U-456

5

société nationale
elf aquitaine (production)

EP/S/EXP.Lab.Pau n°87/74RP

Pau le 18 Juin 1987

WELL 6506/12-3
OILS STUDY
(Haltenbanken area - Norway)

EP/S/EXP.Lab.Pau n°87/74RP

adresse postale : ☐ tour Elf - Cédex 45 92078 Paris La Défense téléphone : 33 (1) 47.44.45.46 télex : Elfa 615 400 F
☒ Pau - 64018 Pau Cédex (33) 59.83.40.00 Petra 560 804 F
☐ Lacq - BP 22 Lacq 64170 Artix (33) 59.05.24.50 Petra 560 053 F
☐ Boussens - Boussens 31360 Saint Martory (33) 61.97.80.00 SNEA 530 385 F

Imp. 7261 SNEA(P) - RGM N° 953 006 002

CONTENTS

Pages

SUMMARY 3

1 - Composition of the oils 4

2 - Genetical pattern 5

3 - Maturity 6

4 - Remark 6

5 - Conclusions 7

Enclosures : 3 Appendices, 2 Tables, 10 Figures

AUTHORS : E. LEGENDRE

TITLE : WELL 6506/12-3 OILS STUDY (Haltenbanken area - Norway)

REFERENCE : EP/S/EXP/LAB.PAU n°87/74RP

SUMMARY

6506/12-3 oils (from DST 2 and 6) are very similar, and notably bear equivalent genetical patterns. They could originate from marine organic matter, with some continental input.

One can see some slight differences in their maturities : DST 6 oil (reservoired in the FINNVAER Group - Lower Cretaceous) seems slightly less mature than DST 2 (from the ALDRA Fm. of Early Jurassic age).

Well 6506/12-3 oils, from DST 2 and DST 6, were analyzed at EAN's request.

DST 2 was performed in the Finnvaer Group of Lower Cretaceous age and DST 6 in the Aldra Fm. reservoir (Early Jurassic).

The location of the well is reported on Fig.1, and its lithological log on Fig.2.

The composition, chromatographical and isotopical data of both oils are reported in table 1 ; and their GC/MS main ratios in table 2.

The chromatographical pictures of DST 2 and 6 oils are given in fig.3 and 4 repectively, in the following order :

a/ Thermovaporization (TV) of the gasoline range (C_5 to C_{15}) hydrocarbons.

b/ Gas chromatography (GC) of C_{12}+ saturates

c/ Gas chromatography of C_{12}+ aromatics

d/ Computerized Gas chromatography/Mass spectrometry (GC/MS) of terpanes (M/Z = 191) and steranes (M/Z = 217)

1 - <u>COMPOSITION OF THE OILS</u> (See table 1)

They have very different GOR (1241 for DST 2 and 191 for DST 6), otherwise, they are quite similar, with particularly :

- low sulfur content (less then 0.13 %)
- distillate content (i.e. hydrocarbons lighter than C_{12}) about 35 %
- low quantities of polar compounds (resins + asphaltenes < 2 % of total product).

A slight difference can be seen in the aromatics content :

19 % in DST 2 (with a saturates/aromatics ratio of # 2)

13 % in DST 6 (with a S/A ratio of # 4).

2 - GENETICAL PATTERN

As discussed in the analytical appendix, both oils contain the same biomarkers, wich may link them to a predominantly marine source rock :

- presence of C_{30} steranes (cf. Fig.3d and 4d)
- C_{29} steranes are not dominant
- moderate Pristane/phytane ratios (cf.Fig.3b and 4b)

However, one can see some continental input, with :

- presence of the "X" compound, in the terpanes fraction (cf. Fig.3d and 4d)
- a lot of light aromatics (toluene and xylenes) in the gasoline range (cf. Fig.3a and 4a).

At this stage, it is difficult to know if these characteristics are due to a single source, containing mixed organic matter (predominantly marine + terrestrial) ; or whether they result from the mixing of hydrocarbons from two sources : a marine, and a terrestrial one.

Remark : One has to remember that, concerning the origin of oils from the Haltenbanken area, the ideas may differ :

- According to HEUM et al. (of STATOIL) : "oil from the hot shale is at present migrating into 6506/12-3 all three reservoir zones"(*)

- According to PITTION and GOUADAIN (of TOTAL) : "oil and gas are probably generated from both Upper Jurassic shales and the Coal Unit of Early Jurassic"(*).

- On the contrary, for THOMPSON et al. (of Robertson Research) : "the Kimmeridgian clay Fm. equivalent appears to be rather thin regionally and insufficiently buried to generate major amounts of oil. By contrast, the late Triassic-Early Jurassic coaly sequence is both thick (>500m) and deeply buried (> 3000m)..."(*).

As we have not studied all the potential source rocks of this area, no definitive conclusion about the oils origin can be drawn up as yet.

---

* - References in appendix 2.

3 - MATURITY

As evaluated after the shape of the saturates GC, as well as after the aromatics Methylphenanthrene Indices, the maturity can be described as normal. (Both fluids were generated in the conventional "oil window").

Some differences can be seen after the GC/MS analysis (cf. table 2, Fig.3d and 4d) :

- in the terpane fraction, the Tm/Ts ratio is higher in DST 6 (1.22) than in DST 2 (0.47). As this ratio decreases with increasing maturity, one can state that DST 2 oil has a higher molecular maturity.

- the steranic fraction supports this assumption, for the 29ββ S/ 29ααR ratio is slightly higher in DST 2 oil (this ratio increases with maturity).

This small difference in maturity between the two fluids can be explained :

- Either by alimentation from the same source rock at different (not too much), levels of maturity.

- Or by the mixing of fluids in different proportions from two source rocks, one being less mature than the other.

4 - REMARK

No phase of biodegradation could be seen in 6506/12-3 oils.

CONCLUSIONS :

6506/12-3 oils (DST 2 and 6) are very similar, especially from a genetic point of view. They have a marine pattern, with, however, some terrestrial biomarkers.

It is not clear yet if their genetical fingerprint results from a single source rock, of mixed origin ; or if it is due to the mixing of hydrocarbons from two sources (a "marine" and a "terrestrial" one).

The only point on which the two oils differ is their maturity : DST 2 being slightly more mature than DST 6.

As the two fluids have quite different GOR, it would be interesting to study their associated gases (and particularly their isotopy).

APPENDICES

1 - ANALYTICAL COMMENTS
2 - SELECTED REFERENCES
3 - ABBREVIATIONS AND UNITS USED IN TABLE 1

APPENDIX 1

ANALYTICAL COMMENTS

- Thermovaporization of the gasoline range (Fig.3a and 4a) :

One can see the predominance of normal alkanes (classical for oils) in both tests ; and some more light aromatics, (toluene + xylenes) in DST 2.

- Gas chromatography of saturates (Fig.3b and 4b) : In both cases, the spectrum of n-alkanes is more represented towards lighter compounds, but a little "peak" can be seen at n-C_{24}.

The Pristane/Phytane ratios are equivalent (1.3 for DST 2 and 1.7 for DST.6).

- Gas chromatography of aromatics (Fig.3c and 4c) :
The lighter (2 rings) compounds such as alkylnaphtalenes are more represented. The information brought up by the methylphenanthrenes must be noted with care, especially for DST 6 : in that case, the 3 Methyl-Phenanthrene is abnormally high. That's why we prefered to calculate the Methyl-Phenanthrene ratio.

$$\text{Or MPR} = \frac{\text{2-Methyl-Phenanthrene}}{\text{1-Methyl-Phenanthrene}}$$

In both cases MPR # 1, indicating that after this parameter, the two oils have comparable maturities.

- Computerized Gas chromatography/Mass spectrometry (Fig.3d and 4d) :

As seen in other analyses, DST 2 and 6 oils bear great resemblances ; notably both contain non ubiquitous biomarkers (i.e. which can lead to genetical correlations) :
. neither show a predominance of C_{29} steranes
. both contain C_{30}steranes (related by some authors to marine precursors(*)

---

* - References in Appendix 2.

. both contain a particular compound (of unknown structure) noted X, the origin of which must be sought in terrestrial environments (upper vegetals)

. Both have a high $C_{27}Sdia/C_{29}\alpha\alpha R$ ratio (linked to a shaly source rock

. Futhermore, they contain more steranes than terpanes (TT/ST <1).

Some differences can be seen however :

. presence of some secohopanes in DST 2 oil

. stronger values of maturity indicators (Tm/Ts, $29\beta\beta S/29\alpha\alpha R$) in DST 2 than in DST 6 oil.

- Isotopical data : there is a 1 ‰ difference between DST 2 and DST 6 ; But in both cases no difference between total and topped oil.

APPENDIX 2

SELECTED REFERENCES

- O.R. HEUM, A. DALLAND and K.K. MEISINGSET (1986). - Habitat of hydrocarbons at Haltenbanken (PVT - modelling as a predictive tool in hydrocarbon exploration) in "Habitat of HC on the Norwegian Continental Shelf" (Graham and Trotman), pp. 259-274.

- J.M. MOLDOWAN (1984). - C_{30}-steranes, novel markers for marine petroleums and sedimentary rocks.
  Geochimica et Cosmochimica Acta, Vol. 48/12, pp.2767-2768

- J.L. PITTION and J. GOUADAIN (1985). - Maturity studies in the Jurassic "Coal Unit" in three wells from the Haltenbanken area.
  In "Petroleum Geochemistry in Exploration of the Norwegian Shelf" (Graham and Trotman), pp.205-211.

- S. THOMPSON et al. (1985). - Facies recognition of some Tertiary coals applied to prediction of oil source rock occurrence. Marine and Petroleum Geology, 1985, Vol.2, pp.288-297.

ABBREVIATIONS AND UNITS USED IN TABLE 1

G.O.R.	Gas oil ratio (m3/m3)
SPEC.GRAV.	Specific gravity (g/cm3)
DIST.	Distillate)
SAT.	Saturated HC)
ARO.	Aromatic HC) % of total product
RES.	Resins)
ASPH.	Asphaltenes)
S/A	Saturated HC/Aromatic HC ratio
X1	n-C6/MCP
MCP	Methylcyclopentane
X2	n-C7/DMCP
DMCP	Dimethylcyclopentane
Y1	n-C7/TOL
TOL	Toluene
Z1	n-C10/DMN
DMN	Dimethylnonane (isoprenoid)
Pr,Ph	Pristane,Phytane (isoprenoids)
A/B	(Pristane/n-C17)/(Phytane/n-C18)
MPI 1	Methylphenantrene Index 1 = 1.5(2MP+3MP)/(P+1MP+9MP)
MPI 2	Methylphenantrene — 2 = 3(2MP)/(P+1MP+9MP)
MPI 3	Methylphenantrene — 3 =(2MP+3MP)/(1MP+9MP)
d13C	Isotopical ratio of the total product (HT) or of the topping residue (RD)

TABLES

1 - COMPOSITION, CHROMATOGRAPHICAL AND ISOTOPICAL DATA OF 6506/12-3 OILS

2 - GC/MS MAIN RATIOS OF 6506/12-3 OILS

TABLE 1 :HALTENBANKEN AREA
COMPOSITION,CHROMATOGRAPHICAL AND
ISOTOPICAL DATA OF OILS FROM WELL 6506/12-3

WELL	6506/12-3	6506/12-3
TEST	DST 6	DST 2
DEPTH (m) "	3162-3173	4165-4170
RESERVOIR "	Finnvaer	Aldra Fm
GOR (m3/m3)"	191	1241
API	_	_
Spec.Grav. "	0.81	0.82
Sulfur (%)	0.06	0.13
DISTILLATE	33.7	38.5
ASPHALTENES	0.1	0.1
RESINS	1.6	1.8
SATURATED HC	51.6	40.5
AROMATIC HC	13.0	19.1
S/A	3.96	2.12
X1=n-C6/MCP	2.07	1.52
X2=n-C7/DMCP	5.08	4.70
Y1=n-C7/TOL	3.62	0.81
Z1=n-C10/DMN	4.09	2.02
n-alk.% TV	34	26
n-alk.% SAT.	18	15
Pr/n-C17 = A	0.70	0.70
Ph/n-C18 = B	0.46	0.59
Pr/Ph	1.70	1.28
A/B	1.52	1.19
MPI 1	(0.87)	0.64
MPI 2	0.69	0.62
MPI 3	(1.05)	0.82
MPR	1.00	0.96
d13 C HT/PDB	-29.2	-28.3
d13 C RD/PDB	-29.5	-28.6

" means after Statoil data

RESULTS :

DST 6 OIL

27 bb S / 27 aa R ..	N / A	C29 DHop / C29 Hop .	N / A
27 aa S / 27 aa R --	N / A	C28 BNHop / C29 Hop-	N / A
27 S dia / 27 aa R .	N / A	C29/5 / C29 Hop.....	0.35
22 4-Me st / 27 aa R	N / A	18 aH Olean/C30 Hop.	N / A
% 20 S C27	N / A	Gammacerane/C30 Hop.	N / A
% bb C27-----------	N / A	30/3(R&S) / C29 Hop-	N / A
		30/3(R&S) / 23/3....	N / A
29 bb S / 29 aa R...	0.98	2.35Hex/C35Hop(R&S).	N / A
29 aa S / 29 aa R...	0.74	C35H(R&S)/C33H(R&S).	N / A
27 S dia / 29 aa R..	2.66	29+30Hop/C35 H(R&S).	N / A
22 4-Me st / 29 aa R	0.08		
% 20 S C29	43.05		
% bb C29 -----------	56.47		
21 st / 22 st	1.59		
22 4-Me st / 22 st--	0.13	X/29ab	0.27
C29 H / C30 H	0.87		
Tm / Ts ------------	1.22		
23/3 / 24/4	1.07		
% 22 S C31 ---------	55.32		
% 22 S C32	59.56		
ba / ab ---- X 100 -	20.20		
23/3 / 21 st	1.09		
TT / ST ------------	0.85		

DST 2 OIL

27 bb S / 27 aa R ..	N / A	C29 DHop / C29 Hop .	v. low.
27 aa S / 27 aa R --	N / A	C28 BNHop / C29 Hop-	v. low.
27 S dia / 27 aa R .	N / A	C29/5 / C29 Hop.....	0.64
22 4-Me st / 27 aa R	N / A	18 aH Olean/C30 Hop.	N / A
% 20 S C27	N / A	Gammacerane/C30 Hop.	N / A
% bb C27-----------	N / A	30/3(R&S) / C29 Hop-	0.16
		30/3(R&S) / 23/3....	0.27
29 bb S / 29 aa R...	1.16	2.35Hex/C35Hop(R&S).	N / A
29 aa S / 29 aa R...	0.80	C35H(R&S)/C33H(R&S).	N / A
27 S dia / 29 aa R..	3.54	29+30Hop/C35 H(R&S).	N / A
22 4-Me st / 29 aa R	0.24		
% 20 S C29	45.26		
% bb C29 -----------	58.51		
21 st / 22 st	1.33		
22 4-Me st / 22 st--	0.29	X/29ab	0.39
C29 H / C30 H	0.46		
Tm / Ts ------------	0.47		
23/3 / 24/4	1.10		
% 22 S C31 ---------	63.13		
% 22 S C32	65.02		
ba / ab ---- X 100 -	5.77		
23/3 / 21 st	0.65		
TT / ST ------------	0.46		

TABLE 2 : 6506/12-3 — GC /MS MAIN RATIOS OF DST 6 AND DST 2 OILS

SNEA(P) ORGANIC GEOCHEMISTRY
Computerized GC / MS Analytical Report on Steranes and Terpanes

SIMPLIFIED MOLECULAR PARAMETERS EXPLANATION CHART

C 29 STERANES RATIOS

29 bb S / 29 aa R	5 ALPHA(H),14 BETA(H),17 BETA(H)-20S-24 ethylCHOLESTANE / 5 ALPHA(H),14 ALPHA(H),17 ALPHA(H)-20R-24 ethylCHOLESTANE	+
29 aa S / 29 aa R	5 ALPHA(H),14 ALPHA(H),17 ALPHA(H)-20S-24 ethylCHOLESTANE / 5 ALPHA(H),14 ALPHA(H),17 ALPHA(H)-20R-24 ethylCHOLESTANE	+
27 S dia / 29 aa R	C 27 (20 S) Rearranged Sterane (Diasterane) / 5 ALPHA(H),14 ALPHA(H),17 ALPHA(H)-20R-24 ethylCHOLESTANE	+
22 4 Me / 29 aa R	5 ALPHA(H),14 BETA(H)-methyl-4 ALPHA PREGNANE / 5 ALPHA(H),14 ALPHA(H),17 ALPHA(H)-20R-24 ethylCHOLESTANE	+
% 20 S C 29	%[14 ALPHA(H),17 ALPHA(H)-20S + 14 BETA(H),17 BETA(H)-20S]/ 14 ALPHA(H),17 ALPHA(H)(20S+R)+14 BETA(H),17 BETA(H)(20S+R) -24 ethylCHOLESTANE	+
% bb C 29	% [14 BETA(H),17 BETA(H)(20S + 20R)-24 ethylCHOLESTANE] / 14 ALPHA(H),17 ALPHA(H)(20S+R)+14 BETA(H),17 BETA(H)(20S+R) -24 ethylCHOLESTANE	+

SHORT-CHAIN STERANES RATIOS

21 st / 22 st	5 ALPHA(H),14 BETA(H),17 BETA(H) PREGNANE / 5 ALPHA(H),14 BETA(H),17 BETA(H)-methyl 20 PREGNANE	
22 4 Me / 22 st	5 ALPHA(H),14 BETA(H),17 BETA(H)-methyl-4 ALPHA PREGNANE / 5 ALPHA(H),14 BETA(H),17 BETA(H)-methyl 20 PREGNANE	+

TERPANES RATIOS

C 29 H / C 30 H	17 ALPHA(H),21 BETA(H) NORHOPANE (C 29) / 17 ALPHA(H),21 BETA(H) HOPANE (C 30)	
Tm / Ts	17 ALPHA(H)-22,29,30 TRISNORNEOHOPANE (C 27, "maturable")/ 18 ALPHA(H)-22,29,30 TRISNORHOPANE (C 27, "stable")	-
23/3 / 24/4	Tricyclic Terpane(C23) / Tetracyclic Terpane(C24)	
% 22 S C 31	% 17 ALPHA(H),21 BETA(H)-22S-30 HOMOHOPANE / 17 ALPHA(H),21 BETA(H)-(22R+22S)-30 HOMOHOPANE	+
% 22 S C 32	% 17 ALPHA(H),21 BETA(H)-22S-30,31 BISHOMOHOPANE / 17 ALPHA(H),21 BETA(H)-(22R+22S)-30,31 BISHOMOHOPANE	+
ba / ab C 30	17 BETA(H),21 ALPHA(H) MORETANE (C 30) / 17 ALPHA(H),21 BETA(H) HOPANE (C 30)	-

TERPANES / STERANES RATIOS

23/3 / 21st	Tricyclic Terpane (C 23) / 5 ALPHA(H),14 BETA(H),17 BETA(H) PREGNANE	
TT / ST	Integration of m/z 191 between Ts and C35(22R) HOPANE / Integration of m/z 217 between 27S dia and C29aaR STERANE	

(+) Value increasing with maturity . (-) Value decreasing with maturity.
Some parameters are source-dependant

F I G U R E S

1 - LOCATION MAP

2 - 6506/12-3 - LITHOLOGIC LOG

3 - DST 2 OIL

a/ Thermovaporization of the gasoline (C_5-C_{15}) hydrocarbons

b/ Gas chromatography of C_{12+} saturates

c/ GC of C_{12+} aromatics

d/ GC/MS of terpanes and steranes

4 - DST 6 OIL

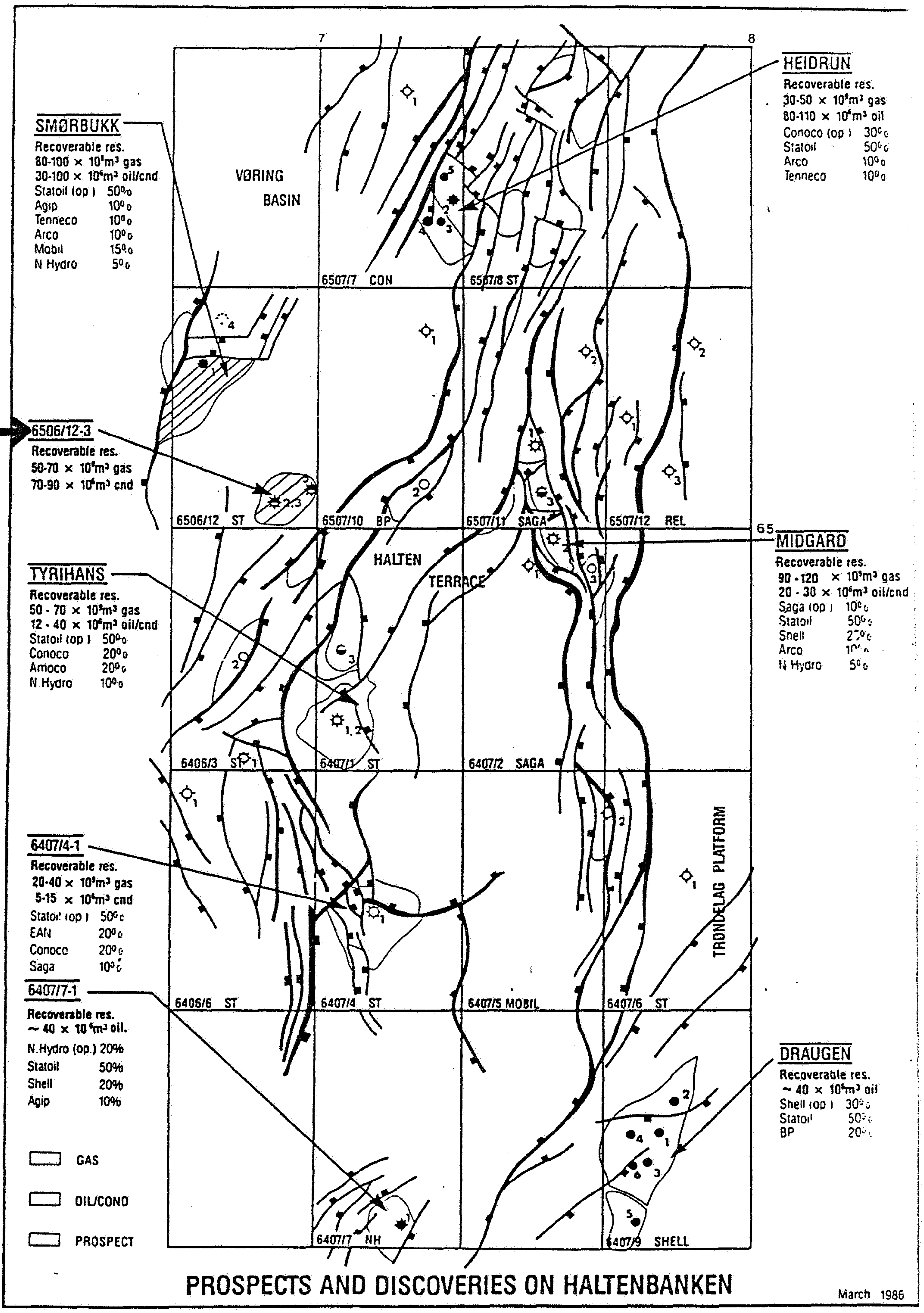
a/ Thermovaporization

b/ GC of C_{12+} saturates

c/ GC of C_{12+} aromatics

d/ GC/MS of terpanes and steranes

FIGURE 1 — LOCATION MAP



PROSPECTS AND DISCOVERIES ON HALTENBANKEN

FIGURE 2 - 6506/12-3 - LITHOLOGIC LOG

6506/12-3 BETA

Nov. 85
KB 22m

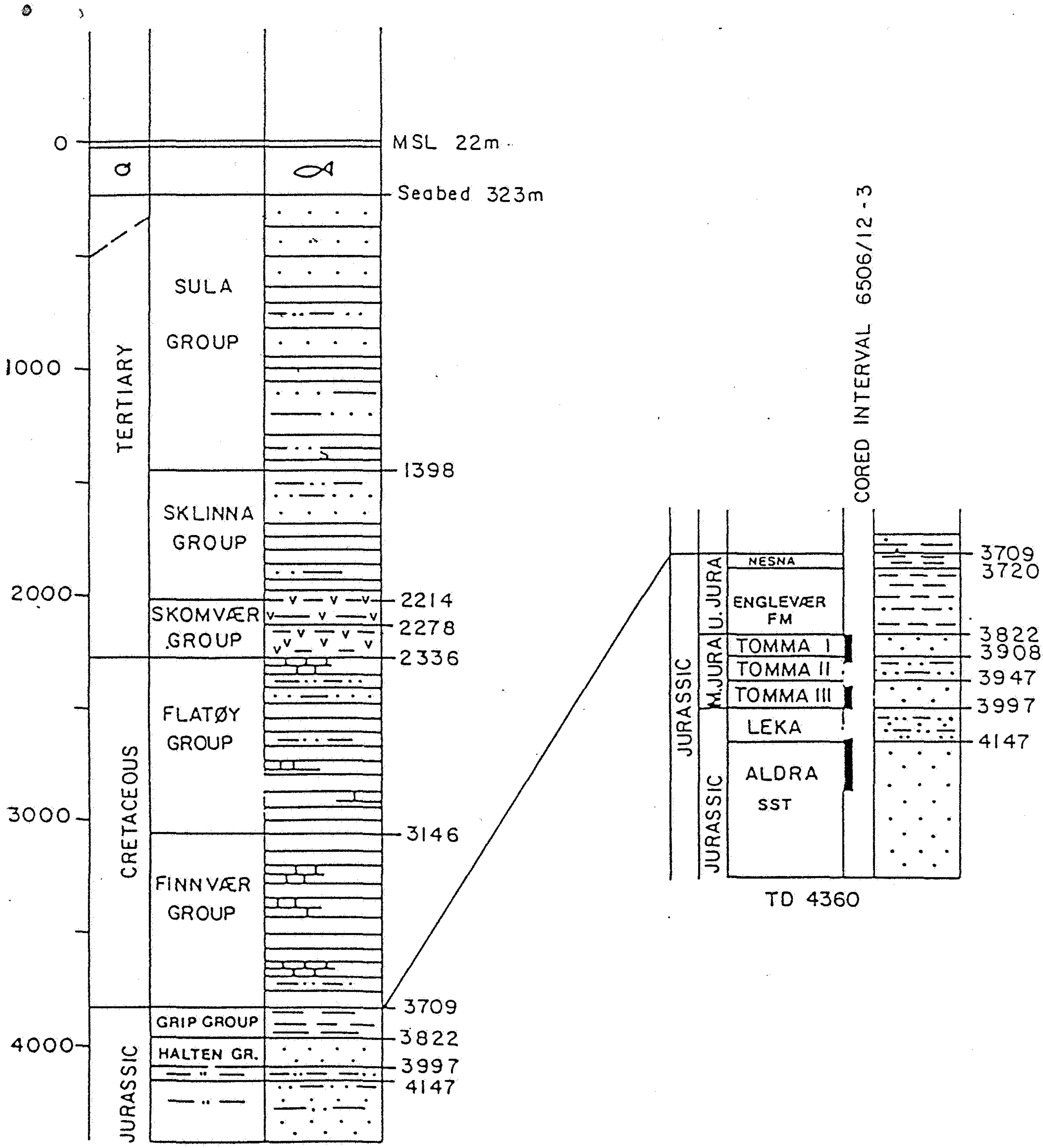
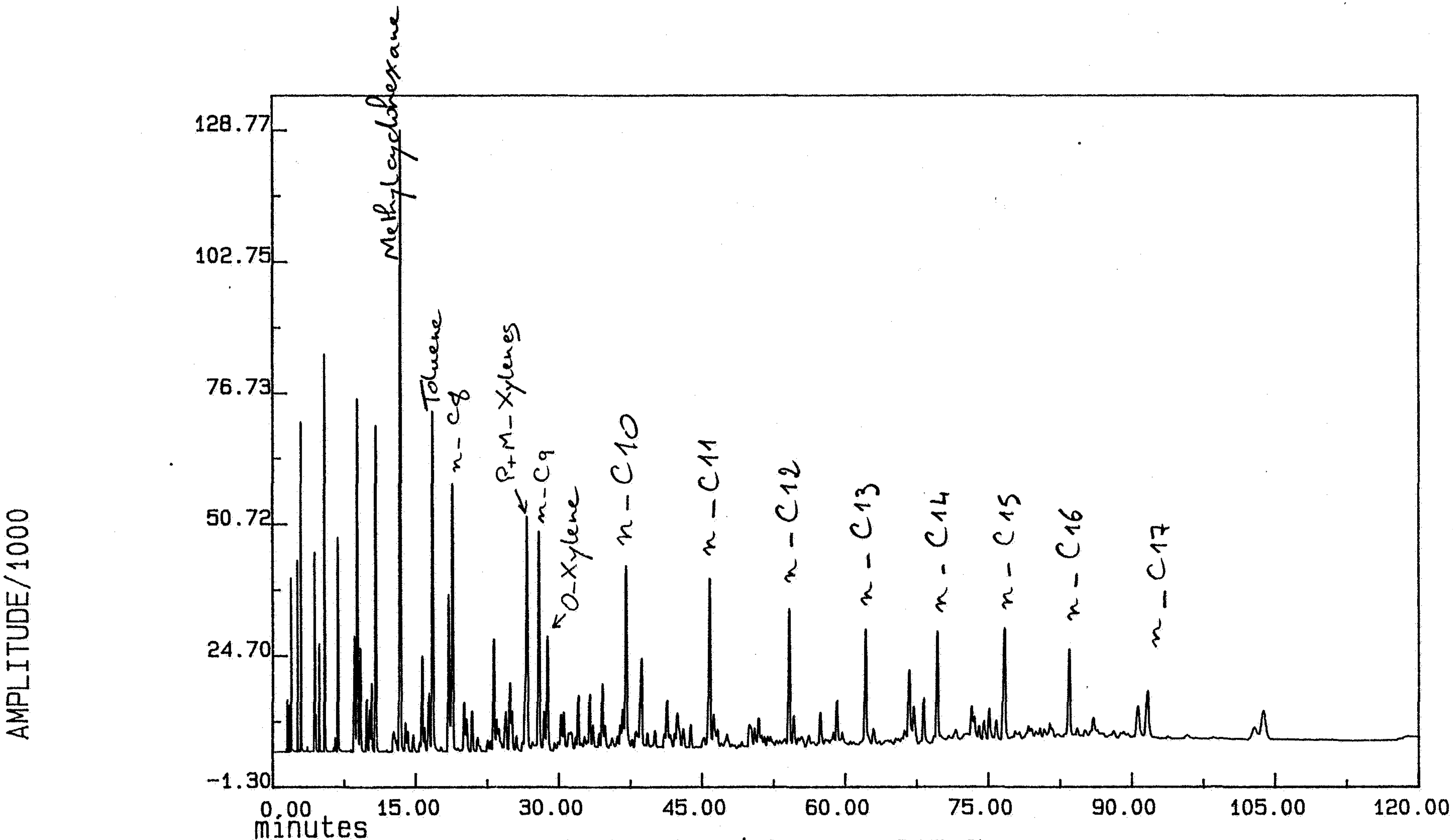


FIGURE 3a – THERMOVAPORIZATION OF DST 2 OIL



SAMPLE: 65-06/12-3 _ DST 2

ANALYZED: Fri Nov 14, 1986 2:14:39 pm

RESULT: /DATA/GO/RESULT/TV1 048.RES

FIGURE 3b – GAS CHROMATOGRAPHY OF C_{12}^{+} SATURATES-DST 2 OIL

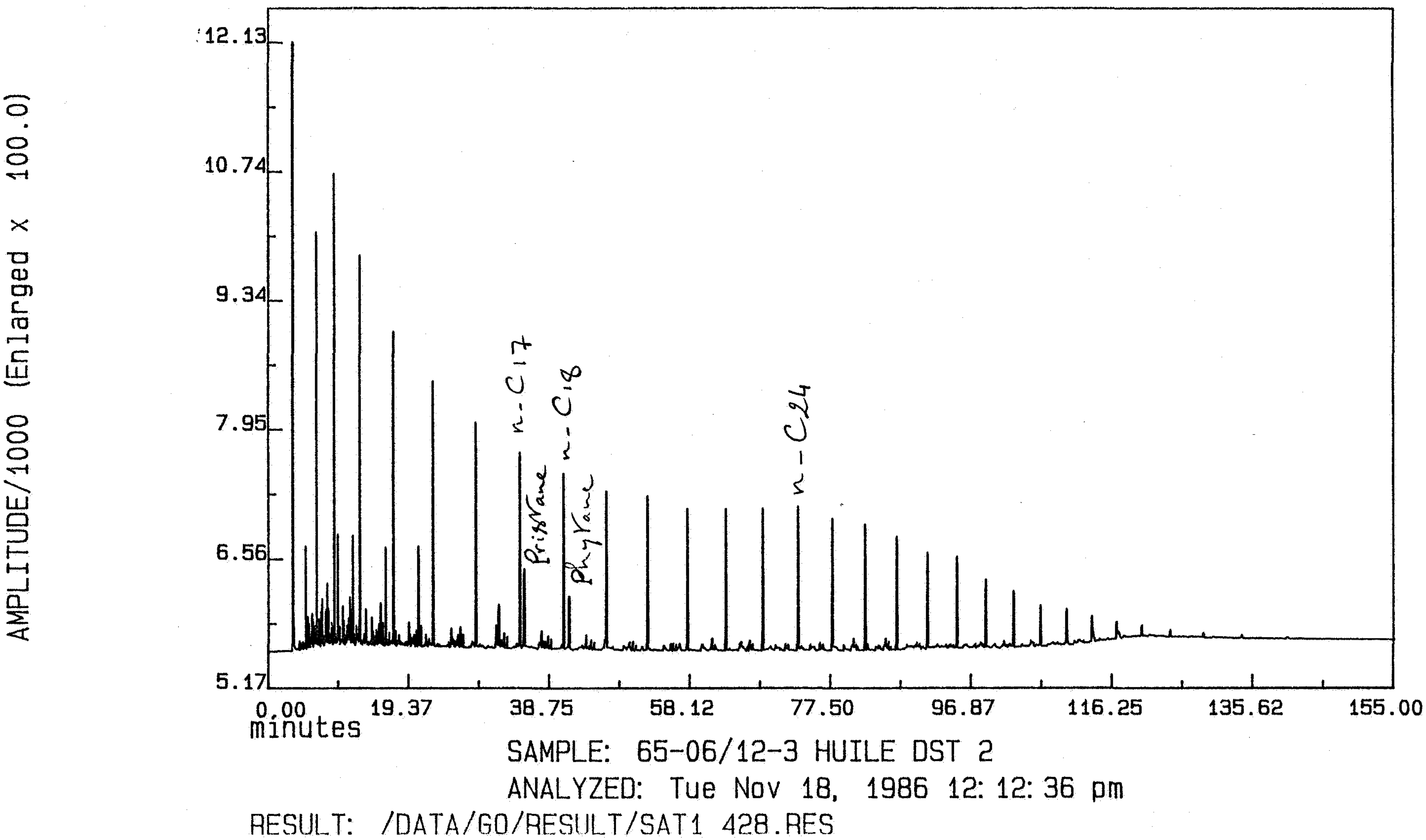
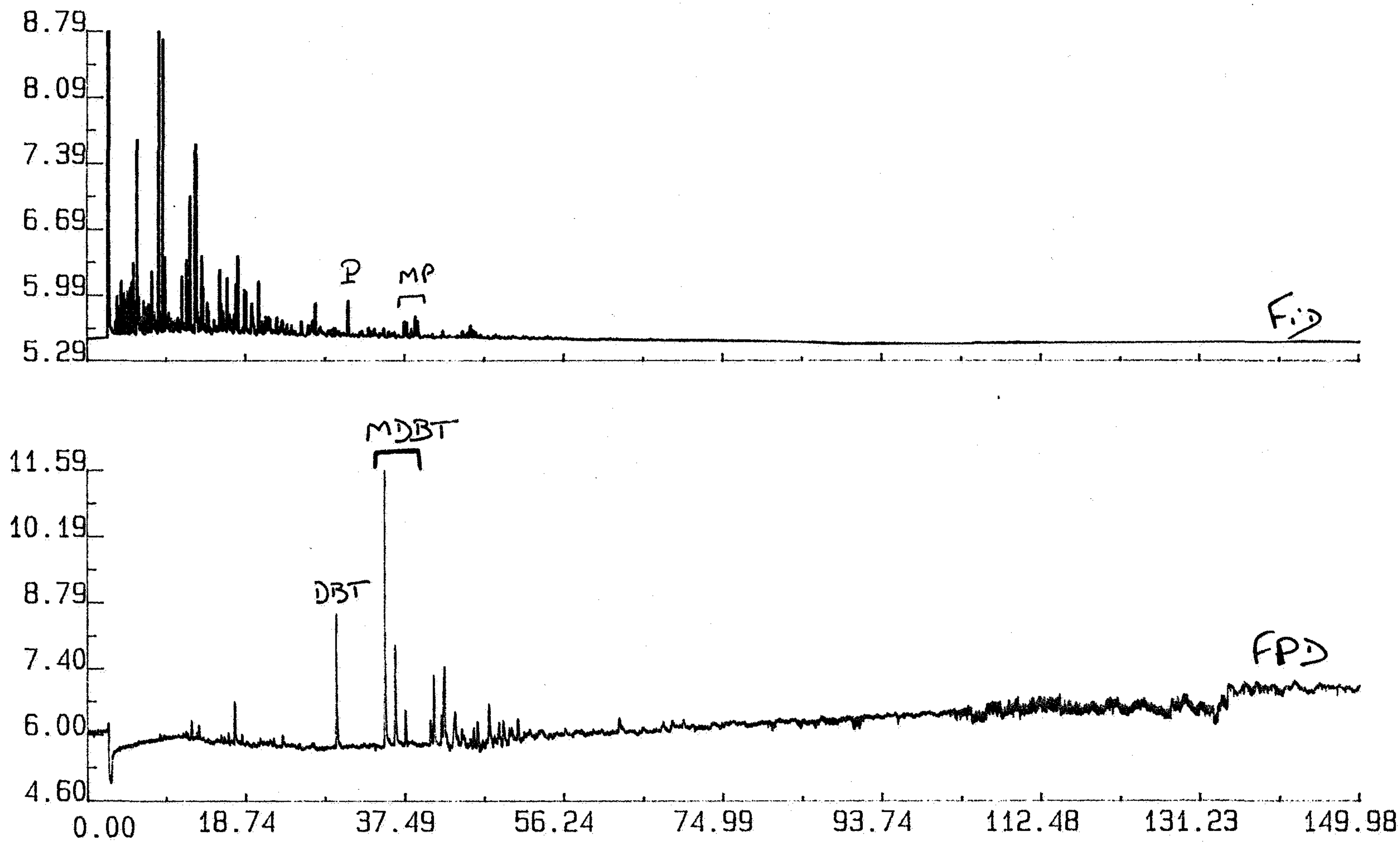


FIGURE 3c - GAS CHROMATOGRAPHY OF C_{12+} AROMATICS-DST 2 OIL



Top: AR02_T_546 (0.0-150.0) (Enlarged x 200.0)
Bottom: AR02_S_546 (0.0-150.0)

MIDMASS CHROMATOGRAMS　　DATA: NORV1784ICM #1　　SCANS 2000 TO 4800
12/16/86 9:11:00　　CALI: OCT022CT #1
SAMPLE: 6506/12-3 1784 I/C DST2 HUILE
CONDS.: CP SIL 8 50 M X .22 MM "ON COLUMN"
RANGE: G 300,4800　LABEL: N 0, 4.0　QUAN: A 0, 1.0 J 0　BASE: U 20, 3

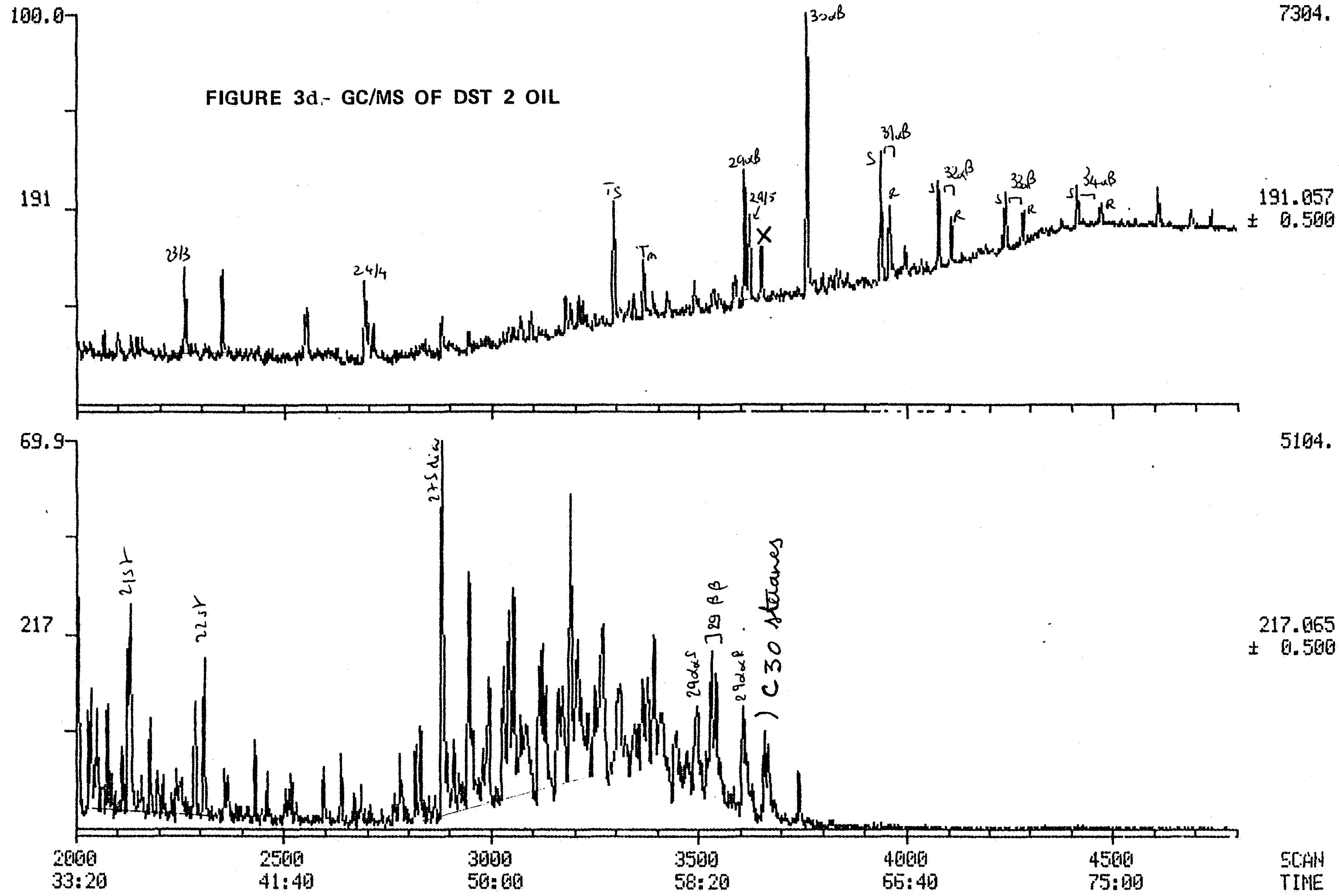
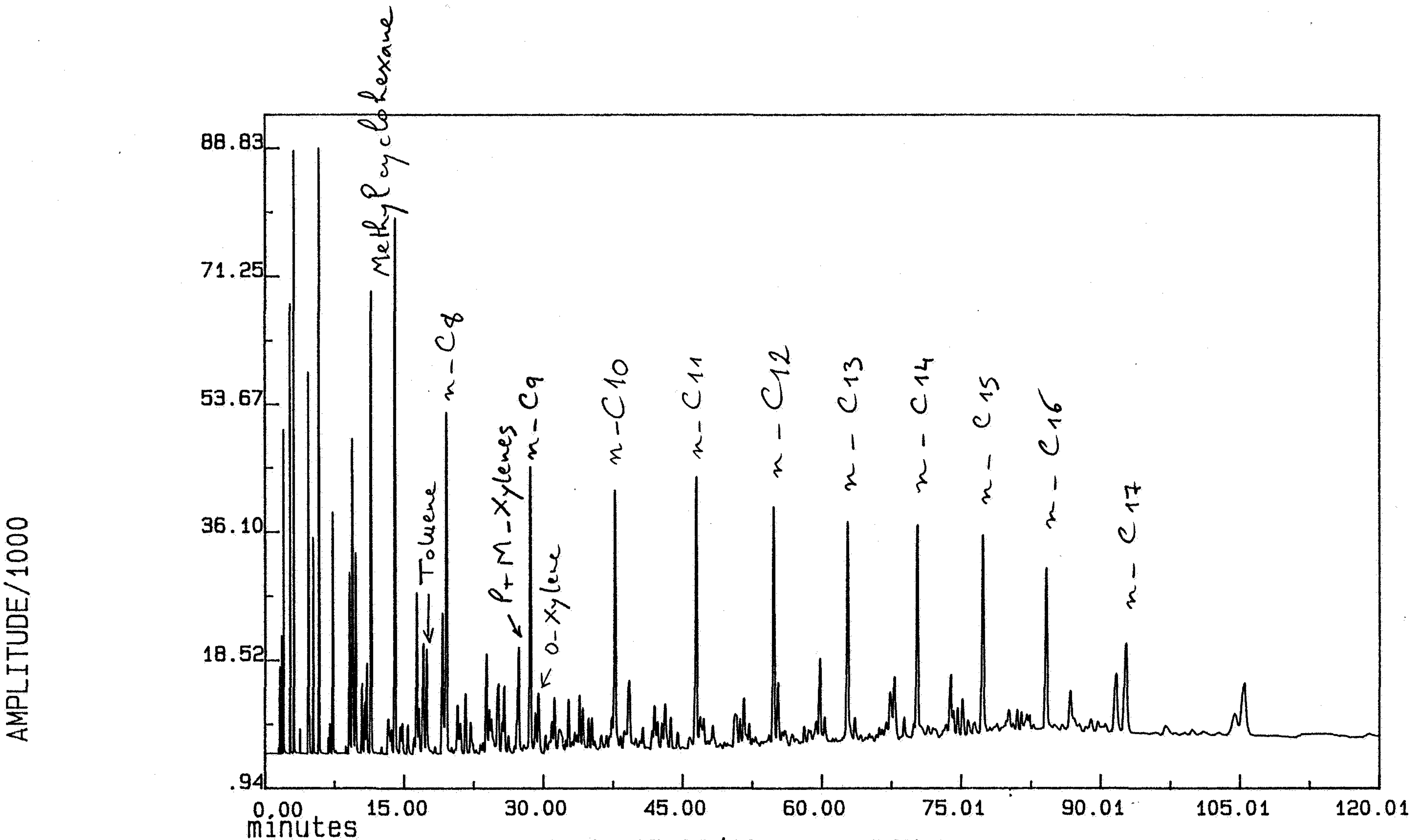


FIGURE 3d.- GC/MS OF DST 2 OIL

FIGURE 4a – THERMOVAPORIZATION OF DST 6 OIL



SAMPLE: 65-06/12-3 _ DST 6

ANALYZED: Mon Nov 17, 1986 2:11:39 pm

RESULT: /DATA/GO/RESULT/TV1 049.RES

FIGURE 4b - GAS CHROMATOGRAPHY OF $C_{12}+$ SATURATES-DST 6 OIL

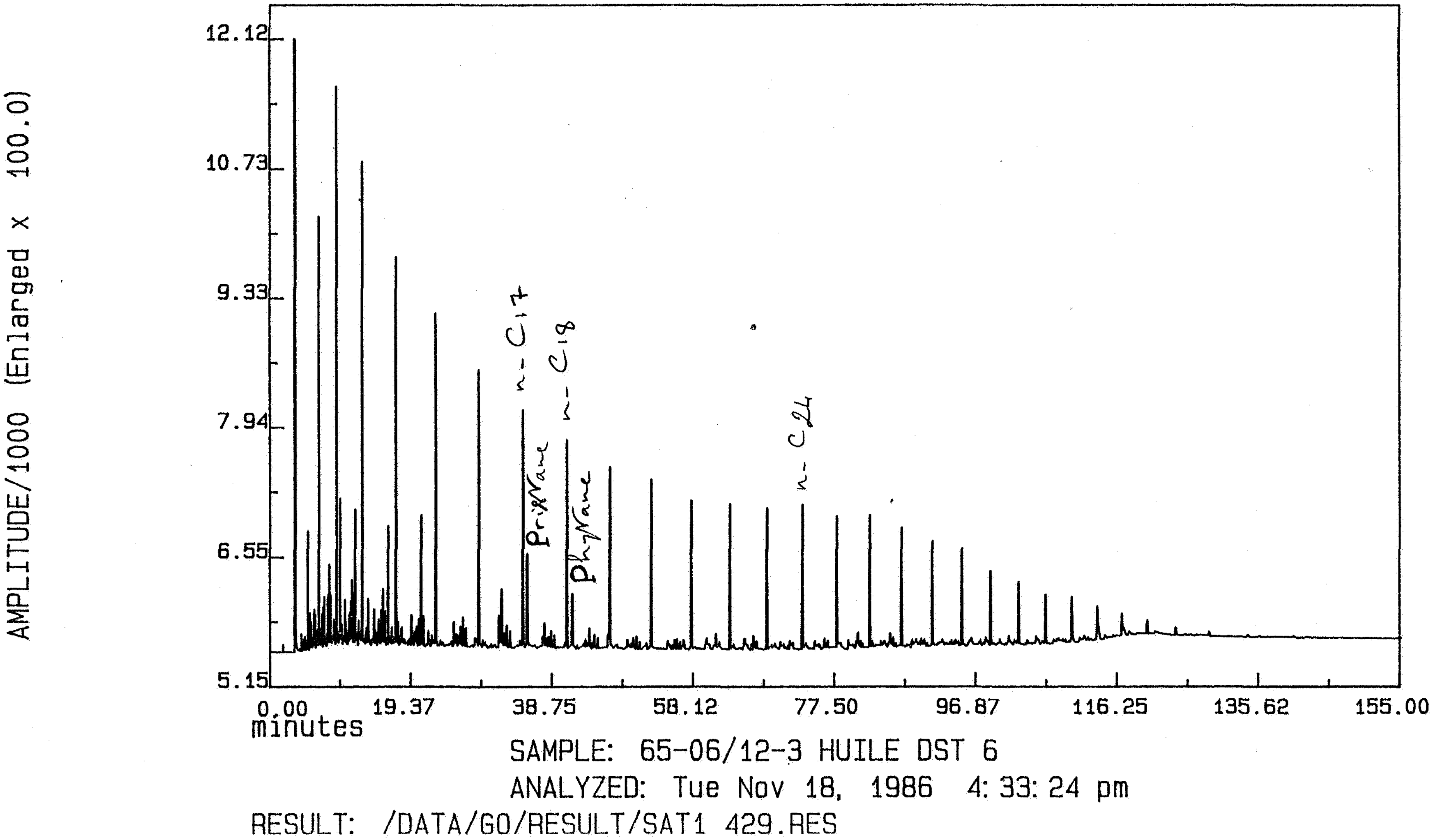
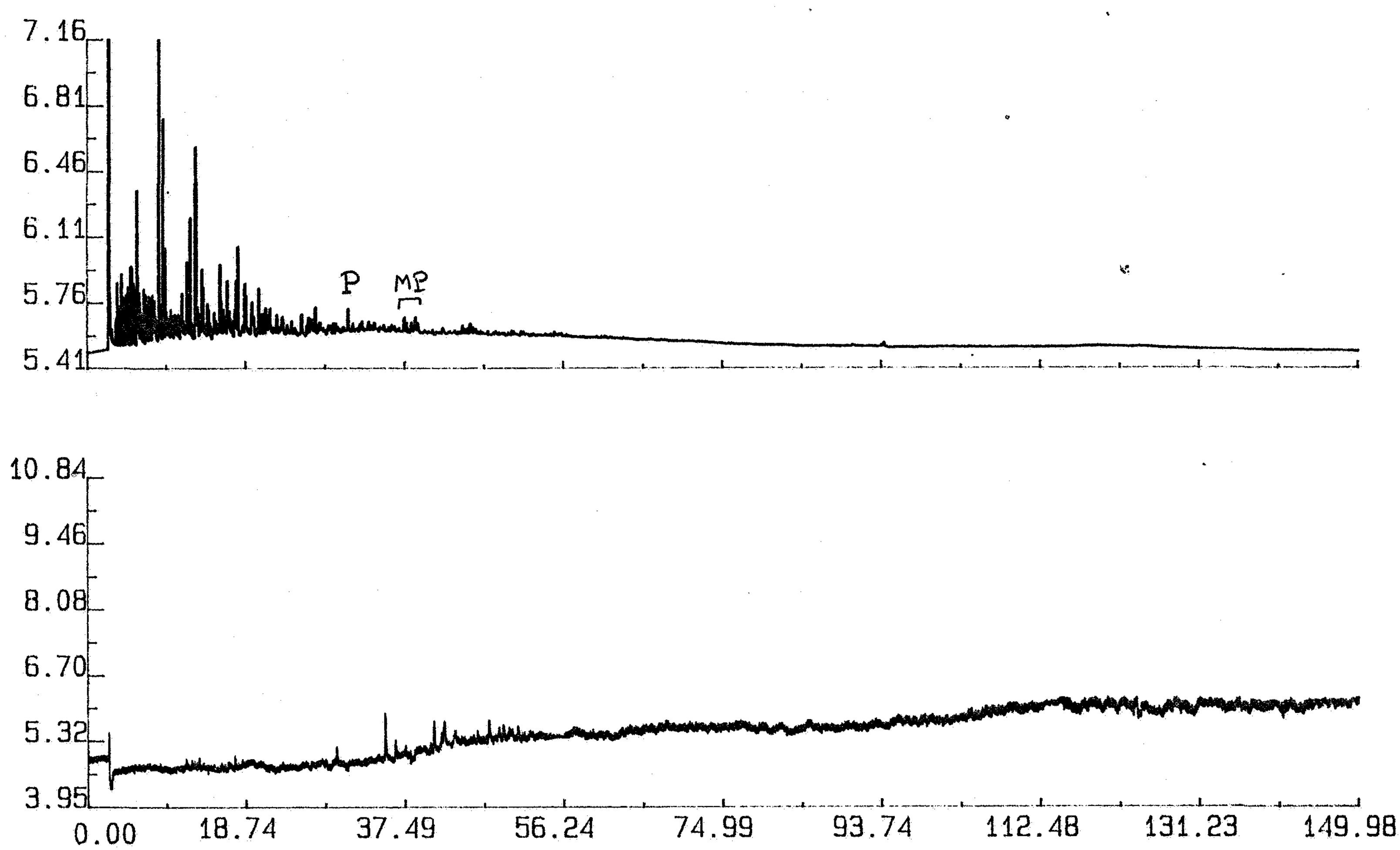


FIGURE 4c -- GAS CHROMATOGRAPHY OF C_{12}^{+} AROMATICS—DST 6 OIL



Top: AR02_T_545 (0.0-150.0) (Enlarged x 400.0)
Bottom: AR02_S_545 (0.0-150.0) (Enlarged x .3)

MIDMASS CHROMATOGRAMS
01/16/87 14:09:00
SAMPLE: NORVEGE 65 06/12-3 DST 6 1785 I/C
CONDS.: CP SIL 8 50 M .. .22 MM "ON COLUMN"
RANGE: G 1,5000 LABEL: N 0, 4.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: NORV1785ICM #248 SCANS 2000 TO 5000
CALI: JAN5CT #1

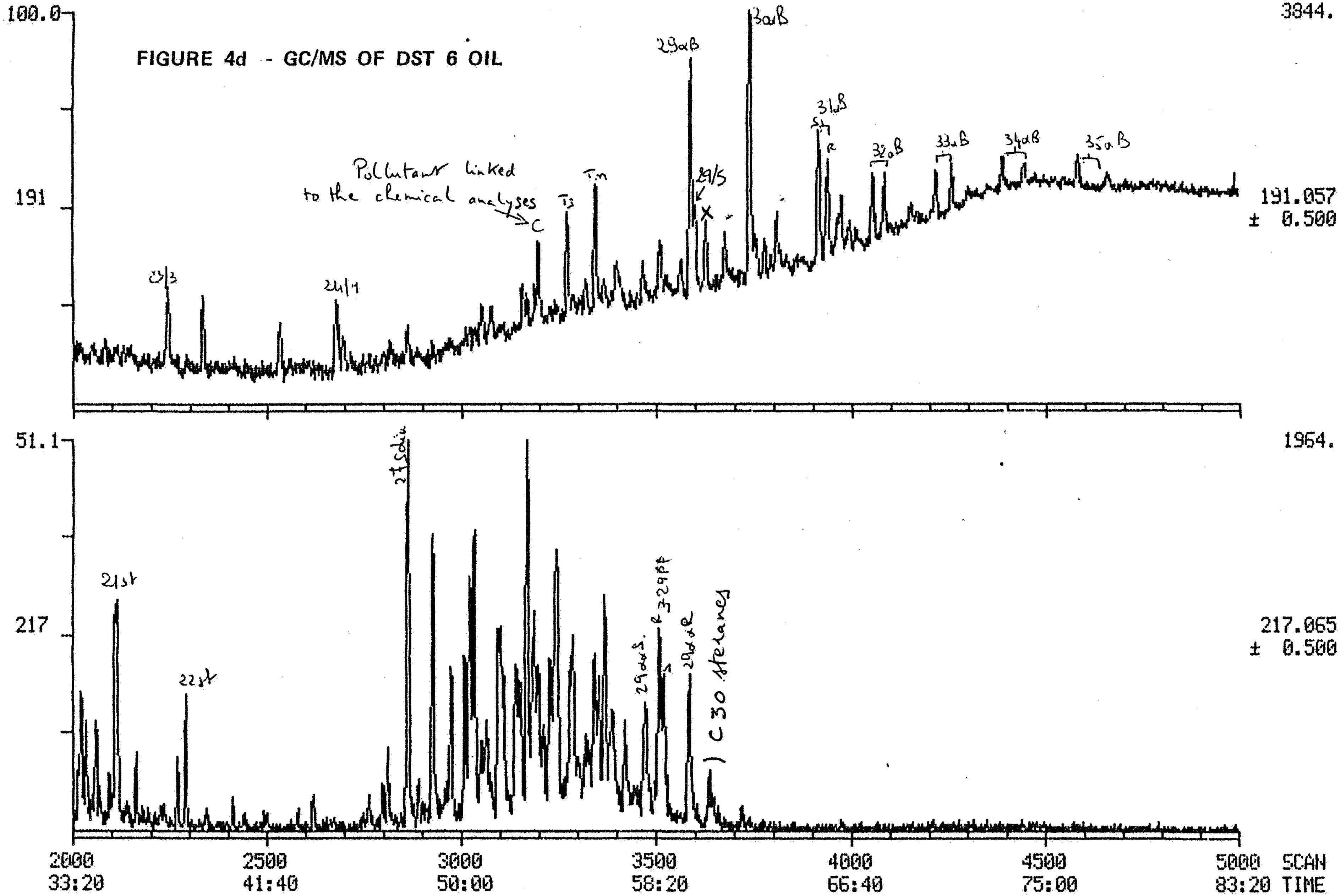


FIGURE 4d - GC/MS OF DST 6 OIL