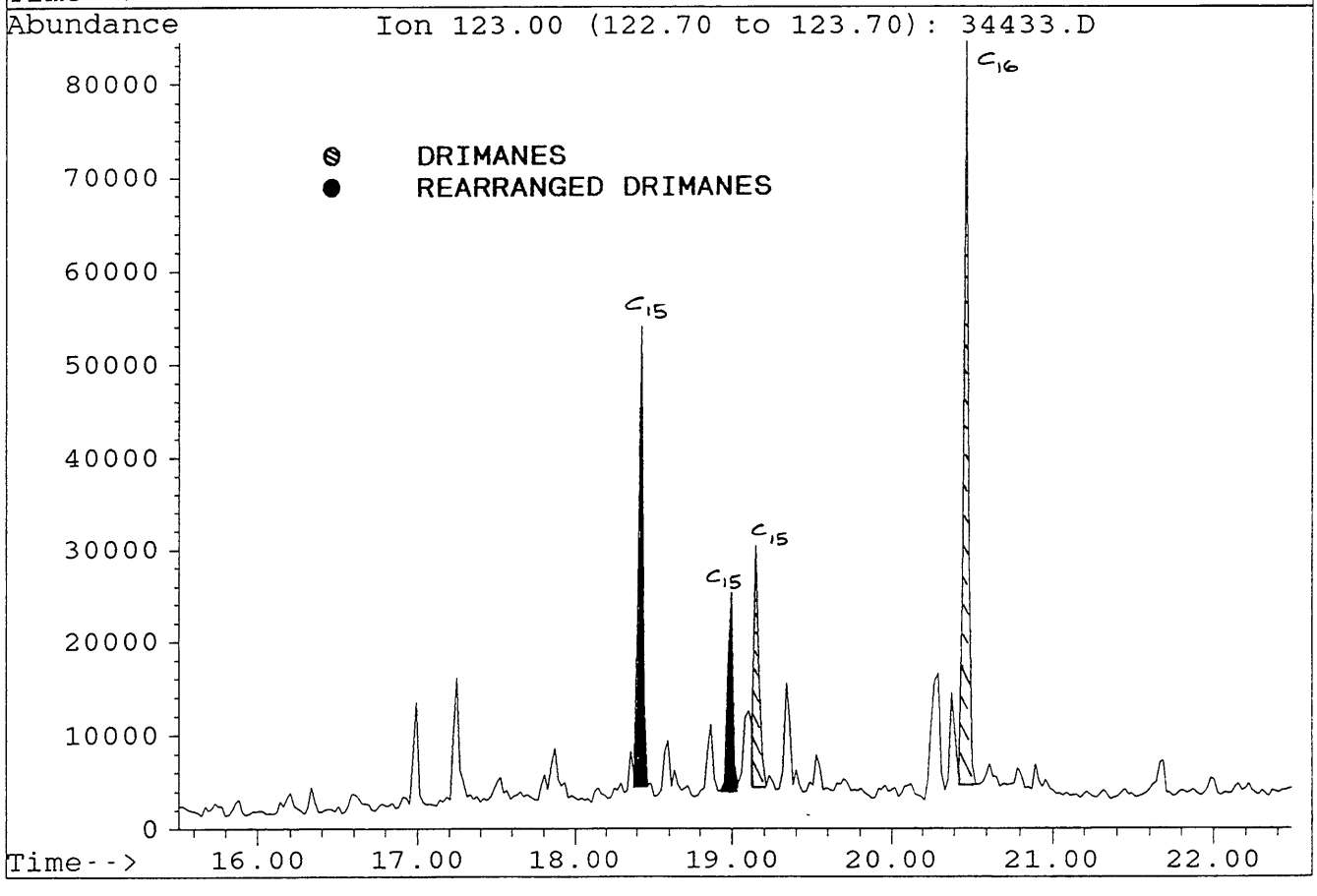

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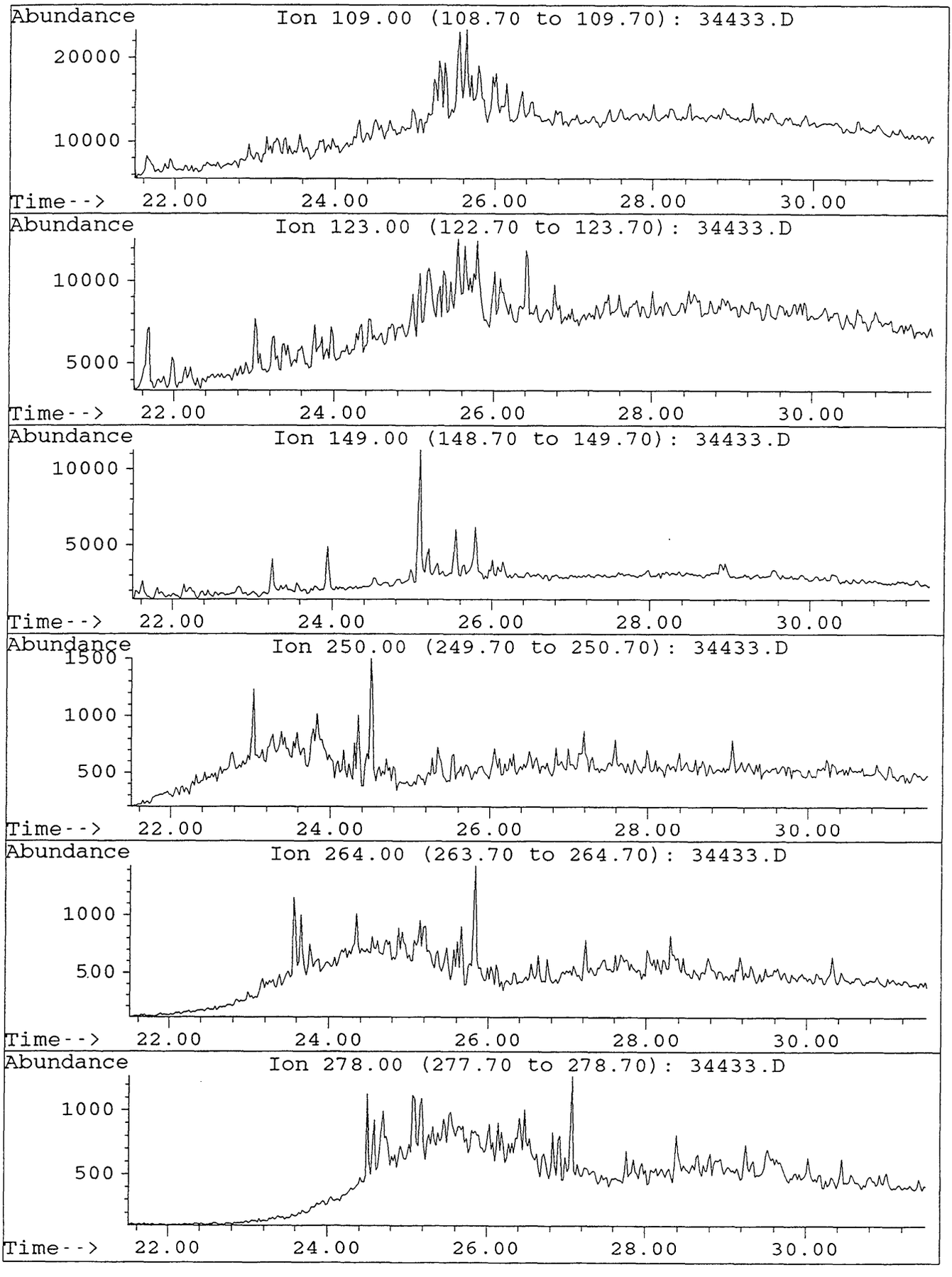

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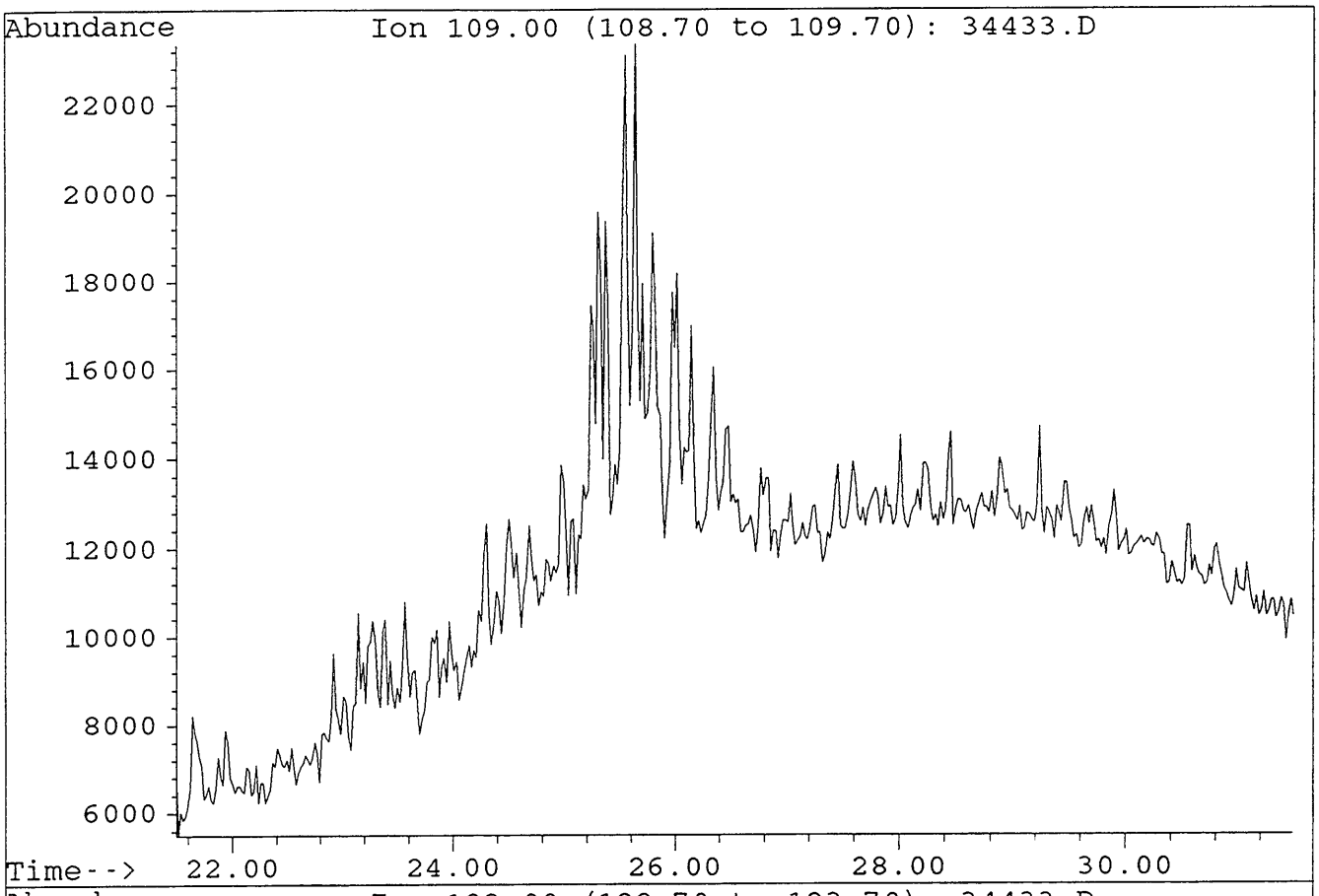

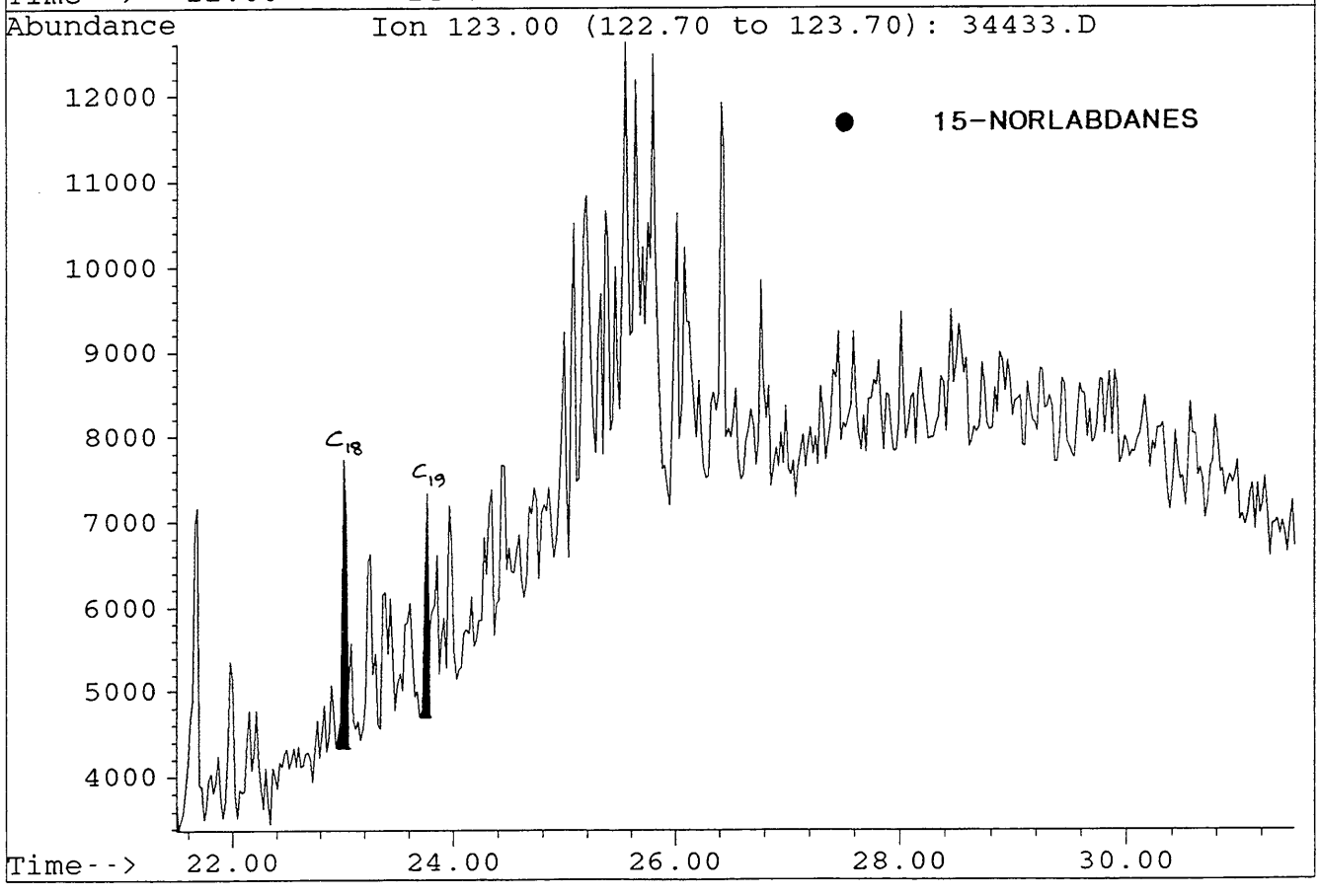

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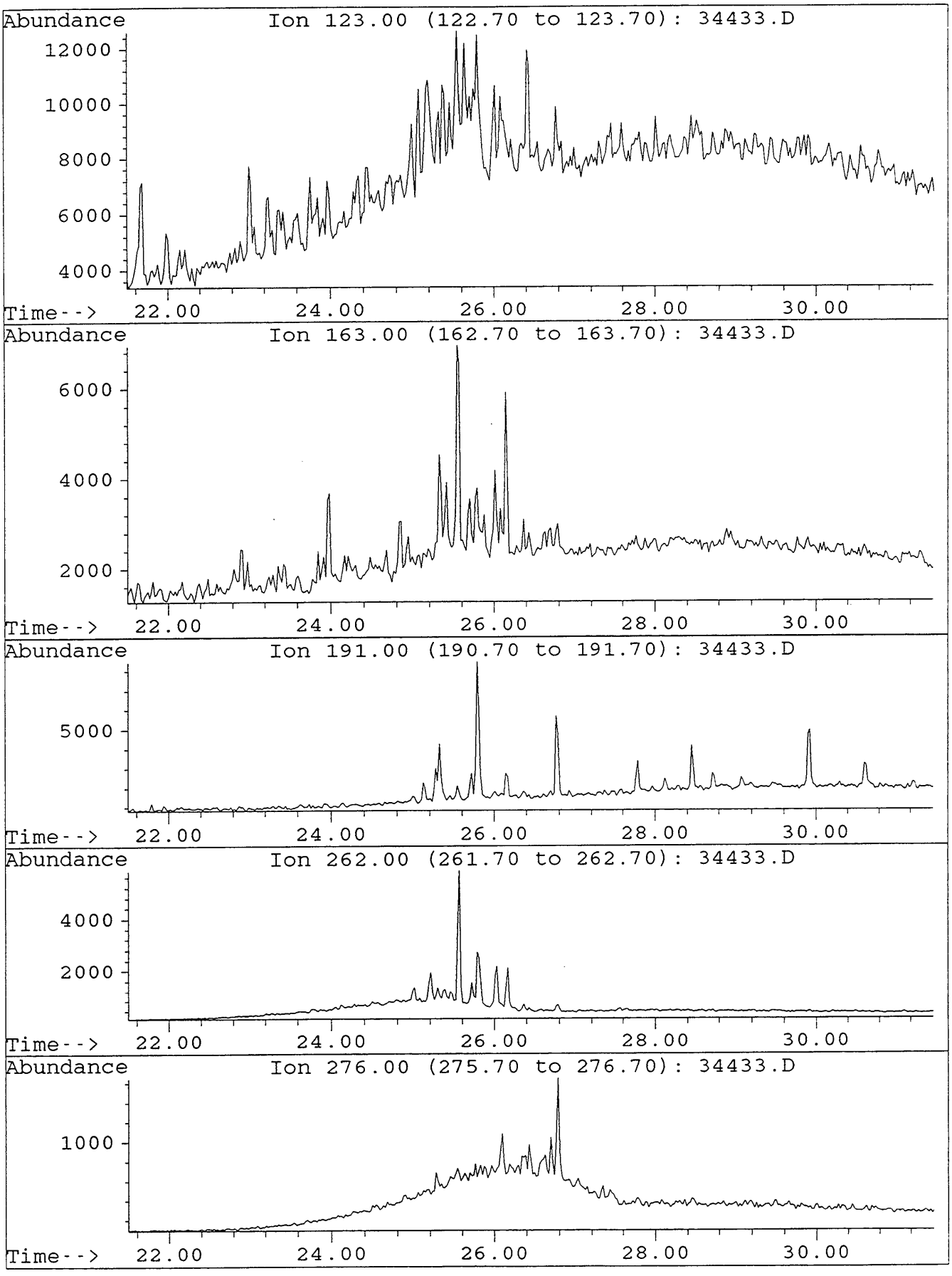

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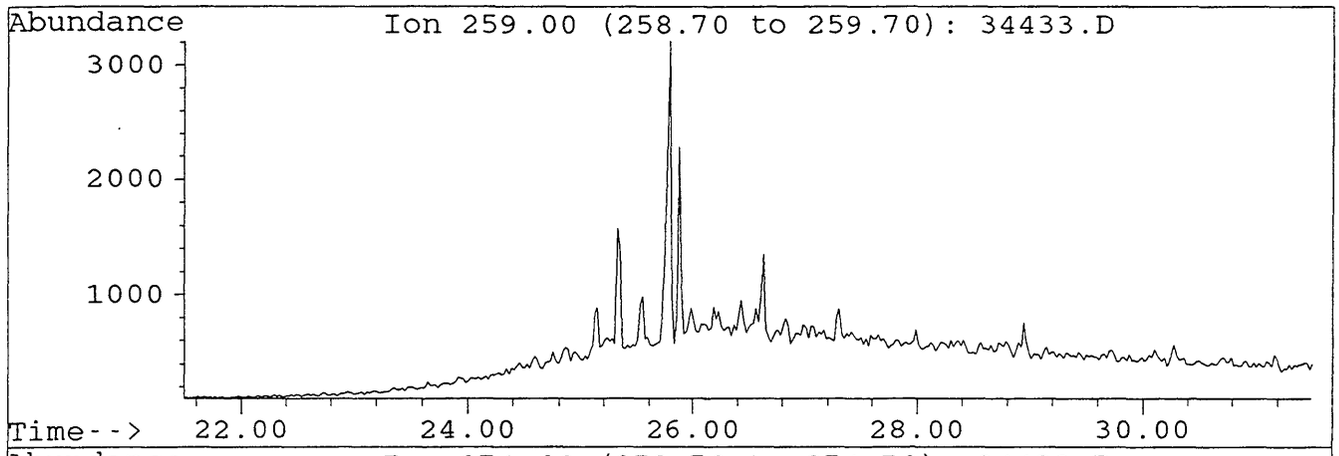

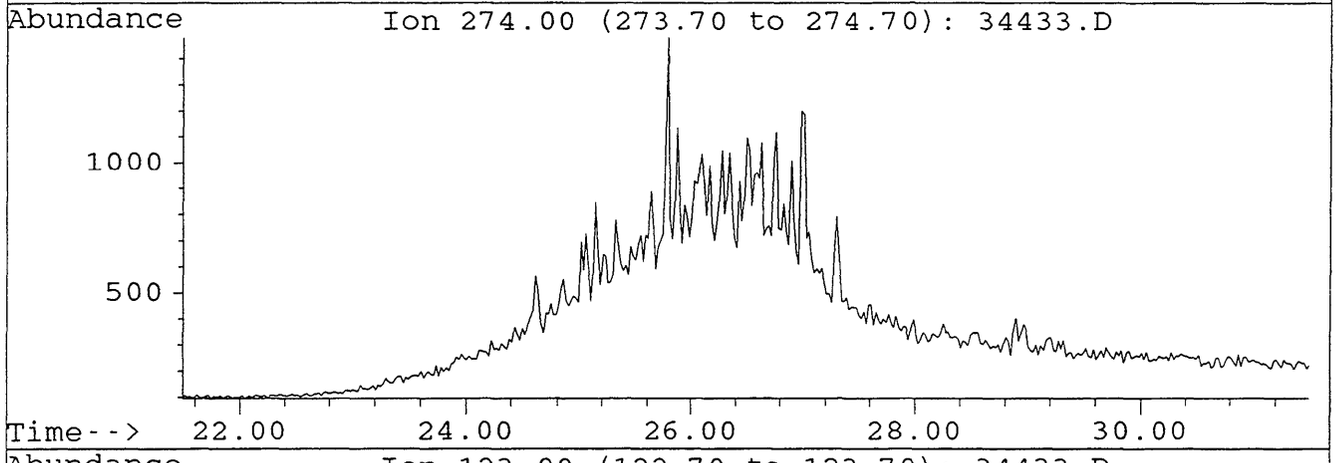

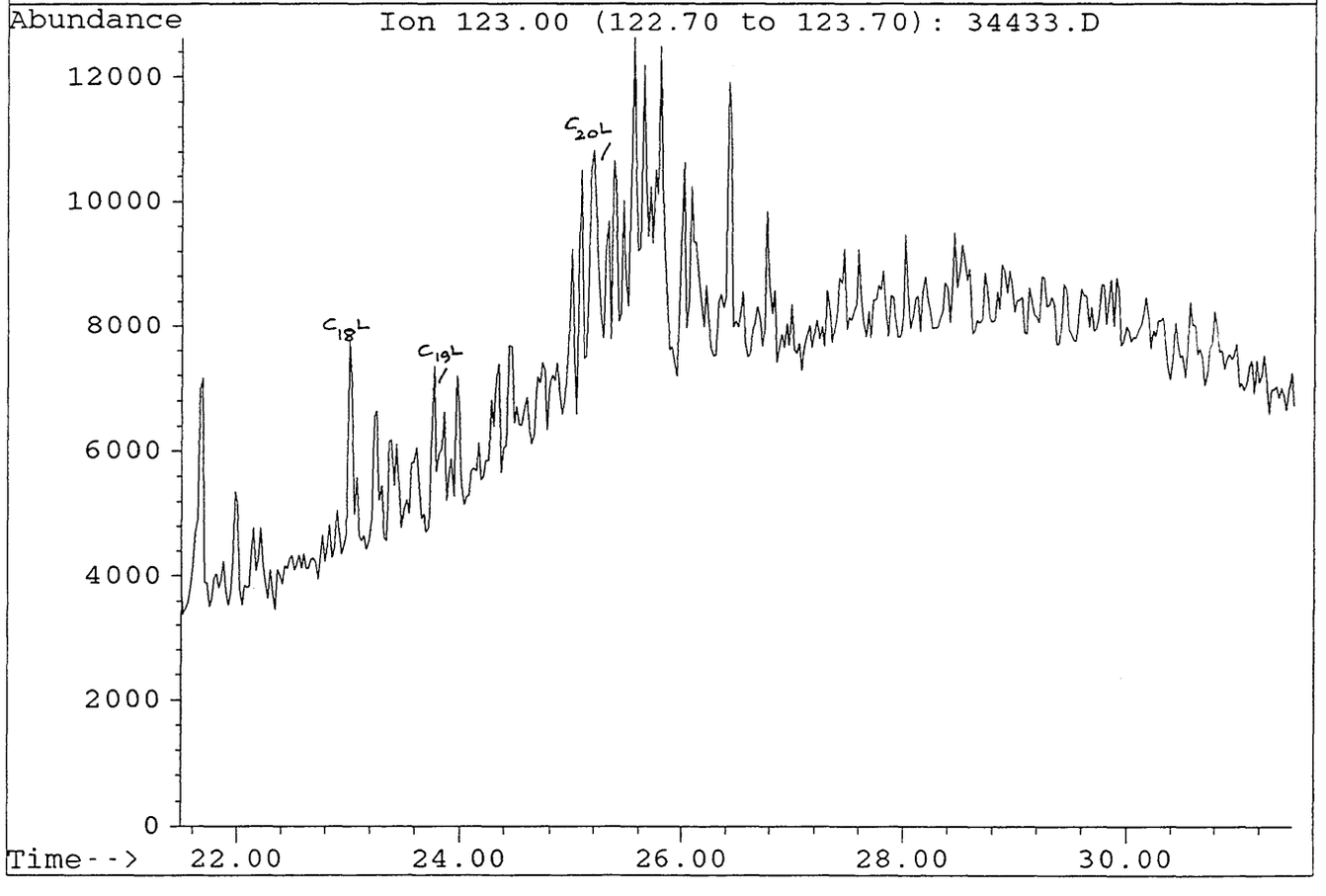

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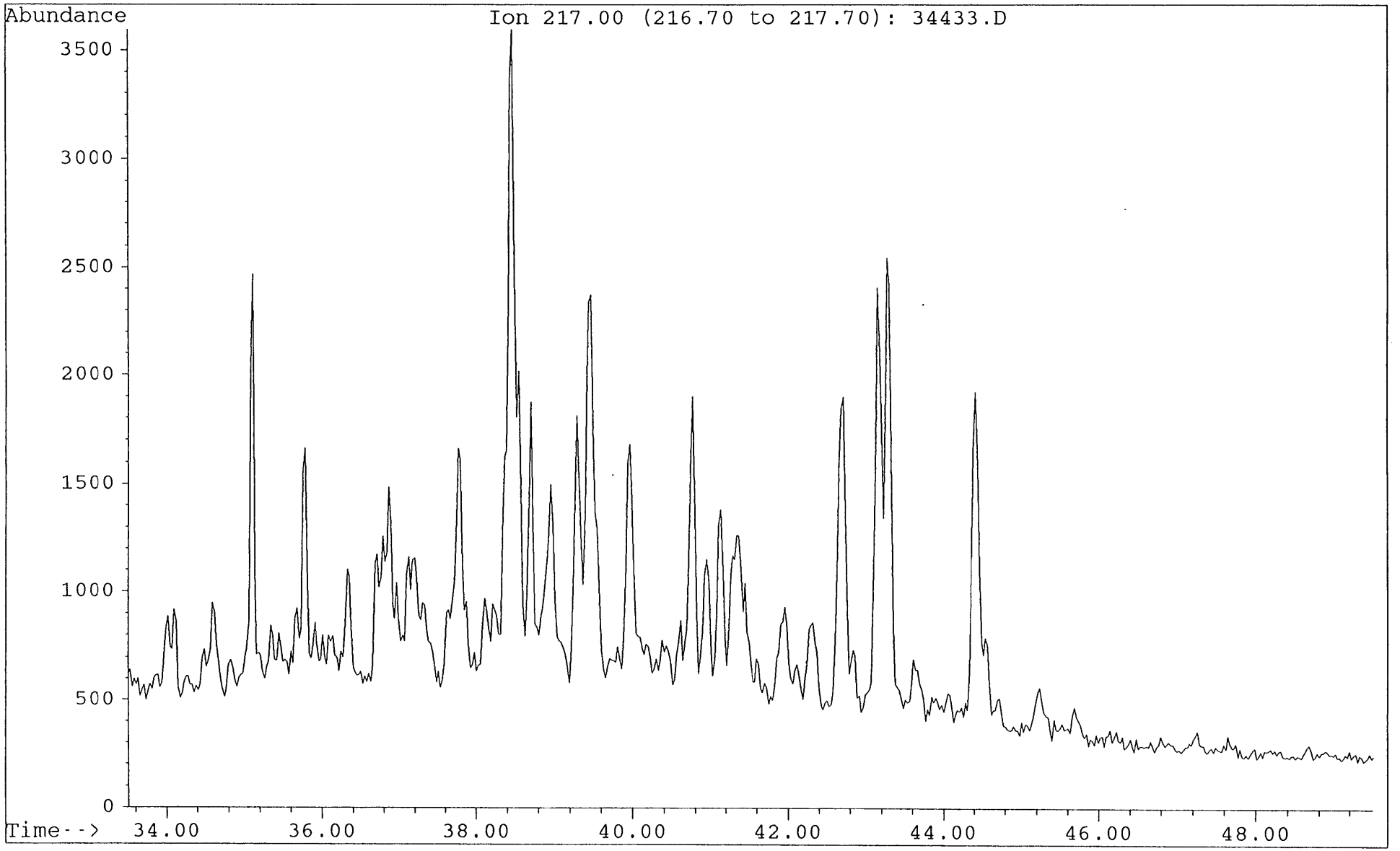
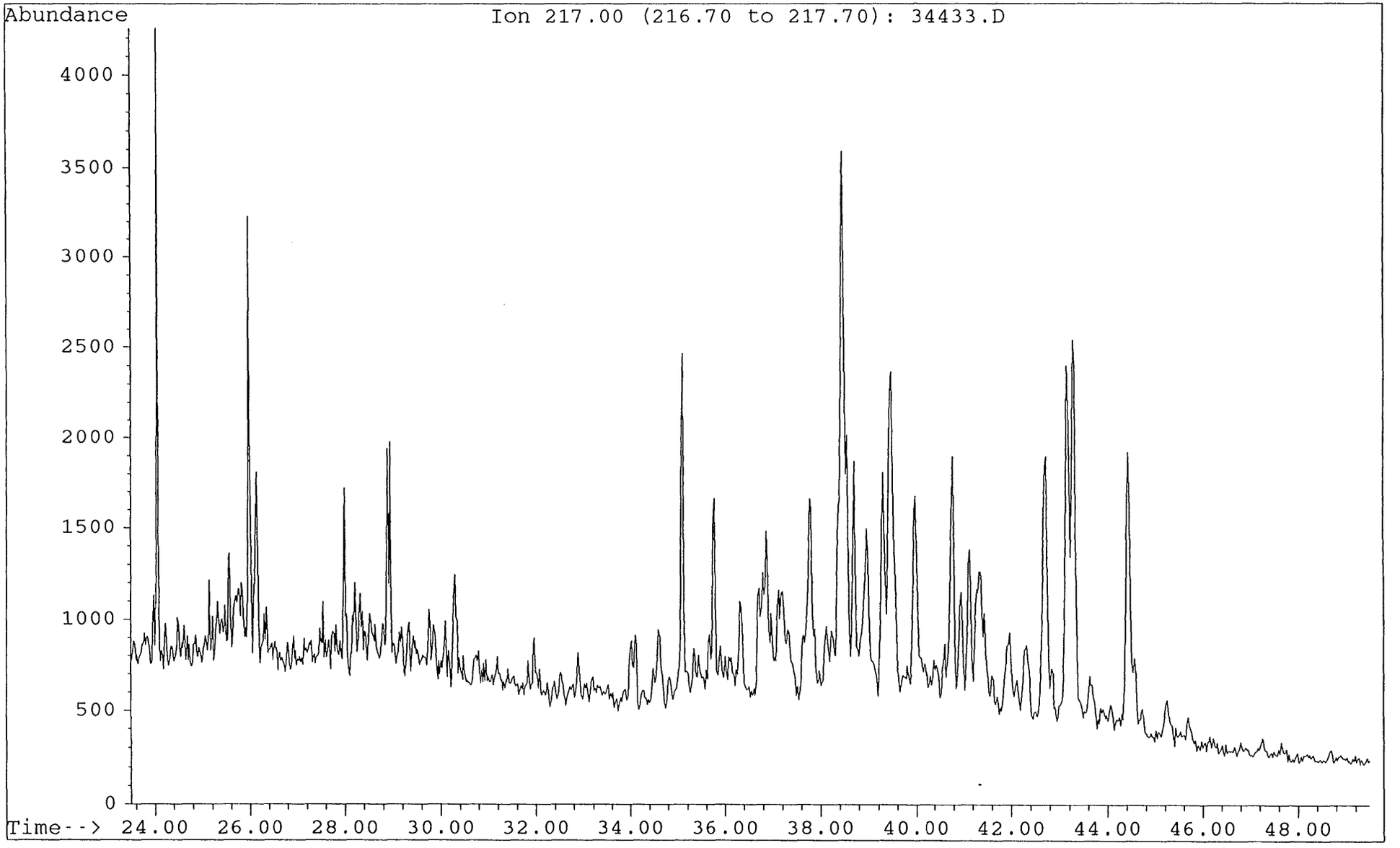
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



File : 34433.D
Sample : DIGBY#1, 1903.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



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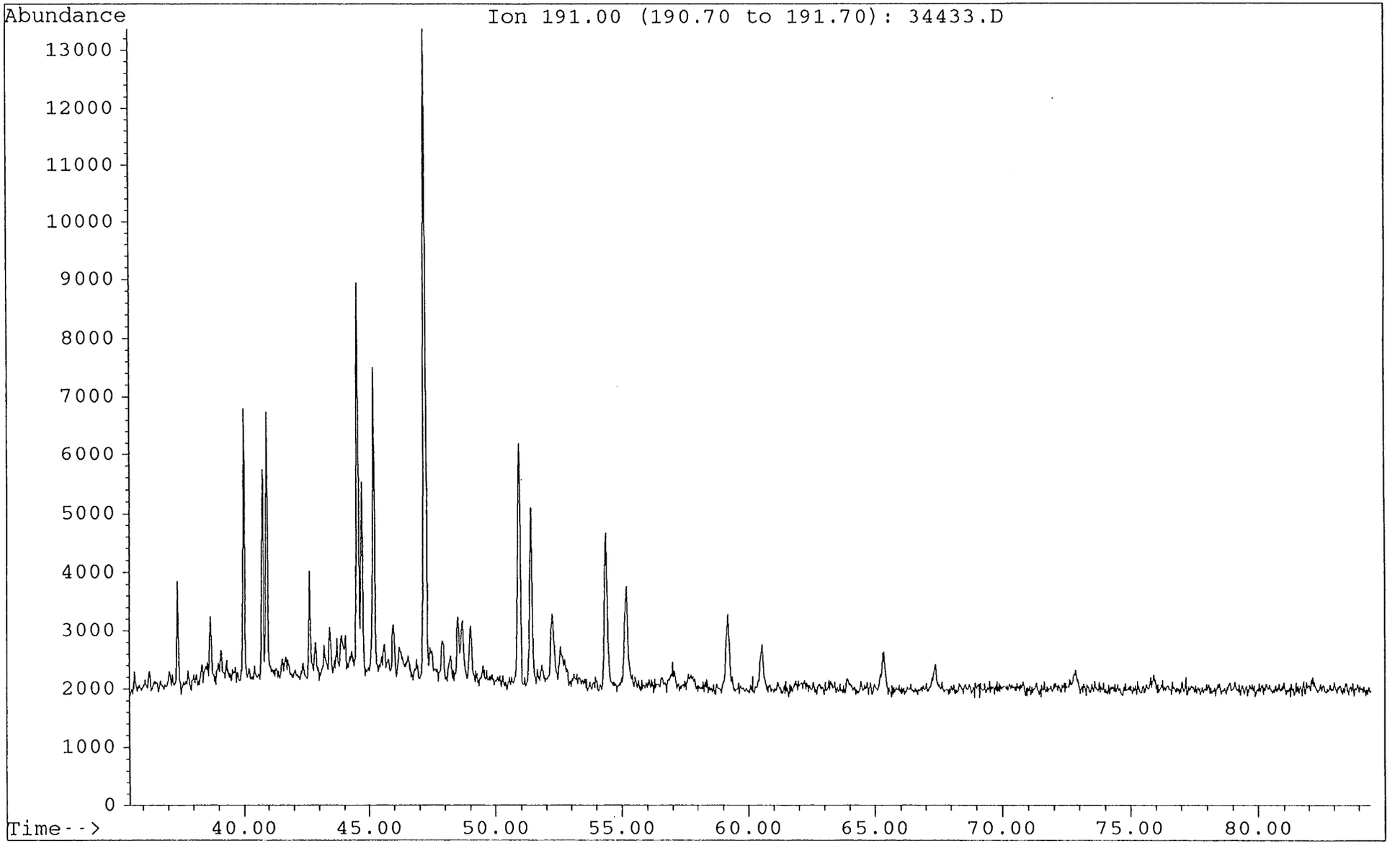

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Sample : DIGBY#1, 1903.2m B/C
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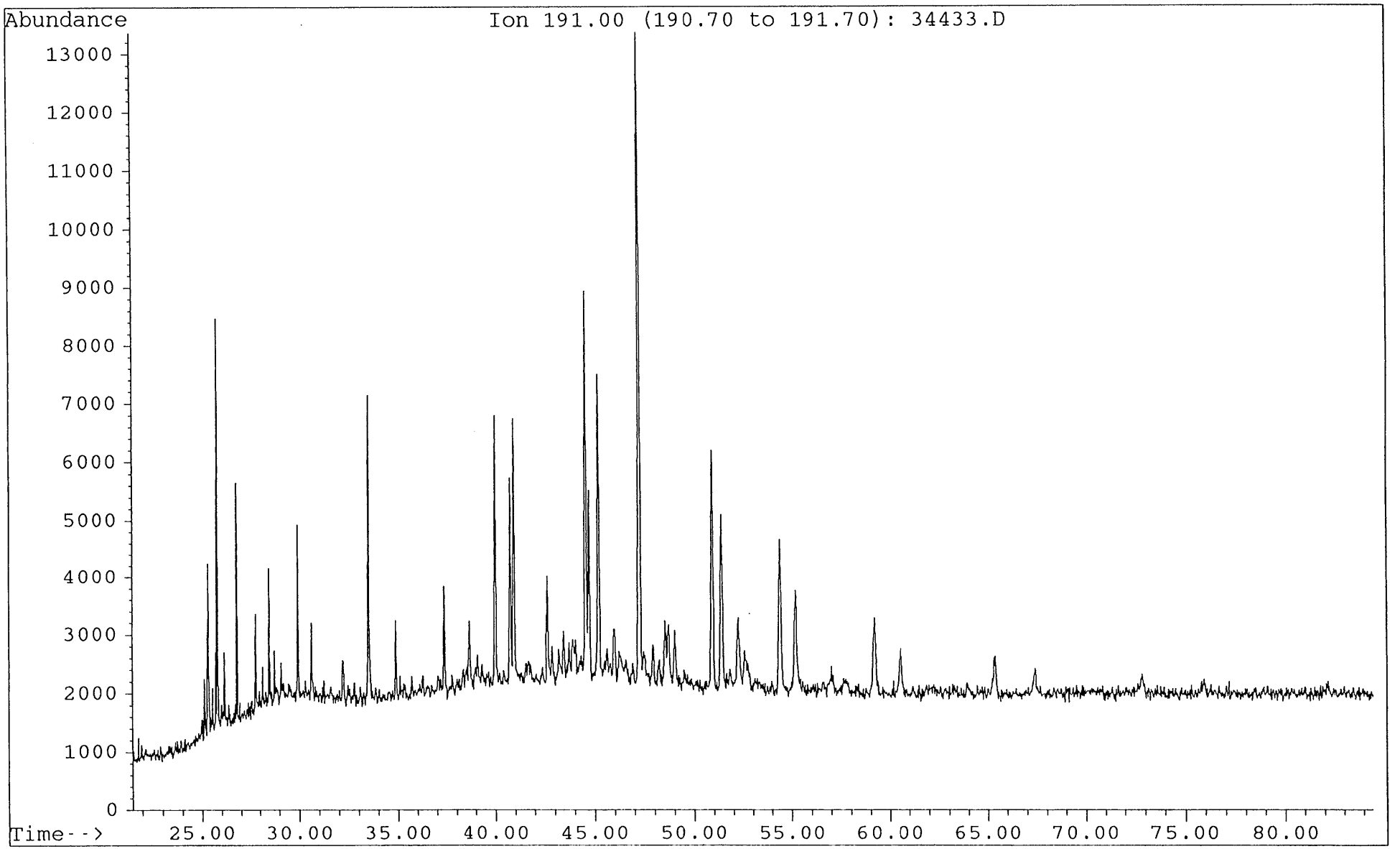
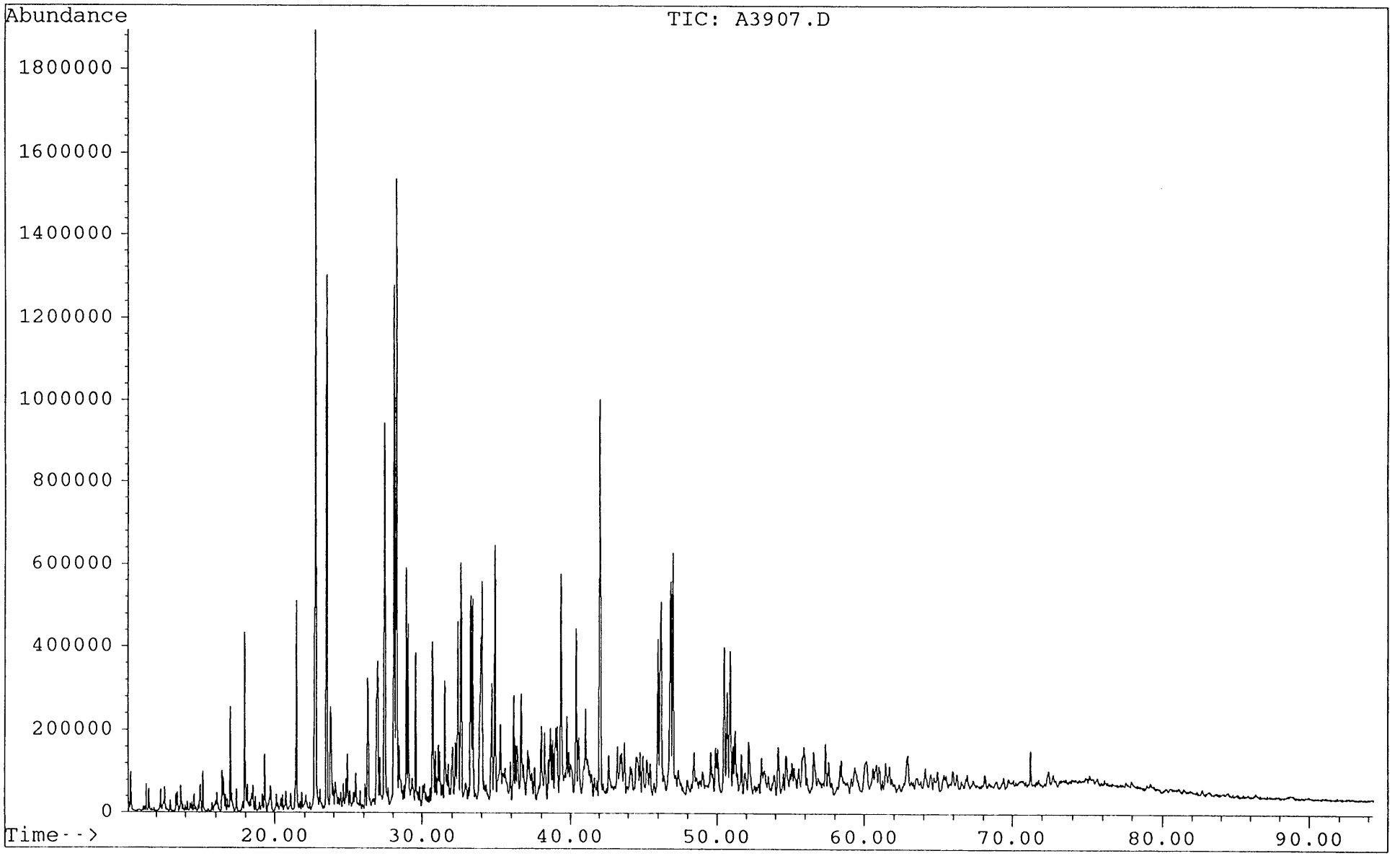


File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

FIGURE 8-2



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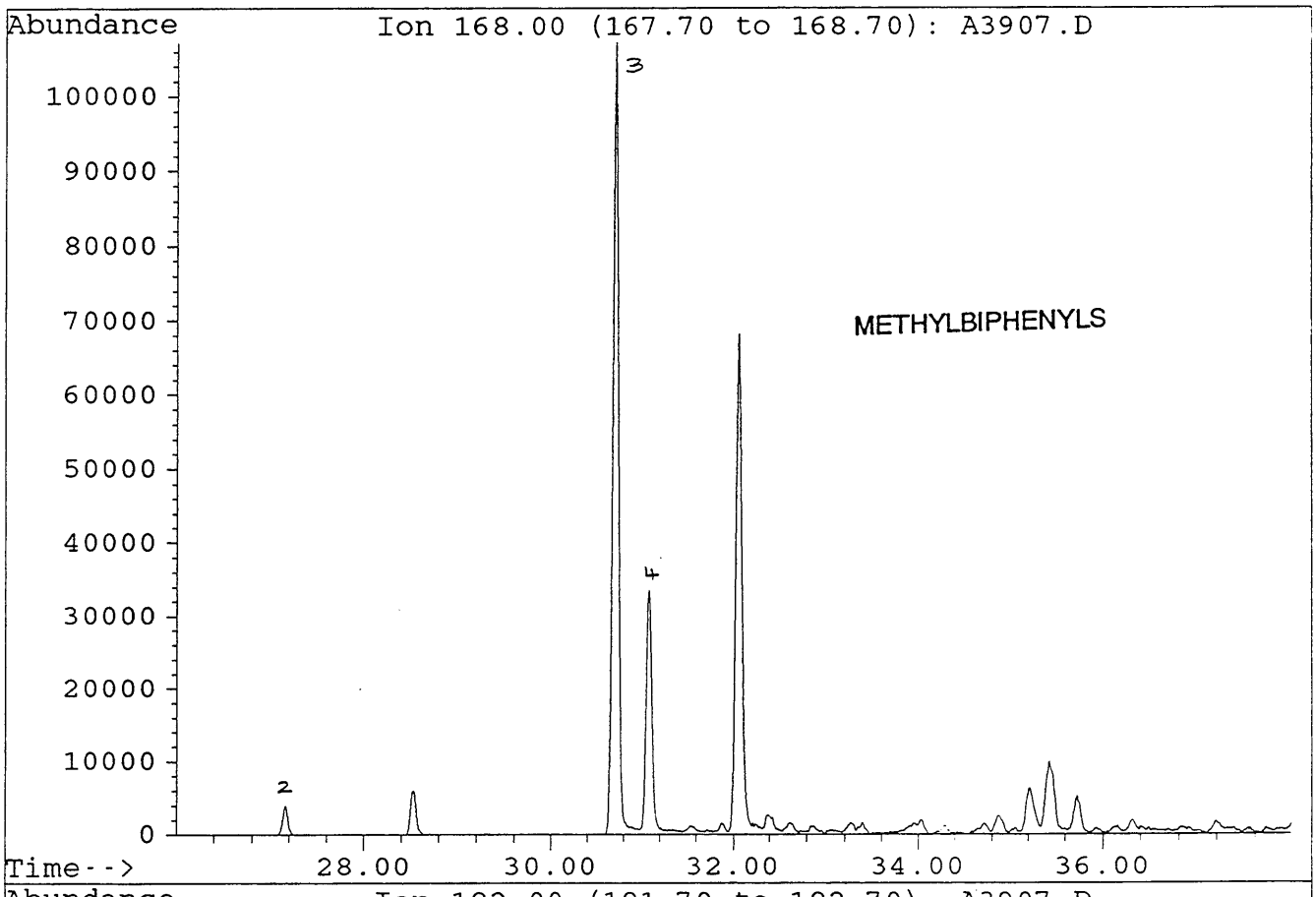
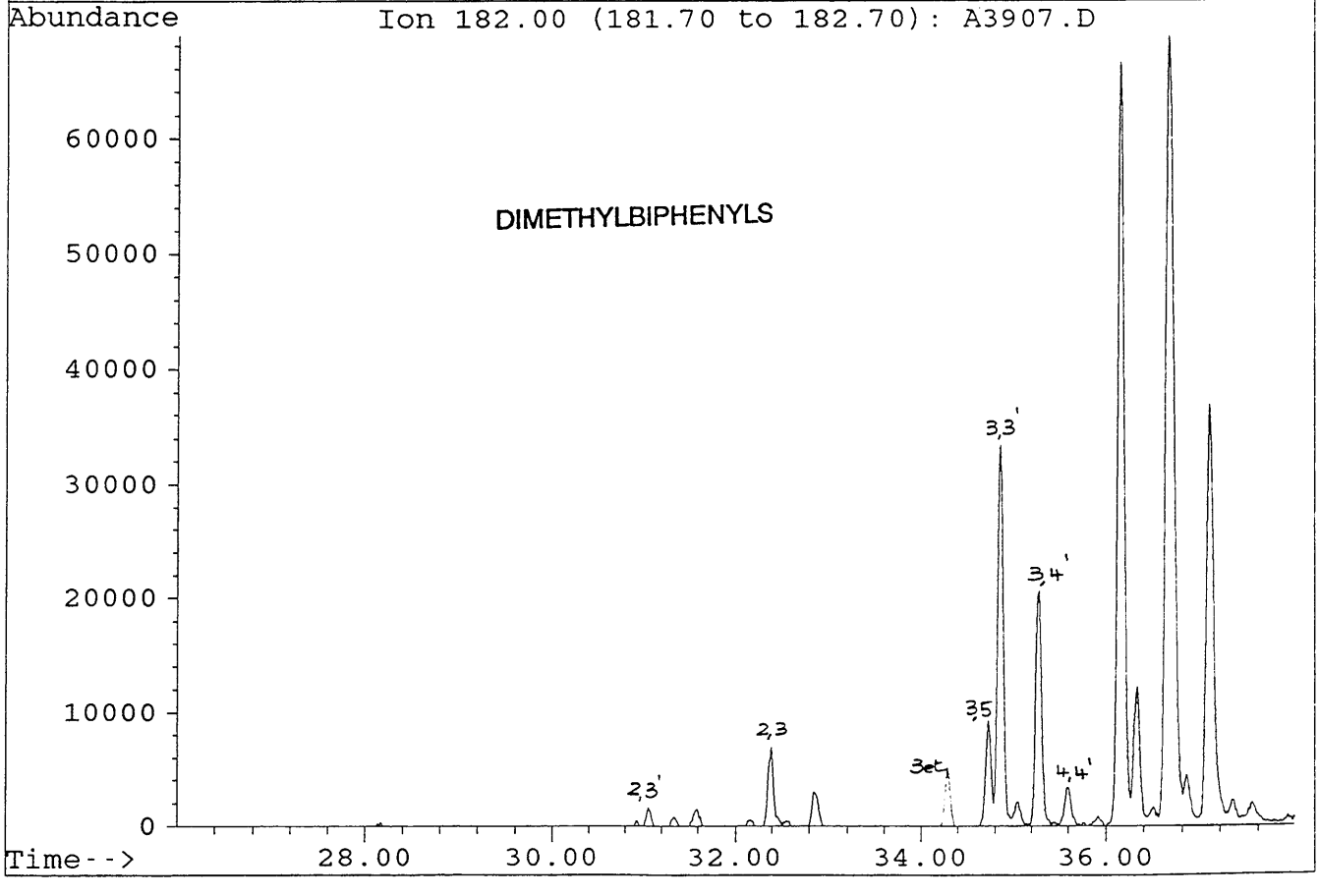
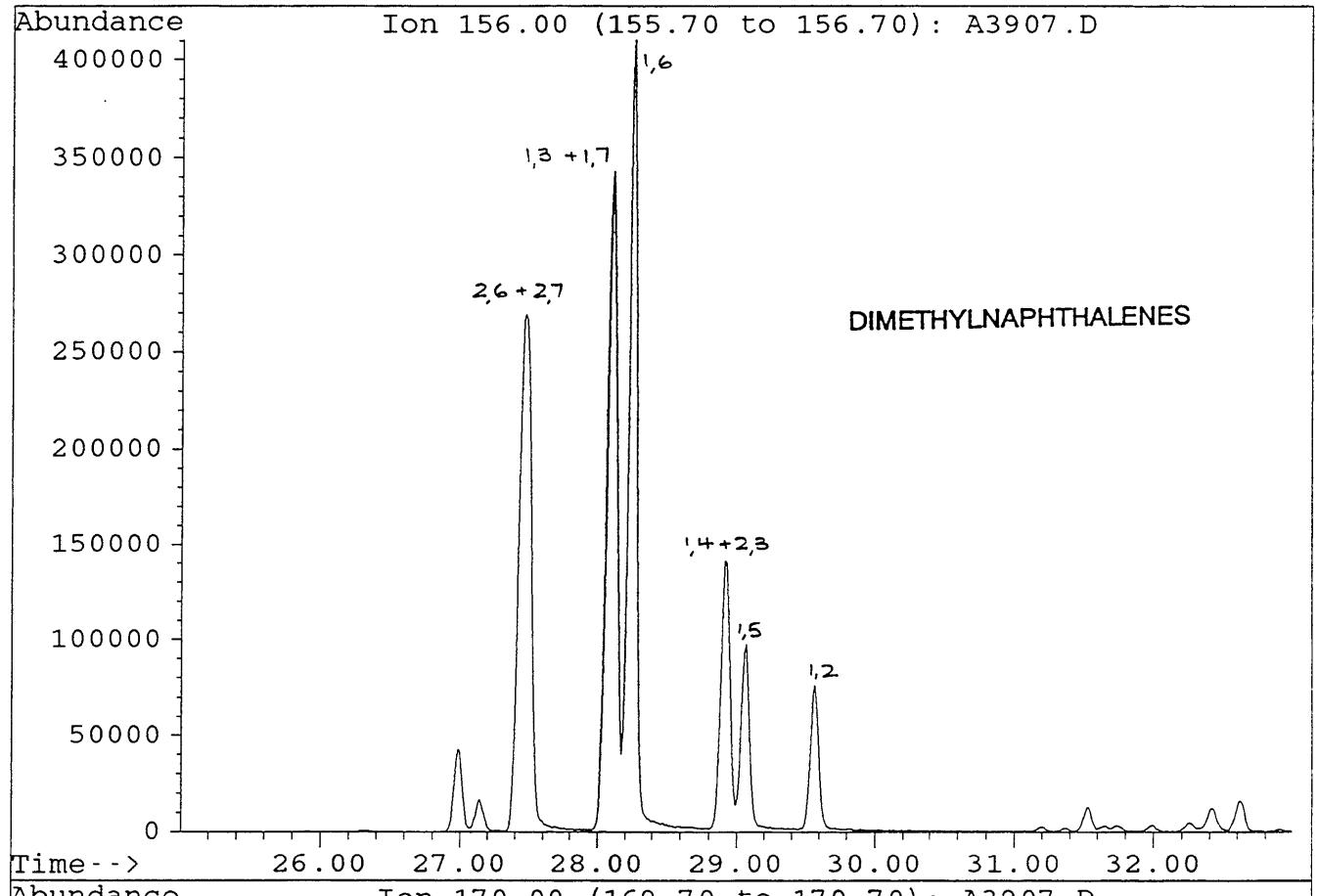
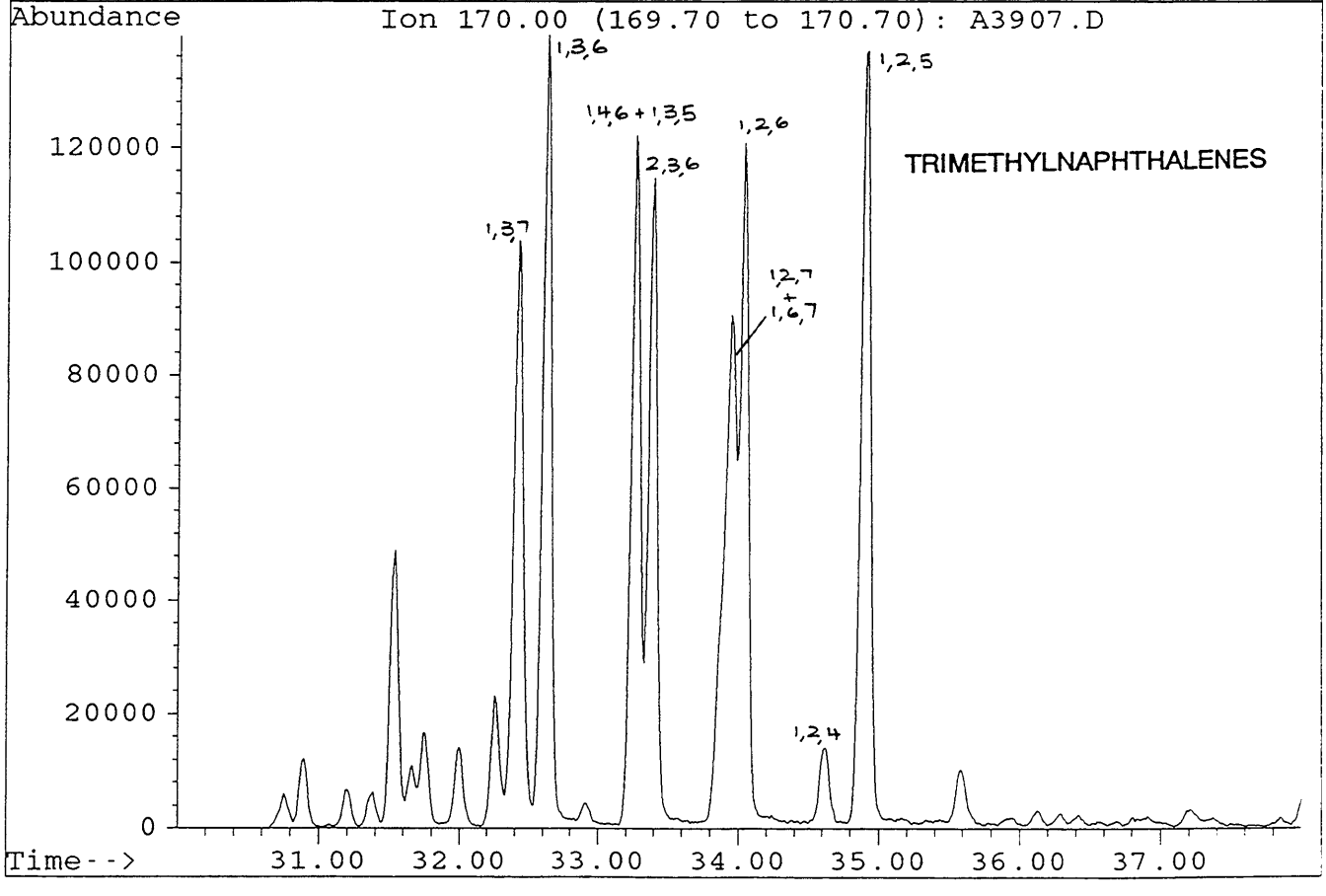
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.





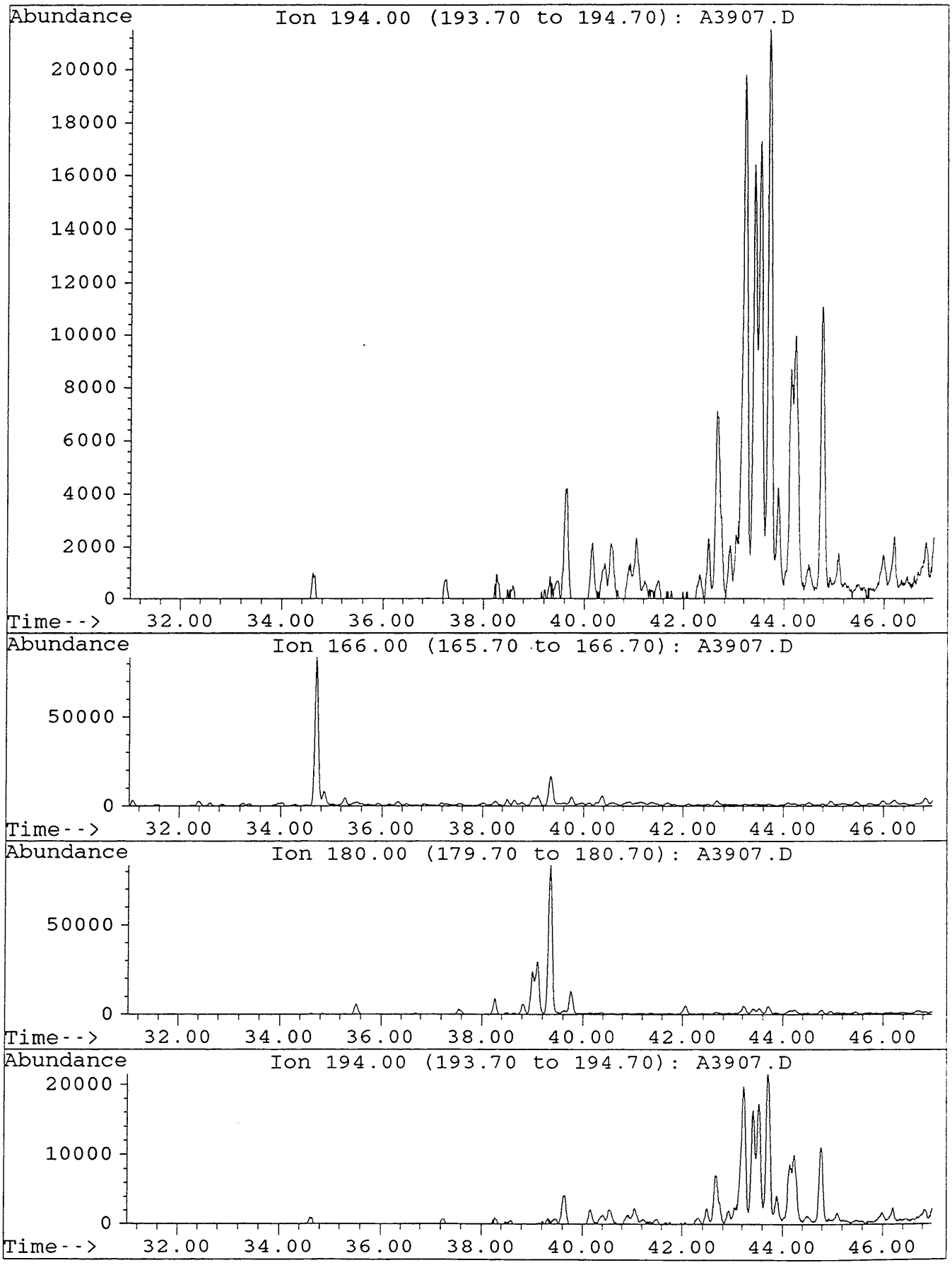
File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.



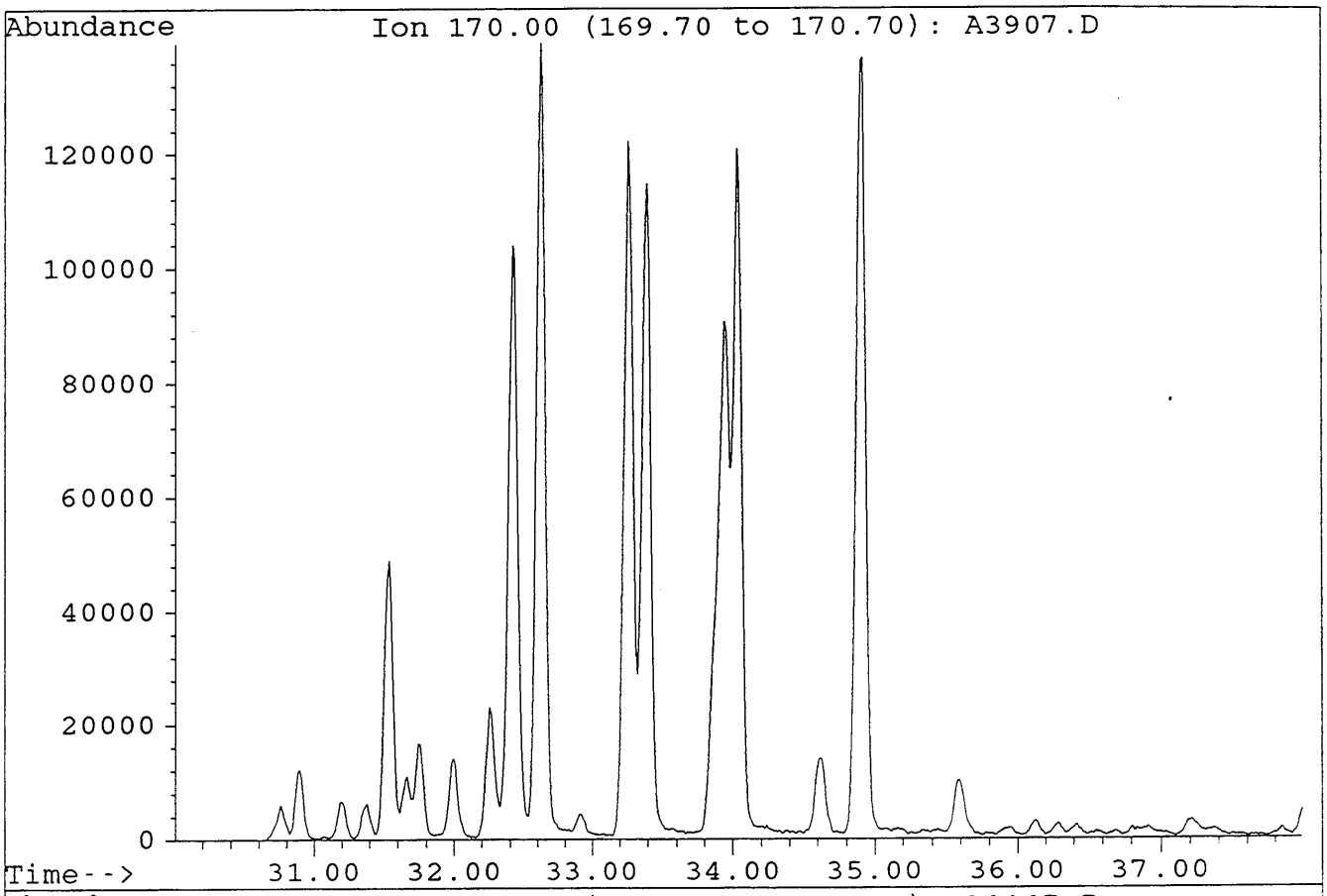


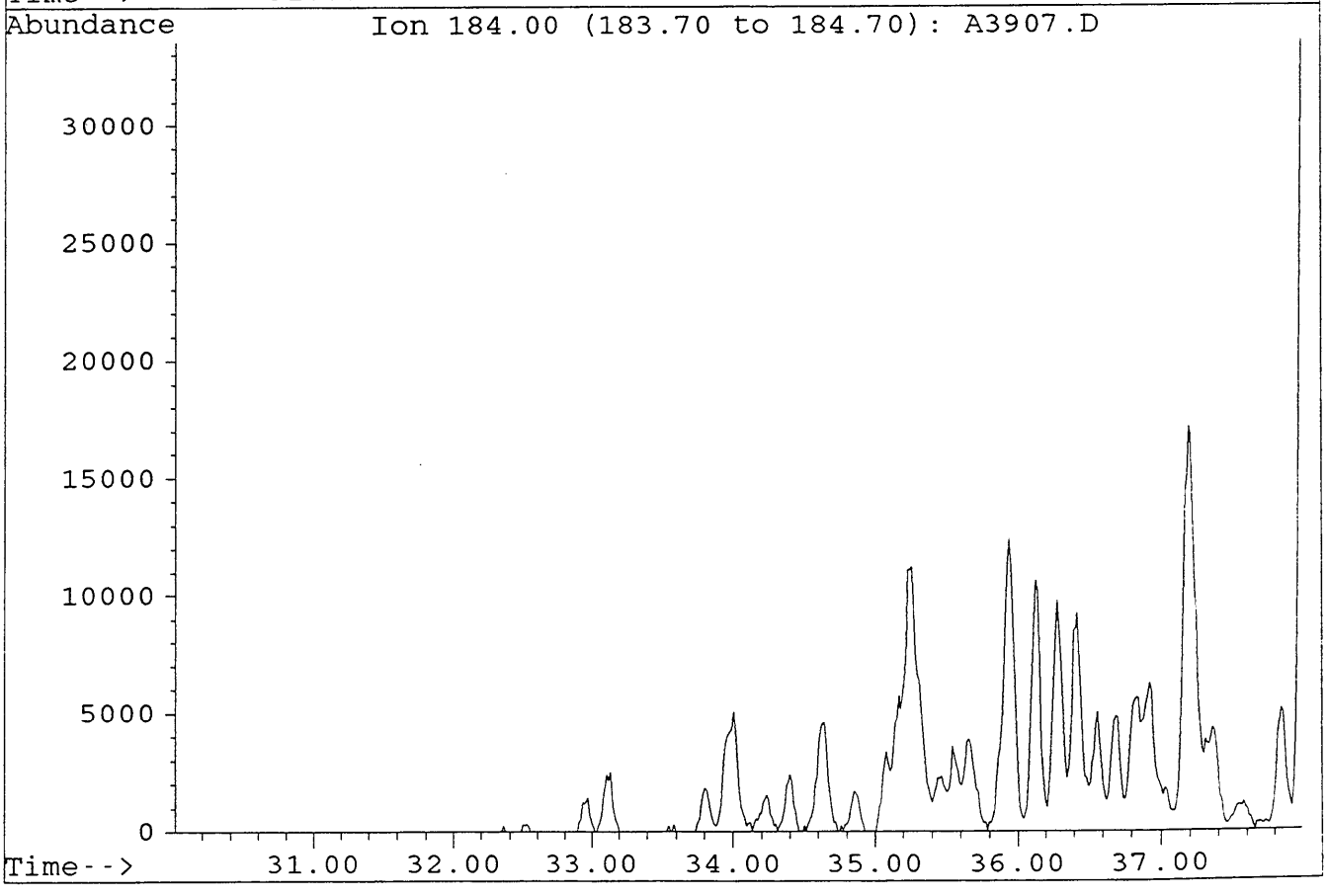
File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

FLUORENES

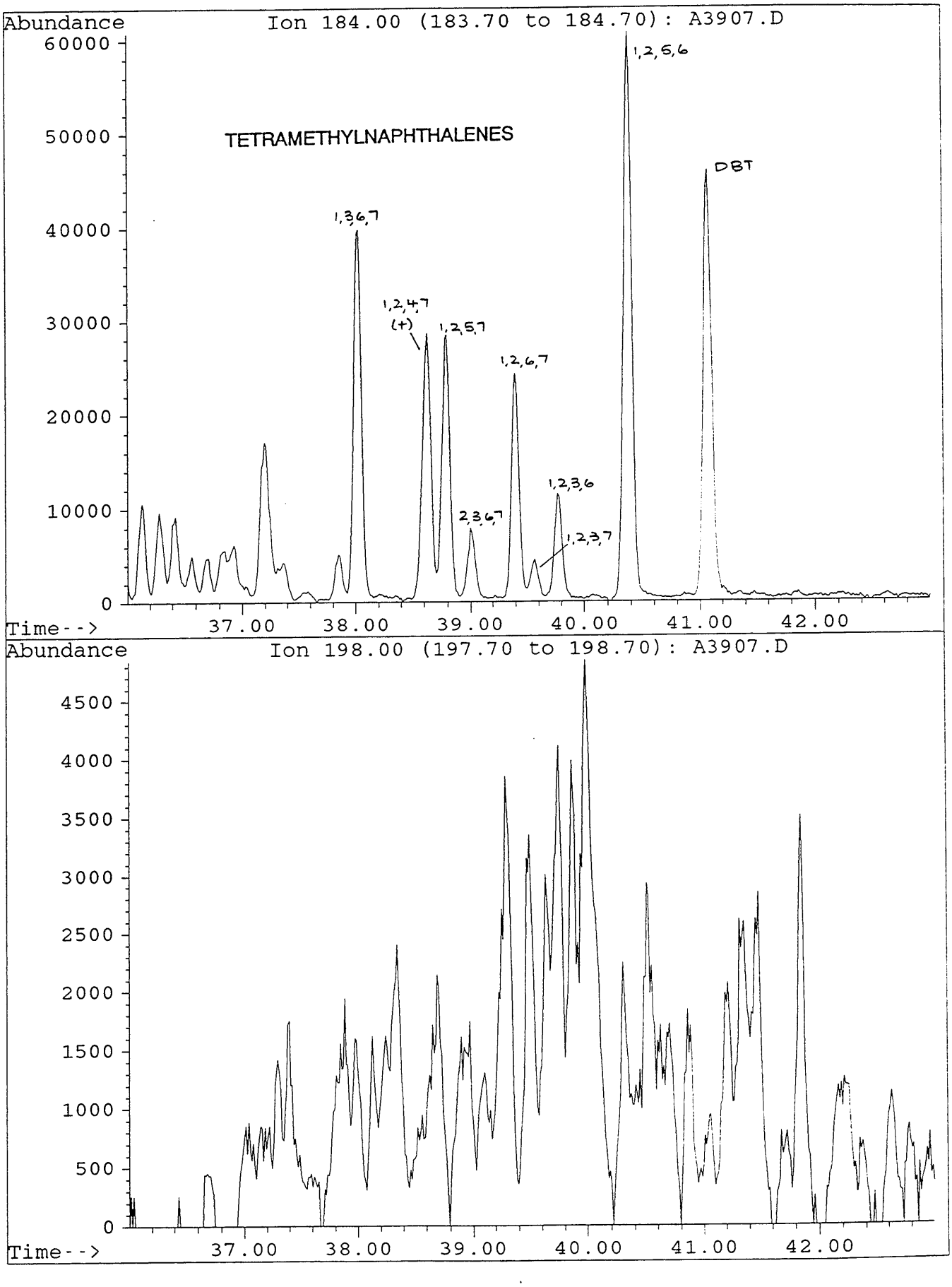


File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

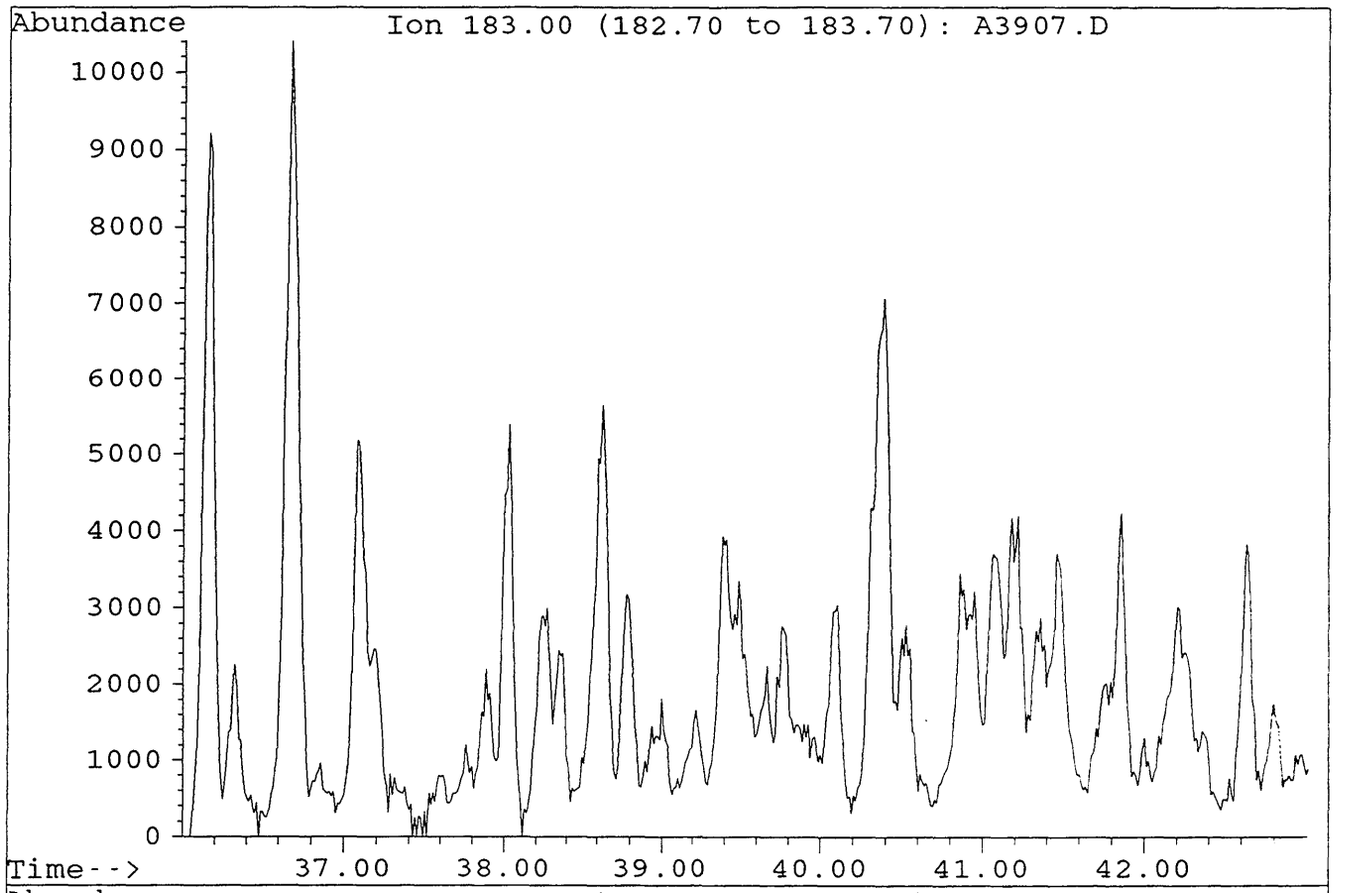


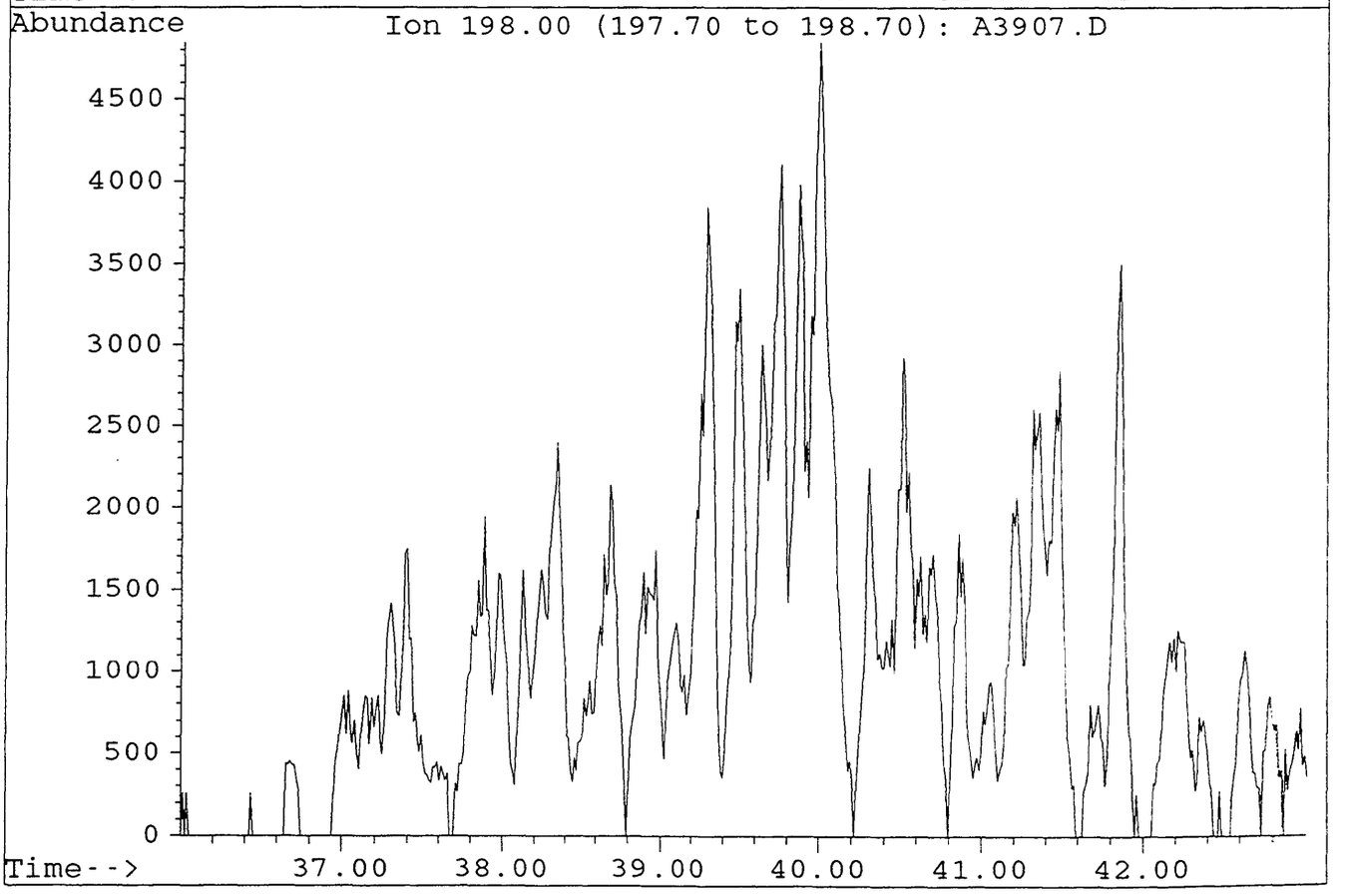


File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

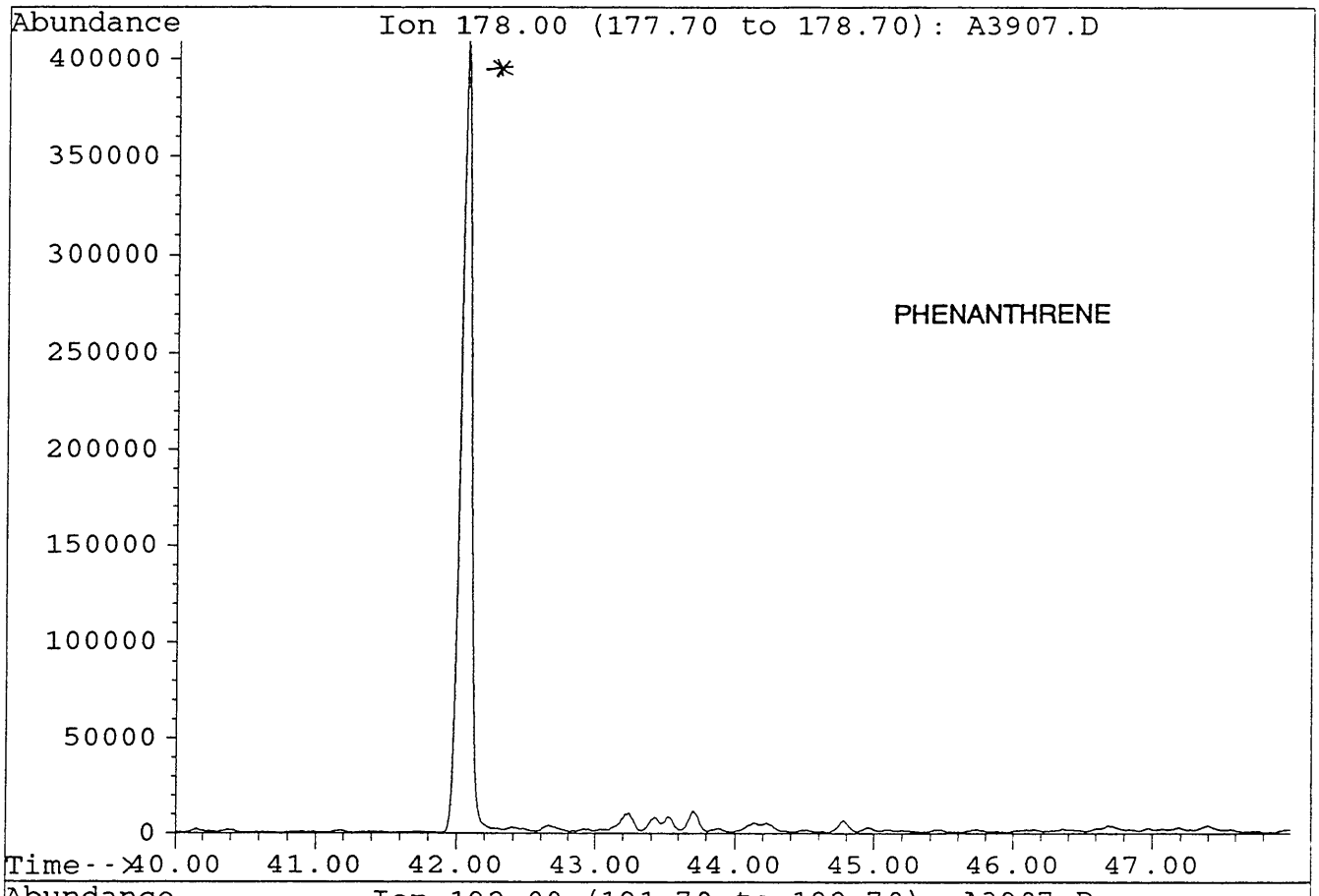


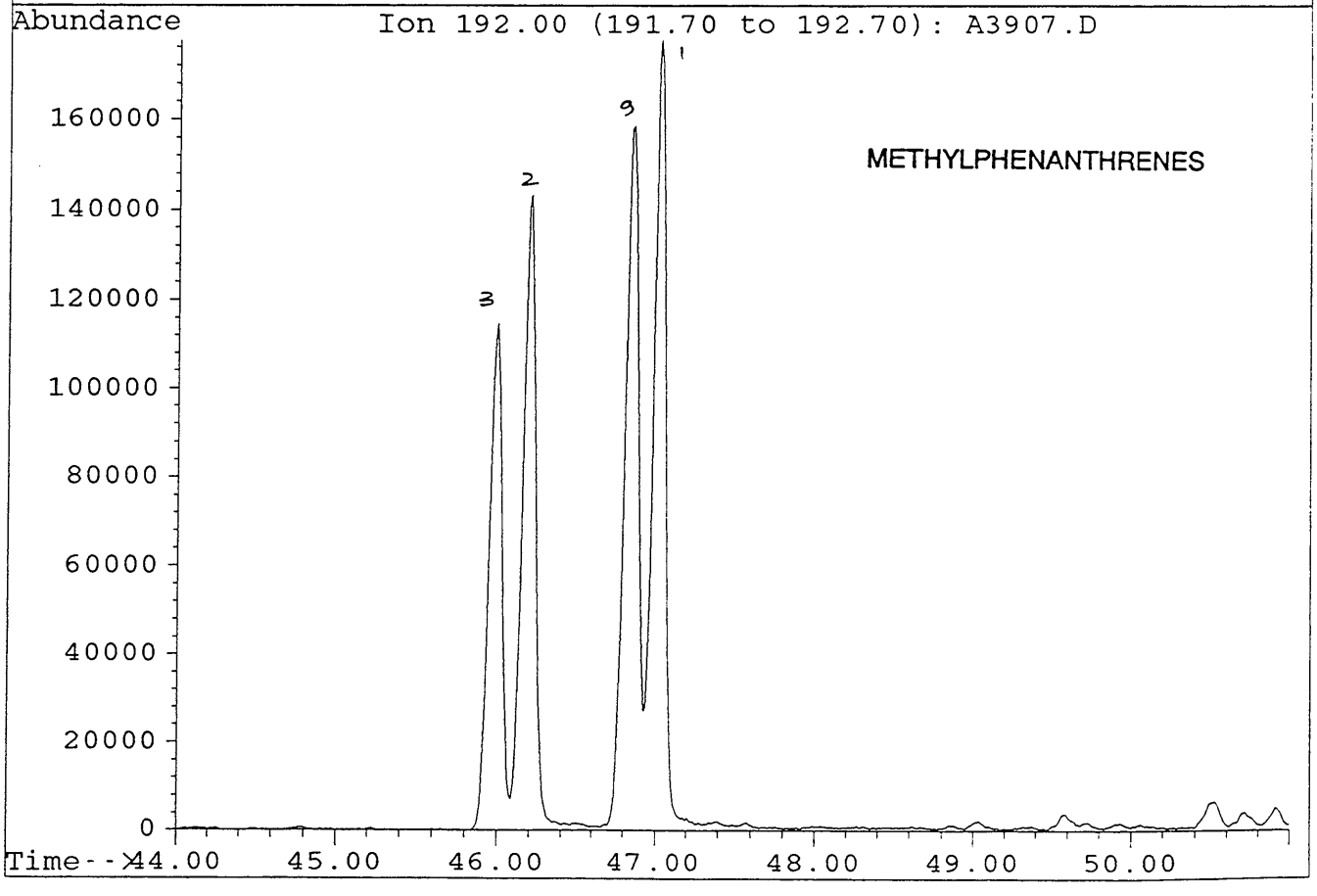
File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.



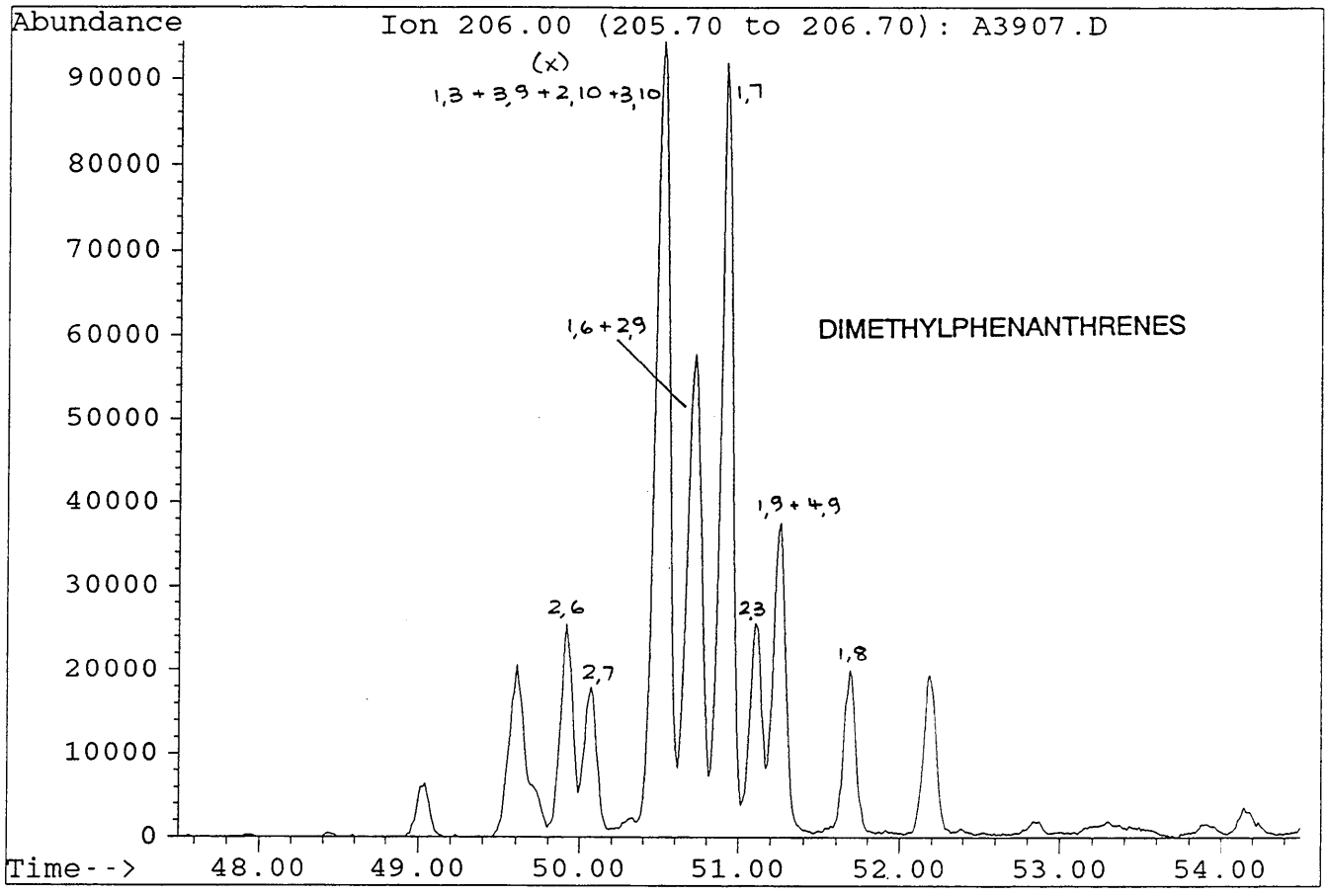


File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

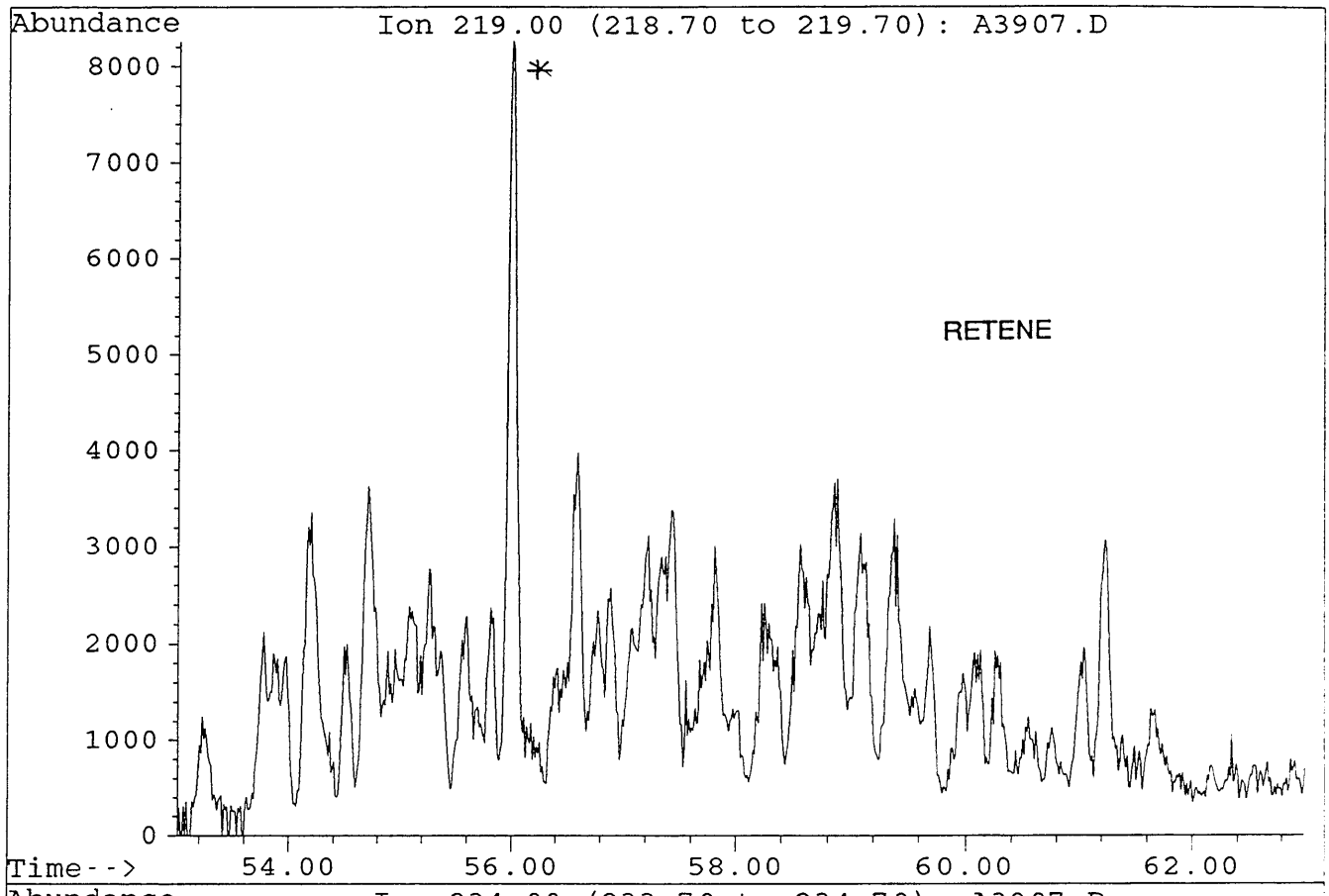




File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.



File : A3907.D
Sample : DIGBY#1, 1903.2m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.



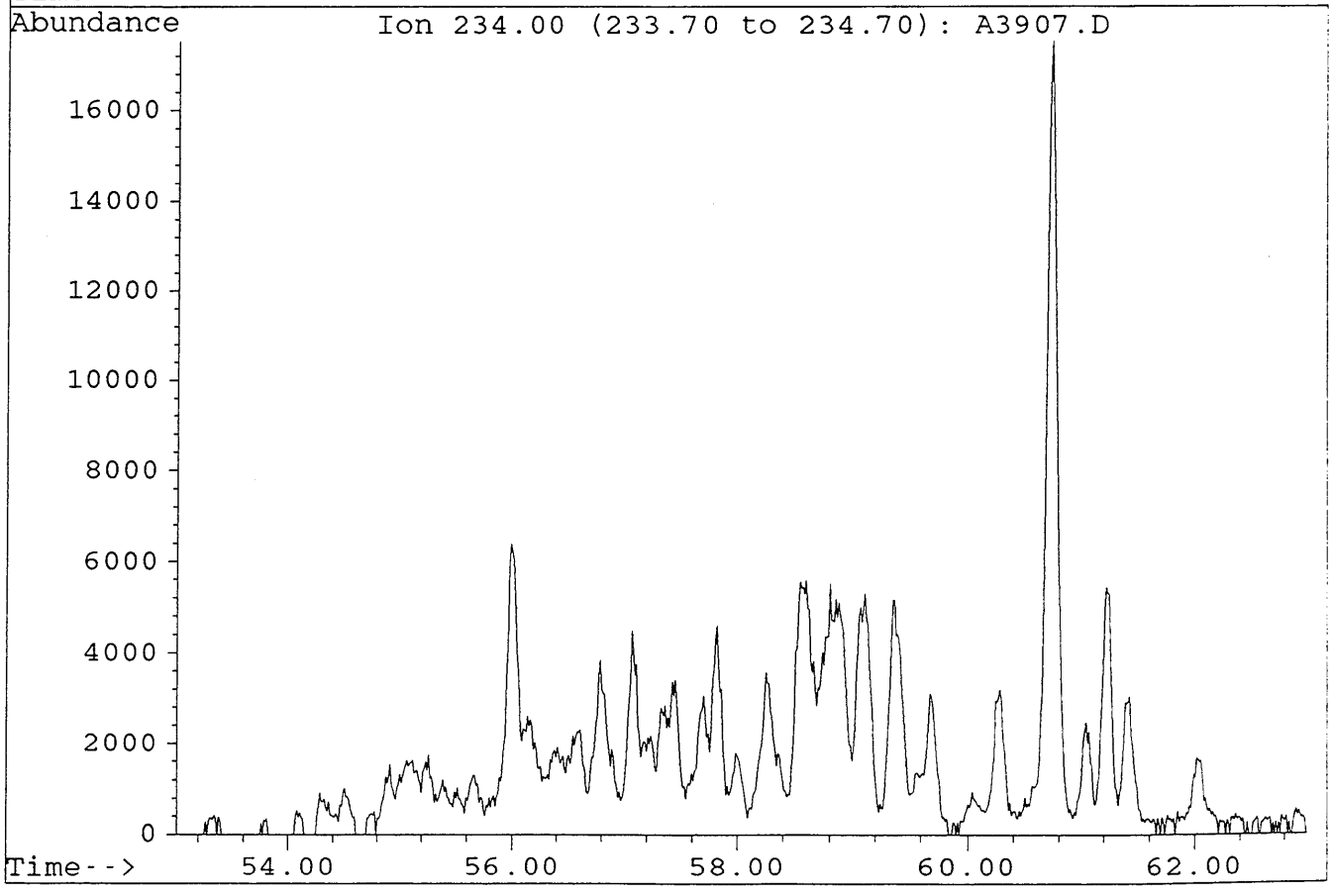


TABLE 9-3

SELECTED PARAMETERS FROM GC/MS ANALYSIS

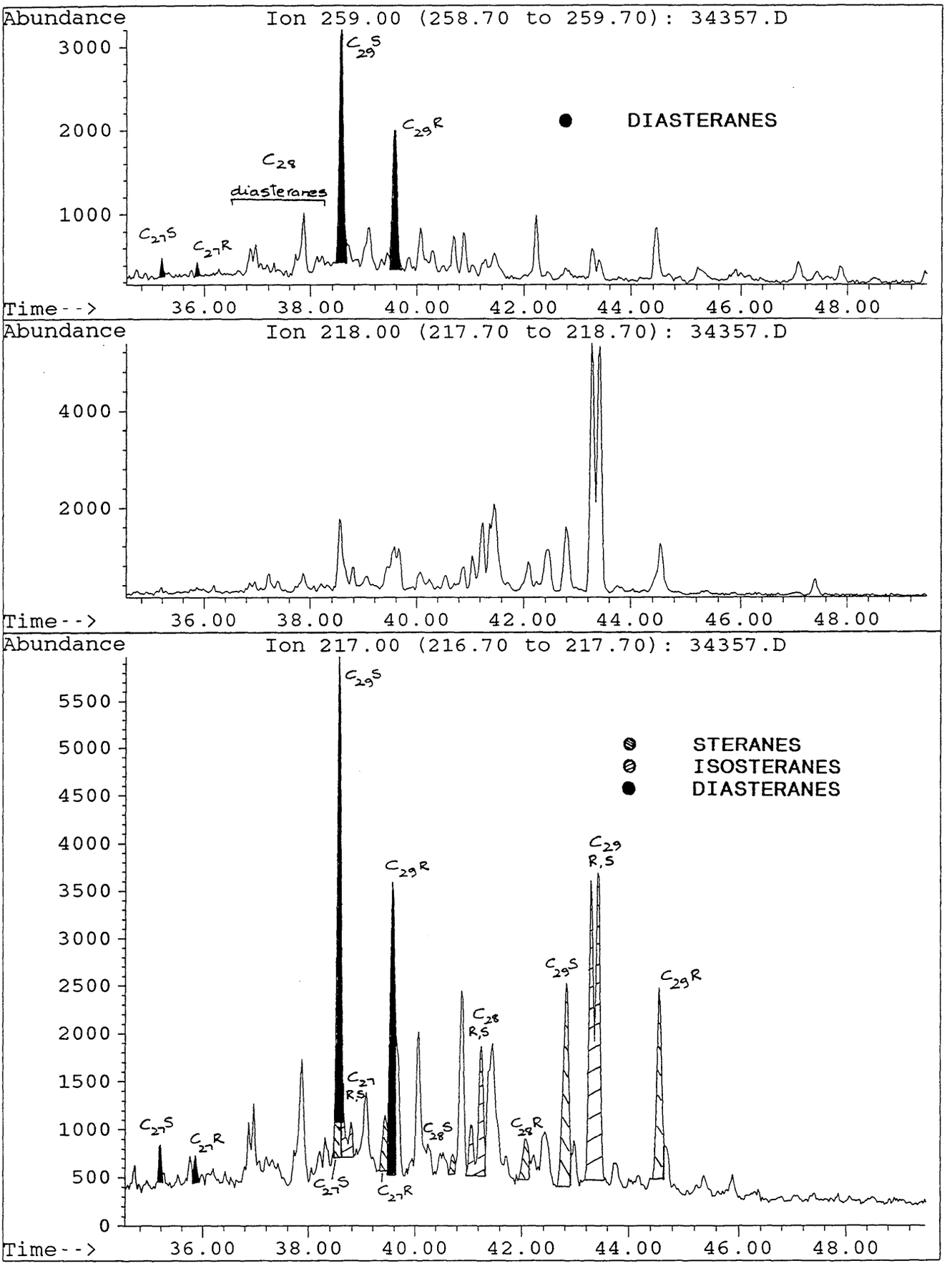
DIGBY 1, 1940.8m, SWC

	Parameter	Ion(s)	Value
1.	18 α (H)- hopane/17 α (H)-hopane (Ts/Tm)	191	1.03
2.	C30 hopane/C30 moretane	191	11.08
3.	C31 22S hopane/C31 22R hopane	191	1.32
4.	C32 22S hopane/C32 22R hopane	191	1.37
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ sterane	217	1.06
6.	C29 $\alpha\alpha\alpha$ steranes (20S / 20S+20R)	217	0.52
7.	C29 $\alpha\beta\beta$ steranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.61
8.	C27/C29 diasteranes	259	0.09
9.	C27/C29 steranes	217	0.29
10.	18 α (H)-oleanane/C30 hopane	191	nd
11.	C29 diasteranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.76
12.	C30 (hopane + moretane) / C29 (steranes + diasteranes)	191/217	0.56
13.	C15 drimane/C16 homodrimane	123	0.40
14.	Rearranged drimanes/normal drimanes	123	0.72

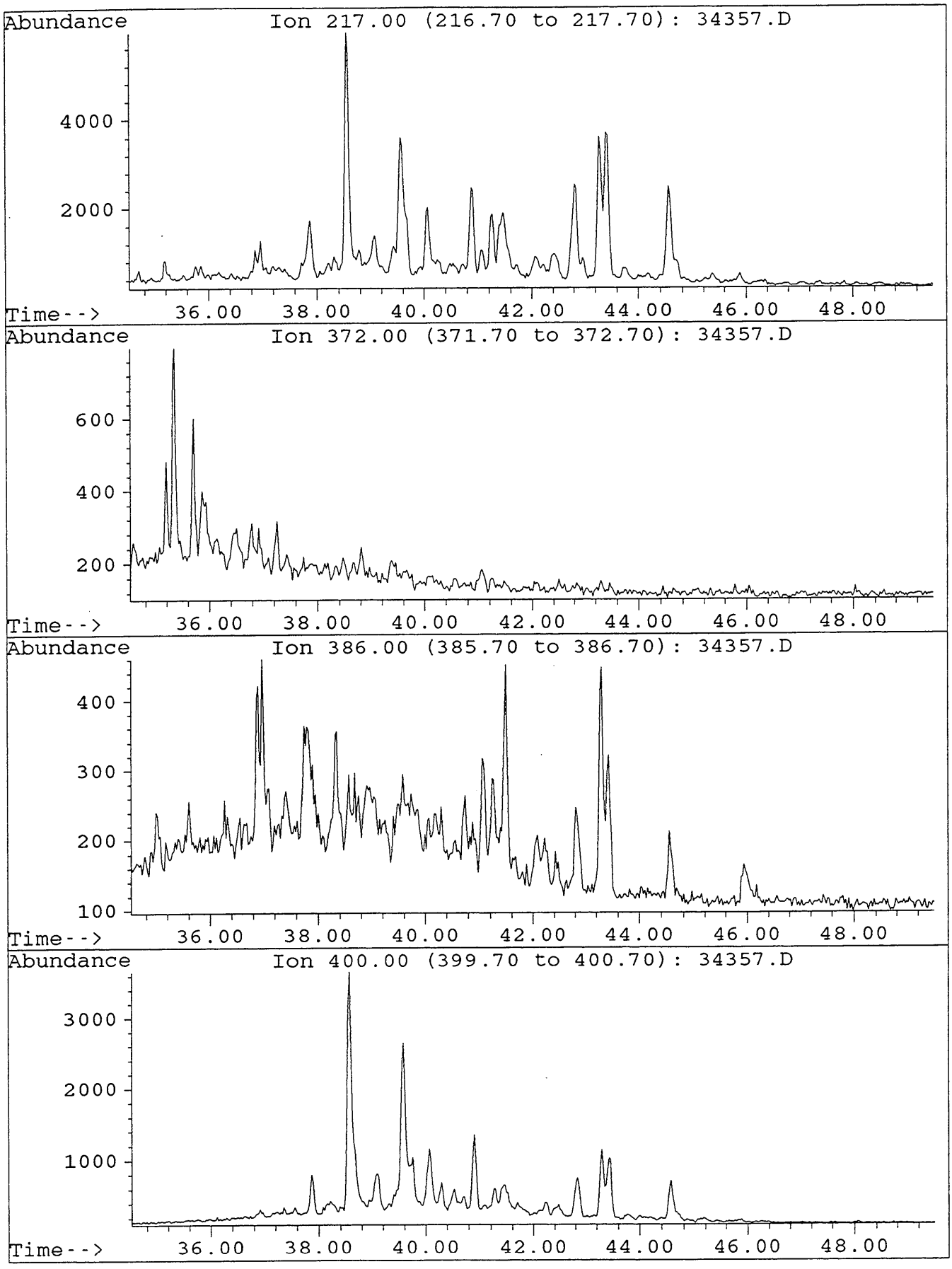
nd = not detectable

File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95

FIGURE 6-3



File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



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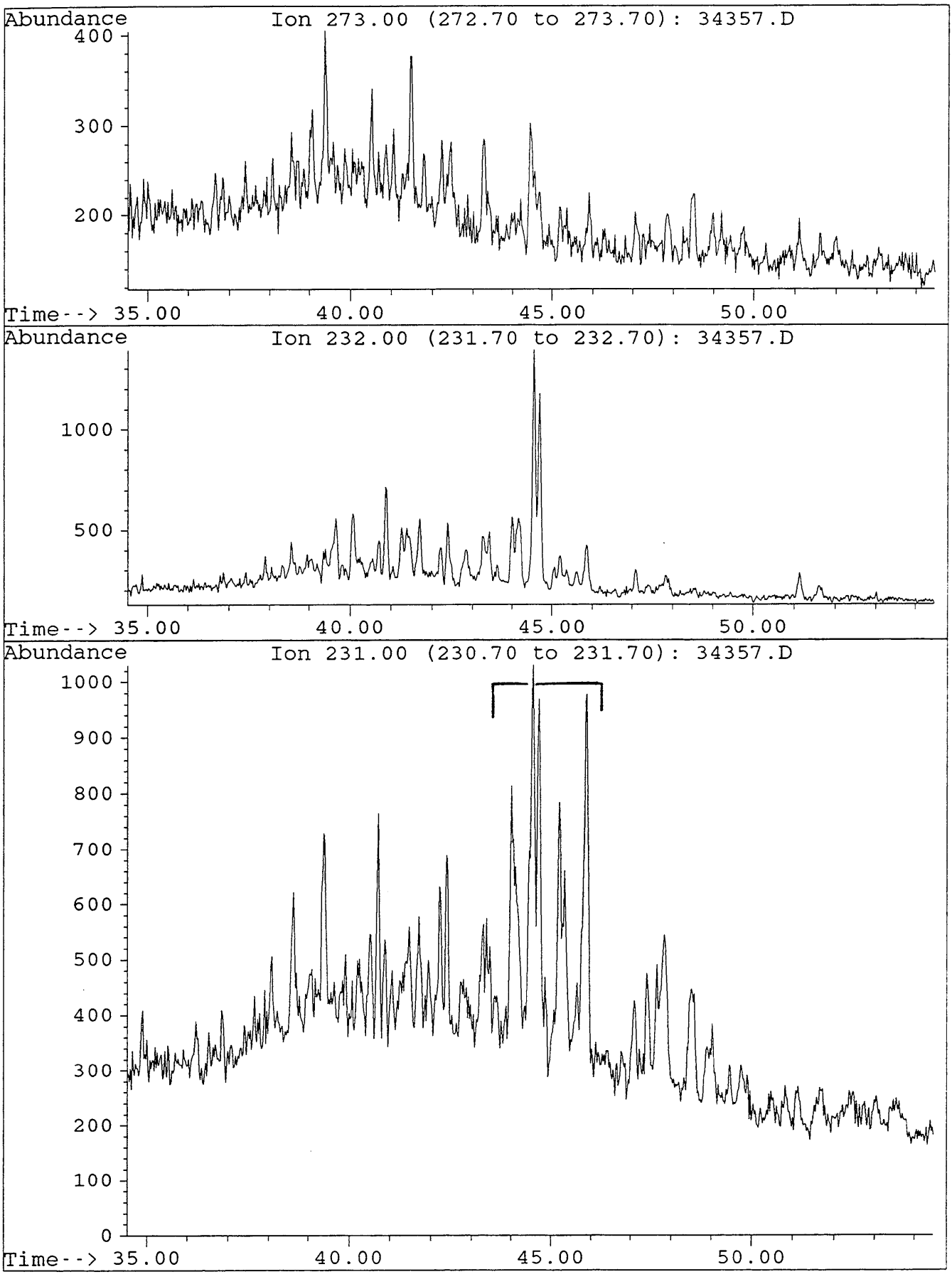
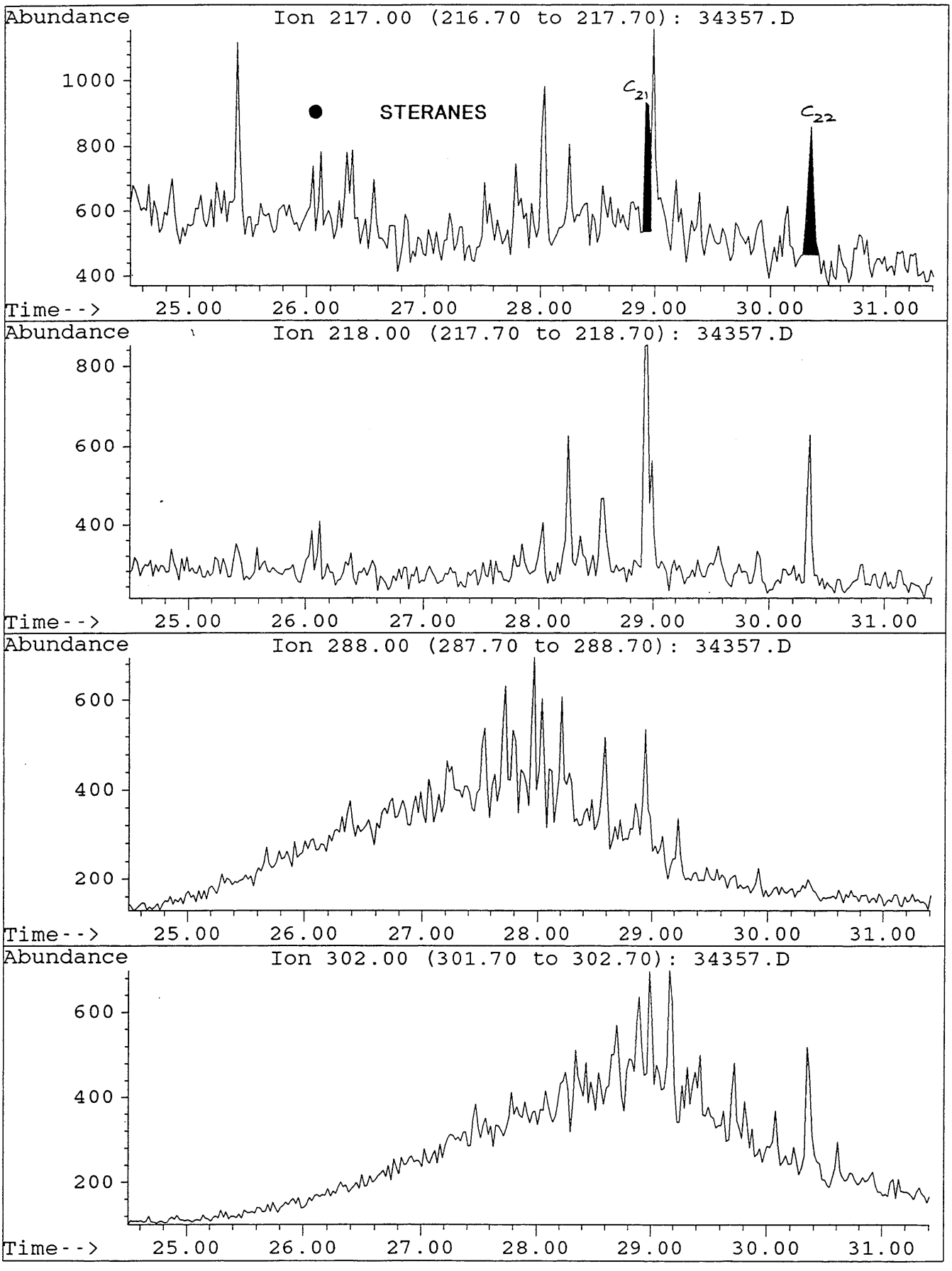
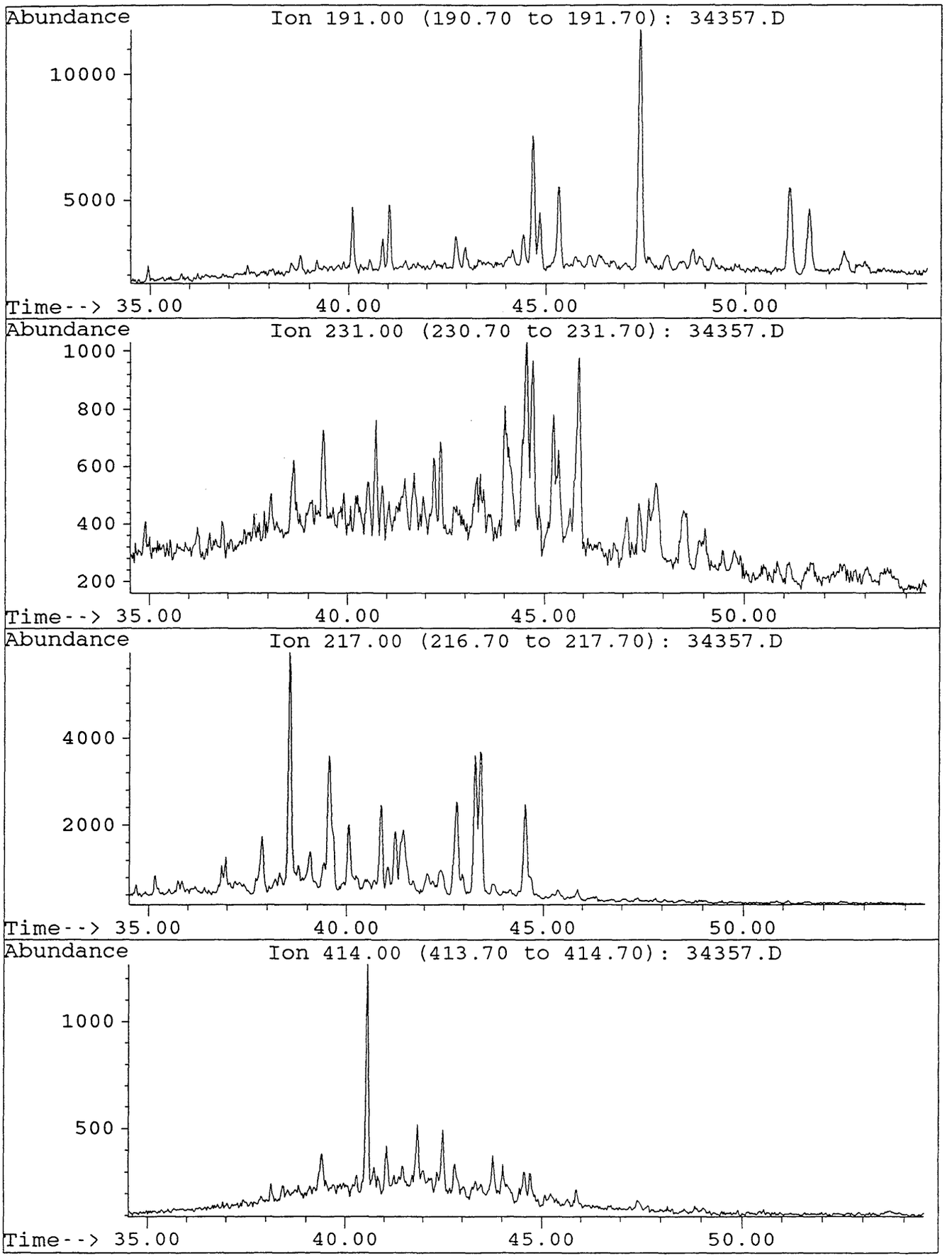
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



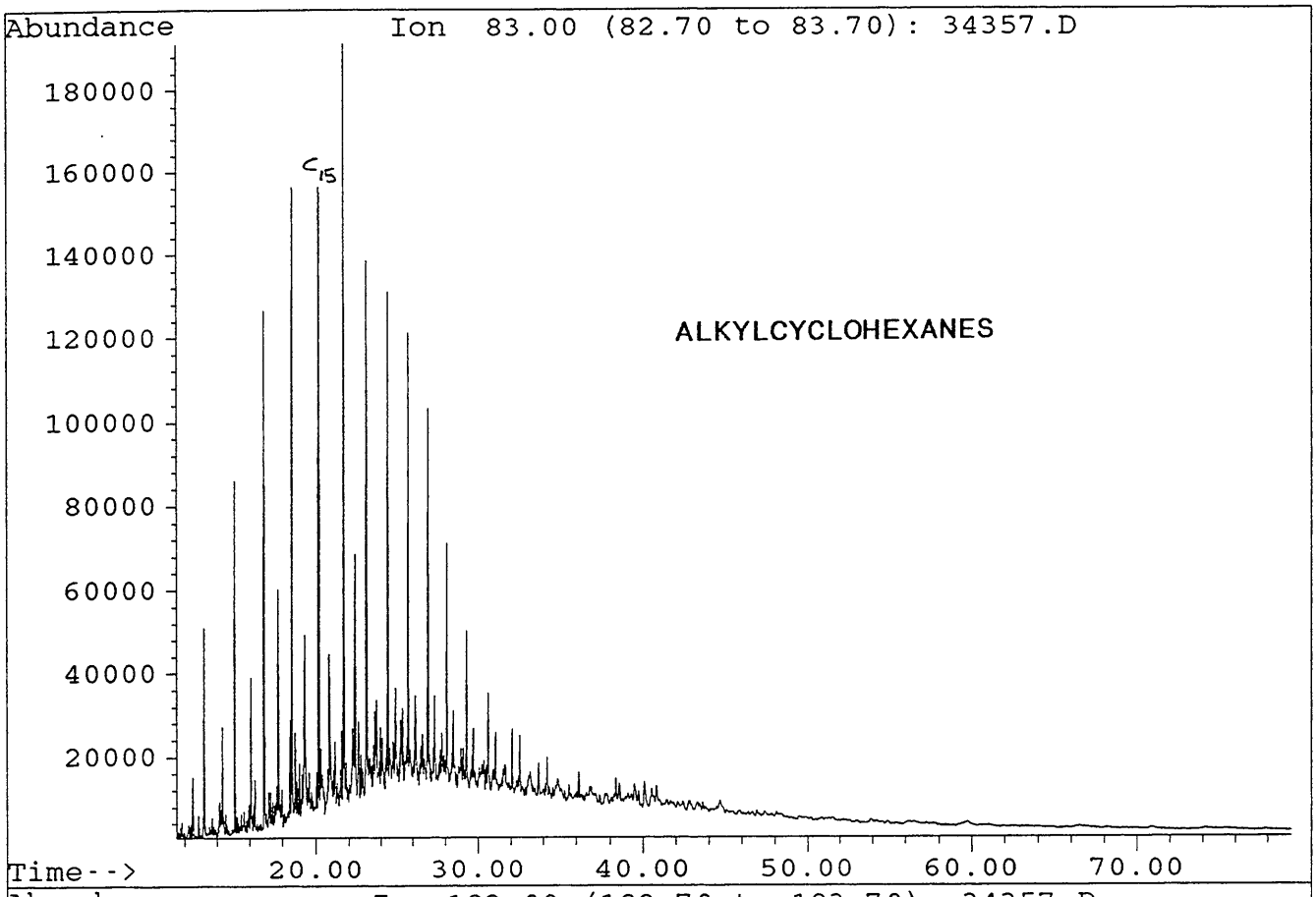
File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95

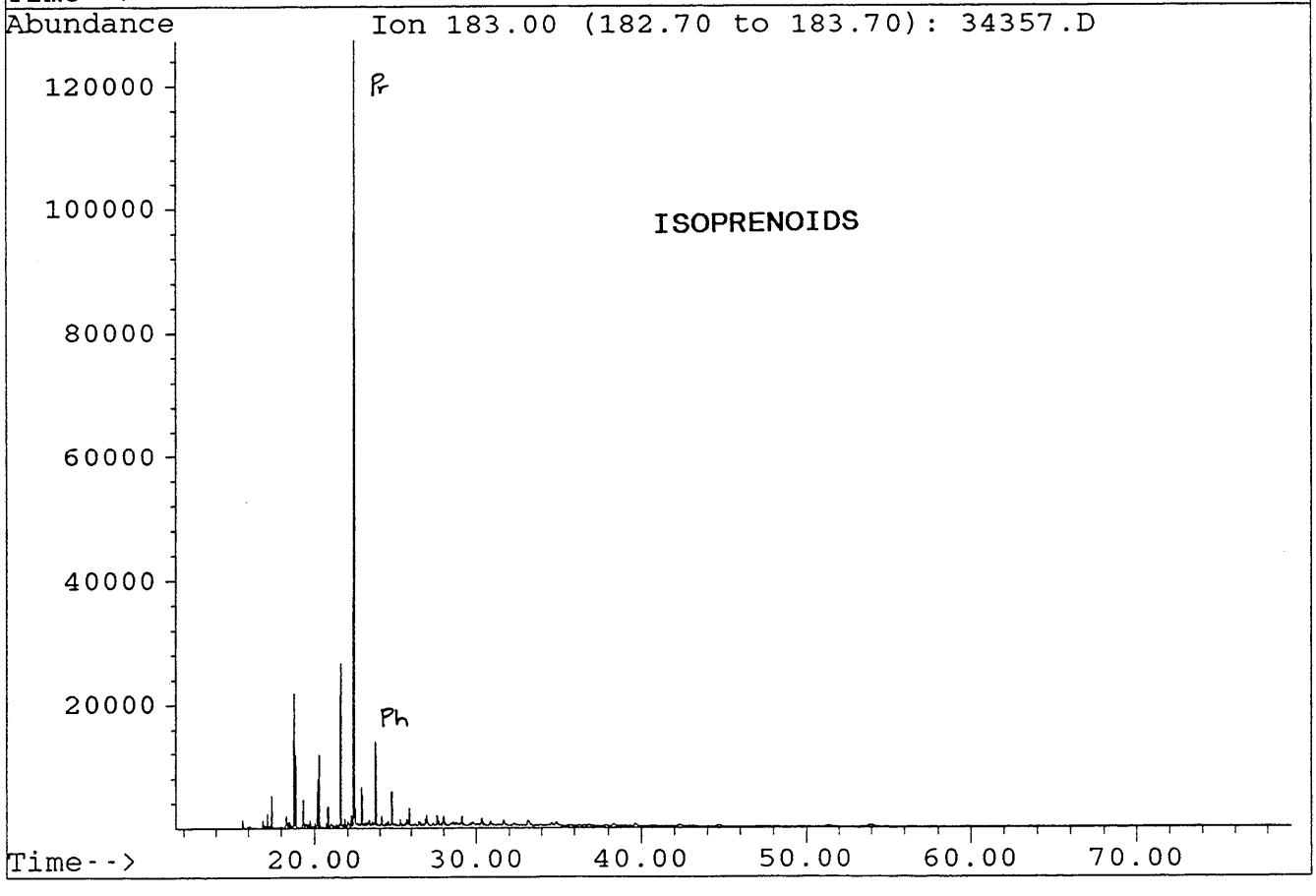


File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95





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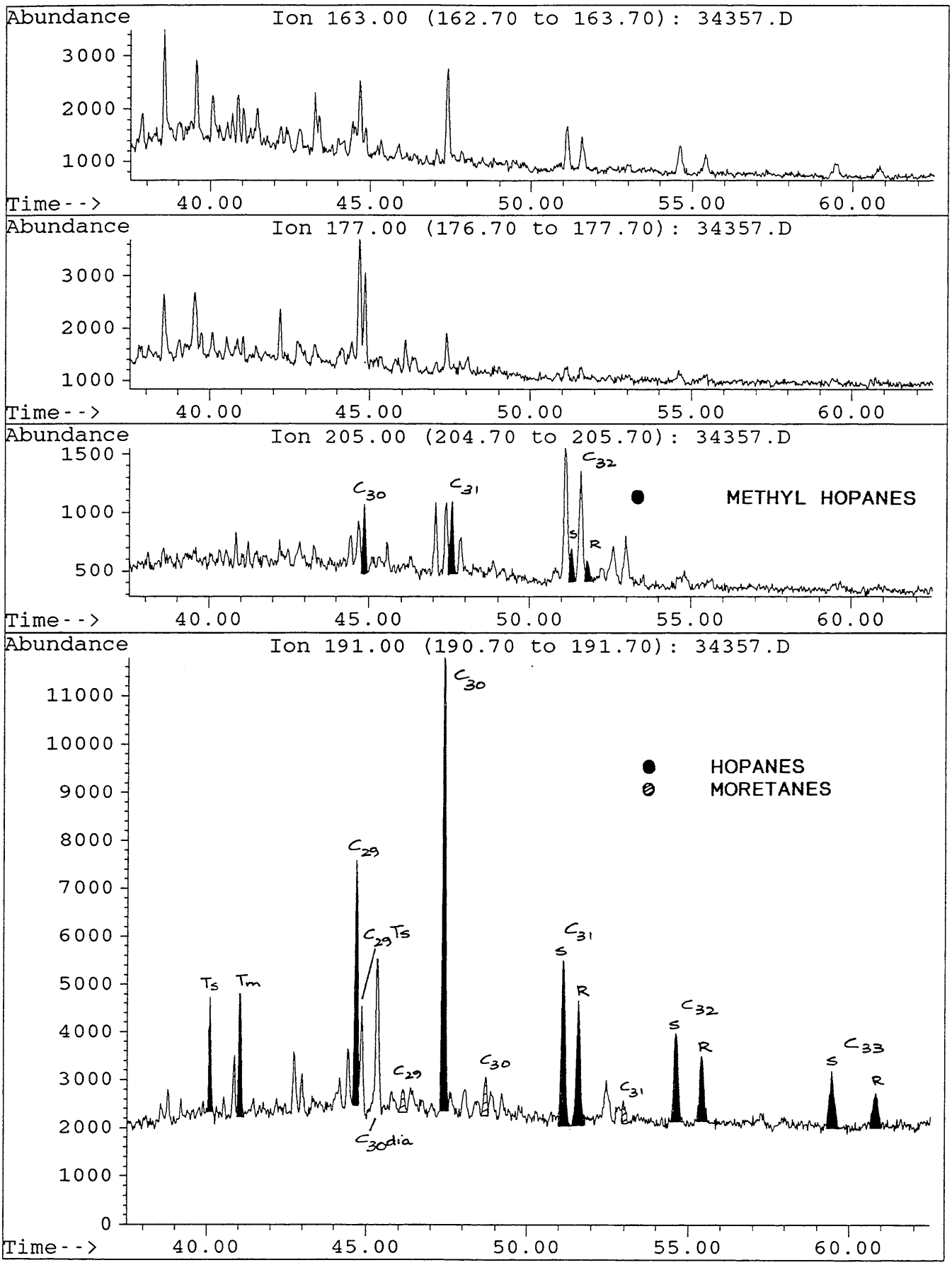
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



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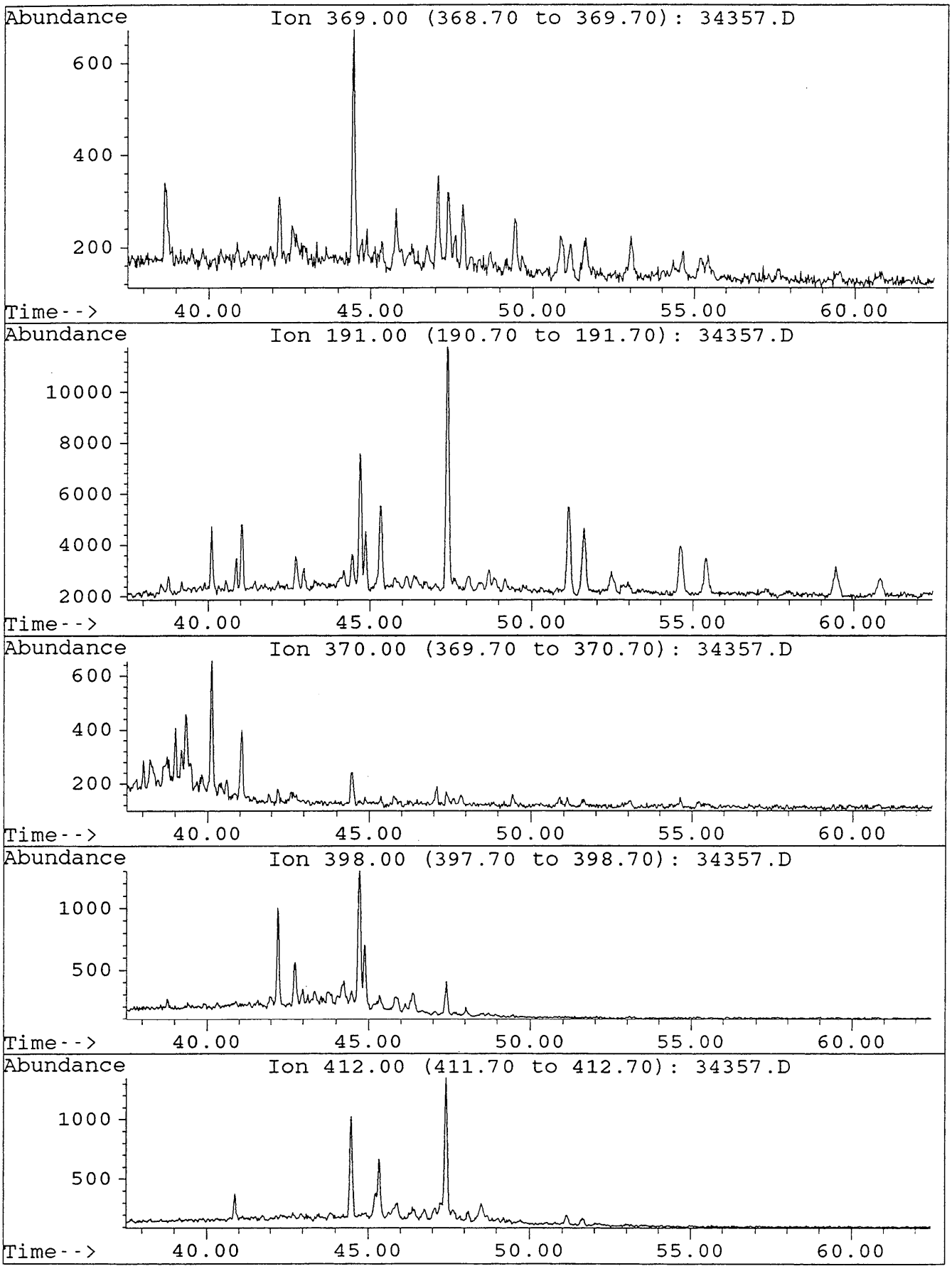
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



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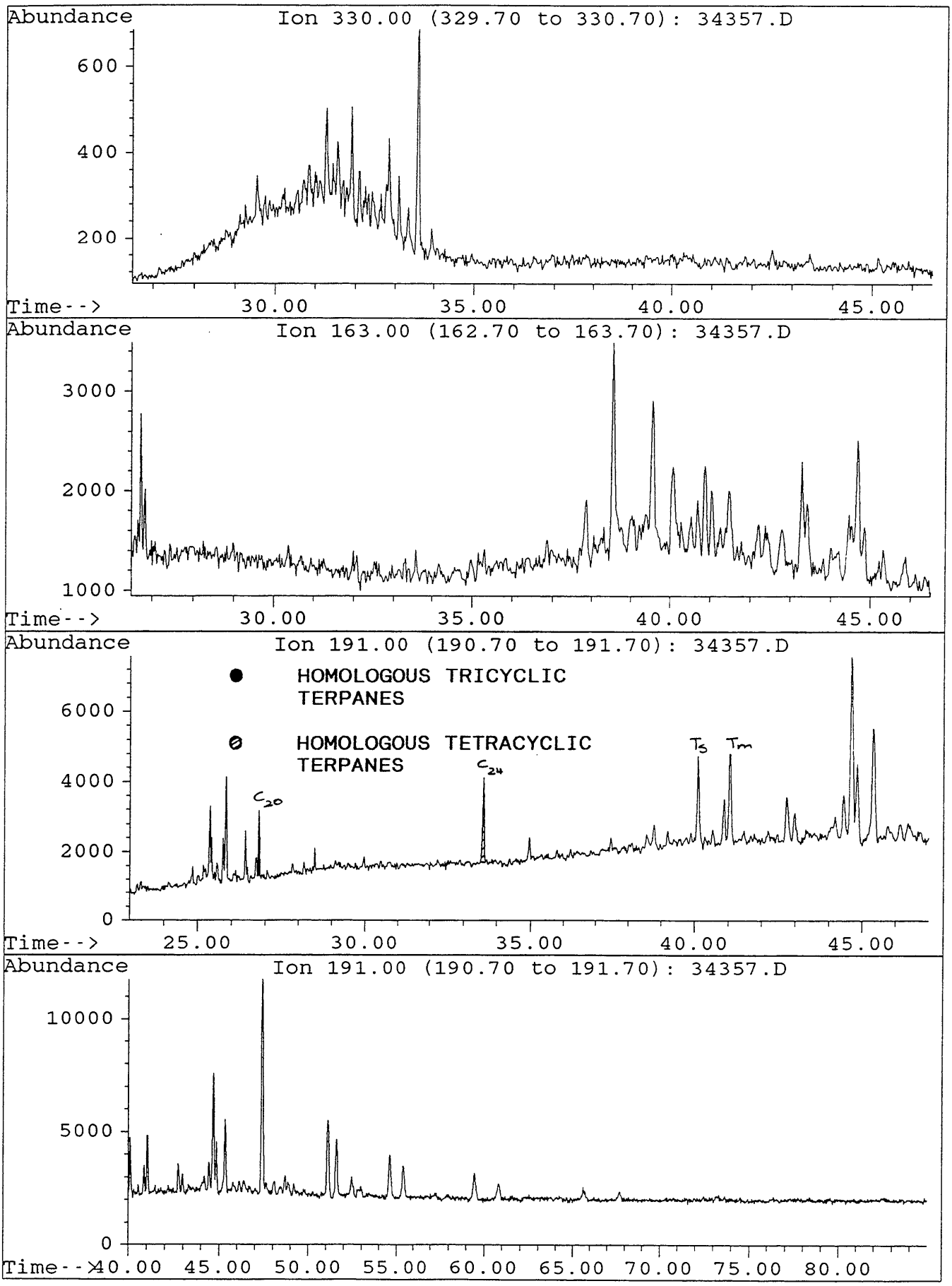
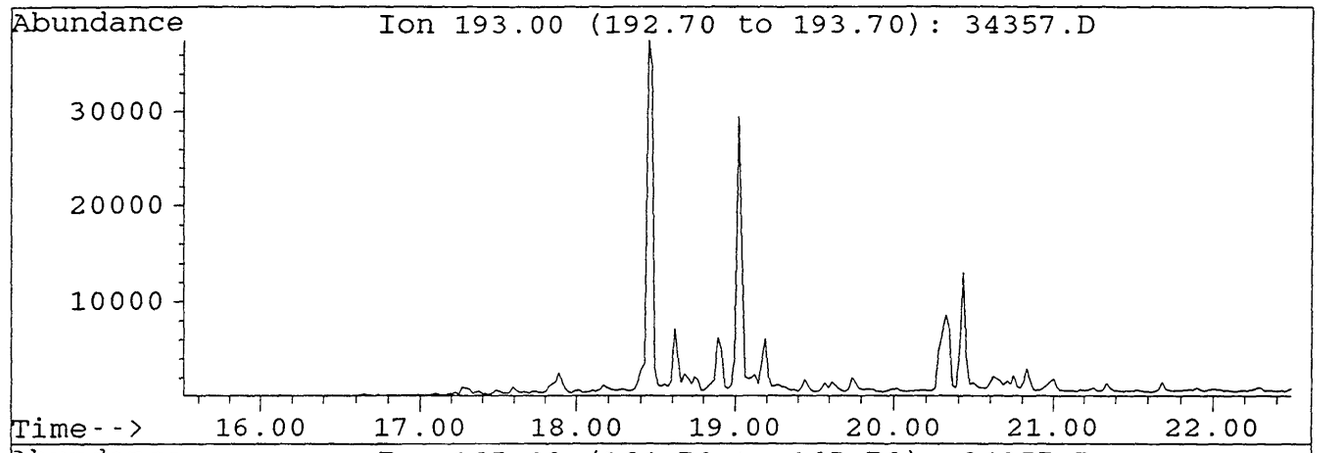
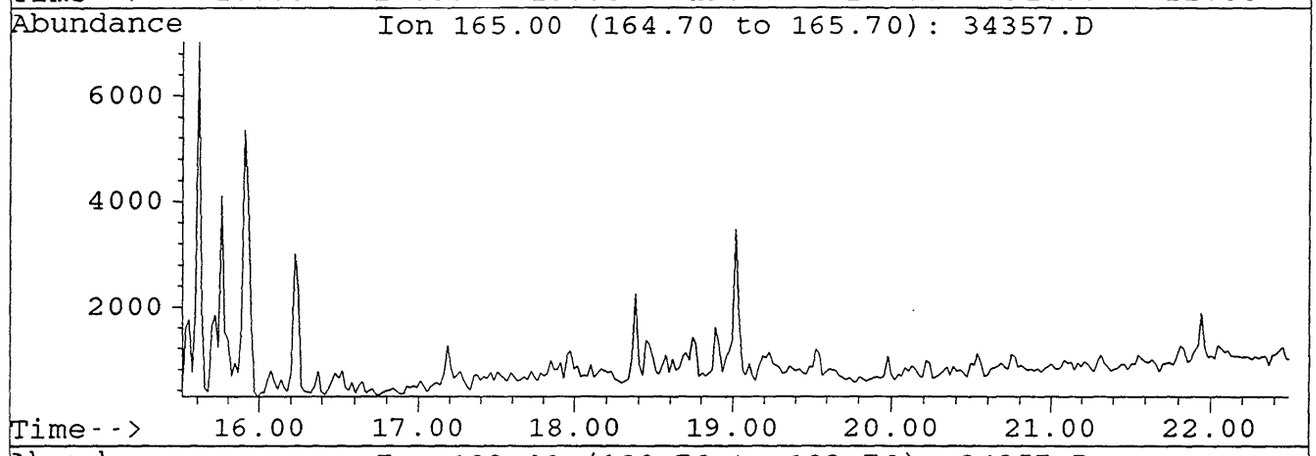
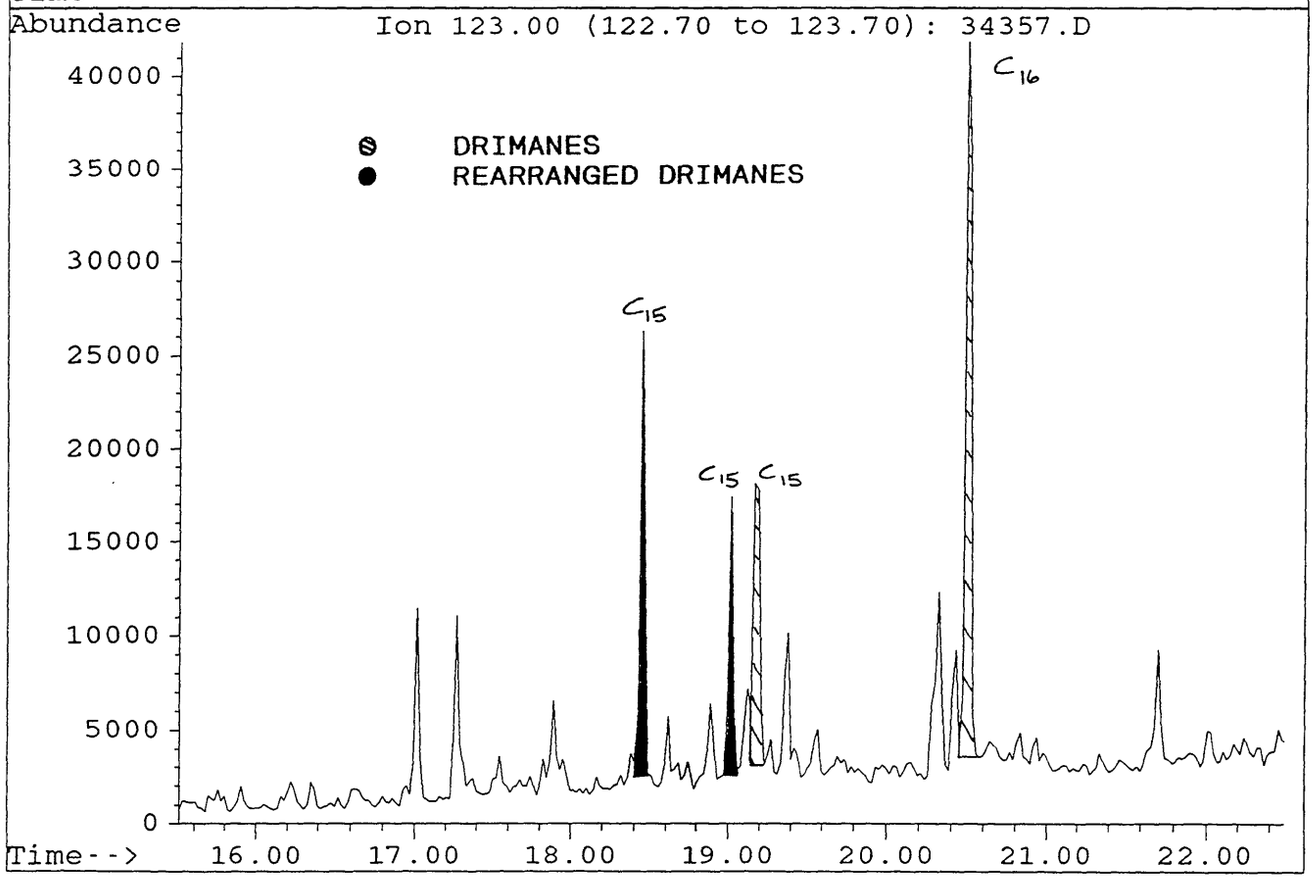
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95







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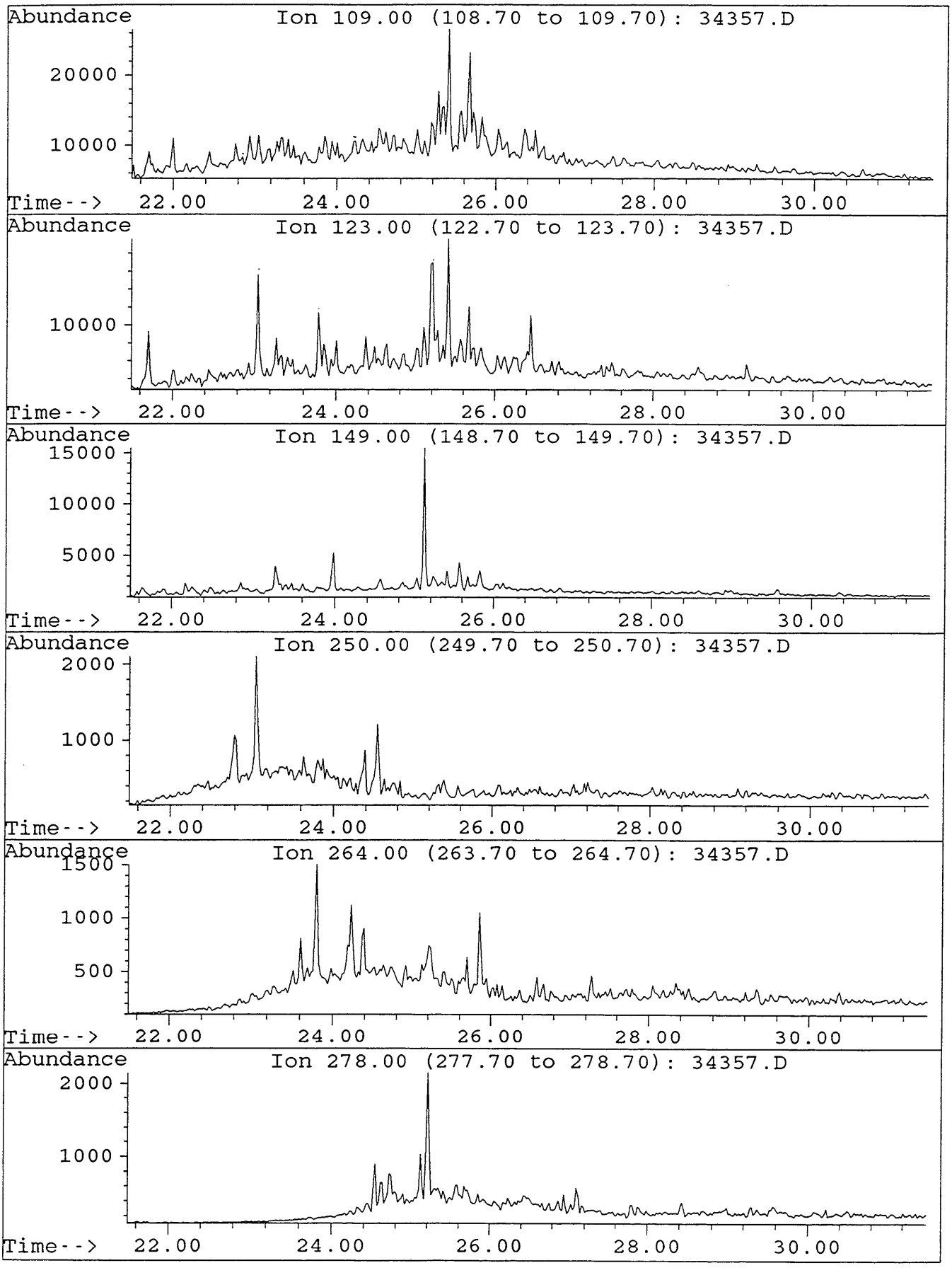
Misc. Info : COL#164. DJ. 10-7-95



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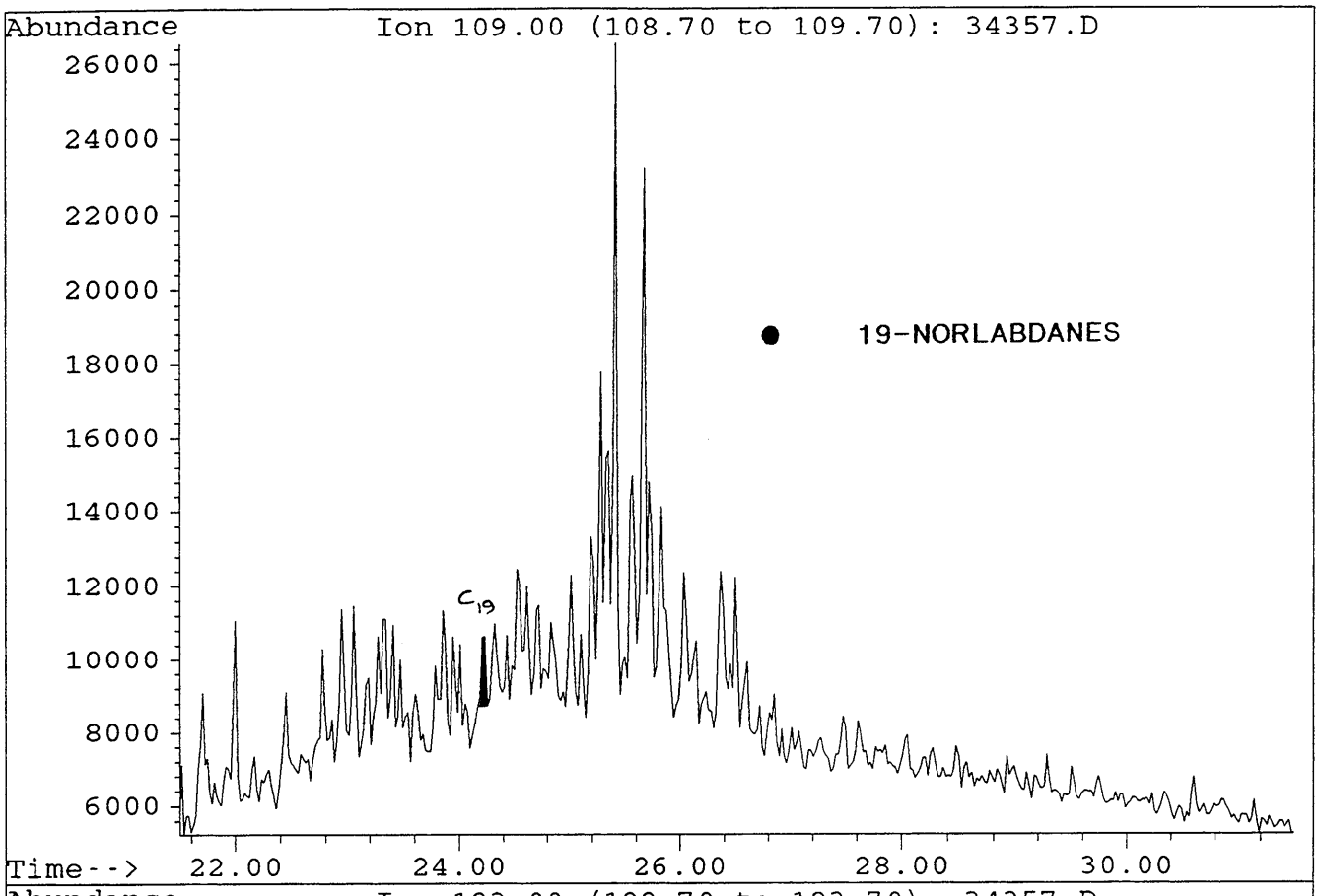

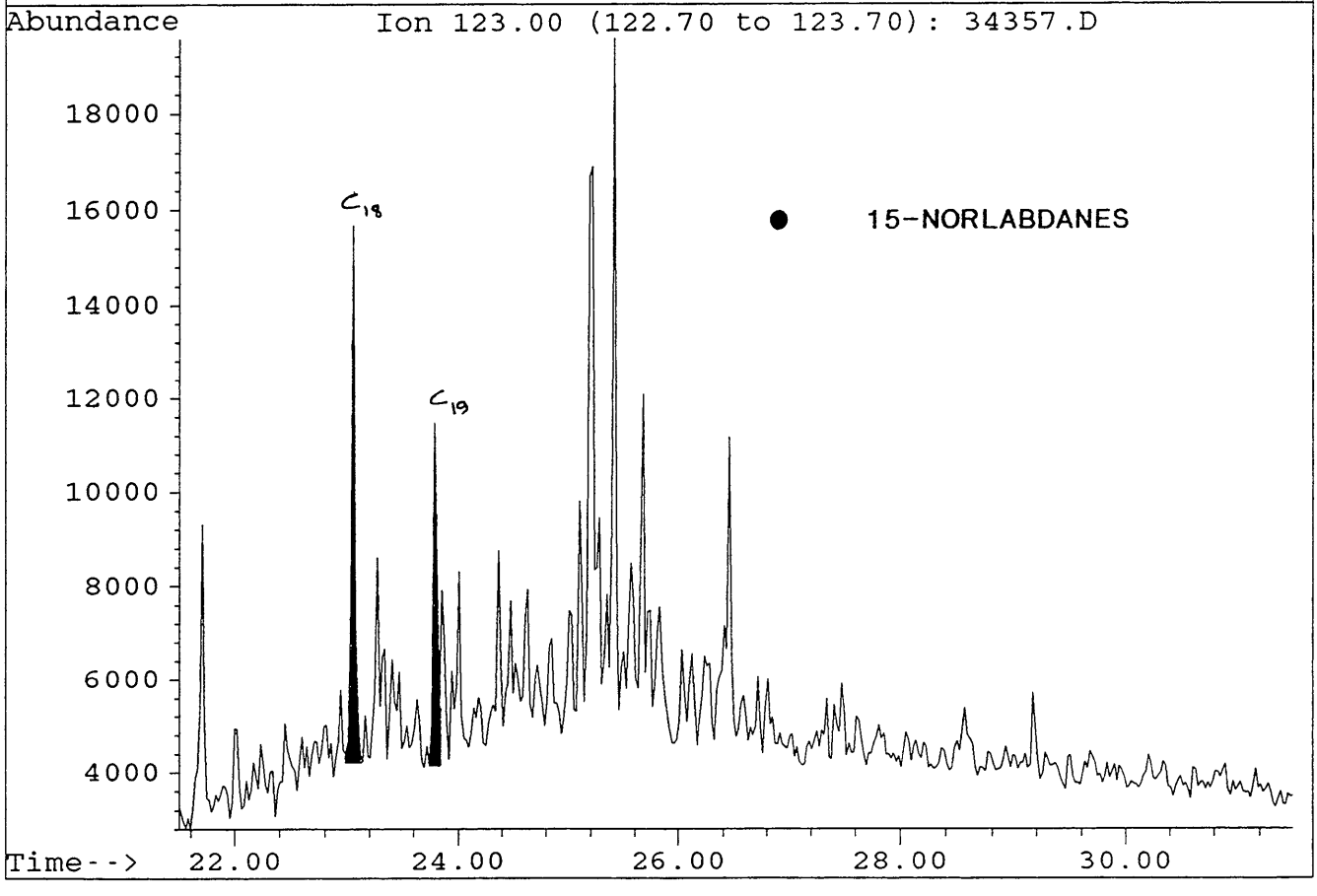

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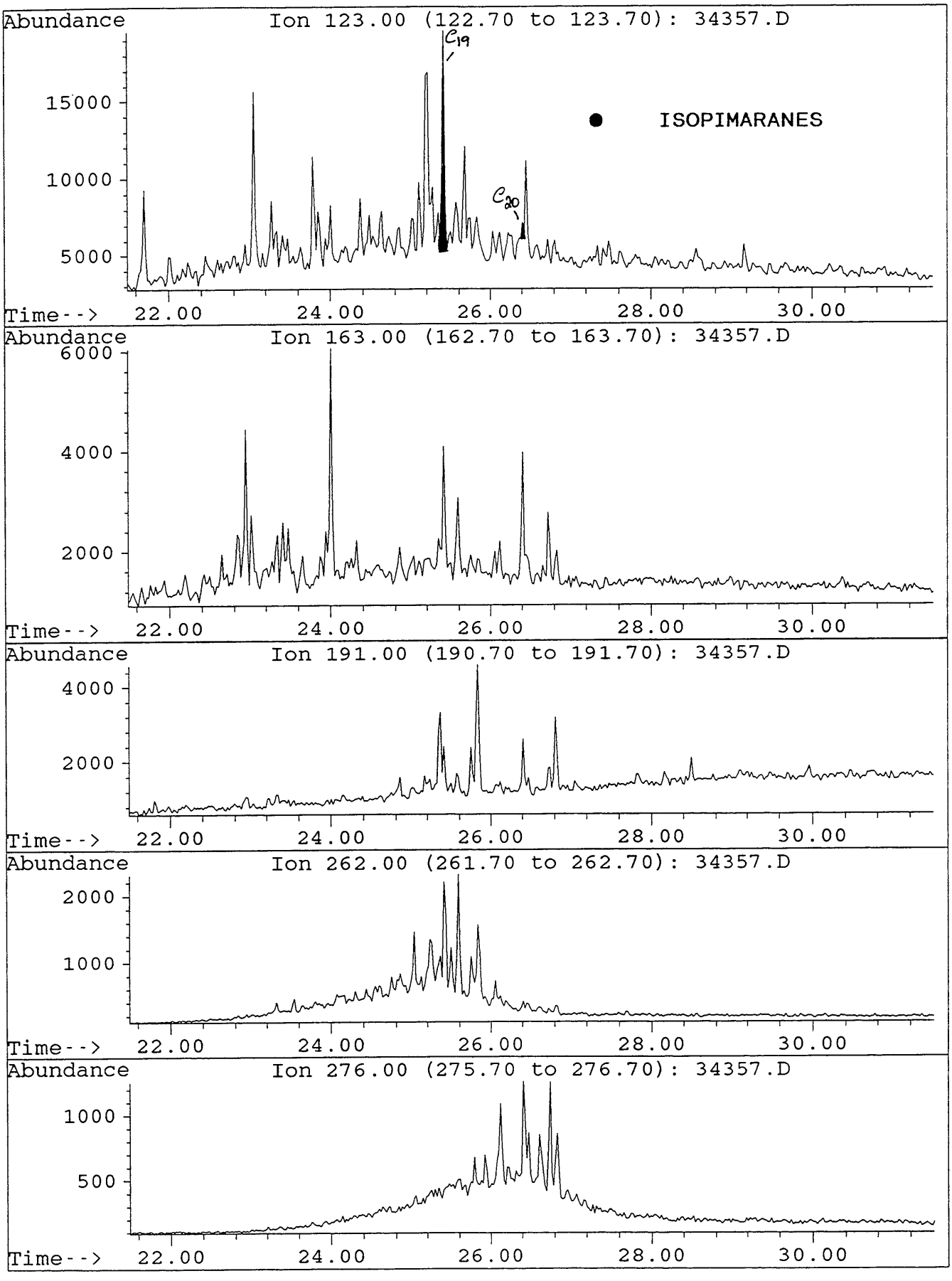
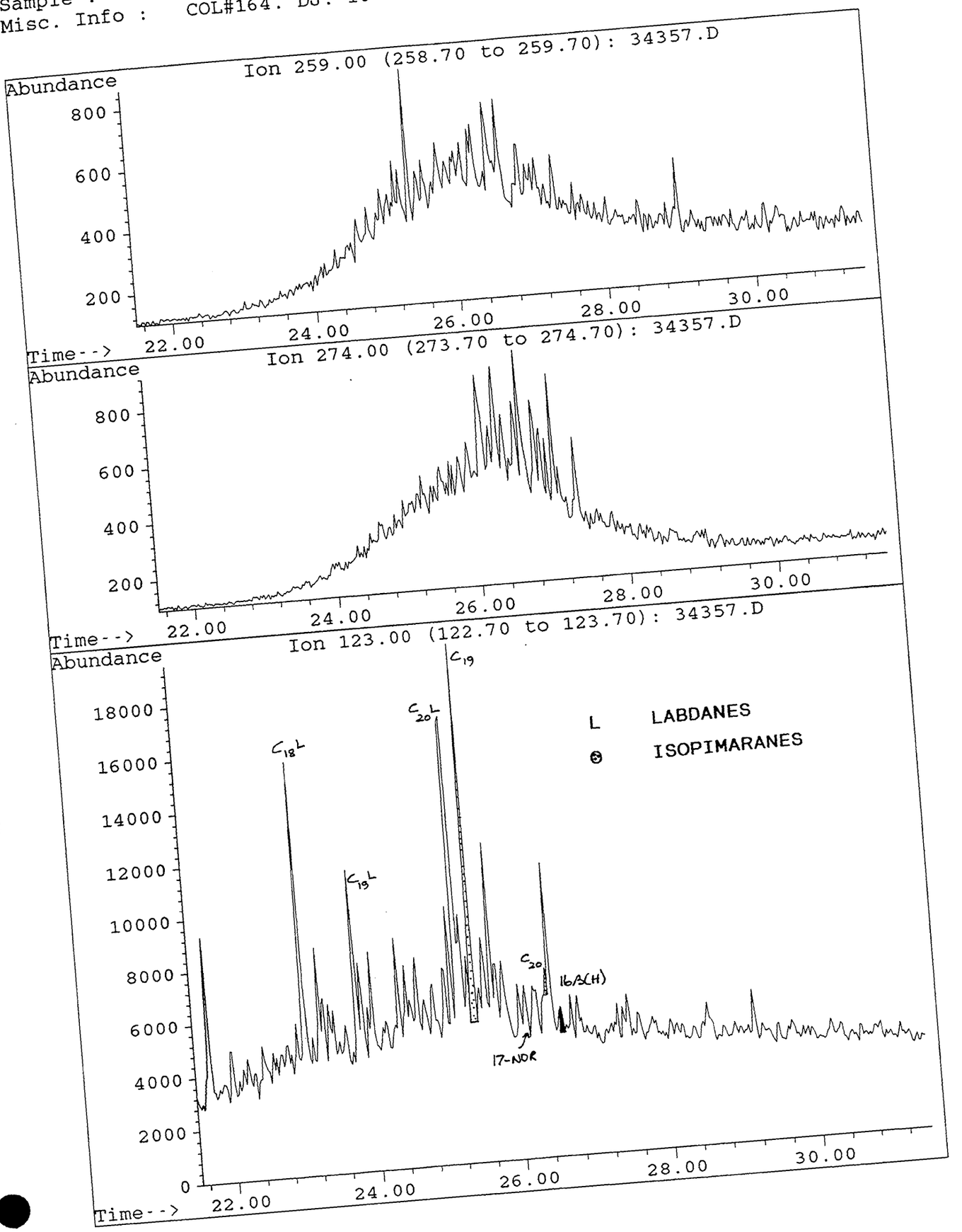
Misc. Info : COL#164. DJ. 10-7-95



File : 34357.D
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



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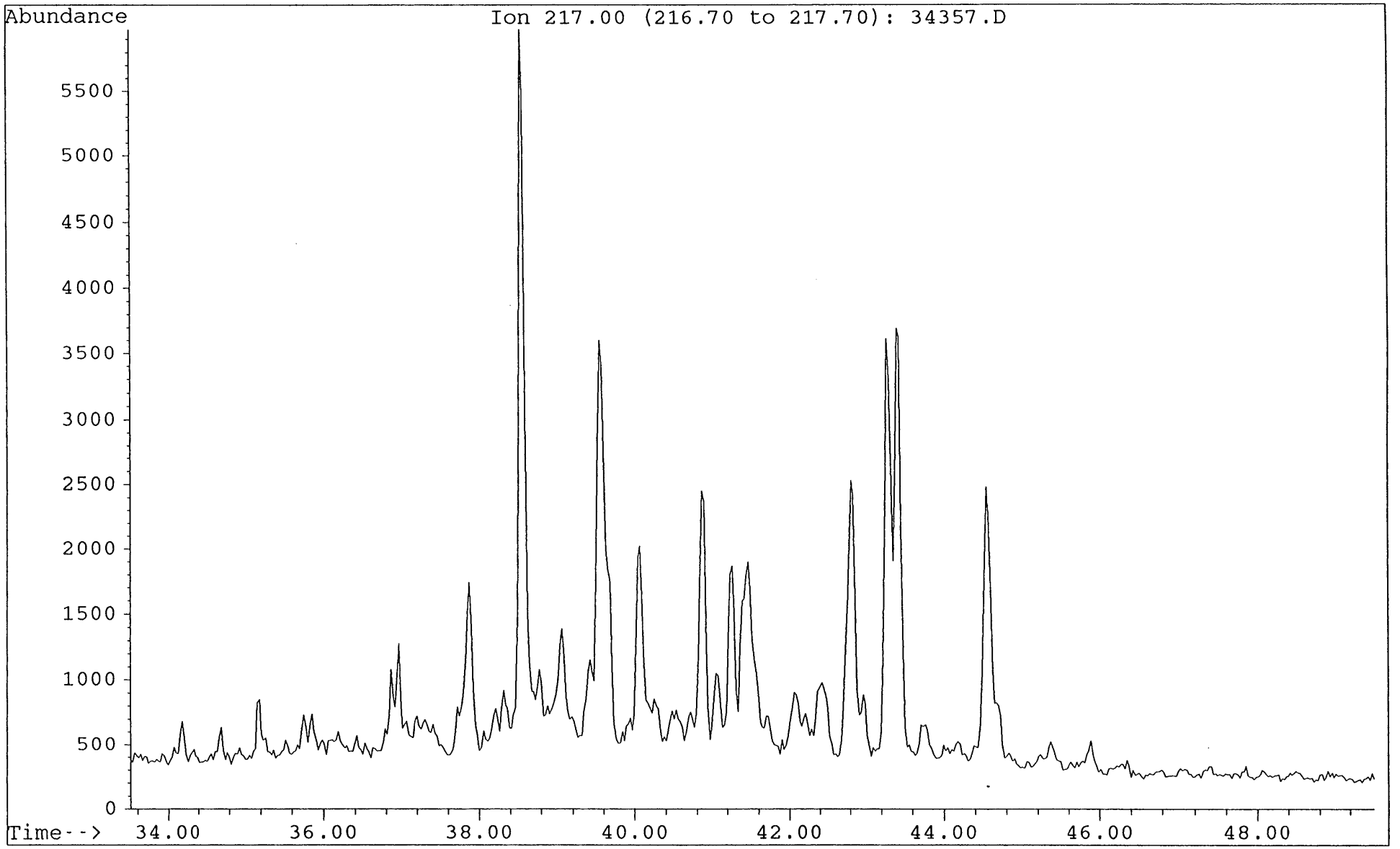
Misc. Info : COL#164. DJ. 10-7-95



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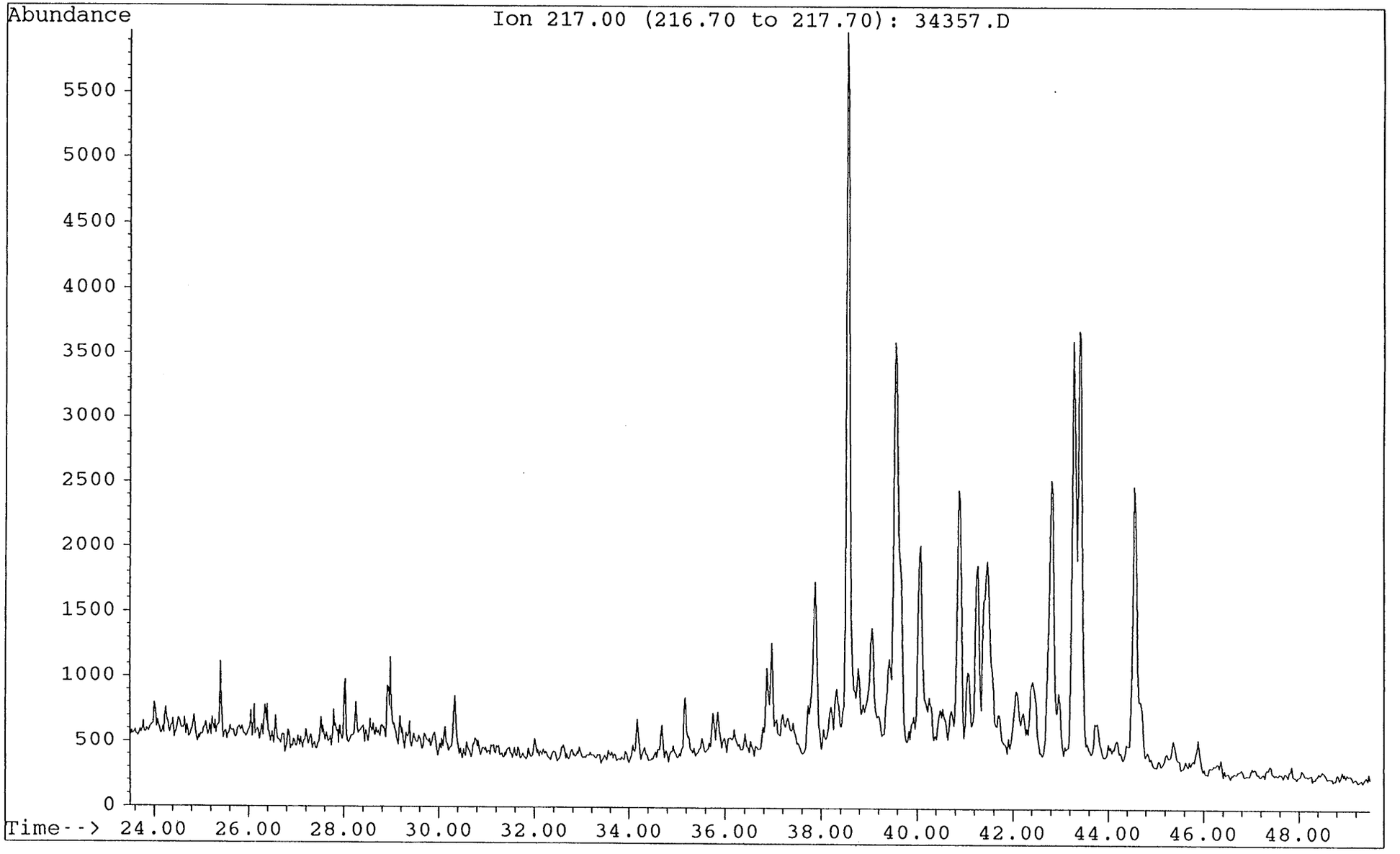
Misc. Info : COL#164. DJ. 10-7-95



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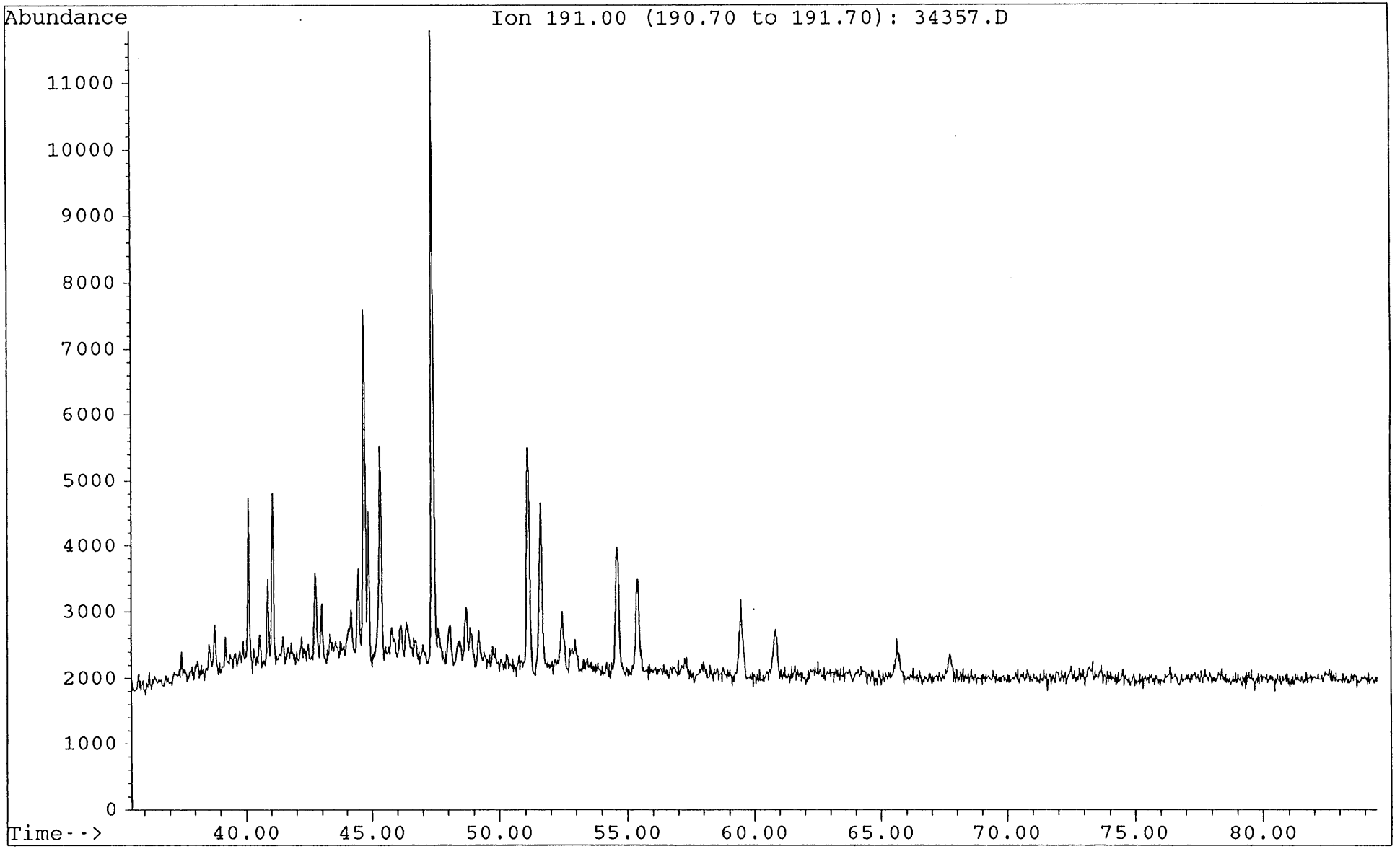
Misc. Info : COL#164. DJ. 10-7-95



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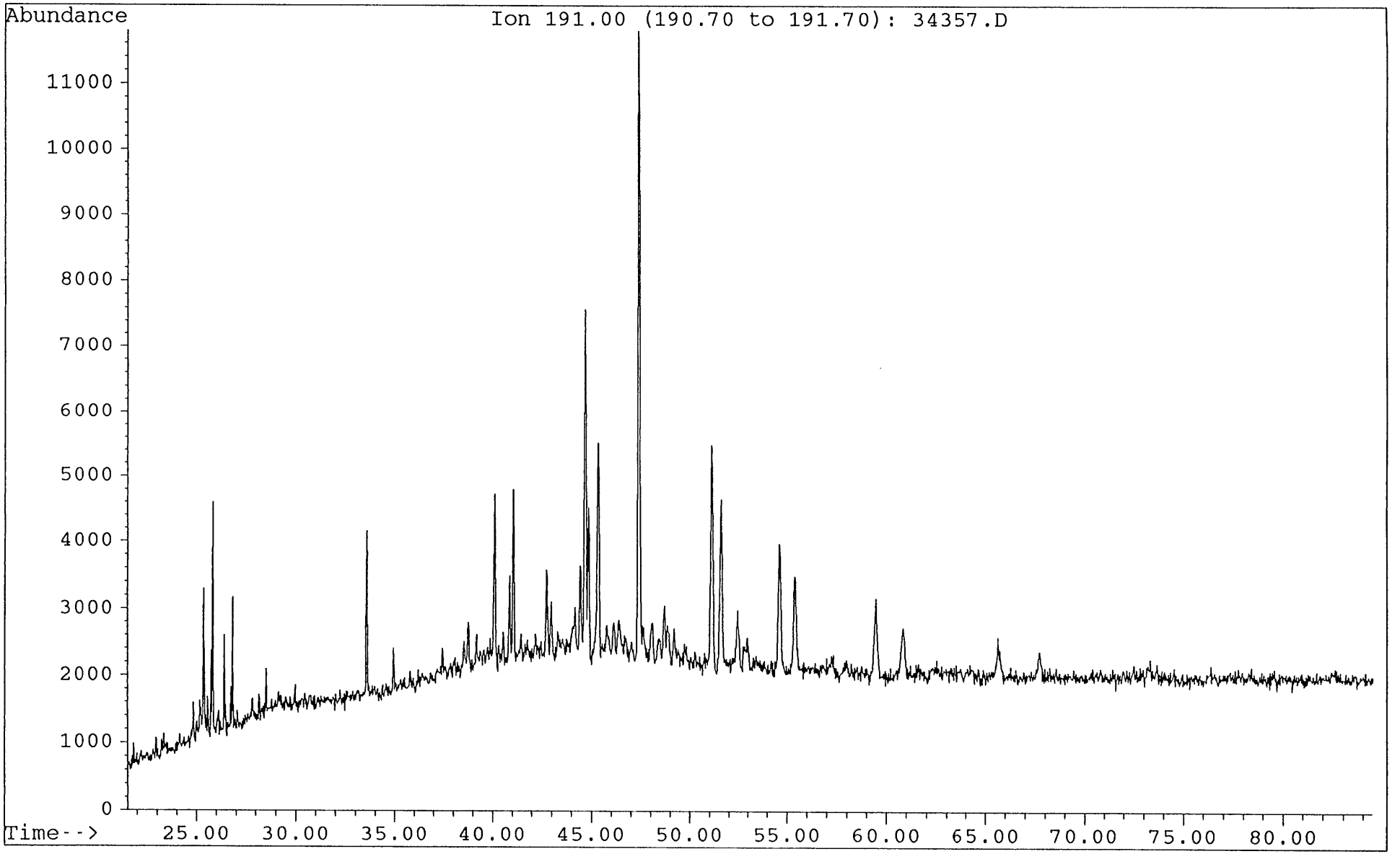
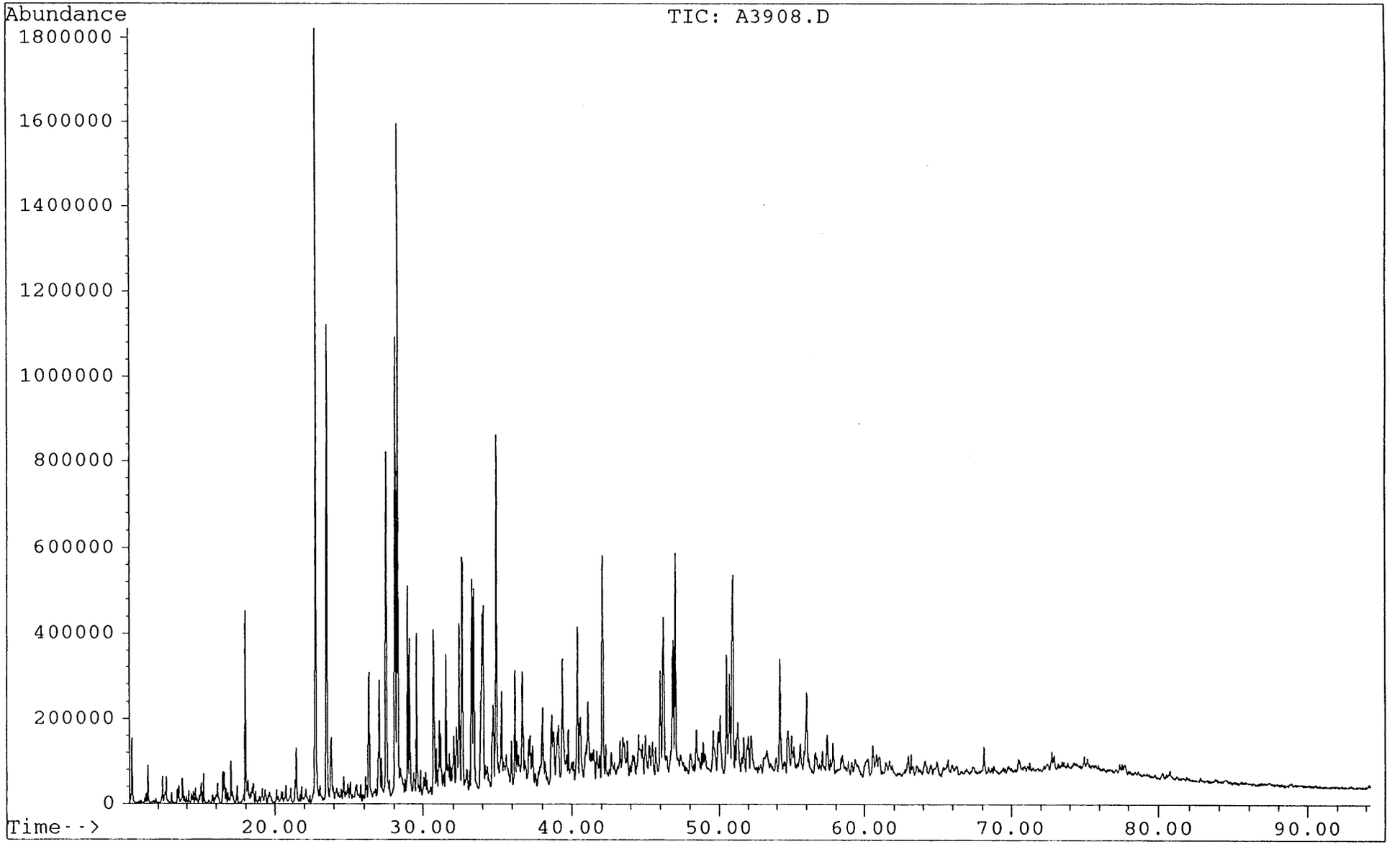
Sample : DIGBY-1 1940.8m B/C
Misc. Info : COL#164. DJ. 10-7-95



File : A3908.D
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

FIGURE 8-3



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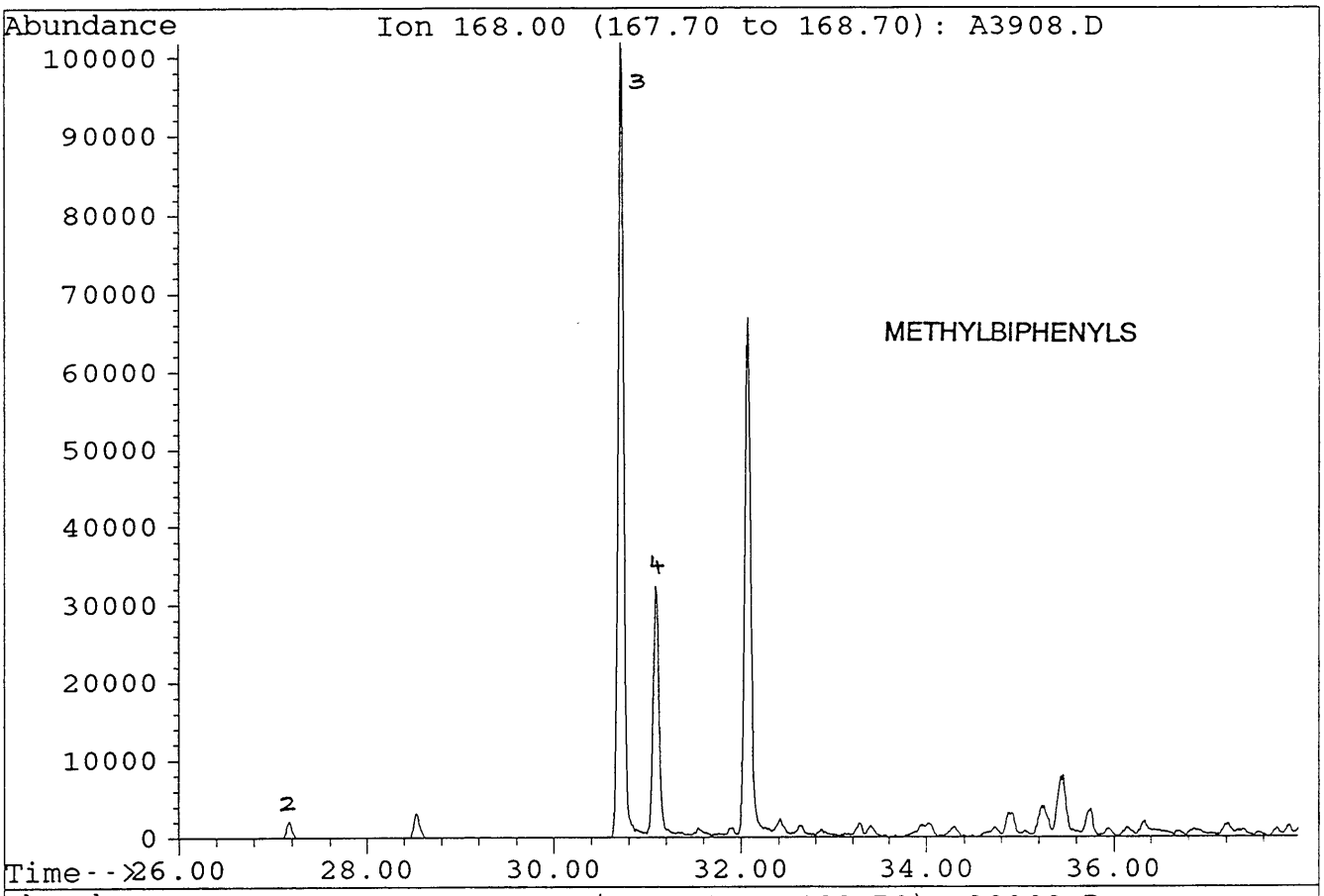
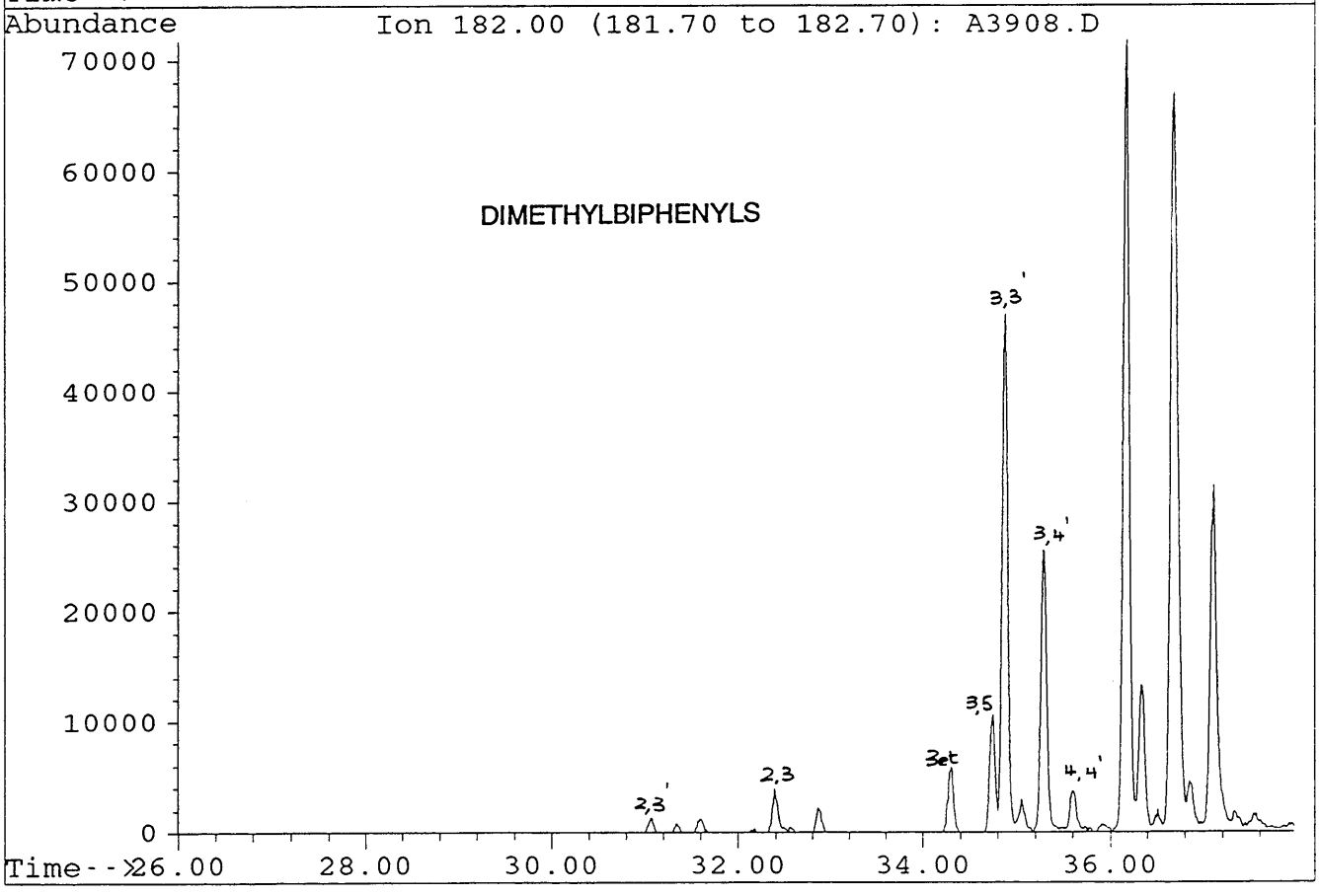
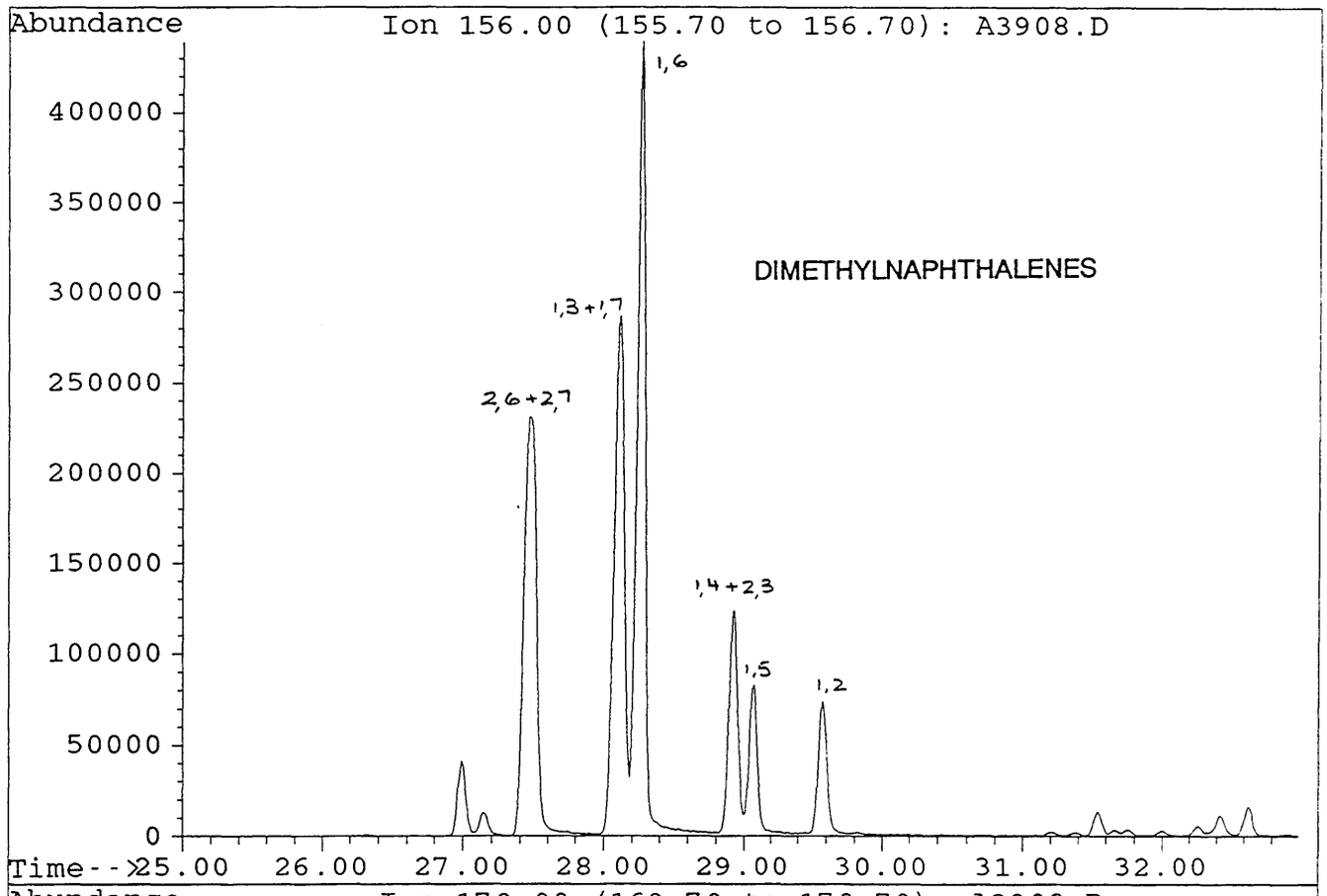
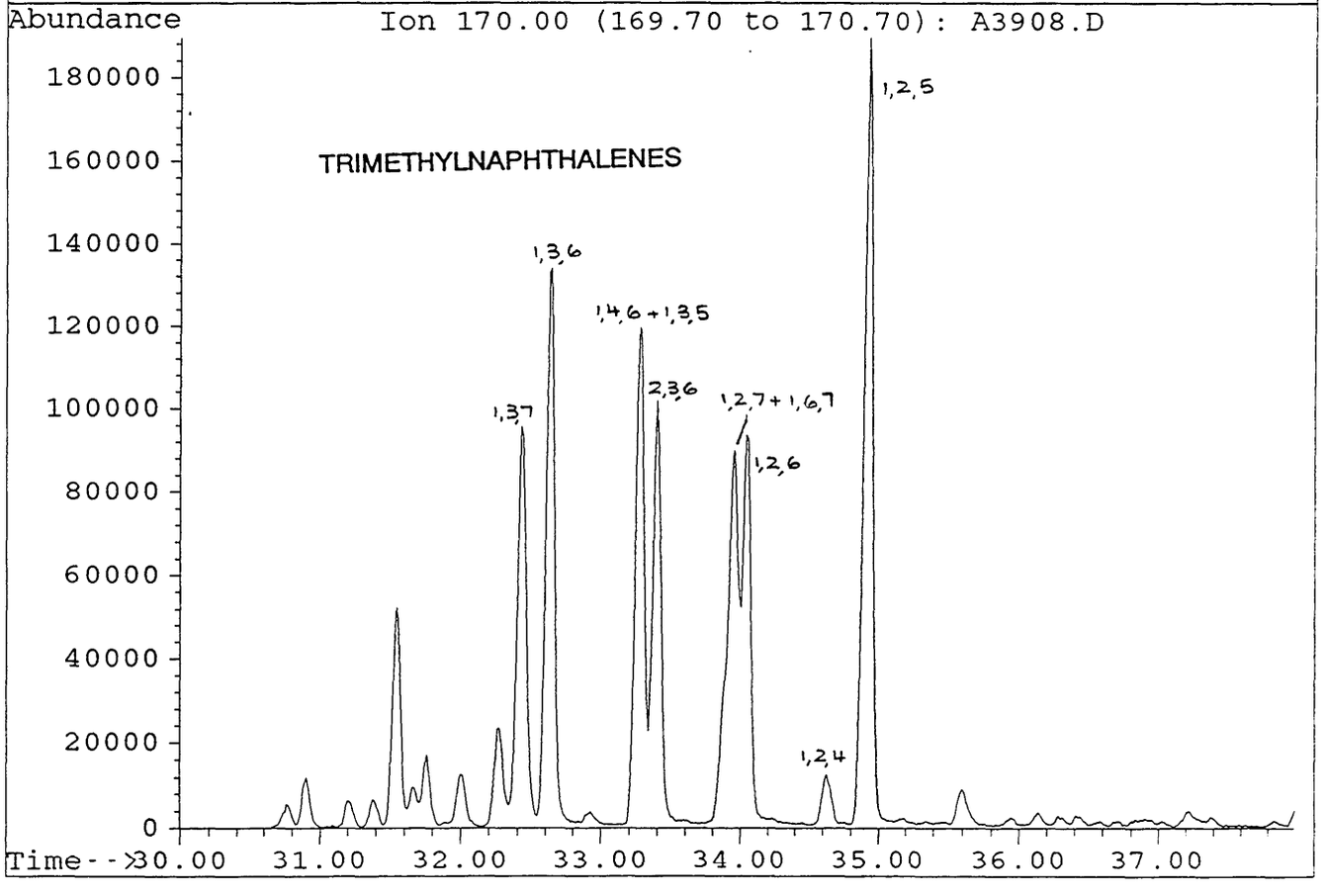
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.





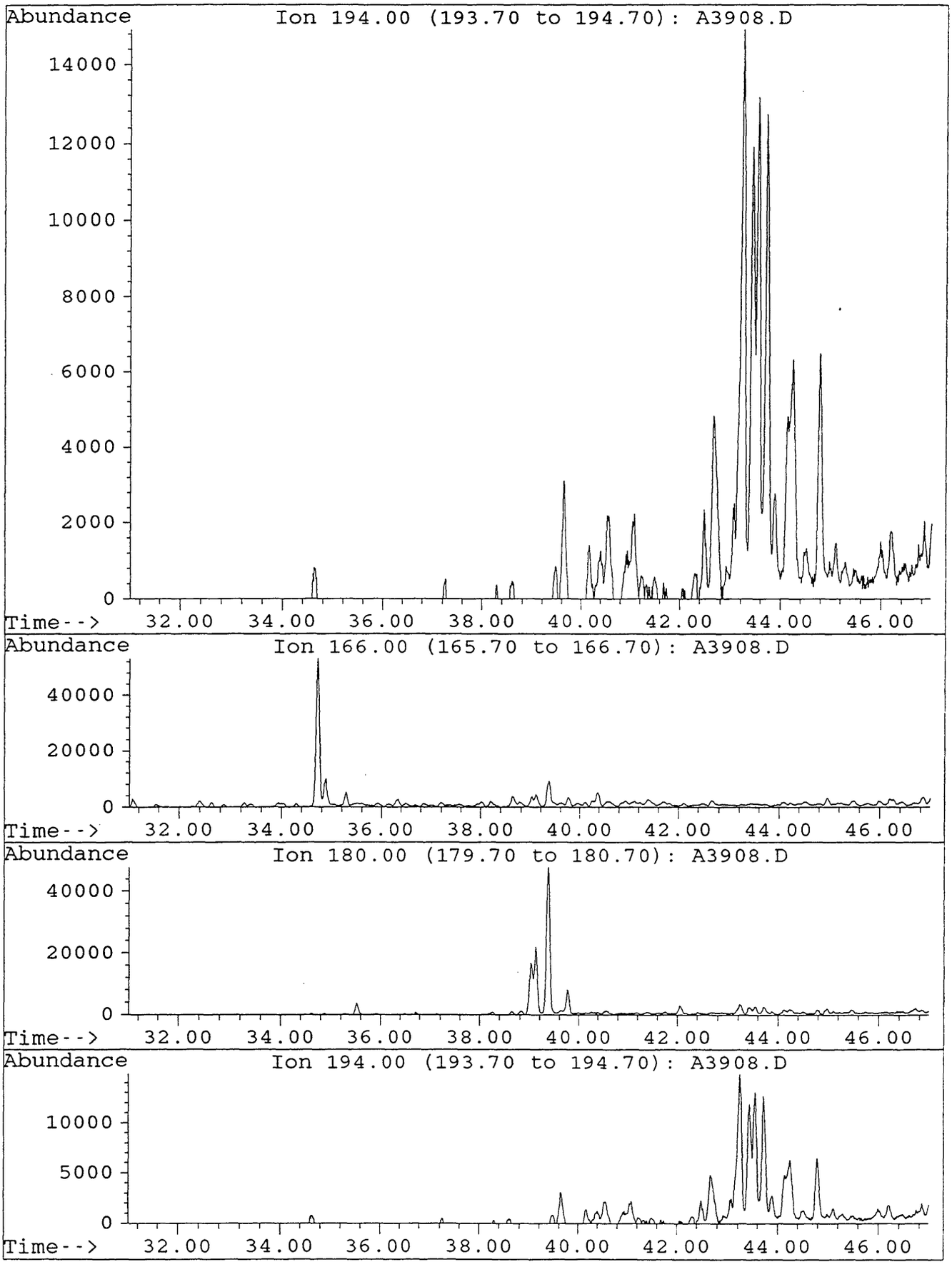
File : A3908.D
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.



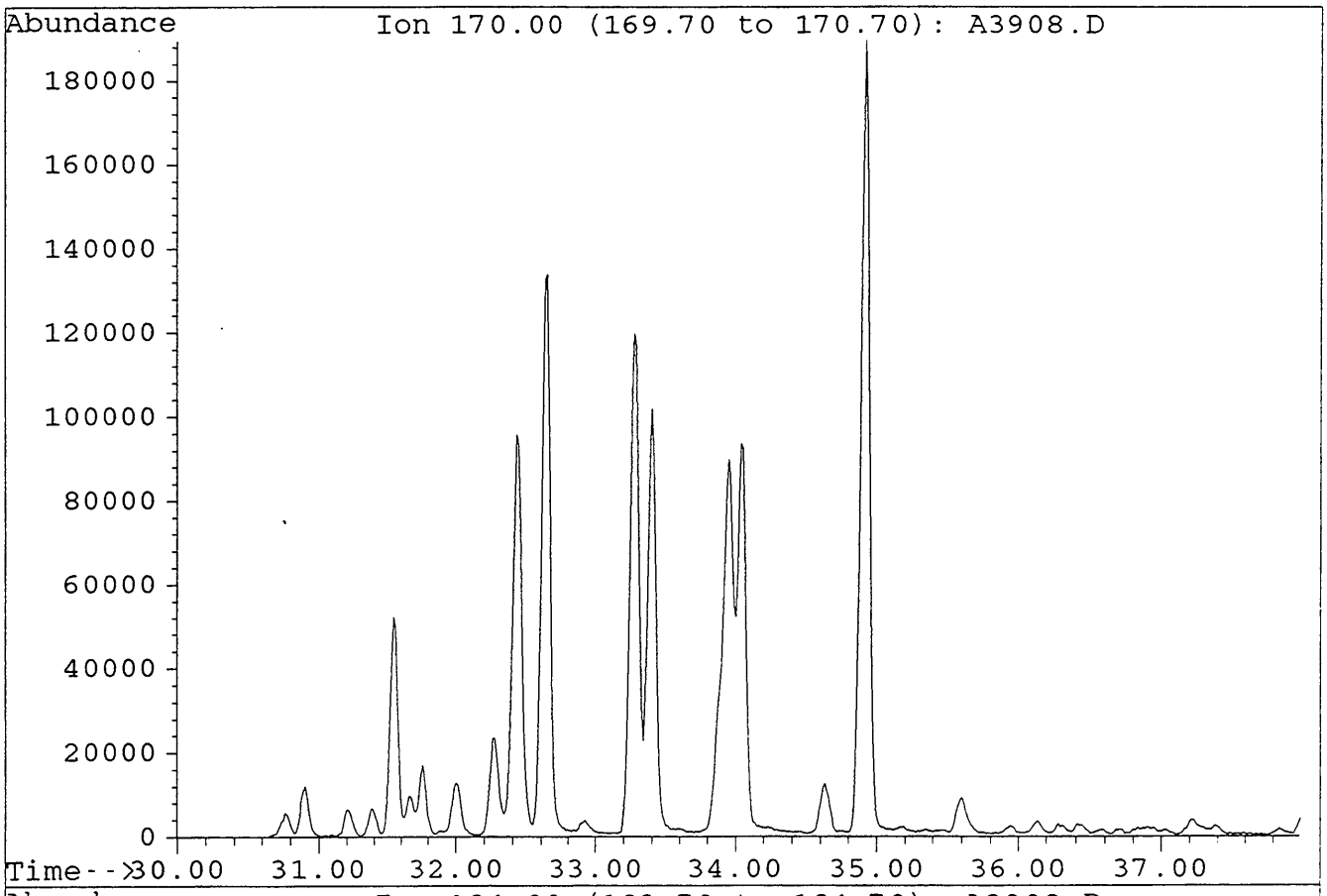


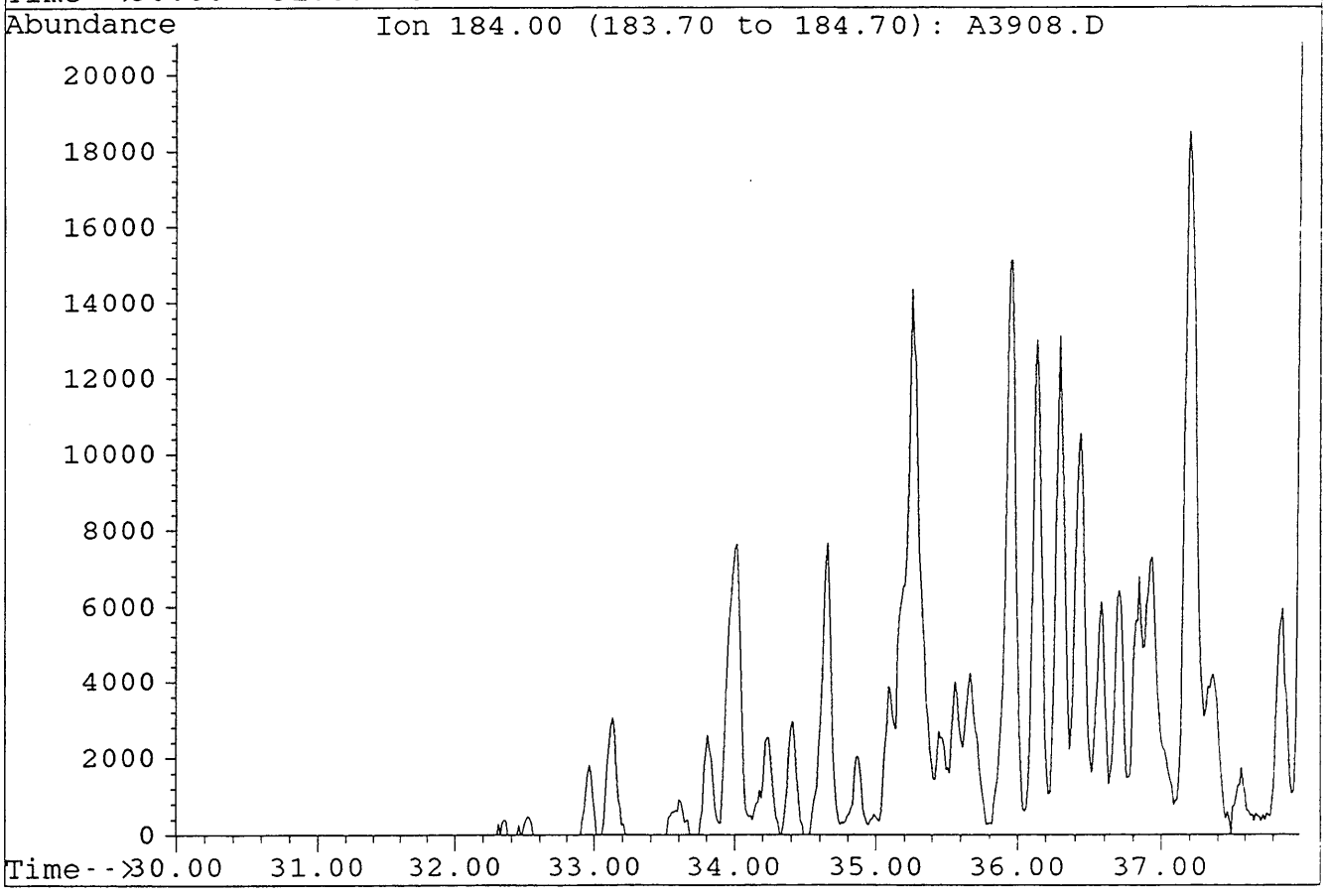
File : A3908.D
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.

FLUORENES



File : A3908.D
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.





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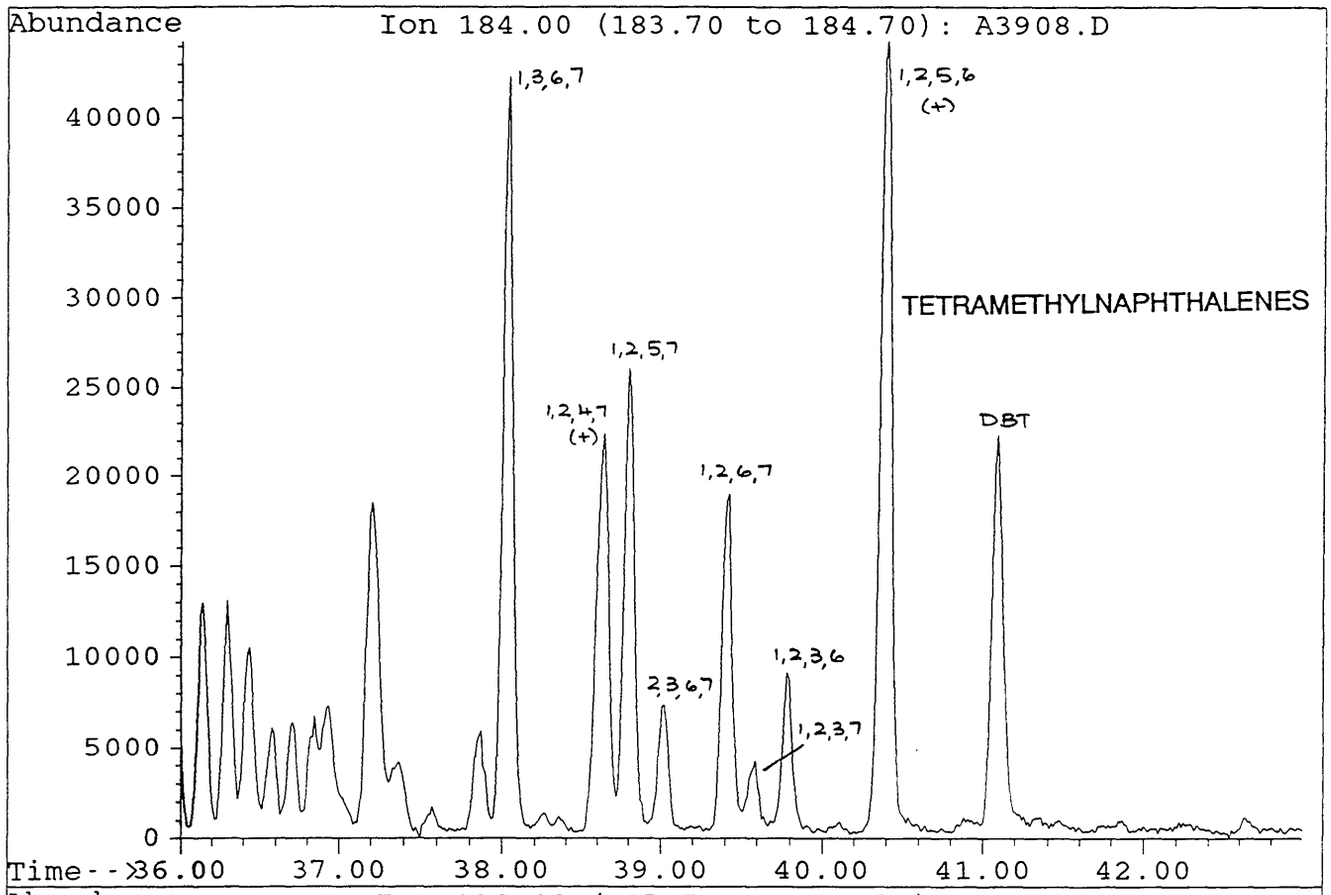
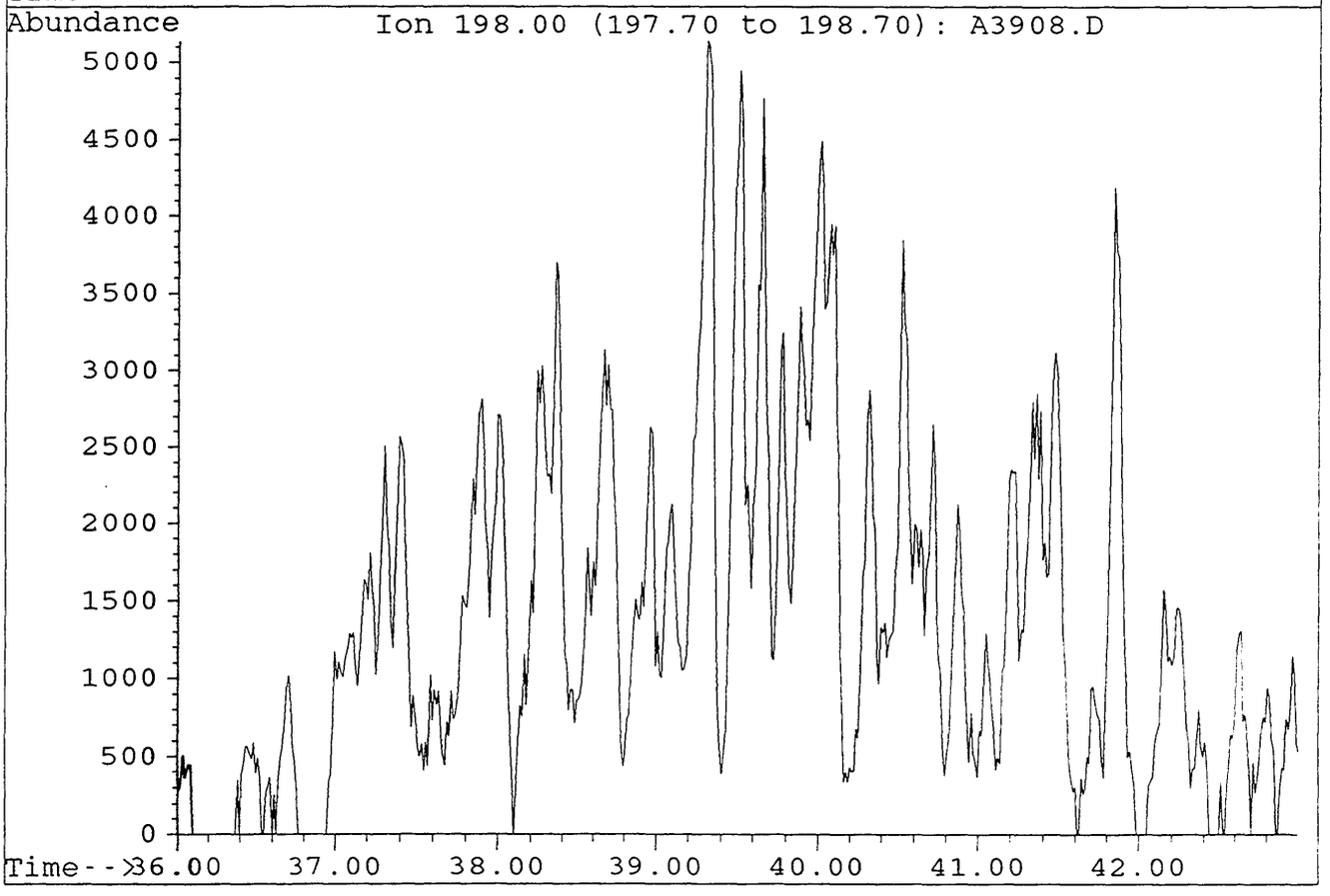
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.





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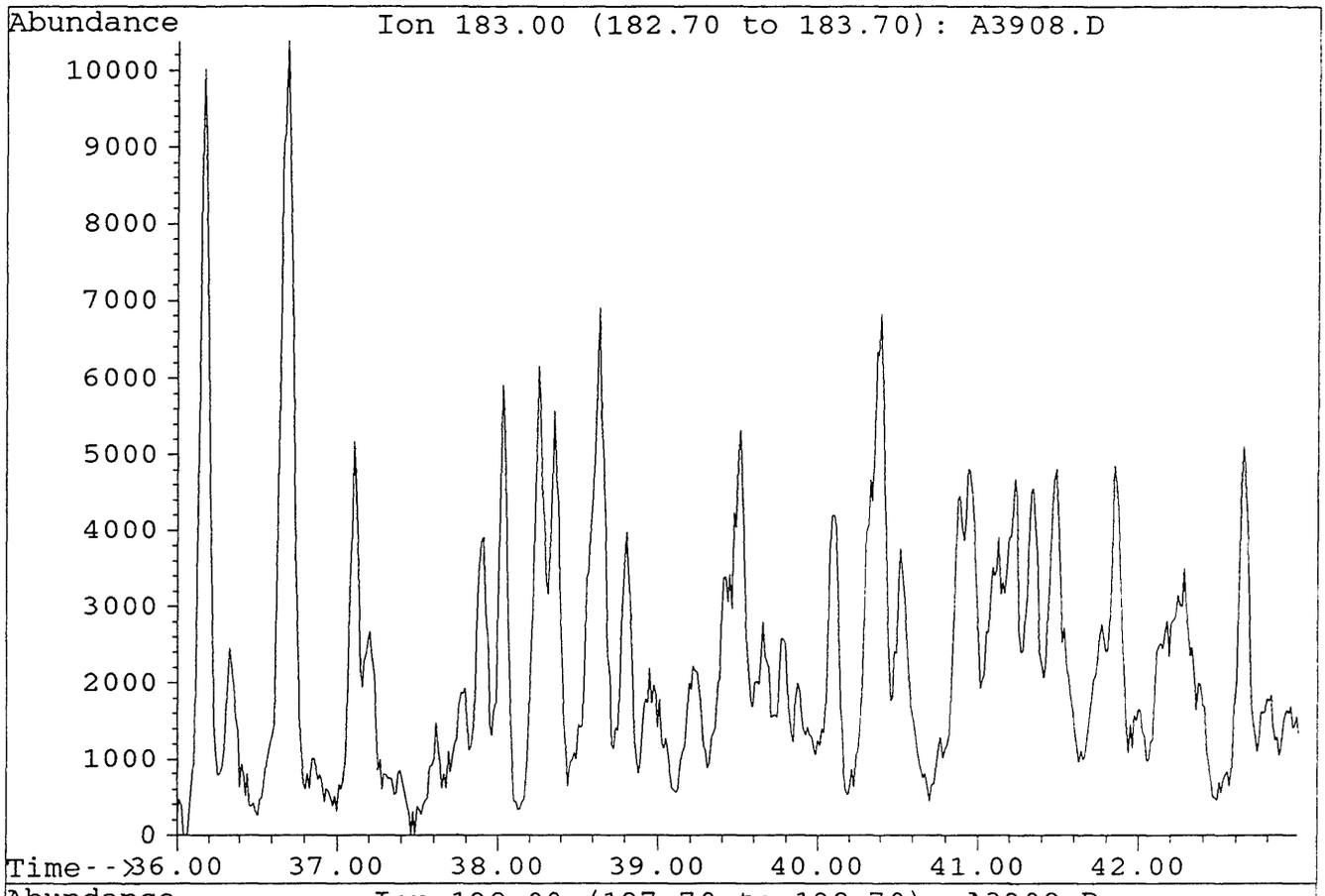
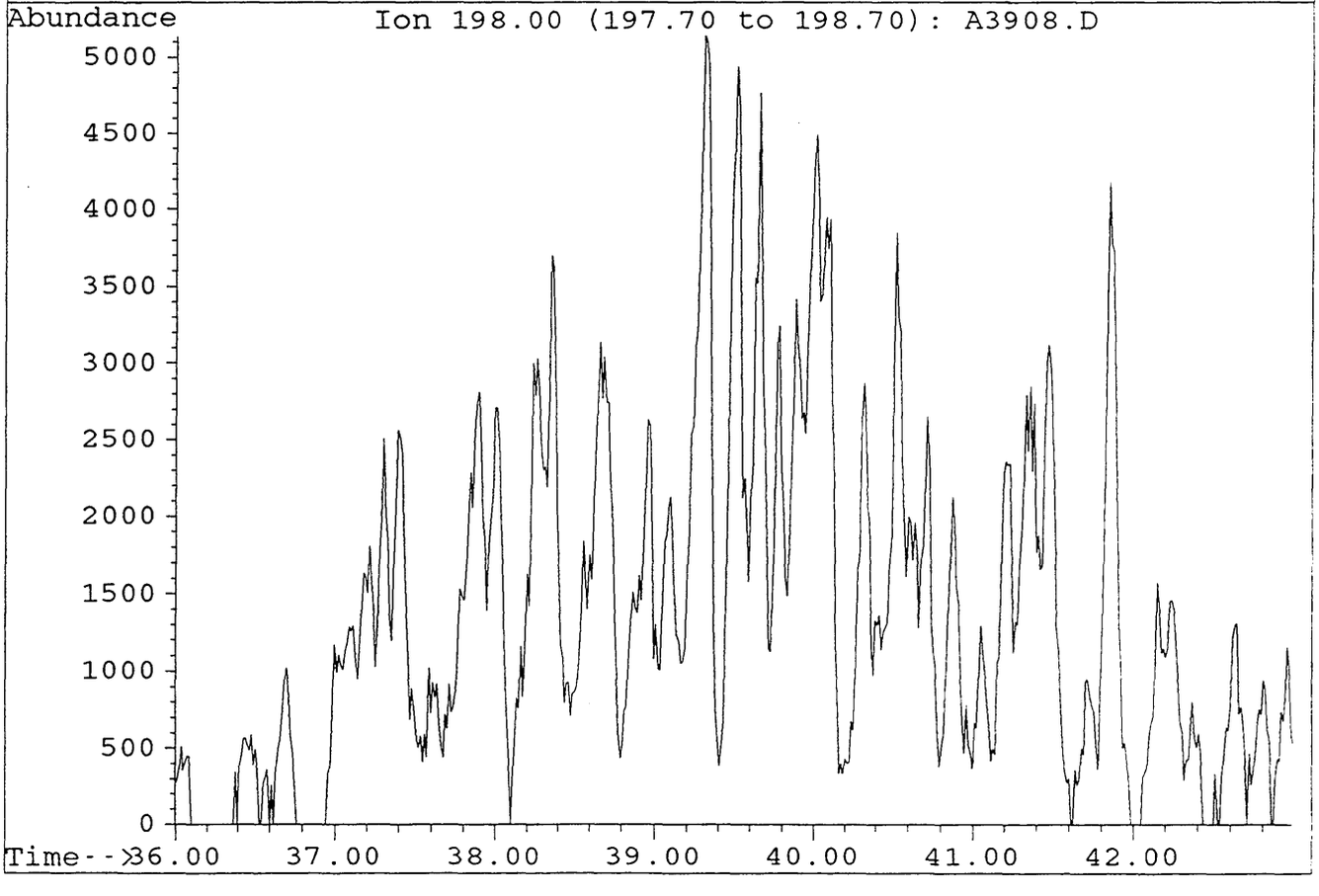
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.





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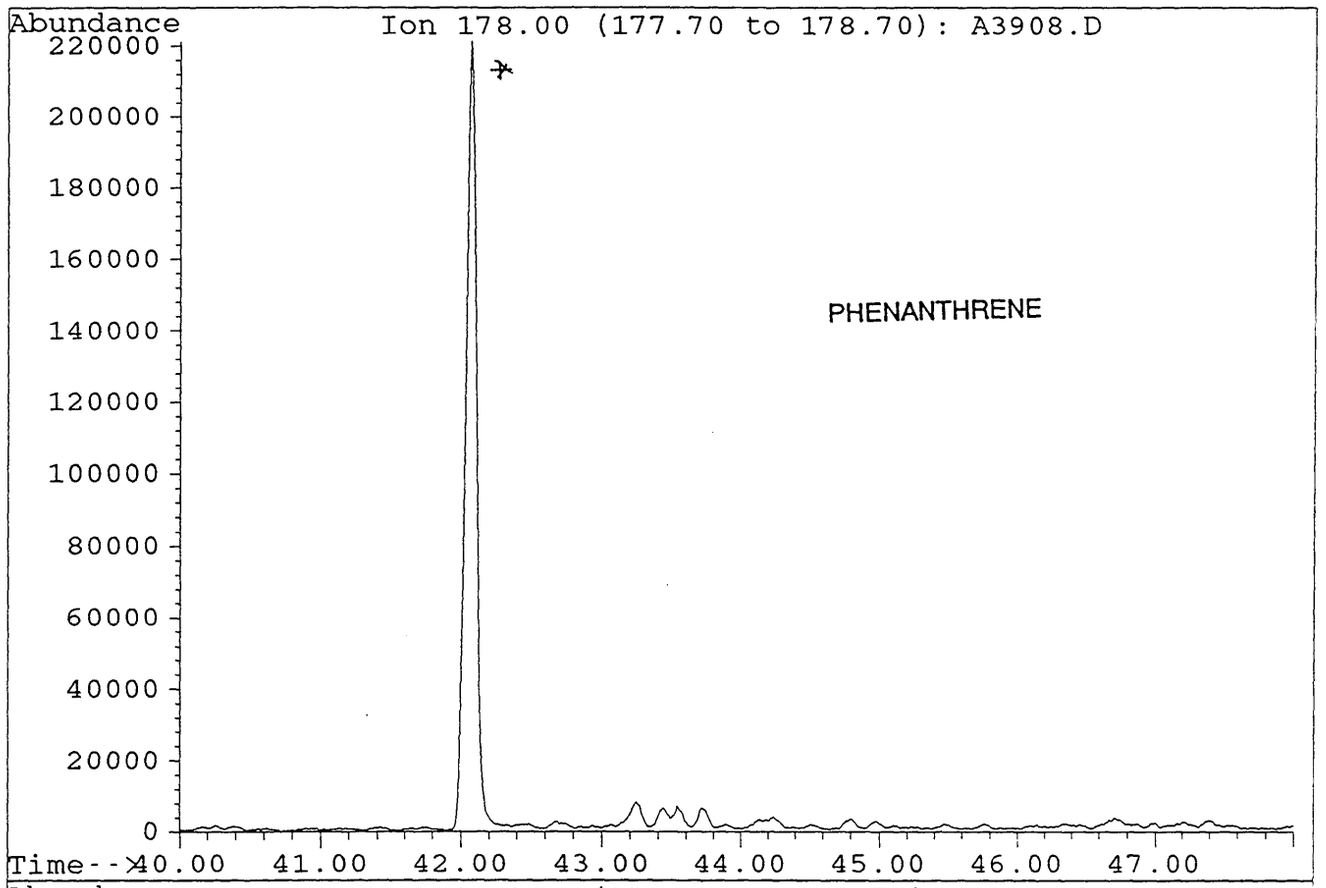
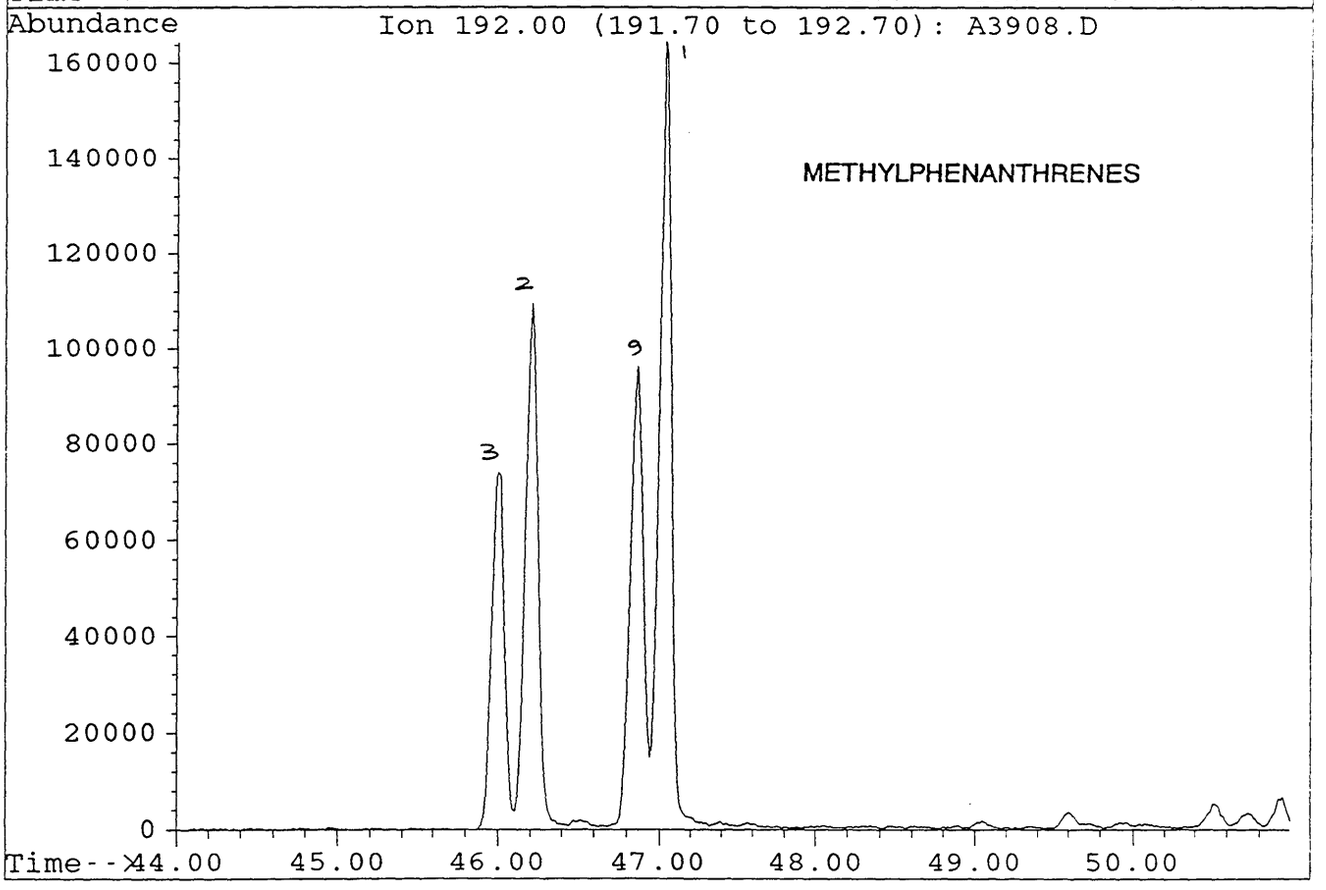
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.





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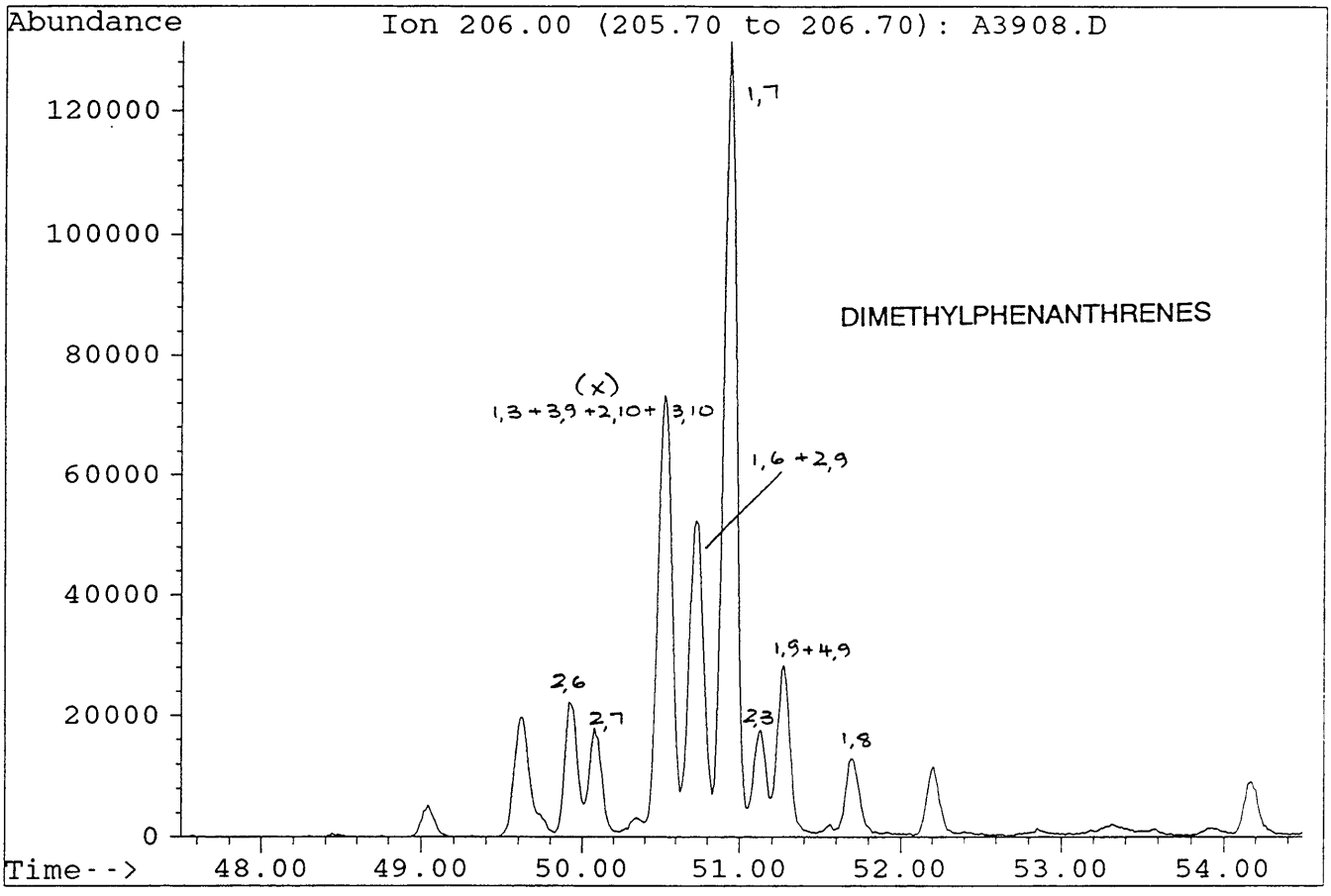
Misc. Info : COL#155. 26-7-95. GEC.



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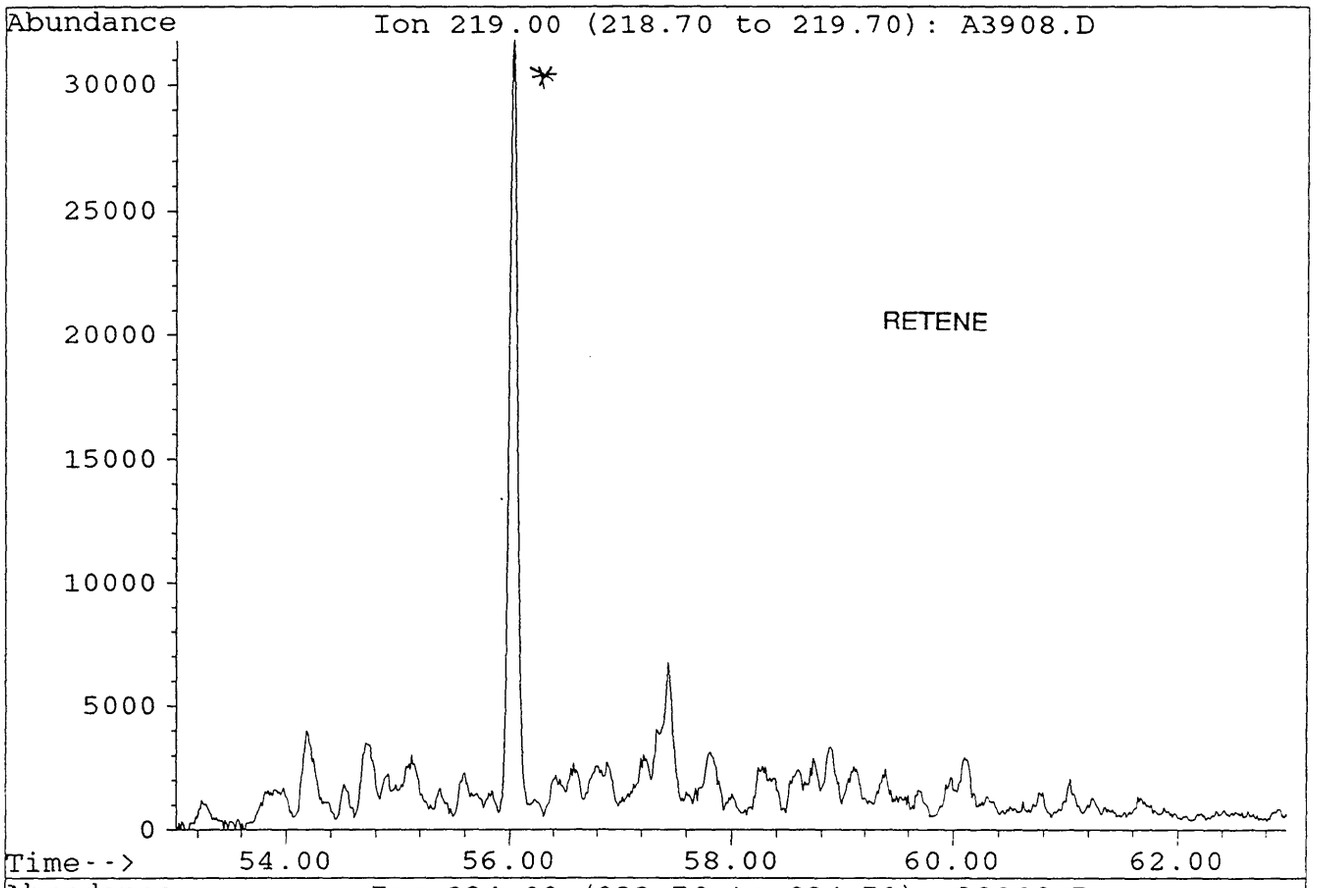
Sample : DIGBY#1, 1940.8m. AROS.
Misc. Info : COL#155. 26-7-95. GEC.



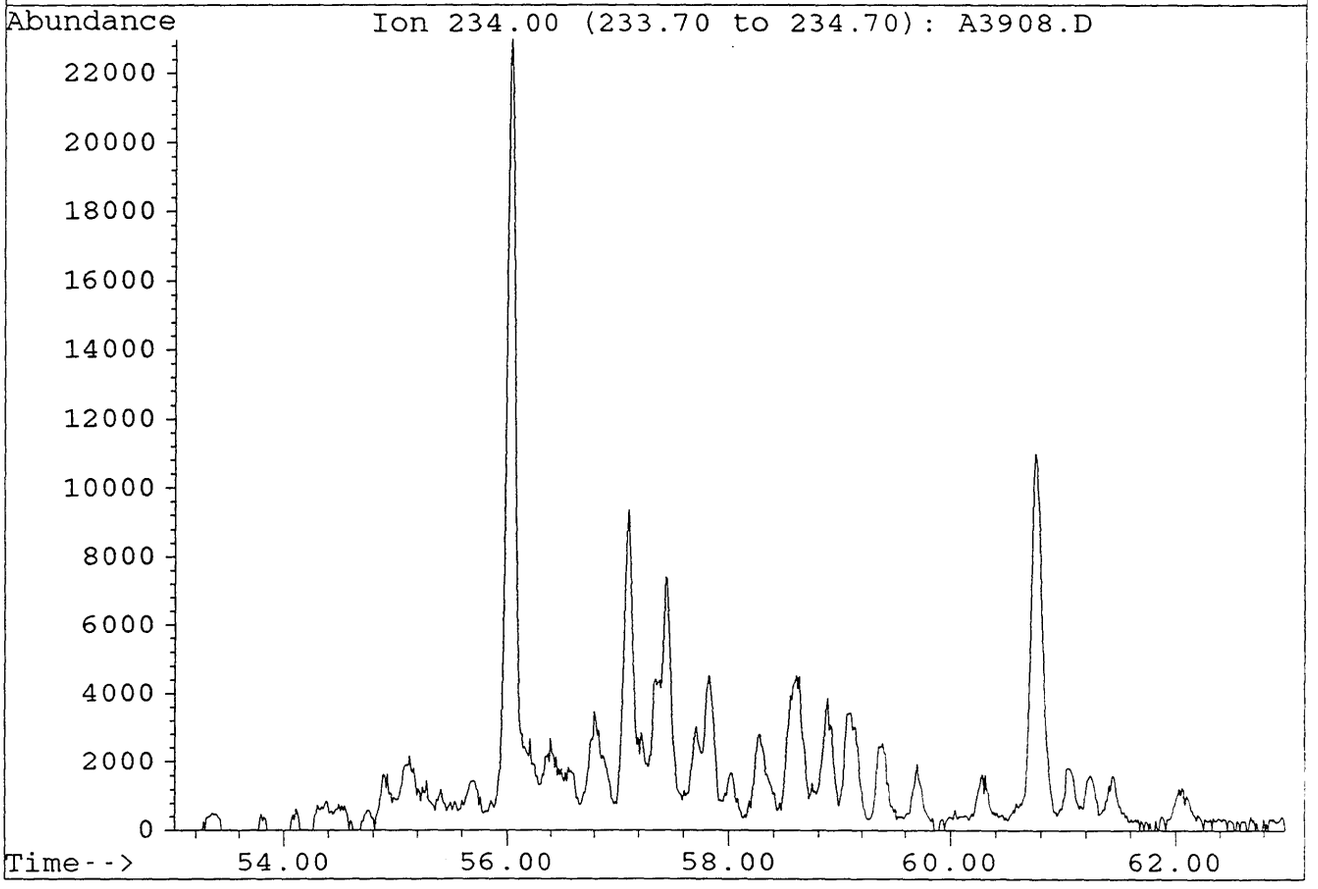


TABLE 9-4

SELECTED PARAMETERS FROM GC/MS ANALYSIS

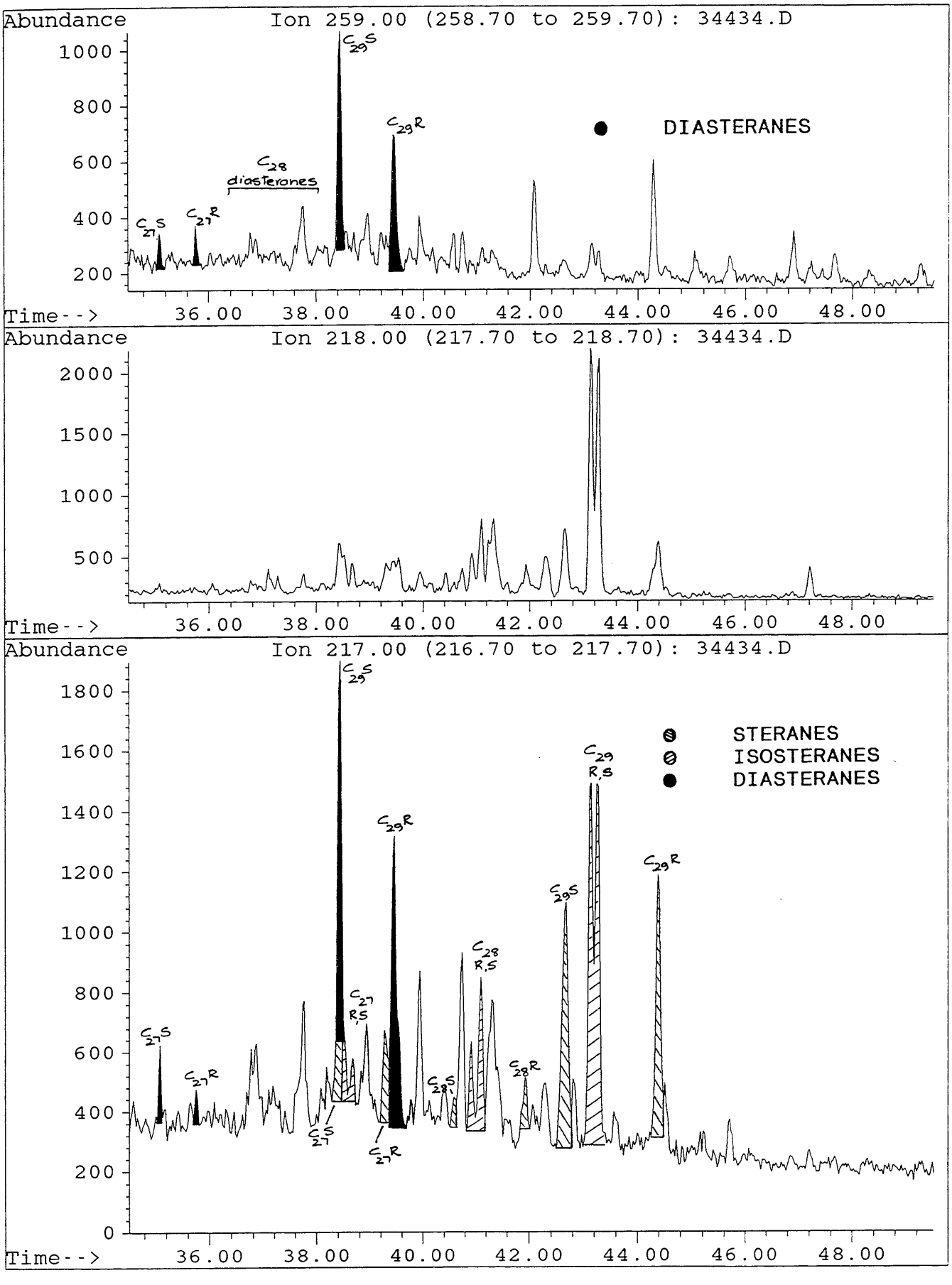
DIGBY 1, 1944.2m, SWC

	Parameter	Ion(s)	Value
1.	18 α (H)- hopane/17 α (H)-hopane (Ts/Tm)	191	0.45
2.	C30 hopane/C30 moretane	191	10.86
3.	C31 22S hopane/C31 22R hopane	191	1.53
4.	C32 22S hopane/C32 22R hopane	191	1.28
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ sterane	217	0.92
6.	C29 $\alpha\alpha\alpha$ steranes (20S / 20S+20R)	217	0.48
7.	C29 $\alpha\beta\beta$ steranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.58
8.	C27/C29 diasteranes	259	0.23
9.	C27/C29 steranes	217	0.35
10.	18 α (H)-oleanane/C30 hopane	191	nd
11.	C29 diasteranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.63
12.	C30 (hopane + moretane) / C29 (steranes + diasteranes)	191/217	1.27
13.	C15 drimane/C16 homodrimane	123	0.57
14.	Rearranged drimanes/normal drimanes	123	0.30

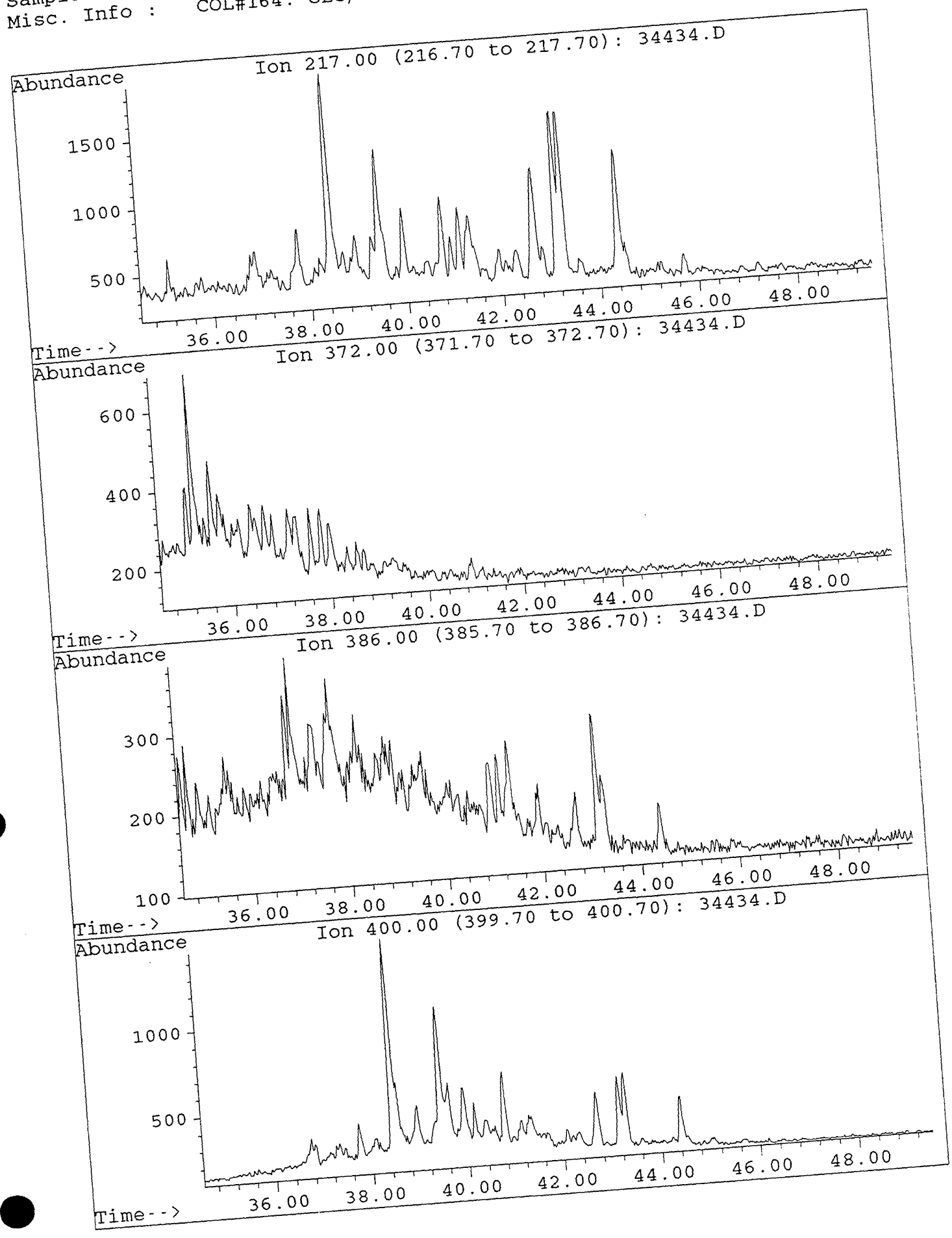
nd = not detectable

File : 34434.D
Sample : DIGBY#1, 1944.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.

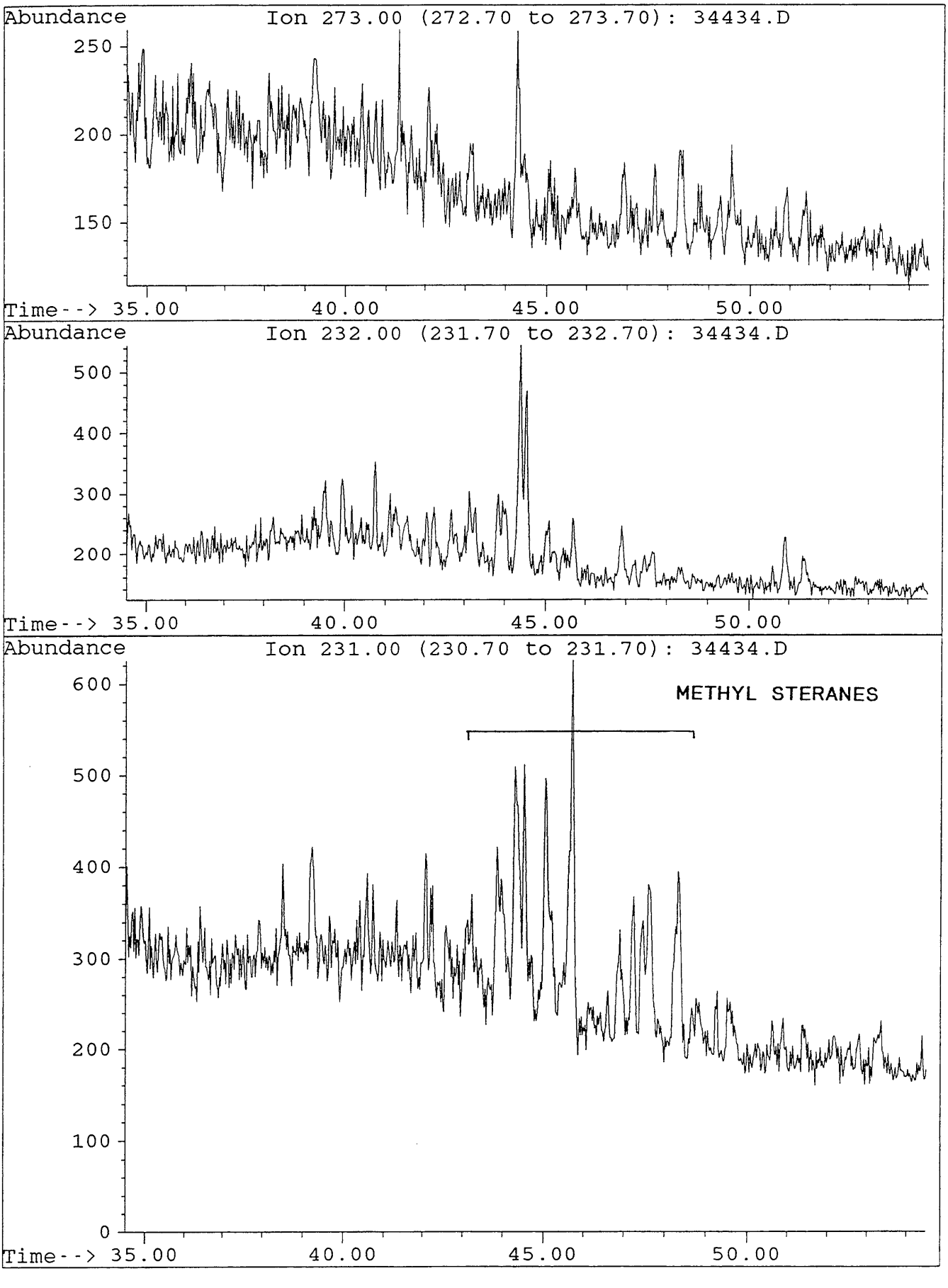
FIGURE 6-4



File : 34434.D
Sample : DIGBY#1, 1944.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



File : 34434.D
Sample : DIGBY#1, 1944.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



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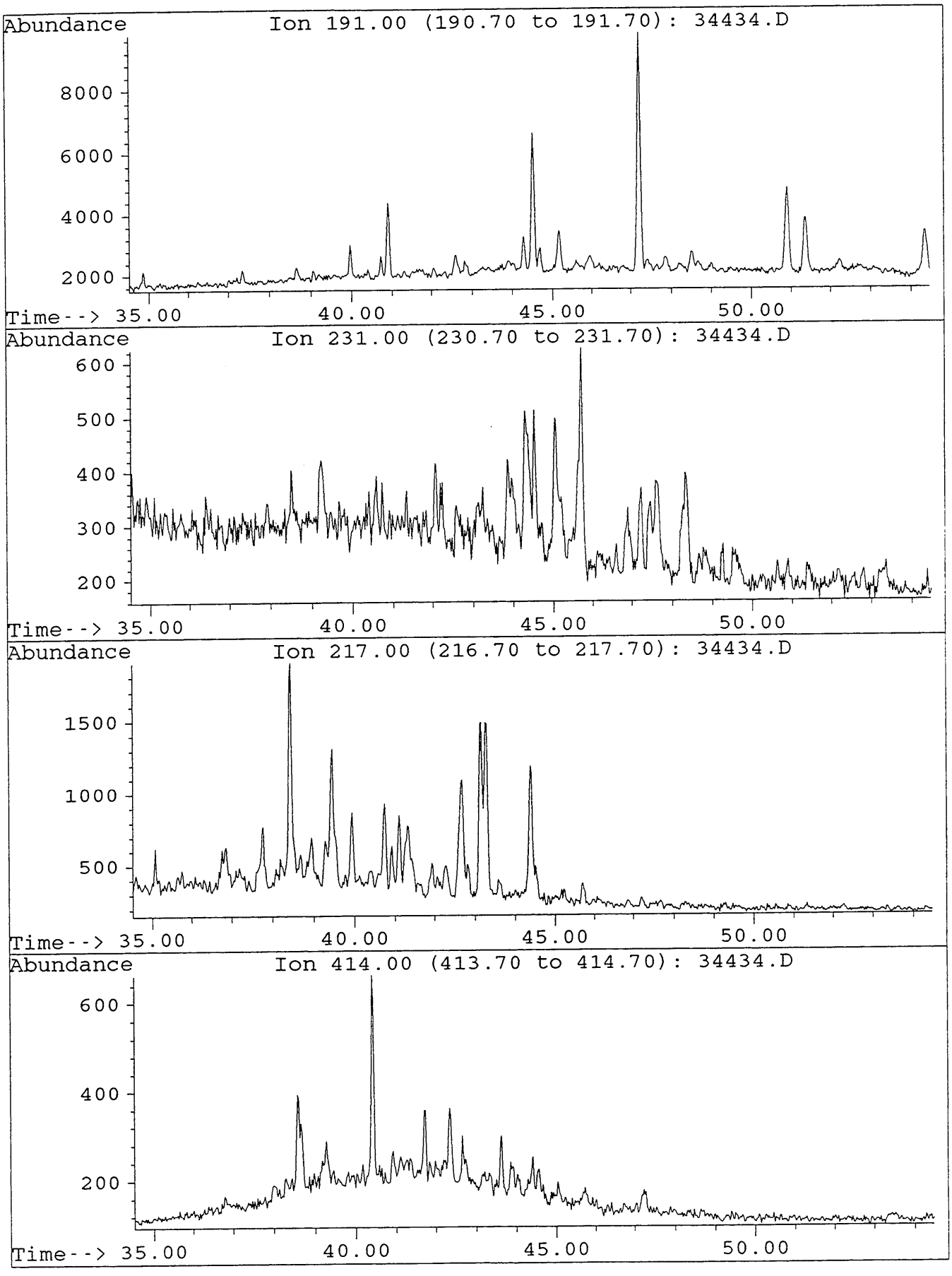
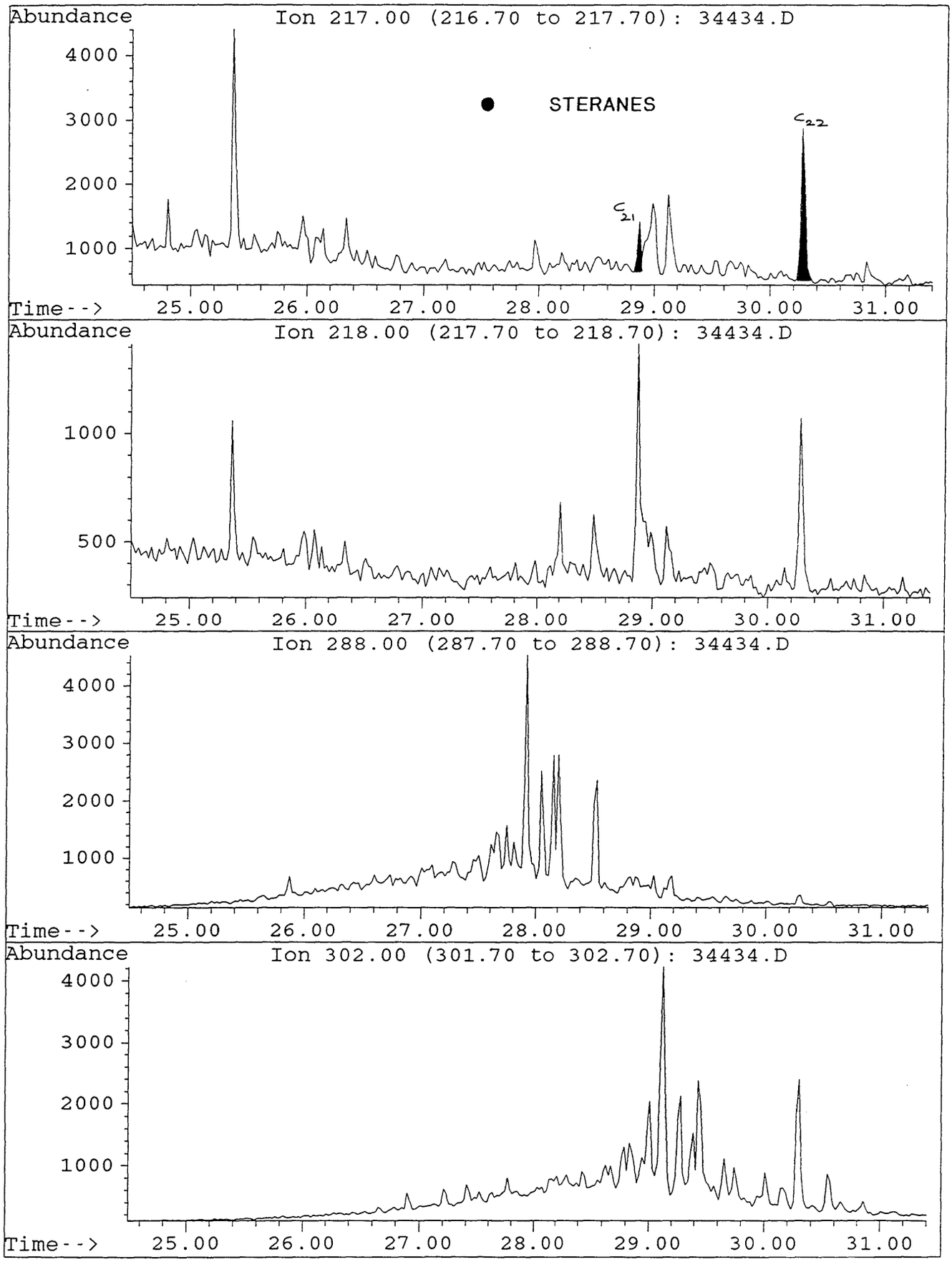
Misc. Info : COL#164. GEC/DJ. 26-7-95.



File : 34434.D
Sample : DIGBY#1, 1944.2m B/C
Misc. Info : COL#164. GEC/DJ. 26-7-95.



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Sample : DIGBY#1, 1944.2m B/C
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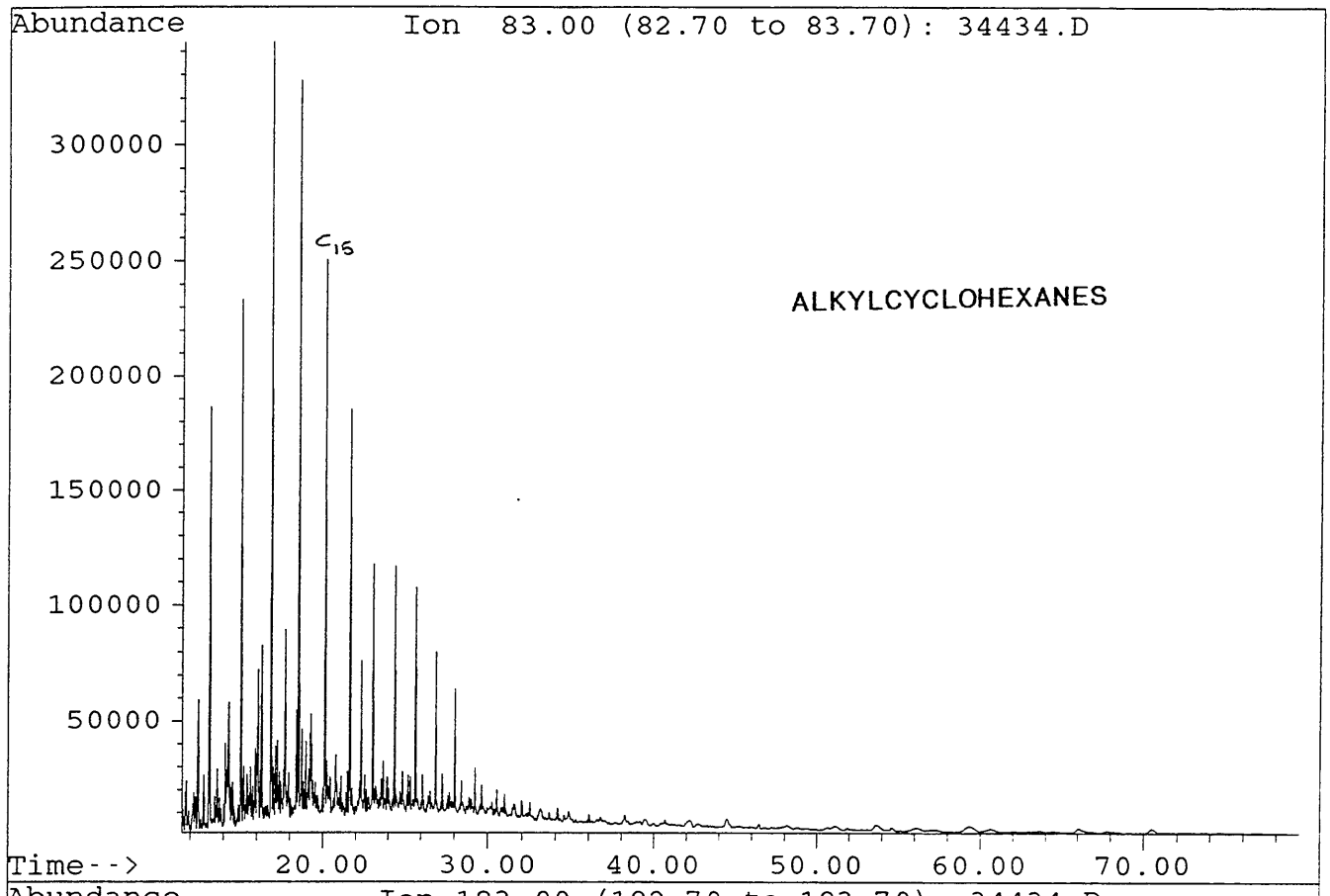

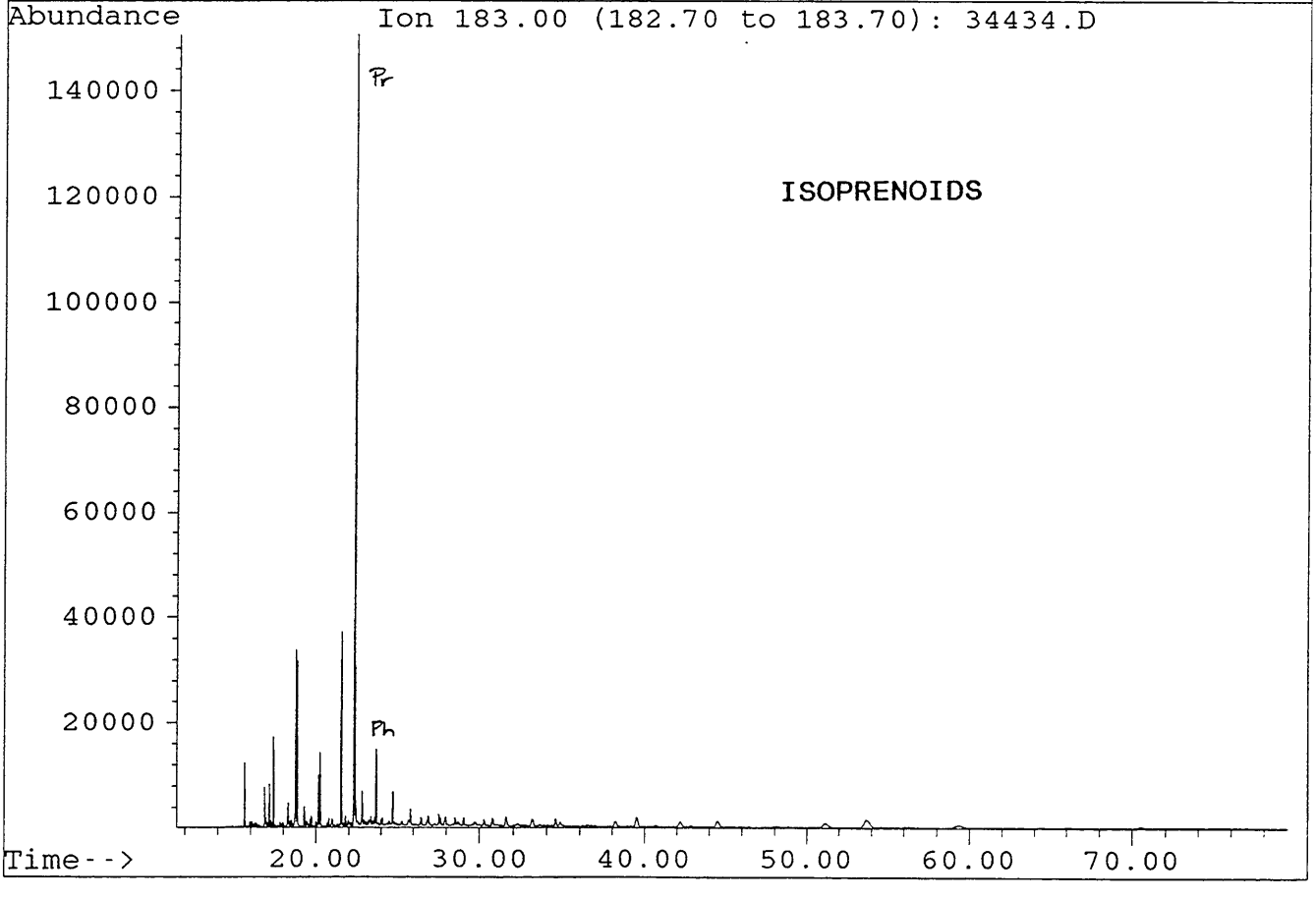

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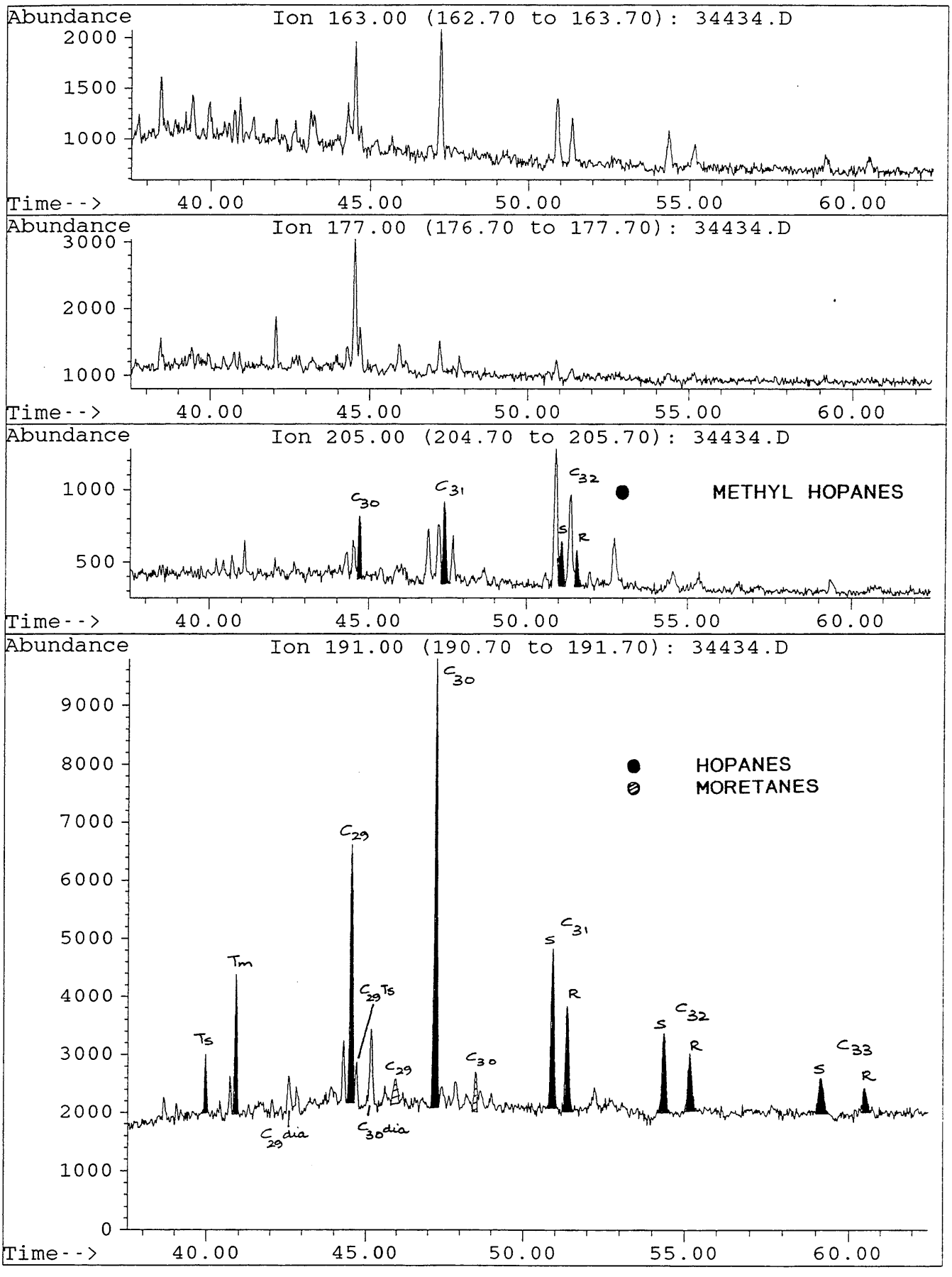

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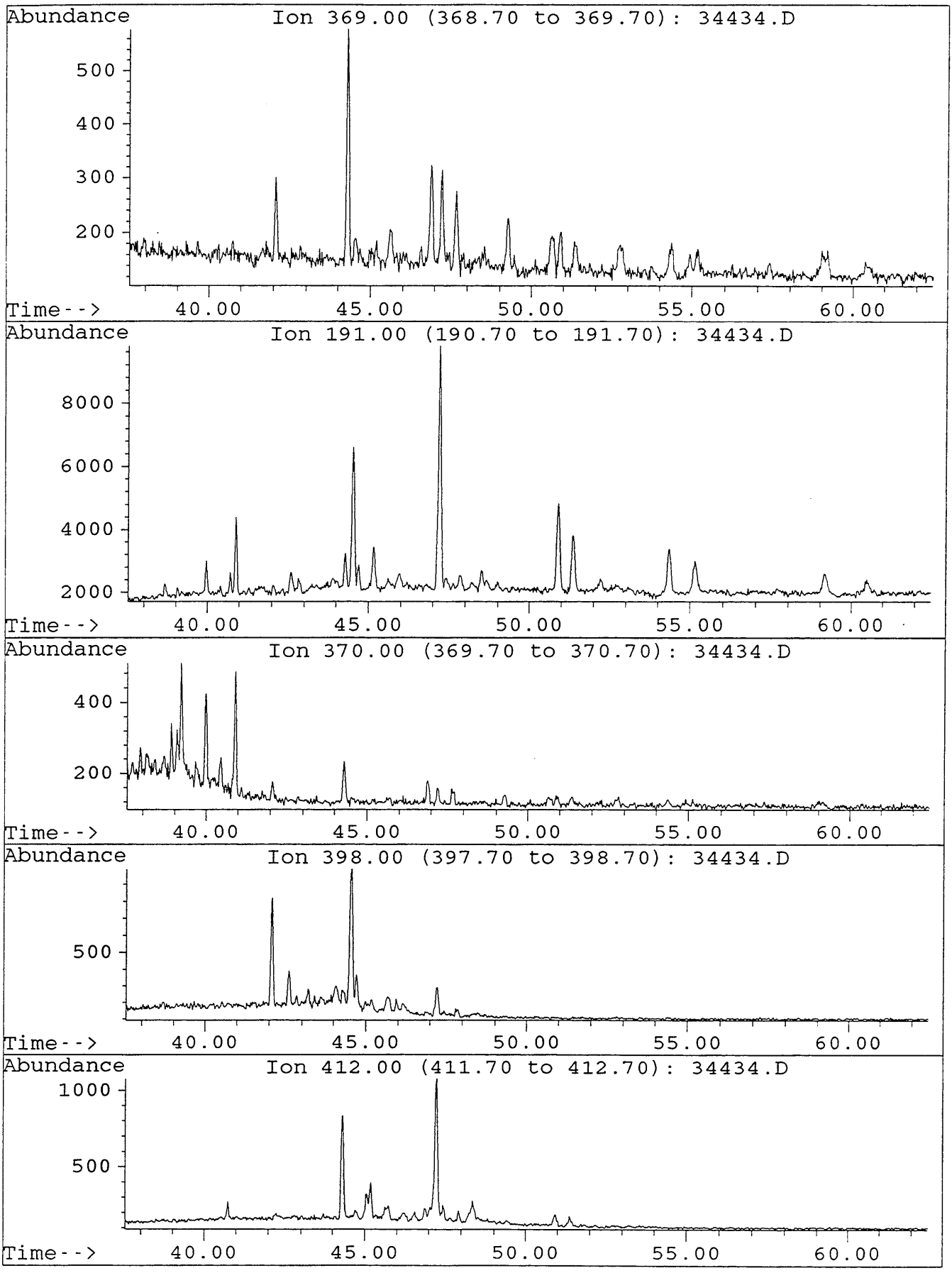

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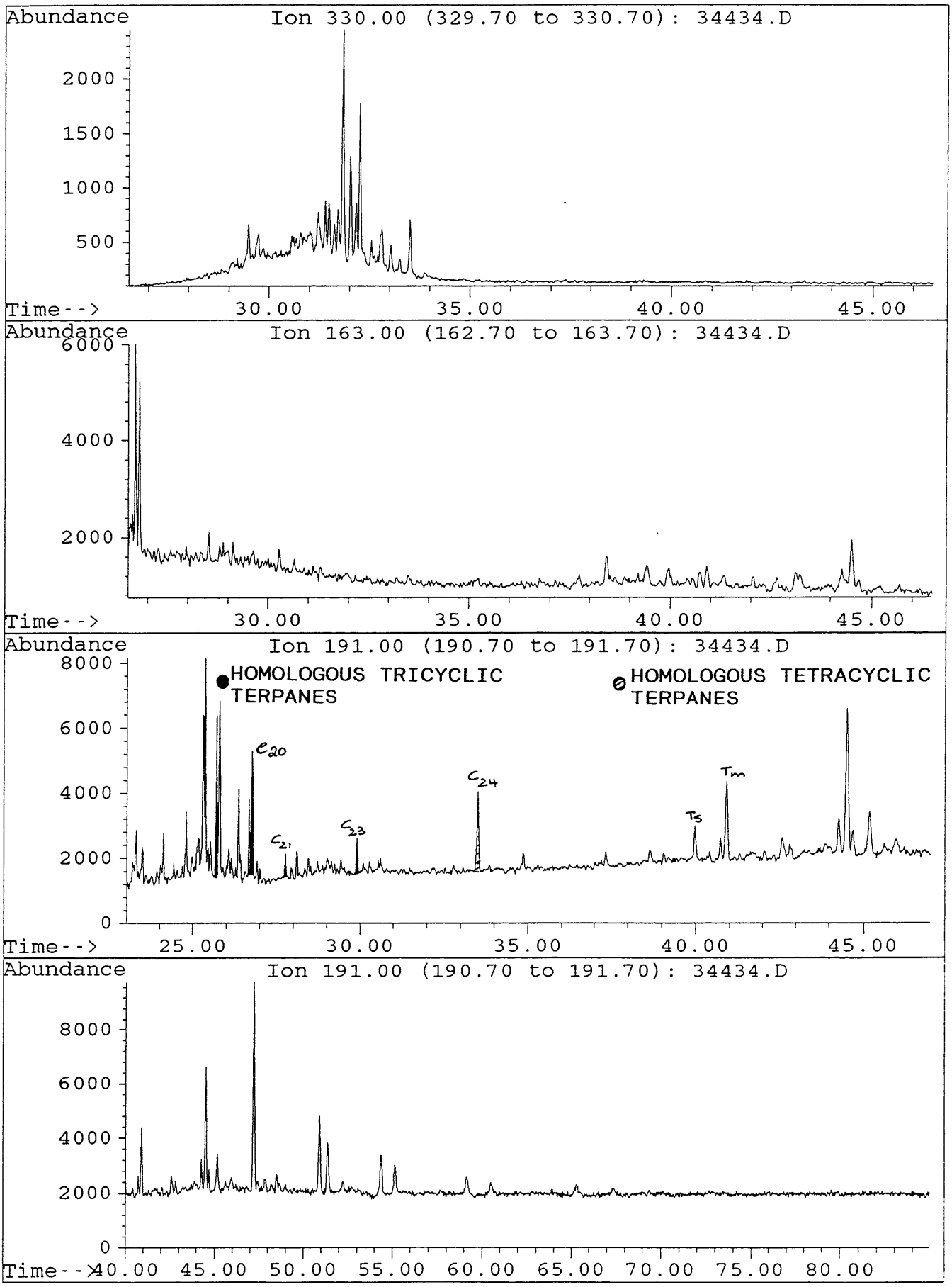

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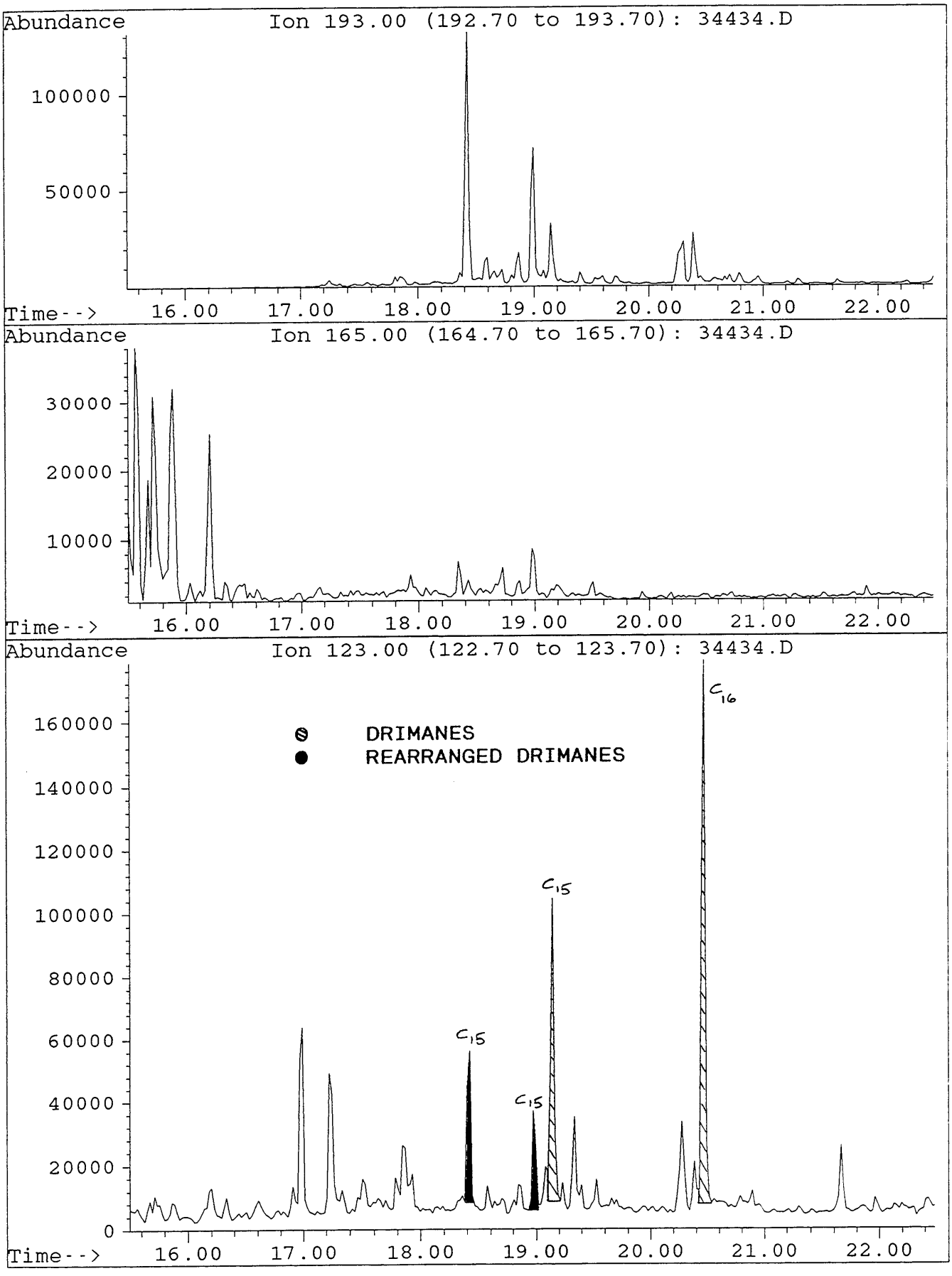

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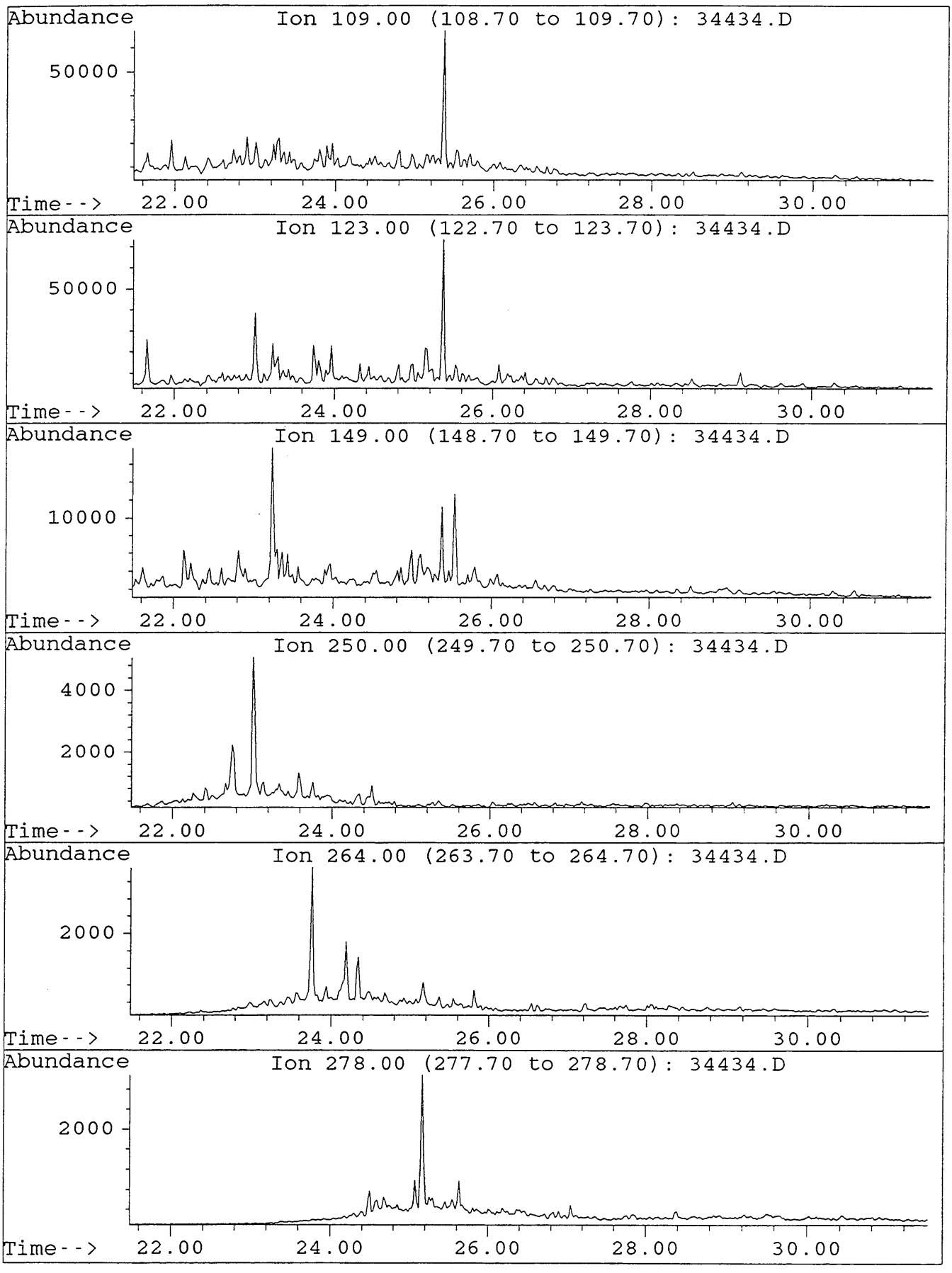

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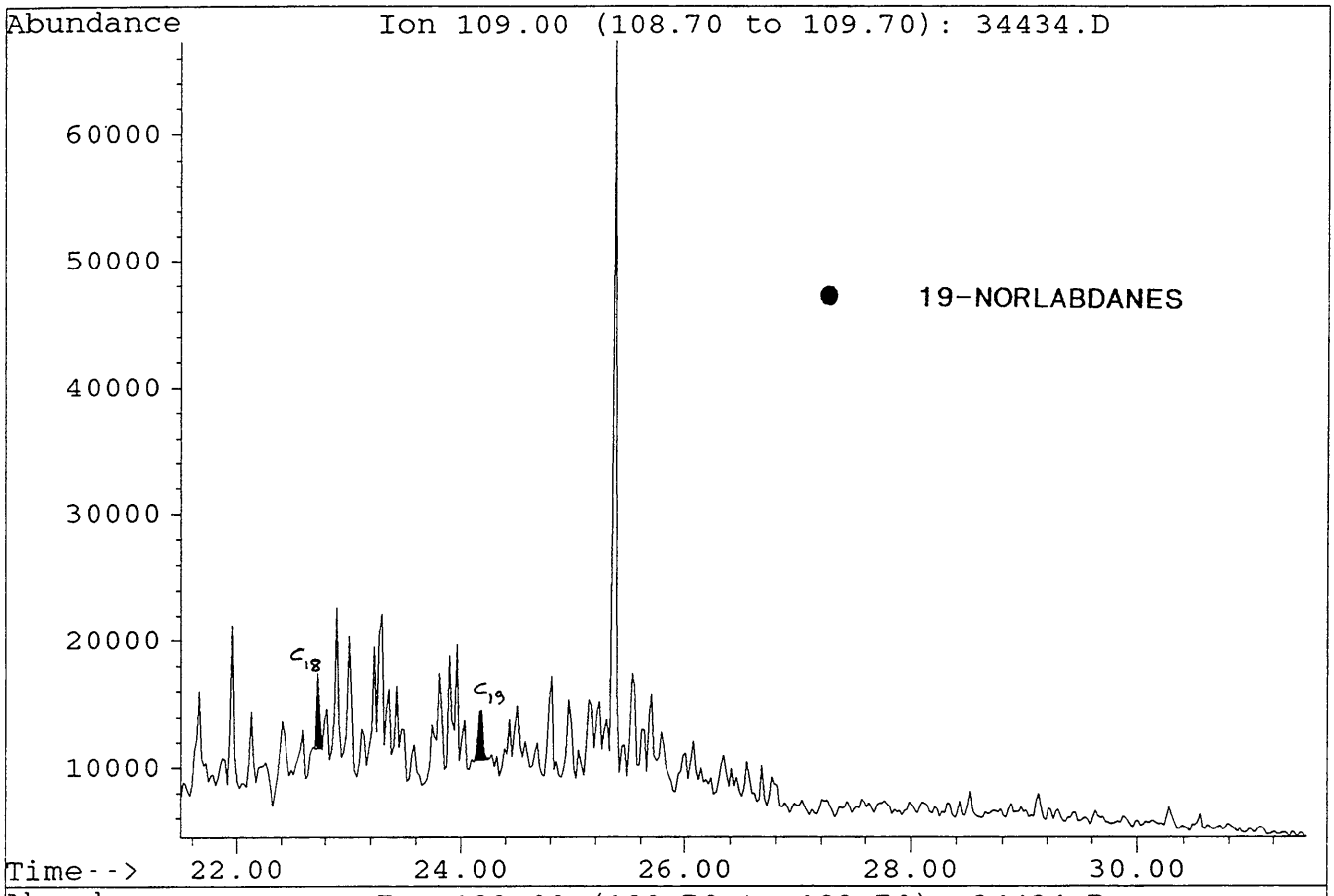

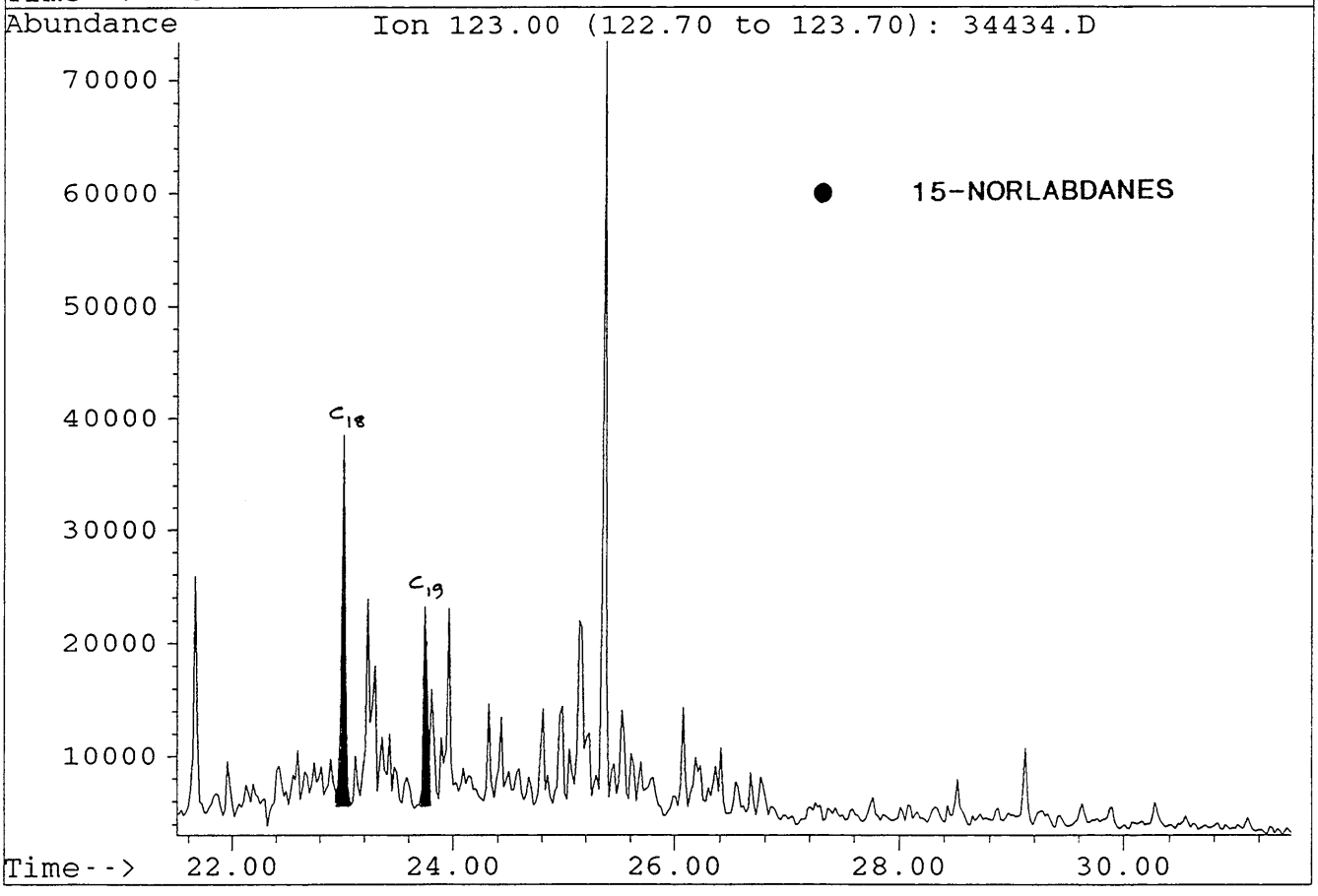

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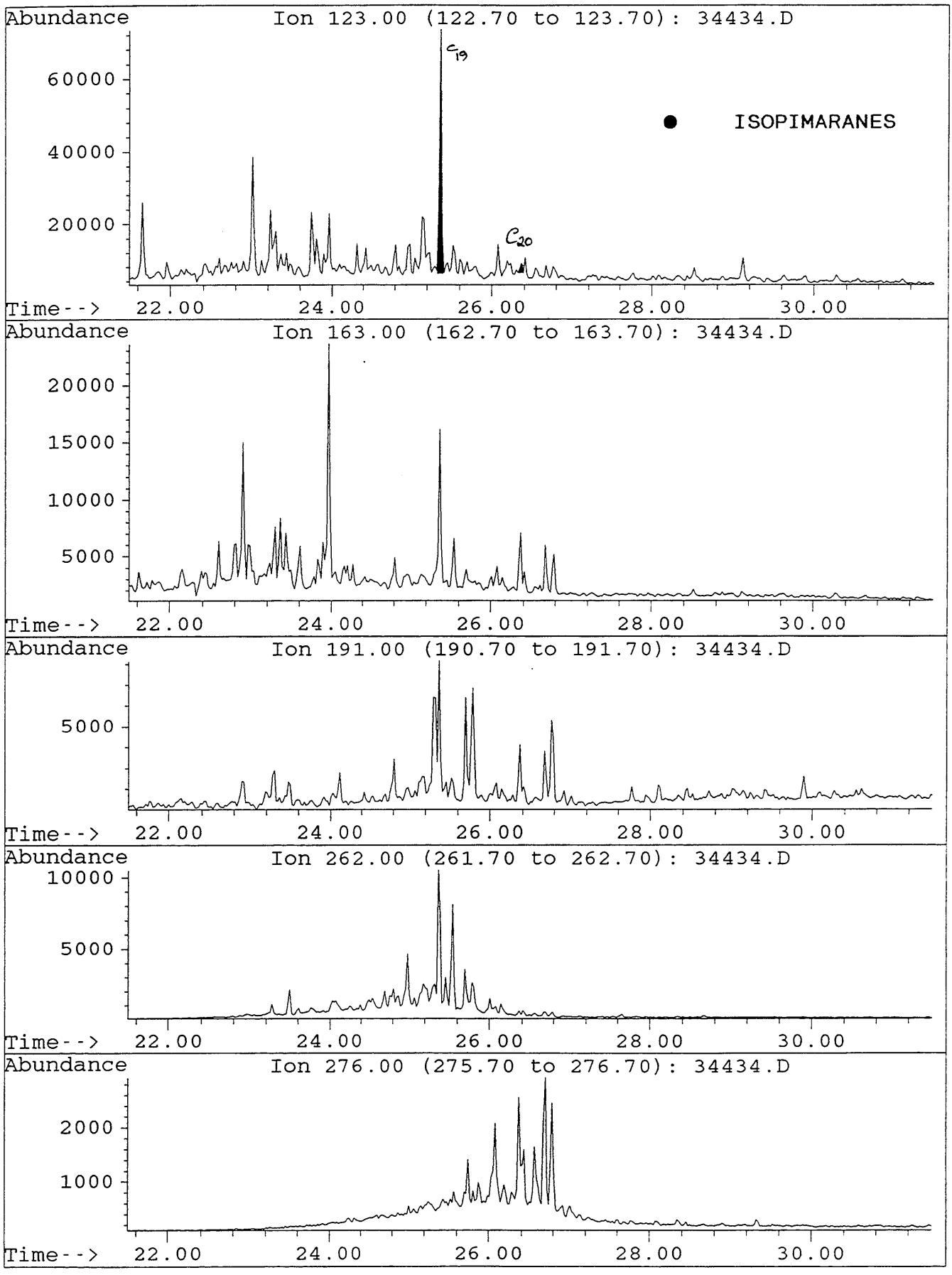

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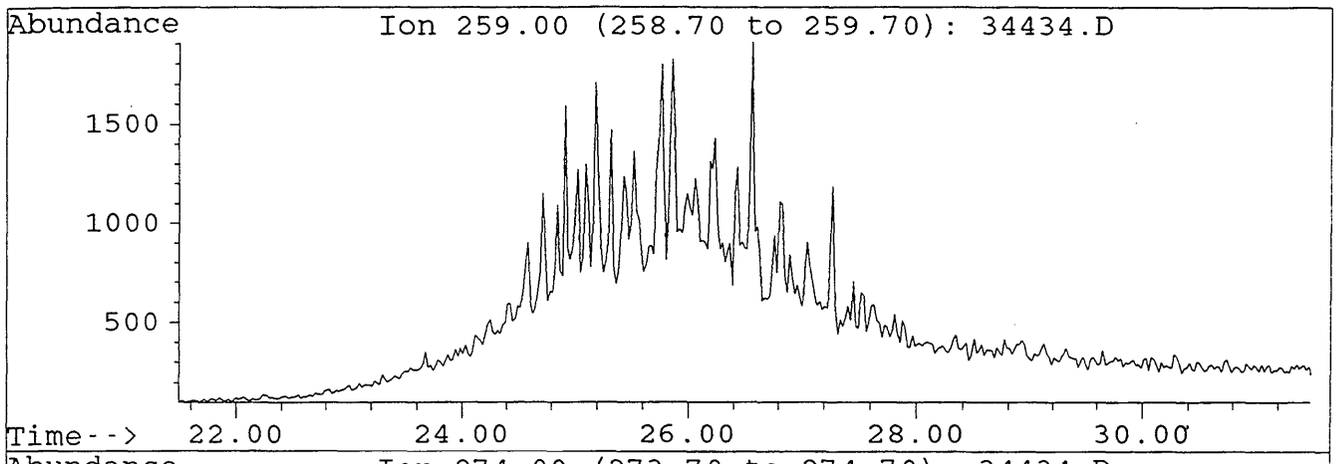

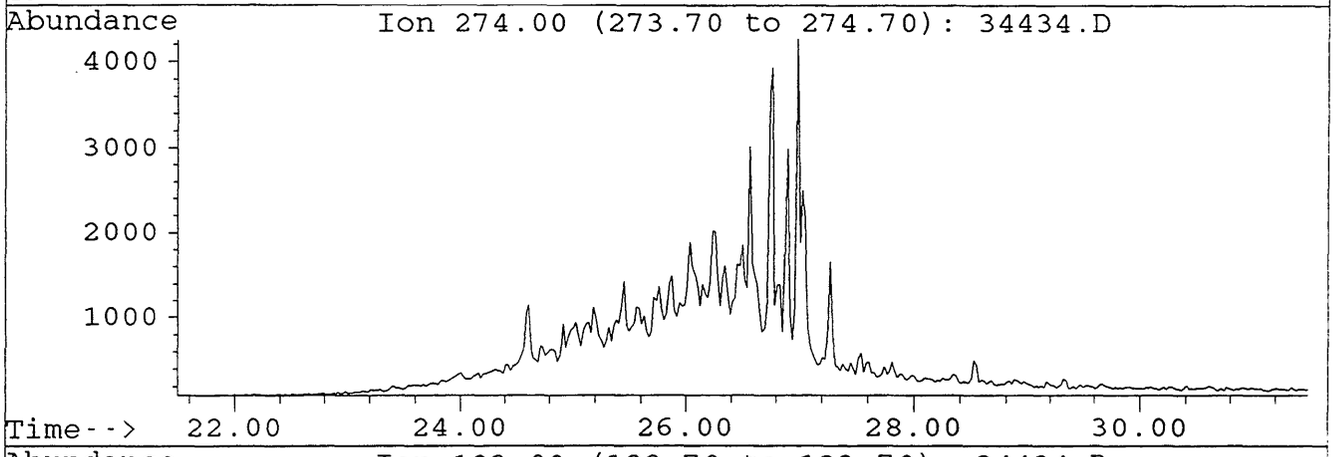

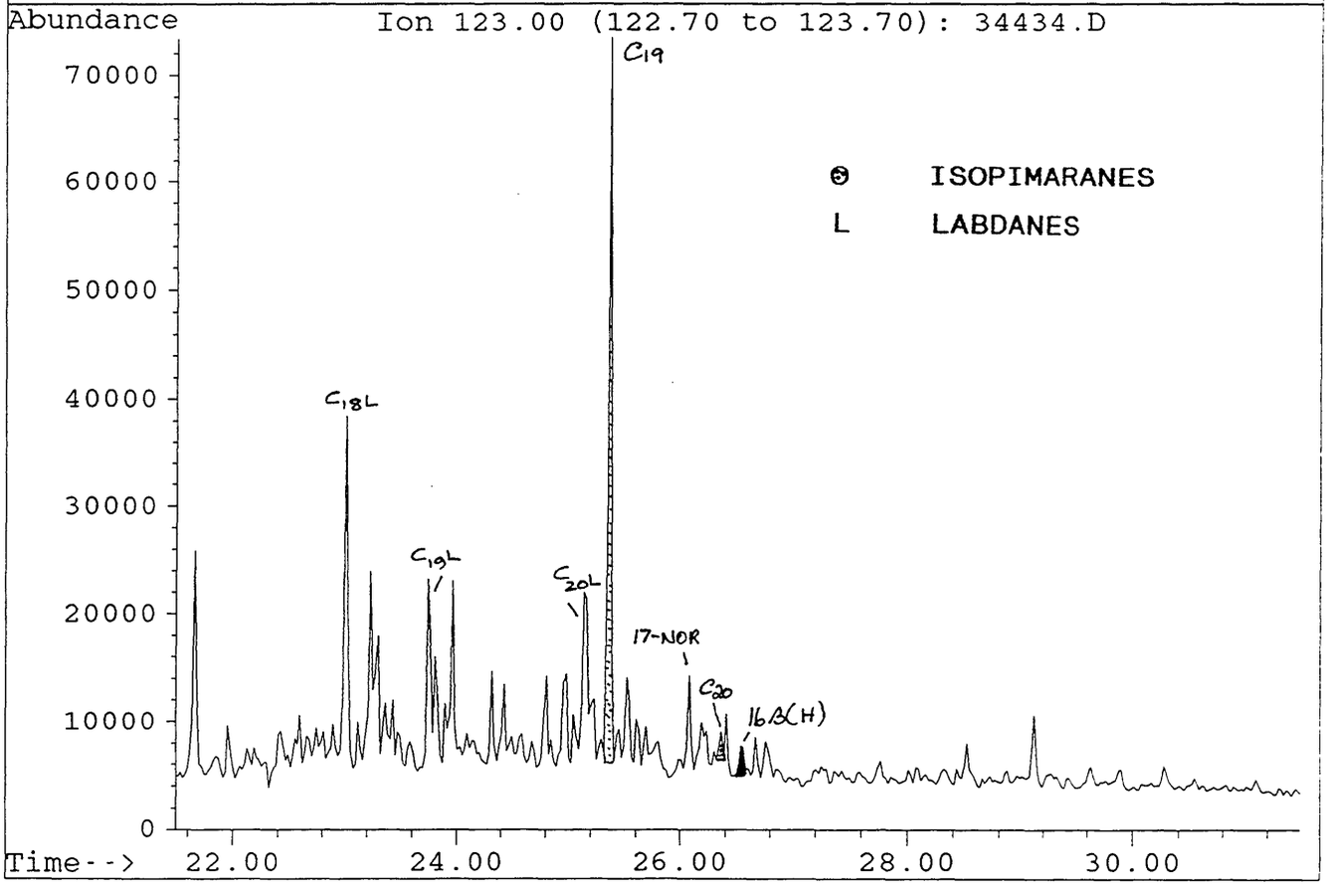

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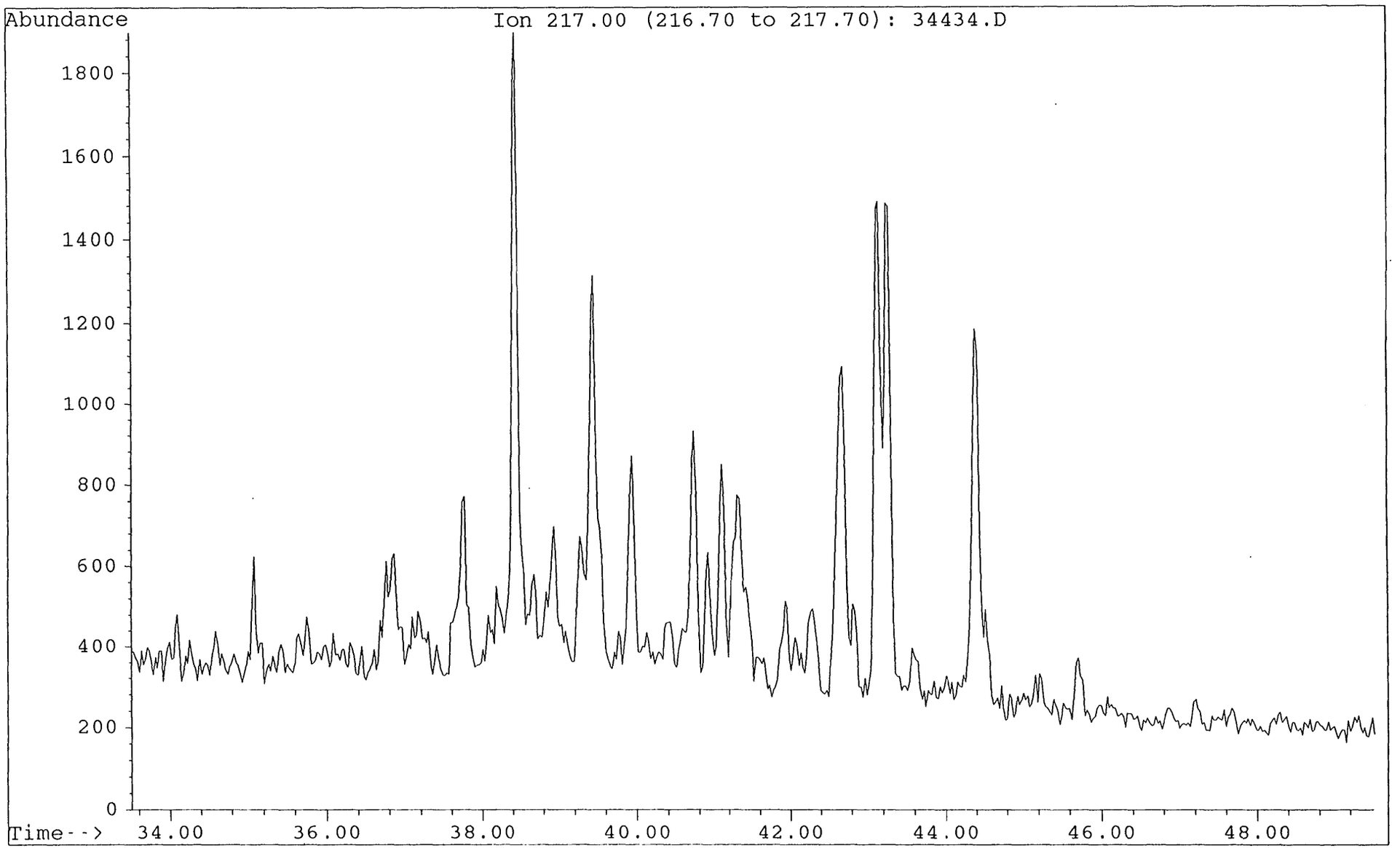

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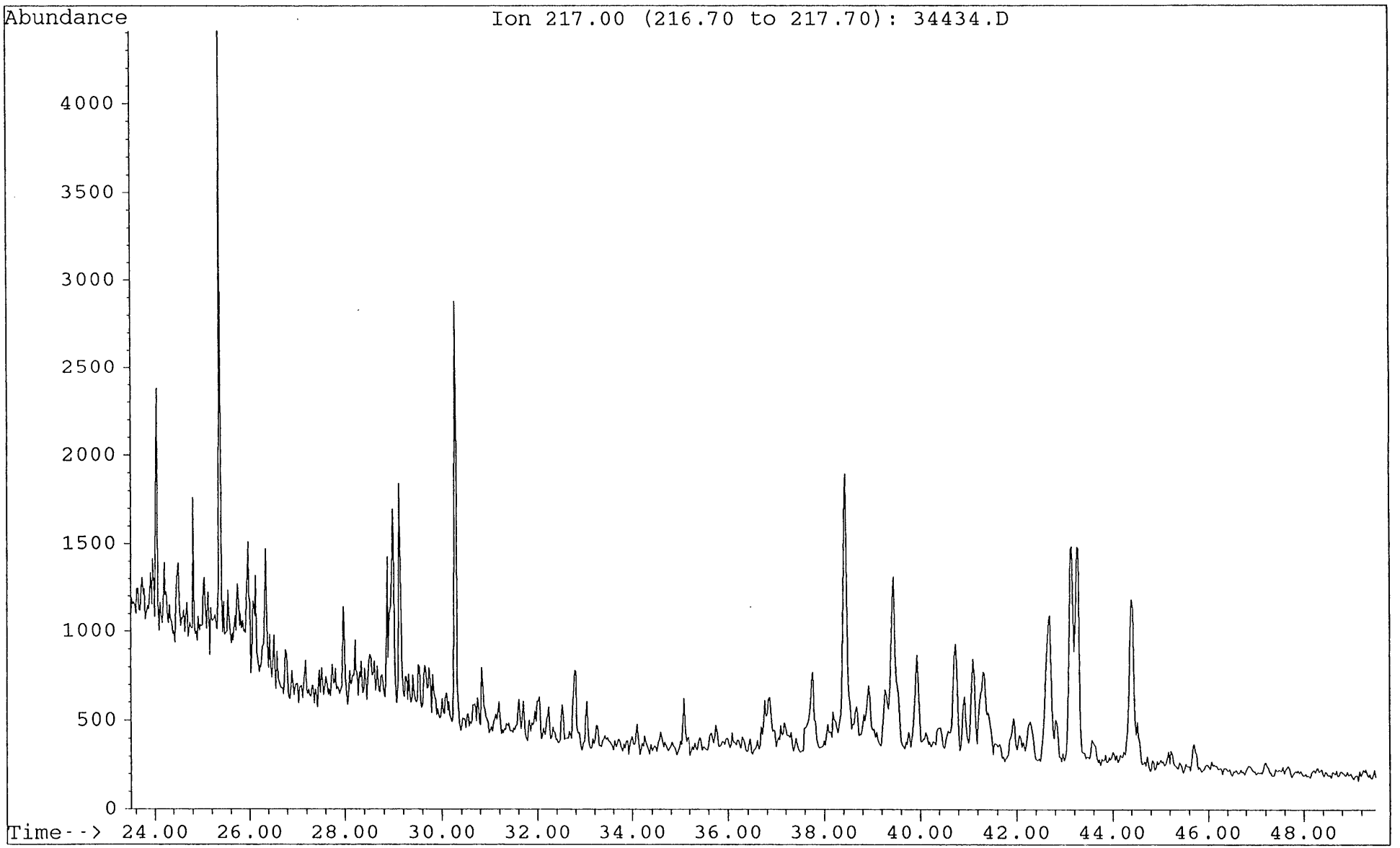

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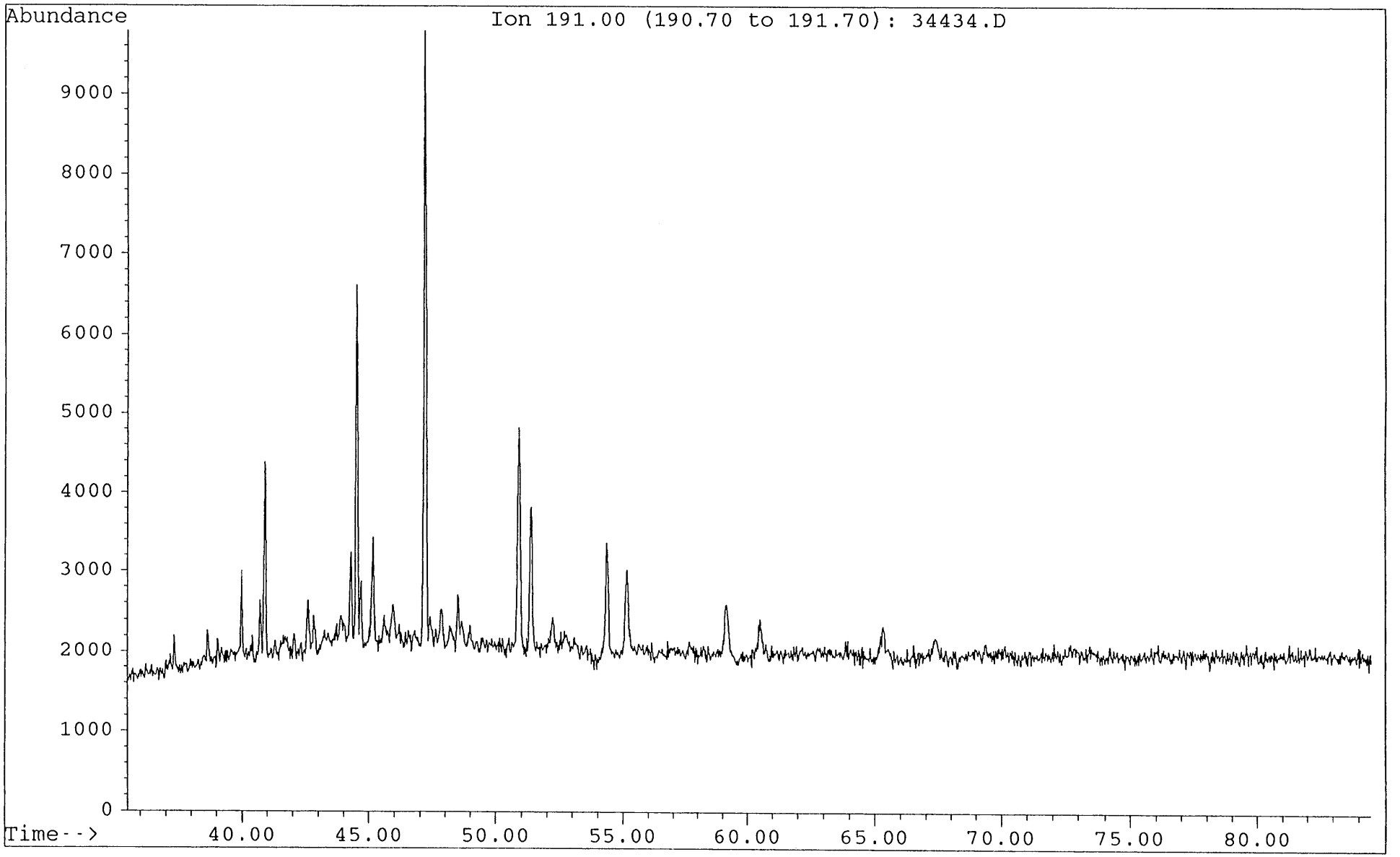

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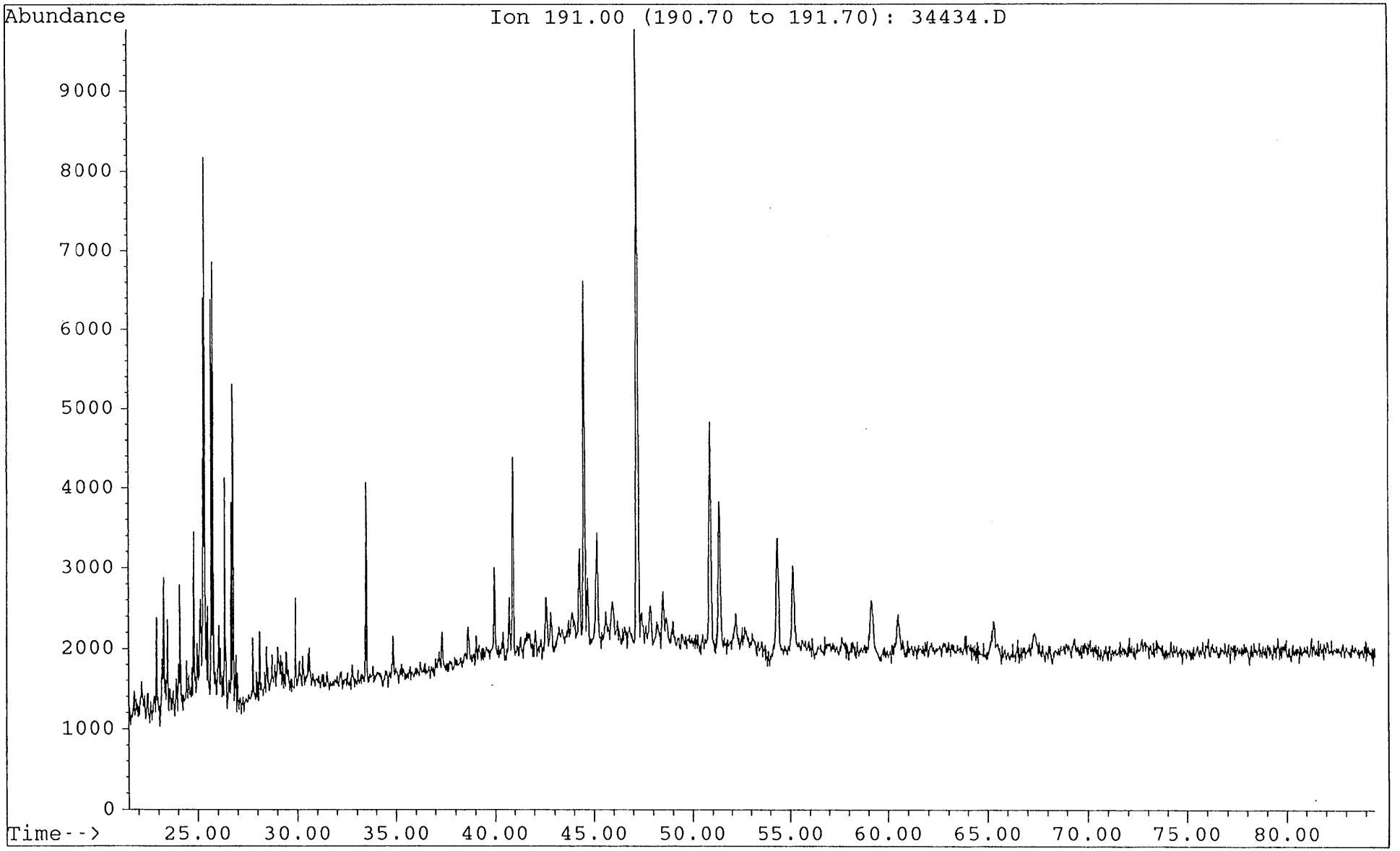
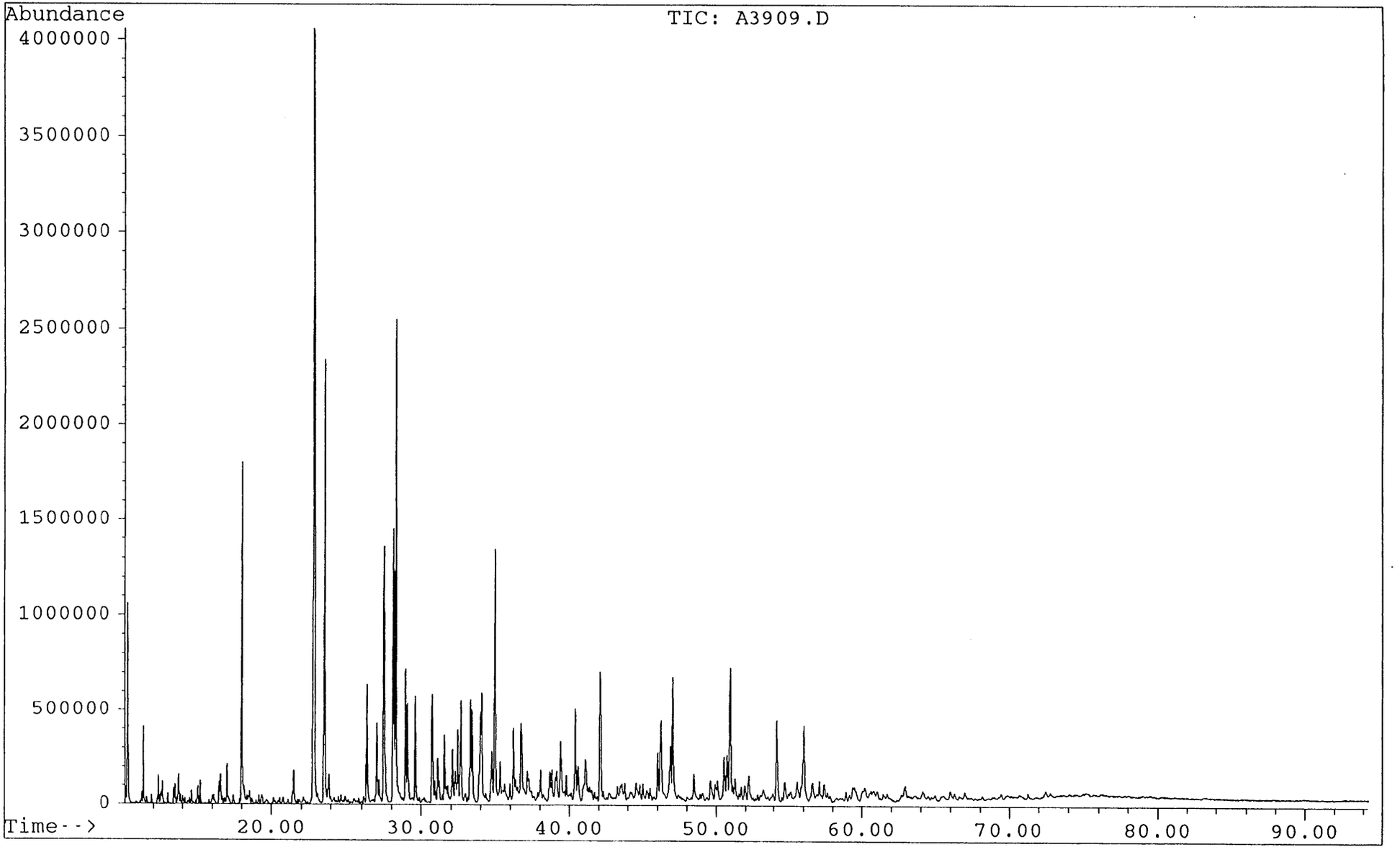


File : A3909.D
Sample : DIGBY#1, 1944m. AROS.
Misc. Info : COL#155. 28-7-95. GEC.

FIGURE 8-4



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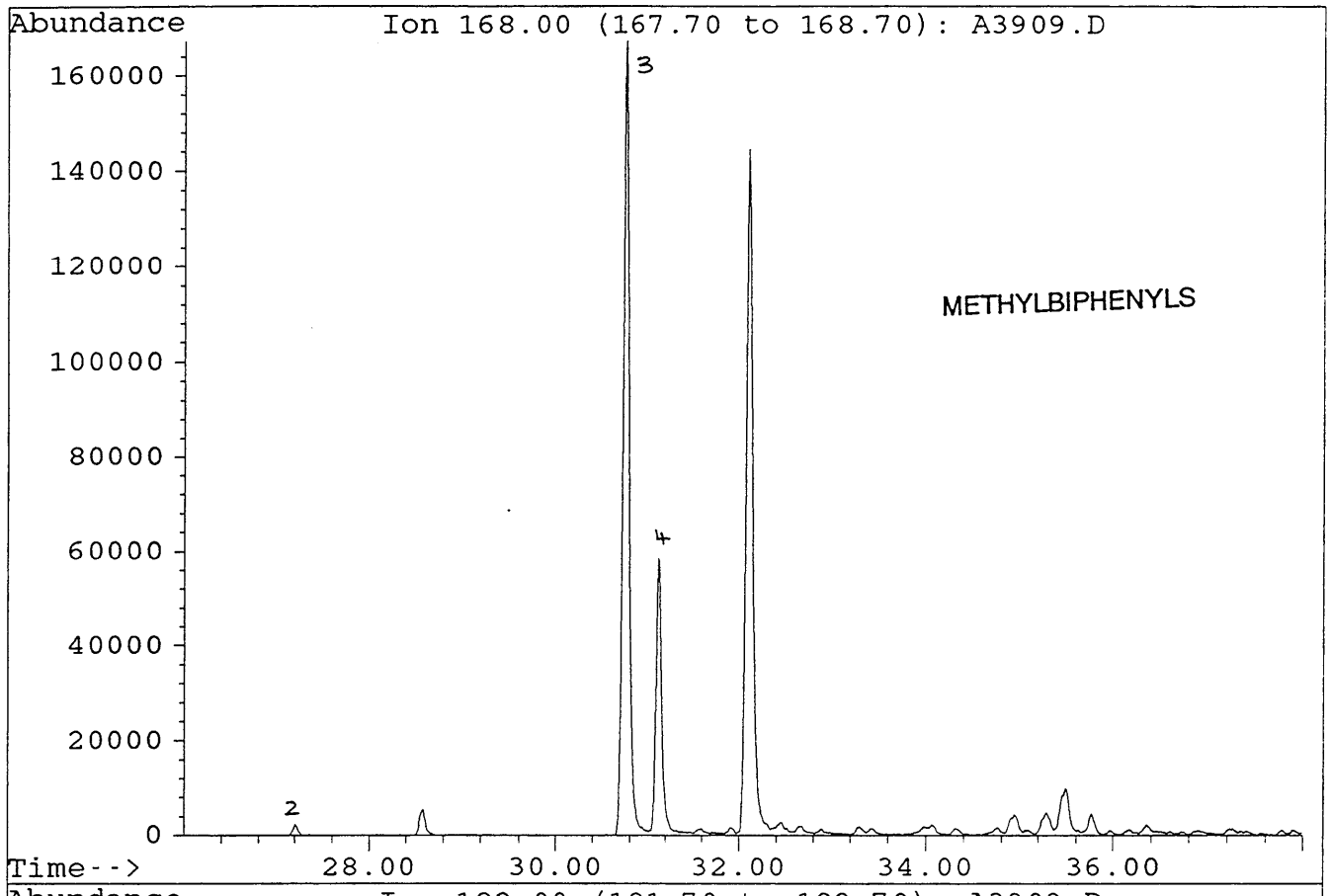

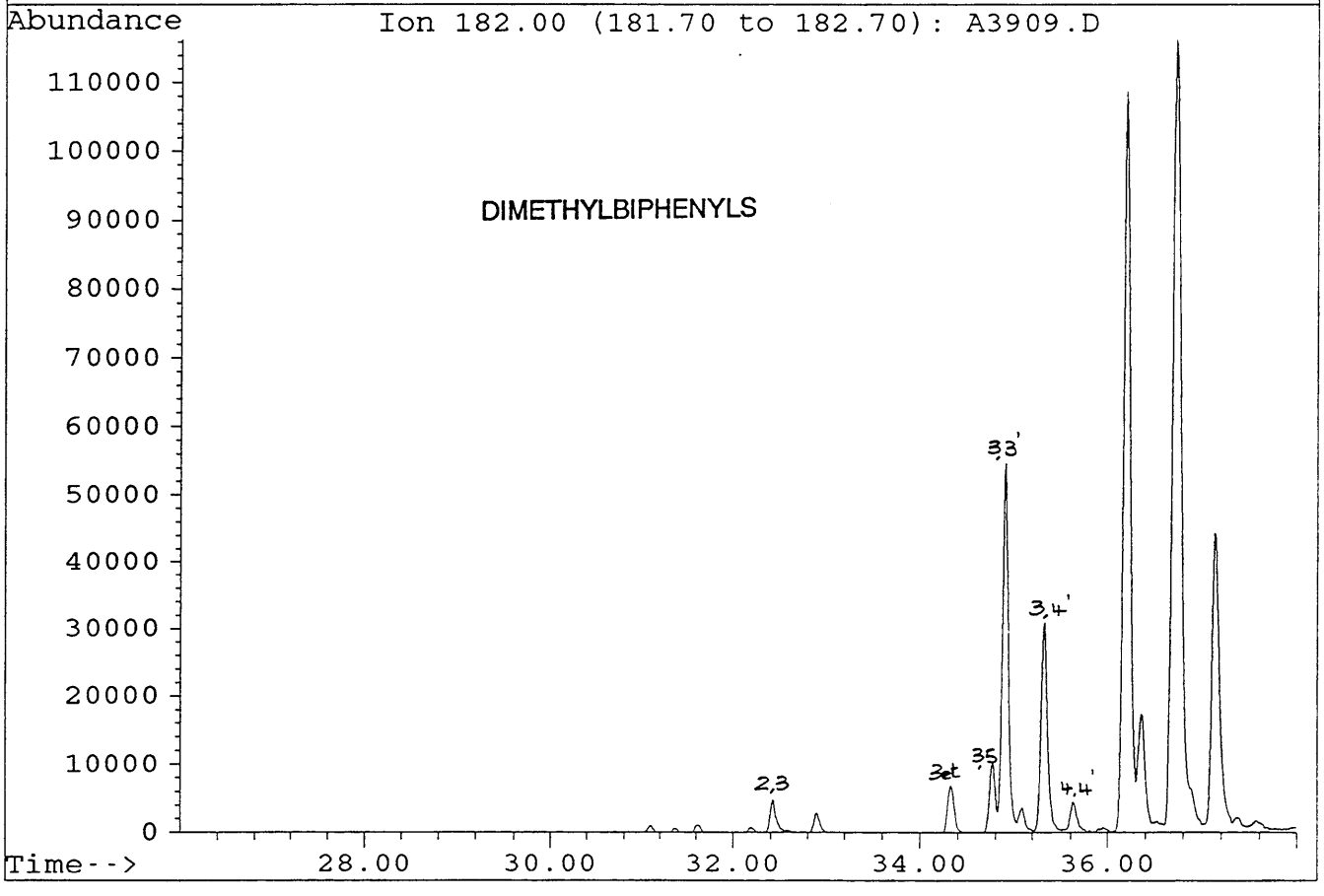

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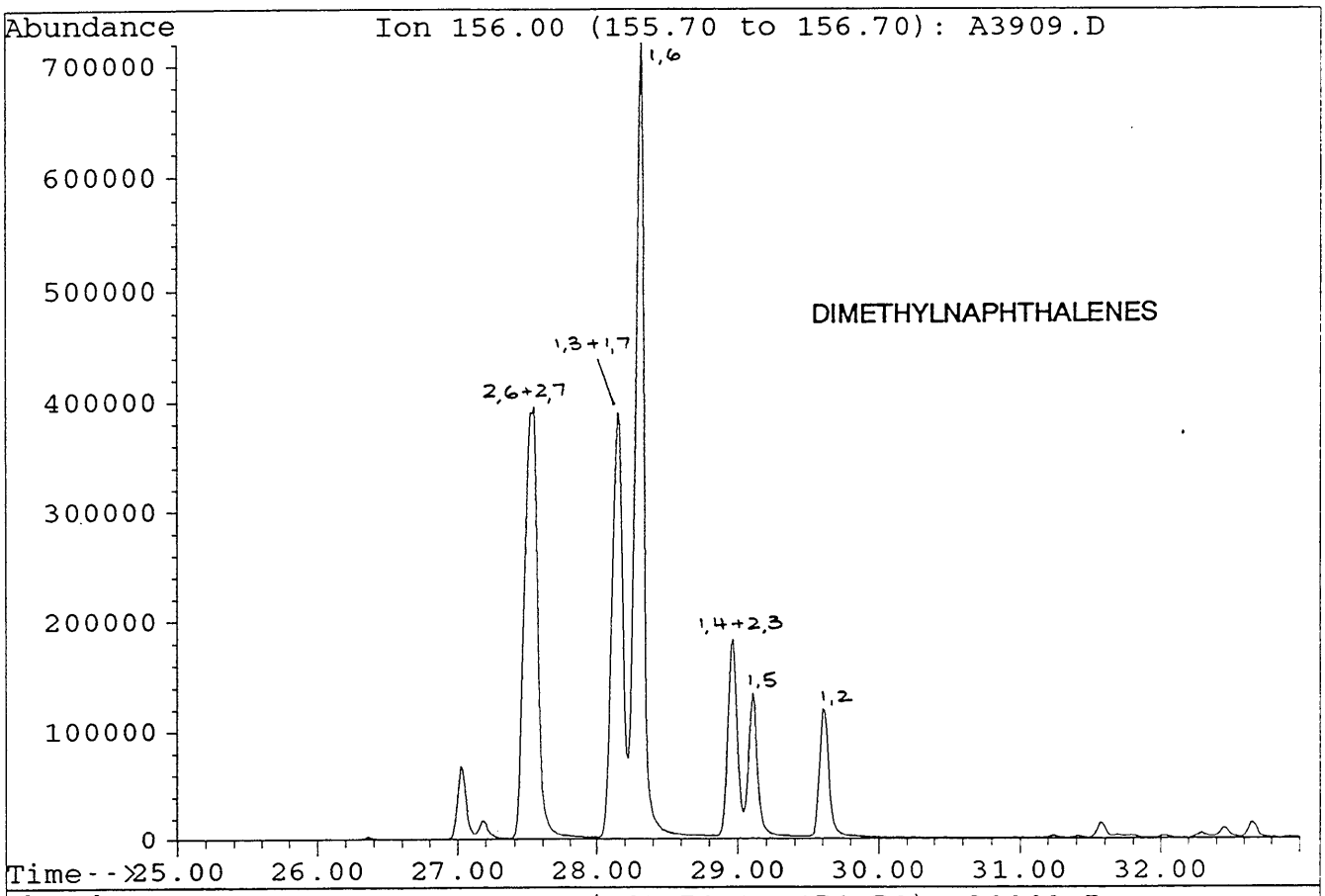

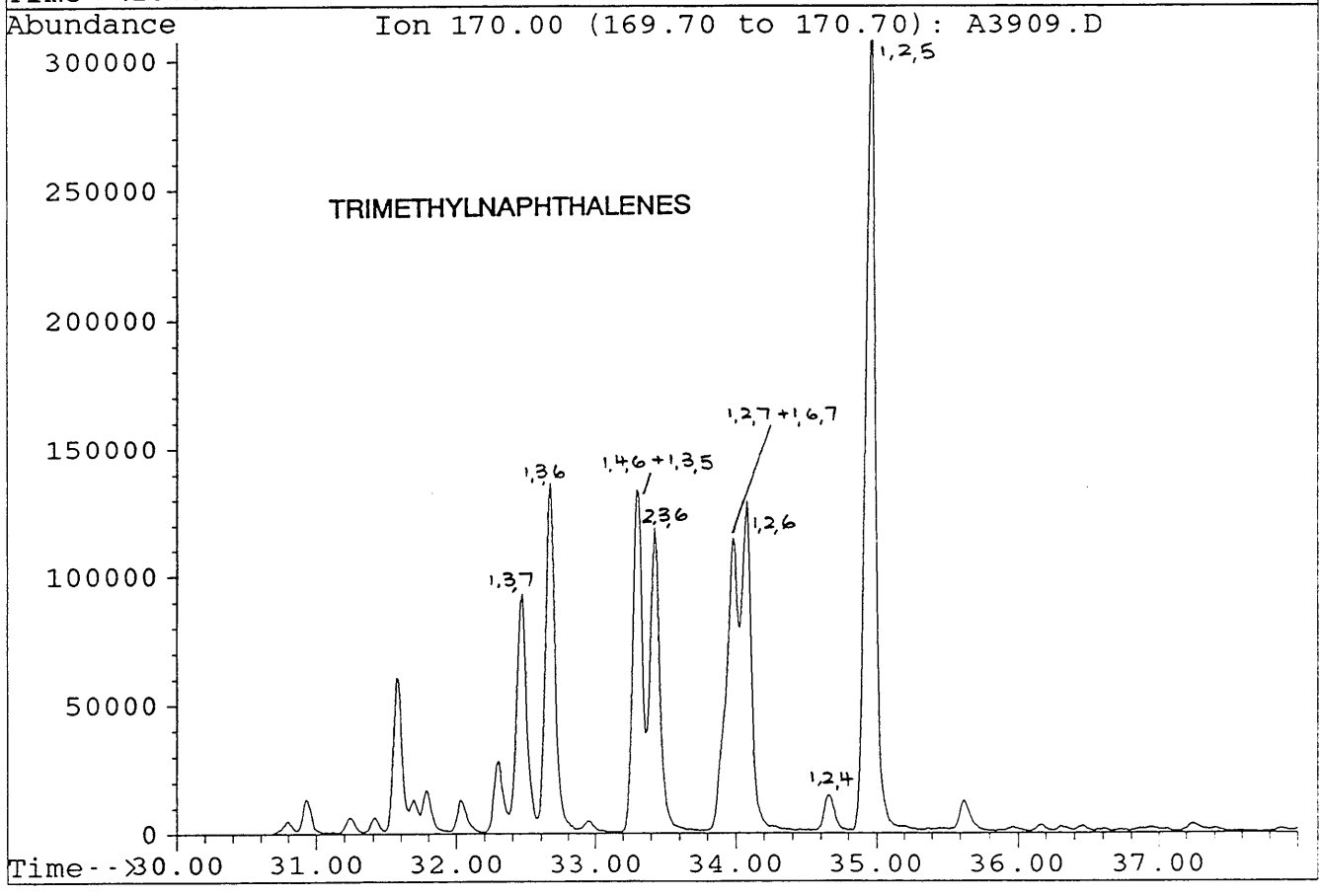

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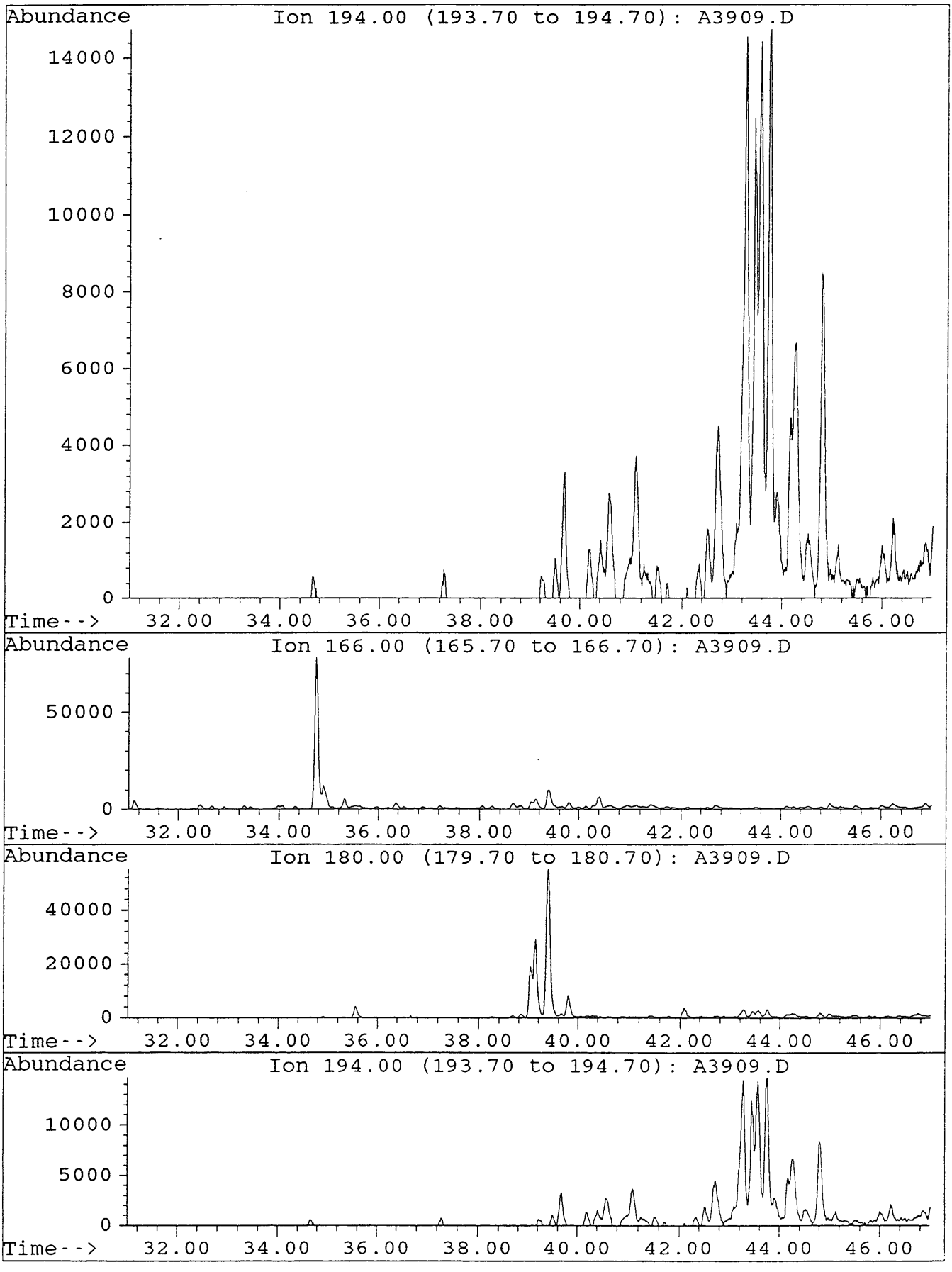
FLUORENES



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Sample : DIGBY#1, 1944m. AROS.
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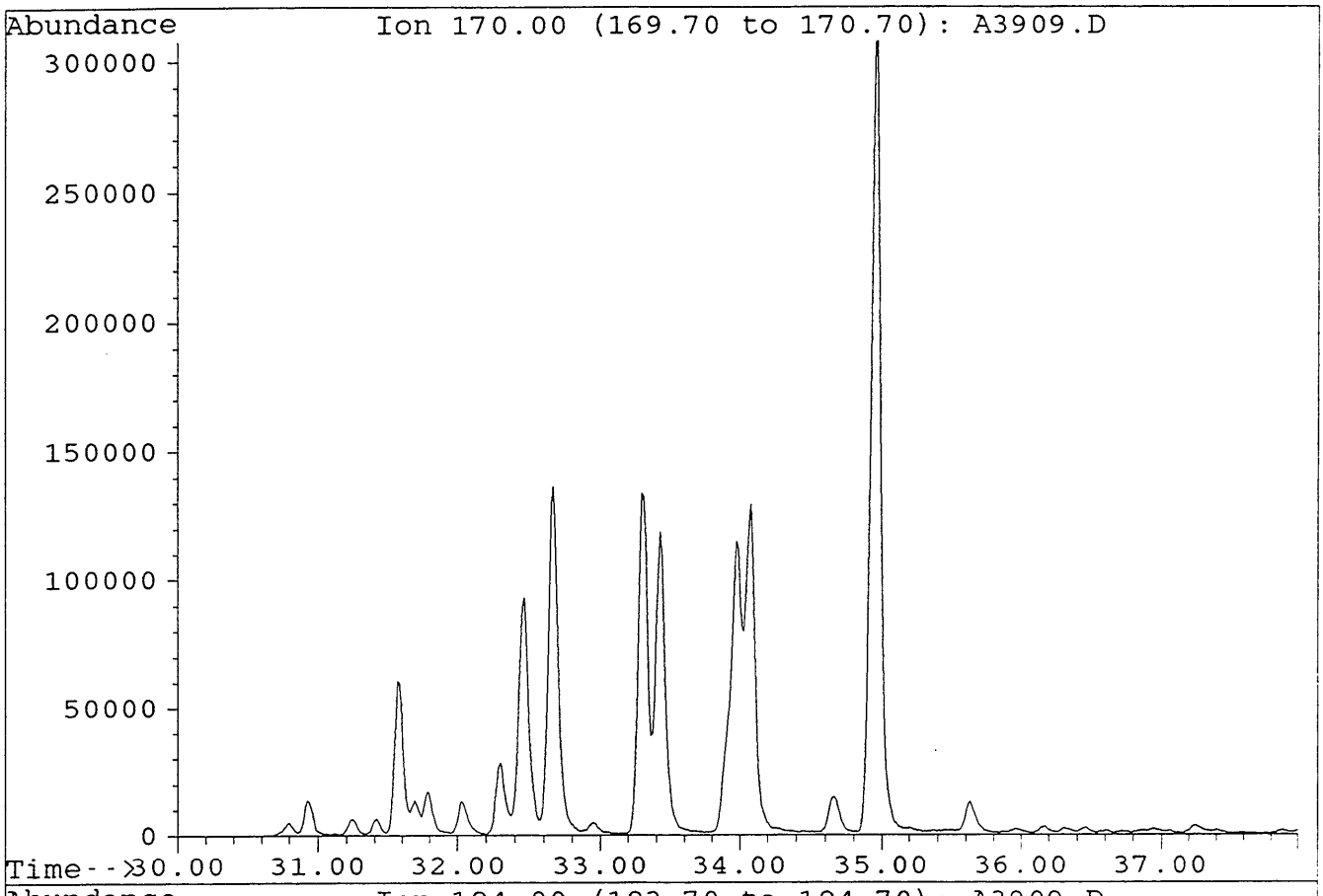

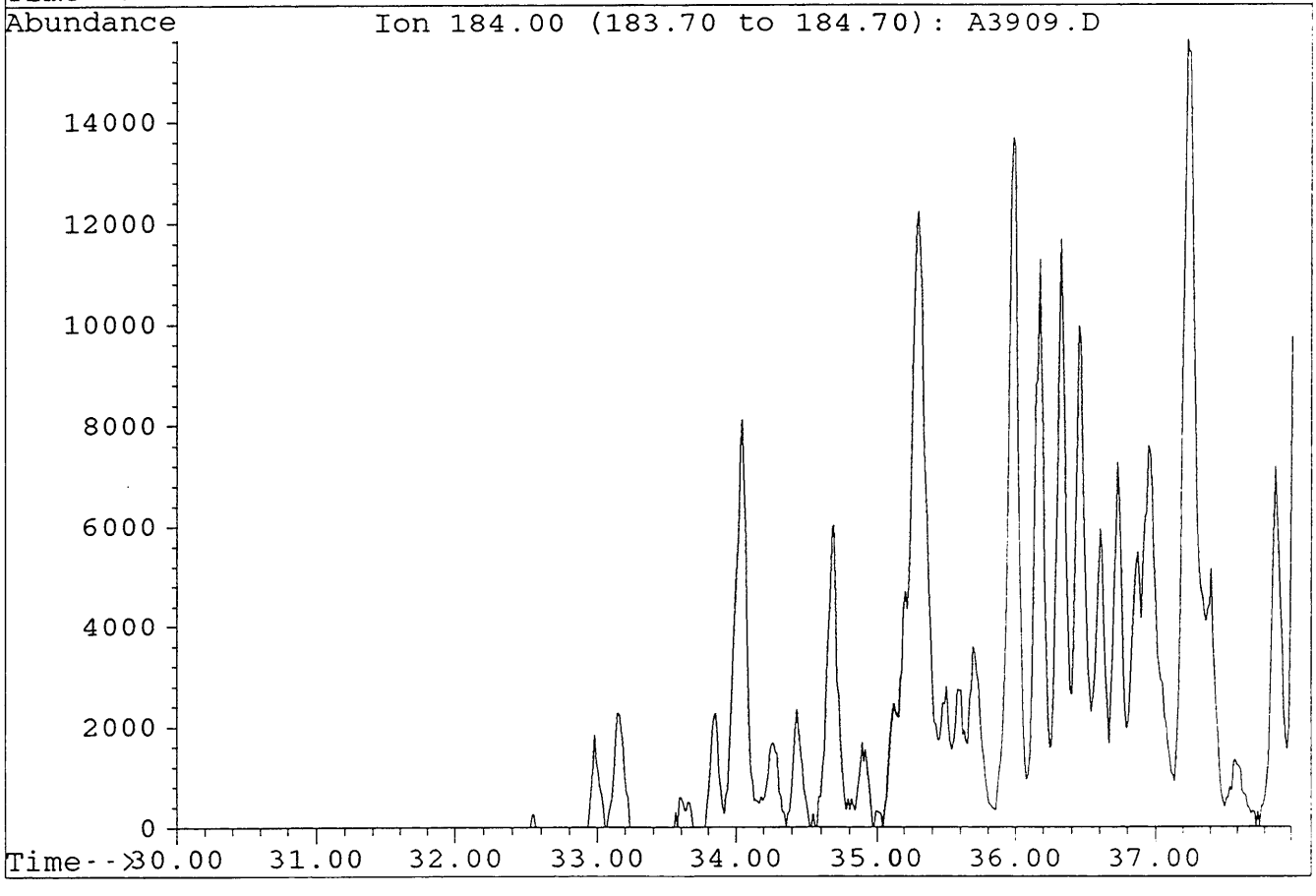

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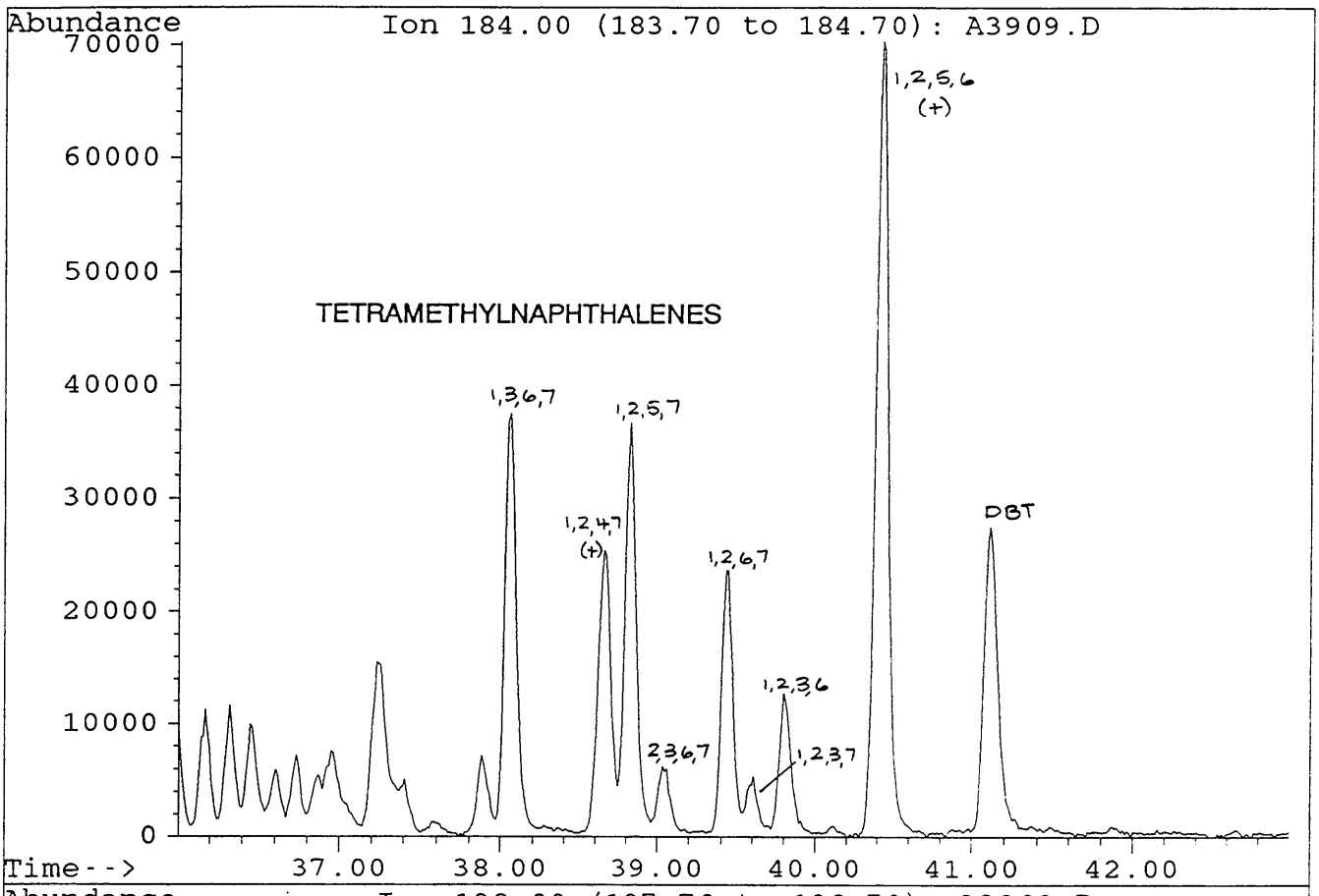

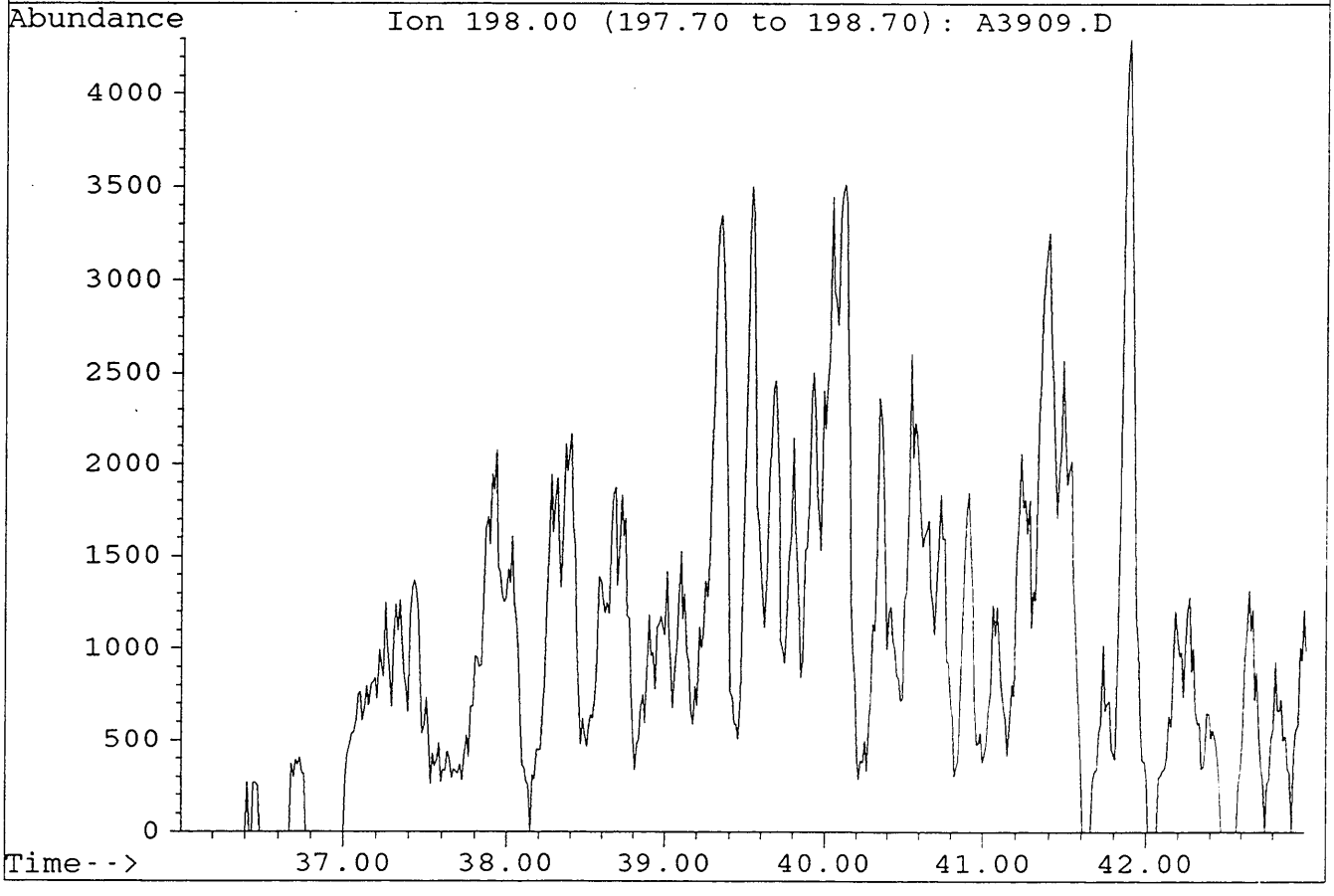

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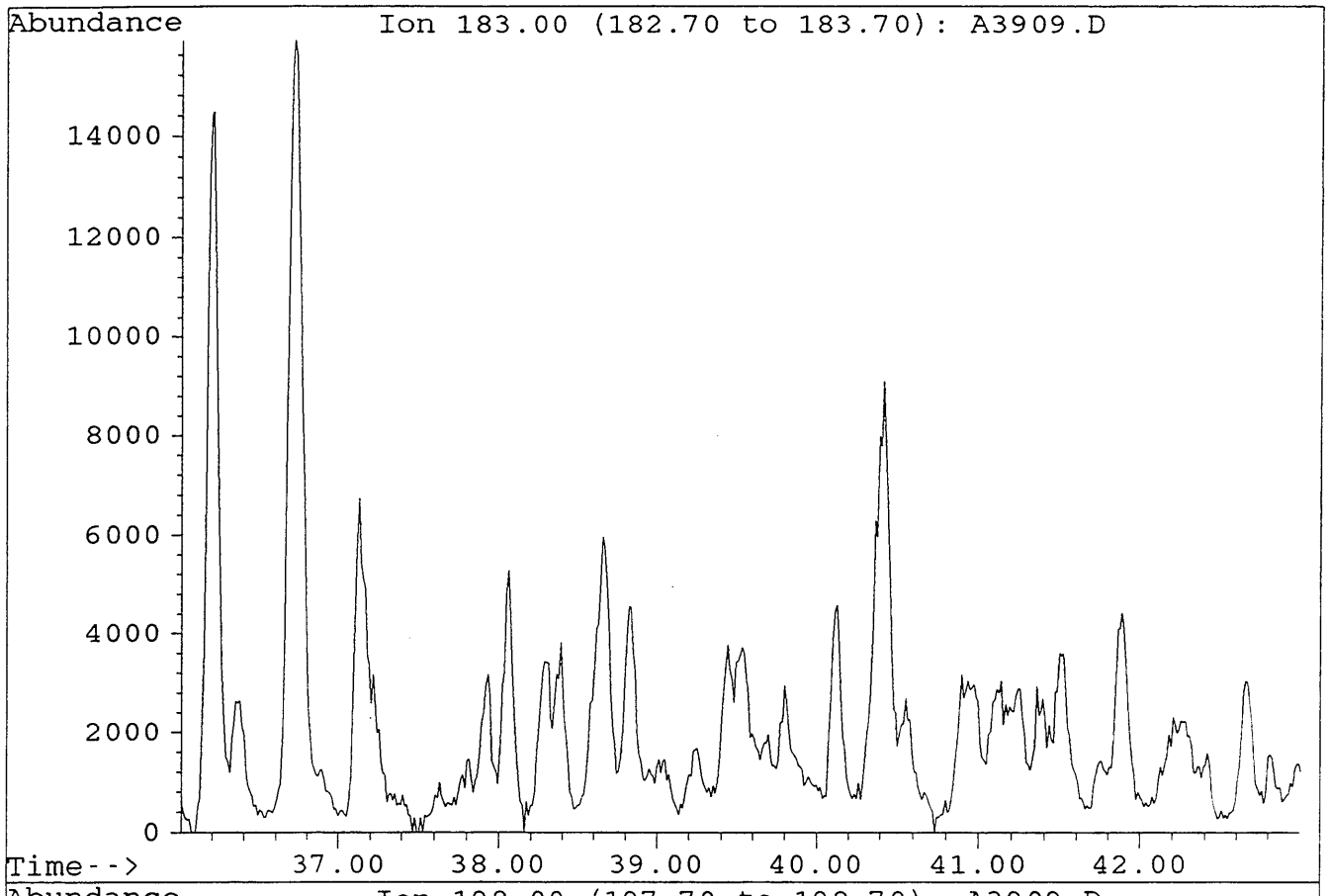

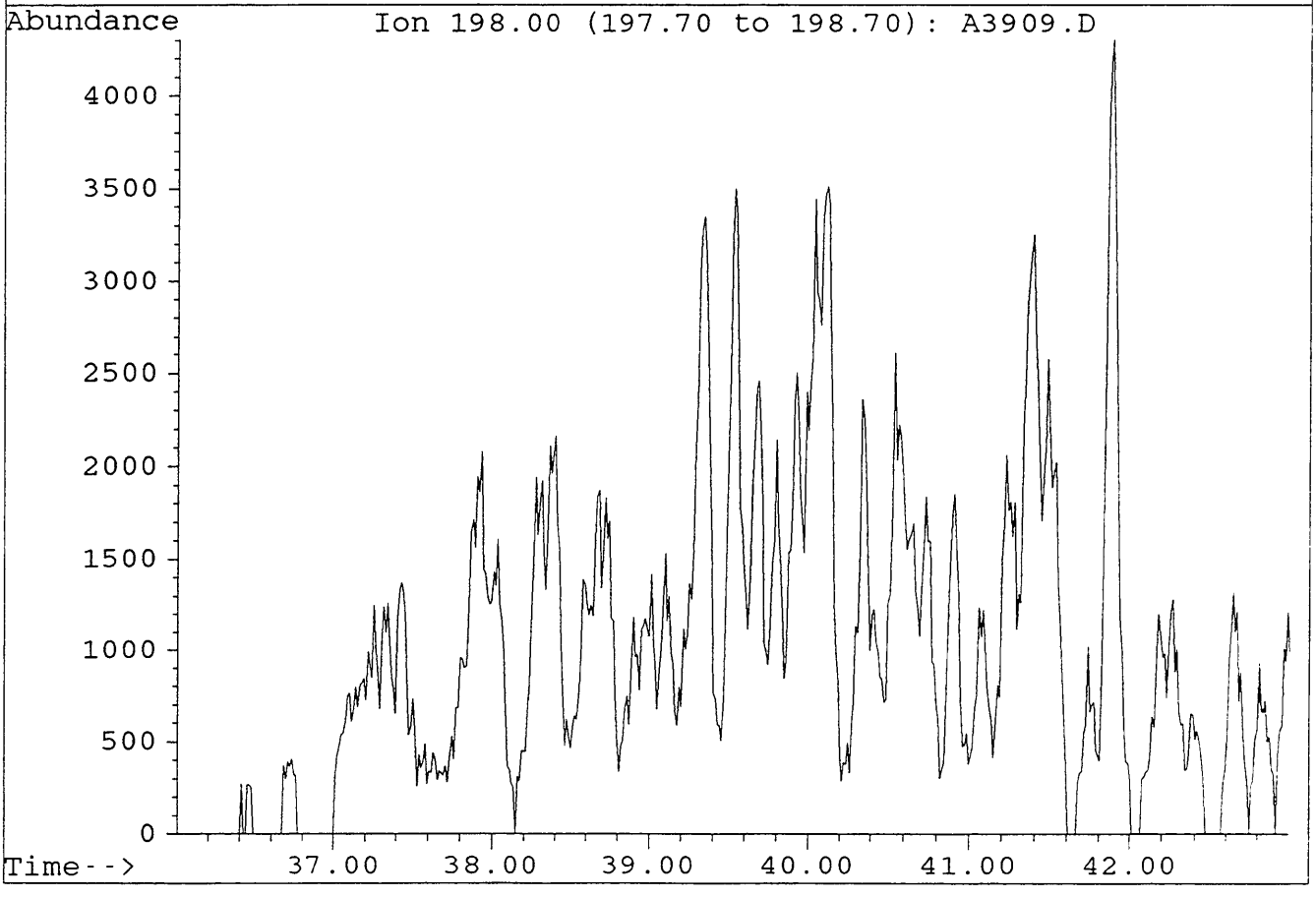

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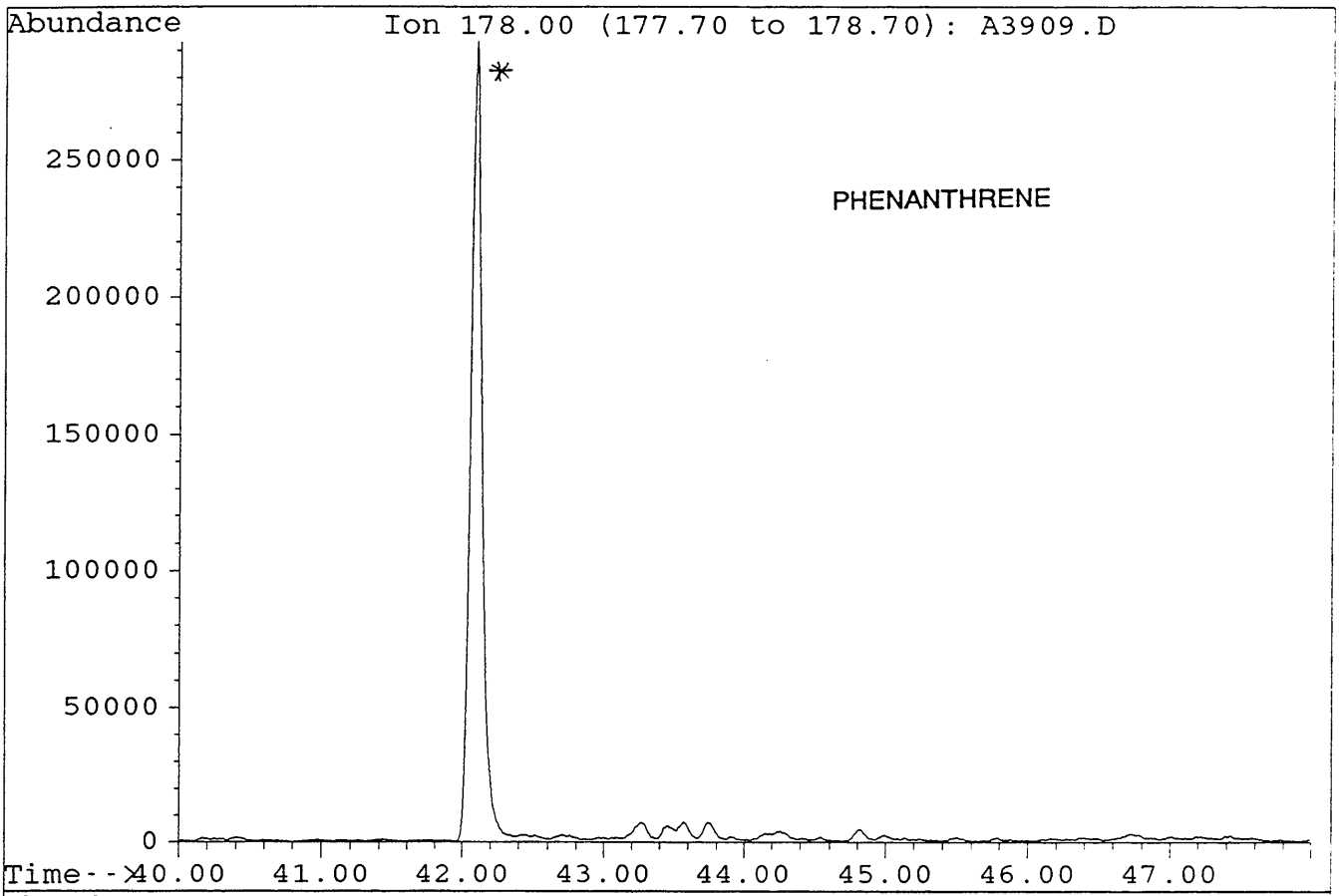

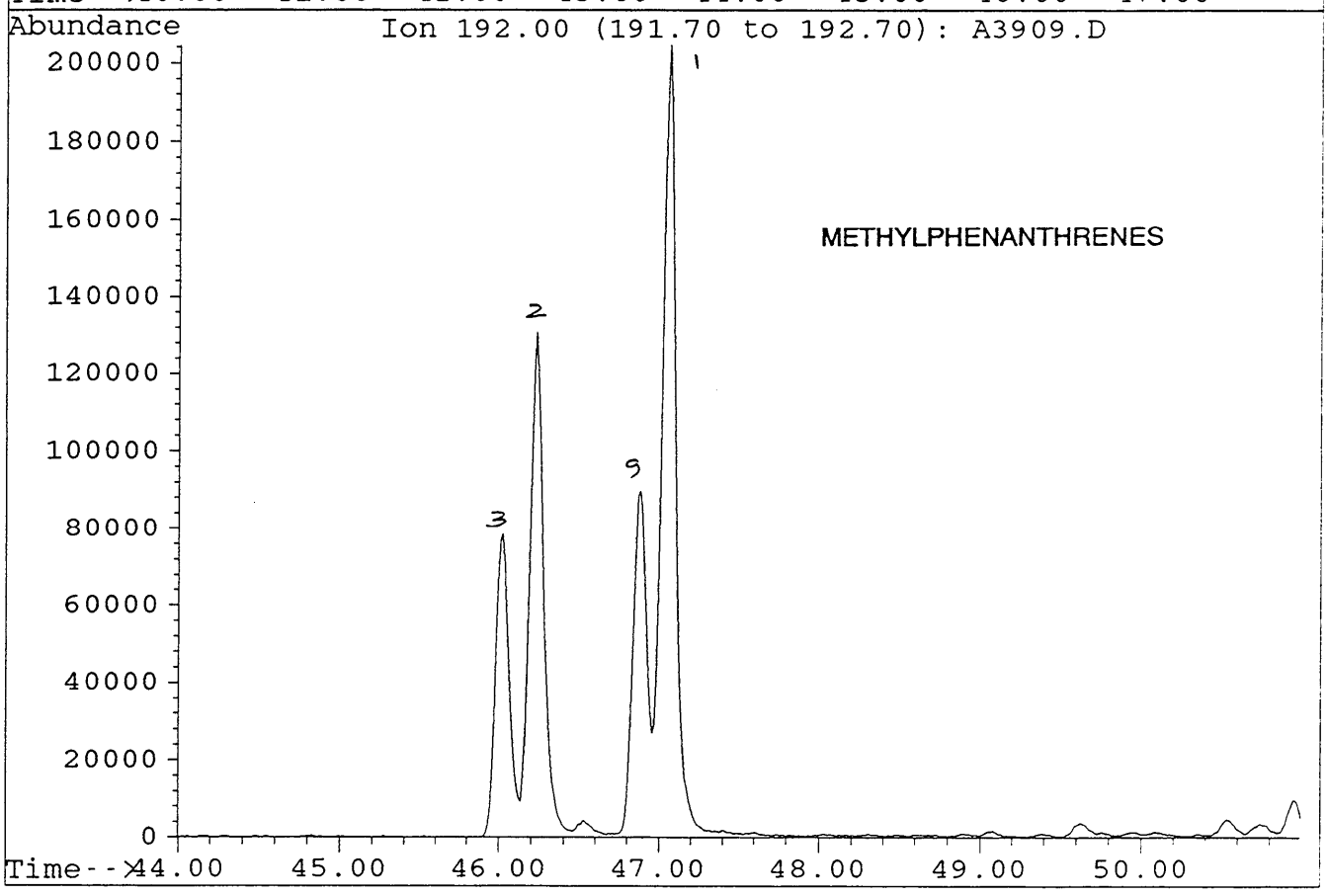

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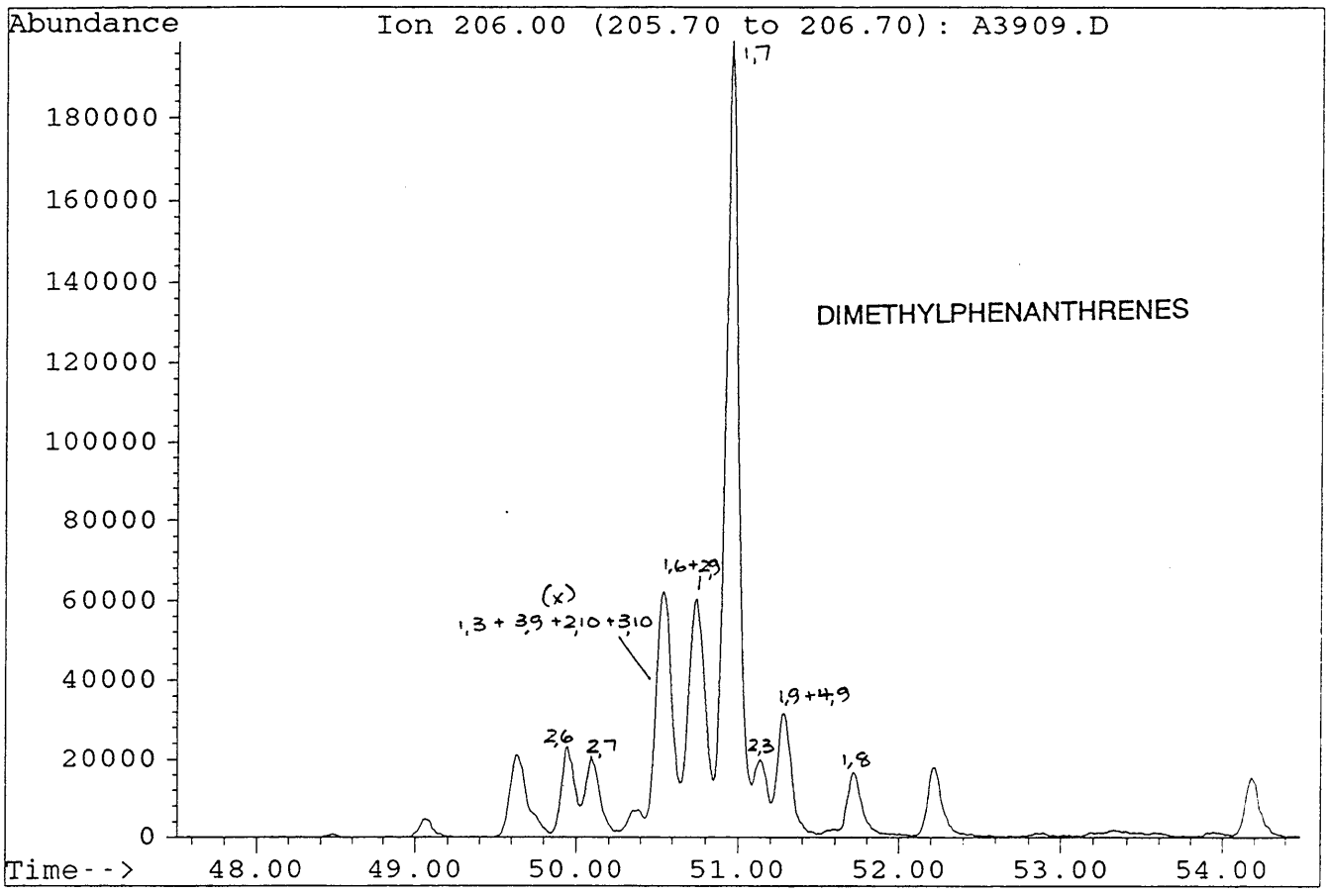

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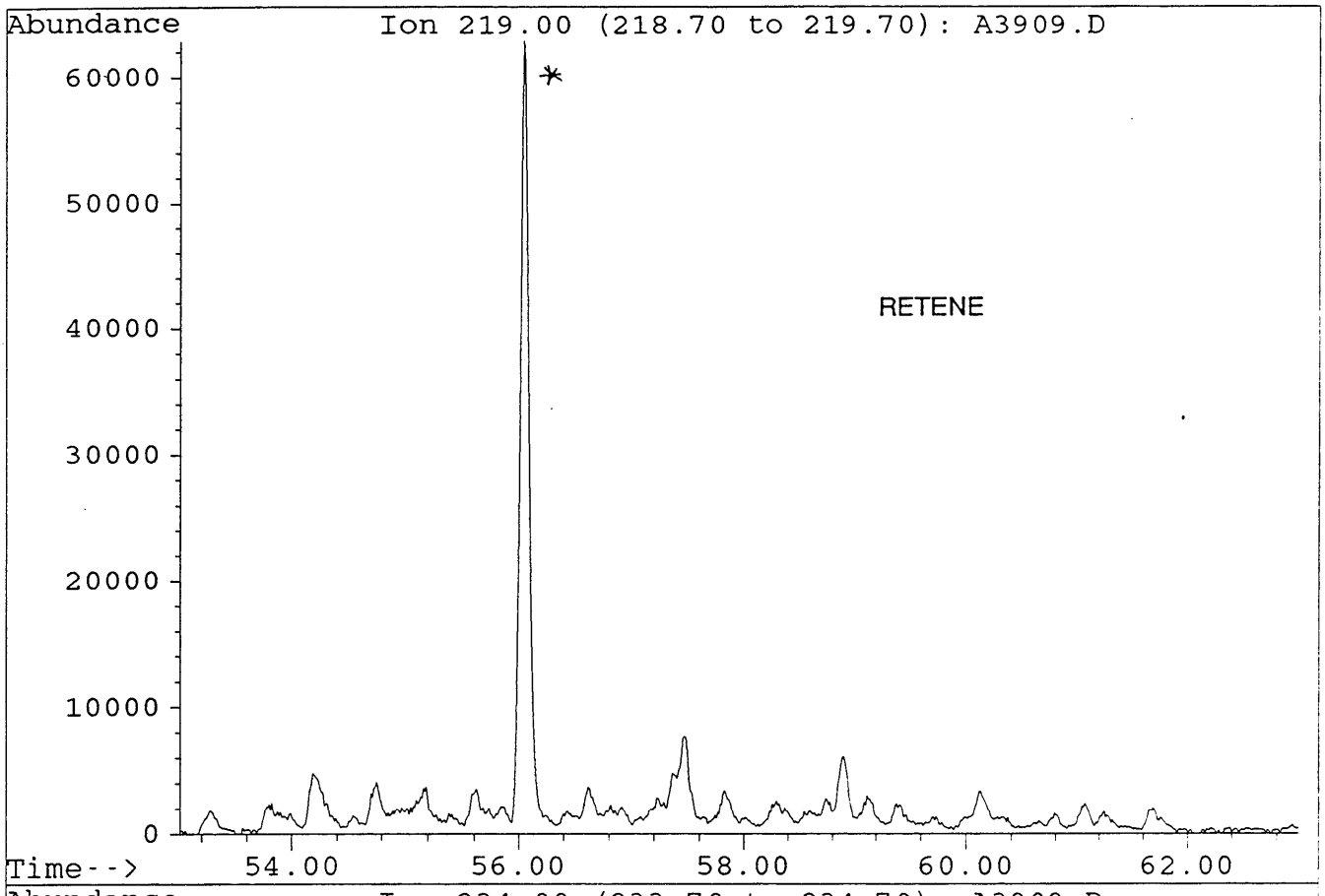

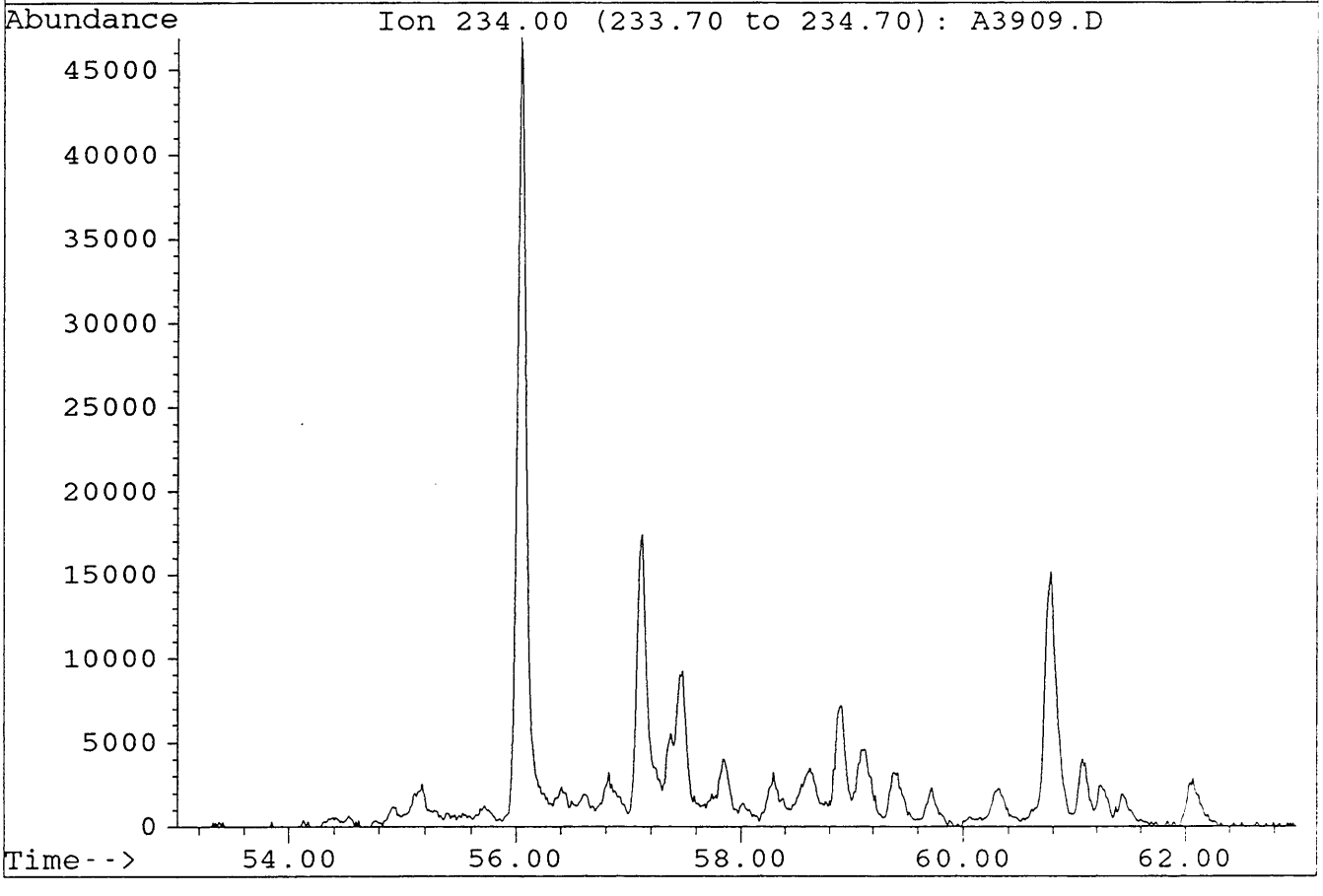

APPENDIX 9F

GC & GC-MS

FROM LINDON-1, 2895m

(AND CORRELATION TO DIGBY-1)

DIGBY-1

GEOCHEMICAL CORRELATION STUDY

DIGBY-1/LINDON-1

Prepared for:

GFE Resources Ltd

September, 1995

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GEOCHEMICAL CORRELATION STUDY
DIGBY-1/LINDON-1

Introduction

Two oil shows (1473.7m and 1940.8m) and two source rock samples (1903.2m and 1944.2m) from the well Digby-1 as well as a source rock from Lindon-1 (2845m) were analysed by saturate GC and GC-MS of both branched/cyclic and aromatic fractions.

The aim of this study was to characterise the extracts in terms of its source material, depositional environment and maturity, and to correlate them with each other.

Results

I Digby-1

The oil shows at 1473.7m and 1940.8m are considerably different from each other in terms of their organic source facies. The deeper oil is significantly more terrestrial than the shallower one, as reflected in C_{27}/C_{29} diasterane and sterane ratios of 0.09 and 0.29 at 1940.8m vs 0.58 and 0.83 at 1437.7m.

Both oils were sourced from predominantly terrestrial organic matter, but the deeper one was generated from a coaly, more or less exclusively higher plant derived source, whereas the shallower one was generated from "normal" terrestrial organic matter with minor input from algae and bacteria.

The depositional environment of the coaly source for the 1940.8m oil was much more oxic than the environment during deposition of the source for the 1473.7m oil, as characterised by a higher pristane/phytane ratio (5.48 vs 3.06) and less prominent dia- and neohopanes.

The oil from 1473.7m correlates well with the source rock from 1903.2m, both in terms of its moderately terrestrial source character and the mixed oxic/anoxic depositional environment.

The oil from 1940.8m is believed to be genetically related to the coaly source rock from 1944.2m: both samples show very terrestrial, coaly biomarker signatures and markers for quite oxic depositional environments.

The high proportion of light ends (up to about n-C_{15}) in the GC trace for 1944.2m is in agreement with the coaly nature of this organic matter (which is also reflected in its PGC trace).

The lower proportions of n-alkanes up to C_{15} in the 1940.8m oil believed to be generated from this organic matter is likely to be due to migration effects.

All four samples analysed are mature at present, with sterane ratios suggesting maturities of about 1.0 to 1.1% V_R equivalent and MPIs equivalent to approximately 0.8 to 0.9% V_R.

II Lindon-1 and Digby-1/Lindon-1 Correlation

The sediment extract from 2895m depth in Lindon-1 is characterised by an organic facies dominated by very terrestrial, possibly coaly organic matter deposited under mixed oxic/anoxic conditions.

The type of organic matter is characterised by the strong predominance of C_{29} over C_{27} steranes and diasteranes, as the C_{29} compounds are attributed to higher plant derived material whereas the C_{27} compounds reflect algal/bacterial matter. The presence of isopimarane and small amounts of phyllocladane is indicative of input from resinous matter in higher plants, and weak odd-even predominances in the C_{25+} n-alkane pattern also point towards terrestrial plant waxes.

The mixed oxic/anoxic depositional environment is characterised by a pristane/phytane ratio of 3.01, the presence of dia- and neohopanes and small amounts of methylhopanes.

The sample is presently mature, equivalent to approximately 0.9 to 1% V_R equivalent, as reflected in a methylphenanthrene index (I) of 0.78, a C_{29} 20S/20R sterane ratio of 0.94 and various di- and tri-naphthalene as well as triterpane ratios.

The organic matter is quite similar to sample 1940.80m in Digby-1, based on the distribution of steranes (incl. methylsteranes), diterpanes and various aromatic parameters, however, the depositional environment characterised in the Lindon-1 sample is less oxic than the one which prevailed during deposition of the Digby-1, 1940.80m sediment.

This assessment is based mainly on pristane/phytane ratios, with a value of 5.48 as obtained in the Digby-1 sample reflecting oxic conditions whereas the value of 3.01 obtained in Lindon-1 being more indicative for a mixed oxic/anoxic environment.

Biomarker patterns for the Digby-1, 1940.80m sediment and the Digby-1, 1944.0m oil provide a considerably better match than the Lindon-1 source rock sample and the Digby-1, 1944.0m oil, and it is regarded as unlikely that the Lindon-1 sediment has generated the Digby-1, 1944.0m oil.

The Lindon sample is also believed to be too coaly to have sourced the oil at 1473.7m in Digby-1, which was probably generated from an organic facies similar to the one analysed at 1903.2m in the same well.

Analytical Methods / Data

Analytical techniques applied are summarised in the Theory and Methods chapter in the back of this report.

Analytical results are presented in the following figures and tables:

Types of Analysis	Figure	Table
I Digby-1		
TOC/Rock-Eval pyrolysis	-	1
Pyrolysis-GC	1	2,3,4
Thermal Extract GC	2	-
Extraction/Liquid chromatography	-	5
GC sat	3	6
Organic Petrology/V_R	4	7
GC-MS b/c	5,6	8,9
GC-MS arom.	7,8	10
II Lindon-2		
Extraction/Liquid chromatography	-	1
GC sat	1	2
GC-MS b/c	2	3
GC-MS arom.	3	4

TABLE 1

Summary of Extraction and Liquid Chromatography

LINDON 1 Aug-95

A. Concentrations of Extracted Material

				——Hydrocarbons——			——Nonhydrocarbons——		
	Weight of	Total	Loss on			HC			NonHC
	Rock Extd.	Extract	Column	Saturates	Aromatics	Total	NSO's	Asphalt.	Total
DEPTH(m)	(grams)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
2895.0	32.9	3170.2	337.9	1046.0	893.1	1939.1	893.1	nd	893.1

TABLE 1

Summary of Extraction and Liquid Chromatography

LINDON 1 Aug-95

B. Compositional Data

	——Hydrocarbons——			——Nonhydrocarbons——			EOM(mg	SAT(mg)	SAT	ASPH	HC
							———	———	———	———	———
DEPTH(m)	%SAT	%AROM	%HC's	%NSO'	%ASPH	%Non HC'	TOC(g)	TOC(g)	AROM	NSO	Non HC
2895.0	36.9	31.5	68.5	31.5	nd	31.5	nd	nd	1.2	nd	2.2

nd = no data

TABLE 2

LINDON 1 Summary of Gas Chromatography Data

A. Alkane Compositional Data SATURATE FRACTION

DEPTH(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
2895.0	3.01	0.64	0.24	1.11	1.10	3.79

TABLE 2

LINDON 1 Summary of Gas Chromatography Data

B. n-Alkane Distributions SATURATE FRACTION

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
2895.0	5.6	6.3	7.5	8.7	9.6	8.7	5.5	7.5	1.8	6.1	5.3	4.8	4.4	4.0	3.3	3.0	2.2	1.9	1.3	1.1	0.8	0.8

nd = no data

LINDON 1, 2895.0m, Cuttings

Saturate Fraction

C12+ GLC

FIGURE 1

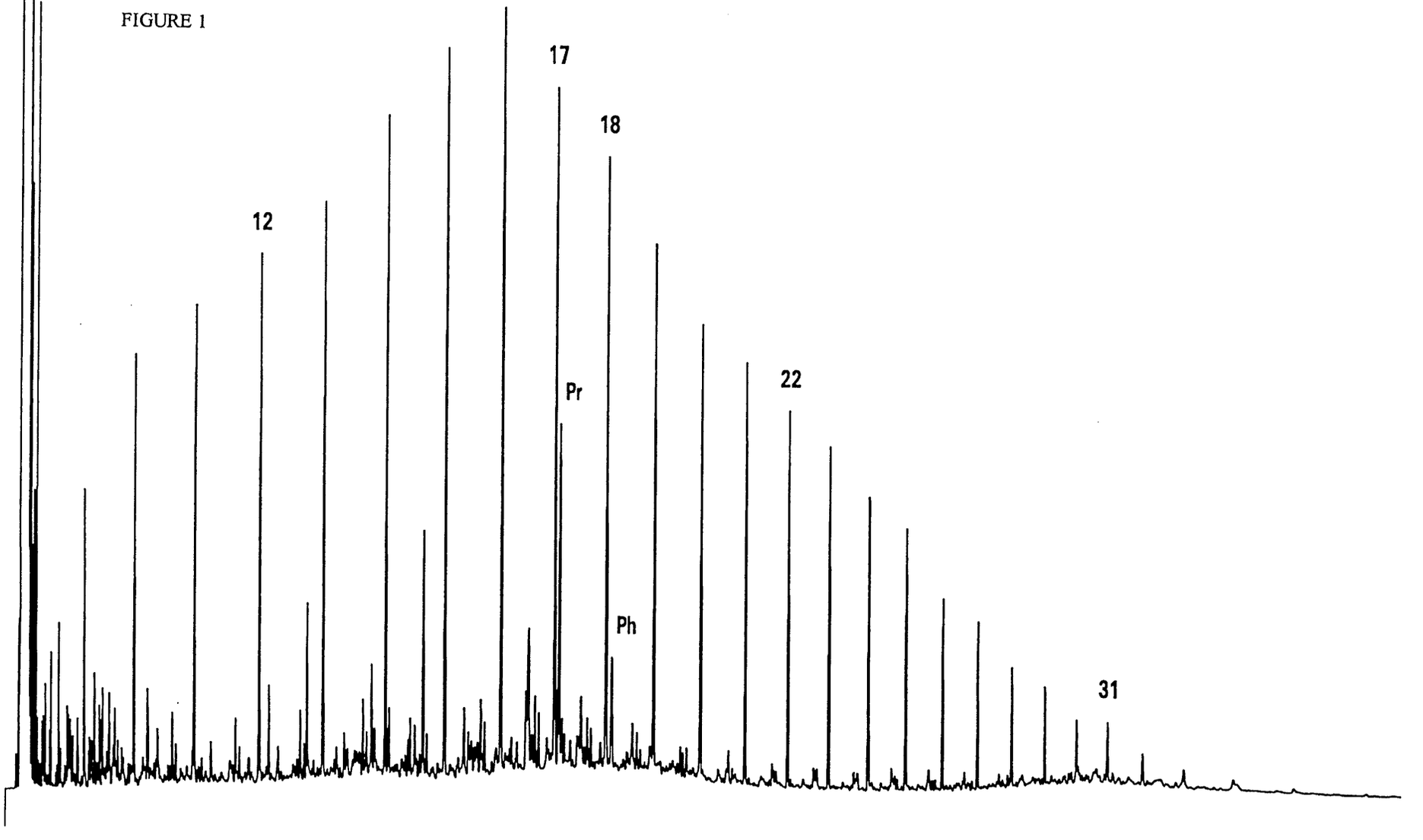

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TABLE 3

SELECTED PARAMETERS FROM GC/MS ANALYSIS

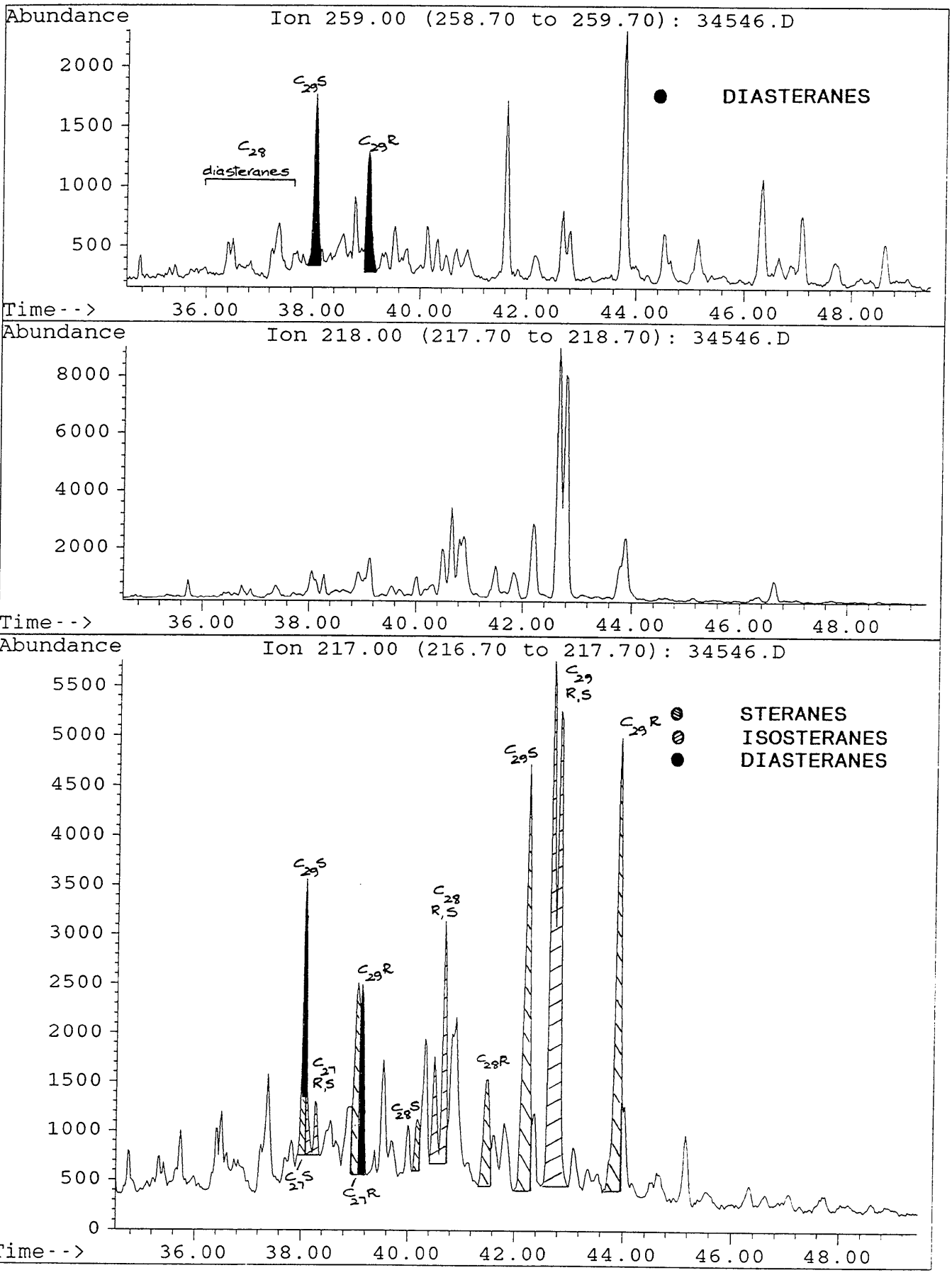
LINDON 1, 2895m, Cuttings

	Parameter	Ion(s)	Value
1.	18 α (H)- hopane/17 α (H)-hopane (Ts/Tm)	191	0.67
2.	C30 hopane/C30 moretane	191	11.26
3.	C31 22S hopane/C31 22R hopane	191	1.52
4.	C32 22S hopane/C32 22R hopane	191	1.36
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ sterane	217	0.94
6.	C29 $\alpha\alpha\alpha$ steranes (20S / 20S+20R)	217	0.48
7.	C29 $\alpha\beta\beta$ steranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.53
8.	C27/C29 diasteranes	259	nd
9.	C27/C29 steranes	217	0.41
10.	18 α (H)-oleanane/C30 hopane	191	nd
11.	C29 diasteranes / C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes	217	0.25
12.	C30 (hopane + moretane) / C29 (steranes + diasteranes)	191/217	0.89
13.	C15 drimane/C16 homodrimane	123	0.46
14.	Rearranged drimanes/normal drimanes	123	0.34

nd = not detectable

File : 34546.D
Sample : LINDON#1, 2895m. B/C.
Misc. Info : COL#164. 21-8-95. GEC.

FIGURE 2



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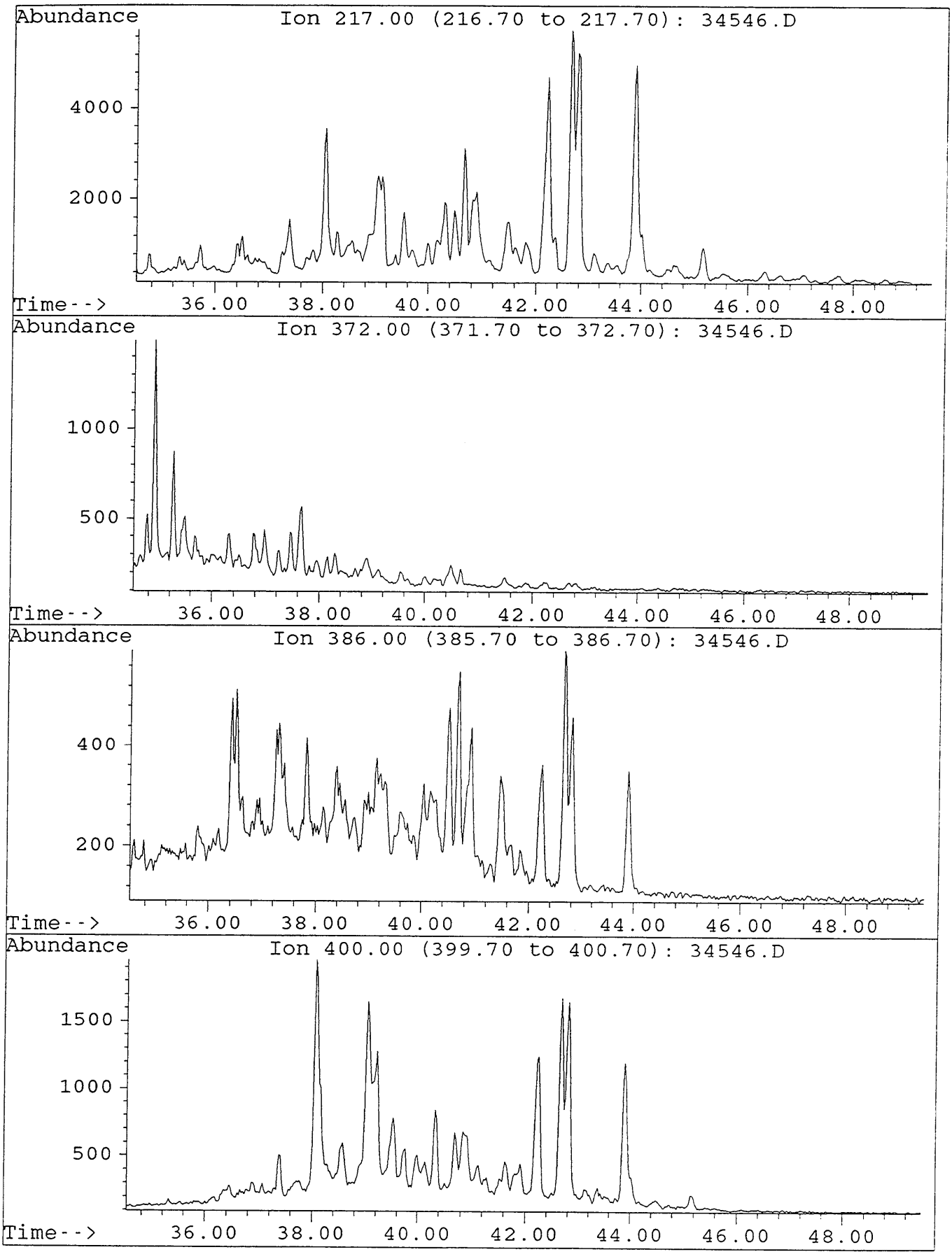

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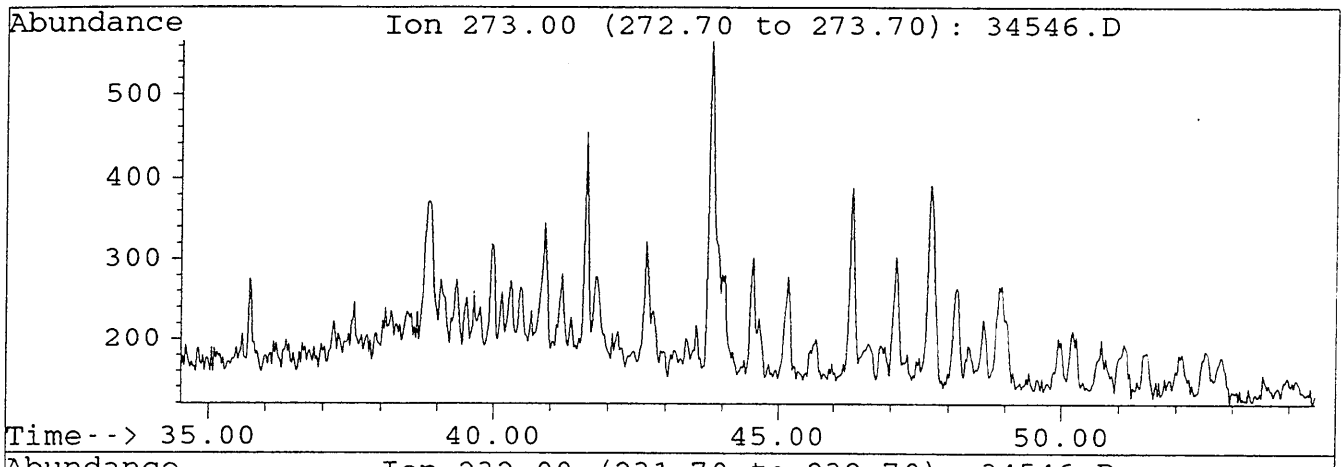

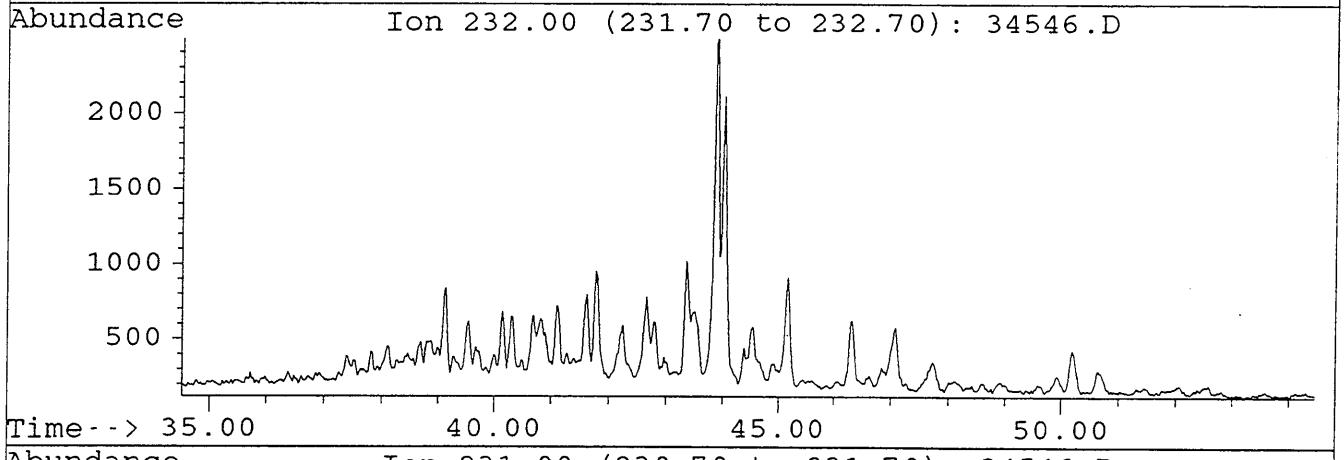

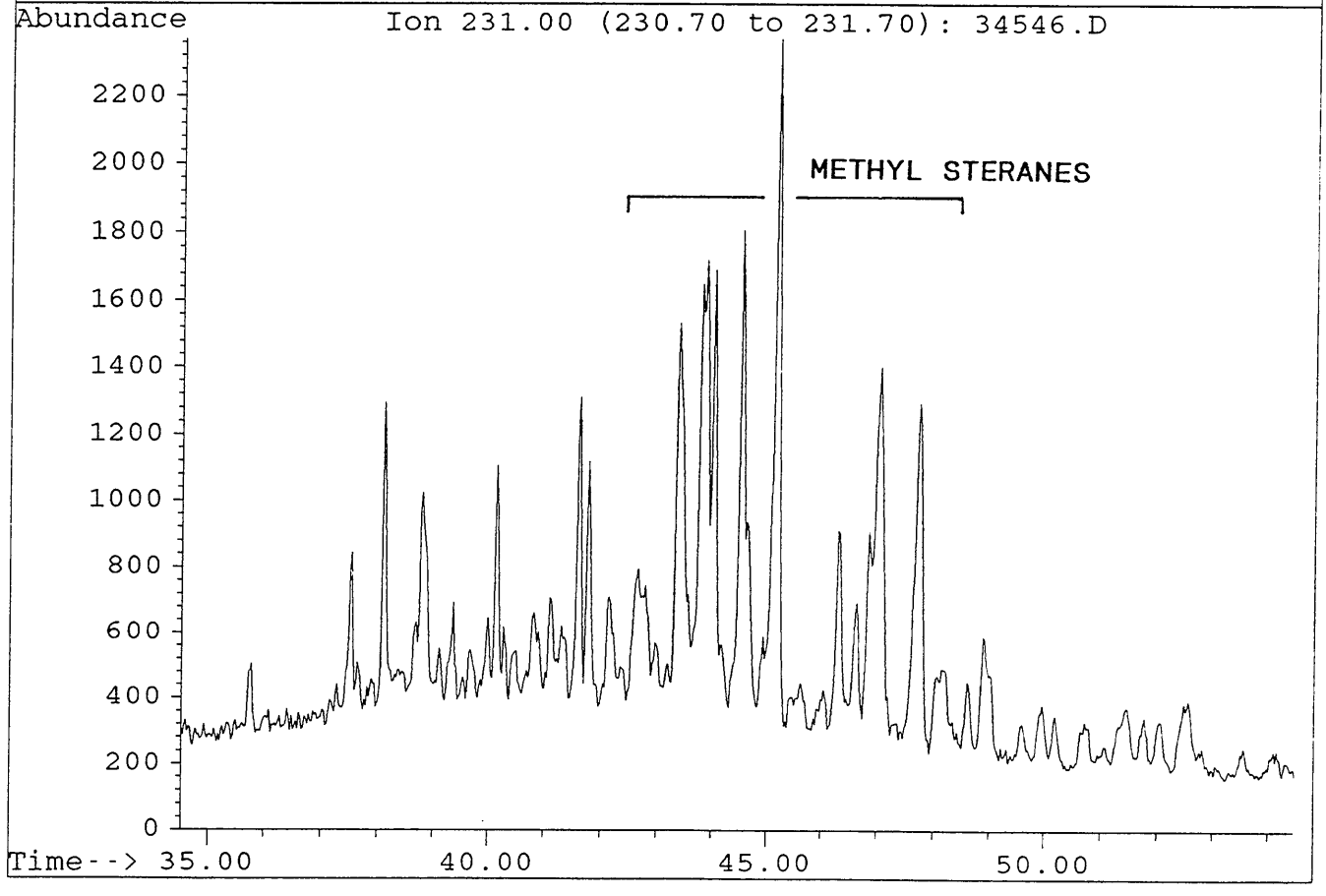

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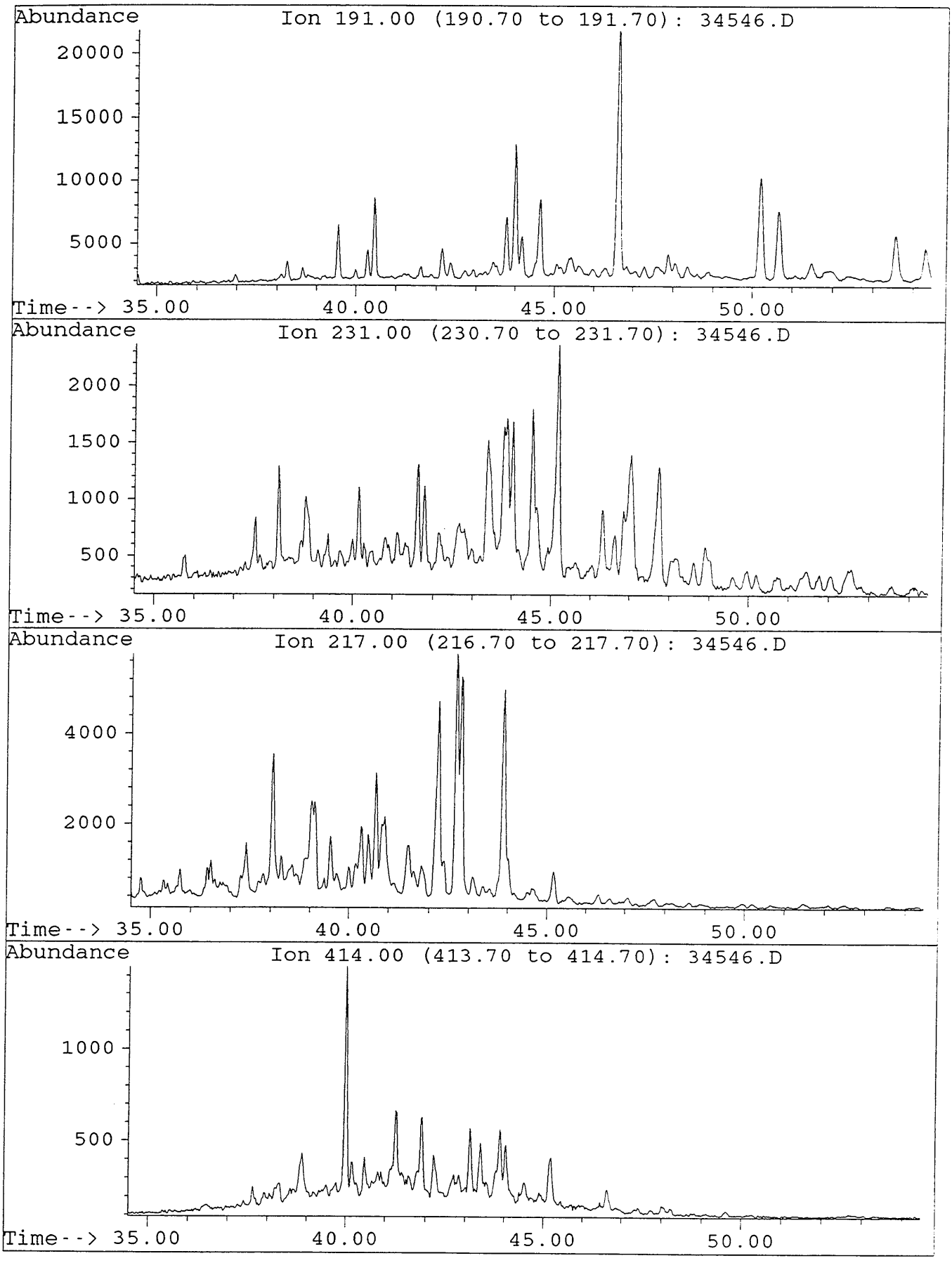

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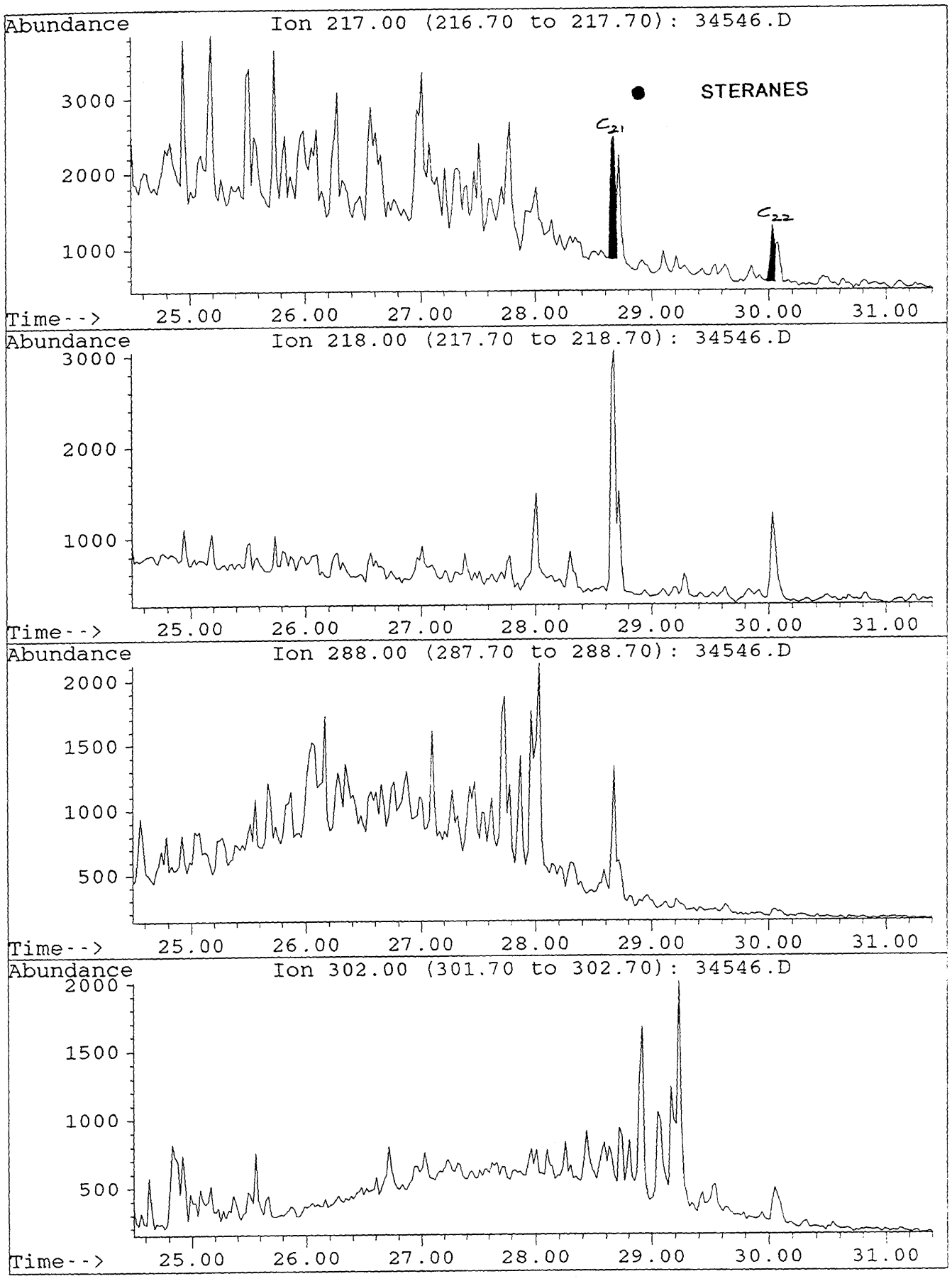

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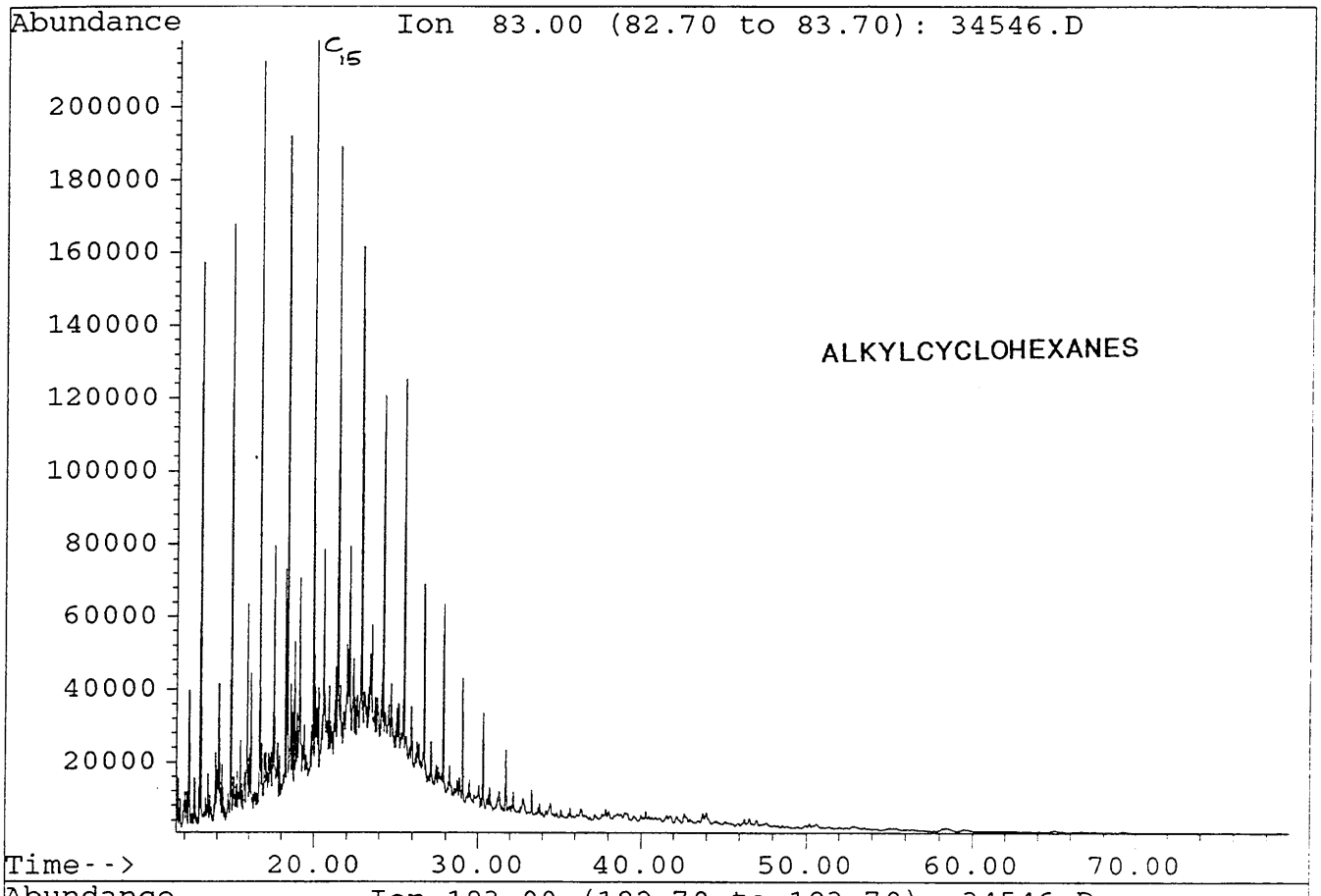

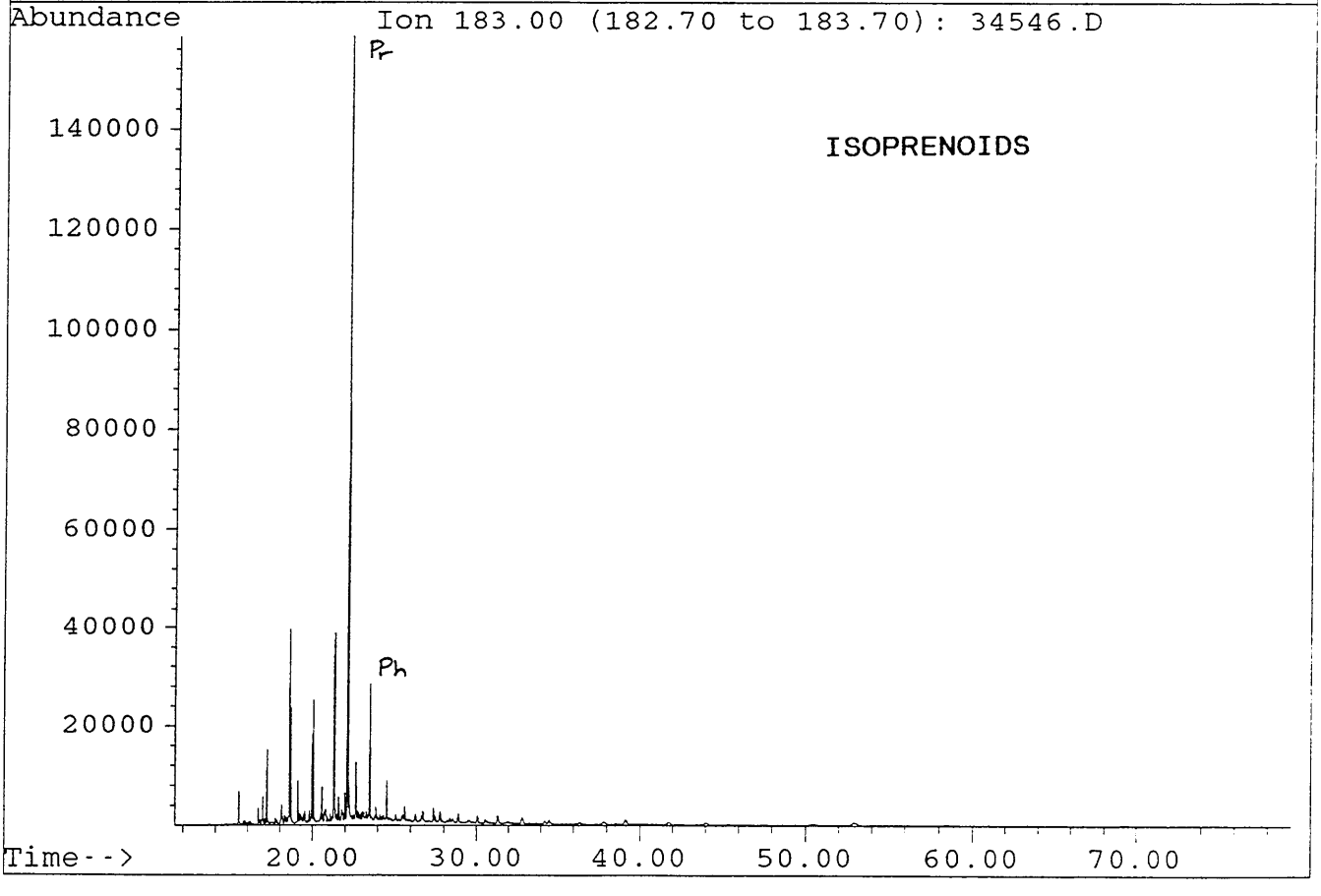

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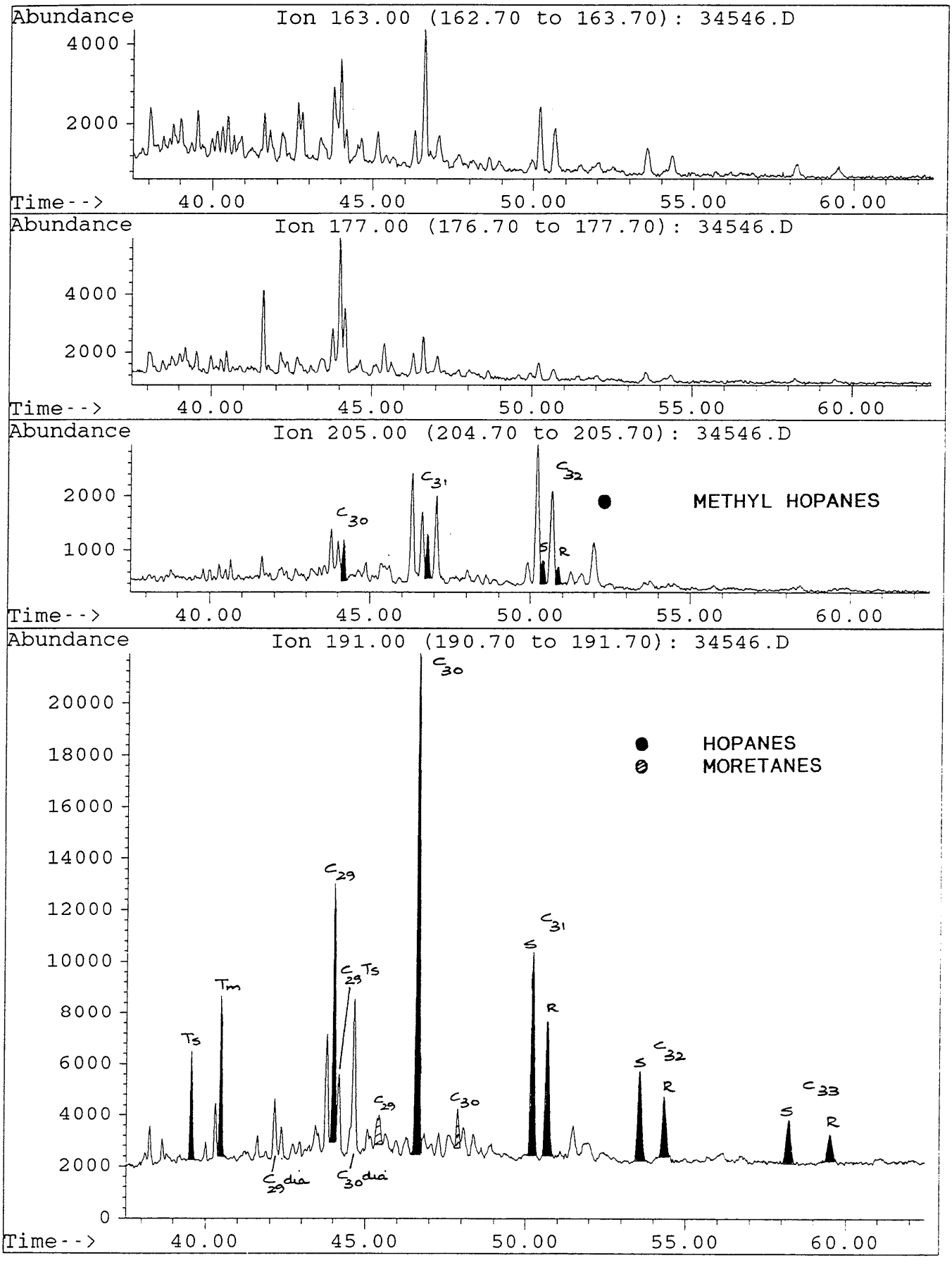

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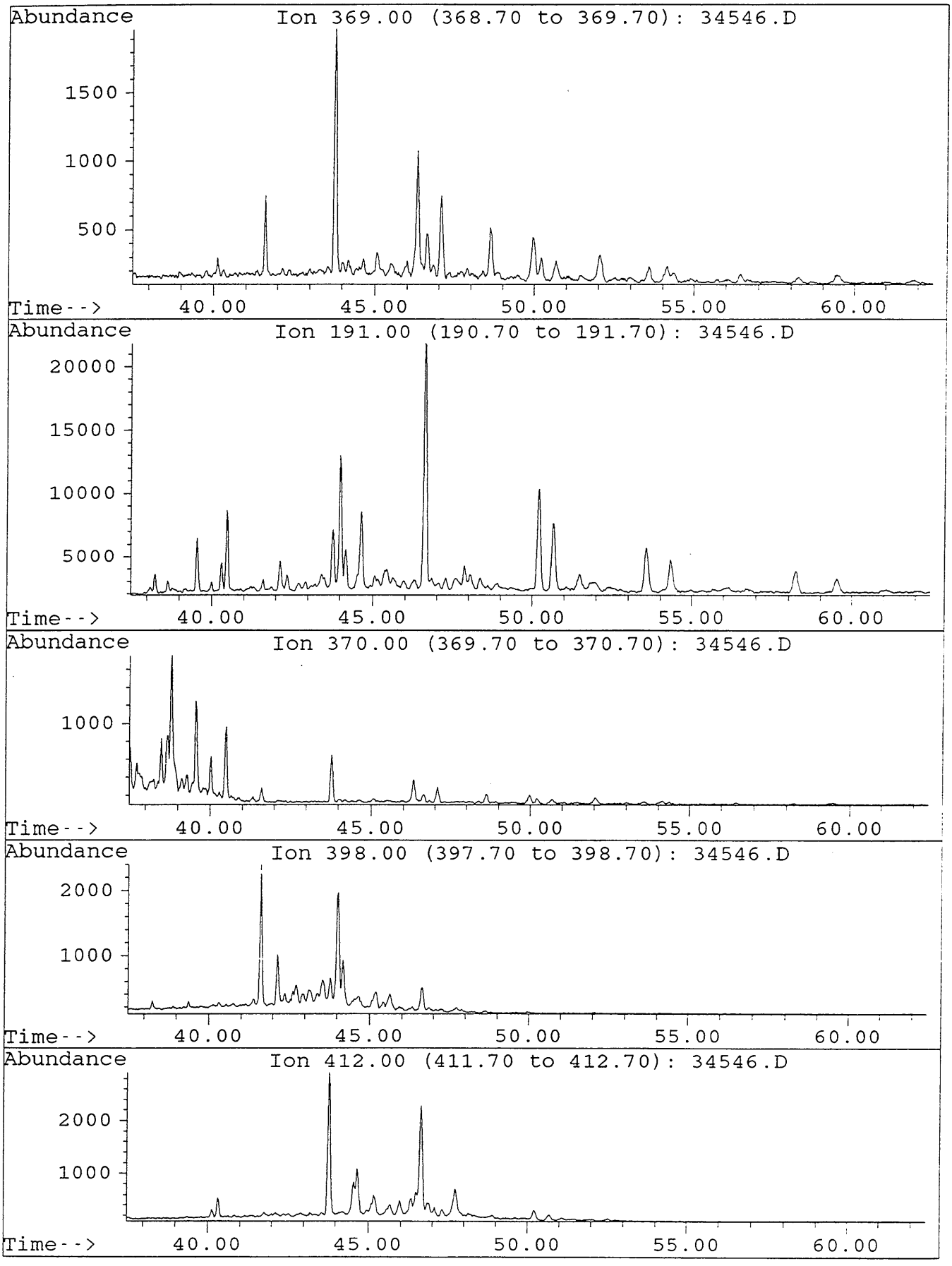

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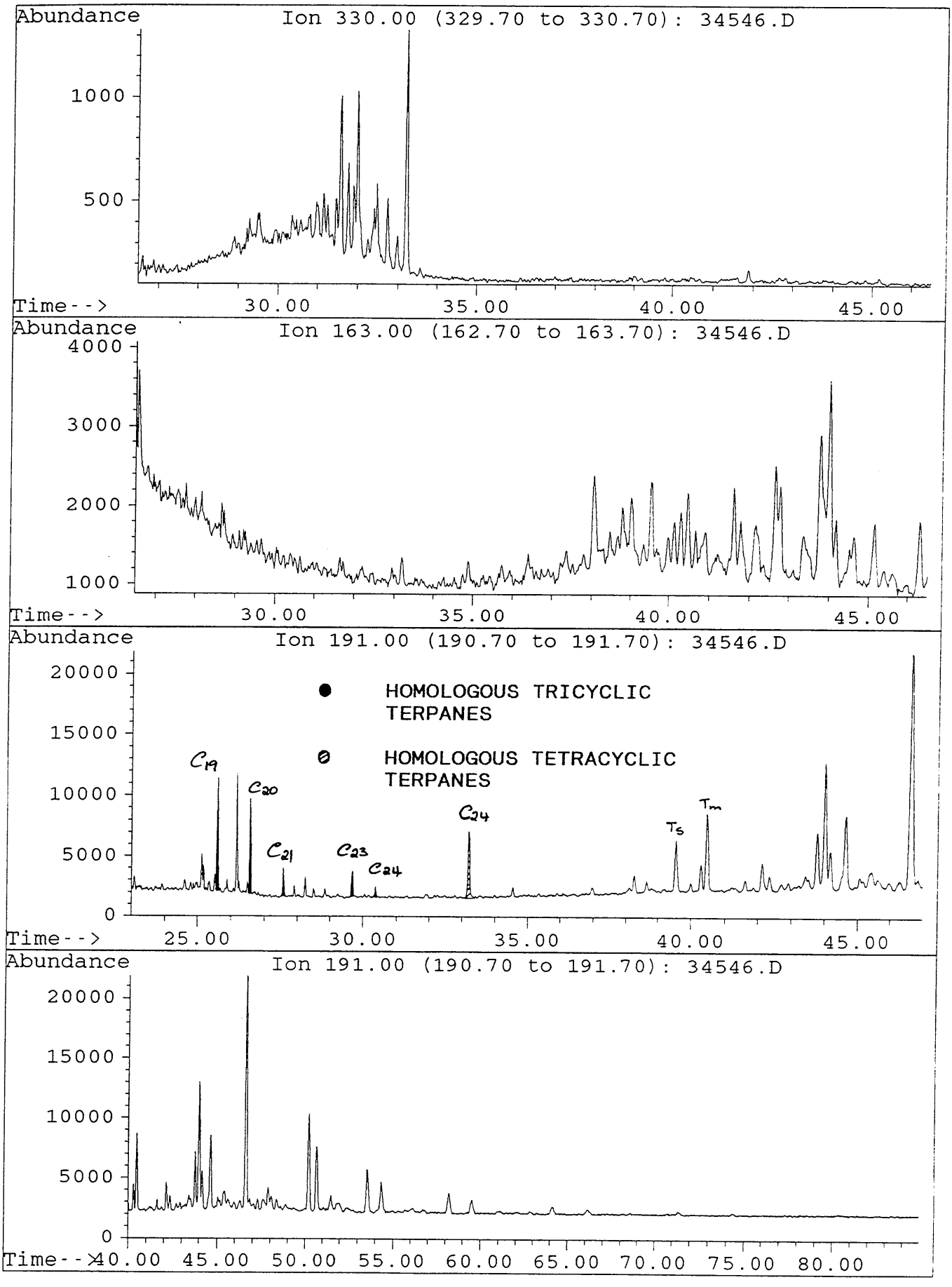

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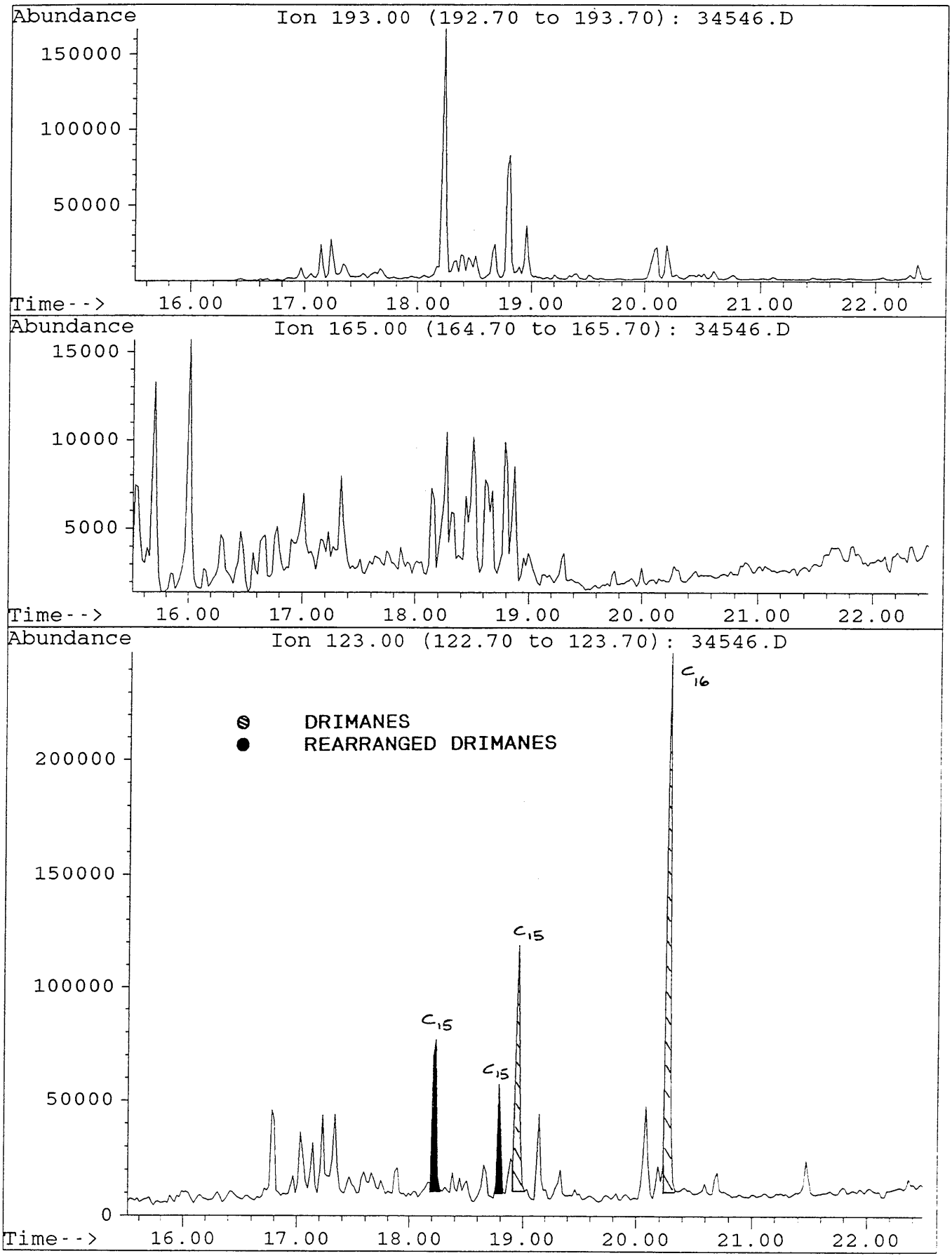

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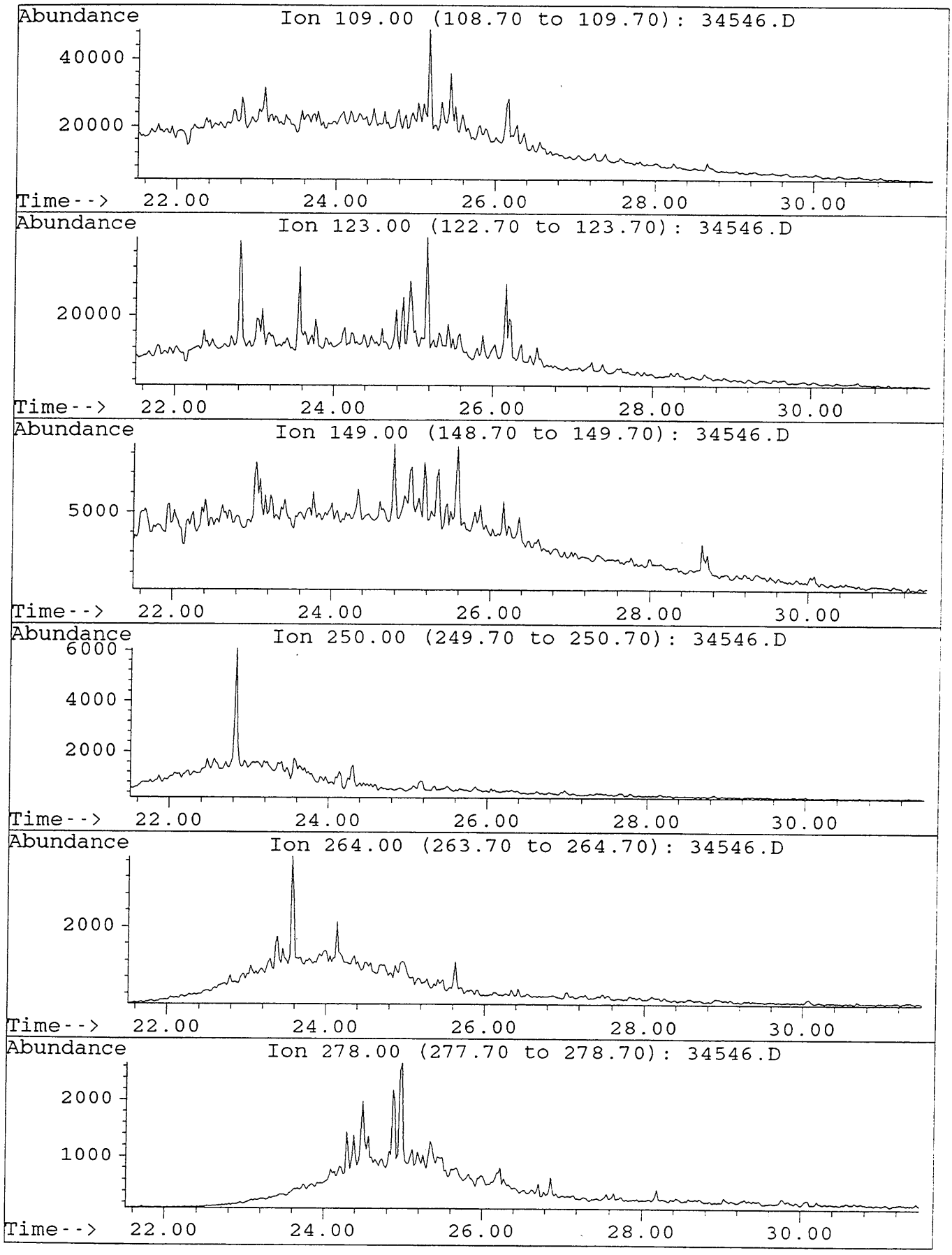

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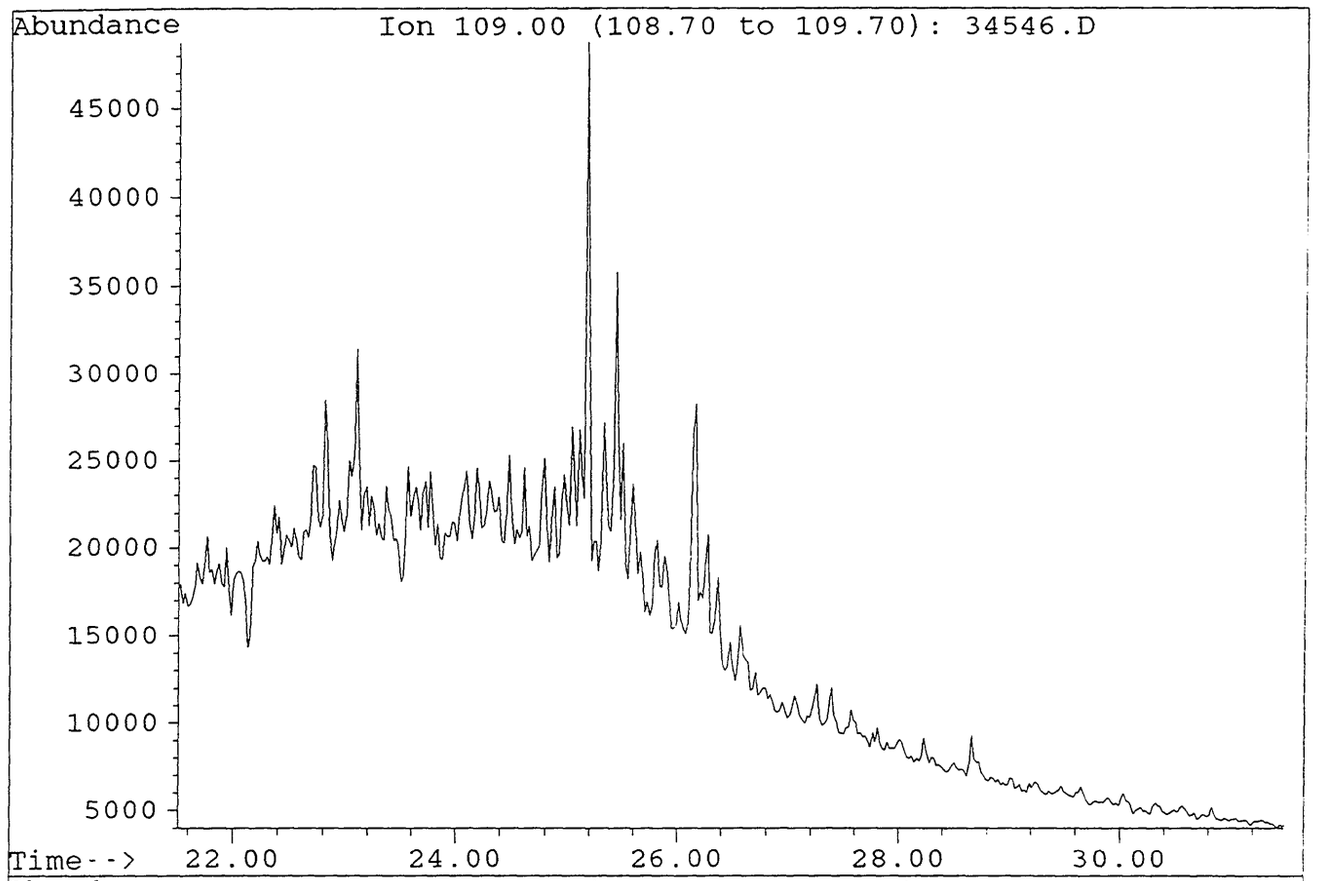

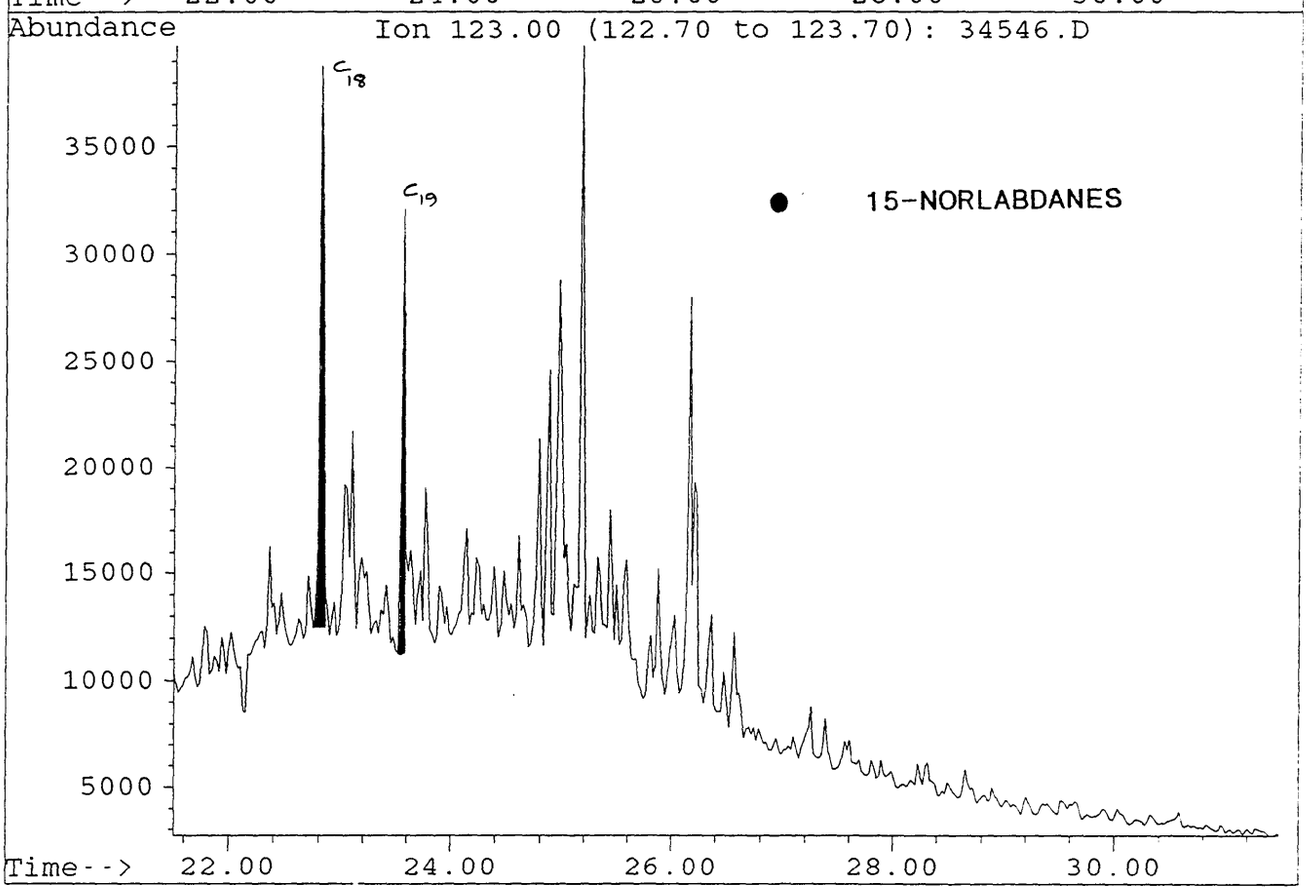

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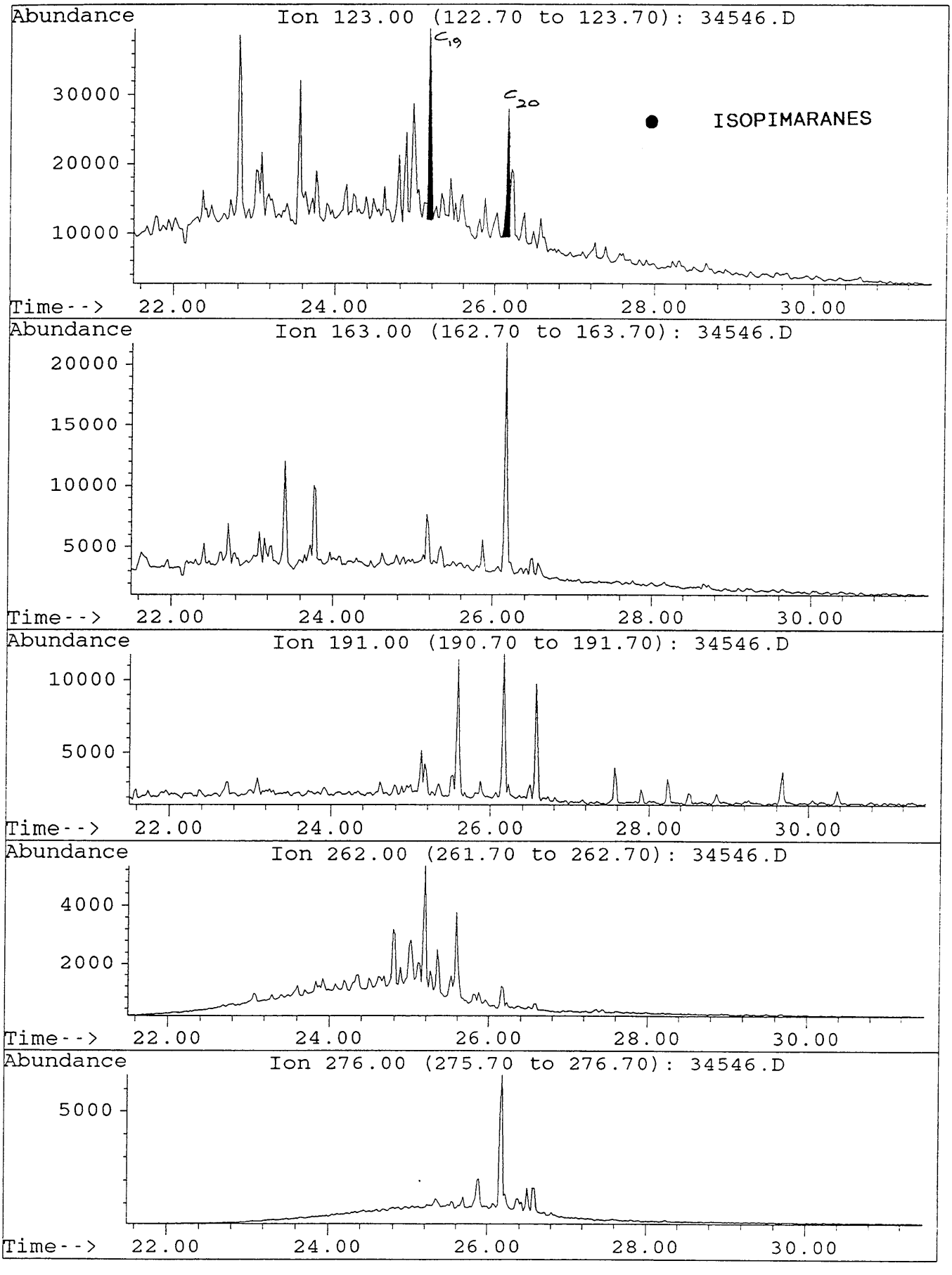

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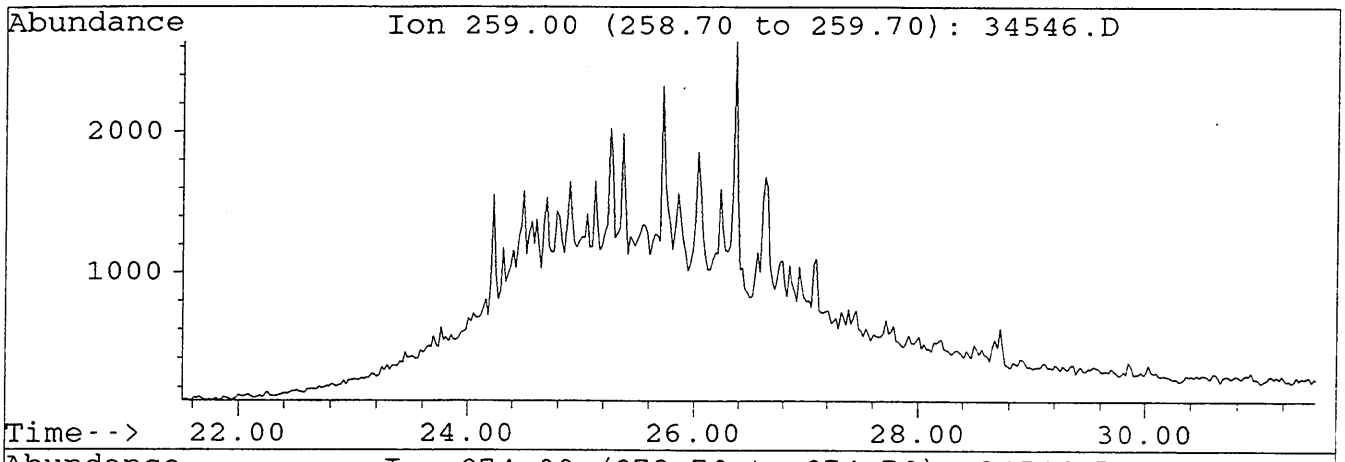

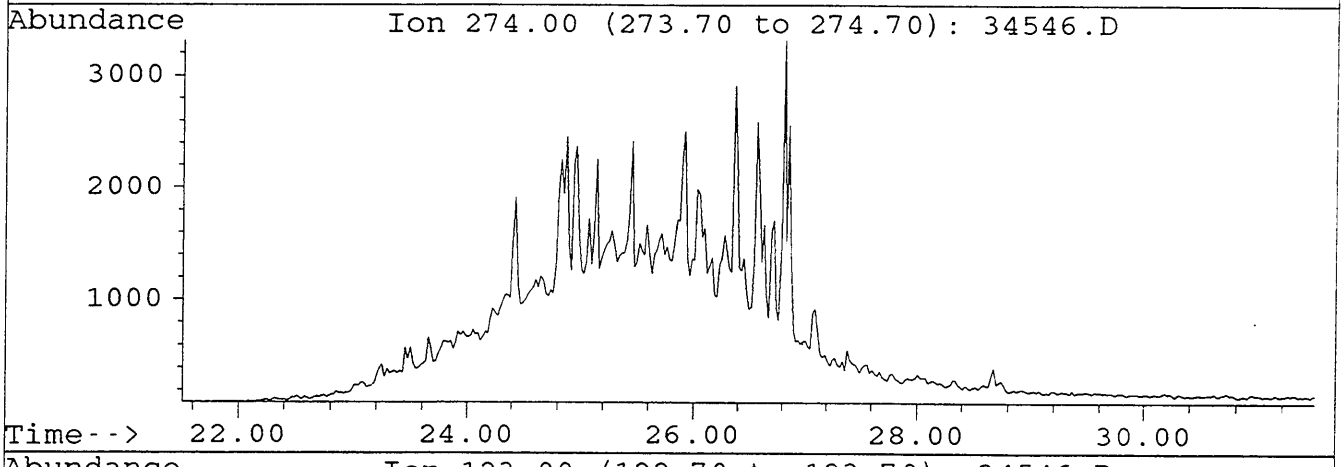

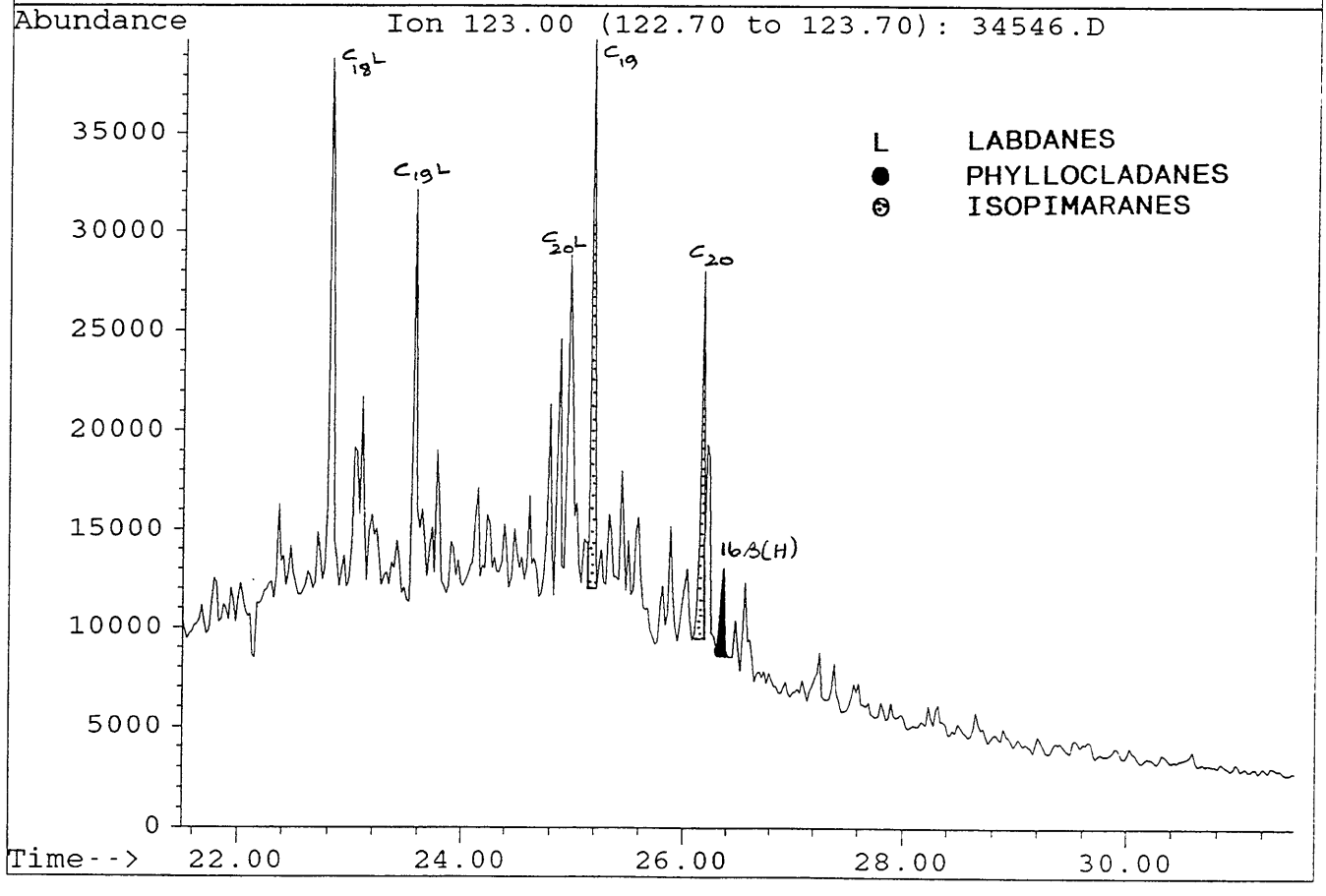

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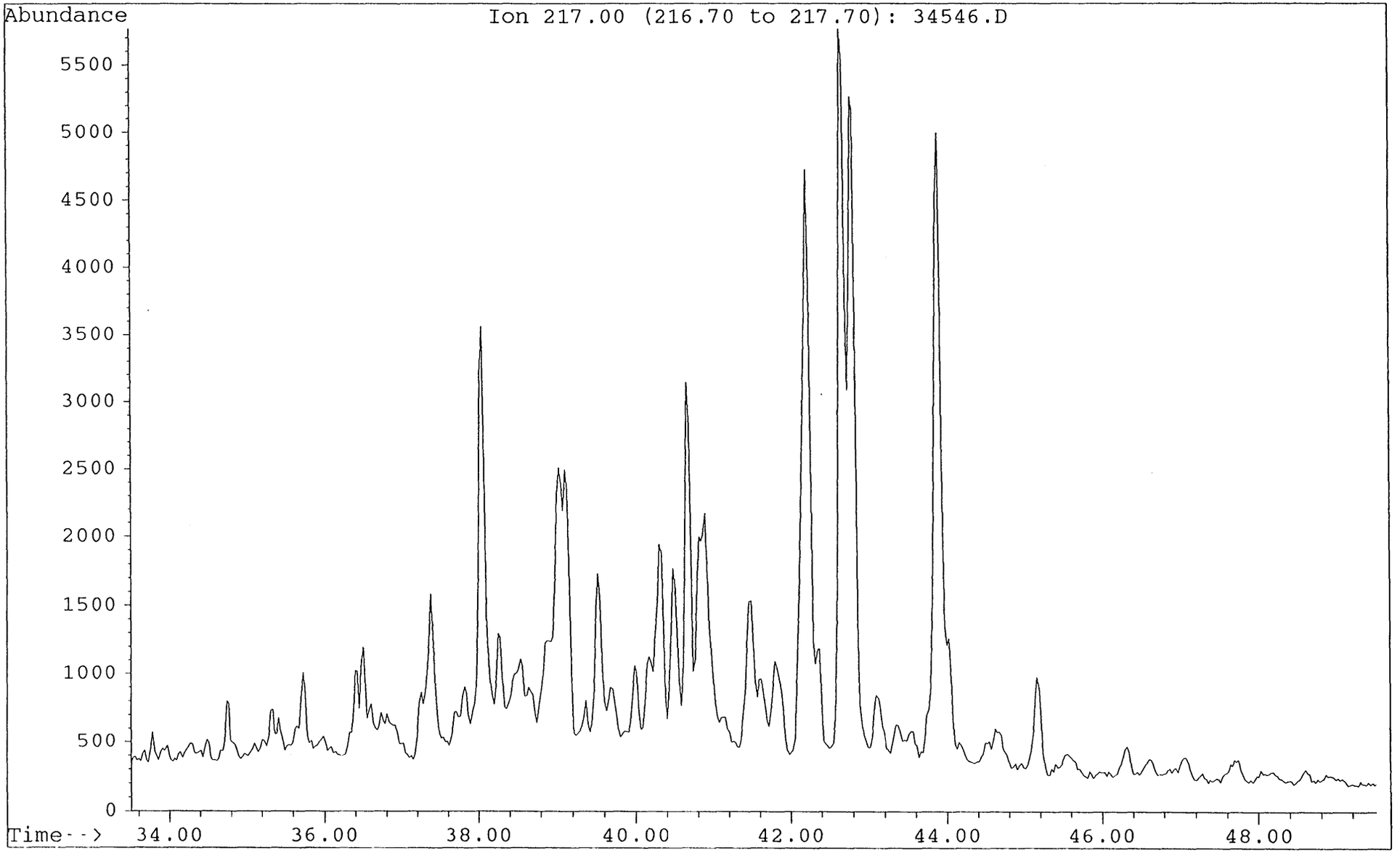

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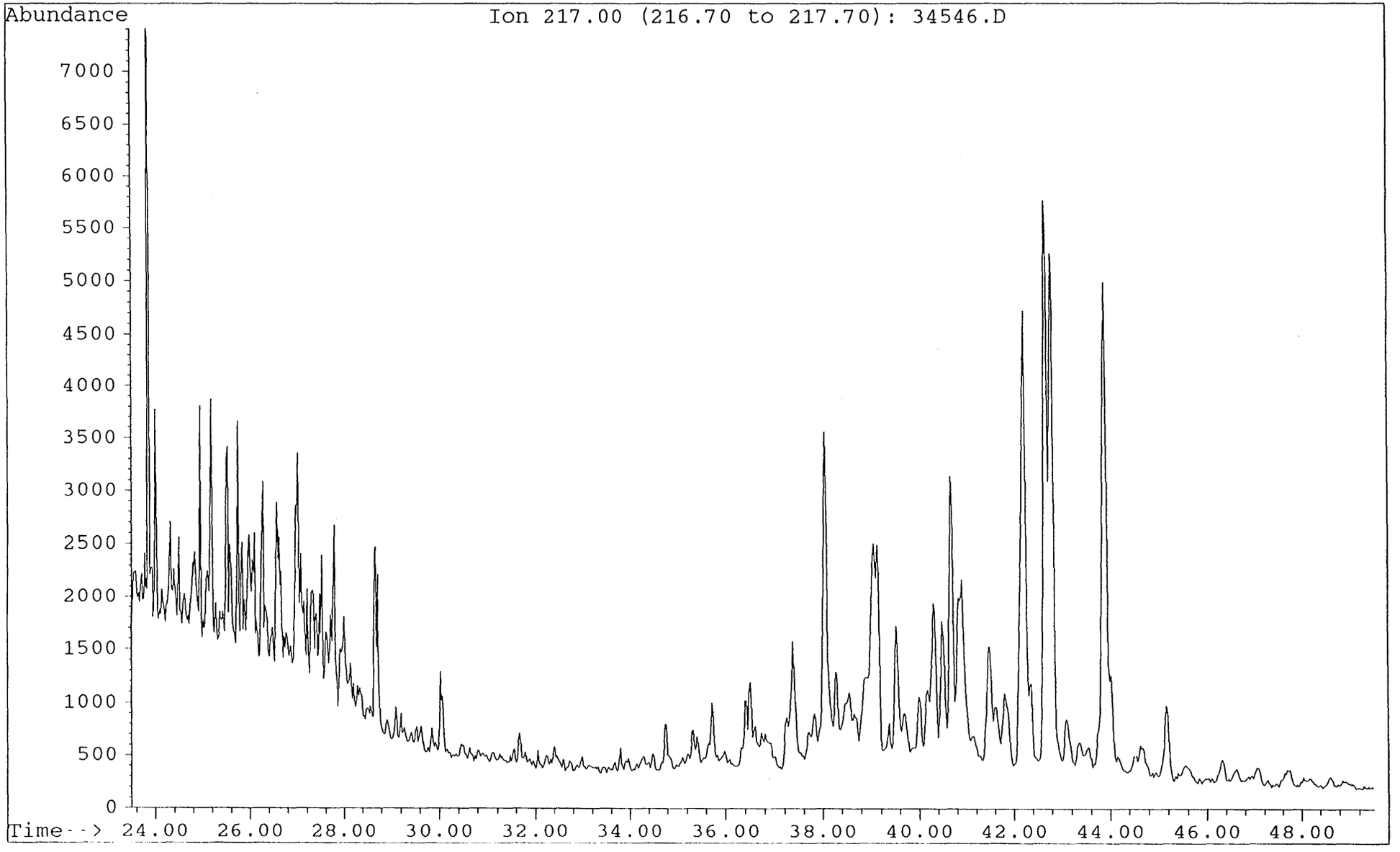

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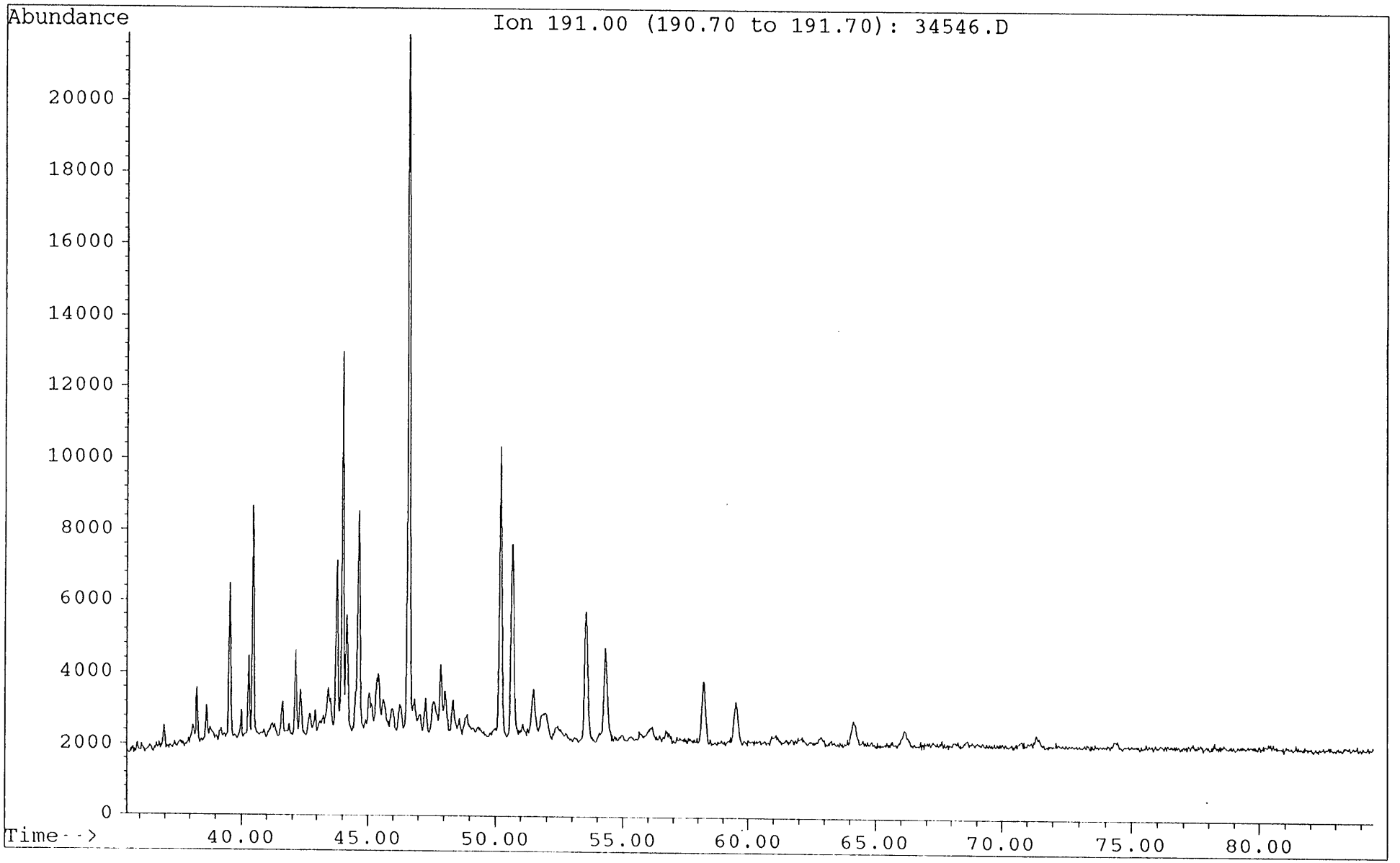

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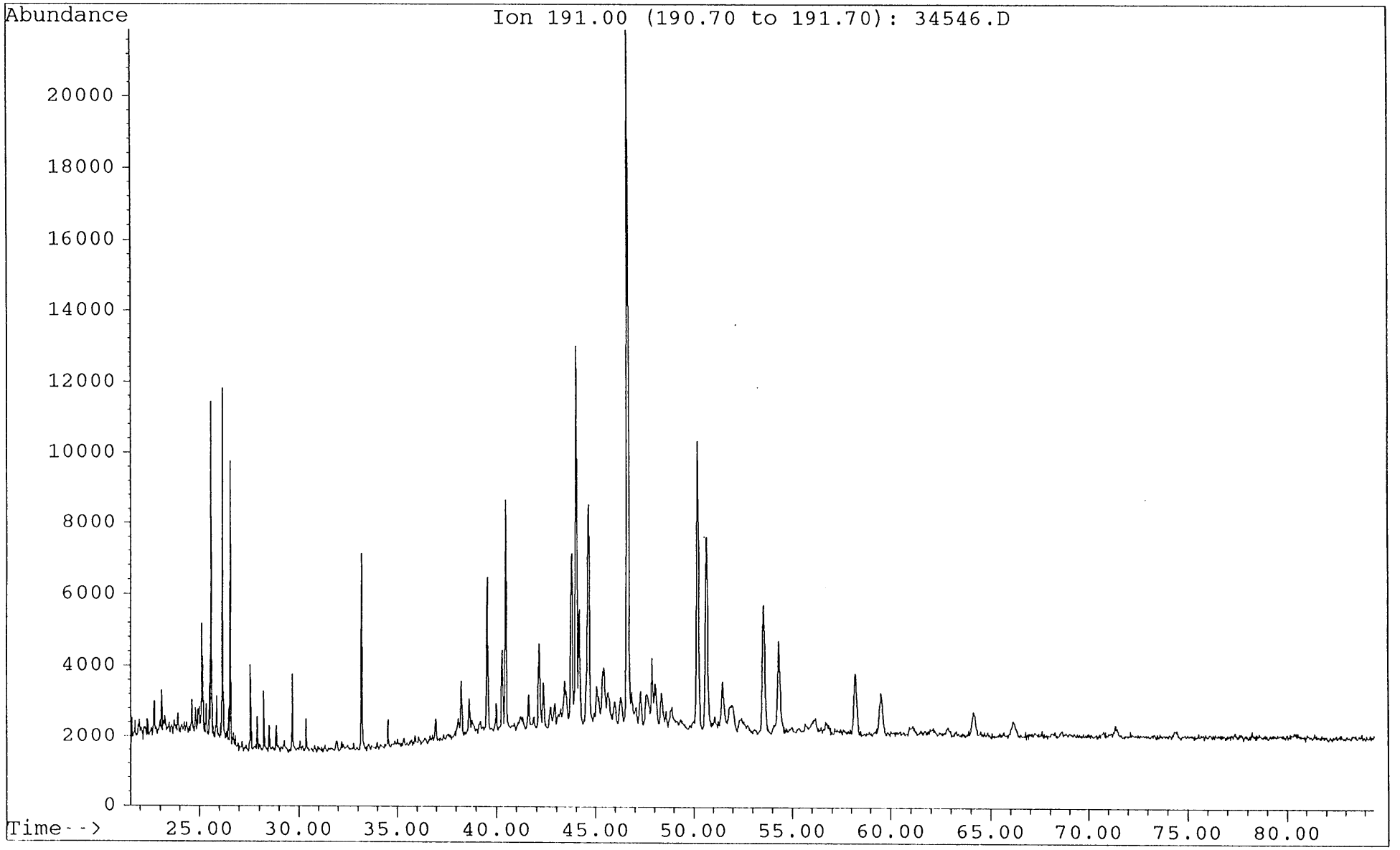


TABLE 4

SELECTED AROMATIC PARAMETERS

LINDON 1 Sep-95

DEPTH	TYPE	DNR-1	DNR-5	DNR-6	TNR-1	TNR-5	TNR-6	MPR-1	MPI-1	MPI-2	Rc(a)	Rc(b)
2895.0m	Cuttings	6.05	nd	2.64	0.81	0.71	nd	1.64	0.78	0.93	0.87	1.83

response factors have been applied to DNR 6, TNR 1, TNR 5, MPI 1 and MPI 2

TABLE 4

SELECTED AROMATIC PARAMETERS CONT.

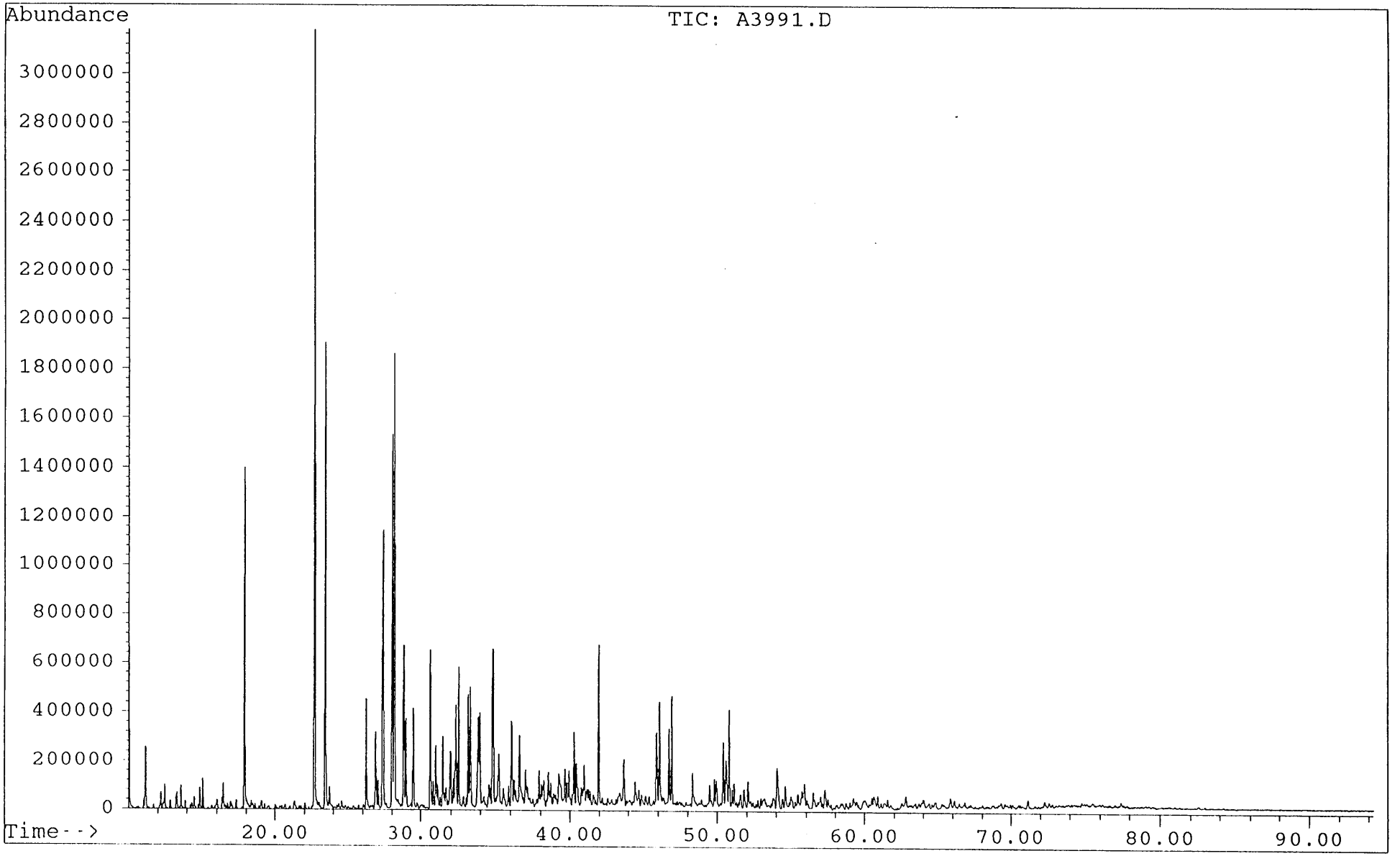
LINDON 1 Sep-95

DEPTH	TYPE	1,7-DMP/X (m/z 206)	RETENE/9-MP (m/z 219,192)	1MP/9MP
2895.0m	Cuttings	1.25	0.16	1.30

nd = no data

File : A3991.D
Sample : LINDON#1, 2895m. AROS.
Misc. Info : COL#155. 30-8-95. GEC.

FIGURE 3



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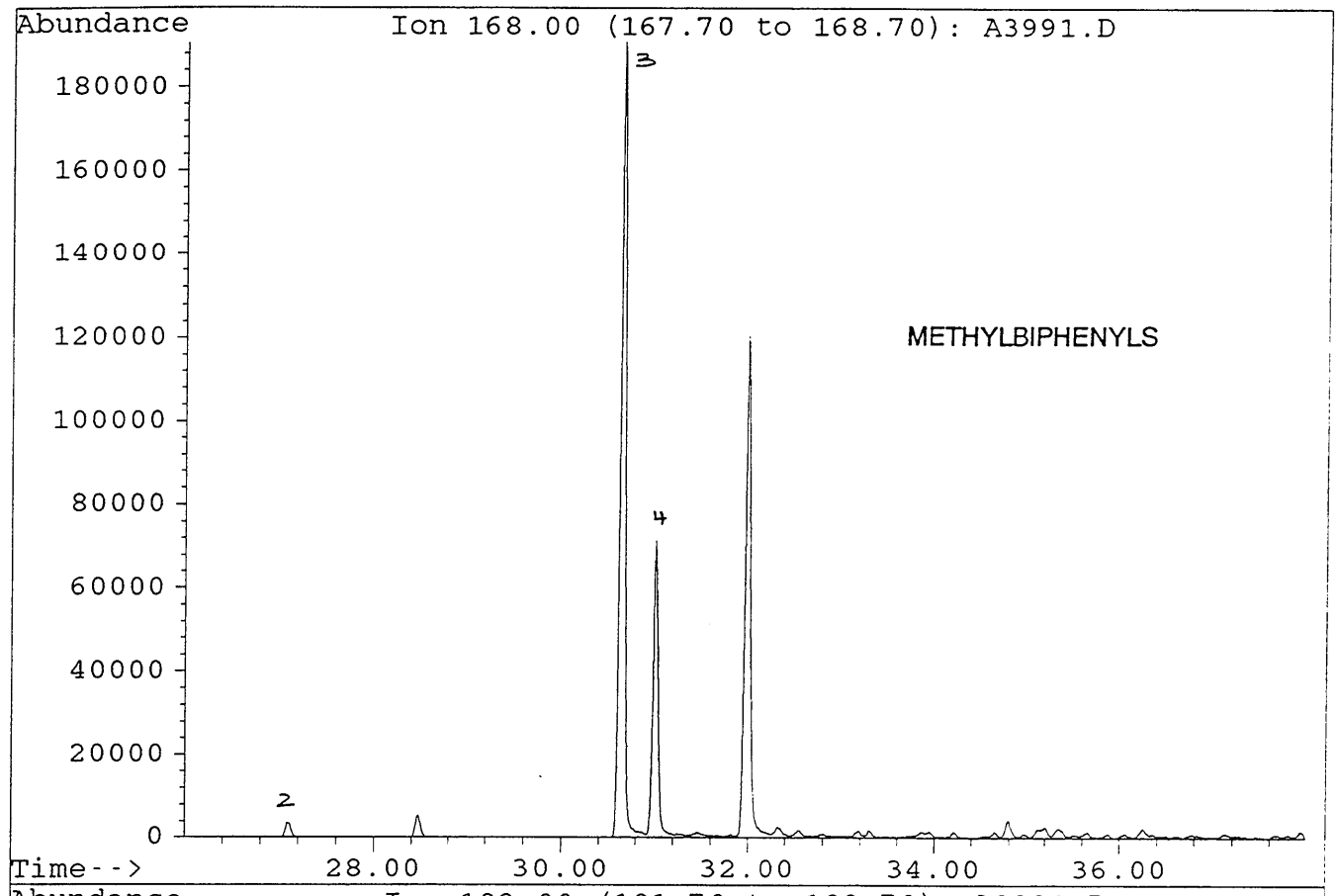
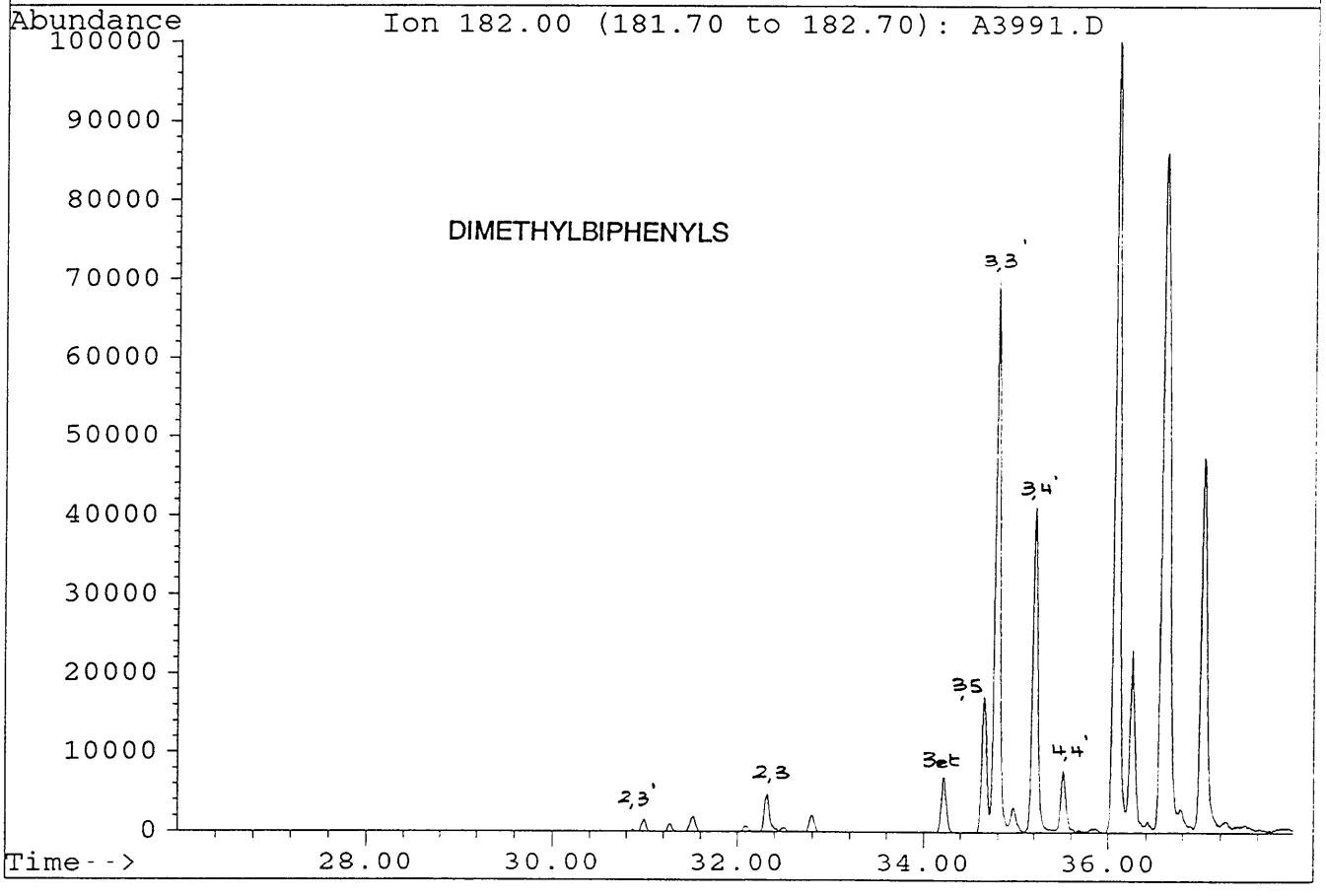
Misc. Info : COL#155. 30-8-95. GEC.





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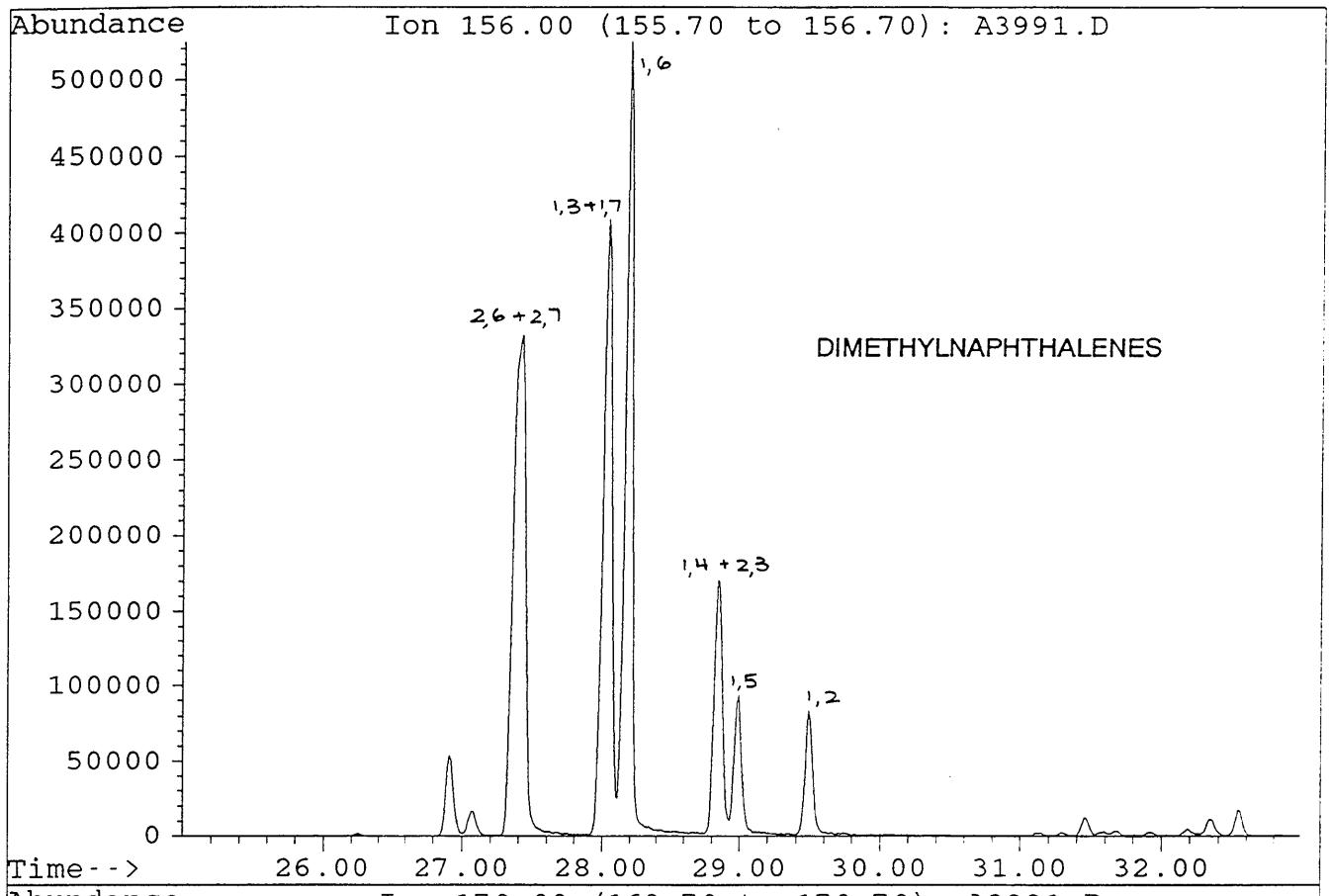

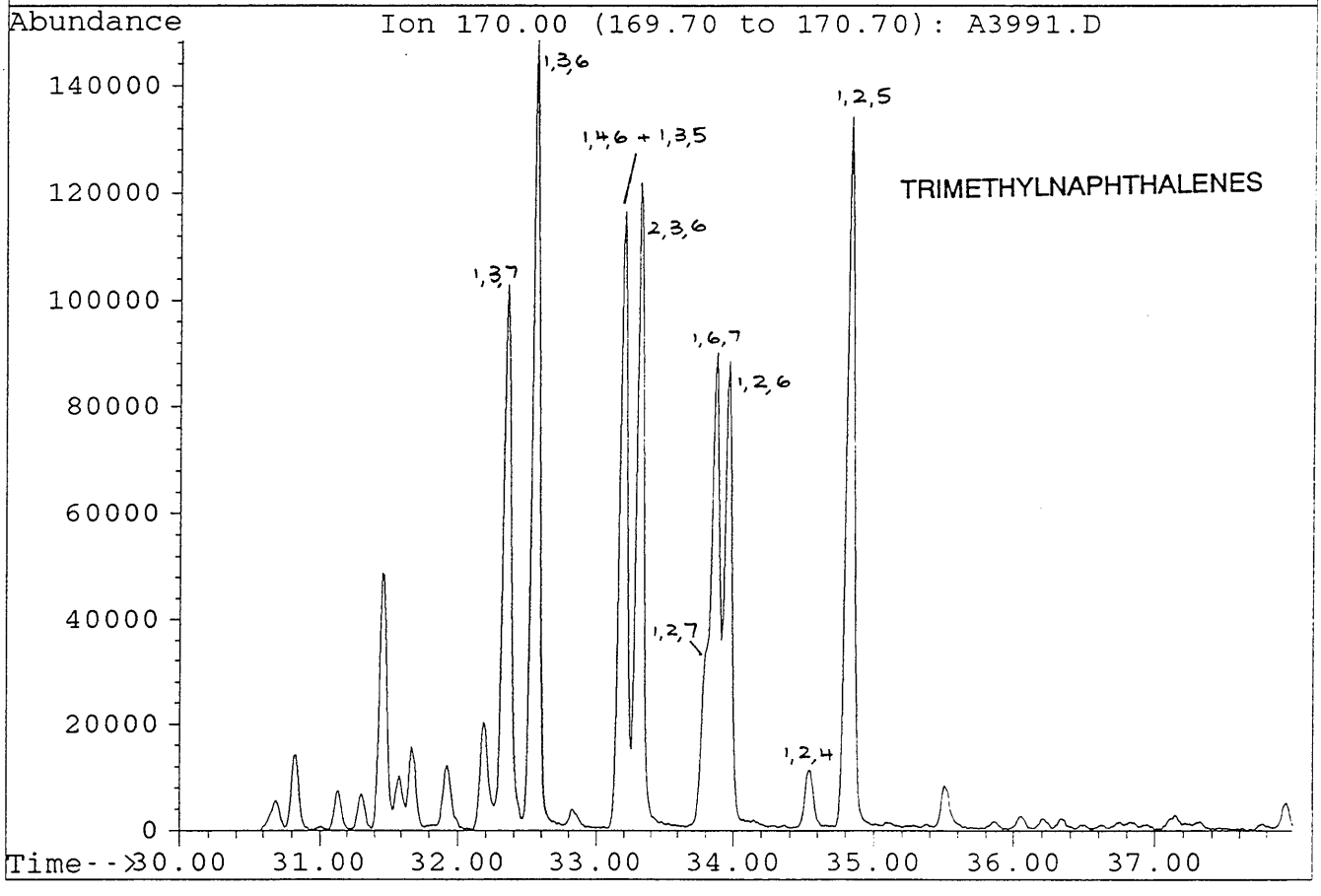

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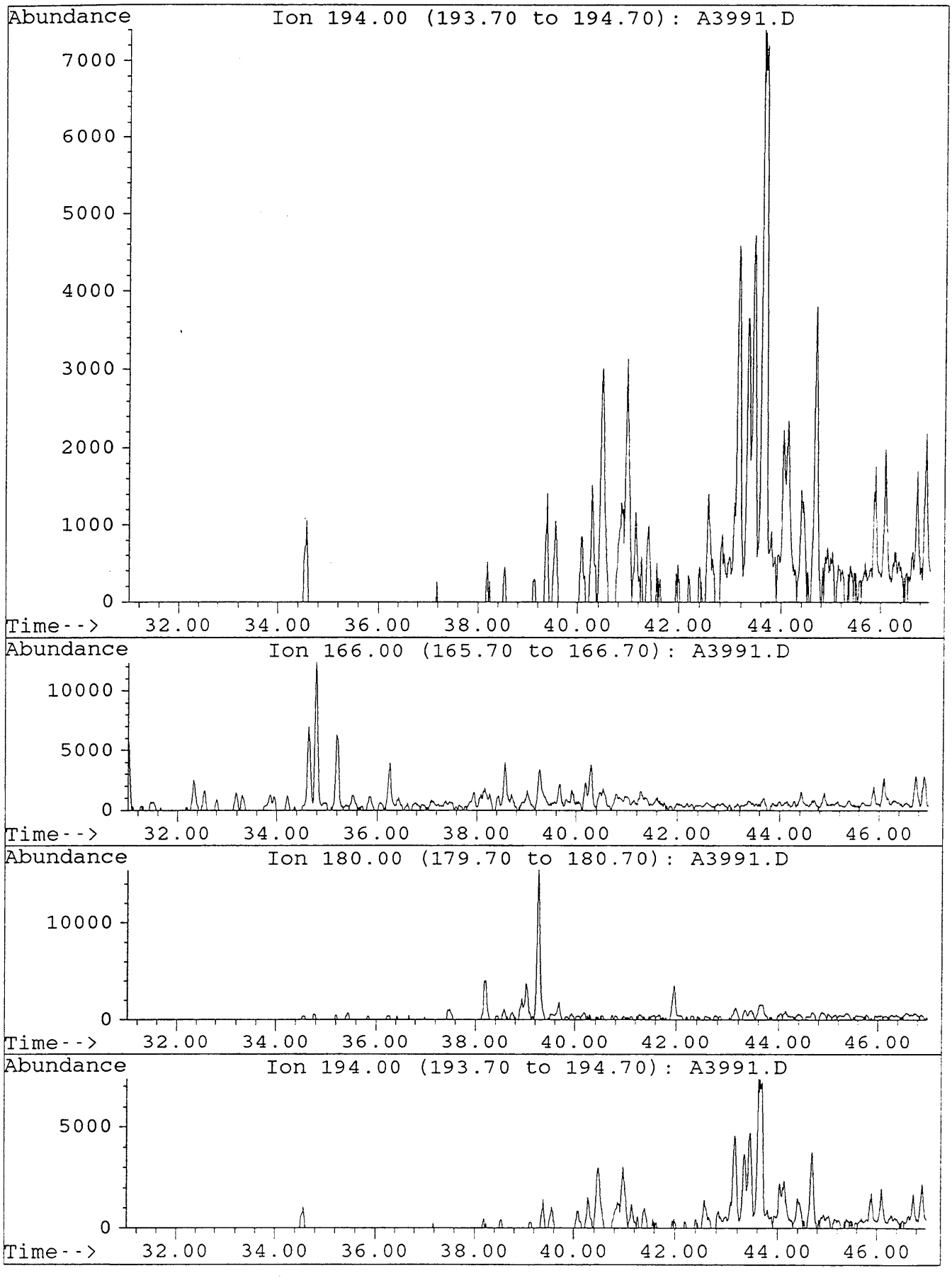
Sample : LINDON#1, 2895m. AROS.
Misc. Info : COL#155. 30-8-95. GEC.

FLUORENES



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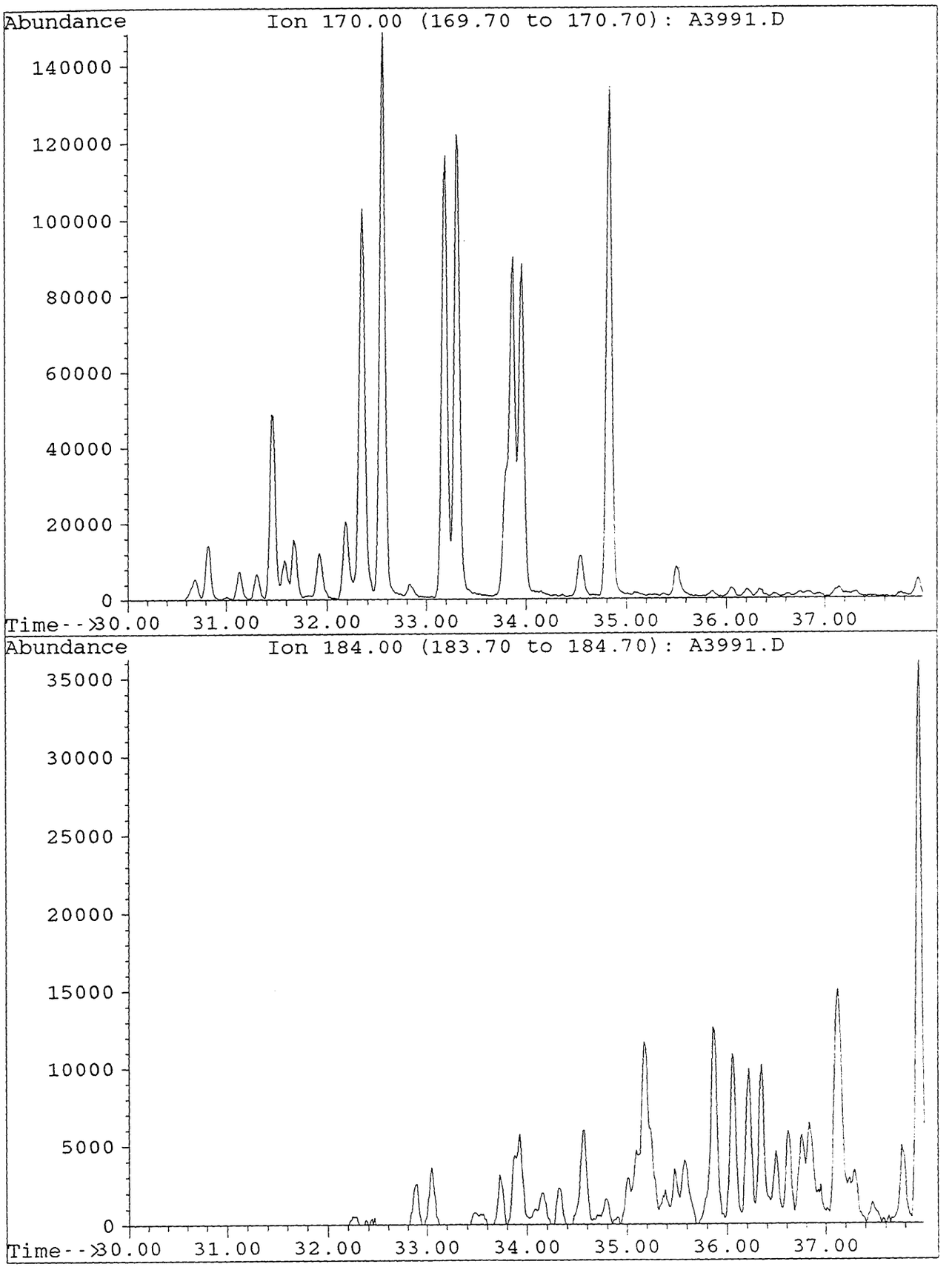

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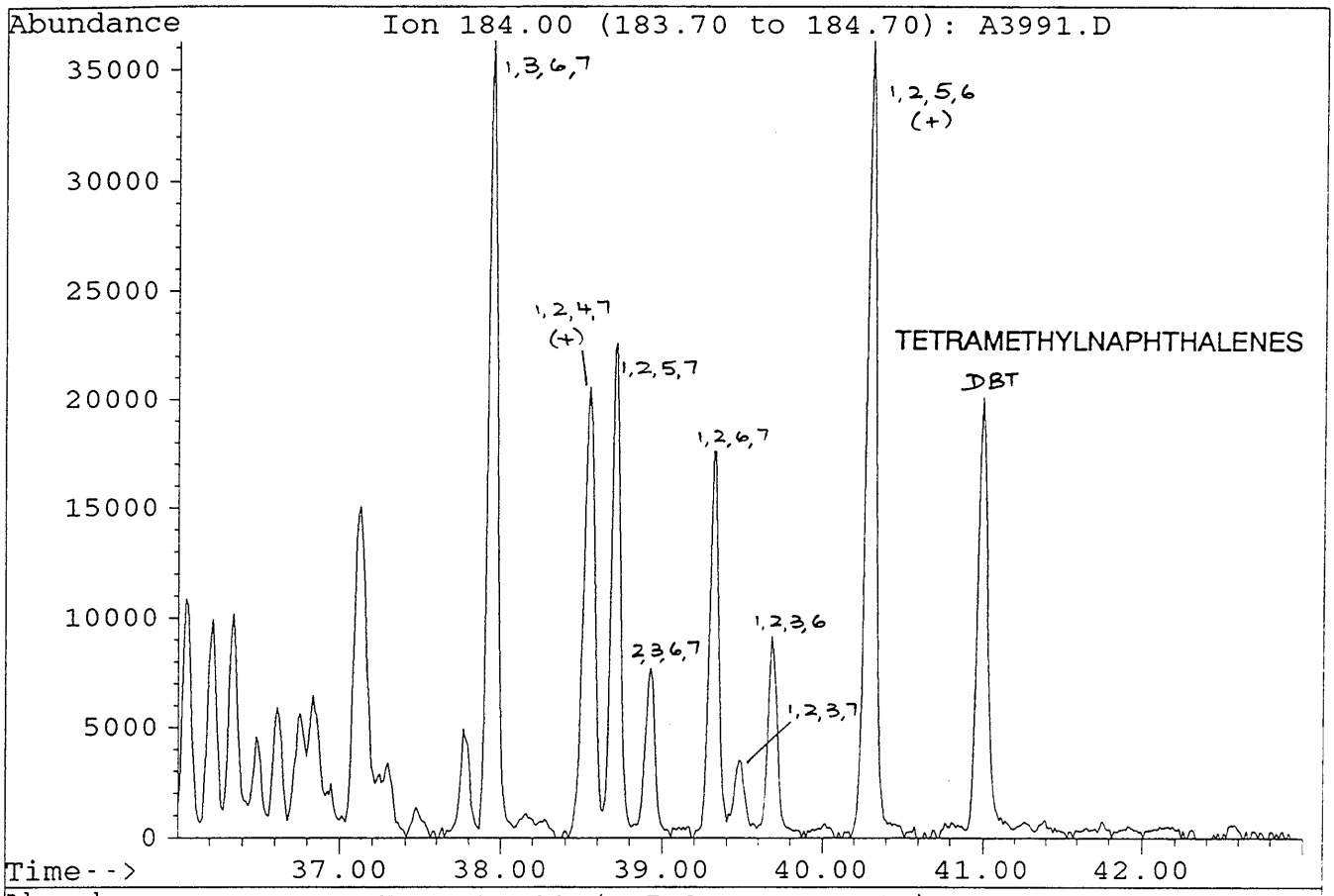

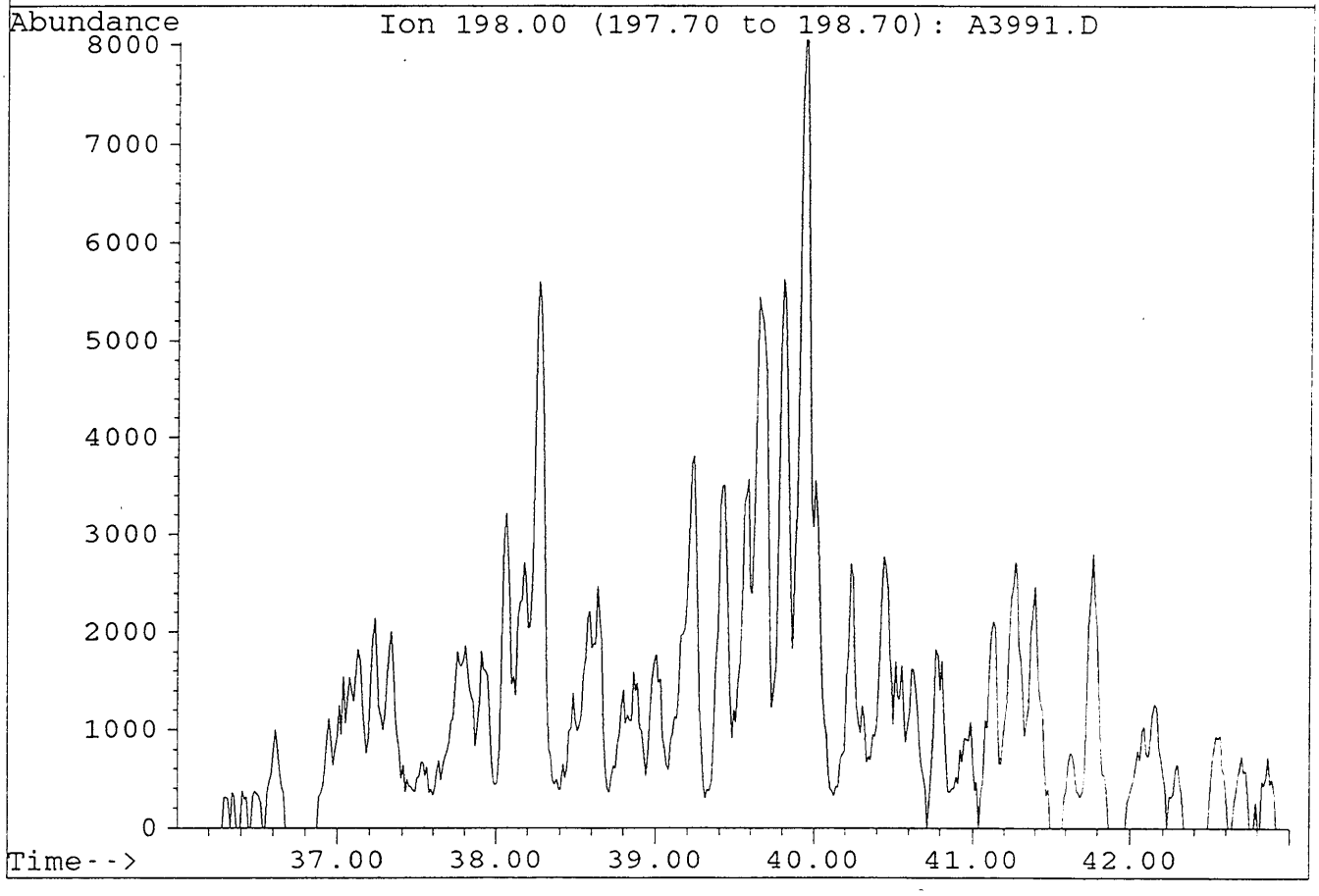

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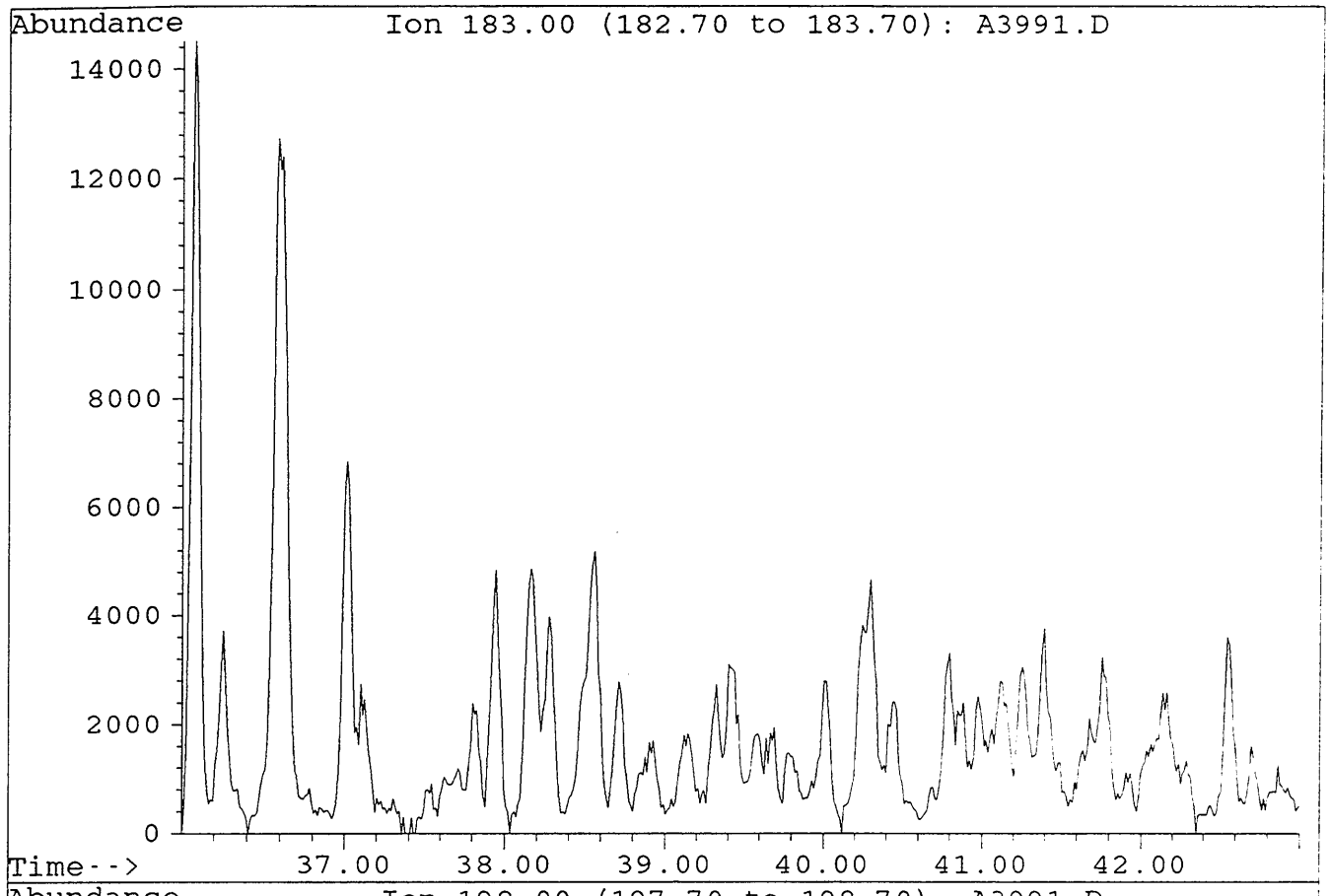

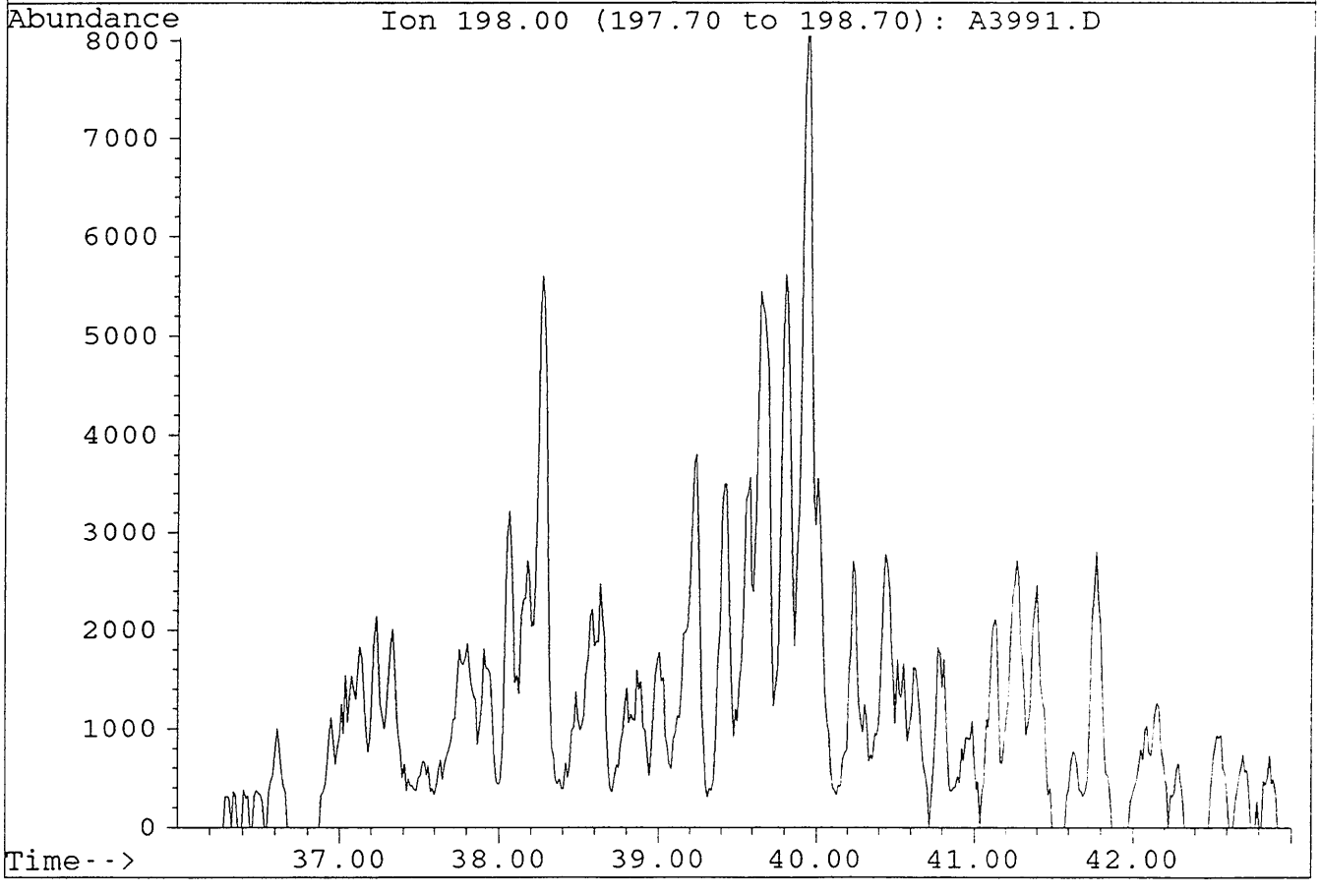

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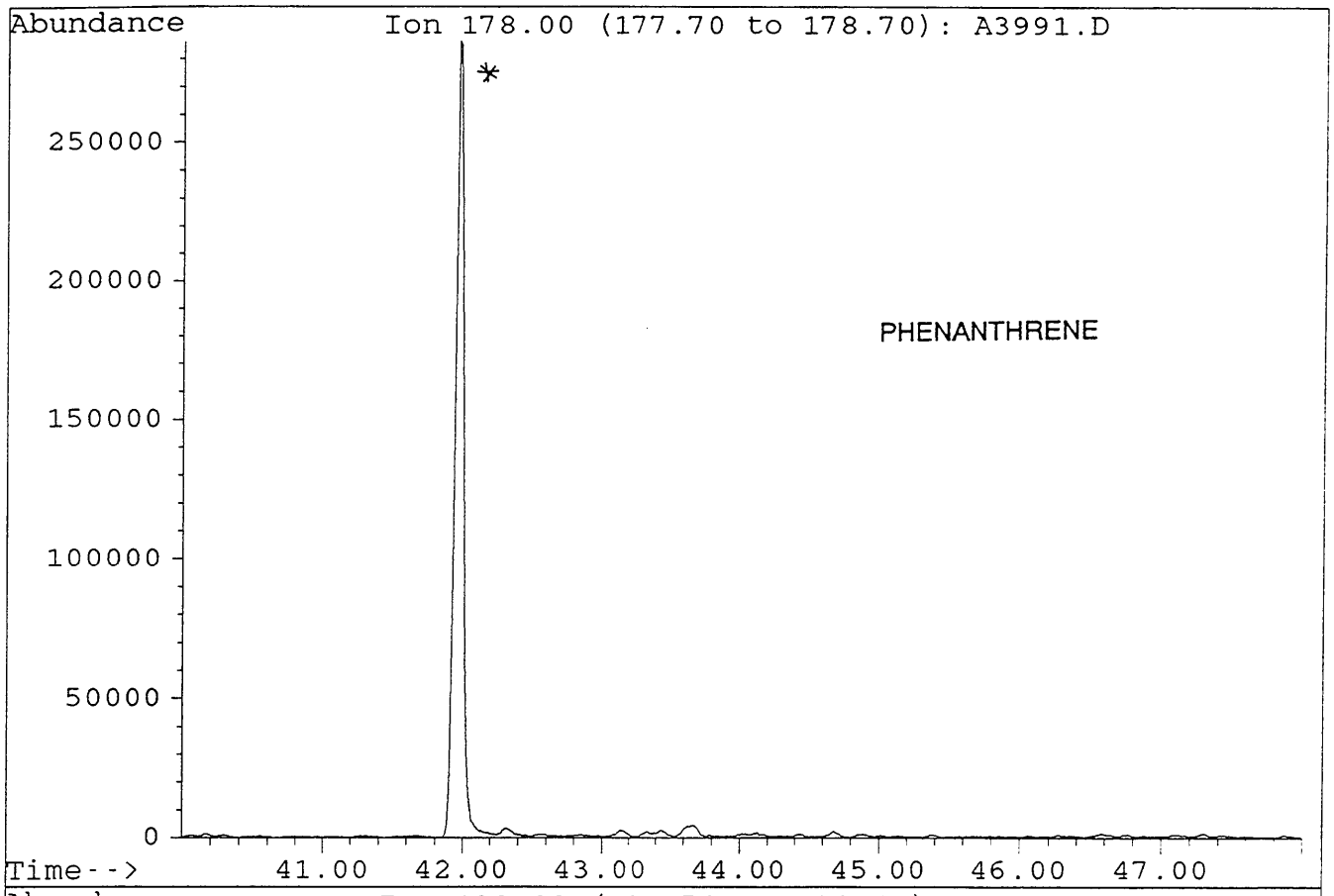

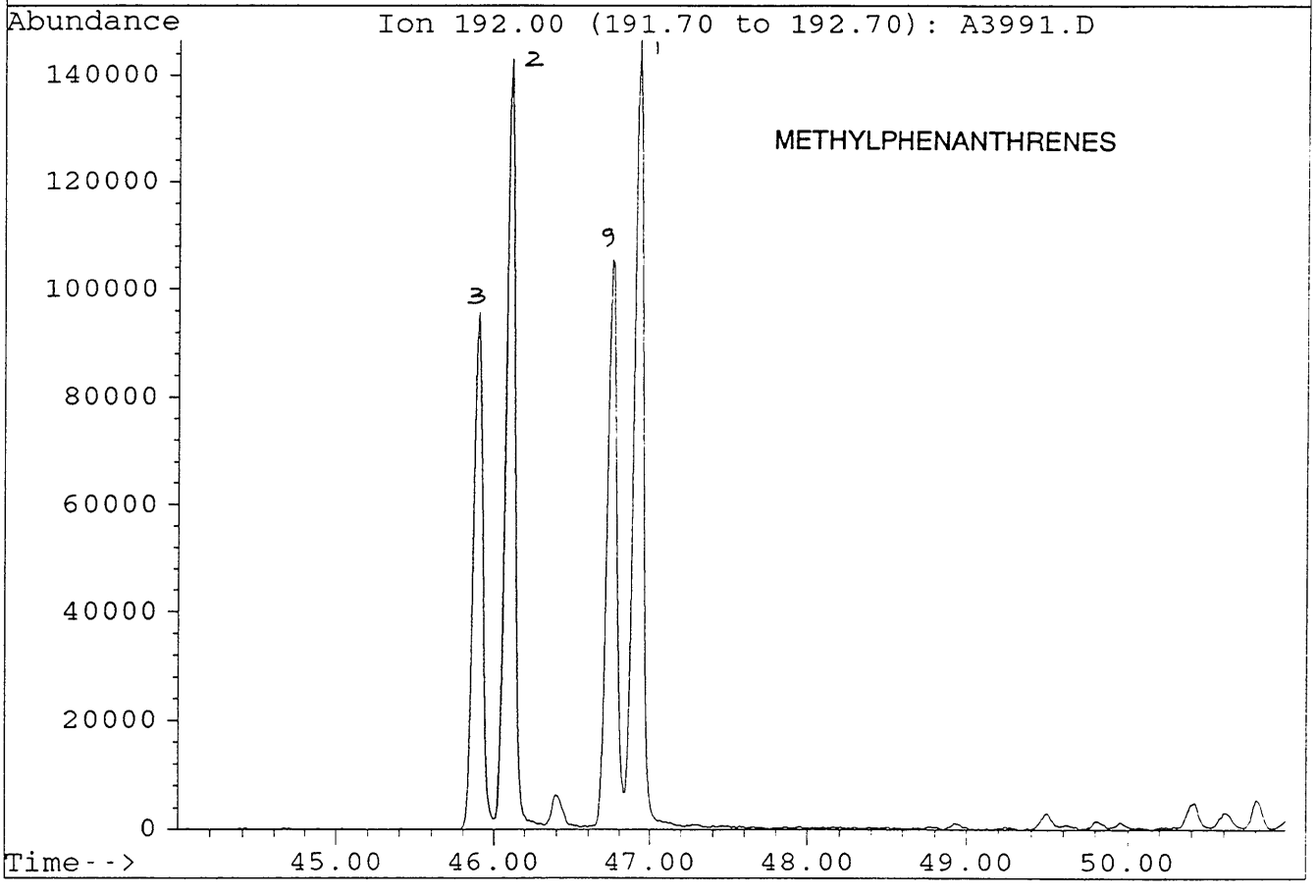

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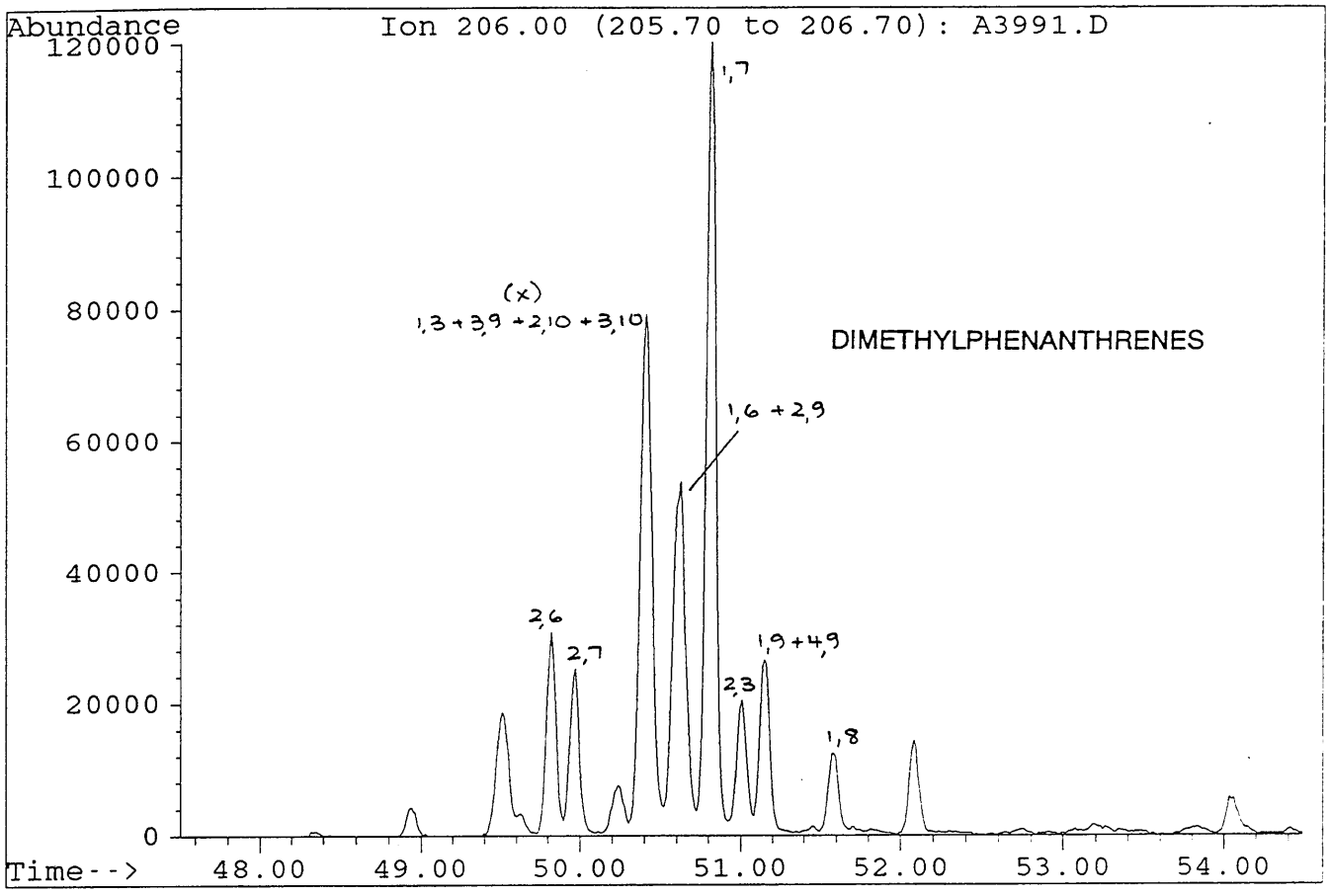

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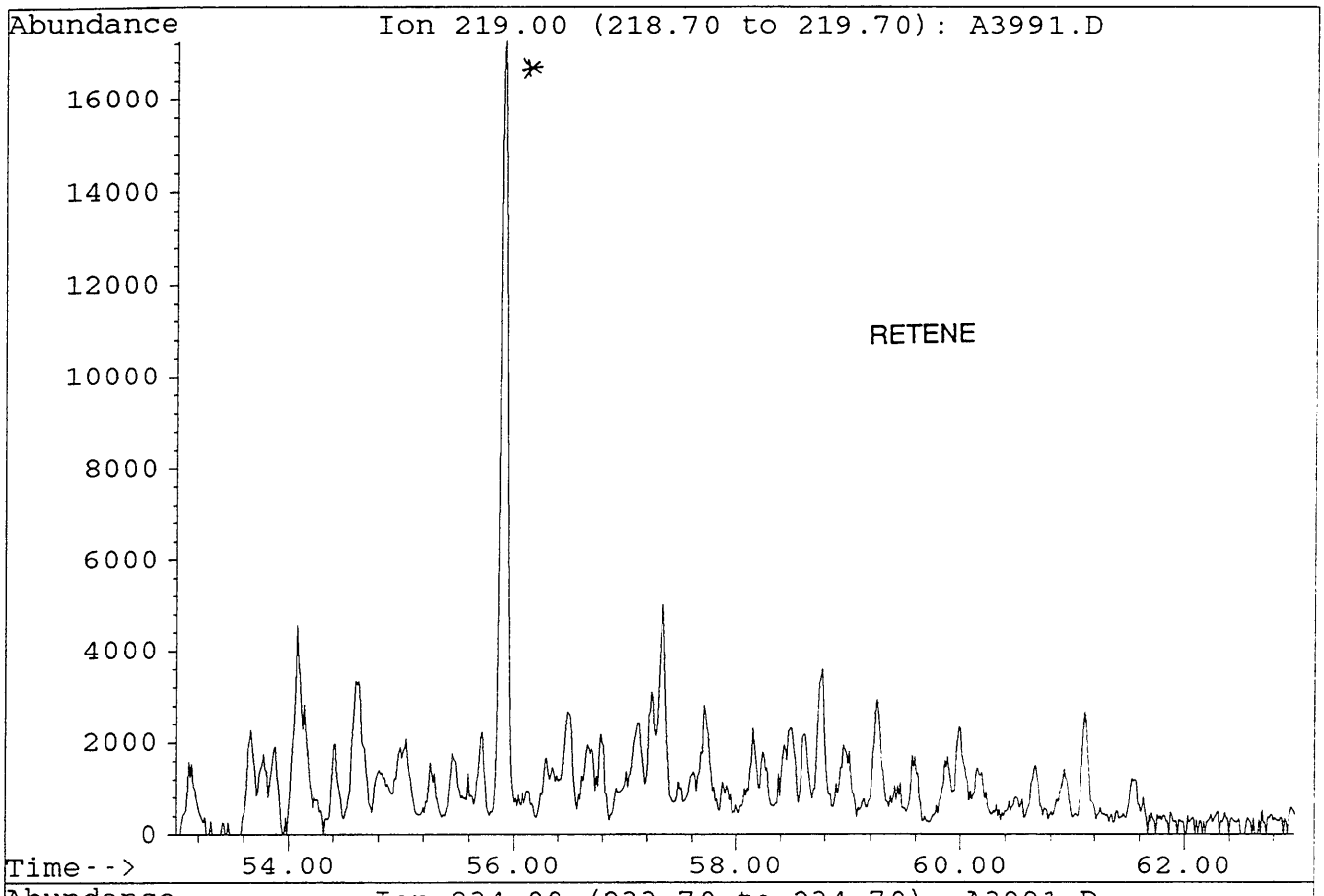
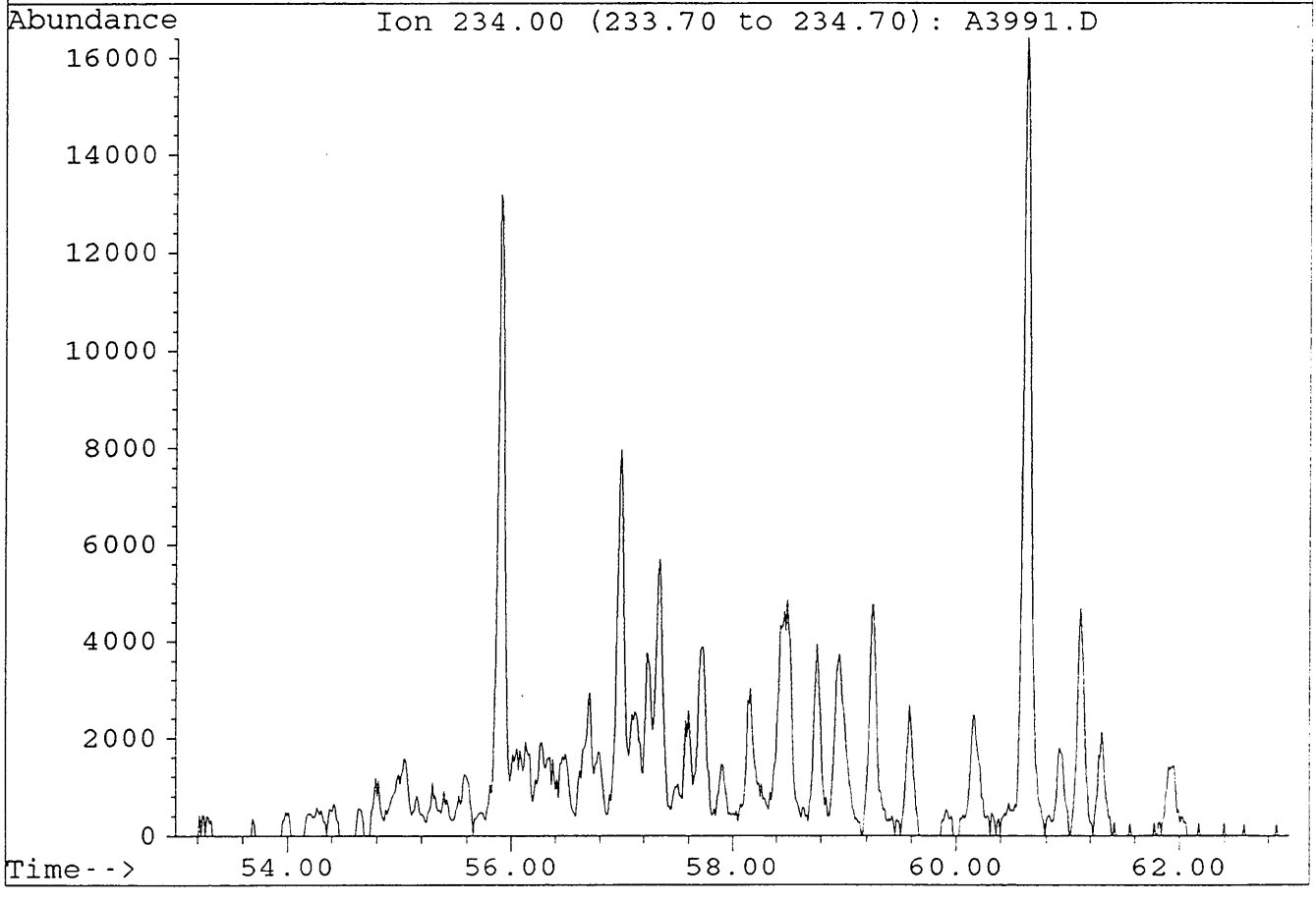
Misc. Info : COL#155. 30-8-95. GEC.





PETROLEUM GEOCHEMISTRY

1.0 INTRODUCTION

Petroleum geochemistry is primarily concerned with the application of organic chemistry to samples of geological interest in hydrocarbon exploration.

Analyses can be carried out on cuttings, sidewall cores, conventional cores, relatively unweathered outcrop samples and fluid hydrocarbons (oil, condensate, gas).

Source rock evaluation is best performed on sidewall cores, since cuttings are more susceptible to contamination from both cavings and organic additives in the mud system. In petroleum geochemical studies it is vitally important for the geochemist/geologist to be aware of the type of mud additives used and the stage at which they are used during the drilling program. Any anomalous results must be carefully considered in conjunction with mud system records.

Petroleum geochemistry in exploration is applied for three major purposes:

1. Identification of richness, maturity and type of kerogen in (a large number of) whole rock samples by screening analyses.

2. Semi-detailed characterisation of kerogen in sediments from selected source intervals, to determine maturity, source type and genetic potential.

3. Detailed characterisation of petroleum fluids (extracts, oils and condensates) by assessment of thermal maturity, source type and depositional environment to enable oil-to-oil and oil-to-source rock correlation studies.

2.0 THEORY & METHODS

Samples are analysed according to the scheme illustrated in Figure 1 which shows the order and type of analysis for both screening and detailed tests.

2.1 Screening Analyses of Whole Rock Samples

2.1.1 Headspace/Cuttings Gas Analysis

The headspace sample is usually provided in a sealed tin can which holds both cuttings and water to approximately three quarters capacity. This allows the volatile hydrocarbons to diffuse easily into an appreciable headspace.

The gas is taken into a syringe through a silicone seal on the lid of the container and analysed by packed column gas chromatography using the following conditions:

Instrument:	Shimadzu GC-8APF
Column:	6'x 1/8" Chromosorb 102
Injector/Detector Temperature:	120°C
Column Temperature:	110°C
Carrier Gas:	Nitrogen

Cuttings gas analysis is performed in the same manner but on samples which do not liberate volatile gases readily. These sediments are subjected to very vigorous agitation prior to sampling.

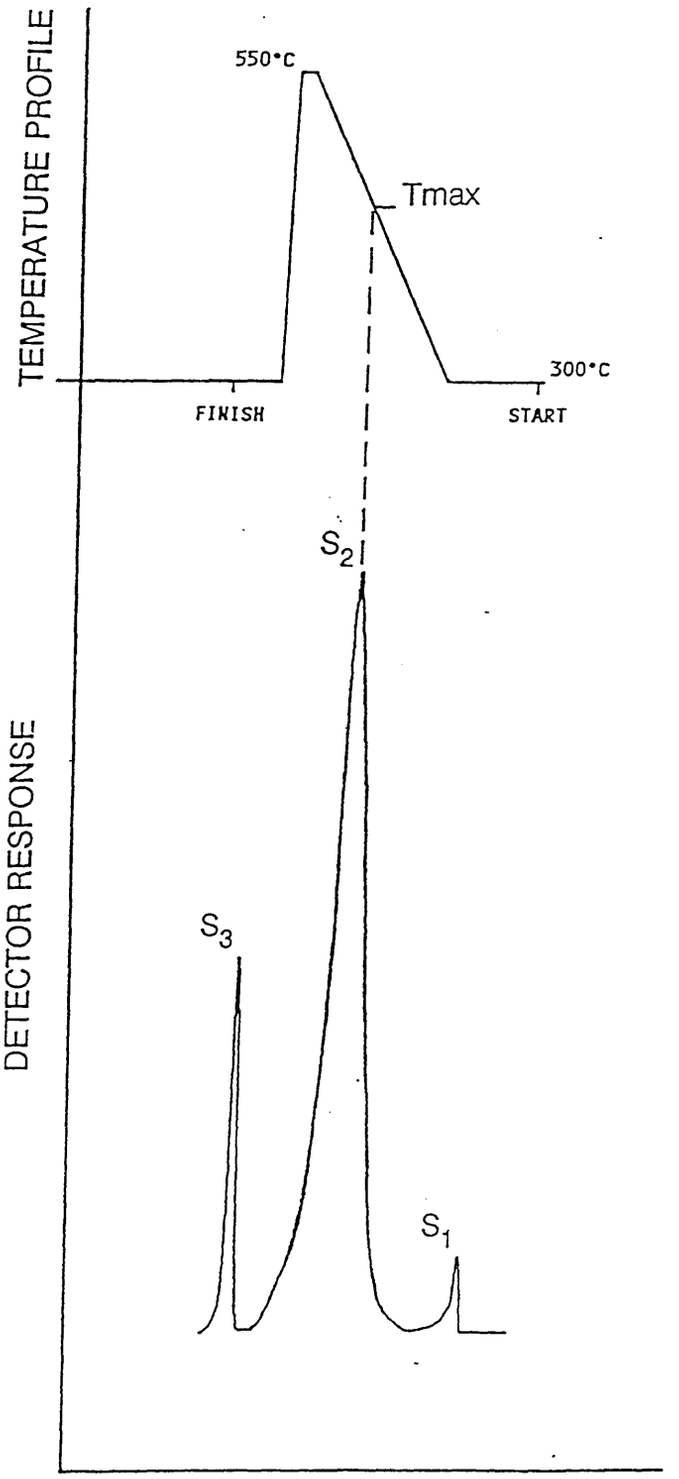
Values are given as volume of gas per million volumes of sediment (ppm) for each hydrocarbon (methane, ethane, propane, iso- and n-butane), as composite values including C5-C7, and as ratios.

Headspace/cuttings gas analyses are used as a screening technique to identify zones of significant gas generation and out-of-place gas (Letran et al, 1974). The classification for gas content is listed below:

Total gas content (C1;C2-C4; or C5-C7)	Description
10 - 100ppm	very lean - lean
100 - 1,000	lean - moderate
1,000 - 10,000	moderate - rich
10,000 - 100,000	rich - very rich

FIGURE 2

SCHEMATIC PYROGRAM OF ROCK-EVAL PYROLYSIS



The abundance of C_2–C_4 components (wet gas) is used to locate the zone of oil generation, since wet gas is commonly associated with petroleum (Fuex, 1977).

It is important to ensure that the gases analysed are not of a biogenic origin, so an anti–bacterial agent must be added to the cuttings when they are stored in water.

2.1.2 Sample Preparation

Depending on drilling mud content, cuttings samples may be water washed before they are air dried, picked free of contaminants and cavings, and then crushed to 0.1mm using a ring pulveriser.

Sidewall cores are freed of mud cake and other visible contaminants, sampled according to homogeneity, air dried and hand crushed to 0.1mm grain size.

Conventional core and outcrop samples are inspected for visible contaminants and crushed to 1/8" chips using a jaw crusher. After air drying, the chips are crushed with a ring pulveriser to small particle size (0.1mm).

Petroleum aqueous mixtures are separated into oil and water/mud fractions by decanting off the oil layer and producing a clean separation by gently centrifuging the oil. If separation by this method is not effective, the petroleum is solvent extracted.

2.1.3 Total Organic Carbon(TOC)

The TOC value is determined on crushed sediment. The minimum sample requirement is one gram, however, results may be obtained from as little as 0.2mg in very rich samples. Carbonate minerals are first removed by acid digest (HCl) and the remaining sample heated to 1700°C (Leco Induction Furnace) in an atmosphere of pure oxygen. The CO_2 produced is measured with an infra–red detector, and values calculated according to standard calibration.

TOC is expressed as % of rock and is used as a screening procedure to classify source rock richness:

Classification	Clastics	Carbonates
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

2.1.4 Rock–Eval Pyrolysis

Although a preliminary source rock classification is made using TOC data, a more accurate assessment of organic source type and maturity is possible by Rock–Eval pyrolysis. Two types of Rock–Eval analyses 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 the decarbonated sediment. The "two run" method provides more accurate S_3 values that the "one run" method. S_1 and S_2 values are of the same accuracy in both methods.

The method requires 0.4g of sample material, although reliable results can often be obtained from smaller amounts.

The crushed sediment is heated in an inert atmosphere of helium over a programmed temperature range. The resulting pyrogram is shown in Figure 2.

Hydrocarbons present in the free or adsorbed state (S_1) are thermally distilled at 300°C and measured by a flame ionisation detector (FID). Hydrocarbons are then cracked from the kerogen (S_2) during a temperature ramp from 300° to 550°C and also measured by FID. CO_2 released during the kerogen cracking process (S_3) is trapped and subsequently measured by a thermal conductivity detector.

The amount of free hydrocarbons in the sediment (S_1) represents milligrams of hydrocarbons distilled from one gram of rock and is a measure of both in situ and out–of–place petroleum.

Free hydrocarbon richness is described by the following:

S_1 (mg/g or kg/tonne)	
0.20 – 0.40	fair
0.40 – 0.80	good
0.80 – 1.60	very good
> 1.60	excellent

The total amount of hydrocarbons present in the free state and as kerogen is a measure of the potential yield (genetic potential) of the sample ($S_1 + S_2$) and is expressed as mg/g or rock.

Source rocks are classified accordingly:

$S_1 + S_2$ (mg/g)	Source Rock Quality
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

The Production Index (PI) represents the amount of petroleum generated relative to the total amount of hydrocarbons present ($S_1/S_1 + S_2$). It is a measure of the level of maturity of the sample. For oil prone sediments PI ranges from 0.1 at the onset of oil generation to 0.4 at peak oil generation. For gas prone sediments, PI shows only a small change with increasing maturity.

The temperature at which the maximum amount of S2 hydrocarbons is generated is called Tmax (Figure 2). This temperature increases with the increasing maturity of sediments.

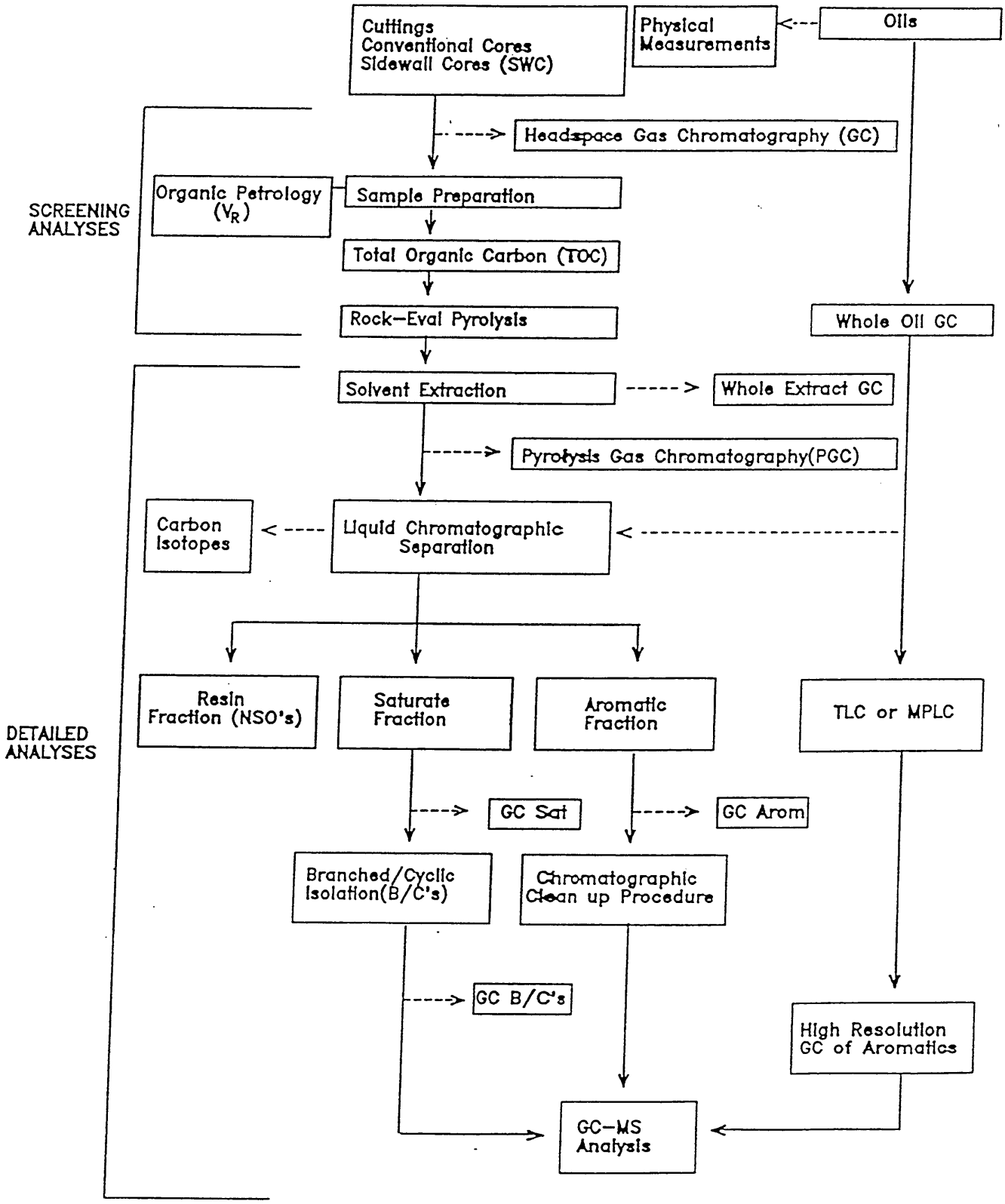
The variation of Tmax is summarised as

< 430°C	immature
430/435° – 460°C	mature (oil window)
> 460°C	overmature

Hydrogen Index (HI = S2 x 100/TOC) and Oxygen Index (OI = S3 x 100/TOC), when plotted against one another, provide information about the type of kerogen and the maturity of the sample. Both parameters decrease in value with increasing maturity. Samples with high HI and low OI are dominantly oil prone and samples with low HI and high OI are gas prone.

FIGURE 1

FLOW DIAGRAM FOR PETROLEUM GEOCHEMICAL ANALYSES



2.2 Analysis of Kerogen

2.2.1 Organic Petrology – Vitrinite Reflectance

Vitrinite is a coal maceral which responds to increasing levels of thermal maturity. This response is measured microscopically by the percent of light reflected off the polished surface of a vitrinite particle immersed in oil.

Measurement of vitrinite reflectance can be carried out on uncrushed, washed and dried cuttings (10–50gms of sample material required), sidewall cores (2–10gms), conventional cores (2–10 gms) or outcrop samples (2–10gms).

The values given are for standard lower size limits. In special cases, however, useful data may be obtained from as little as 0.1gm.

For each sample a minimum of 25 fields is measured in order to establish a range and mean for reflectance values.

Maturity classifications according to vitrinite reflectance values are:

% V_R (approx)	Maturity
0.2 – 0.55	immature
0.55 – 1.2	mature
1.2 – 1.8	overmature
> 1.8	severely altered

Following vitrinite reflectance measurements, microscopic examination in fluorescence mode allows the description of liptinite macerals and an estimate of their abundances. The amount of dispersed organic matter is reported and its composition described.

Vitrinite reflectance results and maceral descriptions are best obtained from coals or rocks deposited in environments which received large influxes of terrestrially derived organic matter. Vitrinite reflectance cannot be measured in rocks older than Devonian age, since land plants had not evolved prior to this time.

2.2.2 Pyrolysis Gas Chromatography

Pyrolysis gas chromatography (PGC) is performed on solvent extracted source rocks or isolated kerogens. The sample is pyrolysed by an SGE pyrojector which is coupled directly to a Hewlett Packard 5890 gas chromatograph. The operating conditions are:

Pyrolysis temperature:	600°C
Column:	25m x 0.22mm ID BP-1 (SGE)
Carrier gas:	helium
Oven conditions:	-20° to 280°C @ 4°/min

Data are collected and recovered using DAPA scientific software.

Pyrolysis GC allows the examination of kerogen on the molecular level and thereby a better classification of source rocks with regard to source type and generative capacity than conventional bulk pyrolysis (ie. Rock-Eval). The analytical procedure is semi quantitative (with yield related to S_2 of Rock-Eval).

Samples are characterised according to the amounts of aliphatic, aromatic and phenolic components in the kerogen. The aliphatic carbon content of a kerogen is the critical factor in determining catagenic hydrocarbon yields in the earth's crust, while the gas/oil ratio is dictated by the distribution of the various structural elements in the kerogen (Larter, 1985). Using pyrogram fingerprint data, it is possible to distinguish substantial variations between kerogens, even those of the same bulk chemical type.

A major strength of pyrolysis methods is that, while quantitative yields of kerogens are maturity related, the qualitative pyrogram fingerprints obtained are relatively rank independent over much of the oil window (Espitatlie et al, 1977; Van Graas et al, 1980; Larter, 1985). At high maturities (>1.2% V_R) characteristics for all kerogen types tend to converge (Horstfield, 1984).

Data are presented by percentage and mg/g of individual substances as well as groups of compounds.

Significant parameters are:

$(C_1 - C_5)/C_6$ + abundance	gas/oil ratio
$C_9 - C_{31}$ (alkenes + alkanes)	oil yield
Type Index R:	aromaticity

(Larter & Douglas 1979, Larter and Senftle, 1985).

2.3 Detailed Analyses of Petroleum Fluids

2.3.1 Solvent Extraction of Sediment

The finely crushed sample (up to 100g) is extracted with dichloromethane (300mL) using sonic vibration. After Buchner flask filtration, the filtrate is re-vibrated with activated copper powder (1g) to remove elemental sulphur. The extractable organic matter (EOM) is afforded by further filtration and fractional distillation of the solvent.

Source rock richness based upon EOM is classified accordingly:

Yield	ppm
Poor	< 500
Fair/Good	500 - 2000
Very Good	2000 - 4000
Excellent	>4000

2.3.2 Liquid Chromatography Separation

Sediment extracts, crude oil and condensate samples are separated into fractions corresponding to three structural types:

saturated hydrocarbons	(SAT)
aromatic hydrocarbons	(AROM)
resins plus ashphaltenes	(NSO)

This separation is achieved by liquid column chromatography using activated silicic acid adsorbent and eluting solvents of varying polarity. Saturated, aromatic

and NSO concentrates are recovered by fractional distillation/evaporation of the solvent and quantitative transfer to a small vial.

The amount of hydrocarbons (SAT plus AROM) can be used to classify source rock richness and the amount of saturates to classify oil source potential, according to the following criteria:

Classification	ppm HC	ppm SAT
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 increasing 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.

Specific ratios are measured from solvent extraction and liquid chromatography data which give an indication of source type and maturity. EOM (mg)/TOC(g) can be used as a maturation indicator when plotted against depth for a given sedimentary sequence. Generally an EOM/TOC value of >100 indicates high maturity. If such a sample has a SAT (mg)/TOC(g) ratio <20, it is likely that the organic matter is gas prone. A value for SAT (mg)/TOC (g) >40 suggests an oil prone source type.

2.2.2 Capillary Gas Chromatography (GC)

C_{12+} gas chromatography is most commonly carried out on saturate fractions, but in certain instances it is used to examine whole extracts/oils, aromatic or branched/cyclic fractions. It is also used as a tool to identify contamination. The analyses are performed under the following conditions:

Instruments:	Hewlett Packard 5890 Gas Chromatography
Injector:	SGE 0CI–3 on column
Column:	25m x 0.2mm ID BP–1
Injector Temp:	280°C
Detector Temp:	320°C
Column Temp:	45°C to 280°C at 4°/min
Carrier Gas:	hydrogen

Data are collected using an IBM compatible PC and DAPA scientific software.

2.3.3.1 C12+ Saturate Gas Chromatography

Saturate GC results provide information pertaining to source type, maturity and depositional environment.

The n–alkane distribution from n–C12 to n–C31 is determined from the area under the peaks representing each of these n–alkanes. The profile can yield information about maturity and source type and is quantified in the C21 + C22/C28 + C29 ratio and Carbon Preference Indices (CPI 1 and 2).

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

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

- carbon preference indices are approximately 1 for marine samples, regardless of maturity
- decrease from 20--> 1 for terrestrial samples as maturity increases

The C21 + C22/C28 + C29 ratio is generally >1.5 for aquatic source material and <1.2 for terrestrial organic matter, however, the values increase with maturity.

Pristane/phytane (Pr/Ph) ratios can indicate depositional environments:

- <3.0 – relatively reducing depositional environments;
- 3.0–4.5 – mixed (reducing/oxidising) environments;
- >4.5 – relatively oxidising depositional environments.

2.3.3.2 C1 – C31 Whole Oil Gas Chromatography

This analytical method is applied to oil and condensate samples. It provides a picture of the whole oil up to n–C31 and allows quantitation of components with more than 4 carbon atoms. Several parameters are measured which illustrate

changes in the degree of biodegradation and water washing in the reservoir. Because these measurements are performed on very volatile components in the oil, care should be taken during sampling, transportation and storage of the fluid to minimise evaporation.

Whole oil analytical conditions are listed below:

Instrument:	Shimadzu GC-9A
Column:	25m x 0.2mm ID BP-1
Injector/Detector Temperature:	290°C
Column Temperature:	-20°C to 280°C at 4°/min
Carrier Gas:	hydrogen

2.3.4 Carbon Isotope Analysis

This measurement is normally carried out on one or more of the following mixtures: topped oil, saturate fraction, aromatic fraction, NSO fraction. The organic matter is combusted in oxygen to produce carbon dioxide which is purified and transferred to an isotope mass spectrometer. The carbon isotope ratio ($\delta C13/\delta C12$) is measured and compared to an international standard (the Peedee Belemnite Limestone - PDB).

Carbon isotope analysis is most commonly used to identify the source of methane according to the following criteria (Fuex 1977):

$\delta^{13}C$ ‰ PDB

-75 to -55	Biogenic methane
-58 to -40	Methane associated with oil
-40 to -25	Thermal methane

Source rock-crude oil correlations have been attempted by observing the change in $\delta^{13}C$ values of components of oils and rocks (Stahl 1977). Source rock extracts are usually isotopically heavier than the corresponding crude oil but are lighter than the asphaltenes of the oil and the kerogen of the rock (Hunt 1979). It has also been observed that marine organic carbon is generally isotopically heavier than contemporaneous terrestrial organic carbon (Tissot & Welte 1978). However, it should be noted that increasing maturity and biodegradation produce a shift toward heavier isotope values.

2.3.5 Gas Chromatography – Mass Spectrometry (GC/MS)

GC/MS analysis is normally performed on the branched and cyclic alkane fraction and/or the aromatic fraction of oils, condensates and sediment extracts. The specific fraction is first isolated and then injected into a gas chromatograph which is linked in series with a mass spectrometer. As compounds are eluted from the chromatography column they are bombarded with high energy electrons. This causes them to fragment into a number of ions each with a molecular weight less than that of the parent molecule. Individual compounds give a characteristic fragmentation pattern (mass spectrum), the major ions of which are presented in a series of mass fragmentograms [ie. plots of ion concentration against GC retention time].

GC/MS analysis can be carried out using one of the following modes of operation:

(i) Acquire mode – in which all ions (within a broad range) 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.

2.3.5.1 GC/MS Analysis of Branched/Cyclic Alkanes

The group of compounds to be analysed is first isolated from the saturate fraction by refluxing the sample with activated 5Å molecular sieves in cyclohexane for 24 hours. Branched/ cyclic alkanes, including alkylcyclohexanes, are recovered from the solvent by fractional distillation.

For condensates, and samples where information about alkylcyclochexanes is not required, the saturate fraction is passed through a small column packed with _____? adsorbent. The branched/cyclic alkanes are recovered from the eluting solvent by fractional distillation.

Analysis is carried out in the SIM mode with a total of 33 ions being recorded over different time spans.

Operating conditions are:

Instrument:	5987HP GC mass spec data system
Column:	60m x 0.25mm ID cross linked methyl–silicone DB–1 (J&W) column of 0.25 micron film thickness connected directly to the ion source
Injector:	OCI–3(SGE)
Carrier gas:	hydrogen
Oven Conditions:	50° to 274°C at 8° /min 274° to 280°C at 1° /min
EM Voltage:	2,000 – 2,300V
Electron Energy:	70eV
Source temperature:	250°C

GC/MS mass fragmentograms are examined for particular 'biomarker' compounds which can be related to biological precursors. These allow the characterisation of petroleum with regard to thermal maturity, source, depositional environment and biodegradation.

The significance of selected parameters from branched/cyclic GC/MS analysis is outlined below:

1. 18α (H)–hopane/17α (H)–hopane (Ts/Tm)

Maturity indicator. The ratio of 18α (H) trisnorhopane to 17α (H) trisnorhopane increases exponentially with increasing maturity from approximately 0.2 at the onset to approximately 1.0 at the peak of oil generation, ie. Tm decreases with maturity. This parameter is not reliable in very immature samples.

2. C30 hopane/C30 moretane

Maturity indicator. The conversion of C30 17β, 21β hopane to 17β, 21α moretane is maturity dependent. Values increase from approximately 2.5 at the onset of oil generation to approximately 10. Once the hopane/moretane ratio has reached 10, no further changes occur. A value of 10 is believed to represent a maturity stage just after the onset of oil generation and hopane/moretane ratios are therefore useful mainly as indicators of immaturity in a qualitative sense.

3&4. C_{31} and C_{32} 22S/22R hopanes

Maturity indicator. An equilibrium between the biological R– and the geological S– configuration occurs on mild thermal maturation. A ratio of S:R = 60:40, ie, a value of 1.5, characterises this equilibrium which occurs before the onset of oil generation. The C_{32} hopane pair is often more reliable for this purpose since co-elution sometimes affects the C_{31} ratio.

5. C_{29}20S *ααα*/C_{29}20R *ααα* steranes

Maturity indicator. Upon maturation, the biologically produced 20R sterioisomer is diminished relative to the 20S form and a stabilisation is reached at approximately 55% 20R and 45% 20S compounds. VR equivalents are approximately 0.45% for a 20S/20R value of 0.2 and 0.8% for a 20S/20R value of 0.75. This parameter is most useful between maturity ranges equivalent to 0.4% to 1.0 VR.

6. C_{29}20S *ααα*/C_{29}20R *ααα* + C_{29}20S *ααα* steranes

Maturity indicator. This ratio is a different way of expressing the relative abundance of the biological 20R to the geological 20S normal sterane (see parameter 5). Expressed as a percentage, a value of about 25% indicates the onset of oil generation, and of about 50% the peak of oil generation.

7. C_{29} *αββ*/C_{29}*ααα* + C_{29} *αββ* steranes

Maturity indicator. The *αα* form is produced biologically. Its abundance diminishes upon maturation until a mixture of 65% *ββ* (iso) steranes and 35% *αα* (normal) steranes is reached, which is equivalent to approximately 0.9% VR.

8&9. C_{27}/C_{29} diasteranes and steranes

Source indicator. It has been suggested that marine phytoplankton is characterised by a dominance of C_{27} steranes and diasteranes whereas a preponderance of C_{29} compounds indicates strong terrestrial contributions. Values smaller than 0.85 for C_{27}/C_{29} diasterane and sterane ratios are believed to be indicative for terrestrial organic matter, values between 0.85 and 1.43 for mixed organic material, and values greater than 1.43 for an input of predominantly marine organic matter.

It has been suggested, however, that marine sediments can also contain a predominance of C_{29} steranes, so the above rules have to be applied with caution. Any simplistic interpretation of C_{27}/C_{29} steranes and diasteranes can be dangerous

and the interpretation of these data should be consistent with other geological evidence.

10. 18α (H) – oleanane/C30 hopane

Source indicator. Oleanane is a triterpenoid compound which has often been reported from deltaic sediments of Late Cretaceous to Tertiary age. It is thought to be derived from certain angiosperms which developed in the late Cretaceous. If the 18α (H) – oleanane/C30 hopane ratio is below 10, no significant proportions of oleanane are present. At higher values, it can be used as indicator for a reducing environment during deposition of land plant–derived organic matter.

11. C29 diasteranes/C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes

Source indicator. This parameter is used to characterise the oxidity of depositional environments. High values (up to 10) indicate oxic conditions, low values (down to 0.1) indicate reducing environments.

12. C30 (hopanes + moretanes)/C29 (steranes + diasteranes)

Source indicator. Triterpanes are believed to be of prokariotic (bacterial) origin, whereas steranes are derived from eukariotic organisms. This ratio reflects the preservation of primary organic matter derived from eukariots, relative to growth and preservation of bacteria in the sediment after deposition.

13. C15 drimane/C16 homodrimane

Drimanes and homodrimanes are ubiquitous compounds most likely derived from microbial activity in sediments. The C15 drimane/C16 homodrimane ratio is a useful parameter for correlation purposes in the low molecular weight region, especially for condensates which lack most conventional biomarkers. Drimanes are also useful to assess the degree of biodegradation as the removal of C15 to C16 bicyclics characterises an extensive level of biodegradation.

14. Rearranged/normal drimanes

Like parameter 13, this ratio can be used for correlation purposes in samples without conventional biomarkers, and to assess levels of biodegradation.

2.3.5.2 GC/MS Analysis of Aromatics

The aromatic fraction or the oil to be analysed is first subjected to thin laye chromatography (TLC) or medium pressure liquid chromatography (MPLC) depending upon the analytical requirements.

1. Di- and tri- nuclear aromatic compounds are isolated by TLC. To effec this separation, the sample is applied to an alumina coated glass plat (0.6mm thickness). The plate is developed with hexane and the requirec band located using short wavelength UV light. The fraction is recovered by extraction and fractional distillation.

   This aromatic fraction may be analysed by GC-FID, but GC/MS is recommended because of possible co-elution problems during GC.

   Samples are analysed by GC/MS in the acquire mode scanning from 50 to 450 atomic mass units (amu).

Analytical conditions are:

Instrument:	HP5970 MSD
Column:	60m x 0.25mm ID, 0.25 micron film thickness, 5% phenylmethyl silicone column DB-5 (J&W) connected directly to the ion source
Injector:	automatic on-column
Carrier Gas:	helium
Oven Conditions:	70°C for 1 min 70°C --> 300°C at 3°/min
Data collection commences at 10 mins	
Mass spectrometry	
Em Voltage	1500 - 1800V
Electron Energy	70eV

Mass fragmentograms are presented for alkylbiphenyls, alkylnaphthalenes, alkylfluorenes and alkylphenanthrenes from a comprehensive data base. Aromatic compounds provide valuable information concerning thermal maturity since they can be applied outside the dynamic range of saturate biomarker indicators and are particularly useful when conventional biomarkers are present in low amounts (Radke & Welte, 1983; Alexander et al, 1985). Maturity ratios are tabled below:

Aromatic Maturity Indicators

Abbrev.	Definition	Range oil onset	Range Wet gas
DNR 1	(2,6DMN, + 2,7DMN)/1,5DMN	1.5	10
DNR 2	2,7DMN/1,8DMN	50	2500
DNR 5	1,5DMN/1,8DMN	50	>3000
DNR 6	(2,6DMN + 2,7DMN)/(1,4DMN + 2,3 DMN)	0.8	2
TNR 1	(1,4,6TMN + 1,3,5TMN)/2,3,6TMN	0.5	4
MPR 1	(2MP + 3MP)/1MP	1.5	3
MPI 1	1.5 x (2MP + 3MP)/(PH + 1MP + 9MP)	0.3	1
MPI 2	(3 x 2MP)/(PH + 1MP + 9MP)	0.3	2
Rc(a)	0.6(MPI–1) + 0.4 (for % Rm <1.35)		
Rc(b)	–0.6(MPI–1) + 2.3 (for % Rm ≥1.35)		

(from Radke et al, 1982; Radke & Welte, 1983; Alexander et al, 1985)

Some aromatic marker compounds have specific natural product precursors and can be used as signatures for sediments of a particular source, depositional environment or geological age:

TNR 5 1,2,5TMN/1,3,6TMN

TNR 6 1,2,7TMN/1,3,7TMN (Strachen et al, 1988)

1,7/X 1,7DMP/(1,3 + 3,9 + 2,10 + 3,10 DMP)

Retene/9MP

1MP/9MP (Alexander et al, 1988)

2. Mono- and triaromatic steranes are analysed by GC/MS under the same analytical conditions as used for di- and tri-nuclear aromatics. However, isolation of this fraction is performed by MPLC. To achieve this, the saturate plus aromatic mixture is injected onto a Merck Si60 column. The separation is monitored with a refractive index detector for saturates and a UV absorbance detector for aromatics.

As aromatic steranes are generally present in low abundances, especially in oils, samples are analysed in the SIM mode and 16 ions are recorded.

The conversion of monoaromatic steranes to triaromatic steranes and the dimethylation of triaromatic steranes in sediments are considered to be maturity dependent (Mackenzie et al, 1981; Mackenzie, 1984). The triaromatic sterane maturity indicator should, however, not be applied to crude oils because migration effects appear to selectively deplete the triaromatic steranes.

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