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REPORT TITLE/ TITTEL

ANALYSIS OF FLUID AND GAS SAMPLES FROM WELL 34/7-6 (DST 2 and DST 3b)

CLIENT/ OPPDRAGSGIVER: Saga Petroleum a.s.

PROJECT MANAGER/ PROSJEKTANSVARLIG: L. Leith

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SUMMARY/ SAMMENDRAG

Two gas/oil samples from well 34/7-6 were analysed to characterise the hydrocarbons.

The gas consists of 25-30% methane and 65-70% C_2-C_5 compounds. The iC_4/nC_4 ratio of 0.32 indicates that the gas is mature and the isotope data also suggests oil window maturity, rather than gas/ condensate range.

The oil samples were seen to be mature with little or no sign of biodegradation. Both fluids are paraffinic-naphthenic oils, and an Upper Jurassic source rock is suggested for the oils.

KEY WORDS / STIKKORD

34/7-6
Hydrocarbons
Analysis
Snorre field

149/m/jbl/1

CONTENTS

INTRODUCTION

One fluid sample and one gas sample both from DST 2 and DST 3b were sent to IKU from GECO Petroleum Lab. for analysis of the reservoired hydrocarbons. The samples that arrived at IKU had the following parameters supplied by GECO.

Flash of reservoir fluid at stock tank conditions.

- Single flash
- Well 34/7-6 DST 2
- Bottom hole sample
- Bottle no. 84014604
- 23 August 1985

Flash conditions:	:	250 barg 93.3°C to atmosphere and 15°C
Gas-oil ratio	:	90.3 sm^3/m^3
Bo at 200 barg	:	1.329 m^3/sm^3
Bo at bubble point	:	1.360 m^3/sm^3
Density of oil at 15°C	:	840.0 kg/m^3
Molecular weight of oil	:	210

- Single flash
- Well 34/7-5, DST 3b
- 12 November 1985

Flash conditions	:	250 barg 90.2°C to atmosphere and 15°C
Gas-oil ratio	:	95.0 sm^3/m^3
Bo at 350 barg	:	1.346 m^3/sm^3
Bo at bubble point	:	1.375 m^3/sm^3
Density of oil at 15°C	:	837.8 kg/m^3
Molecular weight of oil	:	199

Standard conditions: for gas volumes = 15°C and 1 bara
for oil volumes = 15°C and atmospheric pressure.

The samples were subject to the following analytical program:

Stock tank oil

- Sulphur content
- Ni- and V-content
- API gravity
- GC of C_2-C_8 hydrocarbons for recombination
- GC of whole oil
- Chromatographic separation (MPLC) with asphaltene precipitation
- Urea adduction of saturated hydrocarbons
- GC of saturated, branched/cyclic and aromatic hydrocarbons
- GC-MS of saturated hydrocarbons (m/z 217, 218, 191)
- GC-MS of aromatic hydrocarbons
- 13C/12C isotope ratios of SAT, ARO, NSO and asphaltenes

Gas samples

- GC of C_1-C_8 hydrocarbons for recombination
- 13C/12C isotope ratios of C1, C2, C3 and C4
- D/H isotope ratio of C1

The samples were given the IKU project number 22.1779, and the following sample code were assigned:

DST 2 gas - C-1863
fluid - C-1864

DST 36 gas - C-2944
fluid - C-2945

A preliminary report has been sent to Saga Petroleum for approval (Att. E.S. Mo) before ten copies of the final report are sent. Ten copies of the final report will also be stored at IKU. A draft copy of the report that include the analyses of DST 2 was sent to Saga before IKU was informed that a second DST sample would be supplied. This report is now included here.

2. EXPERIMENTAL PROCEDURES

2.1 Gas analysis

C_1-C_{10} analysis was carried out on an HP 5880 gas chromatograph equipped with a 50m x 0.2mm (I.D.) column fused silica column coated with OV 101. Helium was used as a carrier gas at 1ml/min. The inlet split ratio was 1:50. The temperature program was -30°C(1 min.) - 8°C/min. - 130°C (10 min.)

Quantitation was carried out using a standard gas containing methane, ethane, propane, n-butane, n-pentane and n-hexane. In addition a natural gas standard obtained from Norsk Hydro was used.

2.2 Evaporation of the light components in fluid samples

Prior to chromatographic separation of oil/condensate samples, the fractions boiling below 210°C were removed by heating the samples to constant weight at 210°C is obtained. The heating is performed at atmospheric pressure.

The fraction of light components is determined as the weight difference between the original sample and the amount that is left after the heating.

2.3 Chromatographic separation

The fraction of the oil boiling above 210°C was separated into saturated fraction, aromatic fraction and non hydrocarbon fraction using a MPLC system with hexane as eluant (Radke et al., Anal. Chem., 1980). The various fractions were evaporated on a Buchi Rotavapor and transferred to glass vials and dried in stream of nitrogen.

2.4 Urea adduction

Urea-adduction was performed on the saturated hydrocarbon fraction. The sample containing 5 mg of n-alkanes was dissolved in 2 ml of n-hexane and 1 ml of acetone was added. A saturated solution of urea in methanol (1 ml) was then added dropwise. The solvent was removed (N_2) and the adduction step repeated twice. The white crystals were rinsed (3x5ml

hexane) and the combined extract filtered (cotton wool plug covered with Al_2O_3), to afford a non-adduct. GC analyses were performed on the samples after the urea adduction, using the same conditions as for the other GC analyses.

2.5 Gas chromatographic analysis

The C_2-C_8 hydrocarbons of the oil were determined on a Carlo Erba Fractovap GC. The column used was a 30m fused silica capillary column coated with SE-54. The temperature program applied was 50°C (2min.) to 180°C at 4°C/min., which gave good separation from C_3 upwards. Quantitation was carried out using the same standard gas as for C_{1-10} analysis.

The whole oils were run on an HP 5730 GC equipped with a 15 m DB-1 fused silica capillary column, at a temperature program from -50°C (2 min.) to 280°C at 4°C/min.

The saturated, the branched/cyclic and the aromatic hydrocarbon fractions were each diluted with n-hexane and analysed on a HP 5730A. The GC is equipped with a 15m DB-1 fused silica column and hydrogen (ca. 2.5 ml/min.) is used as carrier gas. Injections are performed in split mode (split ratio 1:10). The temperature program applied is 80°C (2 min.) to 280°C at 4°C/min.

The data processing for all the GC analyses was performed on a VG Multichrom lab data system.

2.6 Gas chromatography - mass spectrometry (GC-MS)

GC-MS analyses were performed on a VG Micromass 70-70H GC-MS-DS system. The Varian Series 3700 GC was fitted with a fused silica OV-1 capillary column (30m x 0.3mm i.d.). Helium (0.7kg/cm^2) was used as carrier gas and the injections were performed in split mode (1.5µl, split ratio 1:15).

The saturated hydrocarbons were analysed in multiple ion mode (MID) at a scan cycle time of approximately 2 secs. (Temperature program 120°C (2 min.) - 4°C(min. - 280°C). Full data collection was applied for the aromatic hydrocarbons at a scan time of 1 sec/decade. (Temperature program 80°C (2 min.) - 4°C/min. - 280°C). The mass spectrometer

operated at 70eV electron energy and an ion source temperature of 200°C. Data acquisition was done by VG data systems.

Peak identification was performed applying knowledge of elution patterns in certain mass chromatograms. Calculation of peak ratios was done from peak height in the appropriate mass chromatograms.

2.7 Isotope analysis

The isotope analysis was performed by mass spectrometry at Institute for Energy Technology (IFE) in Oslo according to their method. Their reference value for the standard NBS-22 is -29.8 (^{13}C isotope analysis).

2.8 S, Ni and V content of oil samples

The above analyses were carried out by the technical chemistry department of SINTEF. Atomic adsorbtion spectroscopy was used for Ni and V determination and the Eschka method for sulphur determination.

3. RESULTS AND DISCUSSION

3.1 API gravity

The oil samples from drillstem tests (DST's) 2 and 3b have similar whole oil API gravities of 37.1° and 37.8°, respectively (Table 1). The API gravities of the >210°C oil fractions show a slight difference with values of 27.7° (DST 2) and 31.1° (DST 3b). The API gravities suggest that both oils are moderately light, probably thermally mature oils.

3.2 Sulphur content

The DST 2 and DST 3b oils may be considered low sulphur oils (Table 2), the latter sample having a slightly lower sulphur content of 0.18-0.19% relative to the former oil (0.31-0.35% S).

3.3 Ni- and V content

The DST 2 oil has Ni and V contents of 3.11-3.27 mg/kg and 4.0-4.5 mg/kg, respectively (Table 2). The DST 3b oil has slightly lower Ni and V contents of 1.78-1.82 mg/kg and 3.09-3.11 mg/kg. The difference in the values correlates well with the slight difference in sulphur contents, and are typical of low sulphur oils according to Tissot and Welte (1984).

3.4 Gross composition of oil samples

The data in Table 3 show that 27.1% of the oil from DST 2 consists of hydrocarbons with a boiling point of less than 210°C while DST 3b has a lower percentage of 17.5% for this hydrocarbon fraction. This is in contrast to the API gravity data and the sulphur content of the oils, although the difference is relatively small. The DST 3b oil has a higher asphaltene content of 1.2% (Table 4) than the DST 2 oil (0.5% asphaltenes). The generally low asphaltene contents are consistent with the low sulphur contents of the oils.

The composition the >210°C oil fraction is very similar for both oils (Table 5), and saturated hydrocarbons account for 49.5% and 46.7% of this fraction, respectively. Non-hydrocarbon compounds account for 34.1% (DST 2) and 33.1% (DST 3b) of the >210°C fraction. These data suggest that the oil samples are fairly similar in composition and may be derived from a common source.

3.5 Gas chromatography

Recombination of gas and oil sample (C_1-C_8 hydrocarbons)

Data for C_1-C_8 hydrocarbons in the gas sample are shown in Figure 1 and Table 6. The gas samples consist of 25-30% methane and 65-70% of C_2-C_5 compounds. This leaves less than 4% of compounds above C_5, and thus the lack of standards in this higher molecular weight range does not contribute to significantly erroneous quantitative results. The iC_4/nC_4 ratios were determined to be 0.32 for both samples, and indicate a mature gas. The high wetnesses of 68.9% and 68.5% would be expected in a gas associated with liquid hydrocarbons.

The oil samples are both dominated by n-alkanes with a relatively high abundance of cyclic compounds. The high relative abundance of n-alkanes suggests that no significant biodegradation has taken place.

The quantitative determination of compounds $>C_5$ is subject to some degree of uncertainty due to the lack of standards in this range. The response factors, especially of the aromatic hydrocarbons, are different (lower) to those of the standard compounds (alkanes), producing the results which are approximately 10% too high for these compounds.

Whole oil gas chromatogram

The whole oil gas chromatograms are shown in Figure 2, and some differences may be observed between the two samples. The DST 3b oil has a smoother n-alkane elvelope, sloping down from a maximum at nC_6-C_7. The DST 2 oil has a more curved profile with a maximum at nC_{15}. This difference, however, may be due to a loss of the lighter molecular weight compounds from the DST 2 sample during storage or collection. The distribution of the branched and cyclic compounds tends to suggest that both oil samples are essentially similar.

Saturated hydrocarbons

The saturated hydrocarbon gas chromatograms are shown in Figure 3. Both oil samples show unimodal n-alkane distributions reaching a maximum at

nC_{15} and decreasing relatively smoothly to nC_{35}. The DST 2 oil appears to have a greater content of higher molecular weight alkanes and unresolved compounds than the DST 3b oil. This might be expected from the slightly higher sulphur, Ni and V contents of the DST 2 oil. The DST 3b oil has the more mature n-alkane profile of the two samples. This is also shown in the slightly lower pristane/nC_{17} ratio of the DST 3b oil. Similar pristane/phytane ratios of 1.6 (DST 2) and 1.7 (DST 3b) suggest that the source material of the oils may have been deposited under mildly oxidising conditions and strengthen the indications that the two oils are essentially similar despite some minor differences.

The gas chromatograms of the branched/cyclic compounds (Figure 4) show that the lower molecular weight isoprenoids are the main compounds in both samples with generally poor abundances of sterane and triterpane compounds.

Aromatic hydrocarbons

The aromatic hydrocarbon gas chromatograms are shown in Figure 5 and are very similar for both samples. The gas chromatograms are dominated by the alkylated naphthalenes and less abundant phenanthrene compounds. A "hump" beyond the phenanthrene compounds may indicate the presence of aromatic steranes. The resolution of the methyl-phenanthrenes is fairly poor and makes any calculation of MPI values highly tentative.

3.6 GC-MS analysis

Saturated hydrocarbons

Mass chromatograms representing terpanes and steranes are given in Figure 6 and tabulated data is presented in Tables 9 and 10.

The data indicates a mature distribution of hydrocarbons with maturity ratios at equilibrium values. The abundant regular steranes in m/z 217 suggest a maturity typical of mid-oil window, since highly mature samples would be expected to contain a greater abundance of rearranged steranes (ratio a/a+j in Table 10). The relative low values of 40.2% and 41.2% for the 20S steranes may be due to coelution with the C_{29} 20R sterane.

The high relative amount of 28,30-bisnorhopane (Z in m/z 191) suggests a possible Upper Jurassic source rock for the oils, since this compound is most often encountered in the Draupne or Heather Formations. This may also be suggested by the even molecular weight distribution of C_{27}-C_{29} regular steranes (m/z 218). The DST 3b may be seen to be of slightly higher maturity than DST 2, but the organic matter in the two samples is very similar.

Aromatic hydrocarbons

The aromatic hydrocarbon mass chromatograms presented in Figure 7 show the same main distribution (TIC) as seen from the GC analysis. Smooth distributions of alkylated monoaromatic compounds of relatively low molecular weight are seen, while the naphthalenes and phenanthrenes show the normal distributions in mature samples. No aromatic steranes were detected in DST 2, while the distribution in DST 3b indicates relatively mature hydrocarbons.

3.7 Isotopic analysis

Isotope data for the gas and oil samples are given in Table 11.

The gas data suggests thermogenic gas of early-mid oil window maturity, which is in agreement with the maturity of the oil samples.

The low carbon isotope ratios for the oil samples may be an indication of an Upper Jurassic source rock for the oil. The Draupne Formation has been seen to give isotope ratios of -30o/oo to -29o/oo for the saturated hydrocarbon fraction in samples from the Viking Graben area.

4. CONCLUSION

The gas samples were seen to be of oil window maturity with 96% of the hydrocarbons occuring in the C_1-C_5 range of which methane accounts for 25-30%. The high wetness of the gas would be expected in a gas associated with liquid hydrocarbons.

Both fluids are mature paraffinic-naphthenic oils. The carbon isotope data and the relative abundance of 28,30-bisnorhopane may suggest an Upper Jurassic source rock.

The maturity of the gas and oil samples appears to be relatively similar and is typical of the early-mid mature oil window. DST 3b may be seen to be slightly more mature than DST 2.

IKU SINTEF-GRUPPEN

Project no.: 22.1779
Well ident.: 34/7-6
DATE : 5 - 12 - 85.

T A B L E : 1.

API GRAVITY OF OIL SAMPLE

IKU-No	CODE	API GRAVITY (DENSITY)	
		Crude oil	>210°C
C 1864	DST 2	37.1 (0.8395)	27.7 (0.8886)
C 2945	DST 3B	37.8 (0.8359)	31.1 (0.8701)

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T A B L E : 2.

CONTENT OF SULFUR, NICKEL AND VANADIUM IN OIL

IKU-No	CODE	S (%)	Ni (mg/kg)	V (mg/kg)
C 1864	DST 2	0.35	3.11	4.50
		0.31	3.27	4.00
C 2945	DST 3B	0.18	1.78	3.09
		0.19	1.82	3.11

IKU SINTEF-GRUPPEN

Project no.: 22.1779
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DATE : 5 - 12 - 85.

T A B L E : 3.

FRACTION BOILING BELOW 210°C

IKU-No	CODE	Crude oil (mg)	EOM >210° (mg)	Low molecular weight compounds (mg)	(%)
C 1864	DST 2	215.9	157.5	58.4	27.0
C 1668	DST 3B	227.5	187.7	39.8	17.5

Project no.: 22.1779
Well ident.: 34/7-6
DATE : 5 - 12 - 85.

T A B L E : 4.

AMOUNT OF ASPHALTENES AND NSO IN OIL

IKU-No	CODE	Crude oil (mg)	Asphaltenes (mg)	Asphaltenes (%)	NSO (mg)	NSO (%)
C 1864	DST 2	215.9	1.0	0.5	14.4	6.7
C 2945	DST 3B	227.5	2.7	1.2	25.8	11.3

Project no.: 22.1779
Well ident.: 34/7-6
DATE : 5 - 12 - 85.

T A B L E : 5a

CONCENTRATION OF EOM AND CHROMATOGRAPHIC FRACTIONS

IKU-No	CODE	Crude oil (mg)	EOM >210' (mg)	Sat. (mg)	Aro. (mg)	HC (mg)	Non HC (mg)
C 1864	DST 2	215.9	157.5	78.0	25.8	103.8	53.7
C 2945	DST 3B	227.5	187.7	87.6	37.9	125.5	62.2

IKU SINTEF-GRUPPEN

Project no.: 22.1779
Well ident.: 34/7-6
DATE : 5 - 12 - 85.

T A B L E : 5b

COMPOSITION OF MATERIAL EXTRACTED FROM THE OIL

IKU-No	CODE	Sat EOM %	Aro EOM %	HC EOM %	SAT / Aro x 100	Non HC EOM %	HC / Non HC x 100
C 1864	DST 2	49.5	16.4	65.9	302.3	34.1	193.3
C 2945	DST 3B	46.7	20.2	66.9	231.1	33.1	201.8

IKU SINTEF-GRUPPEN

Table 6a

C_2-C_8 yield in oil sample.

C-1864	area	ug	mg/ml	% of t.oil
iso-C4	23401	.243	.811	.096
nC4	166322	1.730	5.768	.687
iso-C5	190128	1.978	6.593	.785
nC5	338215	3.518	11.729	1.397
CyC5+2,3diMeC4	77788	.809	2.697	.321
2MeC5	200947	2.090	6.968	.830
3MeC5	127270	1.324	4.413	.525
nC6	416140	4.329	14.432	1.719
MeCyC5	293745	3.056	10.187	1.213
benzene	63772	.663	2.211	.263
CyC6	253748	2.640	8.800	1.048
2MeC6	116754	1.214	4.049	.482
2,3diMeC5	46442	.483	1.610	.191
3MeC6	198071	2.060	6.869	.818
DiMeCyC5	323522	3.365	11.219	1.336
nC7	410917	4.275	14.250	1.697
MeCyC6	511916	5.326	17.753	2.114
EtCyC5+2,5diMeC6	82593	.859	2.864	.341
'2,4diMeC6	44523	.463	1.544	.183
triMeCyC5	49179	.511	1.705	.203
toluene	206801	2.151	7.172	.854
2+4MeC7	212732	2.213	7.377	.878
3MeC7	114460	1.190	3.969	.472
DiMeCyC6 [2]	259250	2.697	8.990	1.070
nC8	374970	3.901	13.004	1.549
2,4diMeC7+diMeCyC6	75364	.784	2.613	.311
EtCyC6	127613	1.327	4.425	.527
EtBenzene	70144	.729	2.432	.289
m,p-Xylene	150780	1.568	5.229	.622
2+4MeC8	95268	.991	3.303	.393
o-xylene	53174	.553	1.844	.219
sum		59.053	196.846	23.448

tot.oil - ug inj.: 251.850ug

%C2-C8(tot.area)in tot.oil: 29.454%

IKU SINTEF-GRUPPEN

Table 6a. C_2-C_8 yield in oil sample C-2945.

C-2945	area	ug	mg/ml	% of t.oil
iso-C4	0	.000	.000	.000
nC4	31052	.302	1.006	.120
iso-C5	212929	2.071	6.904	.825
nC5	413412	4.021	13.404	1.603
CyC5+2,3diMeC4	91273	.887	2.959	.354
2MeC5	215046	2.091	6.972	.834
3MeC5	142445	1.385	4.618	.552
nC6	448592	4.363	14.545	1.740
MeCyC5	307156	2.987	9.959	1.191
benzene	72934	.709	2.364	.282
CyC6	281144	2.734	9.115	1.090
2MeC6	126128	1.226	4.089	.489
2,3diMeC5	49131	.477	1.593	.190
3MeC6	179583	1.746	5.822	.696
DiMeCyC5	335620	3.264	10.882	1.301
nC7	442266	4.302	14.340	1.715
MeCyC6	519055	5.048	16.829	2.013
EtCyC5+2,5diMeC6	91715	.892	2.973	.355
'2,4diMeC6	53821	.523	1.745	.208
triMeCyC5	52953	.515	1.716	.205
toluene	241471	2.348	7.829	.936
2+4MeC7	202913	1.973	6.579	.787
3MeC7	110385	1.073	3.579	.428
DiMeCyC6 '	251736	2.448	8.162	.976
nC8	410105	3.989	13.297	1.590
2,4diMeC7+diMeCyC6	78001	.758	2.529	.302
EtCyC6	140520	1.366	4.556	.545
EtBenzene	82665	.804	2.680	.320
m,p-Xylene	193175	1.879	6.263	.749
2+4MeC8	105639	1.027	3.425	.409
o-xylene	73420	.714	2.380	.284
sum		57.938	193.127	23.104

tot.oil - ug inj.: 250.770ug

%C2-C8(tot.area)in tot.oil: 28.833%

Table 6b

C1-C8 YIELD
WELL NO:34/7-6
IKU NO,GAS: C-1863
IKU NO,OIL: C-1864
COR = 90.3 SM3/SM3

C_1-C_8 yield and recombination of oil and gas samples.

COMPOUND	GAS MG/ML	GAS MG/90.3ML	OIL MG/ML	TOTAL HC IN MG/ML OF RESERVOIR FLUID
Methane	0.236	21.311	0.000	21.311
Ethane	0.135	12.191	0.000	12.191
Propane	0.223	20.137	0.000	20.137
i-Butane	0.040	3.612	0.811	4.423
n-Butane	0.126	11.378	5.768	17.146
i-Pentane	0.032	2.890	6.593	9.483
n-Pentane	0.036	3.251	11.729	14.980
Cyclo-C5+				
2,3-diMeC4	0.003	0.271	2.697	2.968
2-MeC5	0.012	1.084	6.968	8.052
3-MeC5	0.000	0.000	4.413	4.413
n-Hexane	0.009	0.813	14.432	15.245
MeCyC5	0.005	0.452	10.187	10.639
triMeC4	0.003	0.271	0.000	0.271
Benzene	0.000	0.000	2.211	2.211
CycloC6	0.003	0.271	8.800	9.071
2-MeC6	0.000	0.000	4.049	4.049
2,3-diMeC5	0.000	0.000	1.610	1.610
3-MeC6	0.001	0.090	6.869	6.959
diMeCyC5	0.000	0.000	11.219	11.219
n-Heptane	0.002	0.181	14.250	14.431
MeCyC6	0.002	0.181	17.753	17.934
EtCyC5+				
2,5-diMeC6	0.000	0.000	2.864	2.864
2,4-diMeC6	0.000	0.000	1.544	1.544
triMeCyC5	0.000	0.000	1.705	1.705
Toluene	0.000	0.000	7.172	7.172
2-MeC7+				
4-MeC7	0.000	0.000	7.377	7.377
3-MeC7	0.000	0.000	3.969	3.969
diMeCyC6	0.000	0.000	8.990	8.990
n-Octane	0.000	0.000	13.004	13.004
2,4-diMeC7+				
diMeCyC6	0.000	0.000	2.613	2.613
EtCyC6	0.000	0.000	4.425	4.425
EtBenzene	0.000	0.000	2.432	2.432
m+p-Xylene	0.000	0.000	5.229	5.229
2-MeC8+				
4-MeC8	0.000	0.000	3.303	3.303
O-Xylene	0.000	0.000	1.844	1.844
SUM	0.868	78.384	196.830	275.214

C1-C8 YIELD
WELL NO: 34/7-6
IKU NO,GAS: C-2944
IKU NO,OIL: C-2945
GOR = 95.0 SM3/SM3

Table 6b.
C_1-C_8 yield and recombination of oil and gas sample.

COMPOUND	GAS MG/ML	GAS MG/95.0ML	OIL MG/ML	TOTAL HC IN MG/ML OF RESERVOIR FLUID
Methane	0.395	37.525	0.000	37.525
Ethane	0.224	21.280	0.000	21.280
Propane	0.361	34.295	0.000	34.295
i-Butane	0.066	6.270	0.000	6.270
n-Butane	0.206	19.570	1.006	20.576
i-Pentane	0.052	4.940	6.904	11.844
n-Pentane	0.056	5.320	13.404	18.724
Cyclo-C5+				
2,3-diMeC4	0.005	0.475	2.959	3.434
2-MeC5	0.010	0.950	6.972	7.922
3-MeC5	0.005	0.475	4.618	5.093
n-Hexane	0.010	0.950	14.545	15.495
MeCyC5	0.005	0.475	9.959	10.434
Benzene	0.000	0.000	2.364	2.364
CycloC6	0.002	0.190	9.115	9.305
2-MeC6	0.000	0.000	4.089	4.089
2,3-diMeC5	0.000	0.000	1.593	1.593
3-MeC6	0.000	0.000	5.822	5.822
diMeCyC5	0.000	0.000	10.882	10.882
n-Heptane	0.000	0.000	14.340	14.340
MeCyC6	0.000	0.000	16.829	16.829
EtCyC5+				
2,5-diMeC6	0.000	0.000	2.973	2.973
2,4-diMeC6	0.000	0.000	1.745	1.745
triMeCyC5	0.000	0.000	1.716	1.716
Toluene	0.000	0.000	7.829	7.829
2-MeC7+				
4-MeC7	0.000	0.000	6.579	6.579
3-MeC7	0.000	0.000	3.579	3.579
diMeCyC6	0.000	0.000	8.162	8.162
n-Octane	0.000	0.000	13.297	13.297
2,4-diMeC7+				
diMeCyC6	0.000	0.000	2.529	2.529
EtCyC6	0.000	0.000	4.556	4.556
EtBenzene	0.000	0.000	2.680	2.680
m,p-xylene	0.000	0.000	6.263	6.263
2-MeC8+				
4-MeC8	0.000	0.000	3.425	3.425
O-Xylene	0.000	0.000	2.380	2.380
SUM	1.397	132.715	193.114	325.829

List of C2-C8 hydrocarbons

C2	ethane
C3	propane
MC3	methyl-propane
nC4	butane
isoC5	iso-pentane
nC5	pentane
2,2DMC4	2,2-dimethyl-butane
CyC5	cyclopentane
2,3DMC4	2,3-dimethyl-butane
2MC5	2-methyl-pentane
3MC5	3-methyl-pentane
nC6	hexane
MCyC5	methyl-cyclopentane
benzene	
CyC6	cyclohexane
2MC6	2-methyl-hexane
2,3DMC5	2,3-dimethyl-pentane
3MC6	3-methyl-hexane
DMCyC5	dimethyl-cyclopentane
nC7	heptane
MCyC6	methyl-cyclohexane
EtCyC5	ethyl-cyclopentane
2,5DMC6	2,5-dimethyl-hexane
2,4DMC6	2,4-dimethyl-hexane
TMCyC5	trimethyl-cyclopentane
toluene	
2MC7	2-methyl-heptane
4MC7	4-methyl-heptane
3MC7	3-methyl-heptane
DMCyC6	dimethyl-cyclohexane
nC8	octane
2,4DMC7	2,4-dimethyl-heptane
EtCyC6	ethyl-cyclohexane
Et benzene	ethyl-benzene
m,p-xylene	meta,para-xylene
2MC8	2-methyloctane
4MC8	4-methyloctane
o-xylene	orto-xylene
int.std.	2,3,4-trimethyl-pentane

T A B L E 7

TABULATION OF DATA FROM THE GASCHROMATOGRAMS

IKU No.	CODE	PRISTANE / n-C17	PRISTANE / PHYTANE	CPI-1	CPI-2
C 1864	DST 2	0.7	1.6	1.0	1.0
C 2945	DST 3B	0.6	1.7	0.9	1.0

DATE : 11 - 12 - 85.

Table 8 Molecular ratios from aromatic hydrocarbon GC's

IKU no.	MPI 1	MPI 2
C-1864	0.83	0.48
C-2945	NOT CALCULABLE	

MPI 1 = methyl-phenanthrene index 1 $1{,}5 \times (3MP+2MP)/(P+9MP+1MP)$

MPI 2 = methyl-phenanthrene index 2 $3 \times 2MP/(P+9MP+1MP)$

Table 9 Molecular ratios calculated from terpanes and steranes mass chromatograms. Maturity ratios.

IKU no.	$\alpha\beta/\alpha\beta+\beta\alpha$ [1]	%22S [2]	%ββ [3]	%20S [4]
C-1864	0.91	54.8	79.4	40.2
C-2945	0.96	61.5	79.8	41.2

1) E/E+F in m/z 191
2) % distribution between first and second eluting isomers of doublet J (m/z 191)
3) 2 (r+s)/(q+t+2(r+s)) in m/z 217
4) q/q+t in m/z 217

Table 10 Molecular ratios calculated from terpane and sterane mass chromatograms. Source characteristic and maturity ratios.

IKU no.	Q/E [1]	Tm/Ts [2]	X/E [3]	a/a+j [4]	Z/E [5]
C-1864	0.03	0.79	0.06	0.63	0.33
C-2945	0.02	0.45	0.04	0.72	0.27

1) Relative abundance of tricyclic terpanes (Q/E in m/z 191)
2) B/A in m/z 191
3) Relative abundance of unknown (X/E in m/z 191)
4) Relative abundance of C_{27} rearranged steranes (a/a+j in m/z 217)
5) Relative abundance of bisnorhopane (Z/E in m/z 191)

Table 11 Isotope analysis

Hydrogen and oxygen isotope ratios of gas sample

IKU no.	δD (C1)	$\delta^{18}O$ (CO_2)
C-1863	-210	-180
C-2944	-195	-

Carbon isotope ratios ($\delta^{13}C$) of gas components

IKU no.	C1	C2	C3	iC_4	nC_4	CO_2
C-1863	-52.9	-35.9	-33.7	-31.6	-31.7	-17.2
C-2944	-49.9	-35.8	-33.3	-25.5	-33.7	-

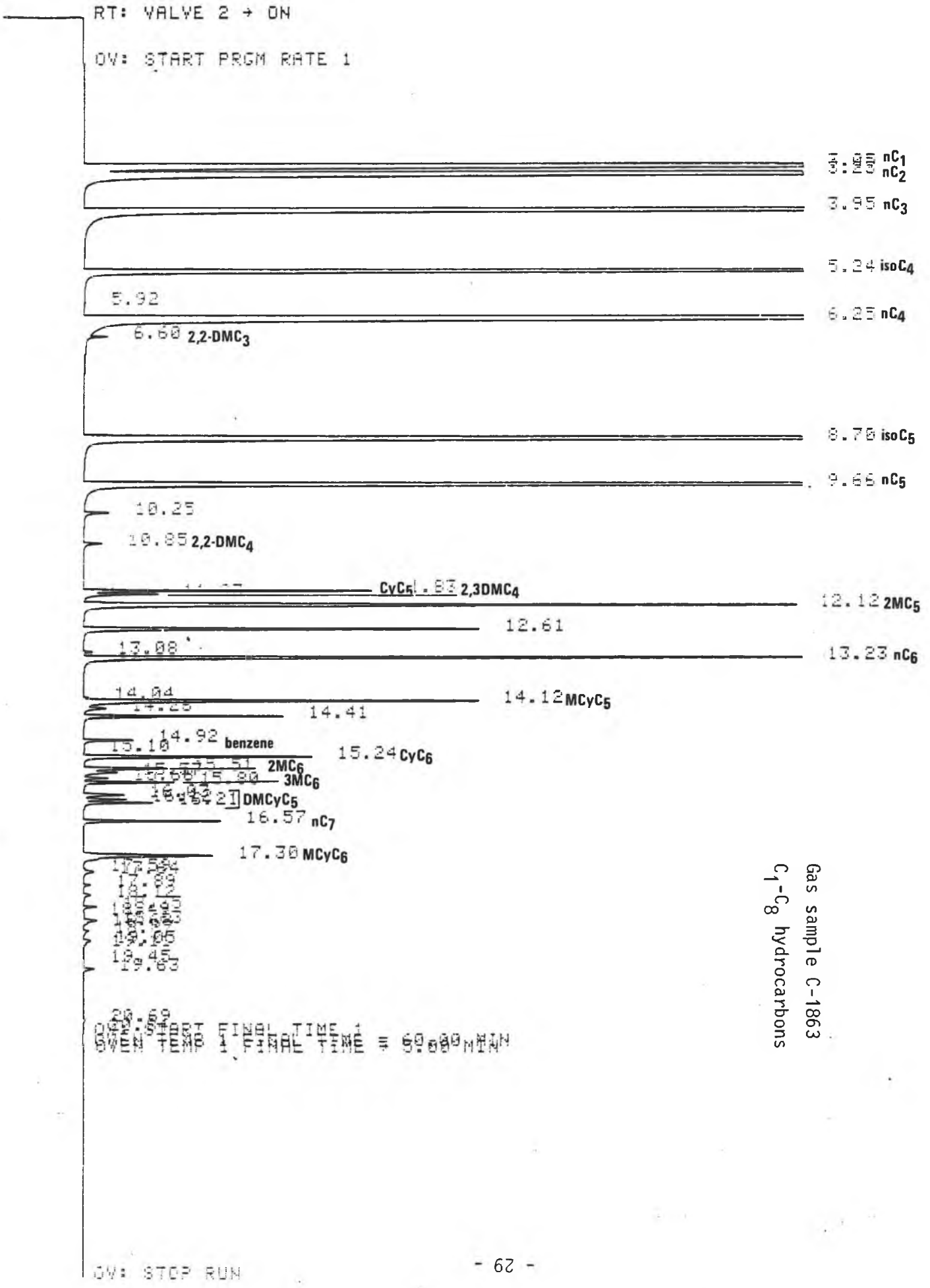
Carbon isotope ratios ($\delta^{13}C$) of fluid fractions

IKU no.	SAT	ARO	NSO	Asphaltenes
C-1863	-30.4	-29.6	-29.3	not enough material
C-2944	-30.4	-29.7	-29.4	-29.3

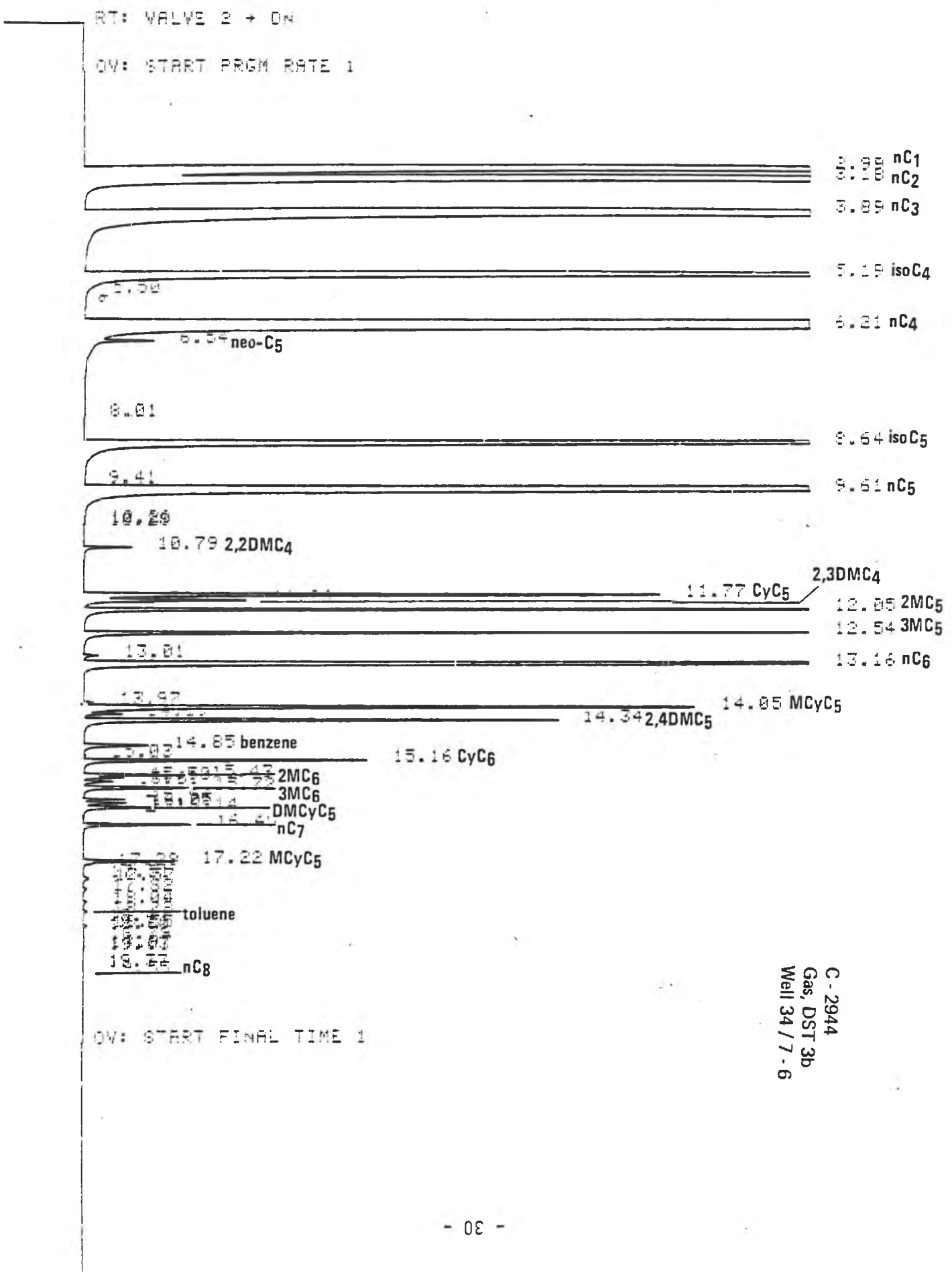
IKU
SINTEF-GRUPPEN

FIGURE 1

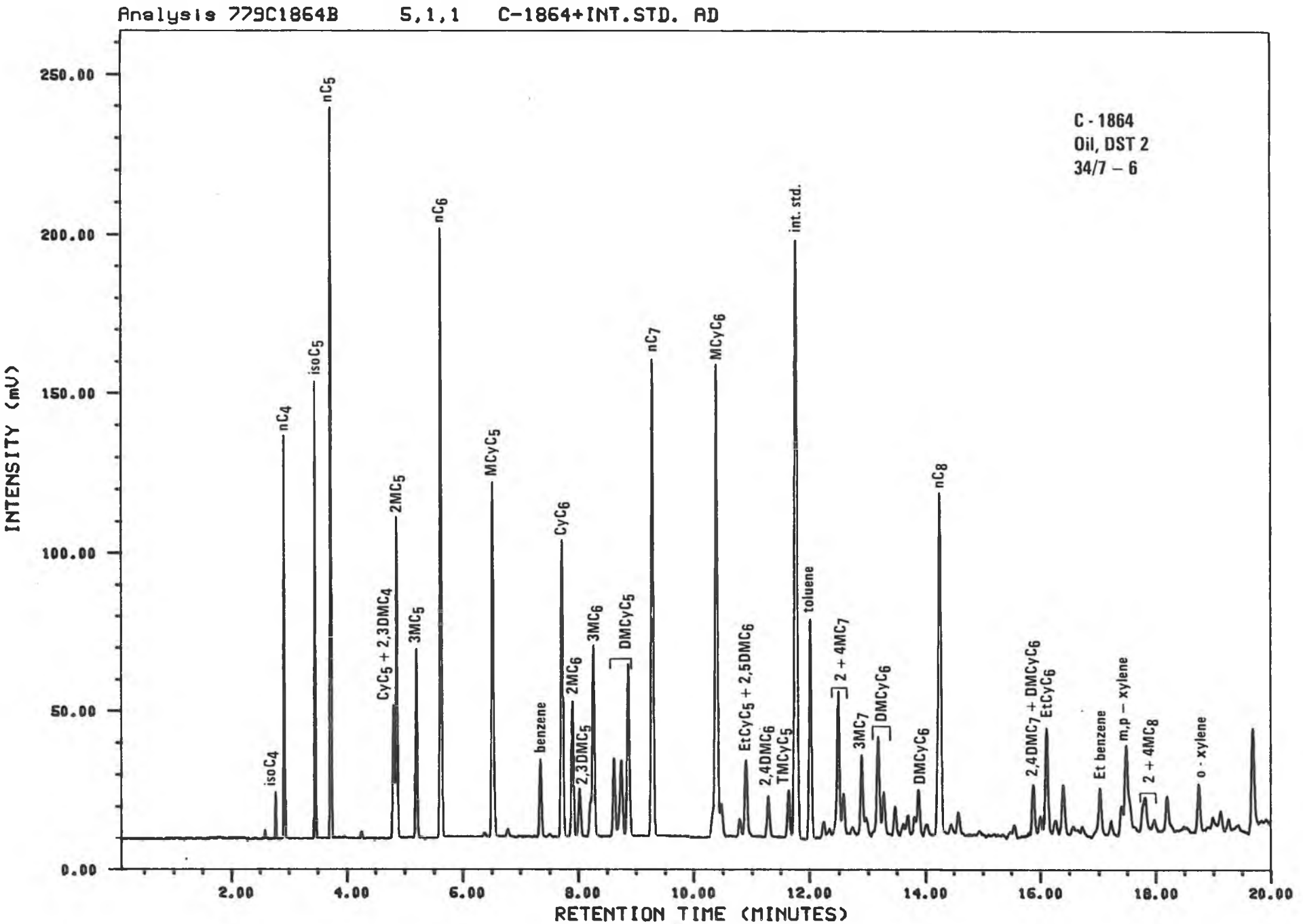
C2-C8 HYDROCARBON GAS CHROMATOGRAMS

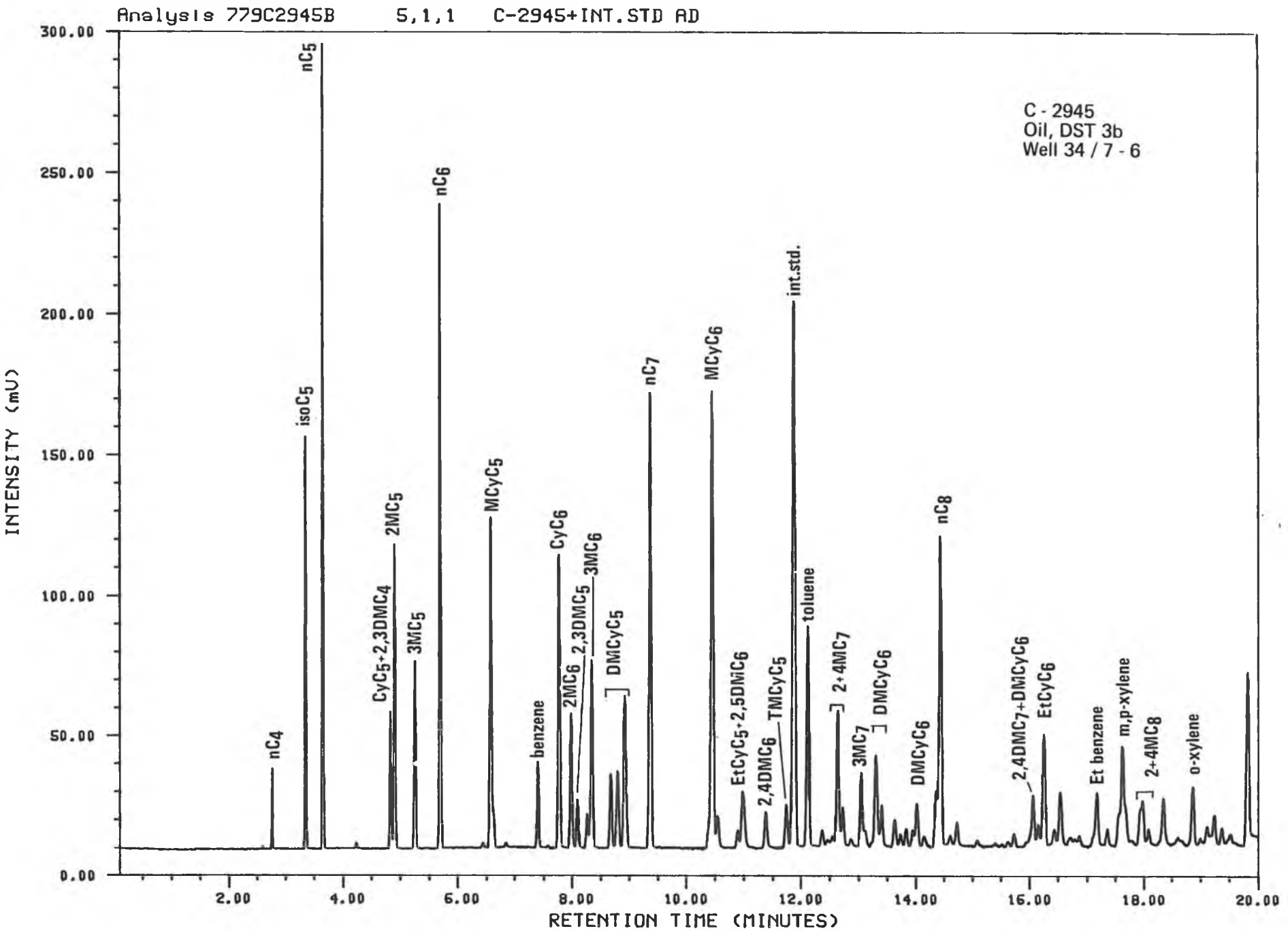


Gas sample C-1863
C_1-C_8 hydrocarbons



C - 2944
Gas, DST 3b
Well 34 / 7 - 6


Analysis 779C1864B 5,1,1 C-1864+INT.STD. AD
C - 1864
Oil, DST 2
34/7 – 6
INTENSITY (mV)
RETENTION TIME (MINUTES)
250.00
200.00
150.00
100.00
50.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
isoC4
nC4
isoC5
nC5
CyC5 + 2,3DMC4
2MC5
3MC5
nC6
MCyC5
benzene
CyC6
2MC6
2,3DMC5
3MC6
DMCyC5
nC7
MCyC6
EtCyC5 + 2,5DMC6
2,4DMC6
TMCyC5
int. std.
toluene
2 + 4MC7
3MC7
DMCyC6
DMCyC6
nC8
2,4DMC7 + DMCyC6
EtCyC6
Et benzene
m,p – xylene
2 + 4MC8
o - xylene

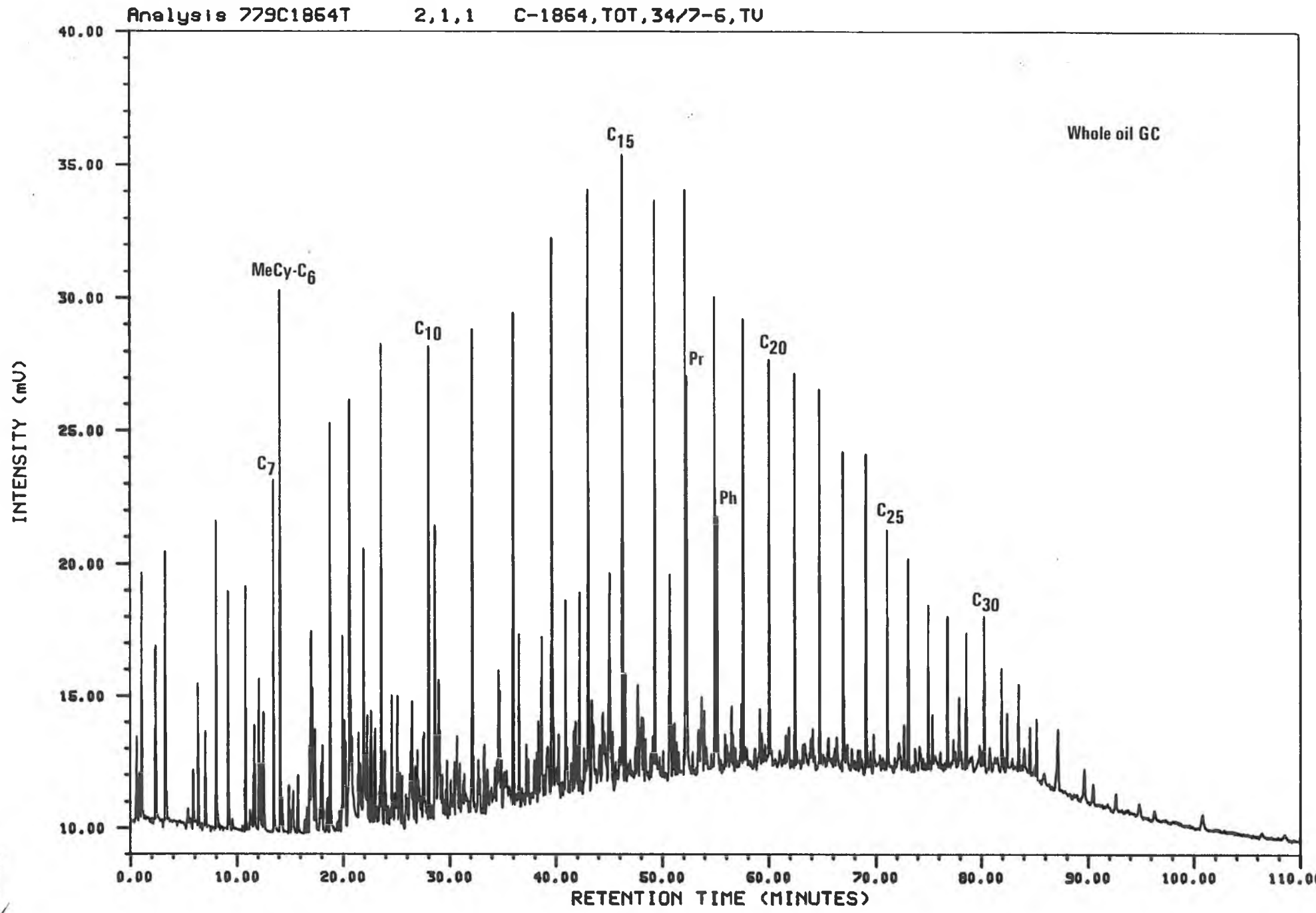

Analysis 779C2945B 5,1,1 C-2945+INT.STD AD
C - 2945
Oil, DST 3b
Well 34 / 7 - 6
INTENSITY (mV)
RETENTION TIME (MINUTES)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
nC4
isoC5
nC5
CyC5+2,3DMC4
2MC5
3MC5
nC6
MCyC5
benzene
CyC6
2MC6
2,3DMC5
3MC6
DMCyC5
nC7
MCyC6
EtCyC5+2,5DMC6
2,4DMC6
TMCyC5
int.std.
toluene
2+4MC7
3MC7
DMCyC6
DMCyC6
nC8
2,4DMC7+DMCyC6
EtCyC6
Et benzene
m,p-xylene
2+4MC8
o-xylene

IKU
SINTEF-GRUPPEN

FIGURE 2

WHOLE OIL GAS CHROMATOGRAMS

Cy-C6	-	cyclohexane
MeCy-C6	-	methylcyclohexane
Pr	-	pristane
Ph	-	phytane
C10 etc.	-	n-alkanes


Analysis 779C1864T 2,1,1 C-1864,TOT,347-6,TV
Whole oil GC
MeCy-C6
C7
C10
C15
Pr
Ph
C20
C25
C30
INTENSITY (mV)
RETENTION TIME (MINUTES)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00

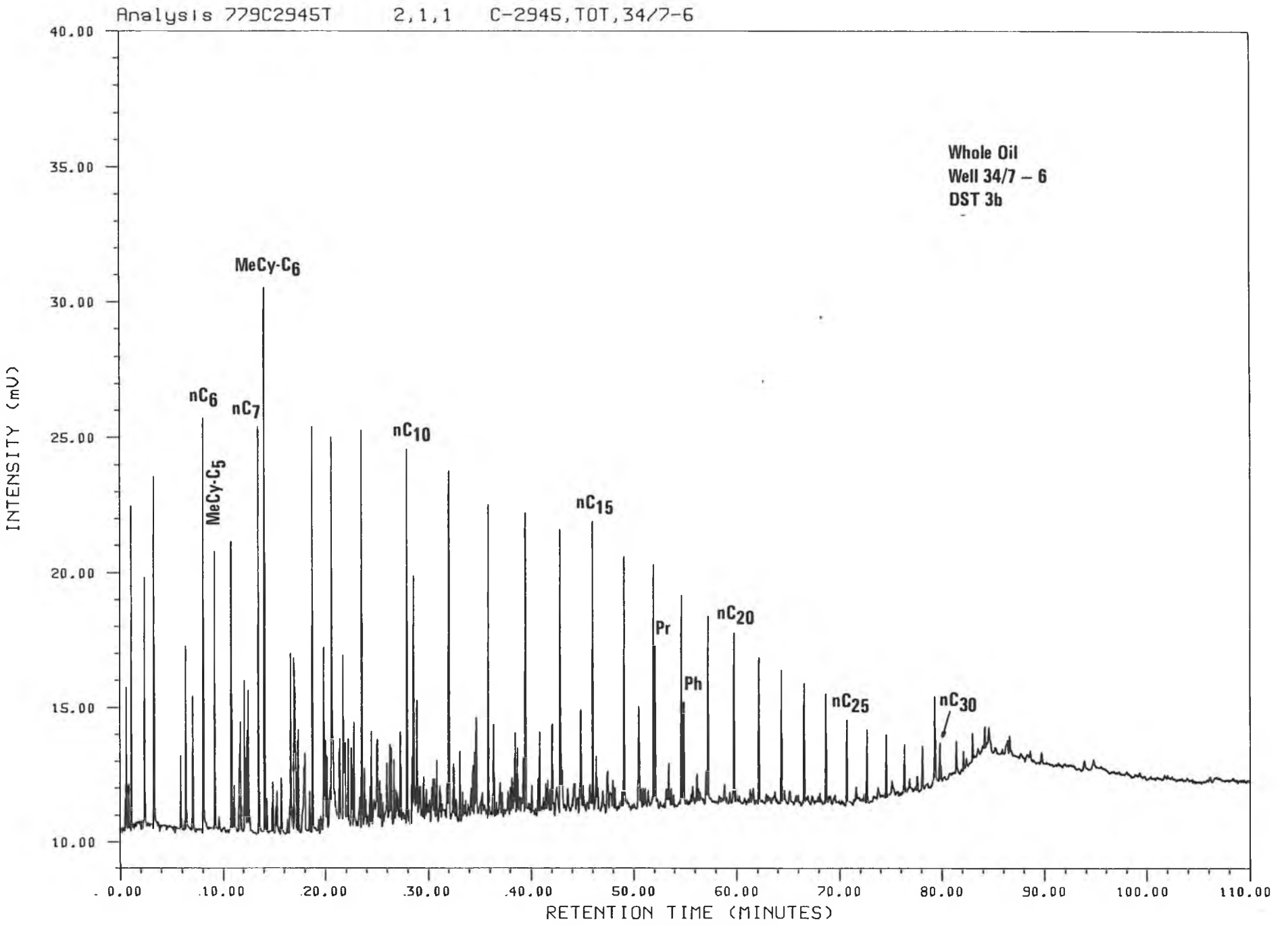
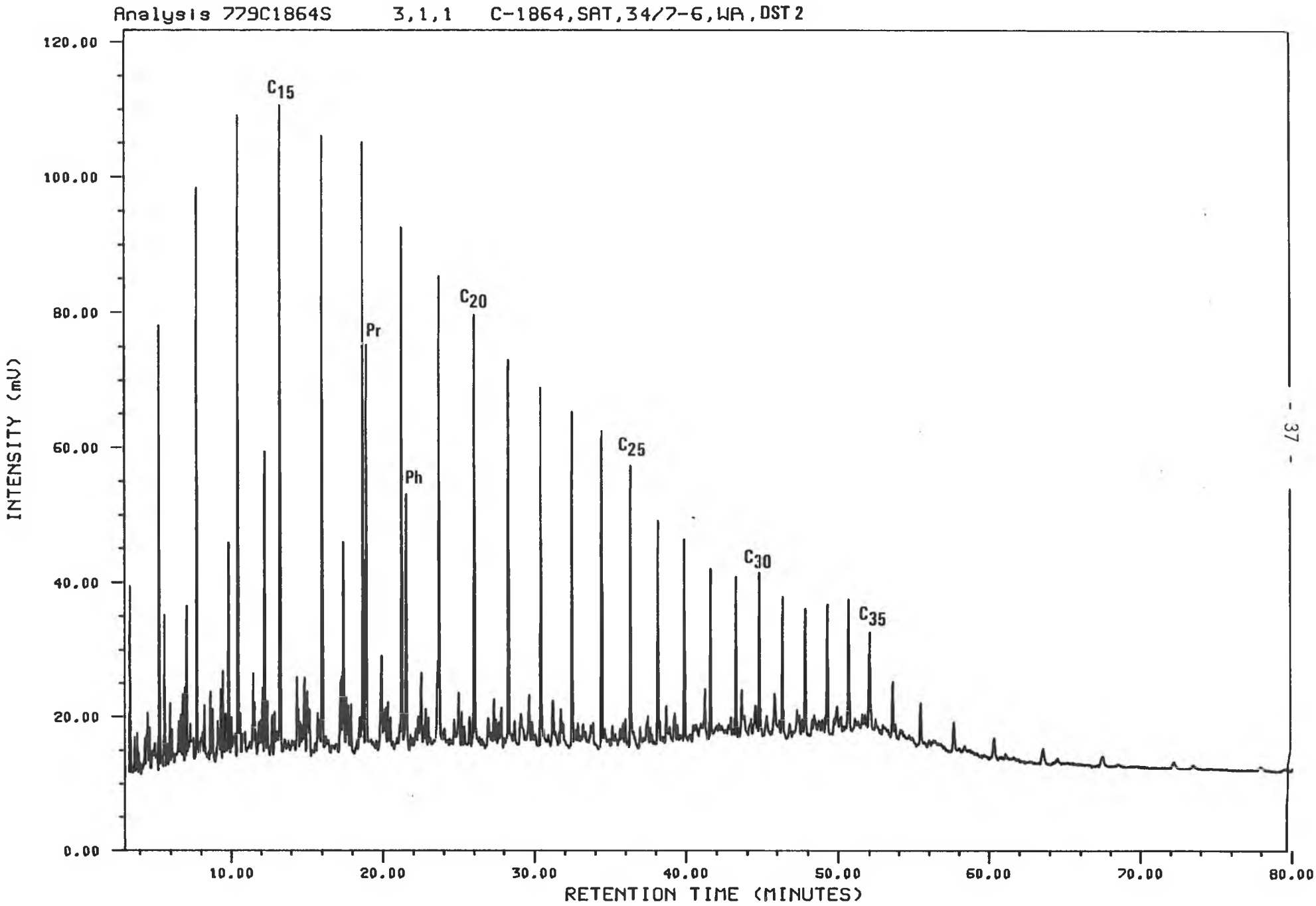

Analysis 779C2945T 2,1,1 C-2945,TOT,34/7-6
Whole Oil
Well 34/7 – 6
DST 3b
MeCy-C6
nC6
nC7
MeCy-C5
nC10
nC15
Pr
Ph
nC20
nC25
nC30
INTENSITY (mV)
RETENTION TIME (MINUTES)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00

FIGURE 3

SATURATED HYDROCARBON GAS CHROMATOGRAMS

Pr - pristane
Ph - phytane
n-C15 etc. - n-alkanes


Analysis 779C1864S 3,1,1 C-1864,SAT,34/7-6,WA,DST 2
120.00
100.00
80.00
60.00
40.00
20.00
0.00
INTENSITY (mV)
C15
Pr
Ph
C20
C25
C30
C35
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)

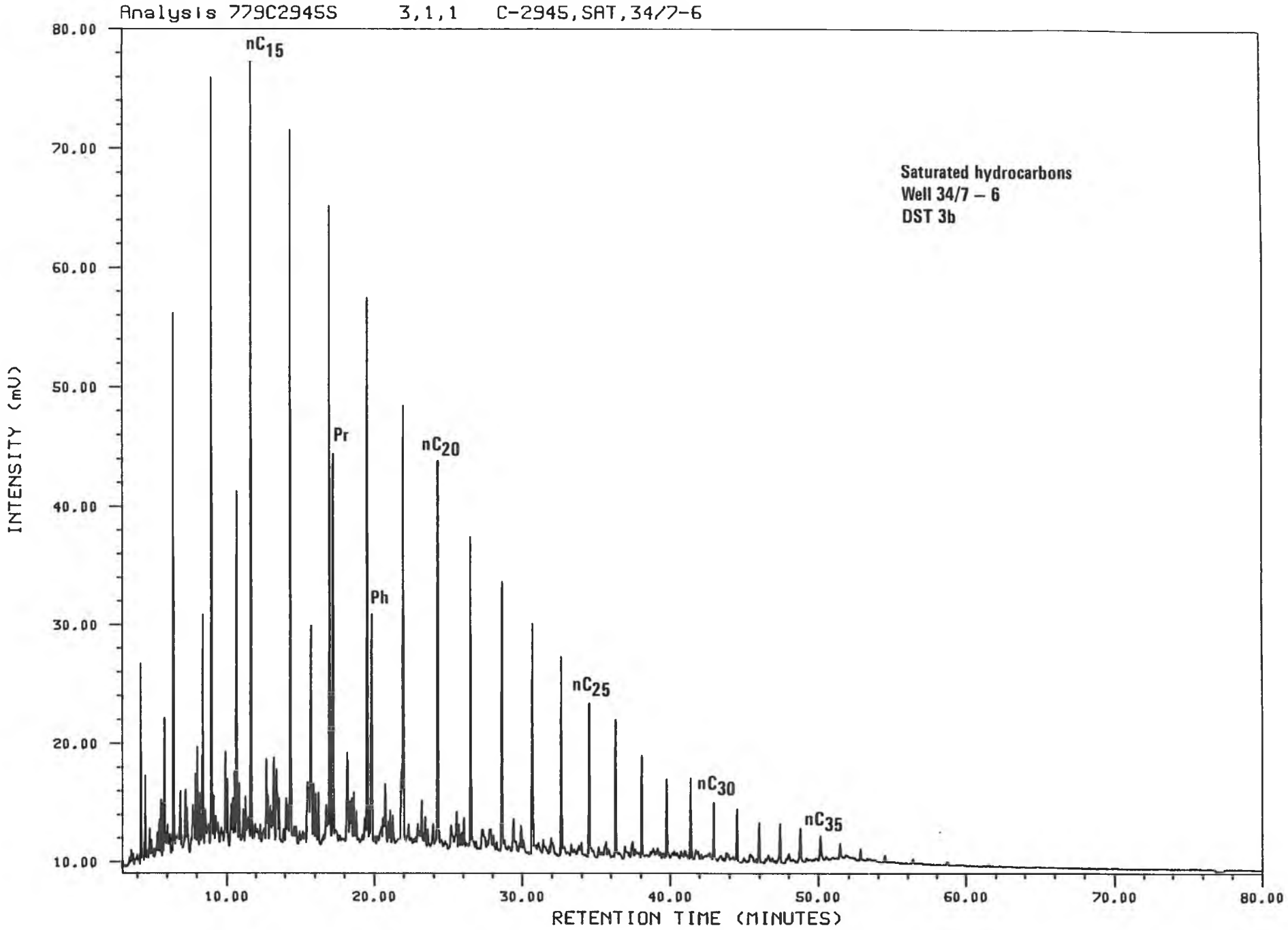
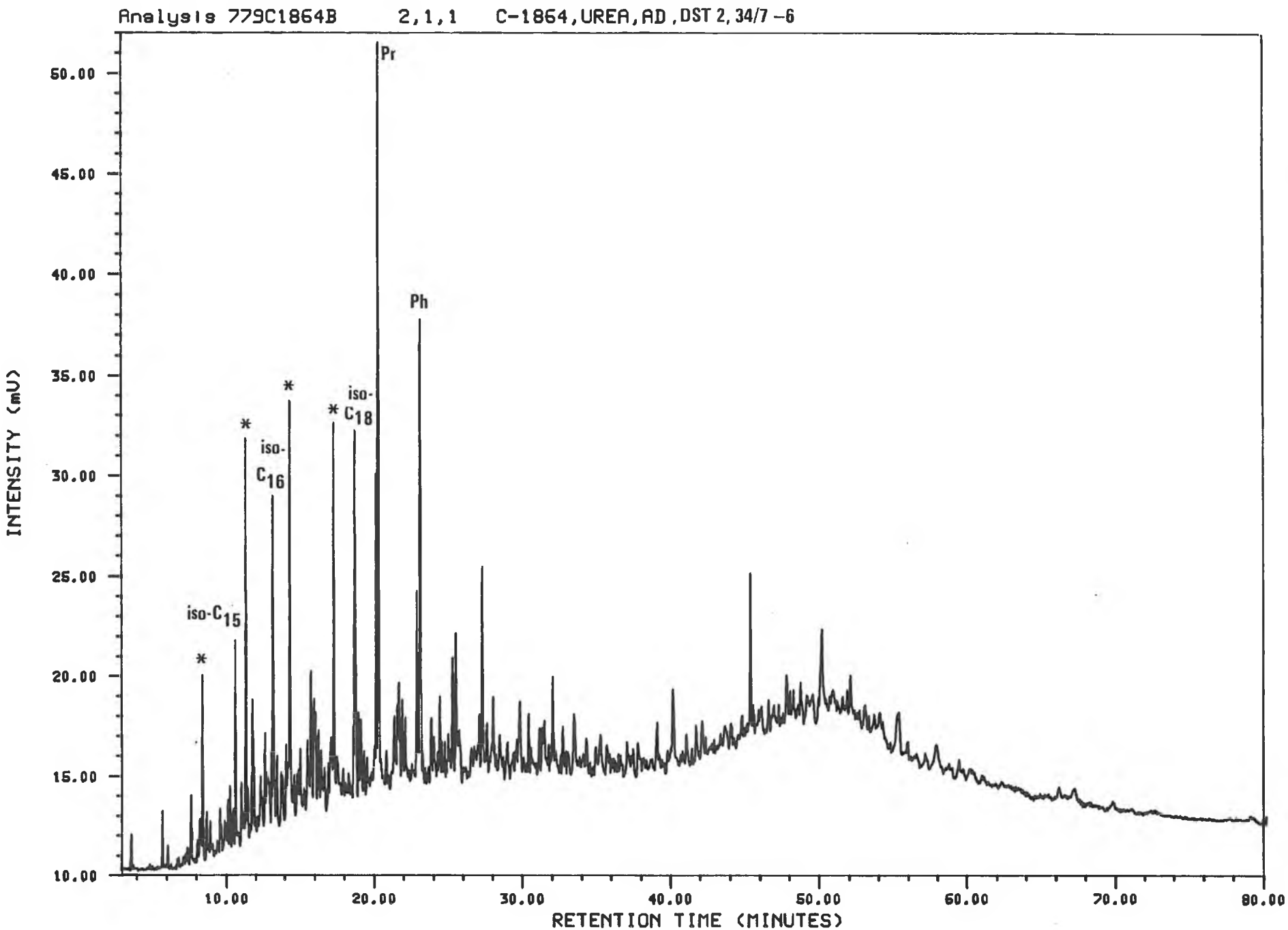

Analysis 779C2945S 3,1,1 C-2945,SAT,34/7-6
Saturated hydrocarbons
Well 34/7 – 6
DST 3b
nC15
Pr
Ph
nC20
nC25
nC30
nC35
INTENSITY (mV)
RETENTION TIME (MINUTES)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00

FIGURE 4

BRANCHED/CYCLIC HYDROCARBON GAS CHROMATOGRAMS

Pr	- pristane
Ph	- phytane
isopr.C18 etc.	- isoprenoids
*	- rest of n-alkanes


Analysis 779C1864B 2,1,1 C-1864,UREA,AD,DST 2,34/7 -6
Pr
Ph
iso-C15
iso-C16
iso-C18
*
INTENSITY (mU)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)

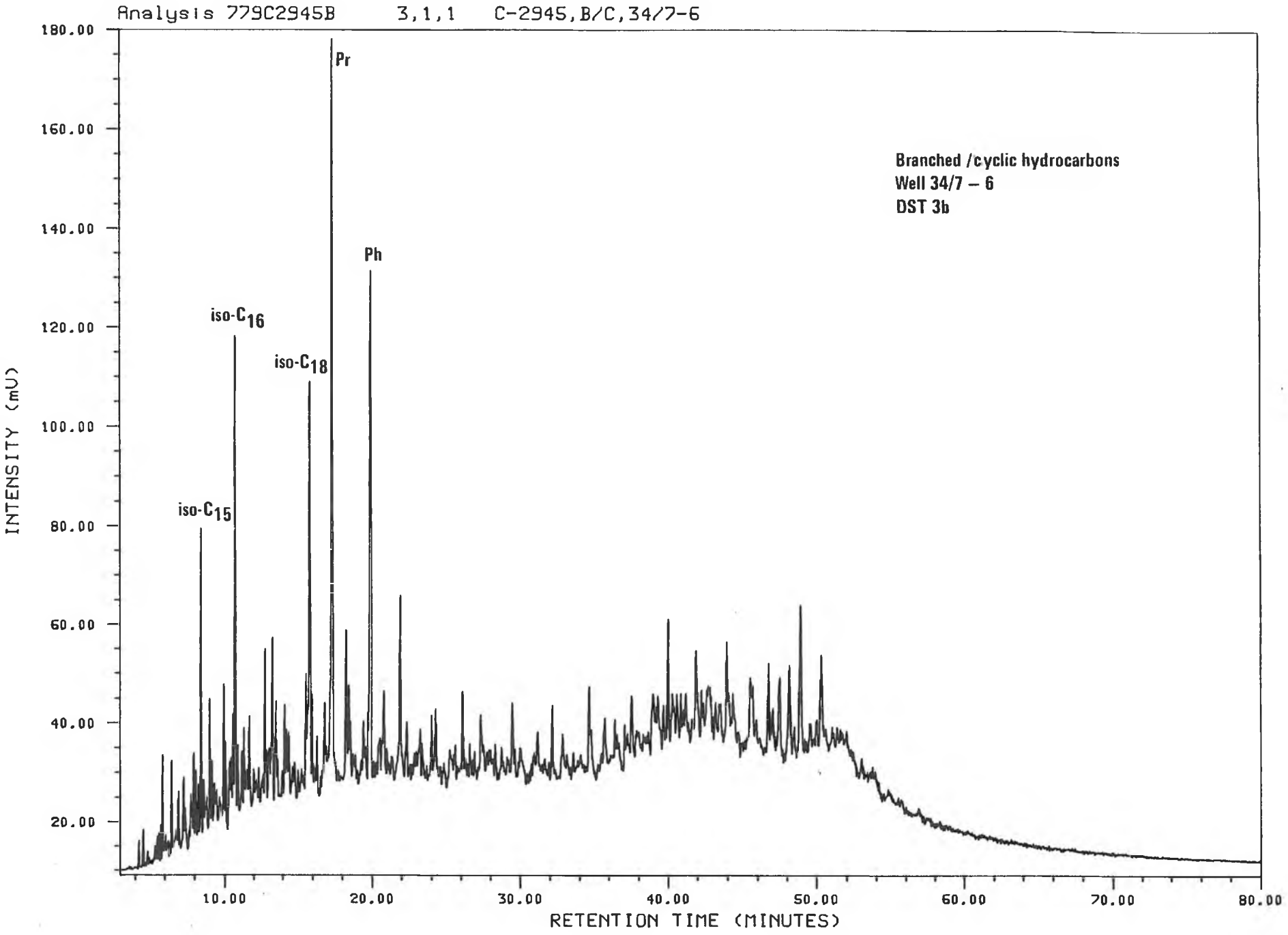
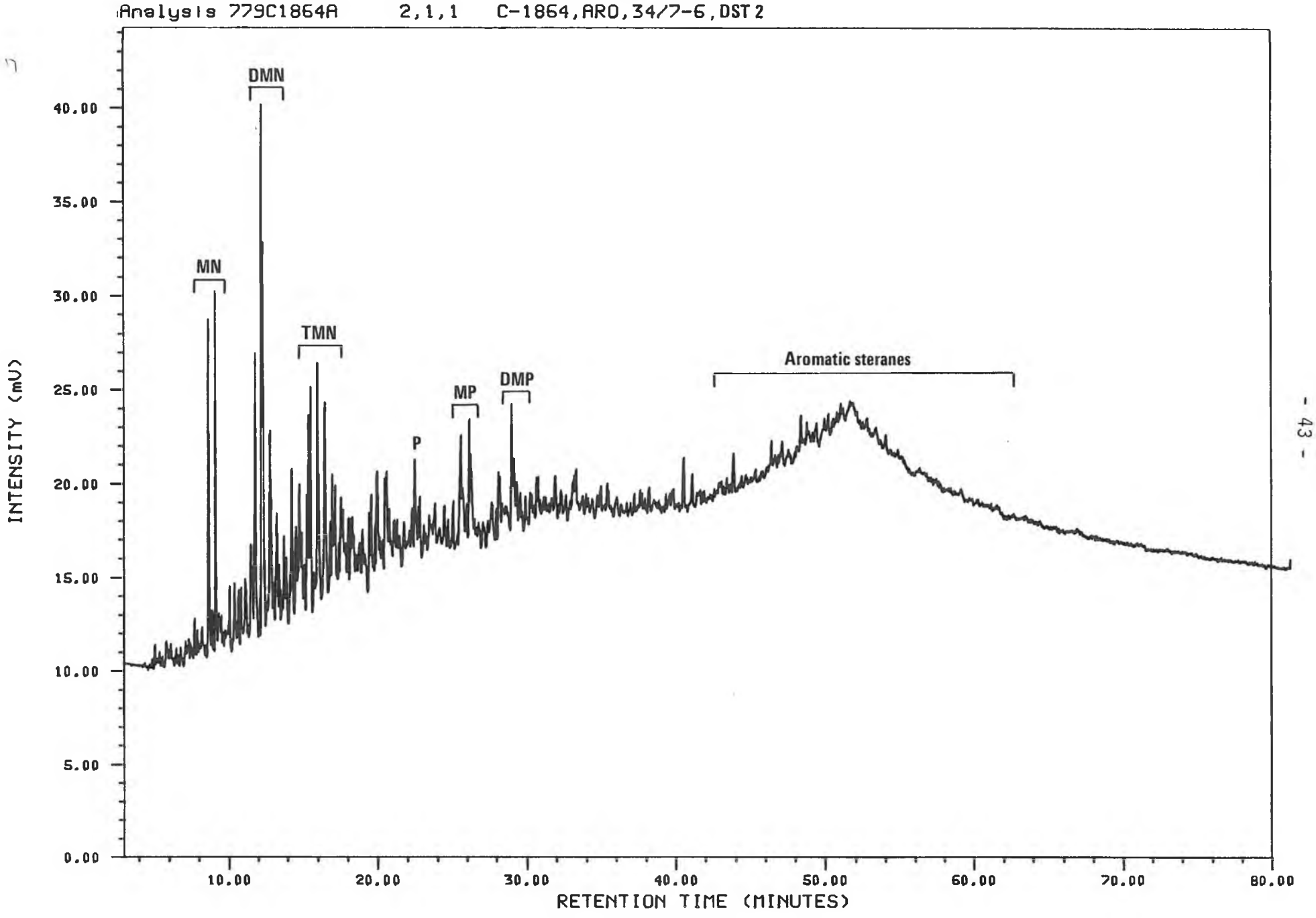
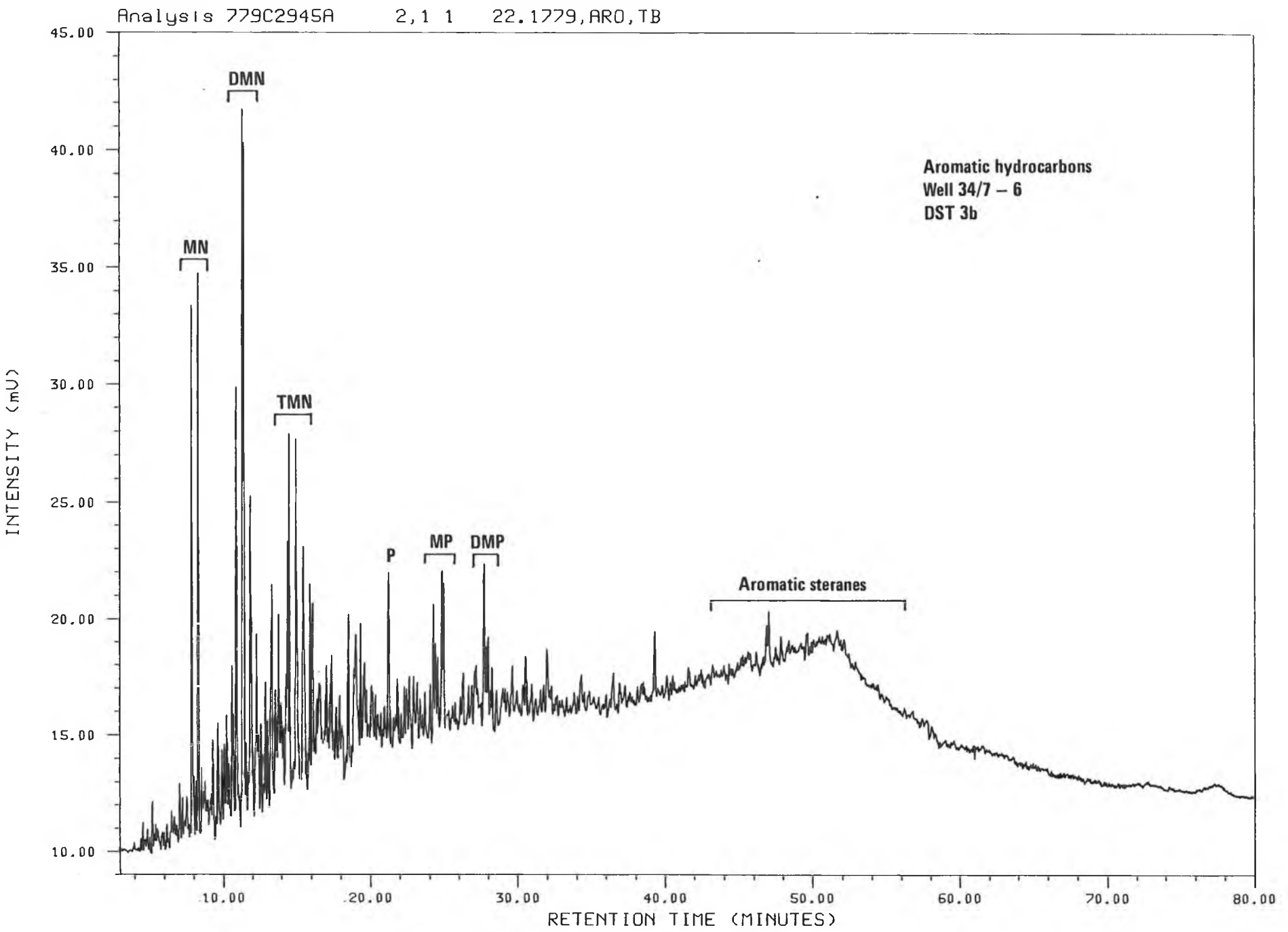

Analysis 779C2945B 3,1,1 C-2945,B/C,34/7-6
Branched /cyclic hydrocarbons
Well 34/7 – 6
DST 3b
Pr
Ph
iso-C16
iso-C18
iso-C15
INTENSITY (mU)
RETENTION TIME (MINUTES)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00

FIGURE 5

AROMATIC HYDROCARBON GAS CHROMATOGRAMS

N,MN,DMN,TMN	- naphthalene and alkylated homologs
P,MP,DMP	- phenanthrene and alkylated homologs


Analysis 779C1864A 2,1,1 C-1864,ARO,347-6,DST 2
DMN
MN
TMN
P
MP
DMP
Aromatic steranes
INTENSITY (mV)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)

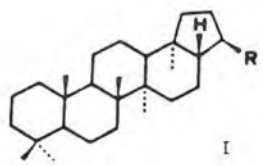

Analysis 779C2945A 2,1 1 22.1779,ARO,TB
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
INTENSITY (mV)
DMN
MN
TMN
P
MP
DMP
Aromatic steranes
Aromatic hydrocarbons
Well 34/7 – 6
DST 3b
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
RETENTION TIME (MINUTES)

IKU SINTEF-GRUPPEN

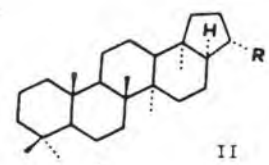
Figure 6a

Mass chromatograms representing terpanes (m/z 191)

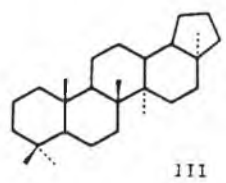
A	T_s, 18α(H)-trisnorneohopane	$C_{27}H_{46}$	(III)
B	T_m, 17α(H)-trisnorhopane	$C_{27}H_{46}$	(I,R=H)
C	17α(H)-norhopane	$C_{29}H_{50}$	(I,R=C_2H_5)
D	17β(H)-normoretane	$C_{29}H_{50}$	(II,R=C_2H_5)
E	17α(H)-hopane	$C_{30}H_{52}$	(I,R=C_3H_7)
F	17β(H)-moretane	$C_{30}H_{52}$	(II,R=C_3H_7)
G	17α(H)-homohopane (22S)	$C_{31}H_{54}$	(I,R=C_4H_9)
H	17α(H)-homohopane (22R)	$C_{31}H_{54}$	(I,R=C_4H_9)
	+ unknown triterpane (gammacerane?)		
I	17β(H)-homomoretane	$C_{31}H_{54}$	(II,R=C_4H_9)
J	17α(H)-bishomohopane (22S,22R)	$C_{32}H_{56}$	(I,R=C_5H_{11})
K	17α(H)-trishomohopane (22S,22R)	$C_{33}H_{58}$	(I,R=C_6H_{13})
L	17α(H)-tetrakishomohopane (22S,22R)	$C_{34}H_{60}$	(I,R,=C_7H_{15})
M	17α(H)-pentakishomohopane (22S,22R)	$C_{35}H_{62}$	(I,R=C_8H_{17})
Z	bisnorhopane	$C_{28}H_{48}$	
X	unknown triterpane	$C_{30}H_{52}$	
P	tricyclic terpane	$C_{23}H_{42}$	(IV,R=C_4H_9)
Q	tricyclic terpane	$C_{24}H_{44}$	(IV,R=C_5H_{11})
R	tricyclic terpane (17R,17S)	$C_{25}H_{46}$	(IV,R=C_6H_{13})
S	tetracyclic terpane	$C_{24}H_{42}$	(V)
T	tricyclic terpane (17R,17S)	$C_{26}H_{48}$	(IV,R=C_7H_{15})



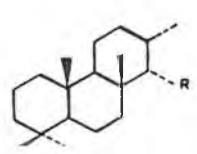
I

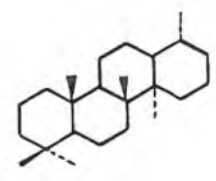


II



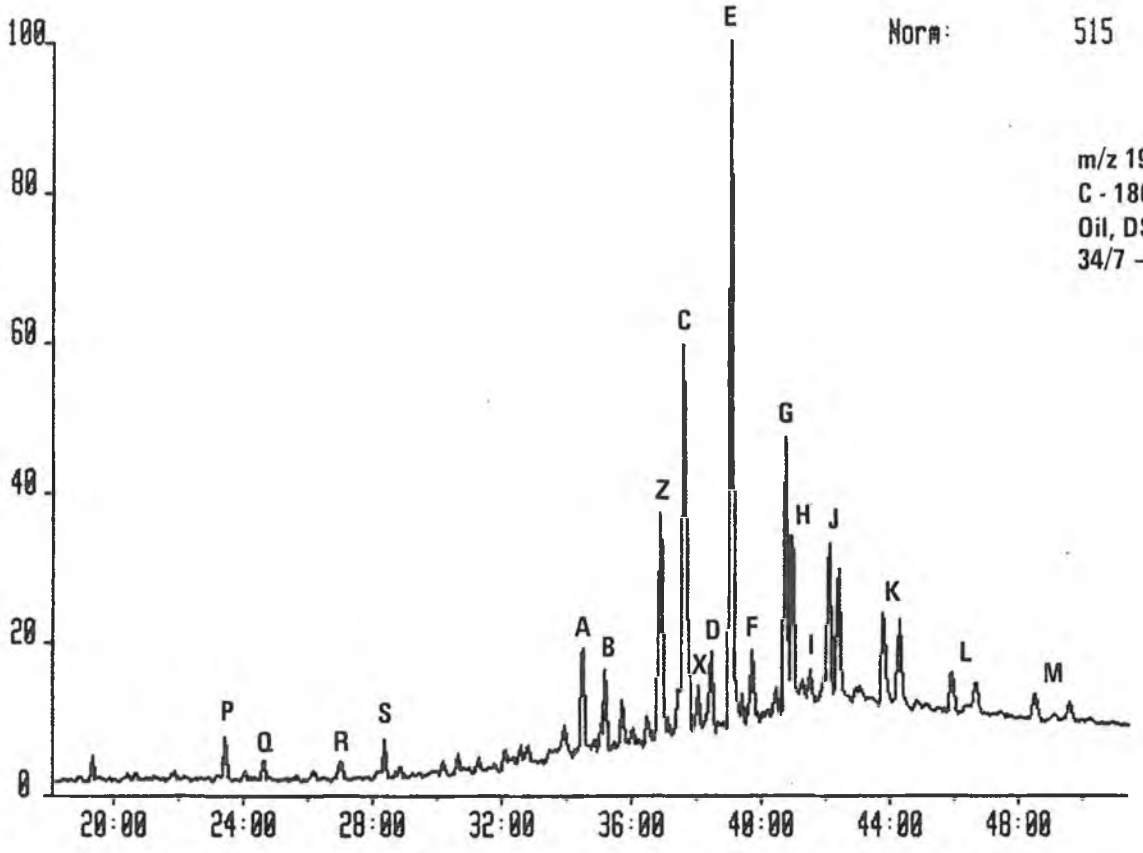
III



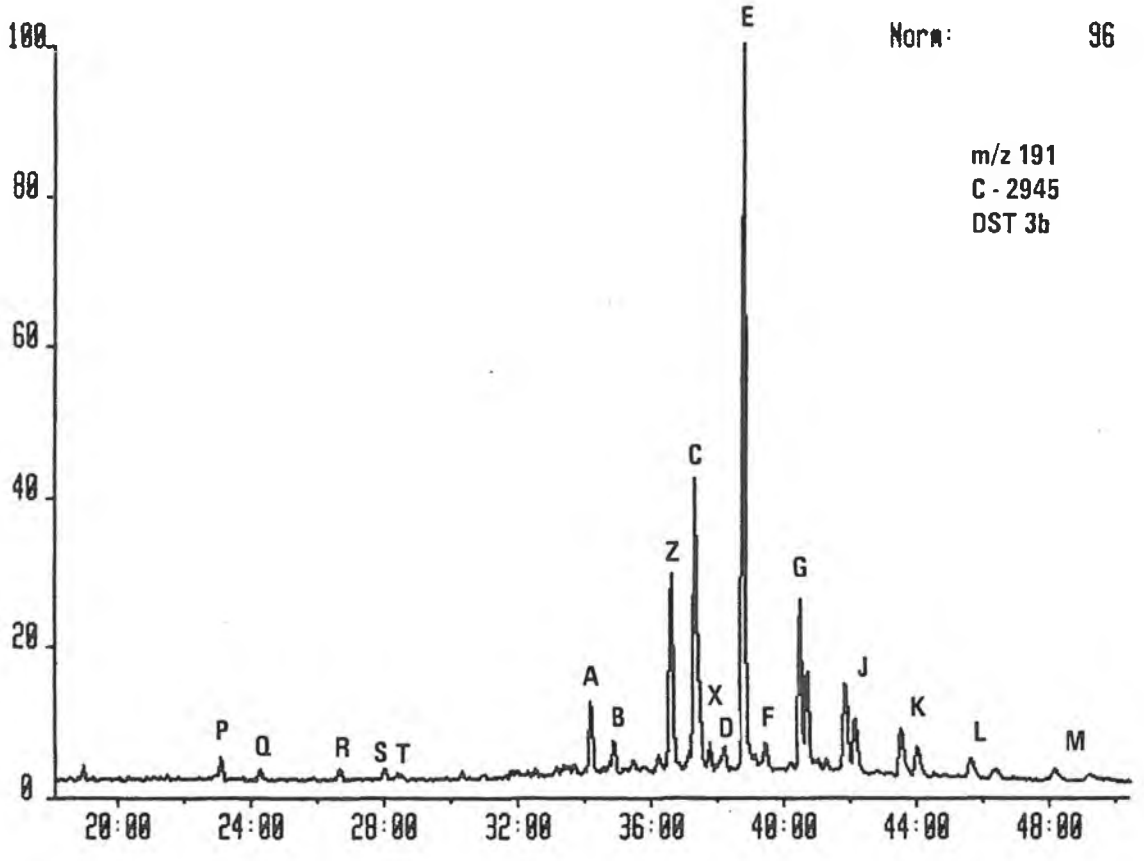


IKU SINTEF-GRUPPEN

C1864SAT 18-OCT-85 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 191.1000
Text:



C2945SATT 9-NOV-85 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 191.1000
Text:

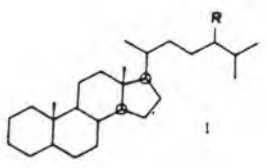


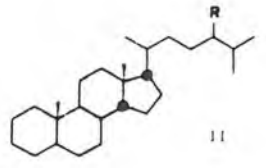
IKU SINTEF-GRUPPEN

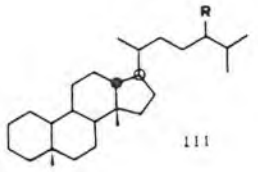
Figure 6b

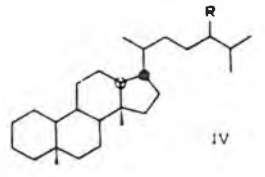
Mass chromatograms representing steranes (m/z 217 and 218)

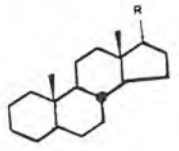
a	13β(H),17α(H)-diasterane (20S)	$C_{27}H_{48}$	(III,R=H)
b	13β(H),17α(H)-diasterane (20R)	$C_{27}H_{48}$	(III,R=H)
c	13α(H),17β(H)-diasterane (20S)	$C_{27}H_{48}$	(IV,R=H)
d	13α(H),17β(H)-diasterane (20R)	$C_{27}H_{48}$	(IV,R=H)
e	13β(H),17α(H)-diasterane (20S)	$C_{28}H_{50}$	(III,R=CH_3)
f	13β(H),17α(H)-diasterane (20R)	$C_{28}H_{50}$	(III,R=CH_3)
g	13α(H),17β(H)-diasterane (20S)	$C_{28}H_{50}$	(IV,R=CH_3)
	+ 14α(H),17α(H)-sterane (20S)	$C_{27}H_{48}$	(I,R=H)
h	13β(H),17α(H)-diasterane (20S)	$C_{29}H_{52}$	(III,R=C_2H_5)
	+ 14β(H),17β(H)-sterane (20R)	$C_{27}H_{48}$	(II,R=H)
i	14β(H),17β(H)-sterane (20S)	$C_{27}H_{48}$	(II,R=H)
	+ 13α(H),17β(H)-diasterane (20R)	$C_{28}H_{50}$	(IV,R=CH_3)
j	14α(H),17α(H)-sterane (20R)	$C_{27}H_{48}$	(I,R=H)
k	13β(H),17α(H)-diasterane (20R)	$C_{29}H_{52}$	(III,R=C_2H_5)
l	13α(H),17β(H)-diasterane (20S)	$C_{29}H_{52}$	(III,R=C_2H_5)
m	14α(H),17α(H)-sterane (20S)	$C_{28}H_{50}$	(I,R=CH_3)
n	13α(H),17β(H)-diasterane (20R)	$C_{29}H_{52}$	(III,R=C_2H_5)
	+ 14β (H),17β (H)-sterane (20R)	$C_{28}H_{50}$	(II,R=CH_3)
o	14β(H),17β(H)-sterane (20S)	$C_{28}H_{50}$	(II,R=CH_3)
p	14α(H),17α(H)-sterane (20R)	$C_{28}H_{50}$	(I,R=CH_3)
q	14α(H),17α(H)-sterane (20S)	$C_{29}H_{52}$	(I,R=C_2H_5)
r	14β(H),17β(H)-sterane (20R)	$C_{29}H_{52}$	(II,R=C_2H_5)
	+ unknown sterane		
s	14β(H),17β(H)-sterane (20S)	$C_{29}H_{52}$	(II,R=C_2H_5)
t	14β(H),17β(H)-sterane (20R)	$C_{29}H_{52}$	(I,R=C_2H_5)
u	5α(H)-sterane	$C_{21}H_{36}$	(V,R=C_2H_5)
v	5α(H)-sterane	$C_{22}H_{38}$	(IV,R=C_3H_7)



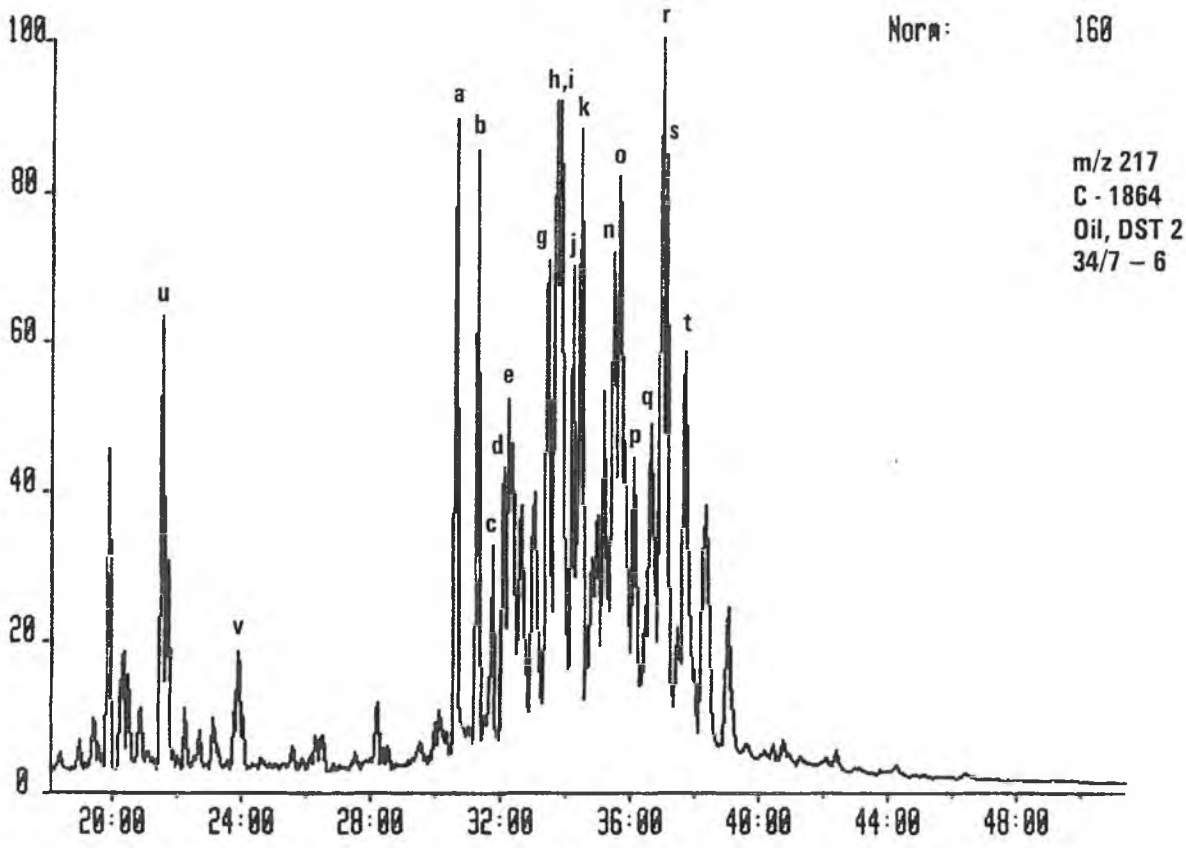




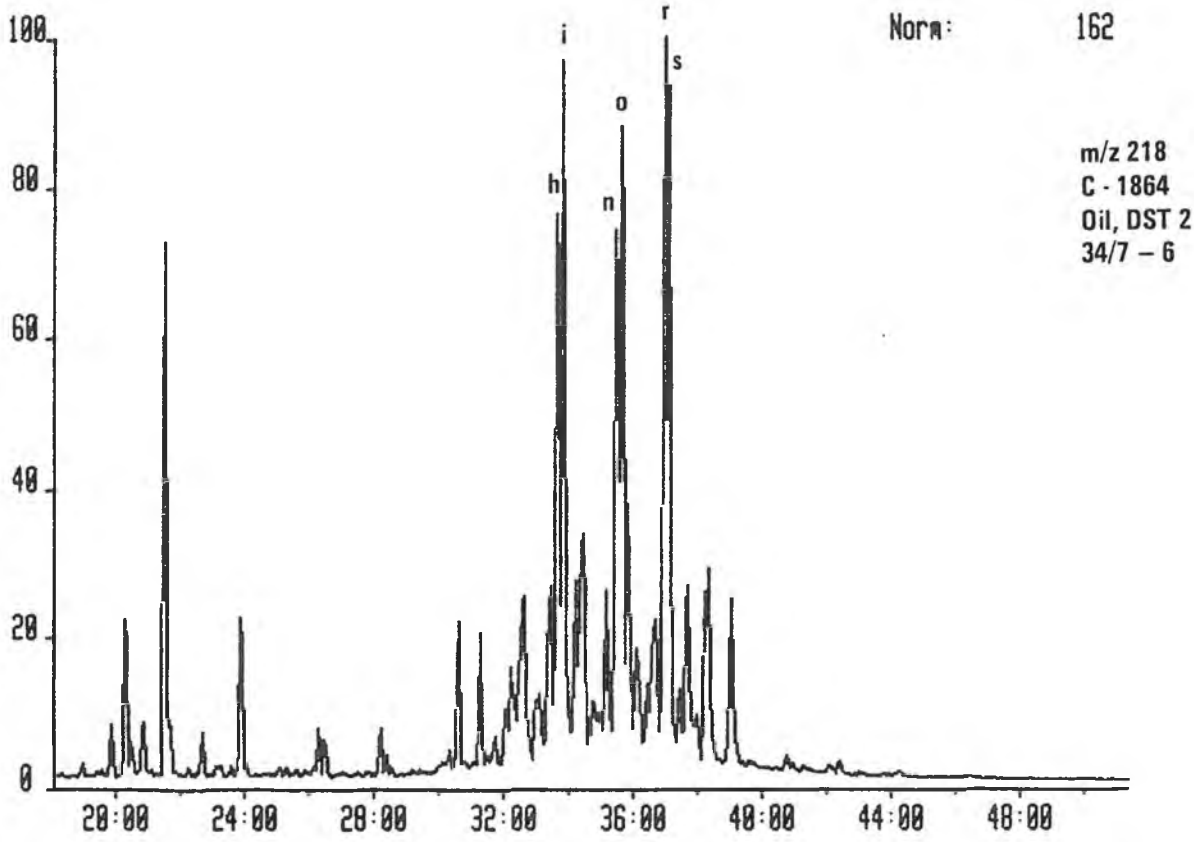




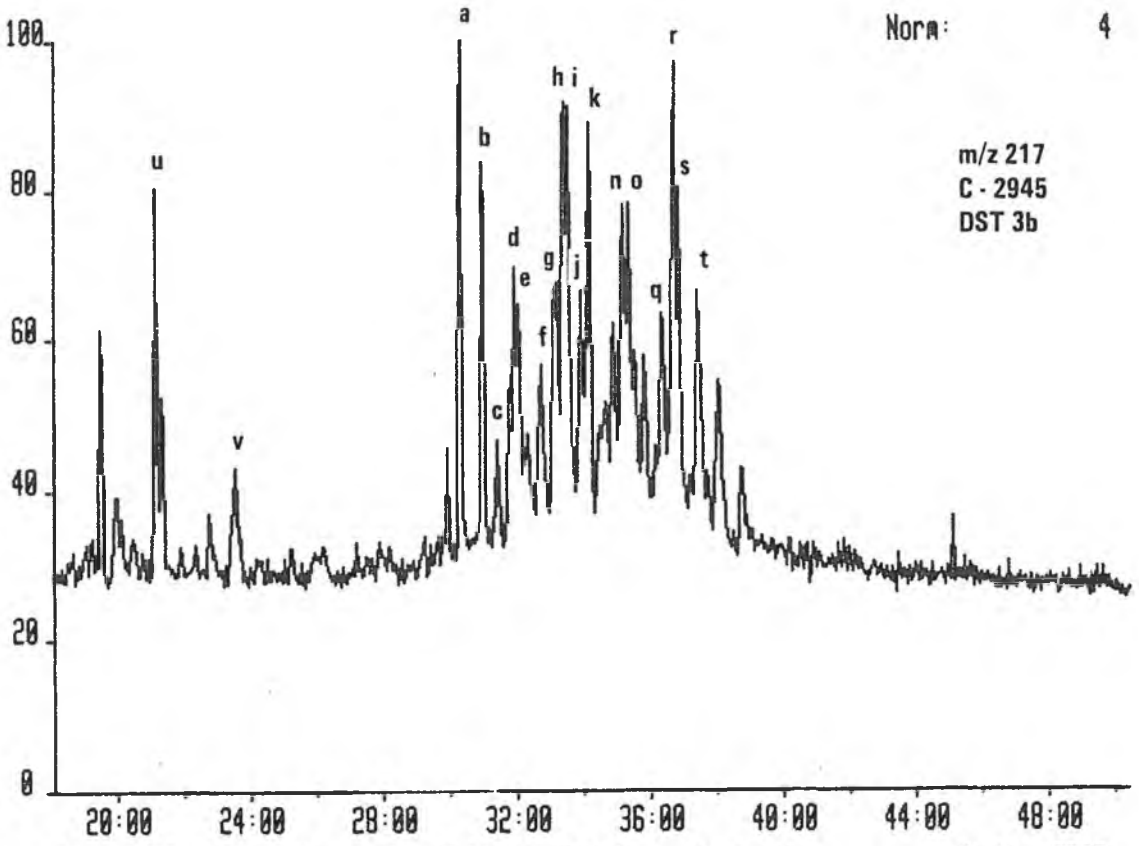
C18G4SAT 18-OCT-85 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 217.1000
Text:



C18G4SAT 18-OCT-85 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 218.1000
Text:



C2945SATT 9-NOV-85 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 217.1000
Text:



C2945SATT 9-NOV-85 Sir:Voltage 7070H Acnt:IKU System:TRIT
Sample 1 Injection 1 Group 1 Mass 218.1000
Text:

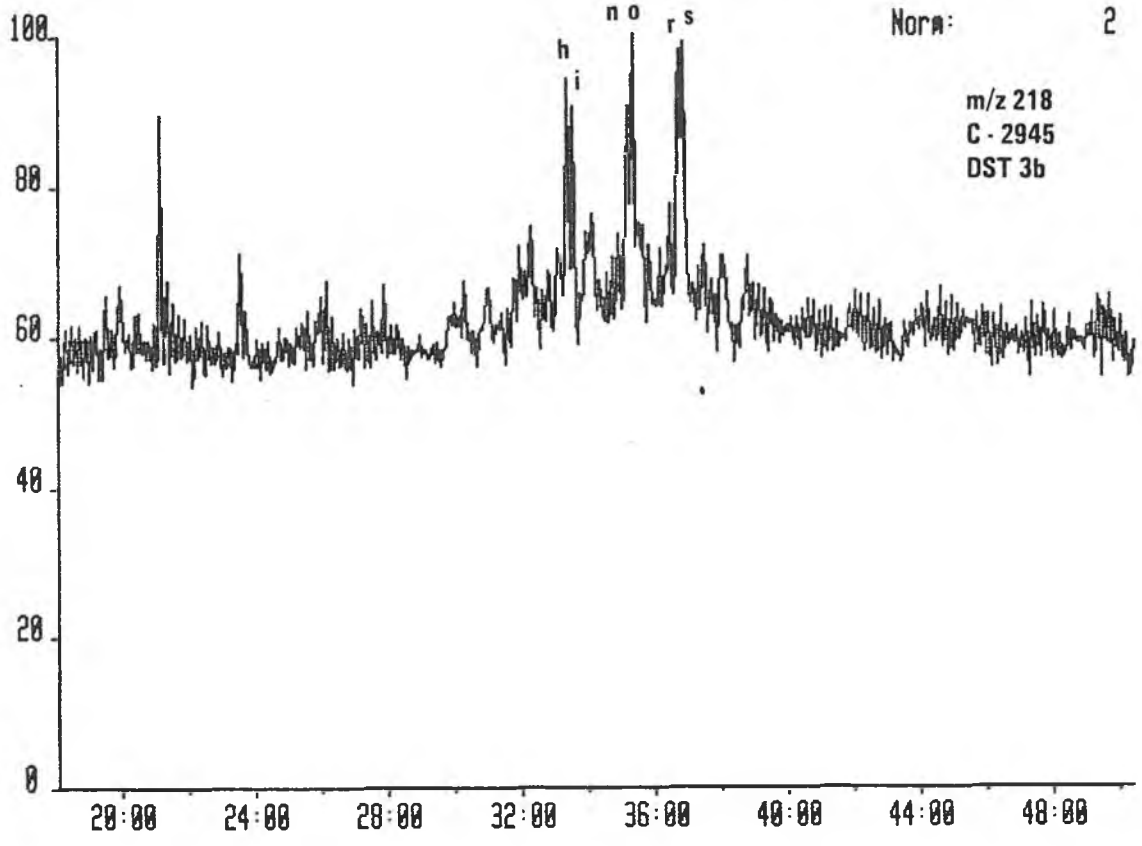


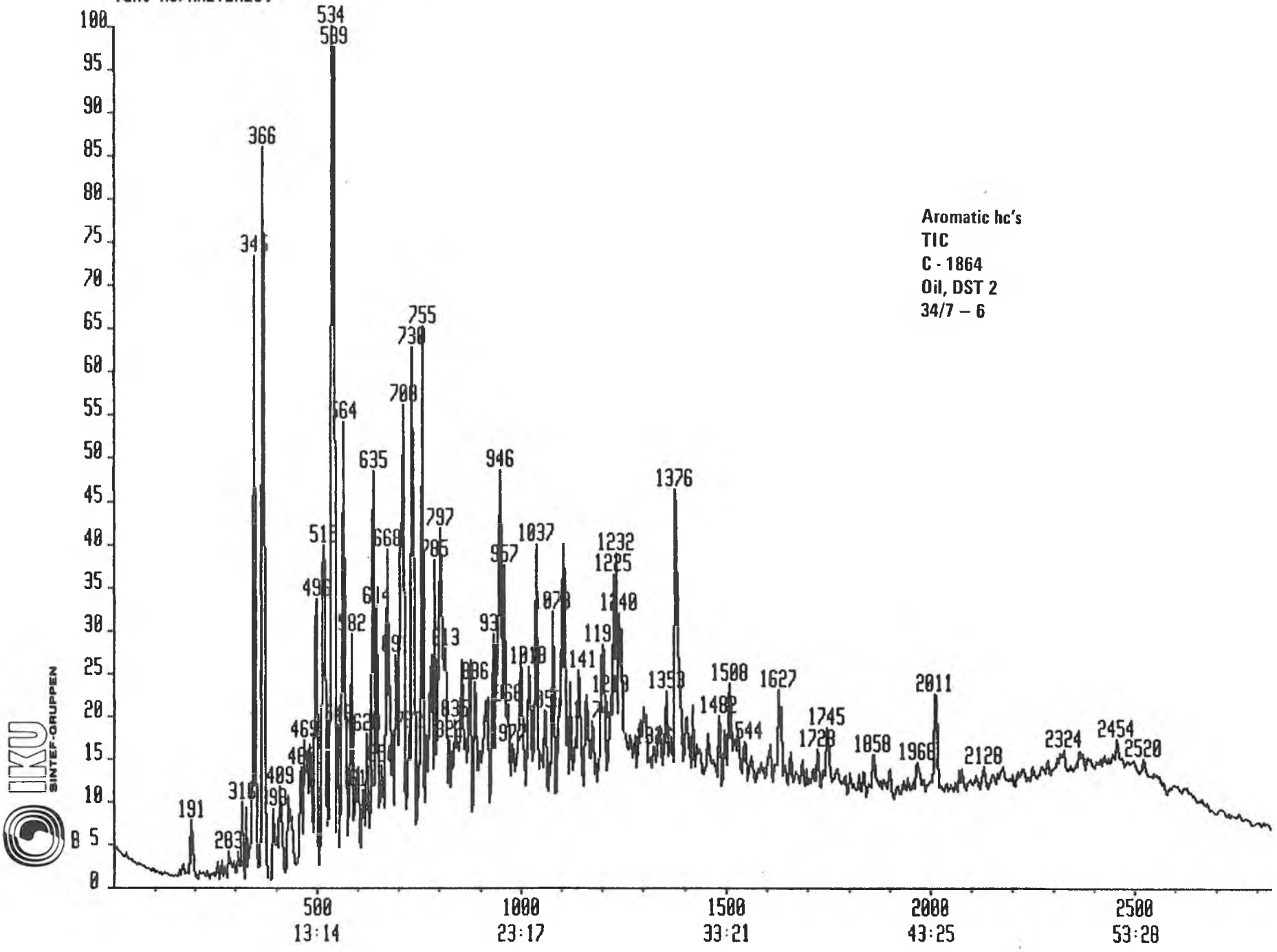
FIGURE 7

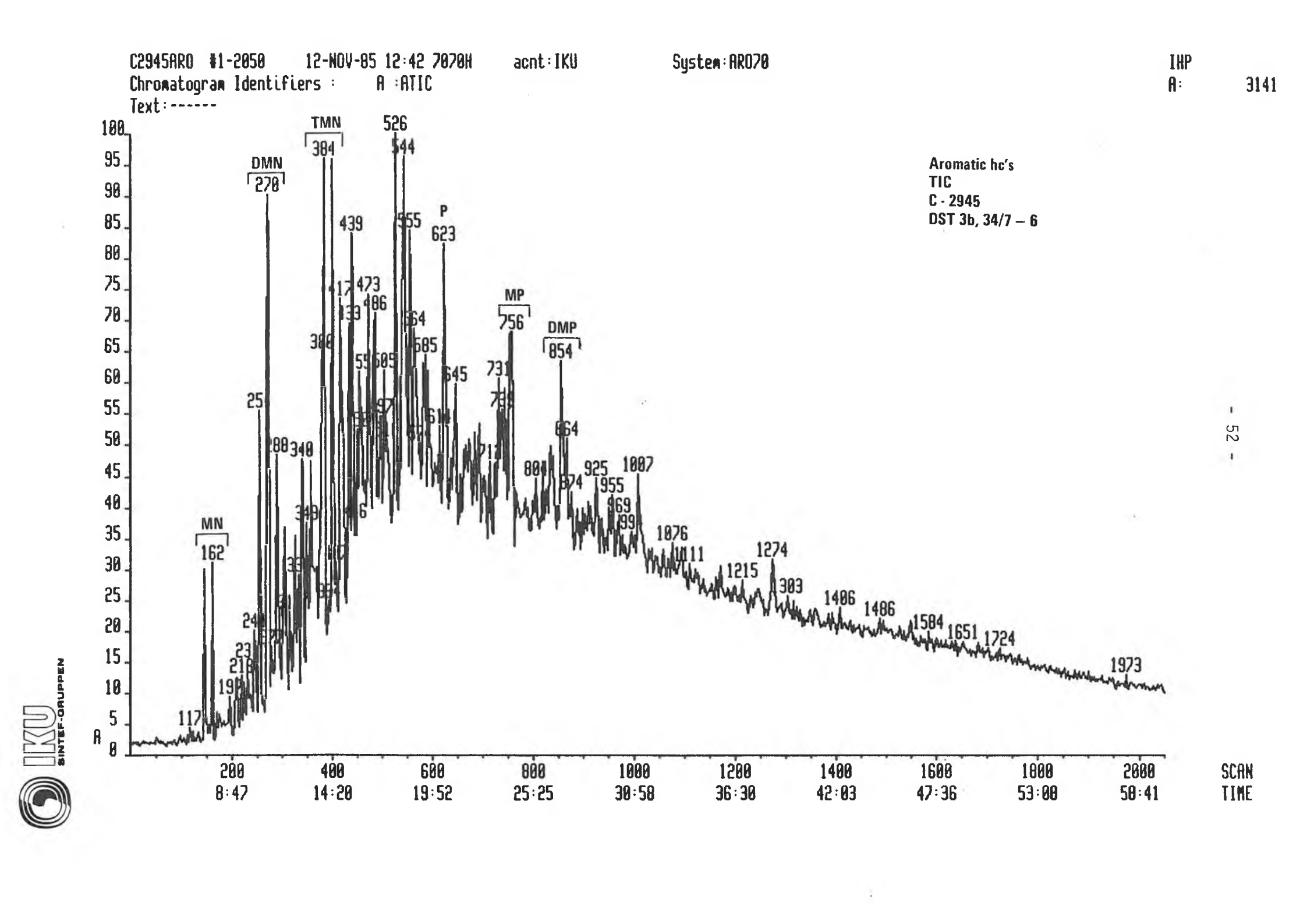
MASS CHROMATOGRAMS REPRESENTING AROMATIC HYDROCARBONS

TIC	- total ion chromatogram
m/z 92,106	- alkyl benzenes
m/z 142,156,170	- alkyl naphthalenes
m/z 178,192,206	- phenanthrene and alkyl phenanthrenes
m/z 184,198,212	- dibenzothiophene and alkyl dibenzothiophenes
m/z 231	- triaromatic steranes
m/z 253	- monoaromatic steranes

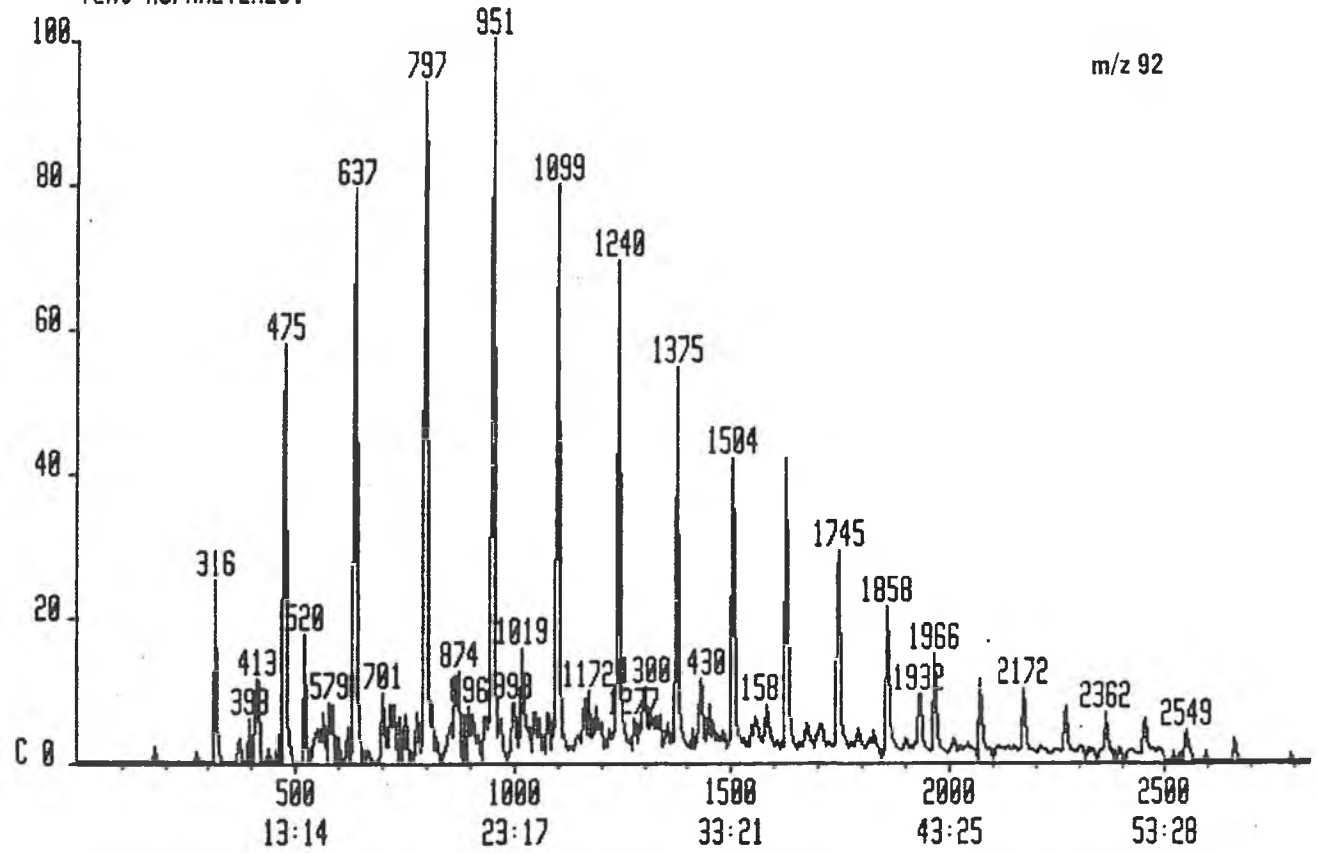
(m/z 231, 253 gave poor traces for DST 2 and are not included).

C1864AR02 #1-2833 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : B1:TIC B: 3930000
Text:ASPHALTENES.

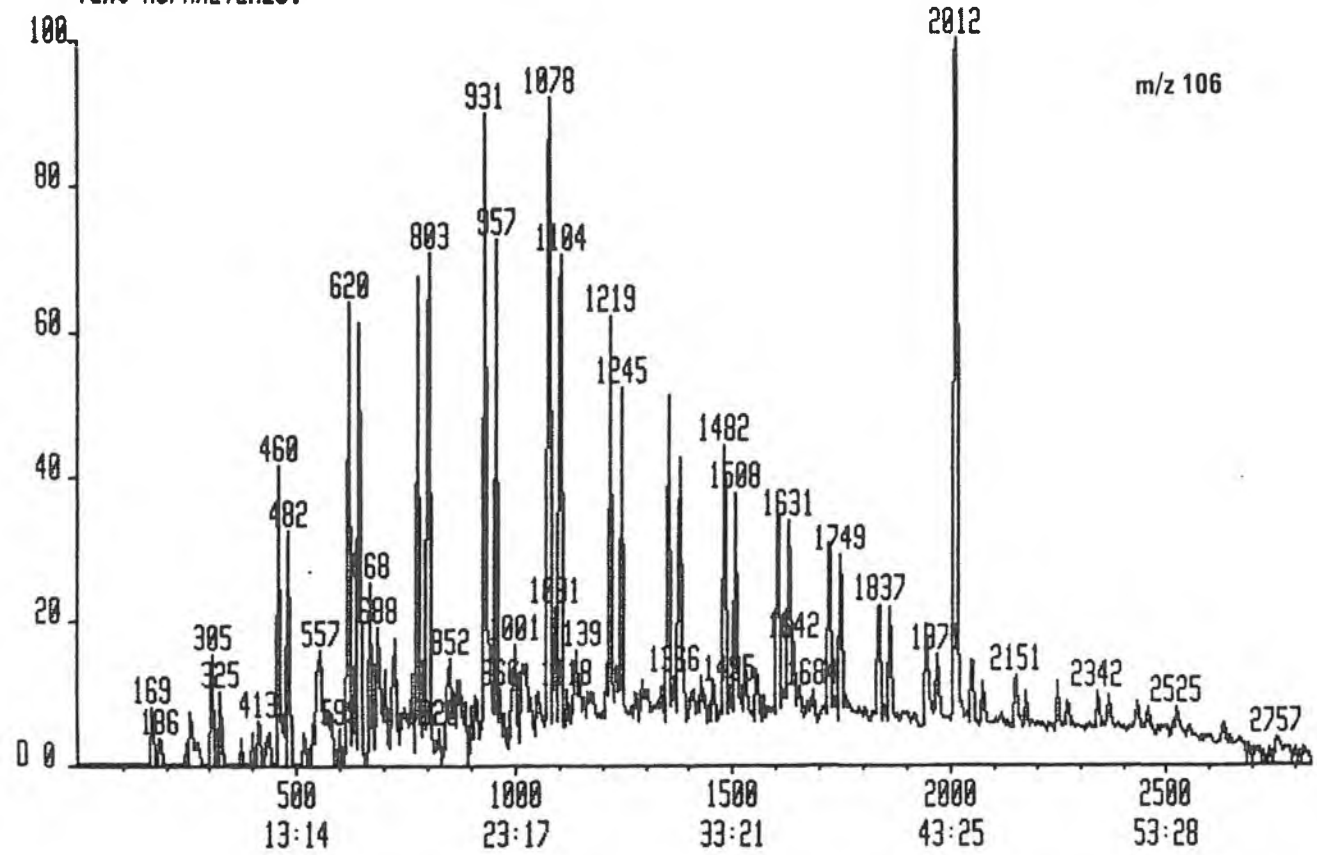


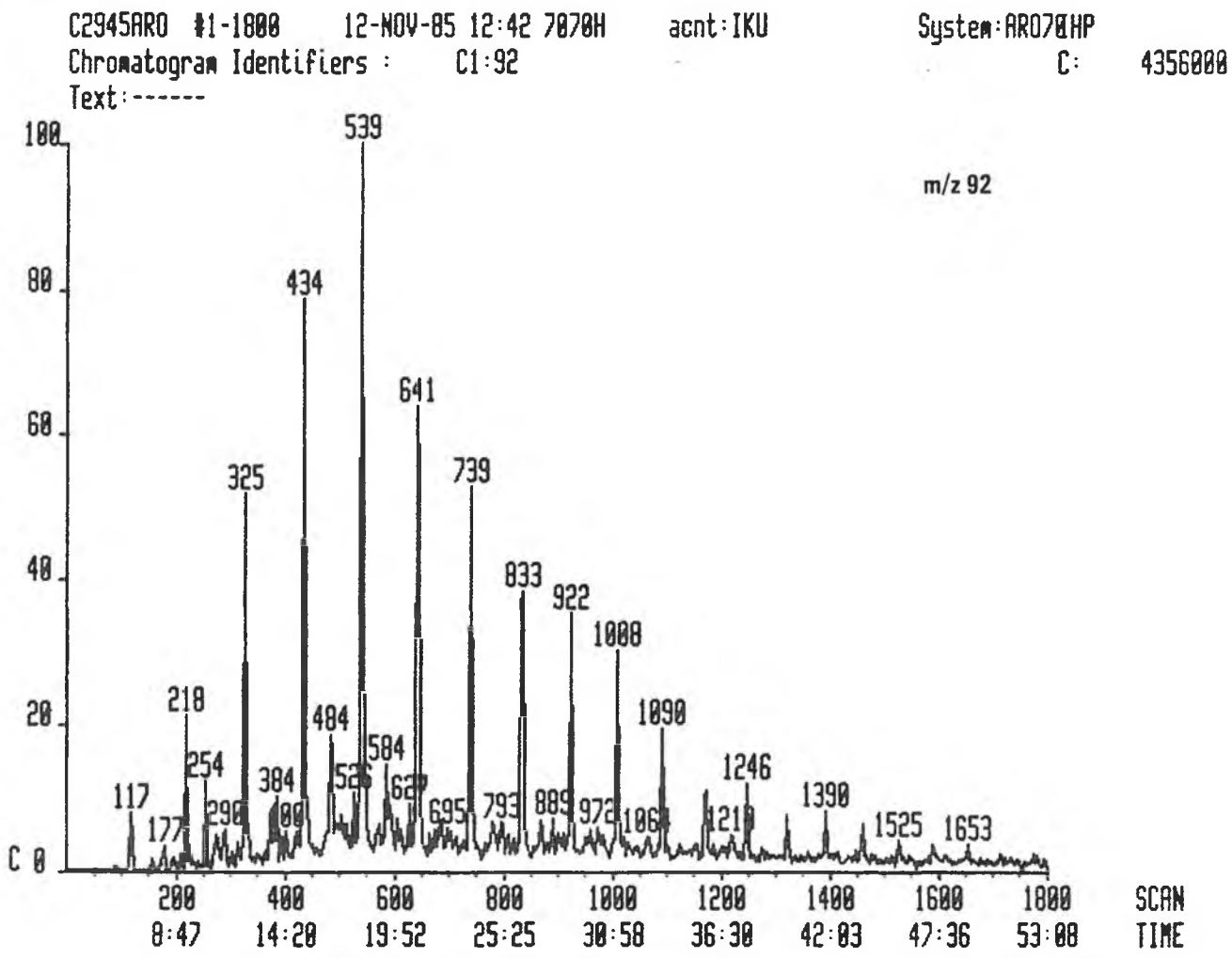

C2945ARO #1-2050 12-NOV-85 12:42 7070H acnt:IKU System:ARO70 IHP
Chromatogram Identifiers : A :ATIC A: 3141
Text:------
Aromatic hc's
TIC
C - 2945
DST 3b, 34/7 – 6
MN
DMN
TMN
P
MP
DMP
A
SCAN
TIME
IKU
SINTEF-GRUPPEN
- 52 -

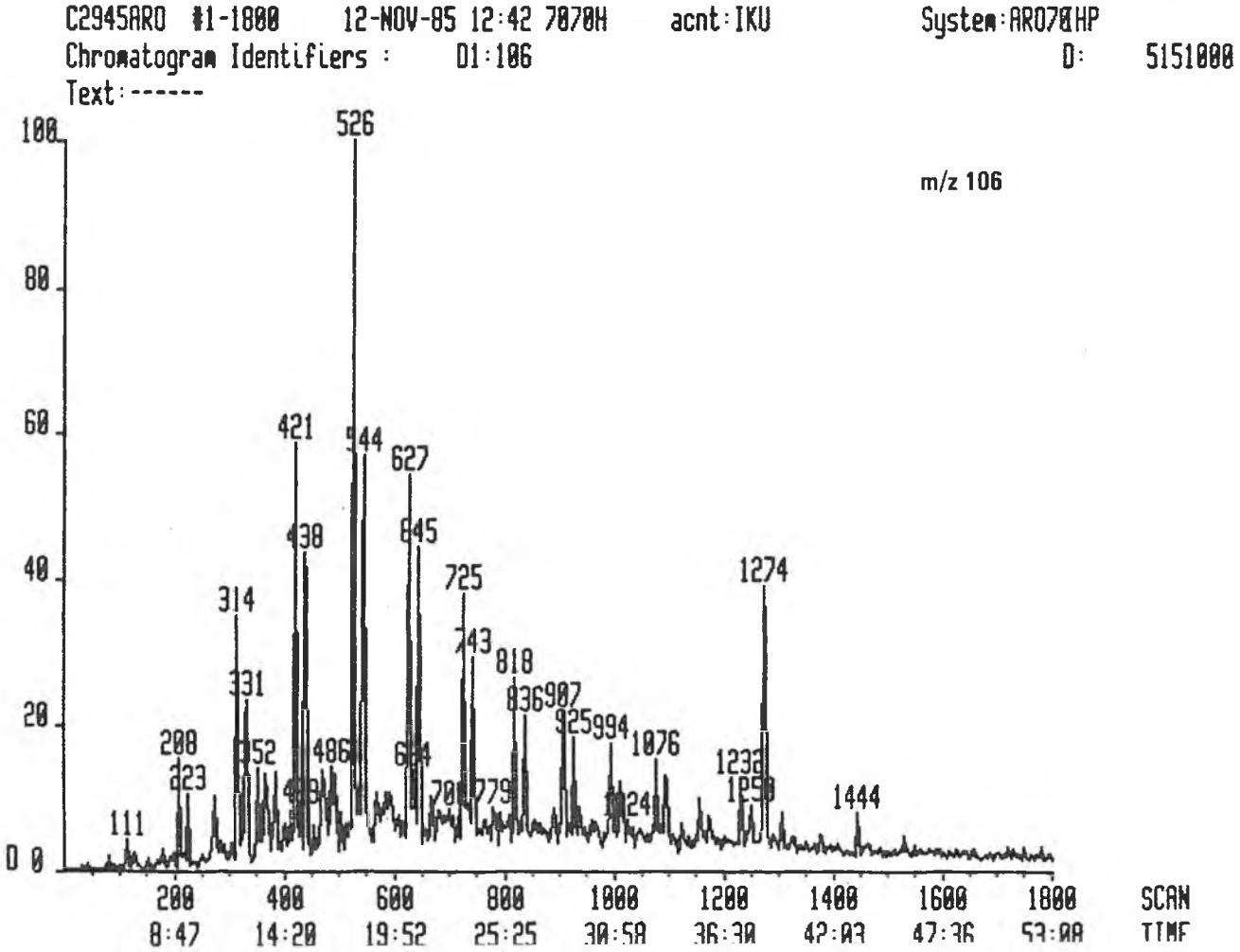
C1864AR02 #1-2833 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : C1:92 C: 300000
Text:ASPHALTENES.



C1864AR02 #1-2833 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : D1:106 D: 231000
Text:ASPHALTENES.

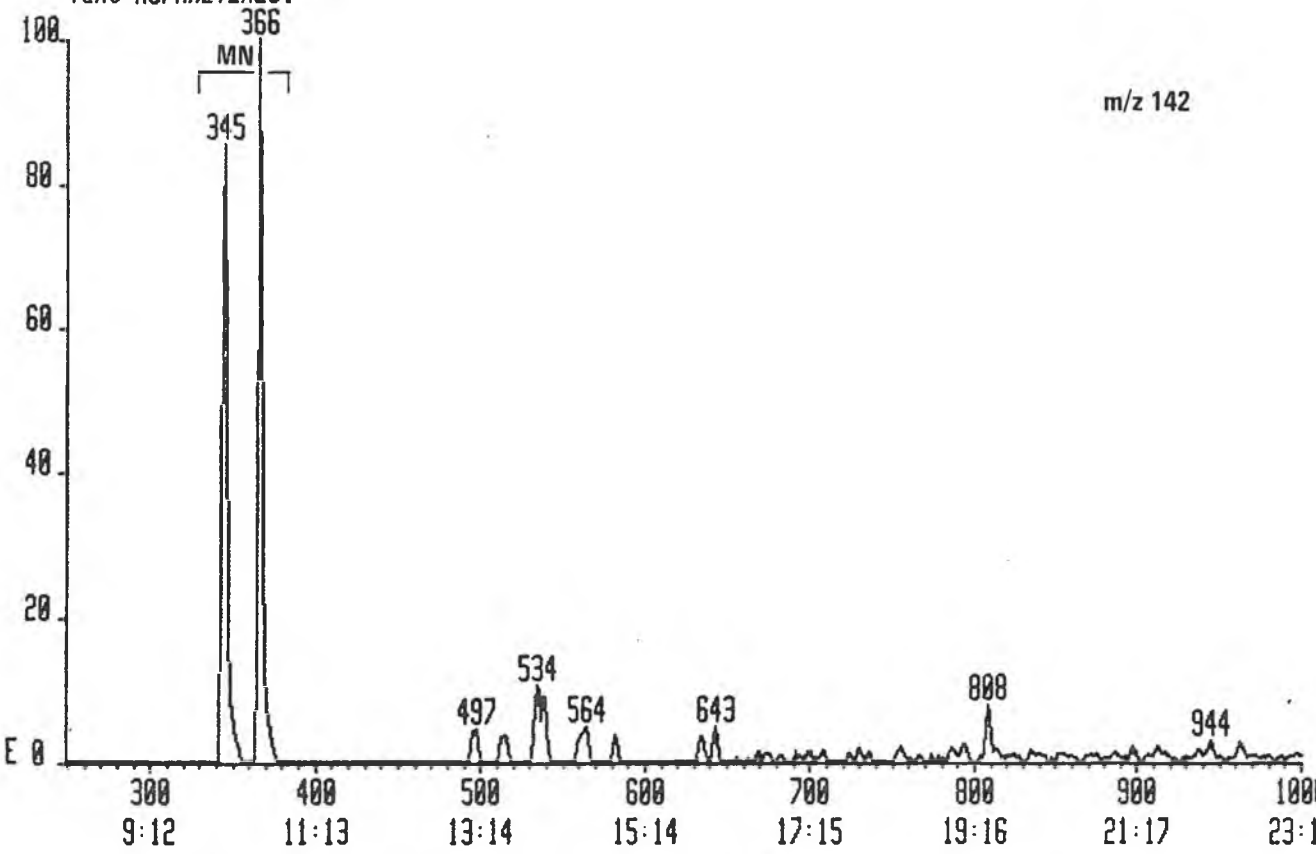



C2945ARO #1-1000 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : C1:92 C: 4356000
Text:------
m/z 92
539
434
641
325
739
833
922
1008
1090
218
484
584
254
384
1246
1390
117
1525
1653
C 0
200 400 600 800 1000 1200 1400 1600 1800 SCAN
8:47 14:20 19:52 25:25 30:58 36:30 42:03 47:36 53:08 TIME

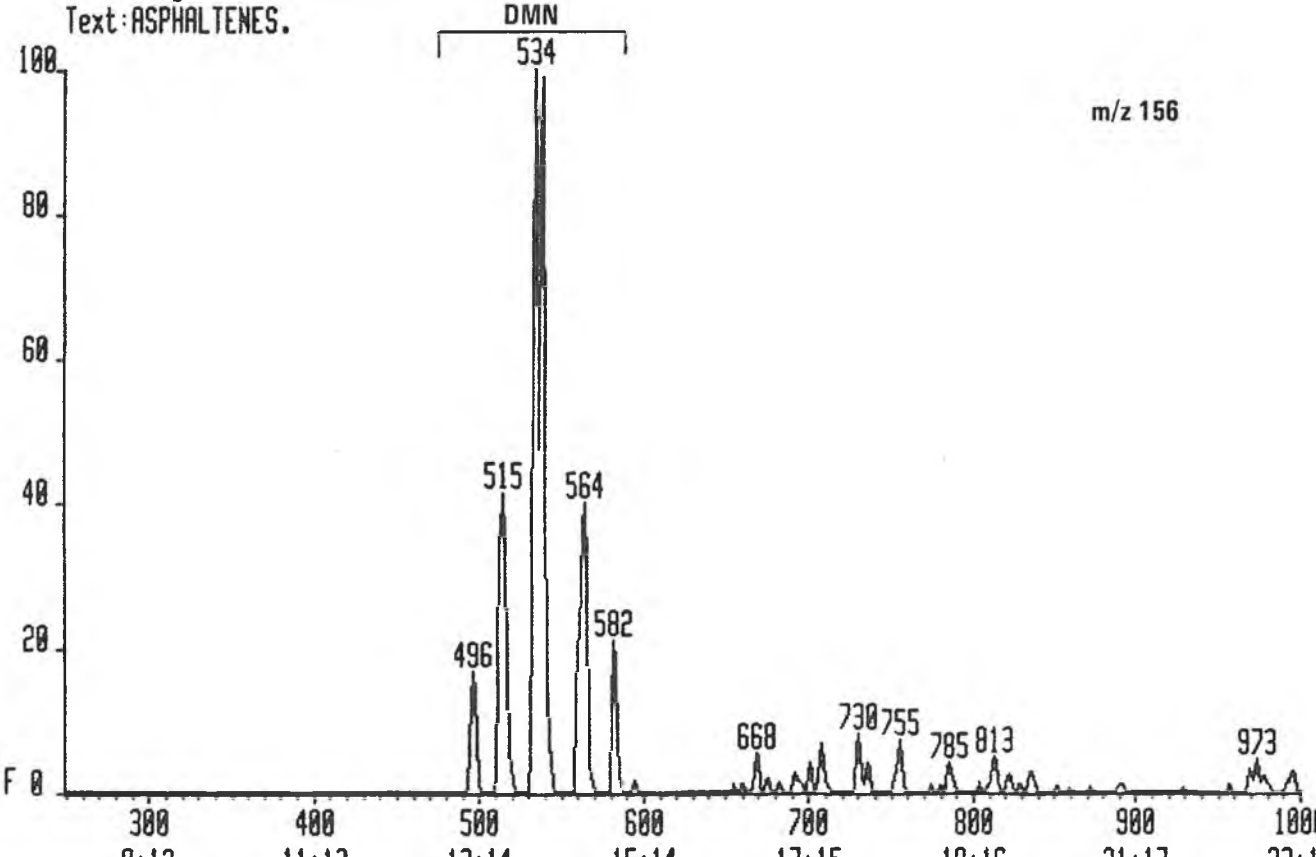

C2945ARO #1-1000 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : D1:106 D: 5151000
Text:------
m/z 106
526
421
627
438
845
314
725
1274
818
331
111
1444
D 0
200 400 600 800 1000 1200 1400 1600 1800 SCAN
8:47 14:20 19:52 25:25 30:58 36:30 42:03 47:36 53:08 TIME

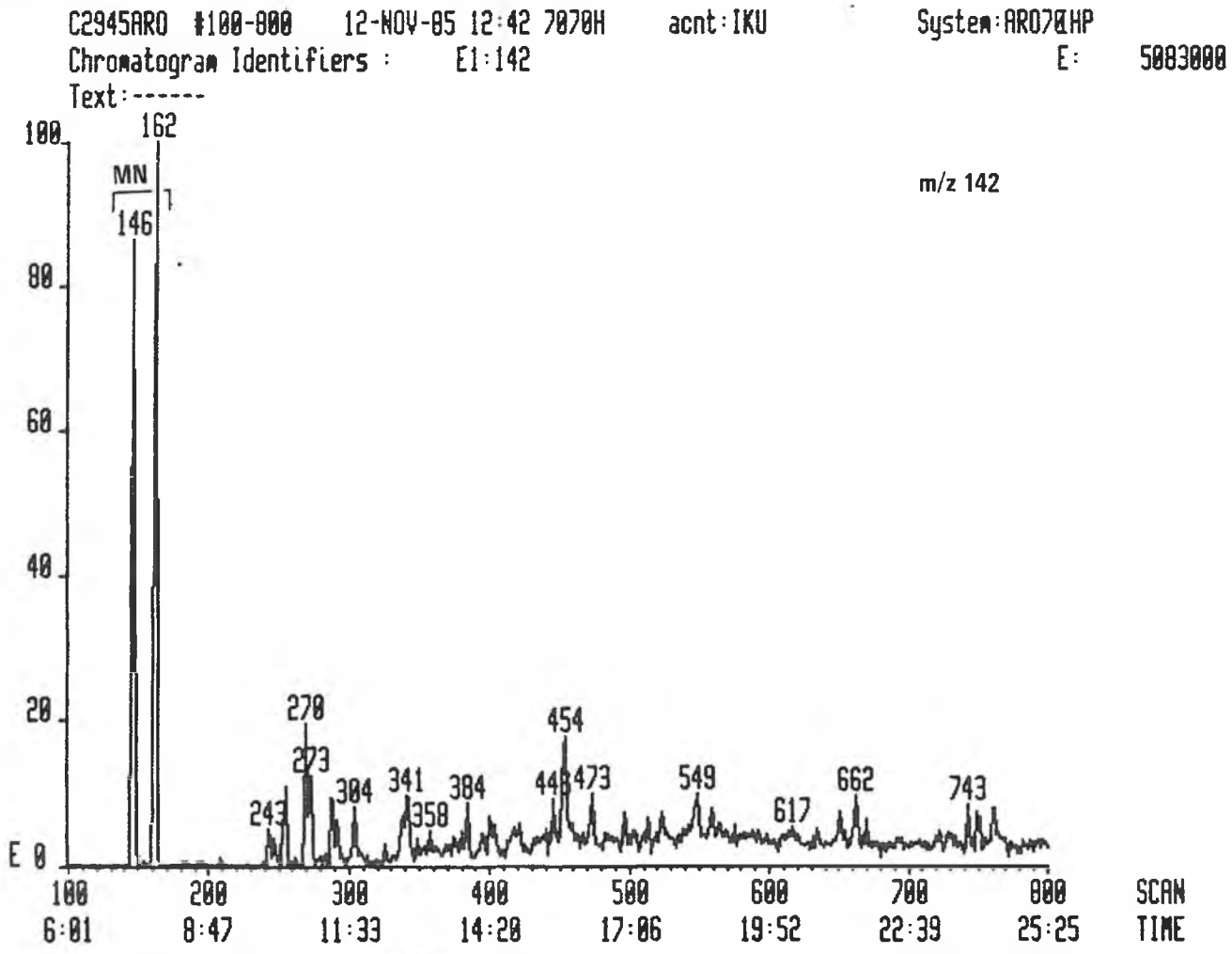
IKU SINTEF-GRUPPEN

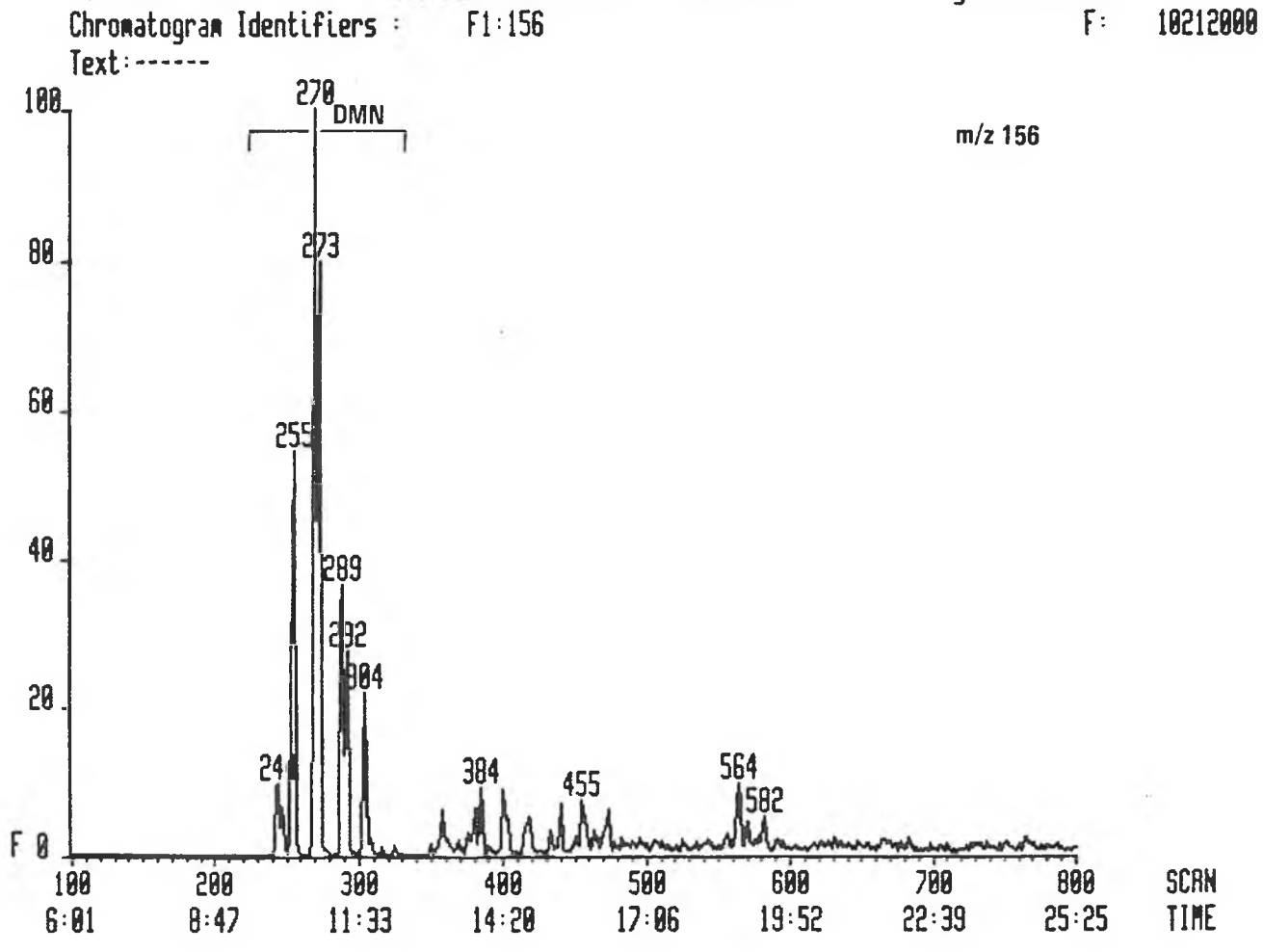
C1864AR02 #250-1000 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : E1:142 E: 744000
Text:ASPHALTENES.



C1864AR02 #250-1000 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : F1:156 F: 706000
Text:ASPHALTENES.

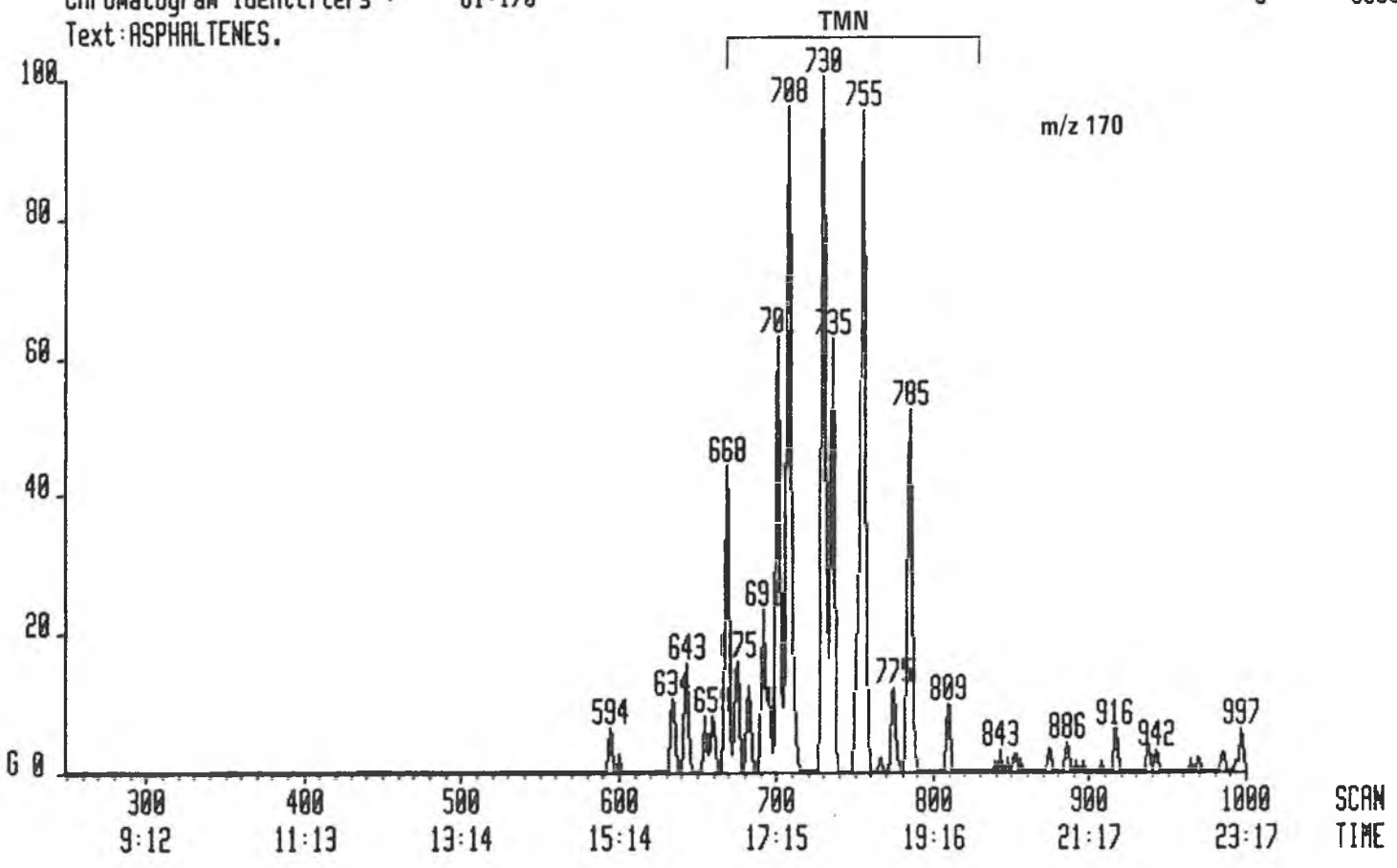



C2945ARO #100-800 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : E1:142 E: 5083000
Text:------
MN
m/z 142
SCAN
TIME


C2945ARO #100-800 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : F1:156 F: 10212000
Text:------
DMN
m/z 156
SCAN
TIME

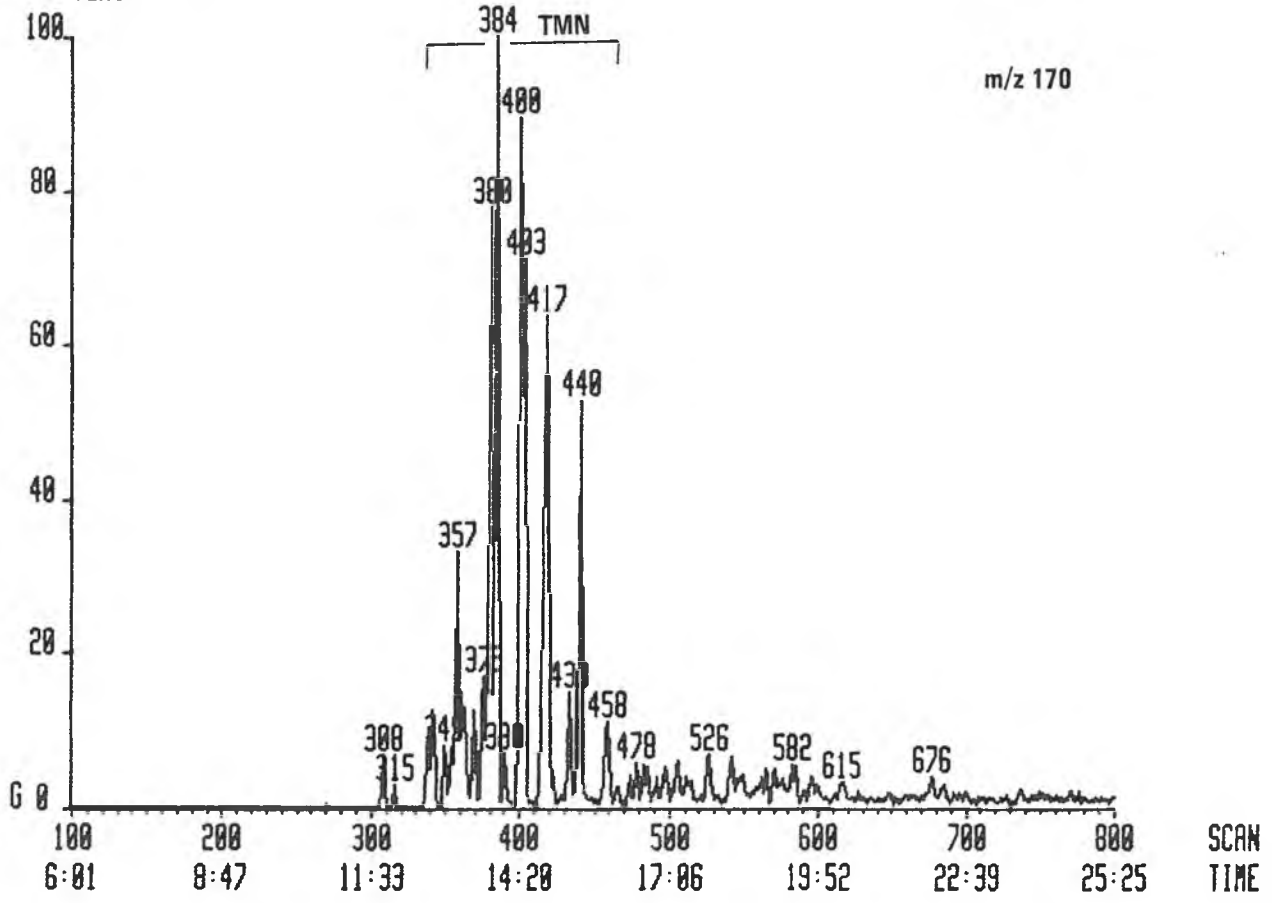
IKU SINTEF-GRUPPEN

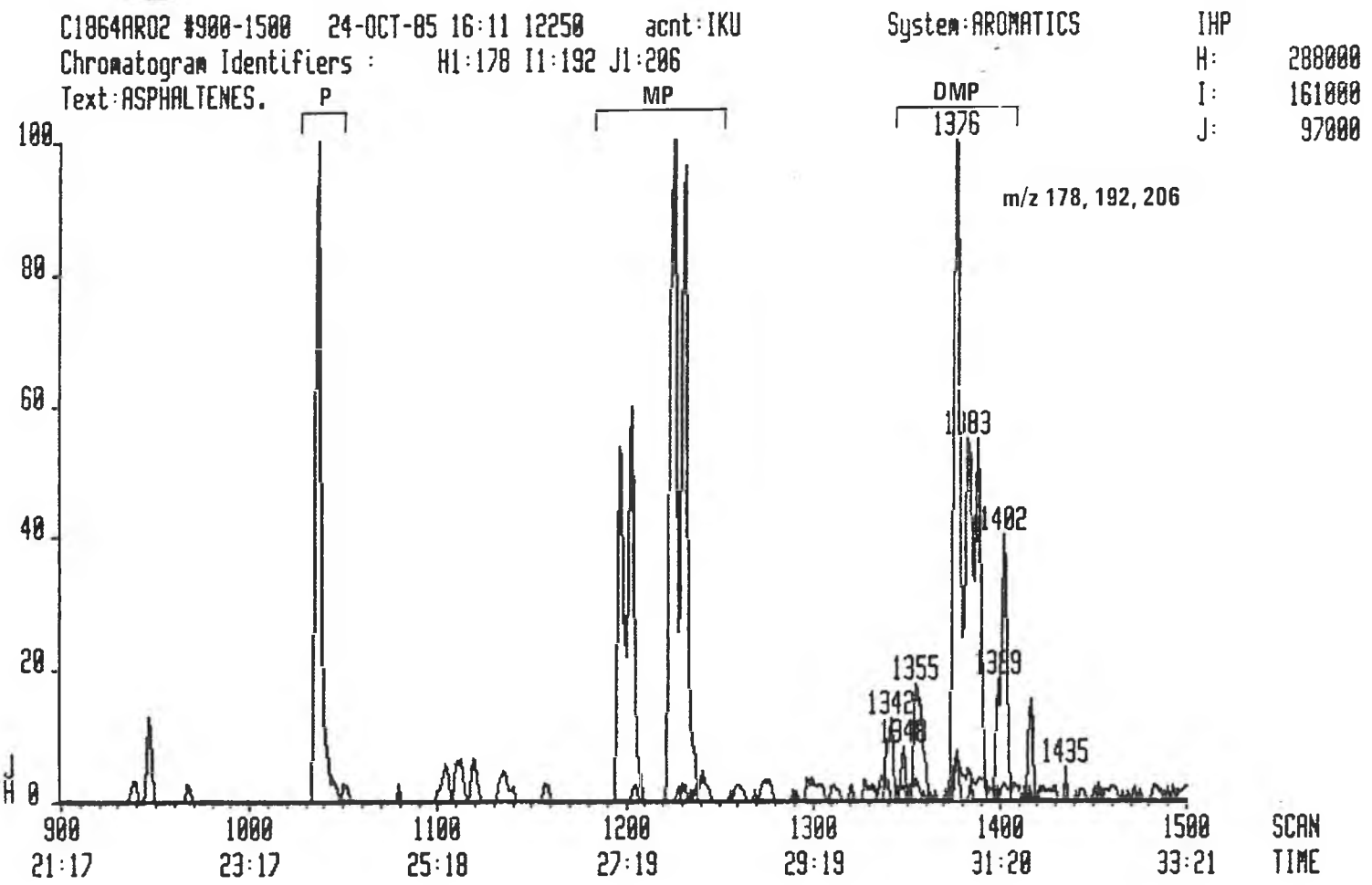
C1864ARO2 #250-1000 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : G1:170 G: 303000
Text:ASPHALTENES.

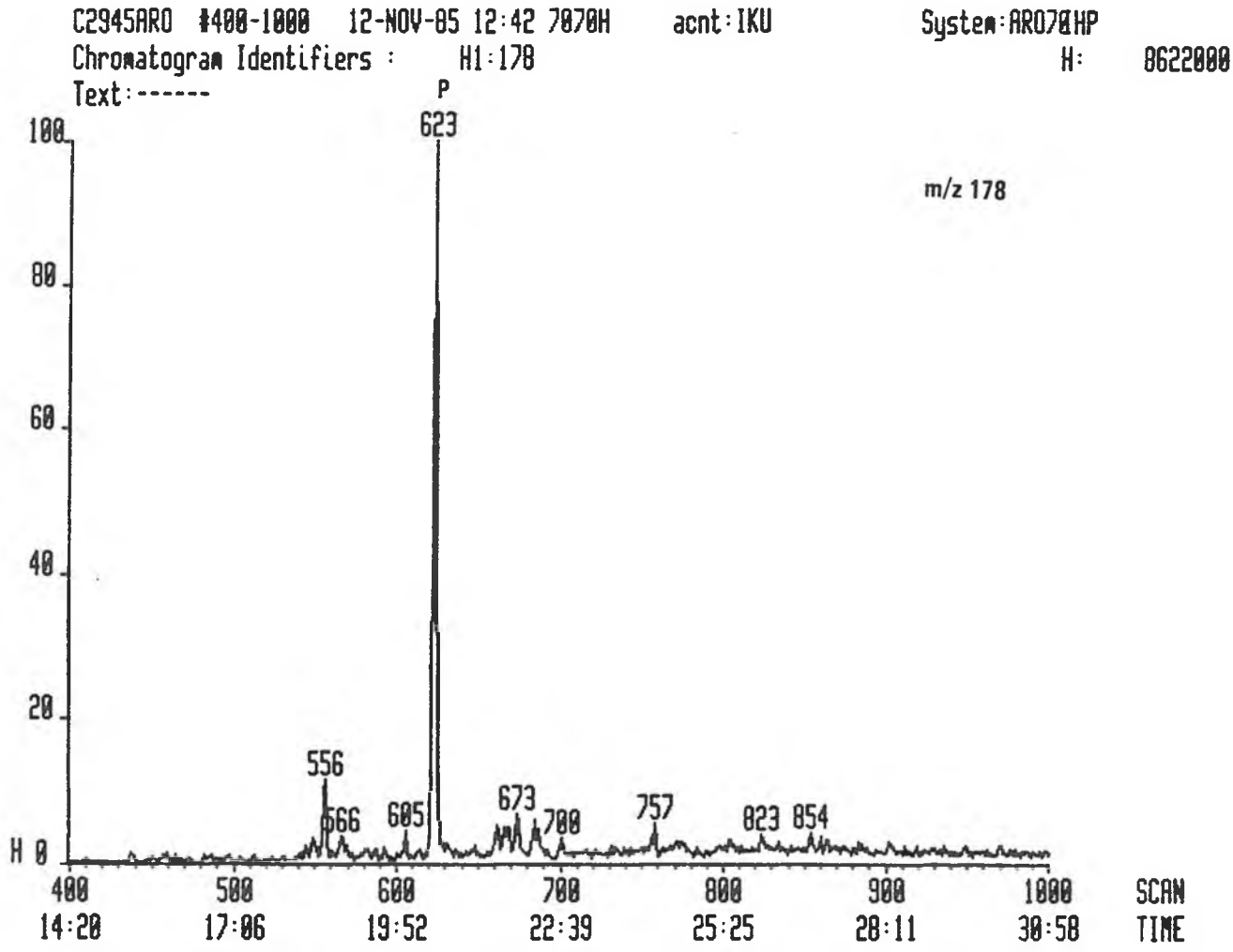


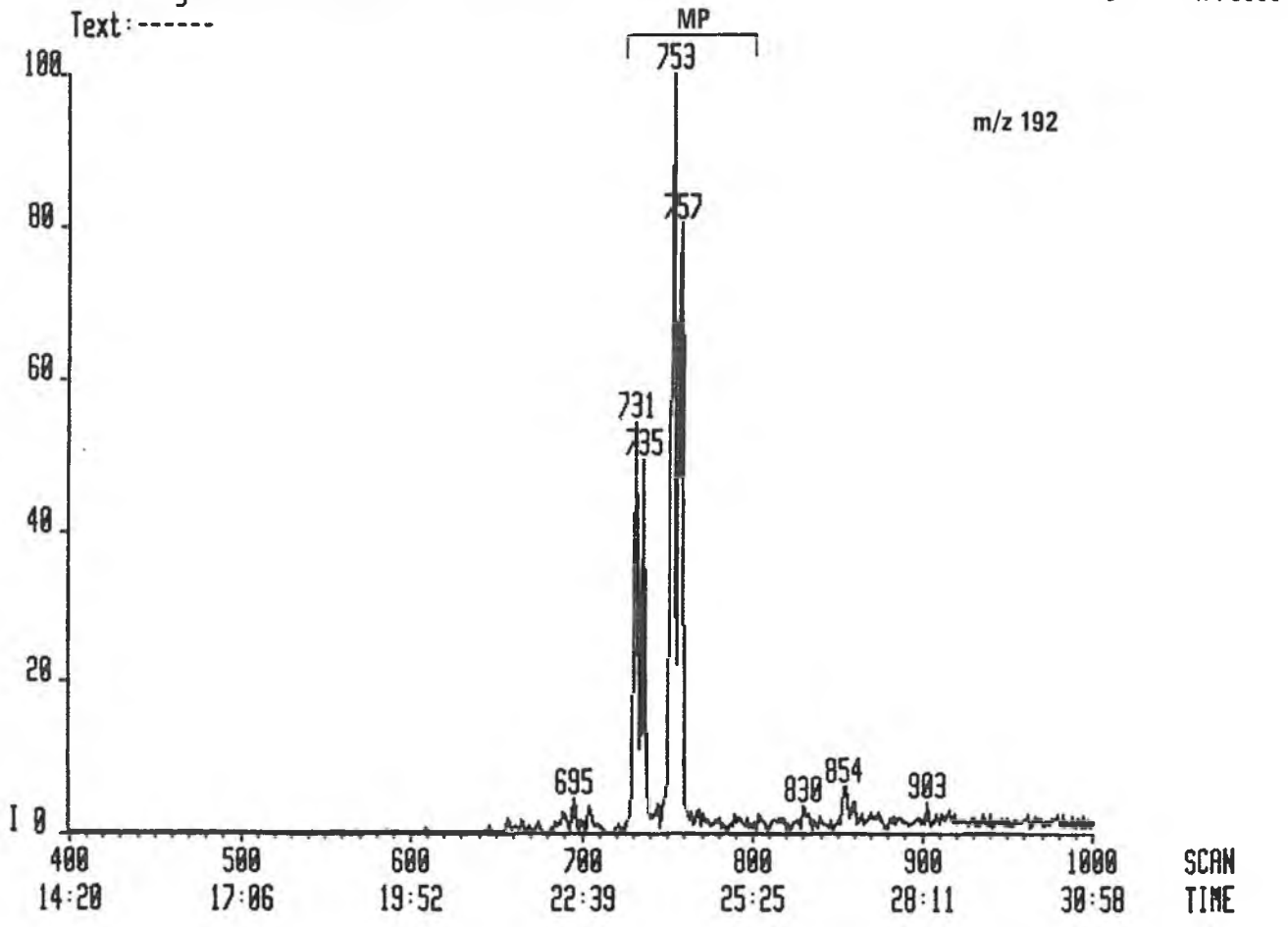
IKU
SINTEF-GRUPPEN

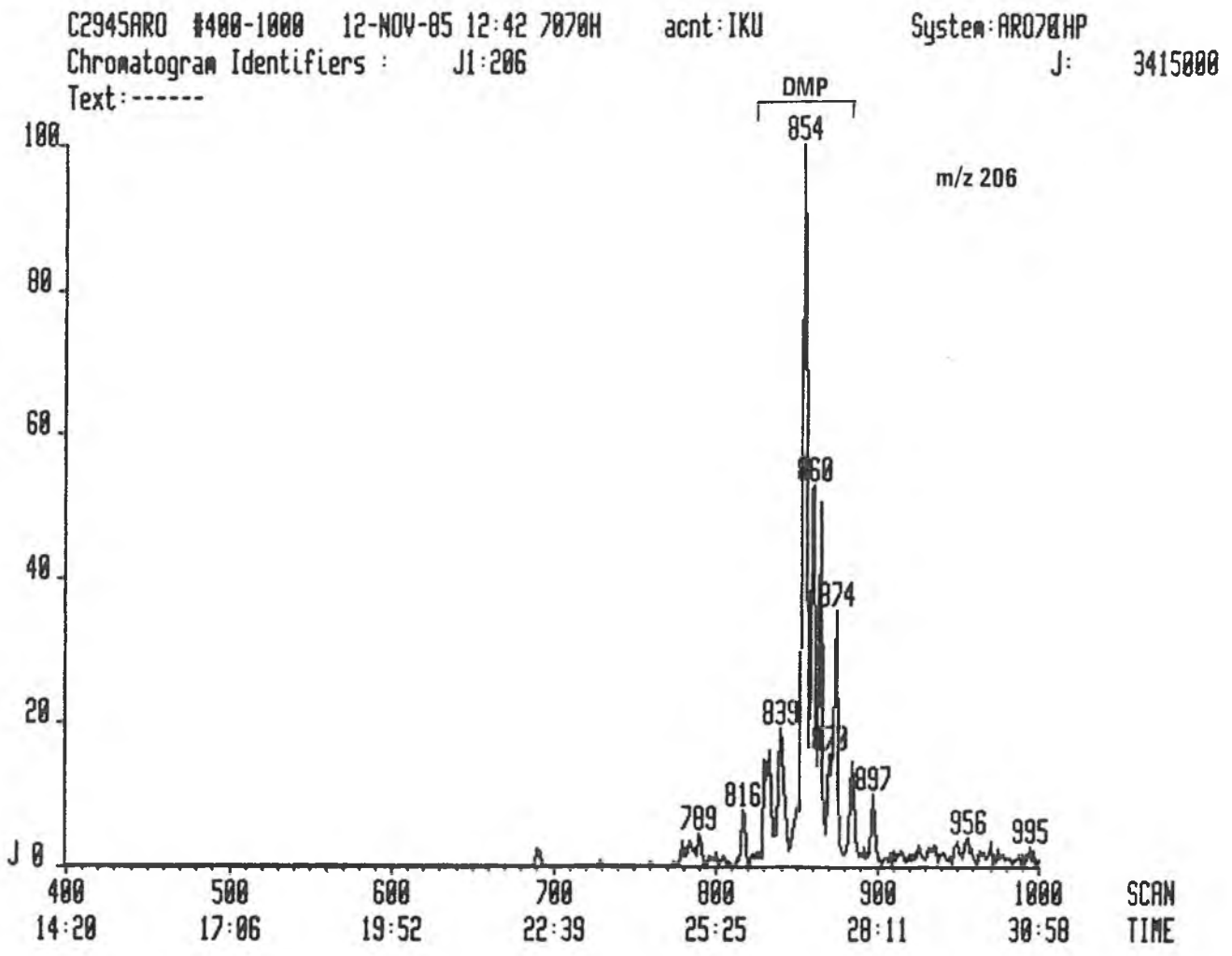
C2945ARO #100-800 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : G1:170 G: 6594000
Text:------

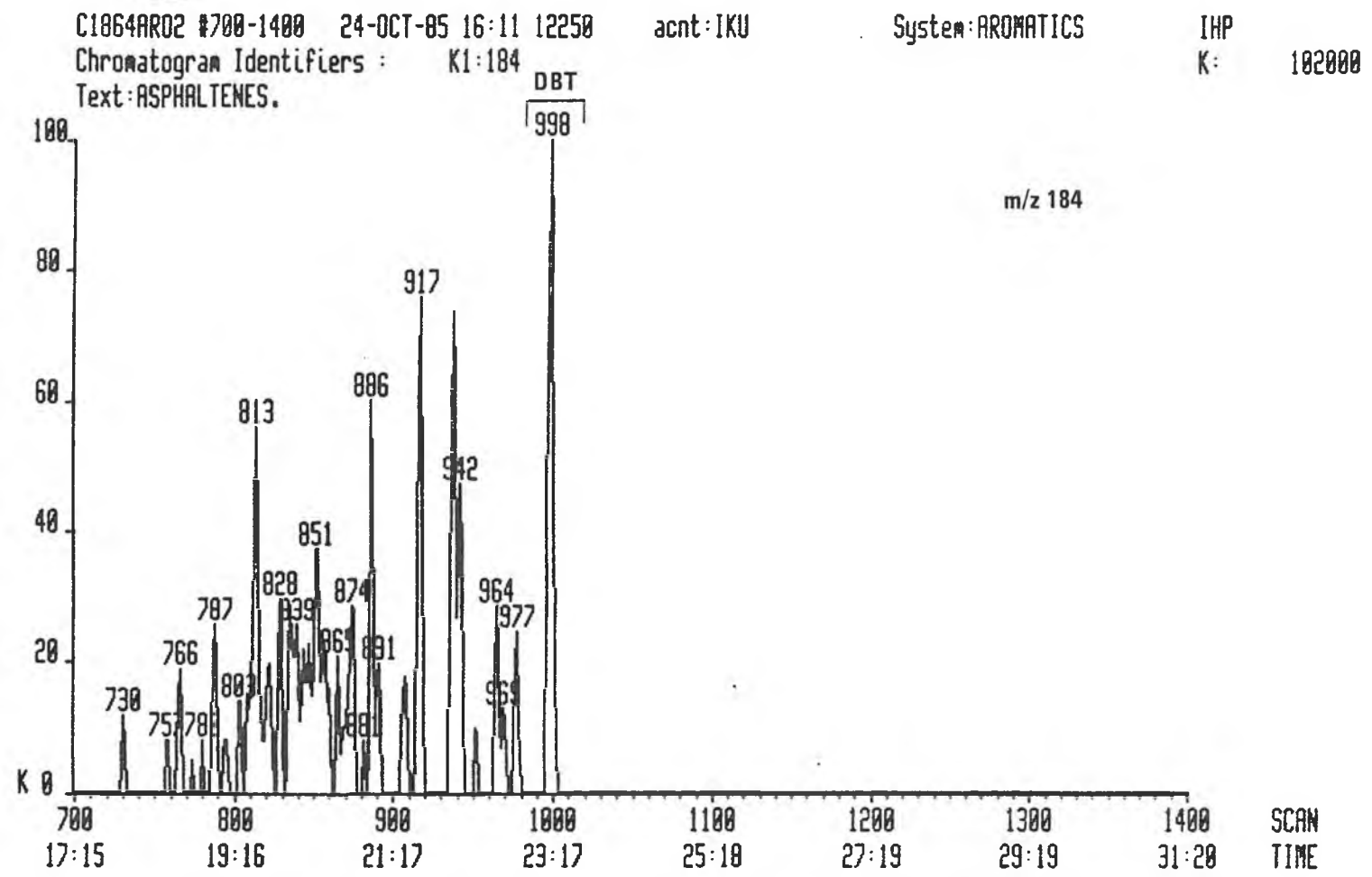


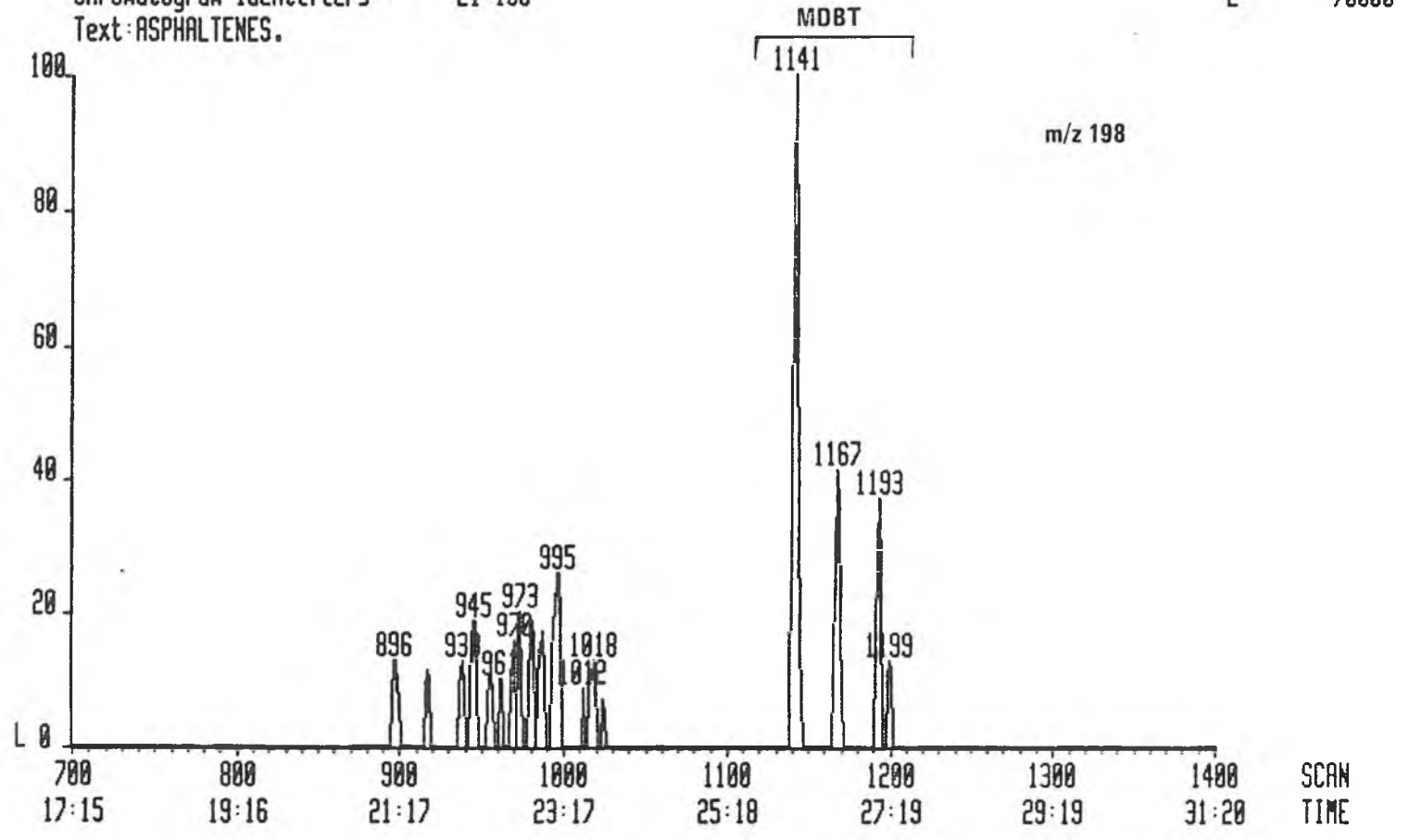

C1864AR02 #900-1500 24-OCT-85 16:11 12250 acnt:IKU
System:AROMATICS
IHP
Chromatogram Identifiers : H1:178 I1:192 J1:206
H: 288000
Text:ASPHALTENES.
I: 161000
J: 97000
P
MP
DMP
1376
m/z 178, 192, 206
1083
1402
1355
1435
100
80
60
40
20
H 0
900
1000
1100
1200
1300
1400
1500
SCAN
21:17
23:17
25:18
27:19
29:19
31:20
33:21
TIME


C2945ARO #400-1000 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : H1:178 H: 8622000
Text:------
P
623
m/z 178
100
80
60
40
20
H 0
556
566
605
673
700
757
823
854
400 500 600 700 800 900 1000 SCAN
14:20 17:06 19:52 22:39 25:25 28:11 30:58 TIME


C2945ARO #400-1000 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : I1:192 I: 4770000
Text:------
MP
753
m/z 192
100
80
60
40
20
I 0
757
731
735
695
830
854
903
400 500 600 700 800 900 1000 SCAN
14:20 17:06 19:52 22:39 25:25 28:11 30:58 TIME

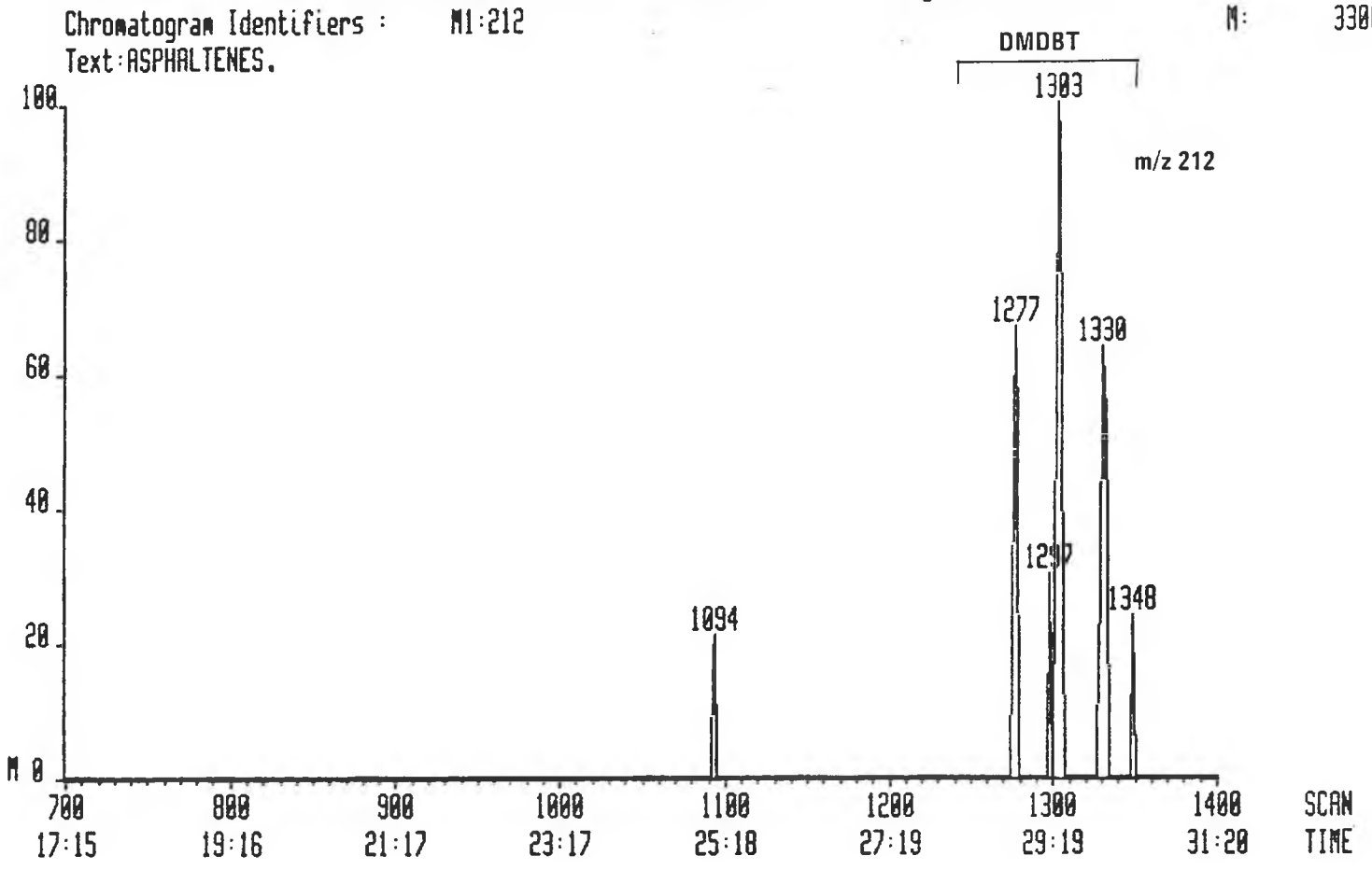

C2945ARO #400-1000 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : J1:206 J: 3415000
Text:------
DMP
854
m/z 206
100
80
60
40
20
J 0
860
874
839
816
789
897
956
995
400 500 600 700 800 900 1000 SCAN
14:20 17:06 19:52 22:39 25:25 28:11 30:58 TIME


C1864AR02 #700-1400 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : K1:184 K: 102000
Text:ASPHALTENES.
DBT
998
m/z 184
917
886
813
942
851
828
874
964
977
787
766
730
803
K 0
700 800 900 1000 1100 1200 1300 1400 SCAN
17:15 19:16 21:17 23:17 25:18 27:19 29:19 31:20 TIME

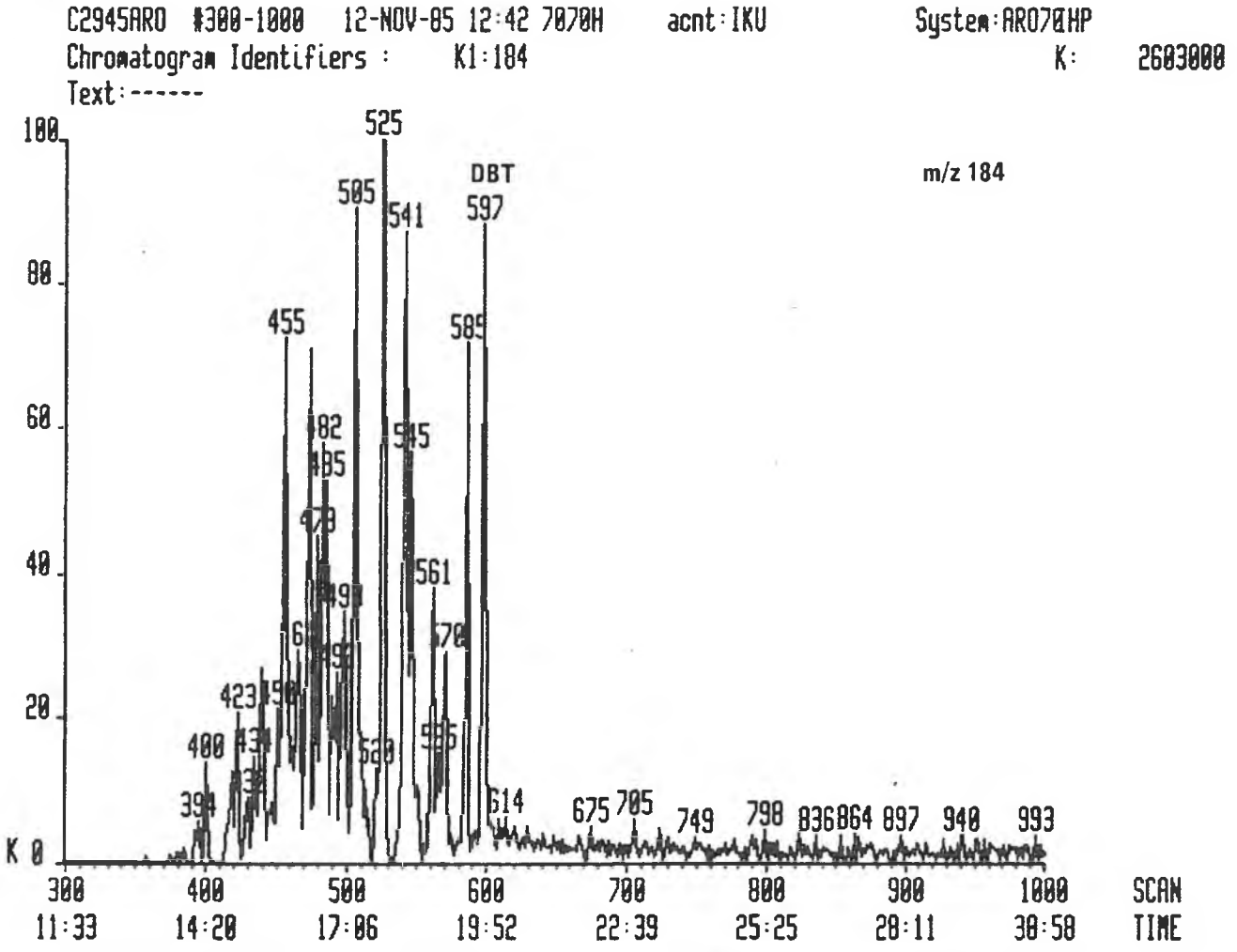

C1864AR02 #700-1400 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : L1:198 L: 70000
Text:ASPHALTENES.
MDBT
1141
m/z 198
1167
1193
995
945
973
896
1018
L 0
700 800 900 1000 1100 1200 1300 1400 SCAN
17:15 19:16 21:17 23:17 25:18 27:19 29:19 31:20 TIME

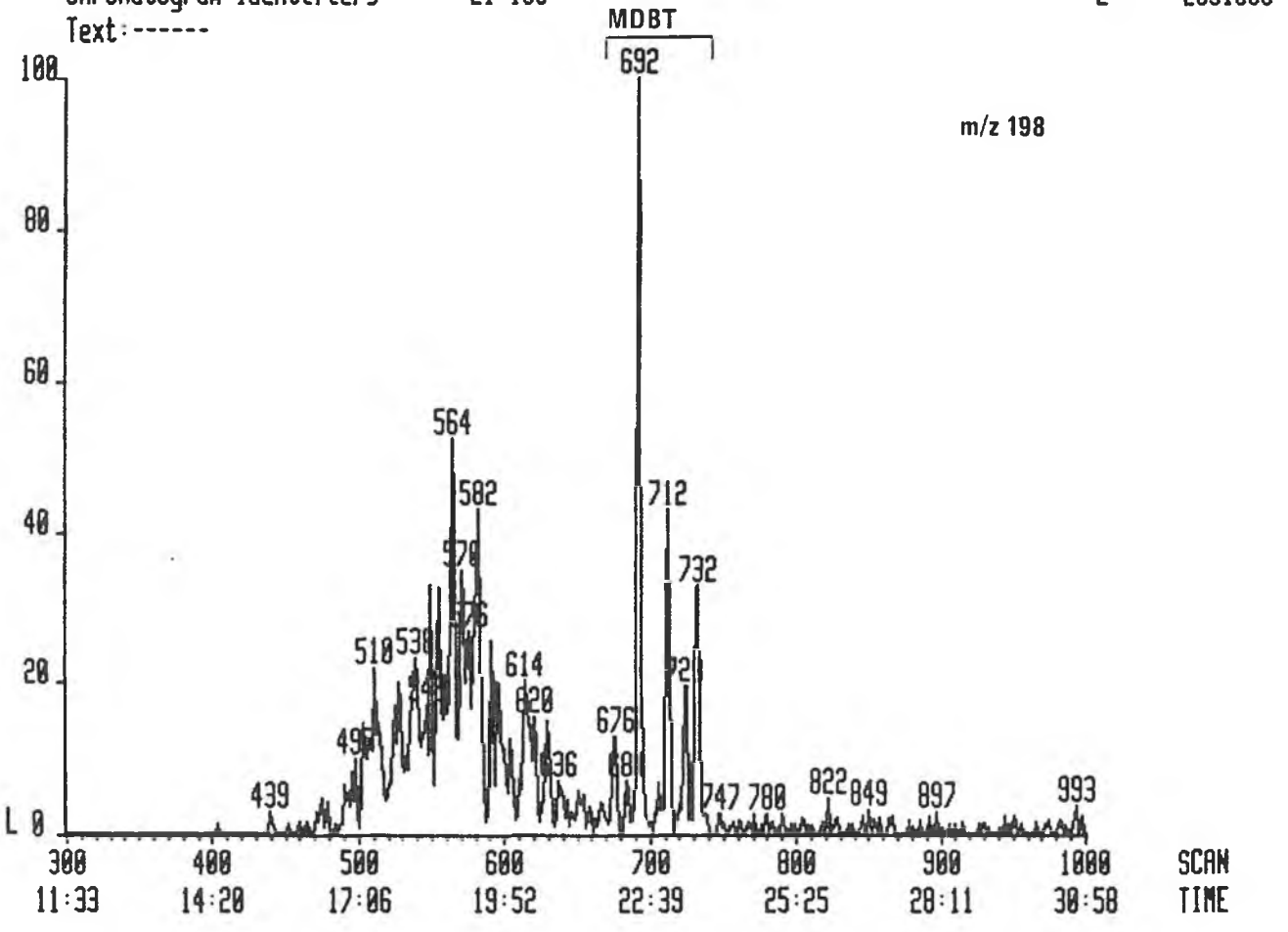
IKU SINTEF-GRUPPEN

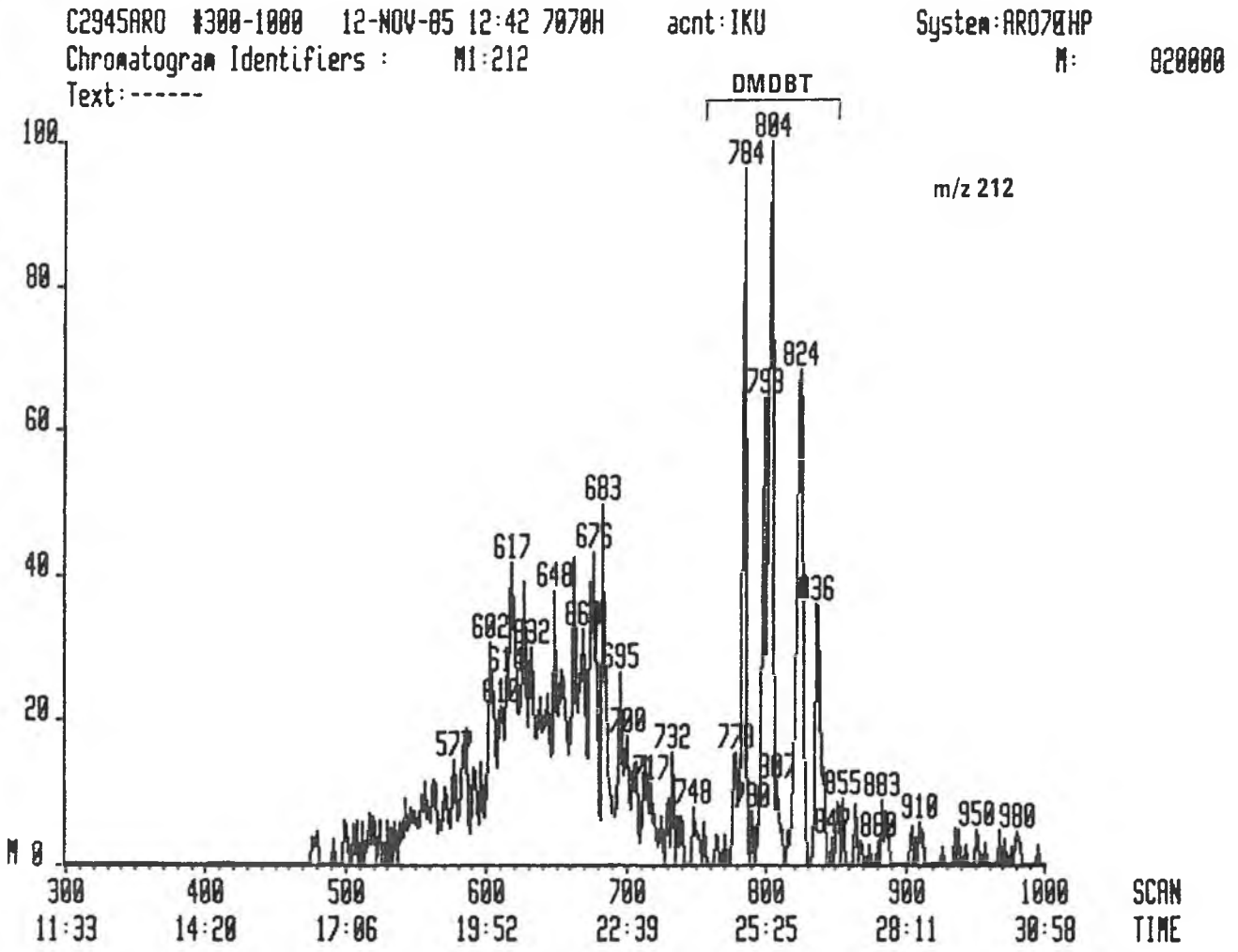
C1864AR02 #700-1400 24-OCT-85 16:11 12250 acnt:IKU System:AROMATICS IHP
Chromatogram Identifiers : M1:212 M: 33000
Text:ASPHALTENES.

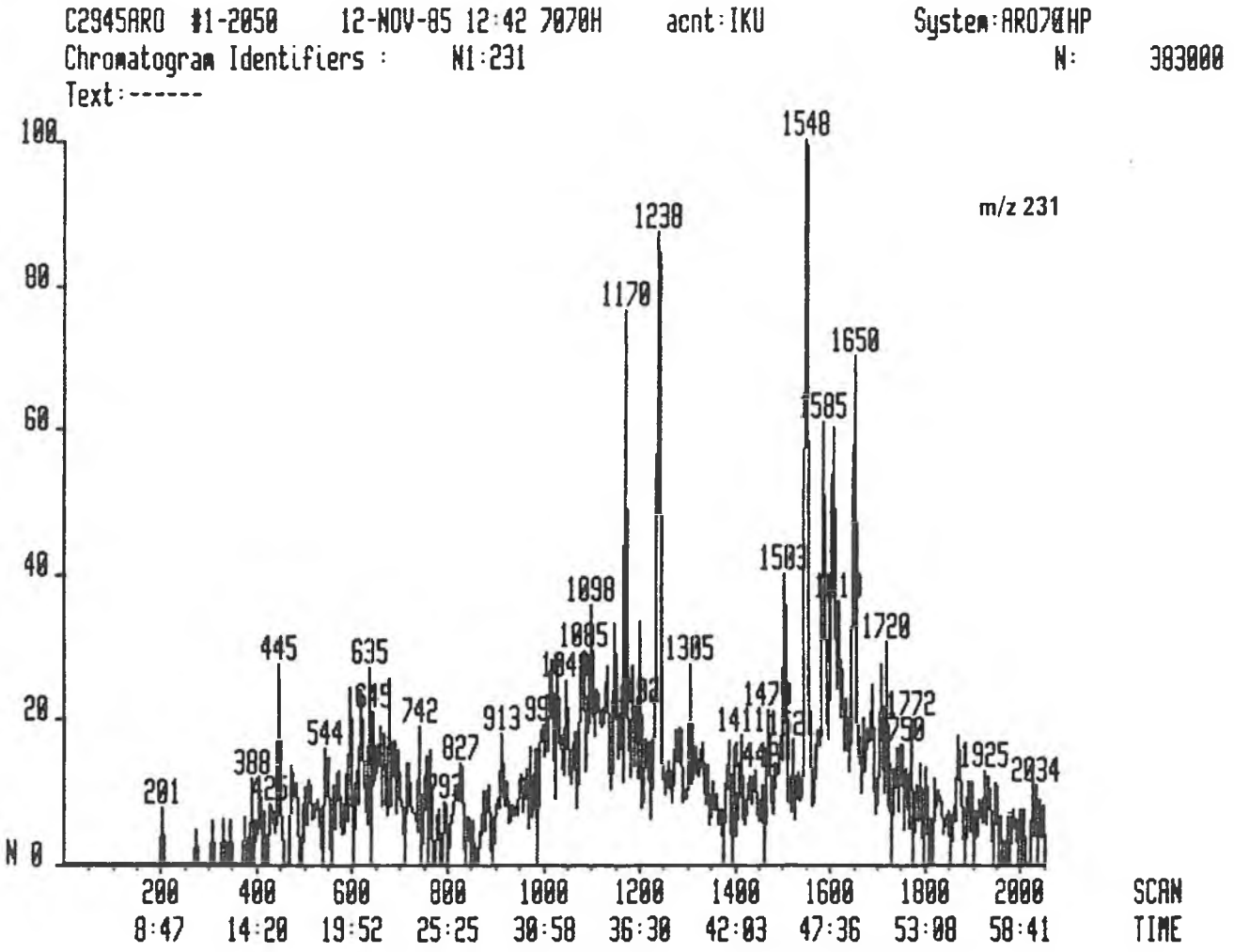


IKU
SINTEF-GRUPPEN



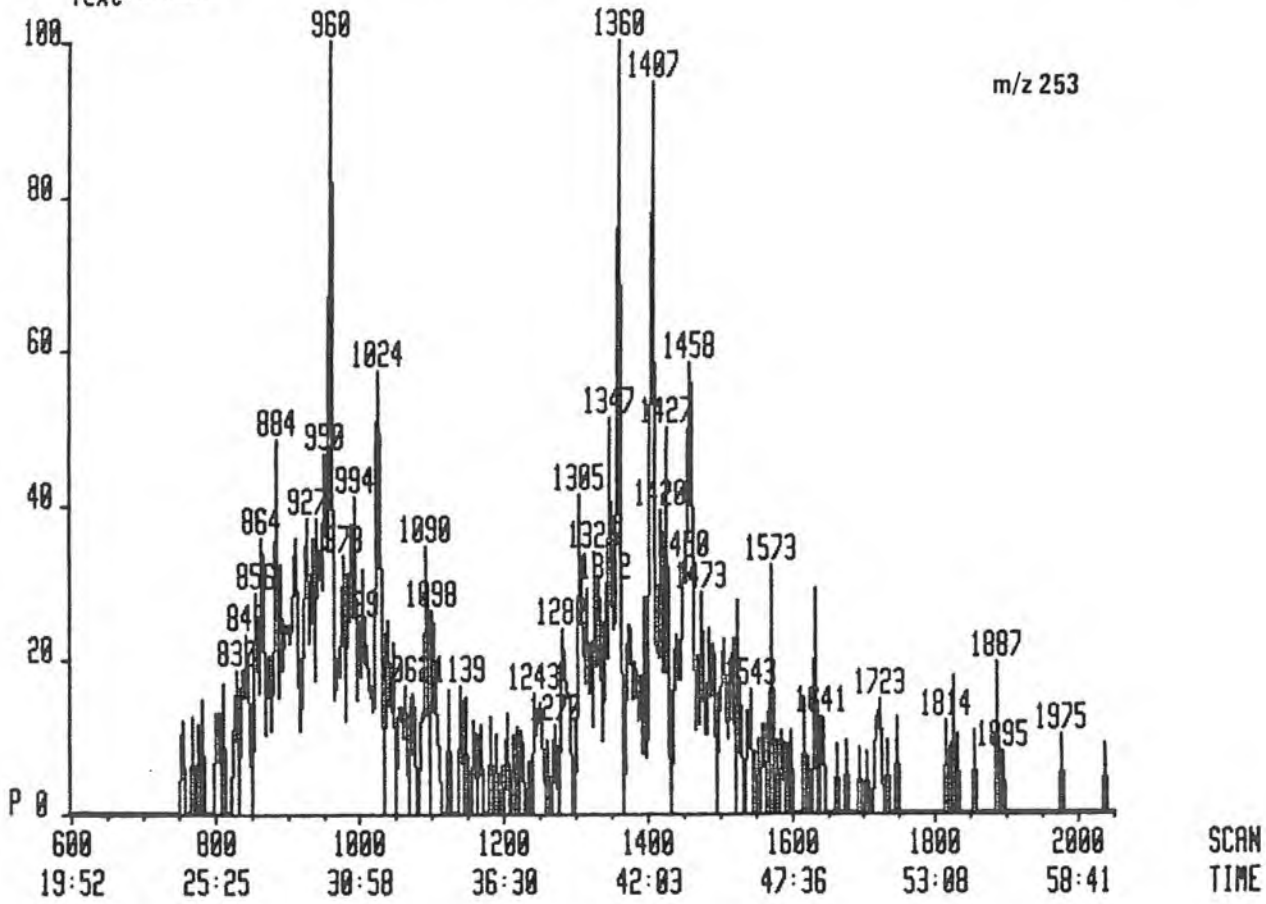



C2945ARO #300-1000 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : M1:212 M: 820000
Text:------
DMDBT
m/z 212
100
80
60
40
20
M 0
804
784
824
798
683
676
617
648
636
695
732
770
748
855
883
910
950
980
300 400 500 600 700 800 900 1000 SCAN
11:33 14:20 17:06 19:52 22:39 25:25 28:11 30:58 TIME


C2945ARO #1-2050 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : N1:231 N: 383000
Text:------
m/z 231
100
80
60
40
20
N 0
1548
1238
1170
1650
1585
1503
1720
1772
1925
2034
1898
1085
1305
445
635
742
913
827
544
388
201
200
400
600
800
1000
1200
1400
1600
1800
2000
SCAN
8:47
14:20
19:52
25:25
30:58
36:30
42:03
47:36
53:08
58:41
TIME

IKU SINTEF-GRUPPEN

C2945ARO #600-2050 12-NOV-85 12:42 7070H acnt:IKU System:ARO70HP
Chromatogram Identifiers : P1:253 P: 225000
Text:------



APPENDIX

Molecular ratios from terpane and sterane mass chromatograms applied as maturity and source characteristic parameters

Geochemical fossils or biological marker components are characteristic of the type of organic matter present at the time the sediments were deposited. The biological isomers of these components undergo changes due to increased maturity in particular, but also to a certain degree caused by migration and weathering processes.

Source characteristic parameters

In the m/z 191 mass chromatograms which represent the terpanes, the hopanes and moretanes are the major components in most extracts and oils. Of the hopanes the C_{27} and C_{29}-C_{35} homologs are ubiquitous, while the C_{28} bisnorhopane is believed to be typical of certain types of source rocks. This is also the case for the component, probably gammacerane, sometimes seen to coelute with the 22S isomer of the C_{31} 17α(H)-hopanes (H). In the sterane mass chromatograms, m/z 217 and m/z 218, the molecular weight distribution of the C_{27}-C_{29} regular steranes is believed to be representative of the original input of organic matter. The highest molecular weight compounds, the C_{29} steranes, represent organic matter of terrestrial origin, while the lower molecular weight analogs originate from more marine type environments.

Maturity dependant parameters

The biological isomers of the hopanes, the 17β(H), 21β(H)-hopanes, undergo structural changes during the maturation process. The isomerisation reactions are thought to be produced via the 17β(H), 21α(H)-hopanes (moretanes) to the most stable 17α(H), 21β(H)-hopanes. At equilibrium 100% of the 17α(H)-hopanes are seen. The ratio $\alpha\beta/\alpha\beta+\beta\alpha$ is used to describe this reaction. In the extended hopanes ($\geq C_{31}$), the thermally stable S configurations at C-22 become increasingly more abundant as compared to the biologically preferred R configurations at increased maturity level. The equilibrium ratio is approximately 60% of the 22S configuration. Another ratio that is known to change with maturity is the Tm/Ts (Seifert et al., 1978) of the C_{27} hopanes. The maturable 18α(H)-trisnorneohopane (Tm) is reduced in intensity relative to the more stable

17α(H)-trisnorneohopane (Ts), causing the Tm/Ts to decrease at increased maturity. This ratio is also believed to be source dependant, and this should be born in mind when applying the ratio for maturity comparison. The amount of tricyclic terpanes is also to a certain extent seen to be maturity dependant.

Two isomerisation reactions taking place in the steranes are most commonly applied for maturity assignments from the m/z 217 mass chromatograms. The biologically preferred 14α(H), 17α(H)-isomers of the regular steranes is transformed to the thermally stable 14β(H), 17β(H)-steranes, the %ββ approaching 75% at equilibrium. An equilibrium concentration of 50% is seen of the stable S configuration at C-20 as opposed to the 100% of the biological 20R epimer (Mackenzie et al., 1980). The abundance of rearranged steranes increased with increasing maturity.

One of the reactions taking place at an early stage of diagenesis is the aromatisation of steranes, leading to the formation of mono- and tri-aromatic analogs. This process is measured as the abundance of tri-aromatic relative to mono-aromatic compounds (% tri/tri + mono) in the m/z 231 and 253 mass chromatograms, respectively. In addition the degree of side chain cracking, as $\%C_{20}/C_{26,\ 27}$ and $\%C_{21}/C_{28,29}$ respectively, is applied. These cracking processes are also taking place during early diagenesis, and are used for maturity assignment together with the previously mentioned ratios.

Migration and weathering

The effect on the geochemical fossils of migration and weathering, is less apparent than the maturity induced changes. Migration is believed to cause an increase in the relative amounts of rearranged and 14β(H), 17β(H) regular steranes (Seifert and Moldowan, 1978, 1981). Severe biological alteration leads to the formation of desmethyl-hopanes (Seifert and Moldowan, 1979).