U-676 .3

BP RESEARCH

Sunbury Research Centre

Copy No. 1

EXPLORATION AND PRODUCTION DIVISION

EXPLORATION TECHNOLOGY
BRANCH

ETB/91P/91

DECEMBER 1991

GEOCHEMISTRY OF HYDROCARBONS FROM WELL 2/1-9, GYDA FIELD, OFFSHORE NORWAY

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Work By
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Sponsored by:

XEU

Approved by:

R A Sedivy

1. INTRODUCTION

This report presents the geochemical characterisation of an oil and gas sample from well 2/1-9, DST-1, offshore Norway.

The crude oil was topped at 200°C. The residue (>200°C) was analysed by HPLC, GC and high resolution GCMS. Stable carbon isotope ratios were determined on the total oil, saturate, aromatic, residue and asphaltene fractions. The distillate (<200°C) was analysed by GC for its light hydrocarbon distribution. Inspection properties were determined on the whole oil.

The gas sample was analysed by GC for its composition and stable carbon isotope ratios were determined for its component carbon-species gases.

TABLE 1

OIL ANALYSIS

SAMPLE 2/1-9
DST No.1

SAMPLE TYPE	CRUDE
LOCATION	OFFSHORE NORWAY
DRILL STEM TEST	DST-1

API GRAVITY @ 15 deg C	41.3
DENSITY @ 15 deg C	0.8184
WAX % wt	6.5
WAX MPT deg C	51
POUR POINT	
ASPHALTENES %wt	0.2
SULPHUR %wt	0.1
NITROGEN ppm	320
NICKEL ppm	<2
VANADIUM ppm	<2
KINEMATIC VISCOSITY cST @ 20deg C	
n-ALKANE CPI	1.02
PRISTANE/PHYTANE	1.29
PR/nC17	0.50
PH/nC18	0.44
R22	1.00
ALKANE INDEX	74

TYPE ANALYSIS BY HPLC ON DE-ASPHALTENED RESIDUE >200 C

SATURATES %wt	84.6
AROMATICS %wt	15.0
RESIDUE %wt	0.4

CARBON ISOTOPE RATIOS per mil

TOTAL OIL	-28.5
ASPHALTENES	
SATURATES	-28.7
AROMATICS	-28.5
RESIDUE	
STANDARD NBS 22	-29.8

LIGHT HYDROCARBONS

MCH %	38
HER	0.41
HXR	0.55

BIOMARKER RATIOS

H1	0.41	S1	0.73	A1	
H2	0.46	S2	0.61	A2	
H3	0.84	S3	47:34:18	A3	
H4	ABS	S4	32:34:33	A4	
H5		S5	39.2	A5	
H6	0.57	S6		A6	
H7	0.35	S7	72		
H10		S8	42		
H11	21	S9		M2	1.16
H12	19	S10		M3	1.03
H13				M4	
H14	53				
H15	21			MDR	8.47
H16				MBP	14.52
H17					

QUANTITATIVE ANALYSIS

SATURATE FRACTION	QSNALK	98124	ppm
	QSNC20	5617	ppm
	QSC29ST		ppm
	QSC30HO		ppm
	QSC32HO		ppm
AROMATIC FRACTION	QAMONAR		ppm
	QATRIAR		ppm
	QAMEPH		ppm

CODING LISTS FOR BIOMARKERS CAN BE FOUND AT THE BACK OF THIS REPORT

TABLE 2

GAS ANALYSIS RESULTS

WELL: 2/1-9

Component	% mol	Del 13C per mil
CH4	56.20	-46.90
C2H6	18.50	-31.80
C3H8	12.20	-29.20
iso-C4H10	6.50	
n-C4H10		-29.40
iso-C5H12	2.60	
n-C5H12		
C6		
CO2	2.60	-6.40
N2	1.40	
O2		
C1/C1-C5	0.590	

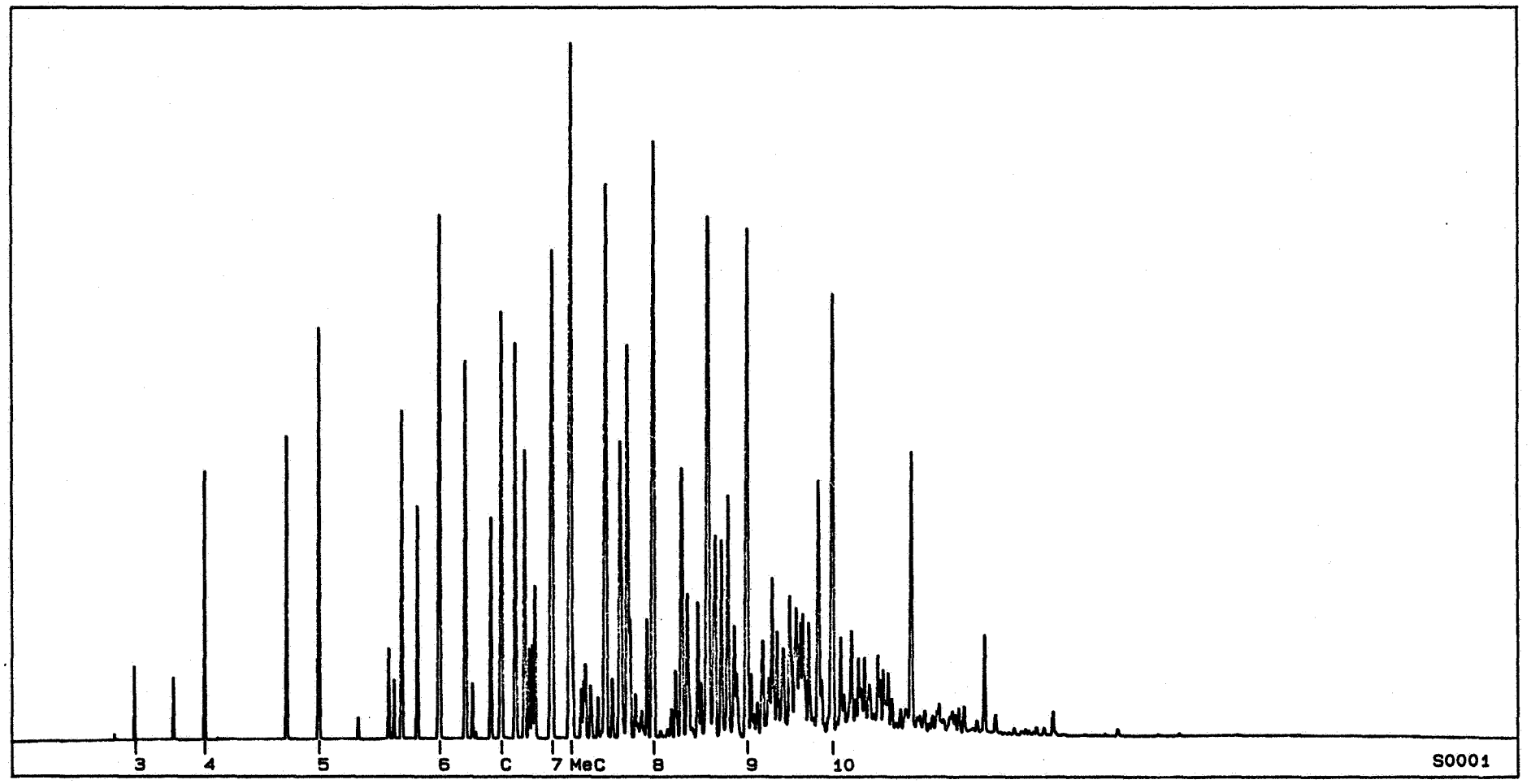

Figure 1

2/1-9 (CRU) DST-1

LIGHT HYDROCARBON DISTRIBUTION

ETB ref. 91080IL002

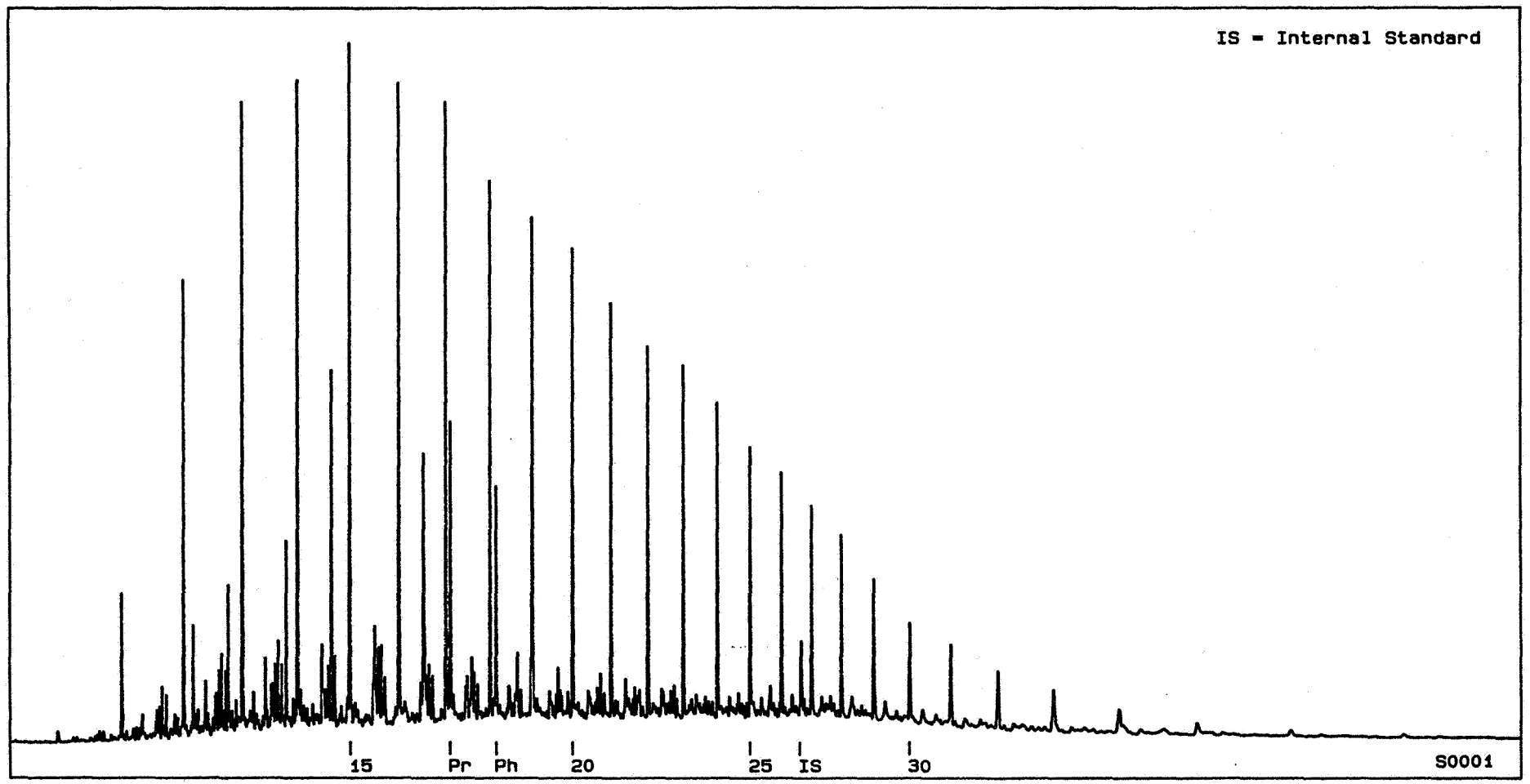

Figure 2

2/1-9 (CRU) DST-1

SAC FRACTION CHROMATOGRAMS

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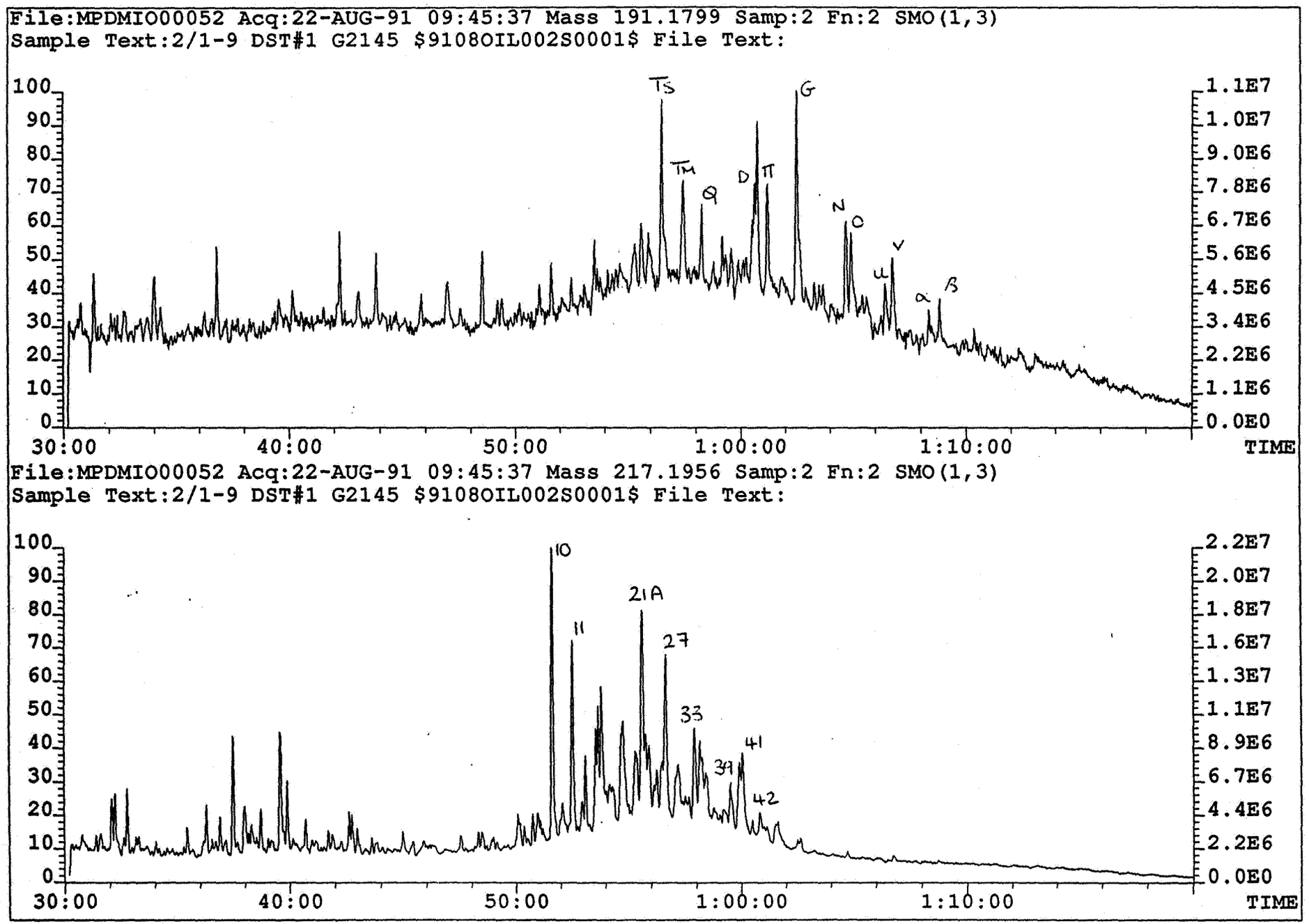
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6.7E6
5.6E6
4.5E6
3.4E6
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1:10:00
TIME
Ts
Tm
Q
D
π
G
N
O
V
α
β
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70
60
50
40
30
20
10
0
2.2E7
2.0E7
1.8E7
1.6E7
1.3E7
1.1E7
8.9E6
6.7E6
4.4E6
2.2E6
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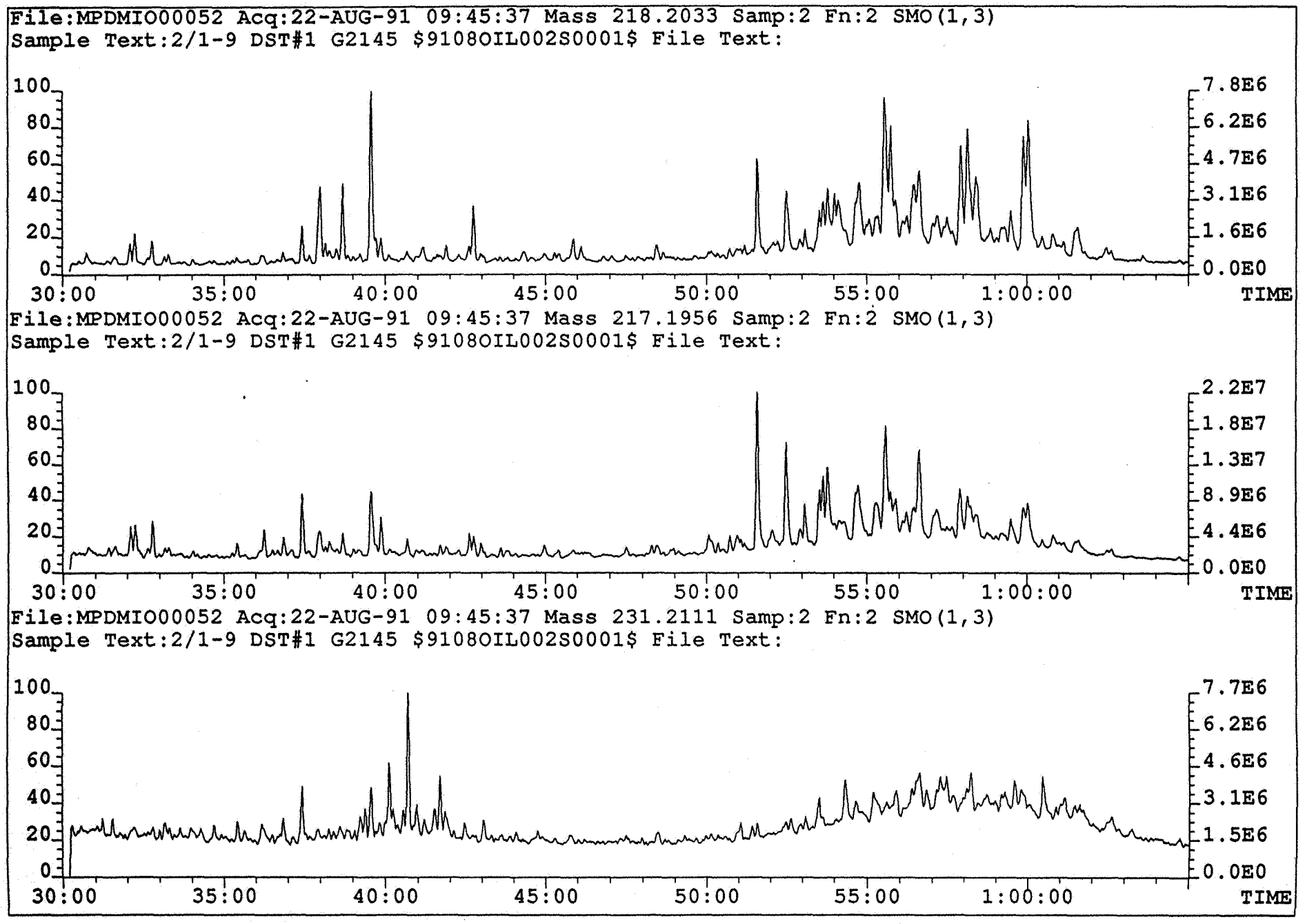
TIME
10
11
21A
27
33
37
41
42

Figure 3.1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20
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7.8E6
6.2E6
4.7E6
3.1E6
1.6E6
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35:00
40:00
45:00
50:00
55:00
1:00:00
TIME
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40
20
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2.2E7
1.8E7
1.3E7
8.9E6
4.4E6
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35:00
40:00
45:00
50:00
55:00
1:00:00
TIME
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80
60
40
20
0
7.7E6
6.2E6
4.6E6
3.1E6
1.5E6
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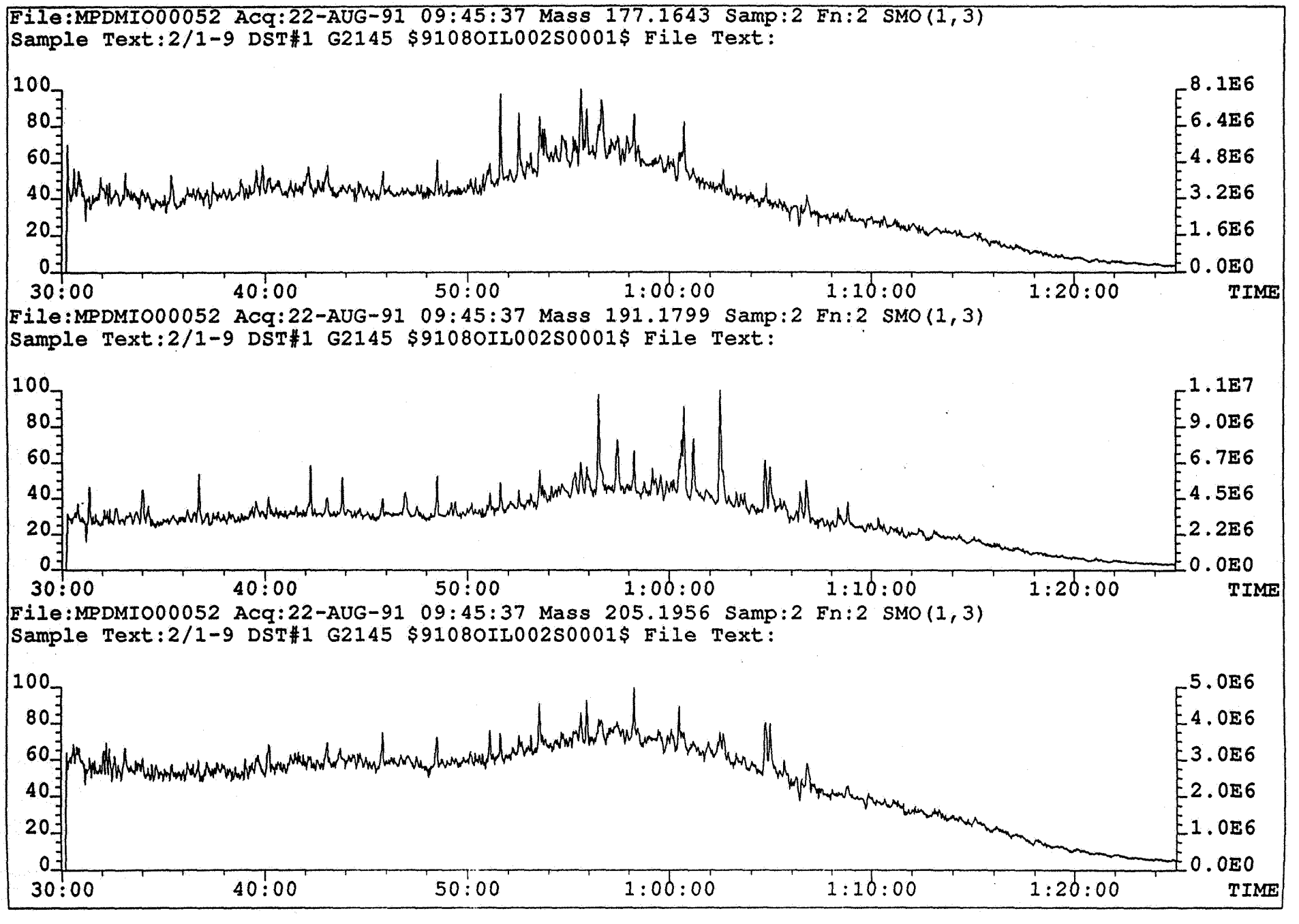
30:00
35:00
40:00
45:00
50:00
55:00
1:00:00
TIME

Figure 3.2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60
40
20
0
8.1E6
6.4E6
4.8E6
3.2E6
1.6E6
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40:00
50:00
1:00:00
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TIME
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60
40
20
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9.0E6
6.7E6
4.5E6
2.2E6
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40:00
50:00
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TIME
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4.0E6
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TIME

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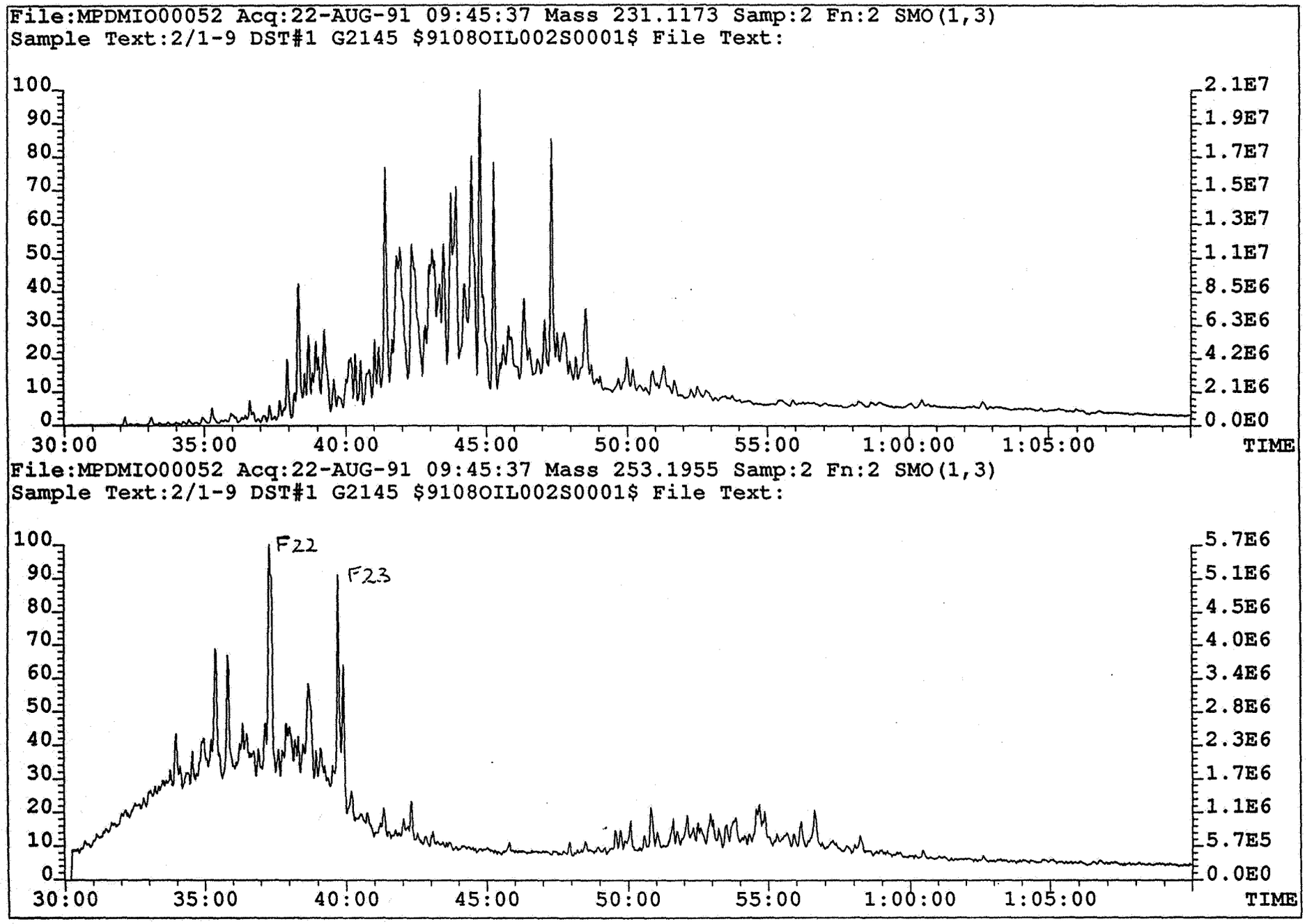
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60
50
40
30
20
10
0
2.1E7
1.9E7
1.7E7
1.5E7
1.3E7
1.1E7
8.5E6
6.3E6
4.2E6
2.1E6
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35:00
40:00
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F23
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70
60
50
40
30
20
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5.1E6
4.5E6
4.0E6
3.4E6
2.8E6
2.3E6
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5.7E5
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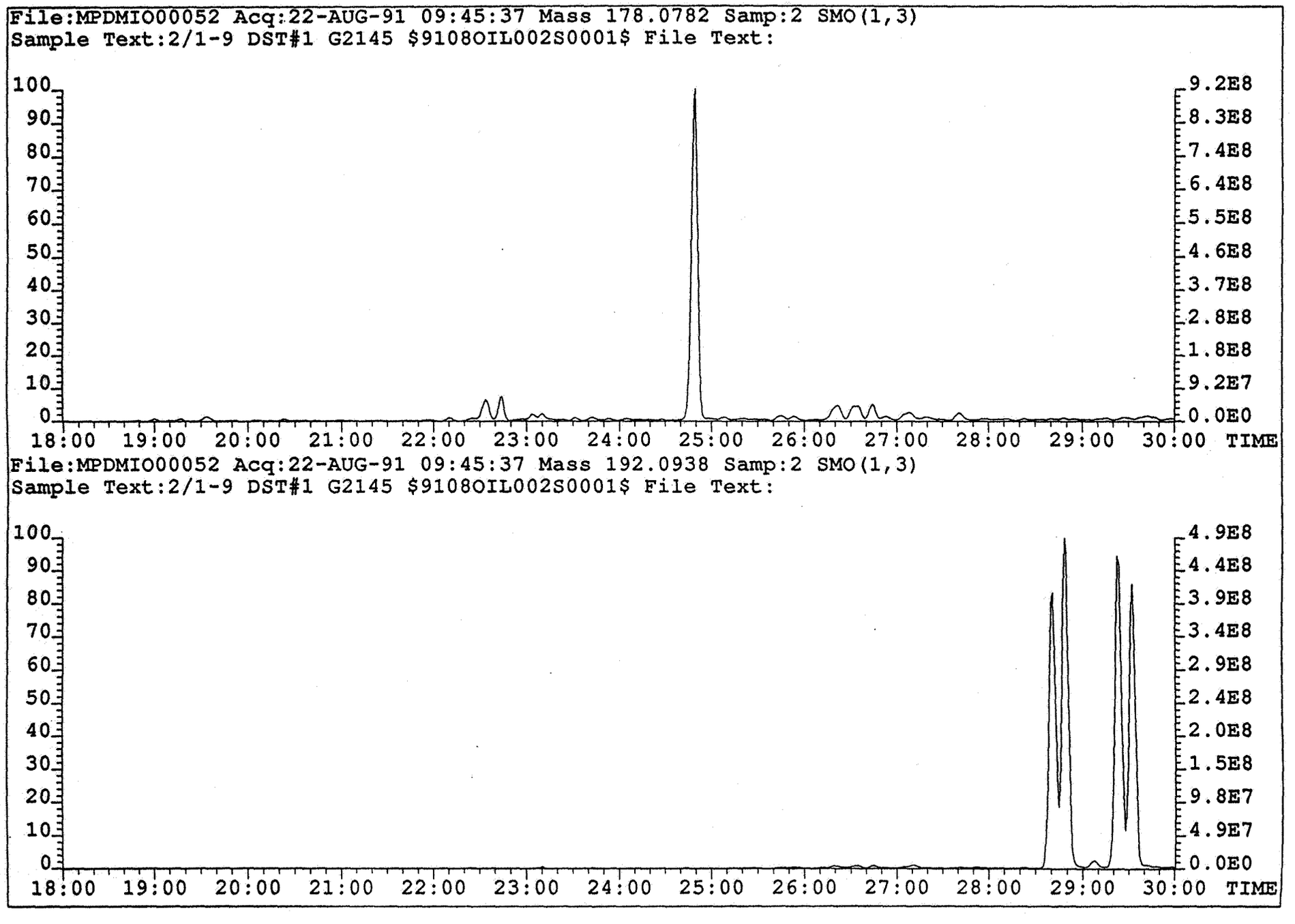
TIME

Figure 3.4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30
20
10
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8.3E8
7.4E8
6.4E8
5.5E8
4.6E8
3.7E8
2.8E8
1.8E8
9.2E7
0.0E0
18:00 19:00 20:00 21:00 22:00 23:00 24:00 25:00 26:00 27:00 28:00 29:00 30:00 TIME
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80
70
60
50
40
30
20
10
0
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4.4E8
3.9E8
3.4E8
2.9E8
2.4E8
2.0E8
1.5E8
9.8E7
4.9E7
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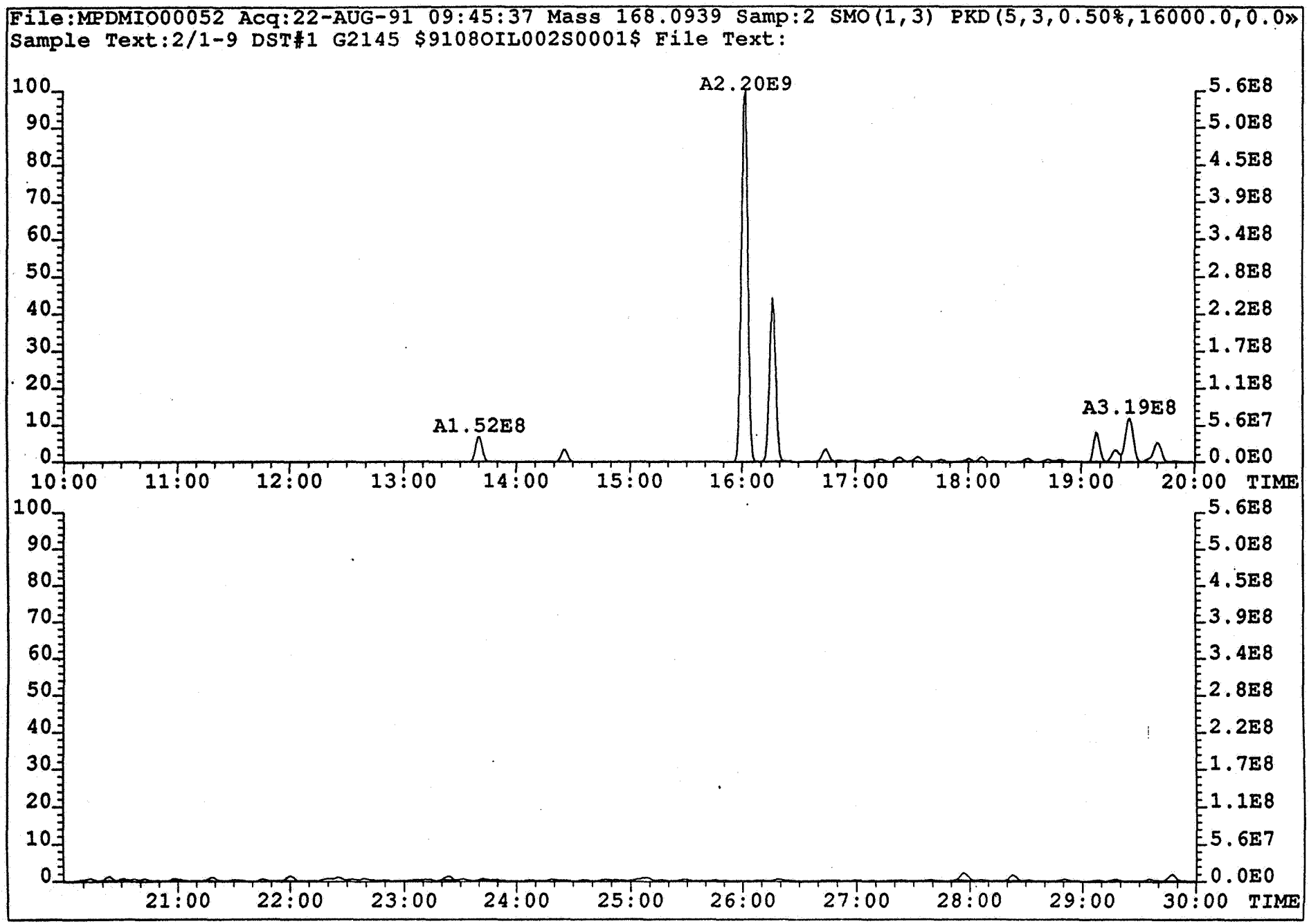
Figure 3.5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4.5E8
3.9E8
3.4E8
2.8E8
2.2E8
1.7E8
1.1E8
5.6E7
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TIME
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22:00
23:00
24:00
25:00
26:00
27:00
28:00
29:00
30:00
TIME

Figure 3.6

MOLECULAR PARAMETER LIST

BP CODE	PARAMETER	USE
H1	C_{32} HOPANE 22S/(22S+22R)	M
H2	C_{31} HOPANE 22S/(22S+22R)	M
H3	C_{30} HOPANE/(C_{30} HOPANE+C_{30} MORETANE)	MS
H4	$\beta\,\beta$ HOPANES PRESENT/ABSENT	M
H5	C_{30}:C_{31}:C_{32}:C_{33}:C_{34}:C_{35} HOPANE DISTRIBUTION	S
H6	C_{27} HOPANES $T_s/(T_s+T_m)$	MS
H7	C_{33} HOPANE 22S/(22S+22R)	M
H8	C_{34} HOPANE 22S/(22S+22R)	M
H9	C_{35} HOPANE 22S/(22S+22R)	M
H10	RESIN DITERPANES % RELATIVE TO C_{30} HOPANE (PEAK G)	S
H11	C_{23} EXT TRICYCLIC TERPANE % RELATIVE TO C_{30} HOPANE (PEAK G)	S
H12	C_{24} TETRACYCLIC TERPANE % RELATIVE TO C_{30} HOPANE (PEAK G)	S
H13	28,30 BISNORHOPANE (PEAK X) % RELATIVE TO C_{30} HOPANE (PEAK G)	S
H14	PENTACYCLANE II % RELATIVE TO C_{30} HOPANE (PEAK G)	S
H15	OLEANANE % RELATIVE TO C_{30} HOPANE (PEAK G)	S
H16	GAMMACERANE % RELATIVE TO (PEAK G)	S
H17	HOPANES $C_{35}/(C_{34}+C_{35})$ %	S
S1	C_{29} $\alpha\alpha\alpha$ STERANES 20S/(20S+20R)	M
S2	C_{29} STERANES $\alpha\beta\beta/(\alpha\beta\beta+\alpha\alpha\alpha)$	M
S3	STERANES $\alpha\alpha\alpha$ C_{27}:C_{28}:C_{29}	S
S4	STERANES $\alpha\beta\beta$ C_{27}:C_{28}:C_{29}	S
S5	$\beta\alpha$ DIASTERANES/(SAME+$\alpha\alpha\alpha$+$\alpha\beta\beta$ STERANES) %	SM
S6	LOW MOLECULAR WEIGHT STERANES RELATIVE TO C_{29} STERANES	S
S7	STERANE INDEX $C_{27}/(C_{27}+C_{29})$ % (FROM S3)	S
S8	4-ME C_{30} STERANE % RELATIVE TO C_{29} 20R $\alpha\alpha\alpha$ STERANE (PEAK 42)	S
S9	4-ME STERANES INDEX $C_{28}/(C_{28}+C_{30})$ %	S
S10	BICADINANES PRESENT/ABSENT	S
A1	C_{28} 20R TRIAROM. STERANE/(SAME+C_{29} 20R MONOAROM. STERANE)	M
A2	SUM TRIAROM. STERANES/(SAME+SUM MONOAROM. STERANES)	M
A3	C_{20} TRIAROM. STERANE/(SAME+C_{28} 20R TRIAROM. STERANE)	M
A4	C_{20}+C_{21} TRIAROM. STERANE/(SAME+SUM C_{26}-C_{28} TRIAROM. STERANES)	M
A5	C_{26} 20S TRIAROM. STERANE/C_{28} 20S TRIAROM. STERANE	S
A6	C_{27} 20R TRIAROM. STERANE/C_{28} 20R TRIAROM. STERANE	S
M2	PHENANTHRENES (3ME+2ME)/(9ME+1ME)	M
M3	MPI [(3ME+2ME)/(PHENANTHRENE+9ME+1ME)] * 1.5	M
M4	SUM C_{27}-C_{35} HOPANES/(SAME+ SUM C_{27}-C_{29} STERANES) %	S
ALKIND	ALKANE INDEX n-C_{17}/(n-C_{17}+n-C_{27}) %	S
R22	R22 INDEX (2 * n-C_{22})/(n-C_{21}+n-C_{23})	SM

NOTES:

1. S=SOURCE PARAMETER, M=MATURITY PARAMETER.

2. TRIAROM. STERANE=MONOMETHYL TRIAROMATIC STERANES
   MONOAROM. STERANE=DIMETHYL MONOAROMATIC STERANES.

(5/6/89)

BIOMARKER IDENTIFICATION - PENTACYCLIC HYDROCARBONS

BP CODE	TENTATIVE ASSIGNMENT BASED ON MASS SPECTROMETRY (m/e 191)
I	9-DODECYLPERHYDROANTHRACENE [INTERNAL STANDARD]
T_s	18α(H)-22,29,30-TRISNORNEOHOPANE
T_m	17α(H)-22,29,30-TRISNORHOPANE
θ	17α(H)-29,30-BISNORHOPANE
Q	17β(H)-22,29,30-TRISNORHOPANE
W	17α(H)-25,30-BISNORHOPANE
X	17α(H),18α(H),21β(H)-28,30-BISNORHOPANE
Y	17α(H)-25-NORHOPANE
D	17α(H),21β(H)-30-NORHOPANE
D2	18α(H)-30-NORNEOHOPANE
π	17α(H),15α(Me)-27-NORHOPANE ("DIAHOPANE")
A	17β(H),21α(H)-30-NORMORETANE
B	18α(H)-OLEANANE
G	17α(H),21β(H)-HOPANE
φ	17α(H)-30NOR-29-METHYLHOPANE
H	17β(H),21β(H)-30-NORHOPANE
K	17β(H),21α(H)-MORETANE
N	(22S)-17α(H),21β(H)-30-METHYLHOPANE
O	(22R)-17α(H),21β(H)-30-METHYLHOPANE
S	GAMMACERANE
P	17β(H),21β(H)-HOPANE
R	17β(H),21α(H)-30-METHYLMORETANE
U	(22S)-17α(H),21β(H)-30-ETHYLHOPANE
V	(22R)-17α(H),21β(H)-30-ETHYLHOPANE
J	17β(H),21β(H)-METHYLHOPANE
α	(22S)-17α(H),21β(H)-30-n-PROPYLHOPANE
β	(22R)-17α(H),21β(H)-30-n-PROPYLHOPANE
L	17β(H),21β(H)-ETHYLHOPANE
γ	(22S)-17α(H),21β(H)-30-n-BUTYLHOPANE
δ	(22R)-17α(H),21β(H)-30-n-BUTYLHOPANE
ε	(22S)-17α(H),21β(H)-30-n-PENTYLHOPANE
ζ	(22R)-17α(H),21β(H)-30-n-PENTYLHOPANE

BIOMARKER IDENTIFICATION - STERANES

BP CODE	TENTATIVE ASSIGNMENT BASED ON MASS SPECTROMETRY (m/e 217)
10	(20S)-13β(H),17α(H)-DIACHOLESTANE
11	(20R)-13β(H),17α(H)-DIACHOLESTANE
13	(20S)-13α(H),17β(H)-DIACHOLESTANE
14	(20R)-13α(H),17β(H)-DIACHOLESTANE
15	(24S/R)-(20S)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
16	(24S/R)-(20S)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
18	(24S/R)-(20R)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
19	(24R/S)-(20R)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
20A	(24S/R)-(20S)-13α(H),17β(H)-24-METHYLDIACHOLESTANE
20B	(20S)-5α(H),14α(H),17α(H)-CHOLESTANE
21A	(24R+S)-(20S)-13β(H),17α(H)-24-ETHYLDIACHOLESTANE
21B	(20R)-5α(H),14β(H),17β(H)-ISOCHOLESTANE
22	(20S)-5α(H),14β(H),17β(H)-ISOCHOLESTANE
25	(20R)-5α(H),14α(H),17α(H)-CHOLESTANE
27	(24S+R)-(20R)-13β(H),17α(H)-24-ETHYLDIACHOLESTANE
29	(24S+R)-(20S)-13α(H),17β(H)-24-ETHYLDIACHOLESTANE
33A	(24S+R)-(20R)-5α(H),14β(H),17β(H)-24-METHYLISOCHOLESTANE
33B	(24S+R)-(20R)-13α(H),17β(H)-24-ETHYLDIACHOLESTANE
34	(24S+R)-(20S)-5α(H),14β(H),17β(H)-24-METHYLISOCHOLESTANE
36	(24S+R)-(20R)-5α(H),14α(H),17α(H)-24-METHYLCHOLESTANE
39	(24S+R)-(20S)-5α(H),14α(H),17α(H)-24-ETHYLCHOLESTANE
40	(24S+R)-(20S)-5α(H),14β(H),17β(H)-24-ETHYLISOCHOLESTANE
41	(24S+R)-(20R)-5α(H),14β(H),17β(H)-24-ETHYLISOCHOLESTANE
42	(24S+R)-(20R)-5α(H),14α(H),17α(H)-24-ETHYLCHOLESTANE
46	(24S+R)-(20R)C_{30} STERANE

BIOMARKER IDENTIFICATION - AROMATIC STEROIDAL HYDROCARBONS (AROMATIC STERANES)

BP CODE	TENTATIVE ASSIGNMENT BASED ON MASS SPECTROMETRY (m/e 253 mass fragmentogram)
F22	C_{21} DIMETHYL MONOAROMATIC STERANE
F23	C_{22} DIMETHYL MONOAROMATIC STERANE
F2	C_{27}(20S)5β(H)DIMETHYL MONOAROMATIC STERANE
F3	C_{27}(20R)5β(H)DIMETHYL MONOAROMATIC STERANE
F4	C_{27}(20S)5α(H)DIMETHYL MONOAROMATIC STERANE
F5	C_{28}(20S)5β(H)DIMETHYL MONOAROMATIC STERANE
F6	C_{27}(20R)5α(H)DIMETHYL MONOAROMATIC STERANE
F7	C_{28}(20S)5α(H)DIMETHYL MONOAROMATIC STERANE
F8	C_{28}(20R)5β(H)DIMETHYL MONOAROMATIC STERANE
F9	C_{29}(20S)5β(H)DIMETHYL MONOAROMATIC STERANE
F10	C_{29}(20S)5α(H)DIMETHYL MONOAROMATIC STERANE
F11	C_{28}(20R)5α(H)DIMETHYL MONOAROMATIC STERANE
F12	C_{29}(20R)5β(H)DIMETHYL MONOAROMATIC STERANE
F13	C_{29}(20R)5α(H)DIMETHYL MONOAROMATIC STERANE
Ω	$C_{20}H_{12}$ POLYAROMATIC HYDROCARBONS
	(m/e 231 mass fragmentogram)
F14	C_{20}METHYL TRIAROMATIC STERANE
F15	C_{21}METHYL TRIAROMATIC STERANE
F16	C_{26}(20S)METHYL TRIAROMATIC STERANE
F17	C_{26}(20R)METHYL TRIAROMATIC STERANE
F18	C_{27}(20S)METHYL TRIAROMATIC STERANE
F19	C_{28}(20S)METHYL TRIAROMATIC STERANE
F20	C_{27}(20R)METHYL TRIAROMATIC STERANE
F21	C_{28}(20R)METHYL TRIAROMATIC STERANE

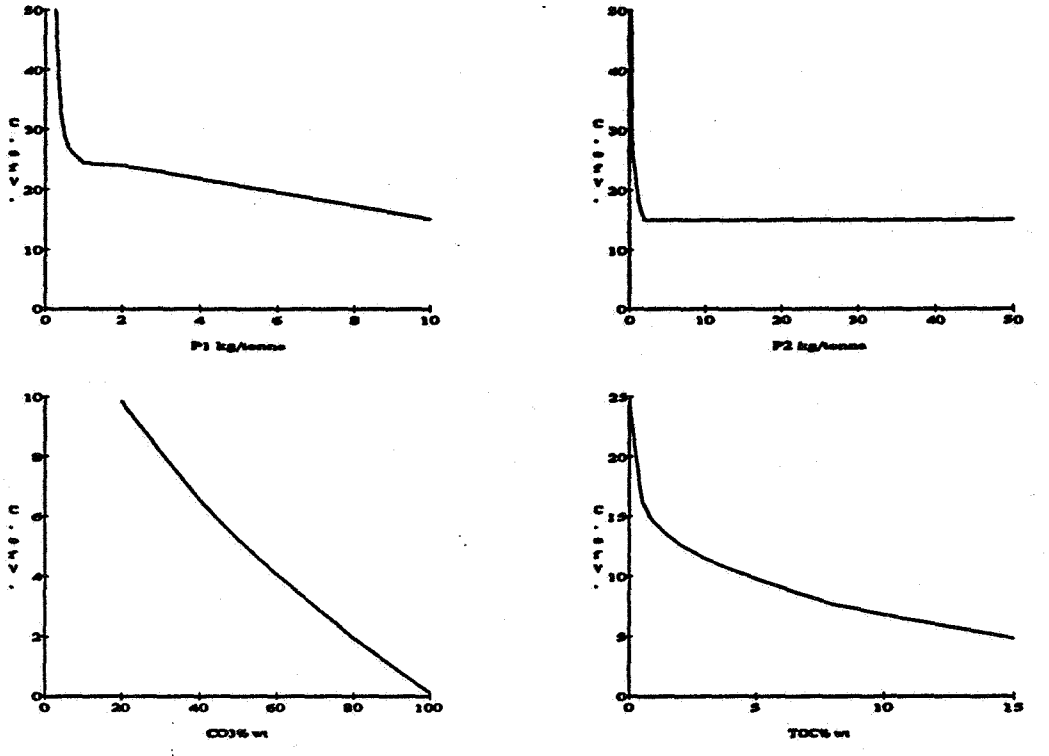
BIOMARKER IDENTIFICATION - NORHOPANES

BP CODE	TENTATIVE ASSIGNMENT BASED ON MASS SPECTROMETRY (m/e 177)
W	17α(H)-25,30-BISNORHOPANE
Y	17α(H)-25-NORHOPANE
D	17α(H),21β(H)-30-NORHOPANE
C1	(22S)-17α(H)-25-NOR-30-METHYLHOPANE
G	17α(H),21β(H)HOPANE
C2	(22R)-17α(H)-25-NOR-30-METHYLHOPANE
C3	(22S)-17α(H)-25-NOR-30-ETHYLHOPANE
C4	(22R)-17α(H)-25-NOR-30-ETHYLHOPANE
C5	(22S)-17α(H)-25-NOR-30-n-PROPYLHOPANE
C6	(22R)-17α(H)-25-NOR-30-n-PROPYLHOPANE
C7	(22S)-17α(H)-25-NOR-30-n-BUTYLHOPANE
C8	(22R)-17α(H)-25-NOR-30-n-BUTYLHOPANE
C9	(22S)-17α(H)-25-NOR-30-n-PENTYLHOPANE
C10	(22R)-17α(H)-25-NOR-30-n-PENTYLHOPANE

SUMMARY OF ANALYTICAL VARIATION - SEDIMENTS

These data were derived from the ETB QA programme. They are updated on a quarterly basis. This sheet is relevant only to data included in this report and should not be used in conjunction with other data.

Pyrolysis Parameters



Measurement	Valid Range	Coefficient of Variation
GOGI	>0.15	≤12%
Pyrolysate Distributions	10 - 35	≤12%

Extract Parameters

Measurement	Valid Range	Coefficient of Variation
%TSE	0.04 - 0.1	30%
%TSE	0.1 - 10	20%
%ASPH	10 - 30	<80%
%SATS,AROMS,RES	0 - 100	<30%

GC Parameters

Measurement	Valid Range	Coefficient of Variation
CPI	1 - 2	8%
Pr/Phy	0.6	9%
Others	-	<8%

GC-MS Parameters

Measurement	Valid Range	Coefficient of Variation
Hopanes	0.3 - 0.6	<15%
Steranes	0.3 - 0.6	<15%
Aromatics	-	Insufficient Data

Absolute Quantification by GC and GC-MS

Coefficient of Variation generally better than 50%.

Carbon Isotope Ratios

Data generally better that ±0.2 °/oo.

SUMMARY OF ANALYTICAL VARIATION - OILS

Type Analysis

Measurement	Valid Range	Coefficient of Variation
%ASPH	5 - 15%	<30%
%SATS	40 - 70%	<10%
%AROMS	25 - 40%	<12%
%RES	5 - 15%	<30%

GC Parameters

Measurement	Valid Range	Coefficient of Variation
CPI	1 - 1.2	<5%
Pr/Phy	0.6 - 10	<7%
Pr/nC17	0.4 - 5	<8%
Phy/nC18	0.4 - 0.7	2%
R22	0.95 - 1.05	2%
ALK	15 - 75	<10%

GC-MS Parameters

Measurement	Valid Range	Coefficient of Variation
H1	0.6	<5%
S1	0.4 - 0.55	<10%
A1	0.5 - 0.9	<12%
A3	0.2 - 0.5	<20%
M3	>0.8	5%

Absolute Quantification by GC and GC-MS

Coefficient of Variation generally around 25%.

Carbon Isotope Ratios

Data generally better than ±0.2 °/oo.