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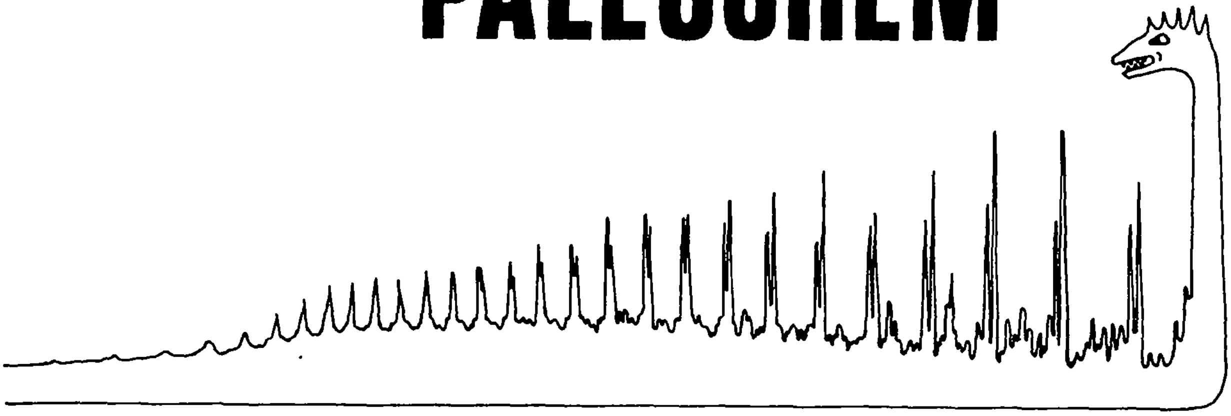

GEOCHEMICAL ANALYSIS OF A CONDENSATE AND THREE CORE EXTRACTS FROM NOCS WELL: 30/2-1.

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PETROLEUM GEOCHEMISTRY REPORT

PREPARED FOR

STATOIL

Geochemical Analysis of a Condensate and Three Core Extracts from NOCS Well: 30/2-1.

November 1983

Contents

Summary

The condensate and core extracts have similar hydrocarbon distributions and belong to the same oil family. They are paraffinic/naphthenic in type, with a moderate aromatic content. CGC/MS data reveal only minor amounts of steranes and triterpanes are present. Carbon isotope data shows a close correlation between condensate and core extracts, very similar to Kimmeridge Clay Formation (KCF) source rocks.

The condensate and core extracts contain high wax contents unlike the majority of KCF oils or the KCF/Heather source rocks on-structure. This may be due to a kerogen facies change and/or input of high molecular weight lipids from intraformational coals.

1. Introduction

A condensate and three core pieces from the NOCS Well: 30/2-1 were analysed using standard geochemical techniques. Oil types were determined by thermal distillation, wax distillate content, fractionation and gas chromatography of the saturate alkane and aromatic hydrocarbon fractions. Detailed correlation of the samples was also carried out using carbon isotope ($\delta^{13}C$) and computerised gas chromatography-mass spectrometry (cgc/ms) data.

The condensate was tested at a depth of 3720 - 3728 m (DST 3) and the core pieces are from 3702.57 - 3702.65 m, 3721.35 - 3721.44 m and 3772.20 - 3772.35 m. For the purpose of clarity, these depths will be referred to throughout this report as 3702 m, 3721 m and 3772 m.

2. Samples and Techniques

The condensate (ca 6 ml) was received in a screw top glass vial for analysis, and the core pieces were wrapped in aluminium foil.

Specific gravity and °API gravity determinations were completed on the condensate using IP Method No.160 and the results are presented in Table 1.

Thermal distillation of the condensate was performed on a modified Hewlett Packard 5880 Gas Chromatograph, fitted with a non polar Scot column, at an injection temperature of 350°C. The cores were similarly examined by placing a small chip of each on a tin boat and volatilizing the enclosed petroleum. This method analyses the hydrocarbon components as standard refinery cuts, and the percentage distribution of each fraction is given in Table 2.

Total Soluble Extracts (TSE's) were obtained by extraction with dichloromethane using a soxhlet apparatus. Weight percent TSE values are presented in Table 3. Aliquots of the condensate and TSEs were deasphaltened by precipitation using n-hexane, and then separated on an activated silica column using liquid chromatographic techniques. Saturated alkane hydrocarbons, aromatic hydrocarbons and NSO fractions were obtained by stepwise elution using n-hexane, toluene and toluene/methanol solvents. Weight percentages of each fraction are given in Table 3.

Saturated alkane fractions (SAC) and aromatic fractions were examined by quartz capillary gas chromatography using a Carlo Erba 2150 Gas Chromatograph with Grob-type splitless injector system. An aliquot of the SACs was also examined by capillary gas chromatography-mass spectrometry (cgc/ms) using a modified Finnigan 4620 gc/ms spectrometer with Grob-type injector. Interpretation of the pentacyclane (m/e 191), total sterane (m/e 217) and $\alpha\beta\beta$ steranes (m/e 218) mass fragmentograms is provided, and the cgc/ms traces are shown in Figures 1 - 16.

Branched and cyclic alkanes were isolated from the four SAC fractions using molecular sieving techniques and subsequently analysed on the Carlo Erba 2150 Gas Chromatograph.

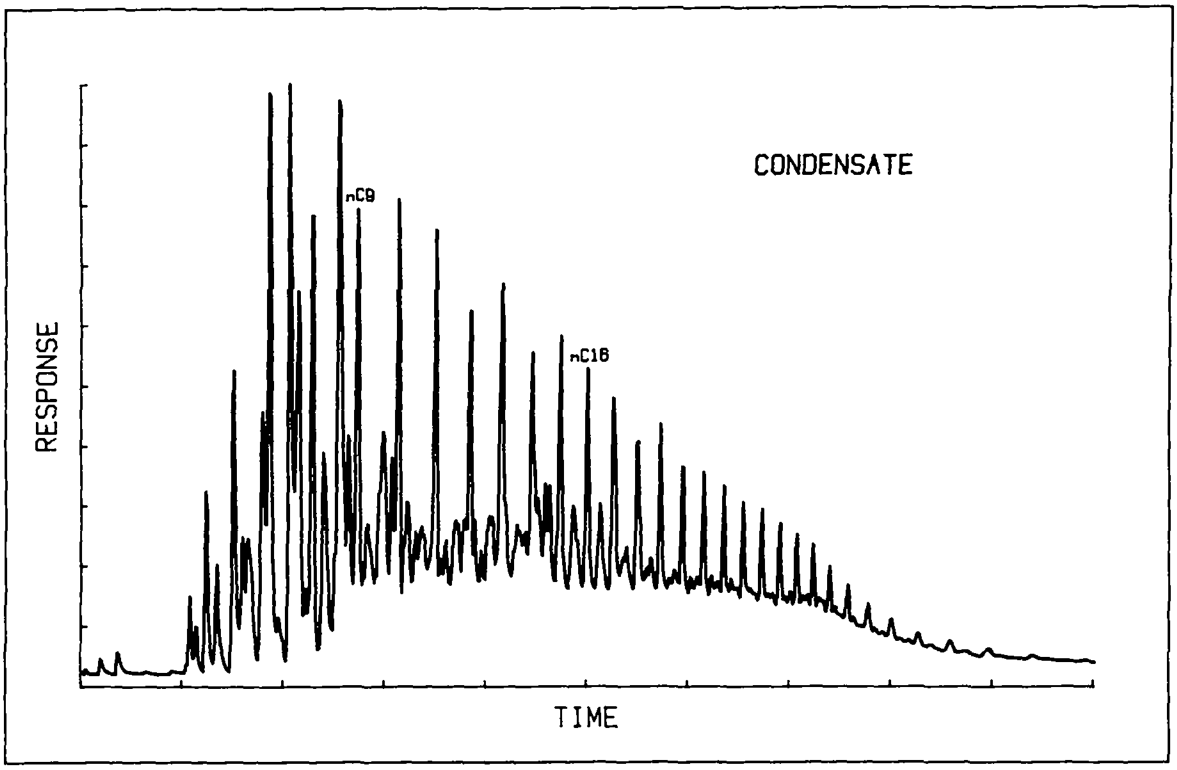
Stable carbon isotope values (δ^{13}C) PDB per mil) were measured for the condensate and TSE's along with their SAC, aromatic and NSO fractions. Results are presented in Table 4, and as Galimov-type plots in Section 3.

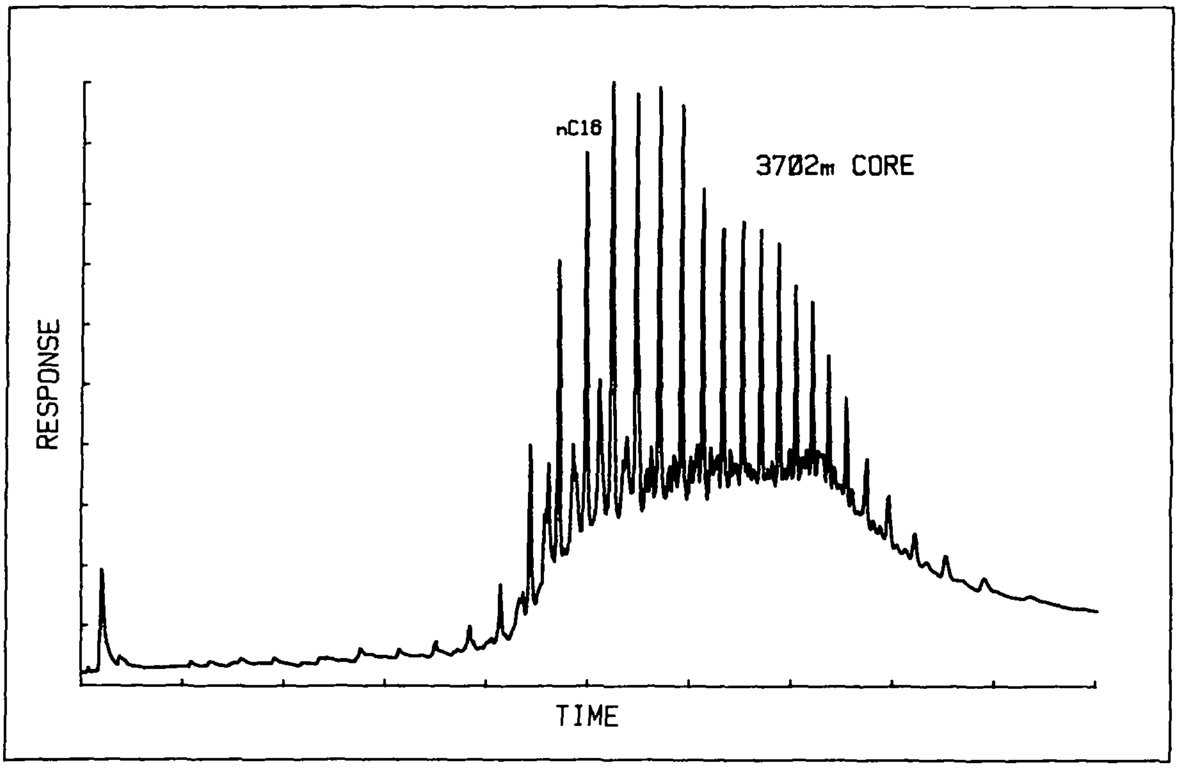
3. Results and Discussion

The condensate is a pale yellow, slightly cloudy, free flowing liquid with S.G. of 0.78 and 50 ^{o}API (Table 1). Thermal distillation and compositional data reveals a paraffinic/naphthenic type oil, with large Gasoline (29%), Kerosine (23%) and Gas Oil (31%) fractions (Table 2), and a high wax distillate content (17%). The chromatographic trace, displayed overleaf, shows abundant long chain alkanes ($> nC_{22}$) which is unusual for a condensate. Normally, n-alkane distributions tail off ca $C_{15} - C_{20}$. Their presence is due to dissolution of high molecular weight alkanes in the condensate caused by high reservoir temperatures and pressures.

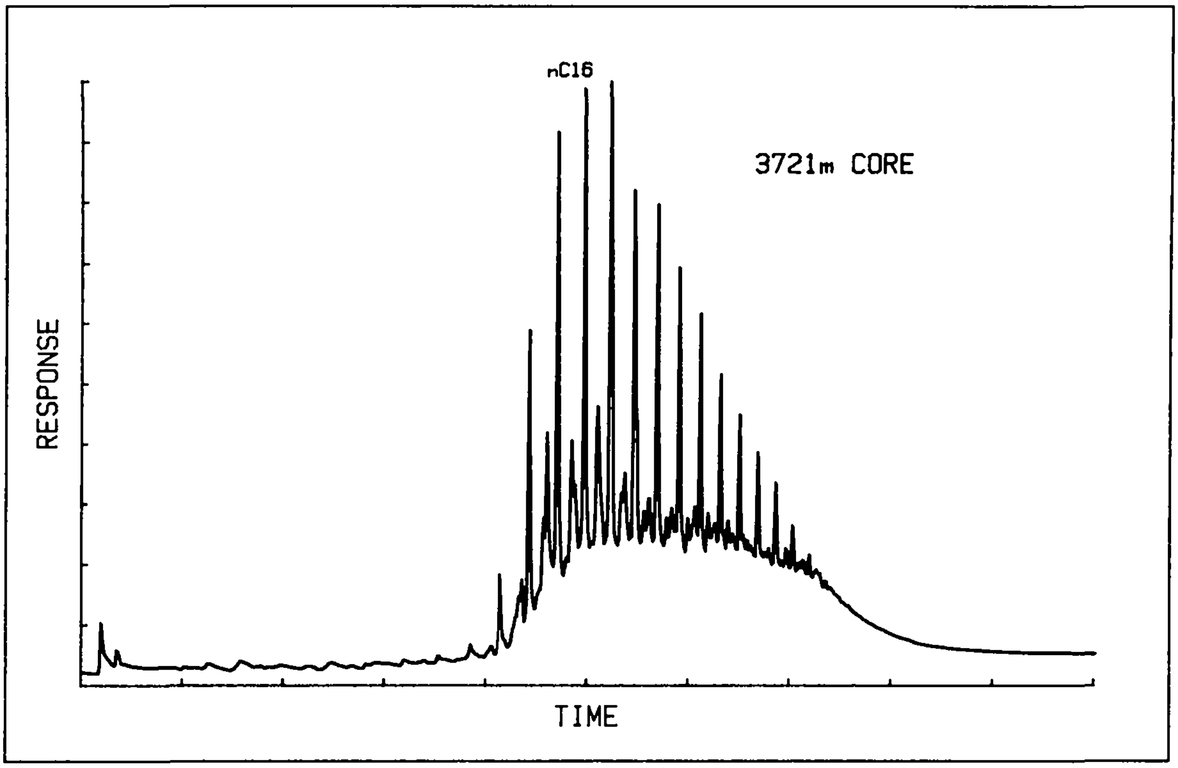
Thermal distillation of the petroleum enclosed in the core chips shows different fraction percentages cf. condensate (Table 2). Gasoline and kerosine are present only in small amounts, while the Gas Oil and wax distillate fractions account for ca 40 - 50% each of the total distillate. These differences can be related to evaporative losses of low boiling point hydrocarbons during collection and storage of the cores. Chromatography (pages 5 and 6) reveals mainly C_{15}+ hydrocarbons, predominantly paraffinic/naphthenic in type. Both the core and condensate contain high wax contents unusual for North Sea oils.

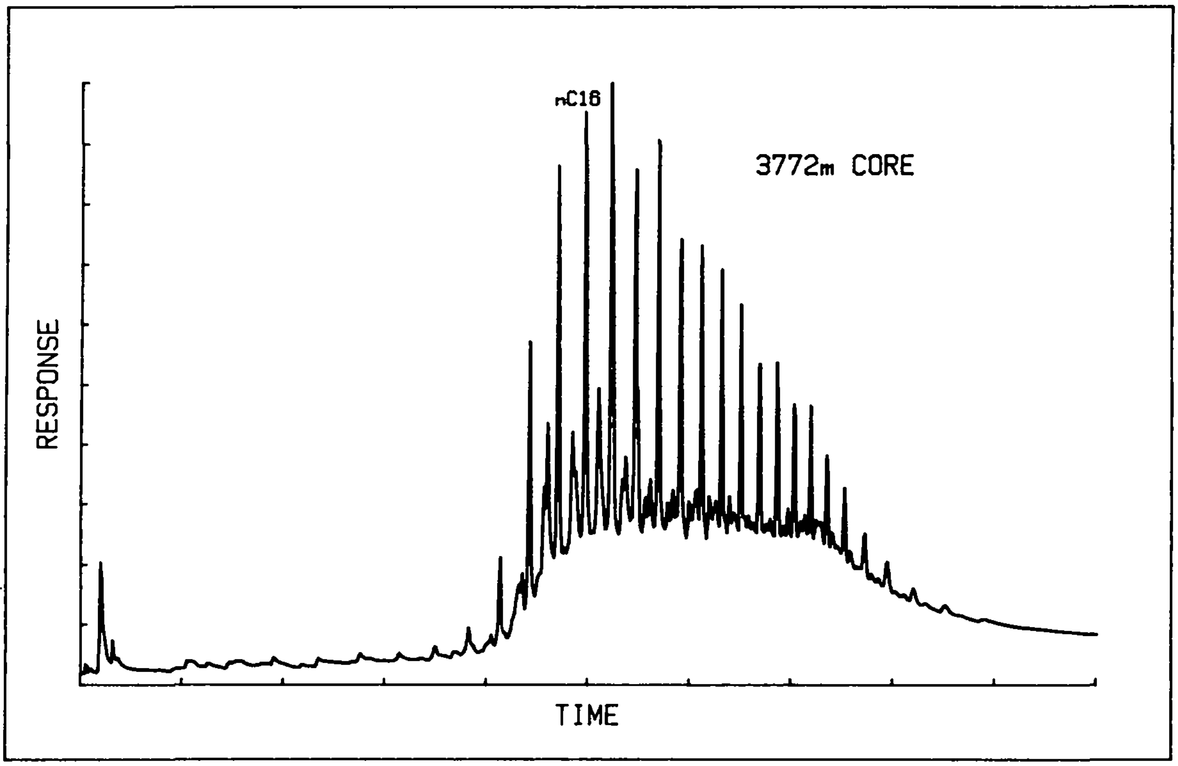
30/2-1 - THERMAL DISTILLATION





30/2-1 - THERMAL DISTILLATION





Core extraction gave TSE yields of 0.21 - 0.3% wt. (Table 3). Oil and TSE fractionation reveals a high saturated alkane content (70.5 - 77.4%), paraffinic/ naphthenic in nature, with moderate amounts of aromatic hydrocarbons and only small NSO fractions. Non-eluted NSO or asphaltene contents are not present.

S.A.C., branched and cyclic alkanes and aromatic hydrocarbon distributions for the condensate and TSE's are presented on pages 9 - 12. The S.A.C. traces show a smooth n-alkane envelope, indicative of maturity, with a slight odd-over-even predominance visible in the core distributions e.g. nC_{17} and nC_{19}.

The branched and cyclic alkane distributions reveal the predominance of four regular isoprenoids - C_{16}, C_{18}, pristane (C_{19}) and phytane (C_{20}). C_{17} is present only in small amounts due to theromodynamic constraints. Pristane/ Phytane ratios are ca 1.8 - 2. Cyclic alkanes (naphthenes) are present as a complex unresolved hump. Isoprenoid alkane distribution for condensate and core extracts are virtually identical suggesting a common origin.

Aromatic hydrocarbon distributions show a suite of prominent peaks between ca C_{12} - C_{20} present in all samples. These are as yet unnamed and would require gc/ms analysis for identification. The chromatogram for 3721 m Core shows a series of large peaks ca C_{10}:- these are considered to be alkyl-aromatic compounds but are so far unnamed. The hump present in all traces represents an unresolved complex mixture. The core distributions are very similar with the exceptions of varying losses of monoaromatics due to core storage. The condensate distribution appears dissimilar but this is thought to be due to major abundances of volatile low molecular weight aromatic compounds.

The similarity of the three fractions in all cases is good evidence for correlation of the oils to the same ~~oil~~

family and source rock.

The S.A.C. fractions were examined by gas chromatography -mass spectrometry, and the traces are presented in Figures 1 - 16. The total ion fragmentograms (RIC) show similar distributions comparable with the S.A.C. gas chromatograms (Figures 1, 5, 9 13).

The m/e 191 fragmentograms reveal a virtual absence of pentacyclane triterpanes, and no definite identification of hopane stereoisomers can be made. (Figures 2, 6, 10, 14). Their absence indicates deep burial or a high temperature reservoir regime which has effectively detroyed these compounds, leaving behind residual amounts which do not have any significant correlative usefulness. The condensate trace displays an homologous series of unknown compounds.

Total sterane m/e 217 fragmentograms reveal only trace amounts of these compounds are present, which again is a reflection of the maturity (Figures 3, 7, 11 15). The S and R stereoisomers have peak height ratios ca 1.3 (excepting the diacholestanes) which agrees well with the theoretical equilibrium composition (Table 5).

The m/e 218 fragmentograms in Figures 4, 8, 12 and 16 enhance the 5α 14β 17β sterane configurations of the iso-cholestane series. These show S/R ratios between 0.5 - 0.9, with the abundance of the S stereoisomer indicating a highly mature oil sample.

Carbon isotope data is presented in Table 4 and on page 13 as a Galimov type plot. A good correlation is seen between the condensate and three TSE's (1 per mil variation). Similarly, the S.A.C., aromatic hydrocarbon and NSO fractions show a good match, with the largest range (1.4 per mil for NSO) well within the limits for correlative purposes. The data corroborates the chromatographic evidence that the [illegible]

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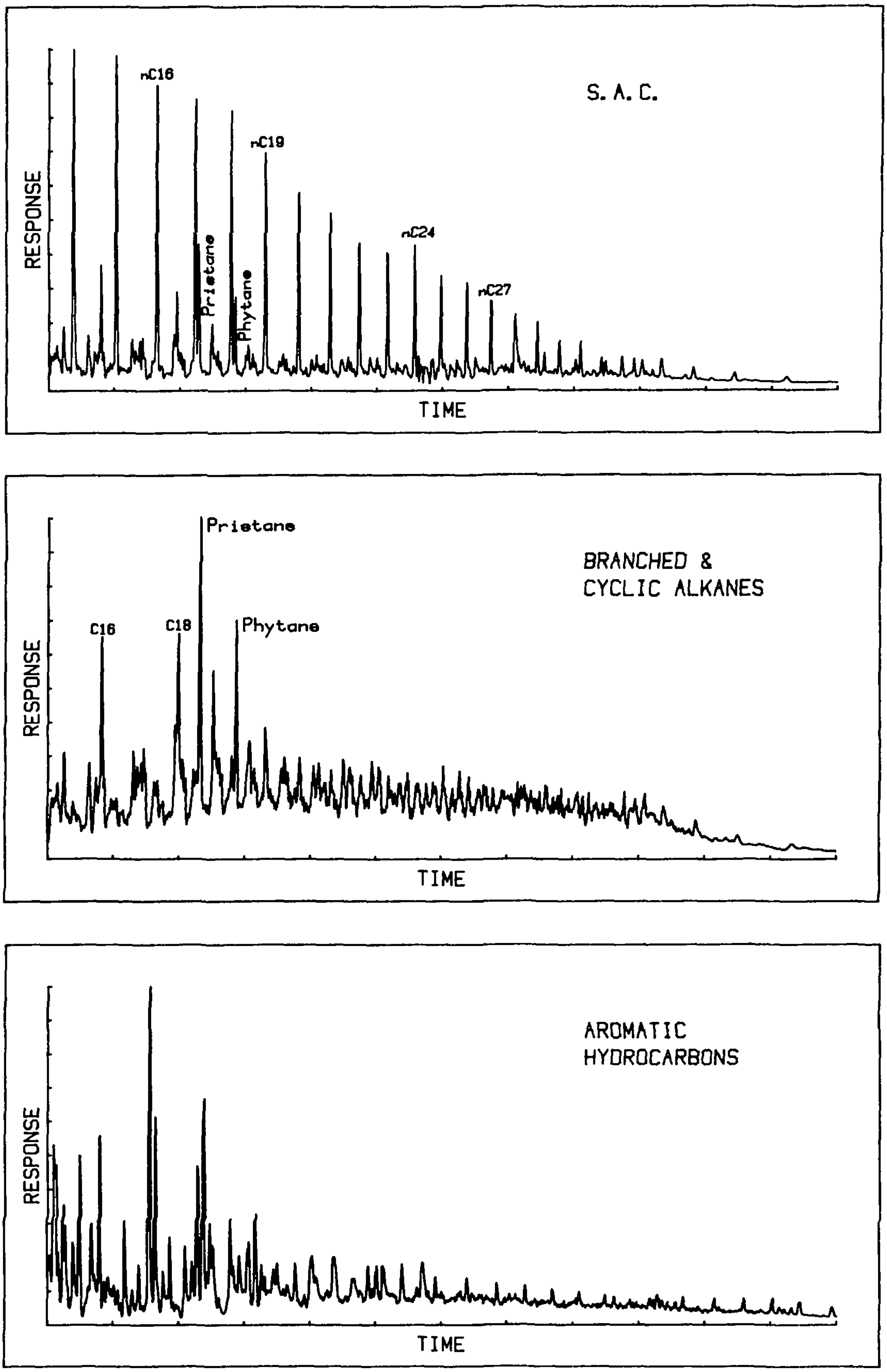
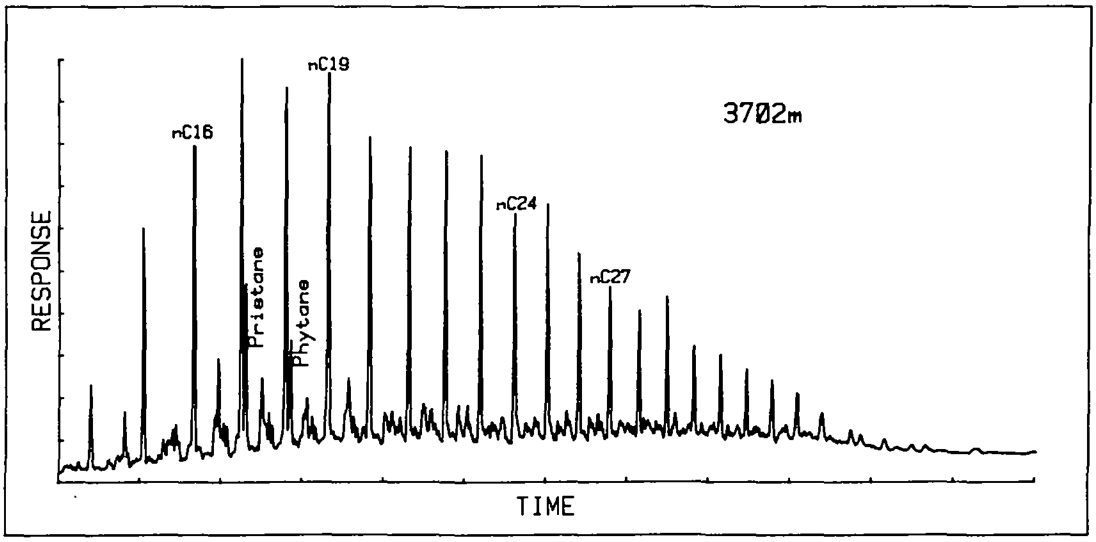
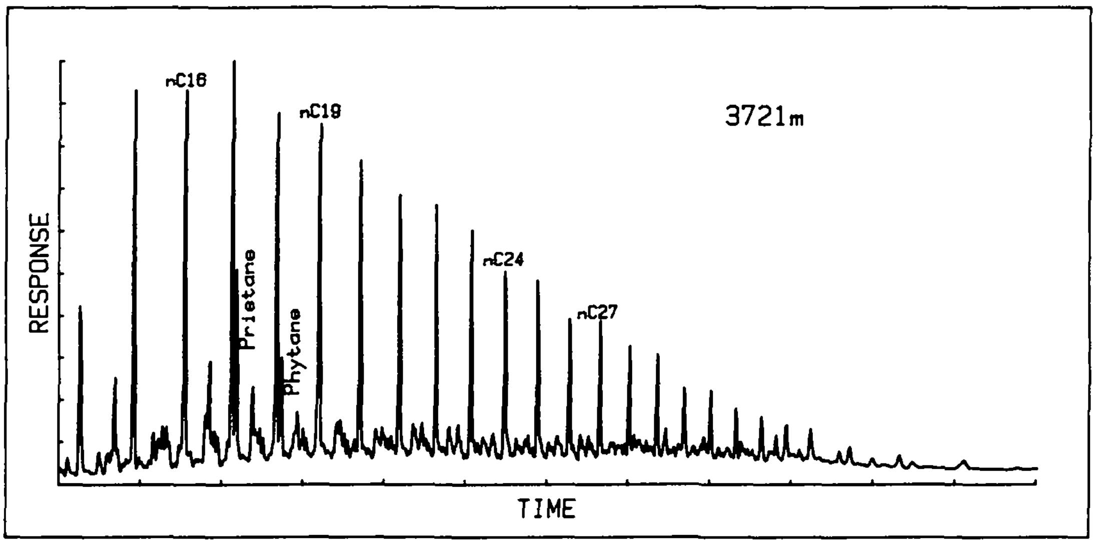
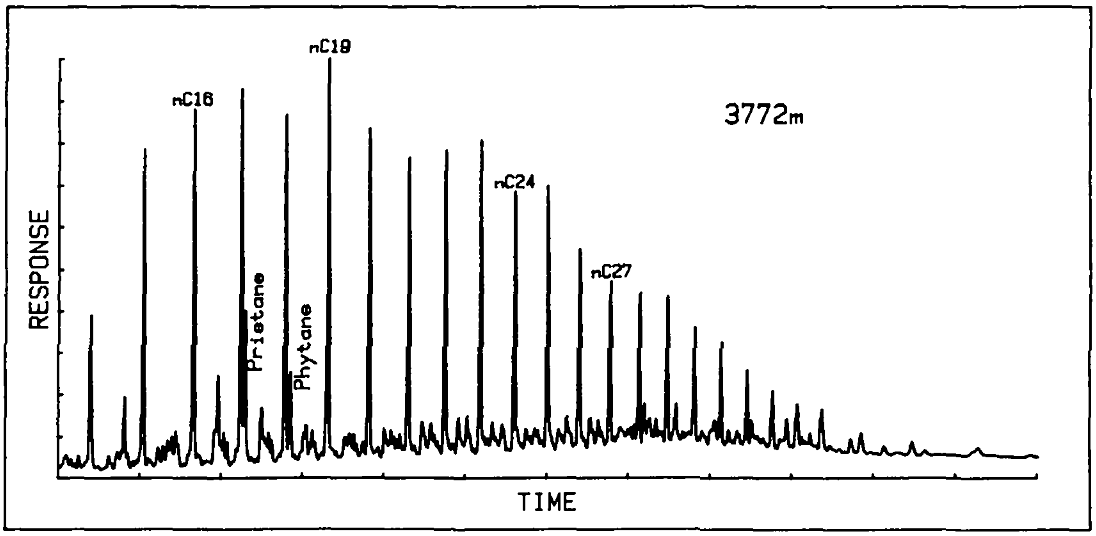
30/2-1 CONDENSATE - HYDROCARBON DISTRIBUTION



30/2-1 CORES - S.A.C. DISTRIBUTION







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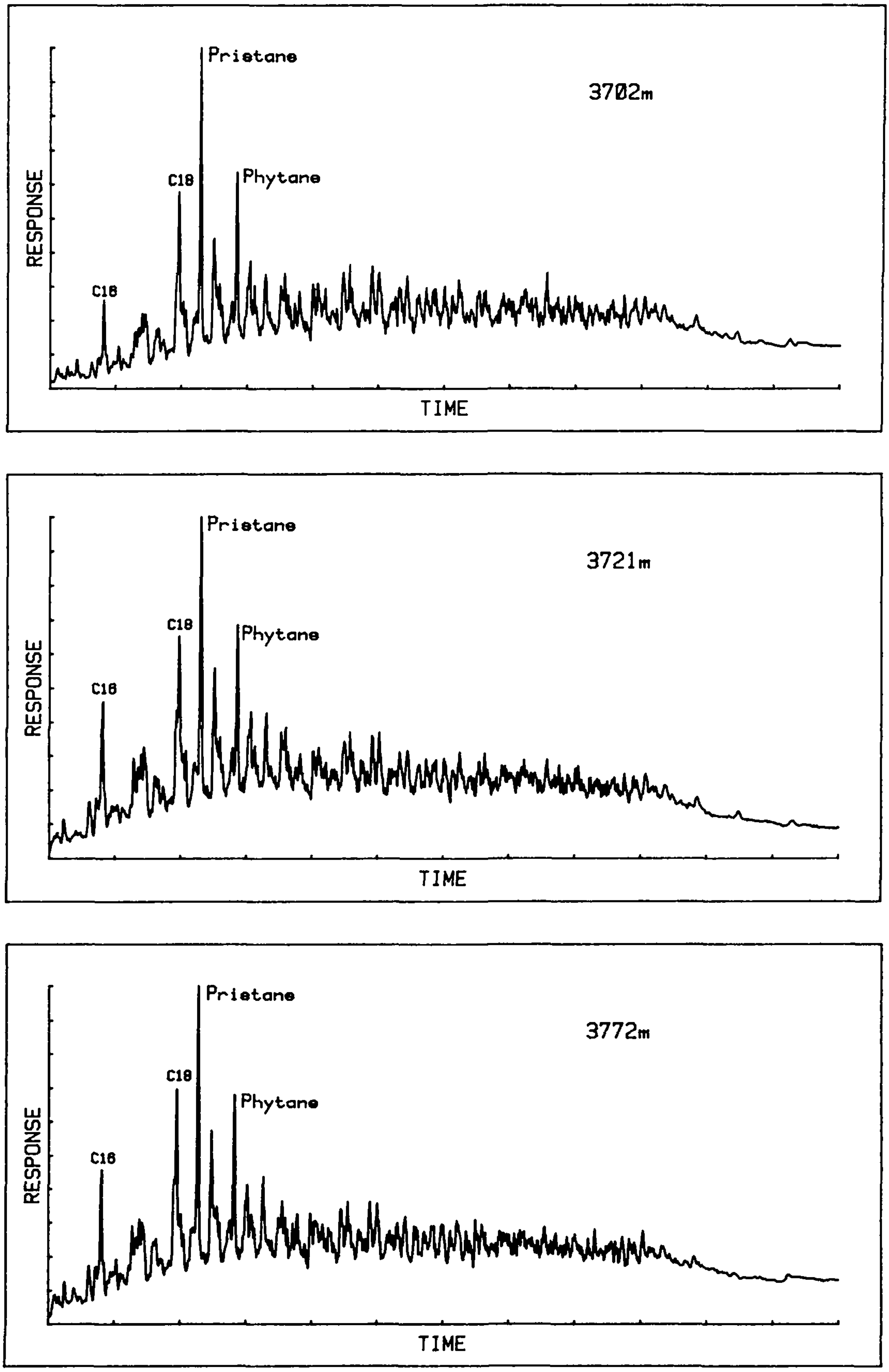
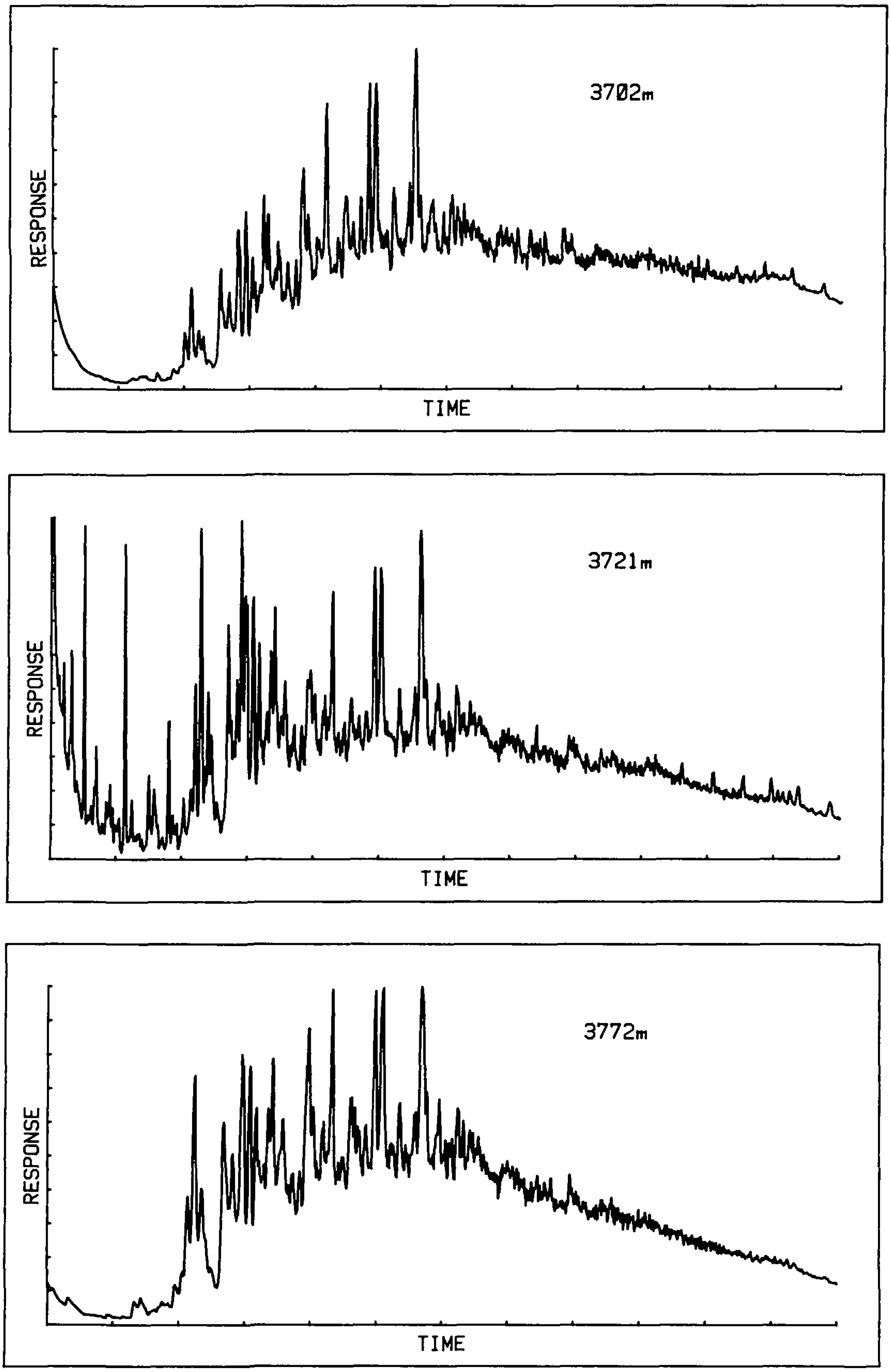
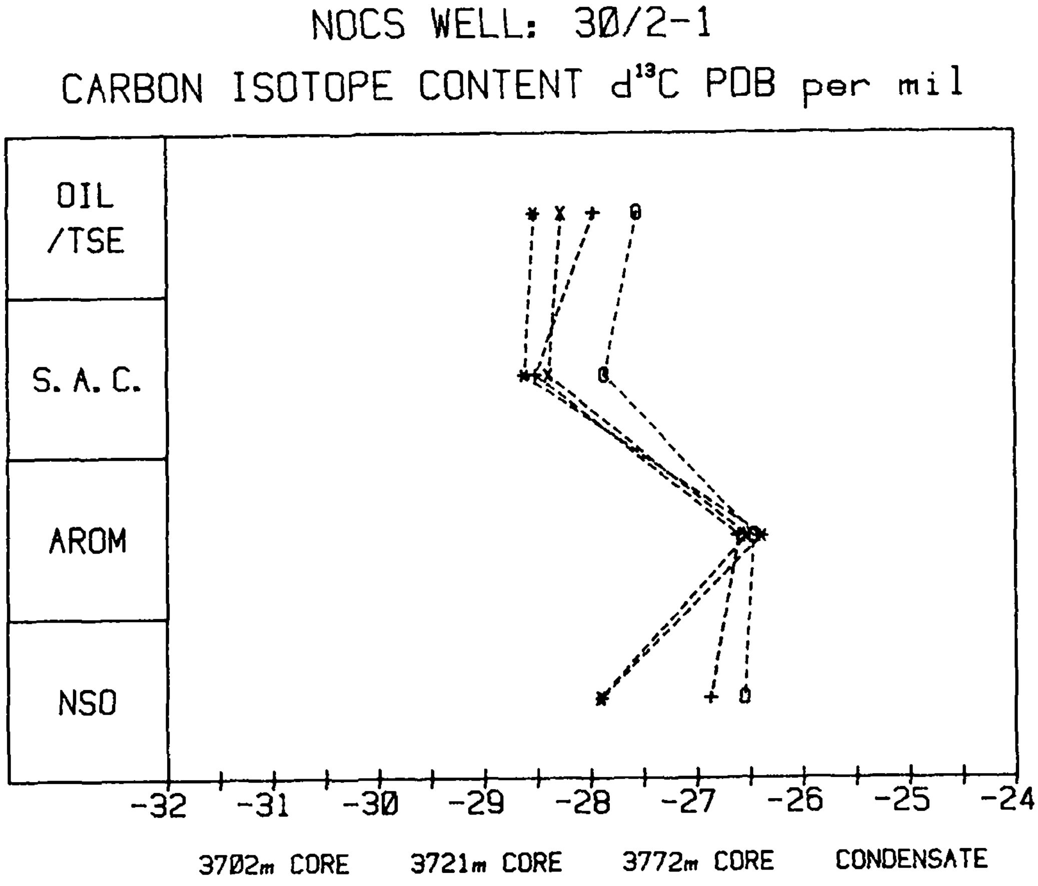
30/2-1 CORES - BRANCHED & CYCLIC ALKANES



30/2-1 CORES - AROMATIC HYDROCARBON DISTRIBUTION



belong to the same oil family. The whole oil values, -28 ± .5 per mil, suggest that the oils are North Sea KCF type oils, as these usually have δ^{13}C values of -28 to -29 per mil. Hence, the KCF deeply buried off-structure is the most likely progenitor of these oils. The high wax content of the condensate and core extracts is unusual however, since the vast majority of KCF derived oils have wax contents less than 10%. Possibly source rock kerogen facies are more humic in character in nearby drainage volumes. On-structure at 3755 - 3770 m the previous Paleochem report (1, pp 15) reveals a very similar S.A.C. distribution with high wax content. Extracts from the Kimmeridge Clay and Heather Formations at 3560 to 3575 m and 3650 to 3665 m are notable in that their wax contents are much less abundant than those from the condensate and core extracts.



4. Conclusions

i) The condensate and extracts are considered to belong to the same oil family, being paraffinic/ naphthenic in type with a moderate aromatic hydrocarbon content.

ii) GC/MS data reveal only minor amounts of steranes and triterpanes due to deep burial and associated high reservoir temperatures degrading polycyclanes. Sterane 20S/R epimer ratios have reached thermodynamic equilibrium, i.e. oil generation at Ro $>$ 0.8%.

iii) Carbon isotope data shows a good correlation between the condensate and extracts and indicates that they are likely to be derived from KCF source rocks.

iv) Variation of kerogen facies is suggested by the high wax contents of the condensate and low/moderate wax contents of the KCF and Heather Formations on-structure.

Reference

1. Paleochem Ltd. Geochemical Source Rock Evaluation of Sediments from NOCS Well: 30/2-1. January 1983.

CONDENSATE

Specific Gravity	0.78
°API at 15.6°C (60°F)	50

Table 1.

Well: 30/2-1

THERMAL DISTILLATION

Fraction	Carbon No.	Temperature Equivalent °C	Condensate DST 3	3702 m Core	3721 m Core	3772 m Core
Wet Gases	$C_1 - C_4$	up to 36	0	1	1	1
Gasoline	$C_5 - C_9$	36 - 168	29	2	2	2
Kerosine	$C_{10} - C_{13}$	168 - 250	23	3	3	3
Gas Oil	$C_{13} - C_{22}$	250 - 380	31	44	60	51
Wax Distillate	$C_{22}+$	380+	17	50	34	43

% Composition of Distillation Fractions of Oils

Table 2.

Well: 30/2-1

OIL AND TSE ANALYSIS

	Condensate DST 3	3702 m Core	3721 m Core	3772 m Core
S.A.C.	76.9	70.5	73.2	77.4
Aromatic HC	18.0	23.3	16.5	15.4
Eluted NSO's	5.1	6.2	10.3	7.2
Non Eluted NSO's	-	-	-	-
Asphaltenes	-	-	-	-
TSE % wt.	-	0.30	0.21	0.24

% Composition of Condensate and Extracts

Table 3.

Well: 30/2-1

CARBON ISOTOPE DATA

	Condensate DST 3	3702 m Core	3721 m Core	3772 m Core
Whole Oil/TSE	-28.0	-27.5	-28.3	-28.5
S.A.C.	-28.5	-27.8	-28.4	-28.6
Aromatic HC	-26.6	-26.5	-26.5	-26.4
N.S.O.	-26.9	-26.5	-27.9	-27.9

δ^{13}C PDB per mil Composition of Oils and their fractions.

Table 4.

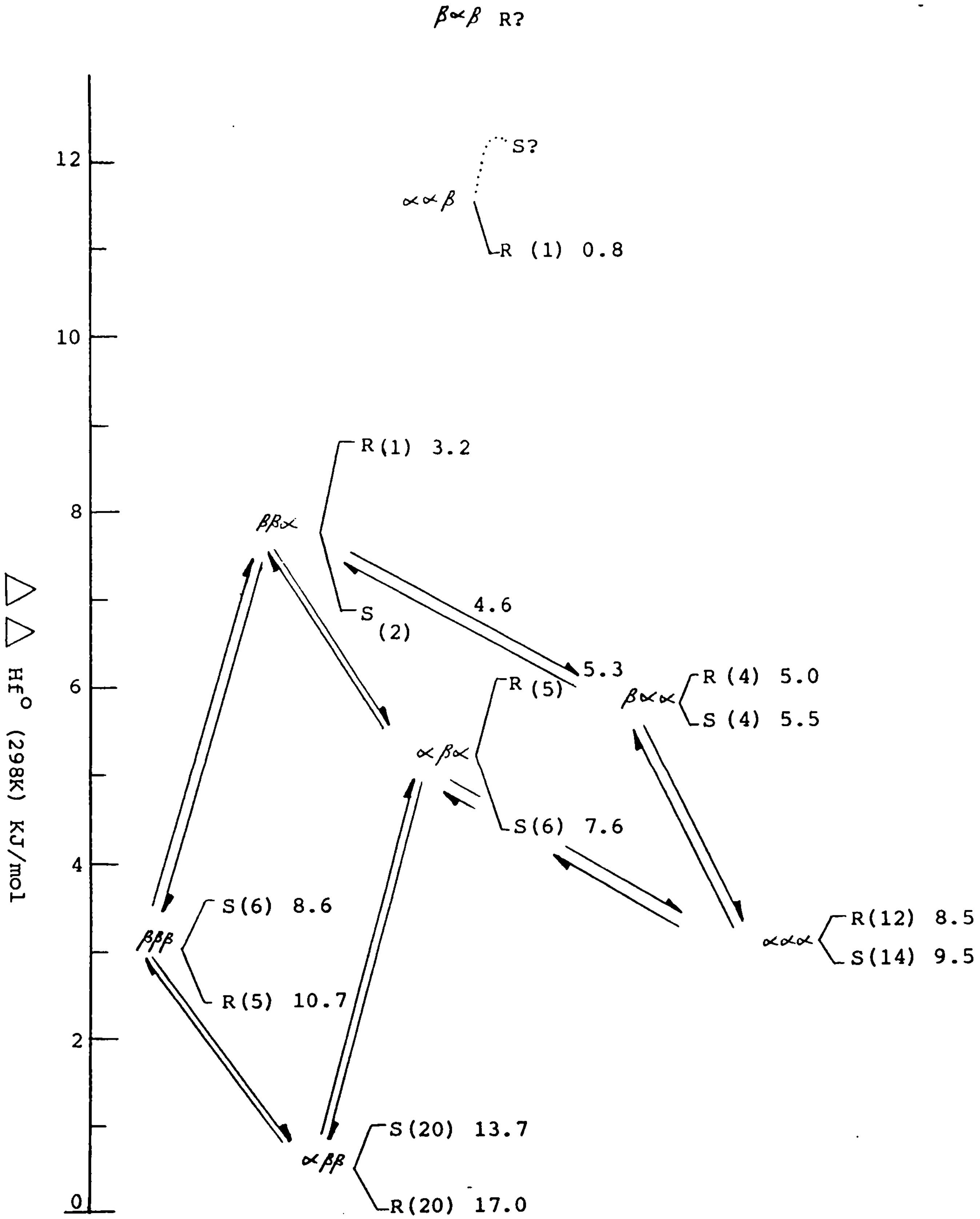


TABLE. 5

Energy differences between cholestane isomers. Composition of isomers at equilibrium (mol %). Allowed conversions (⇌). Forbidden transitions not shown.

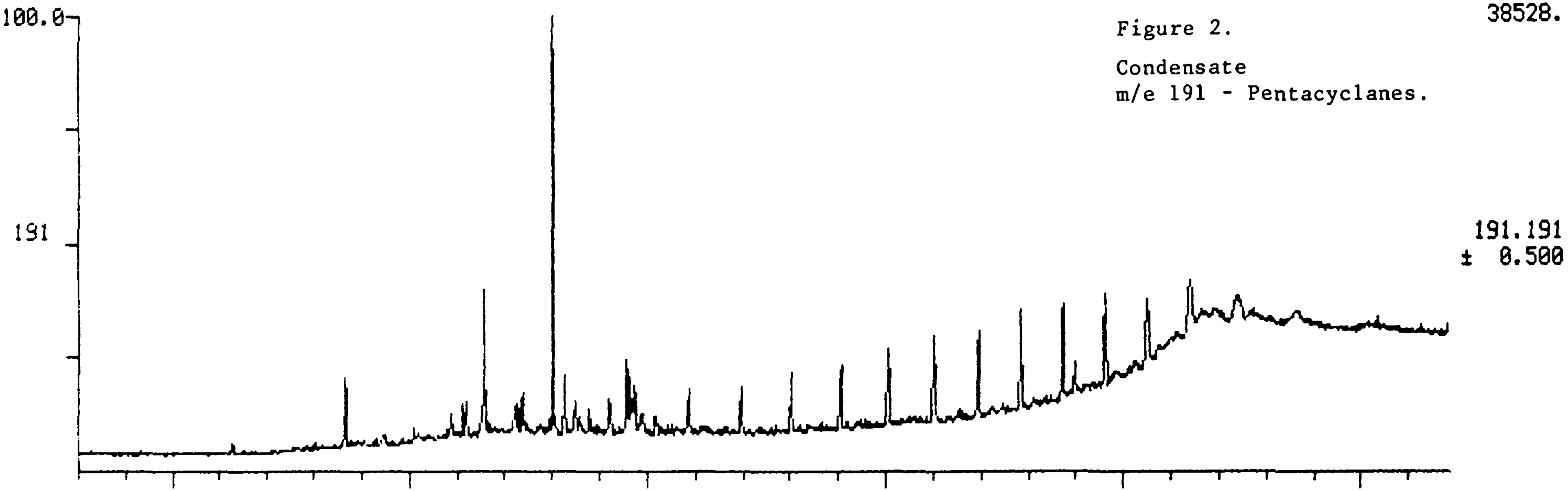


Figure 2.

Condensate
m/e 191 - Pentacyclanes.

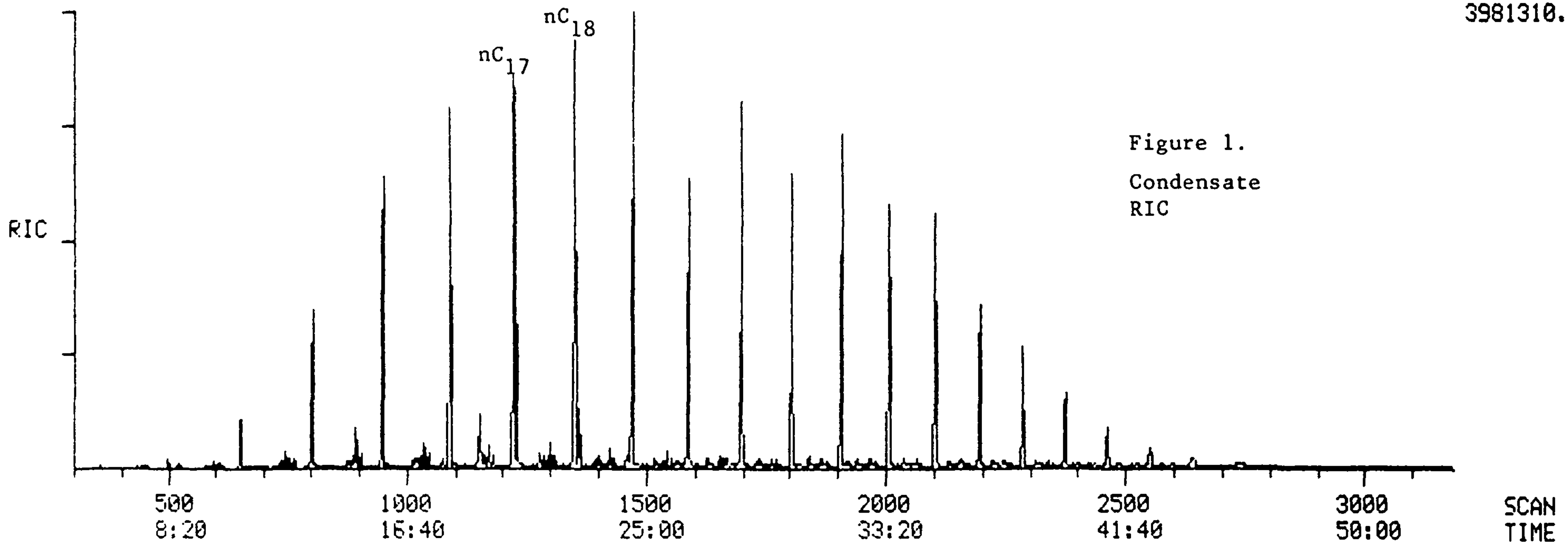


Figure 1.

Condensate
RIC

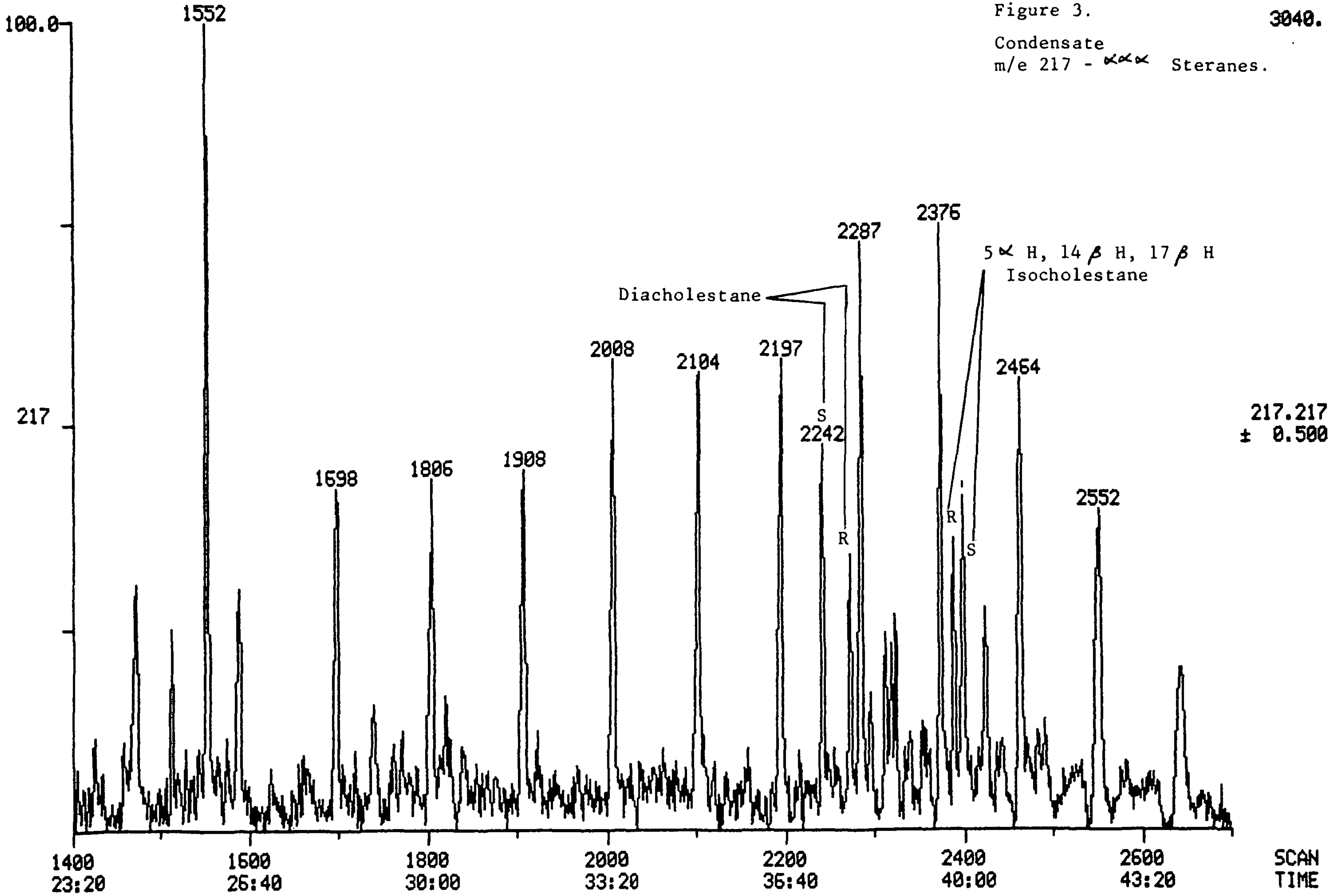


Figure 3.

Condensate
m/e 217 - ααα Steranes.

DST 3

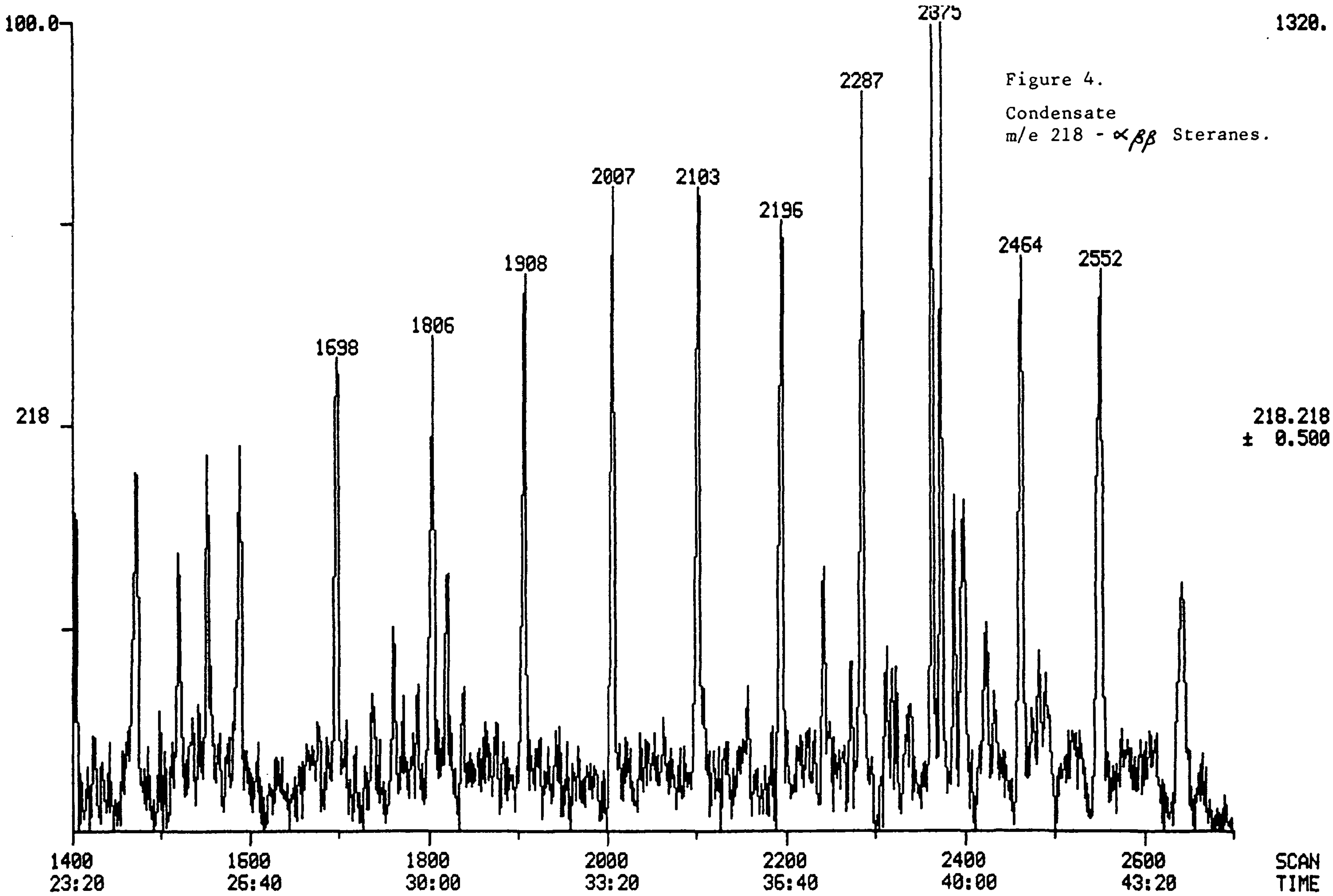


Figure 4.
Condensate
m/e 218 - αββ Steranes.

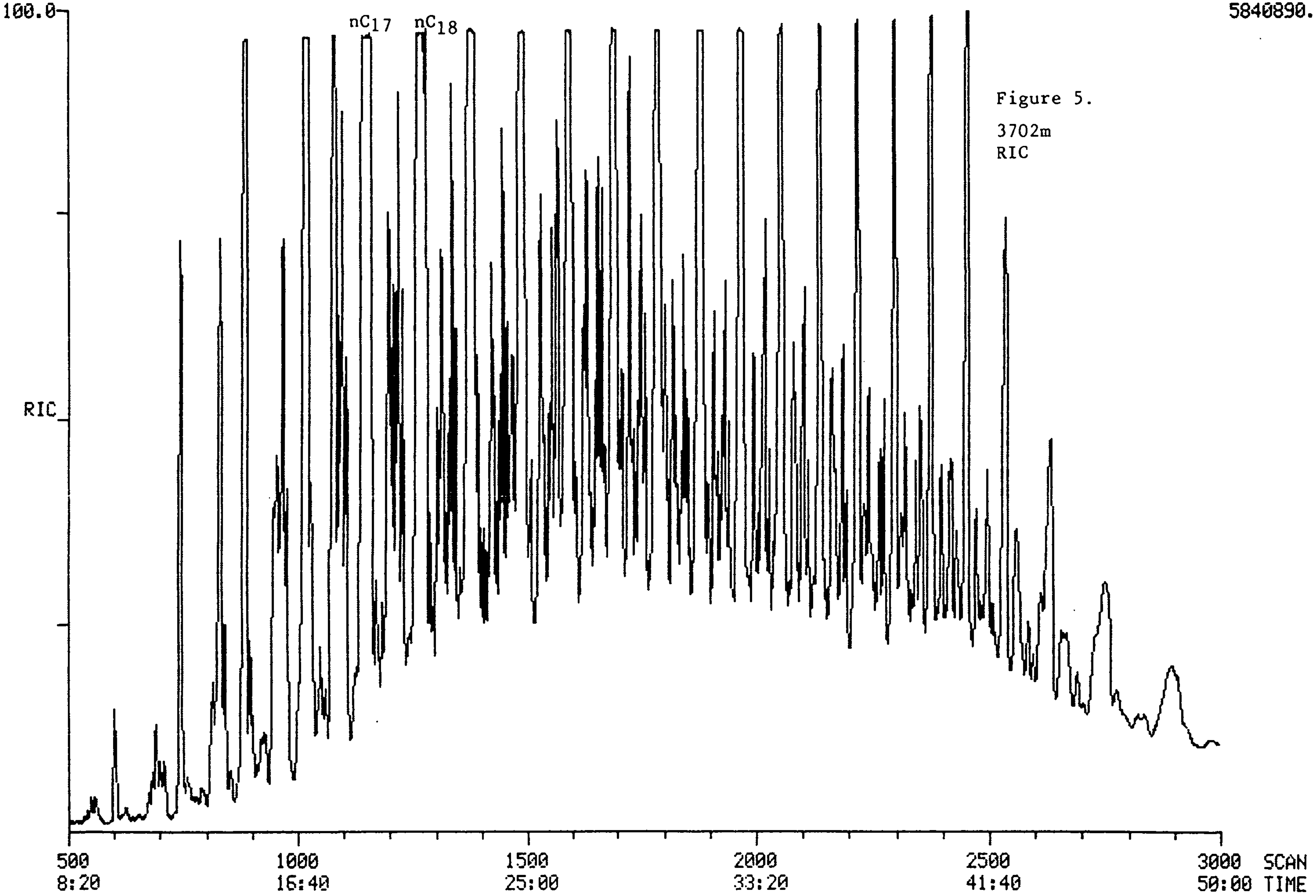


Figure 5.

3702m
RIC

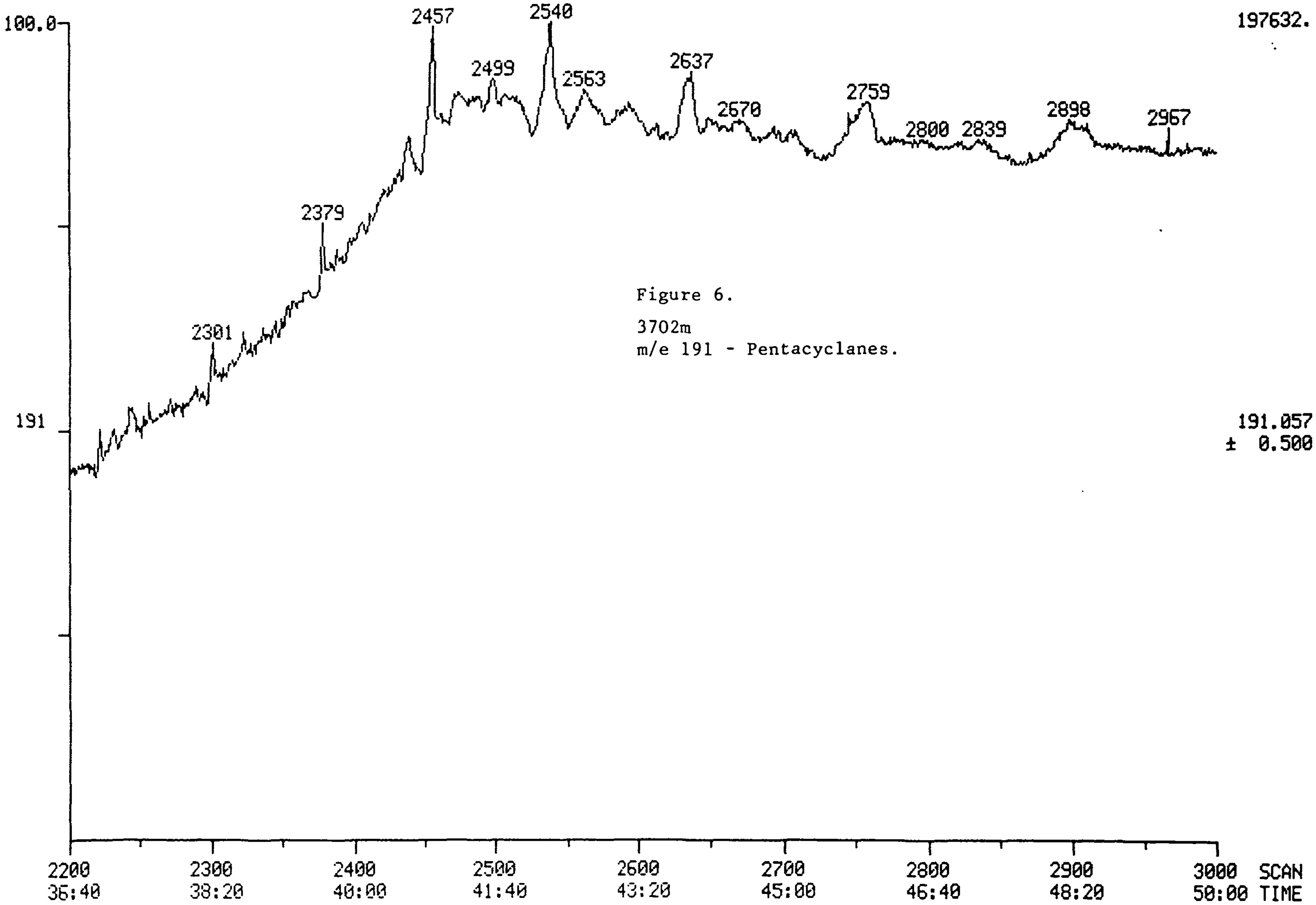


Figure 6.

3702m
m/e 191 - Pentacyclanes.

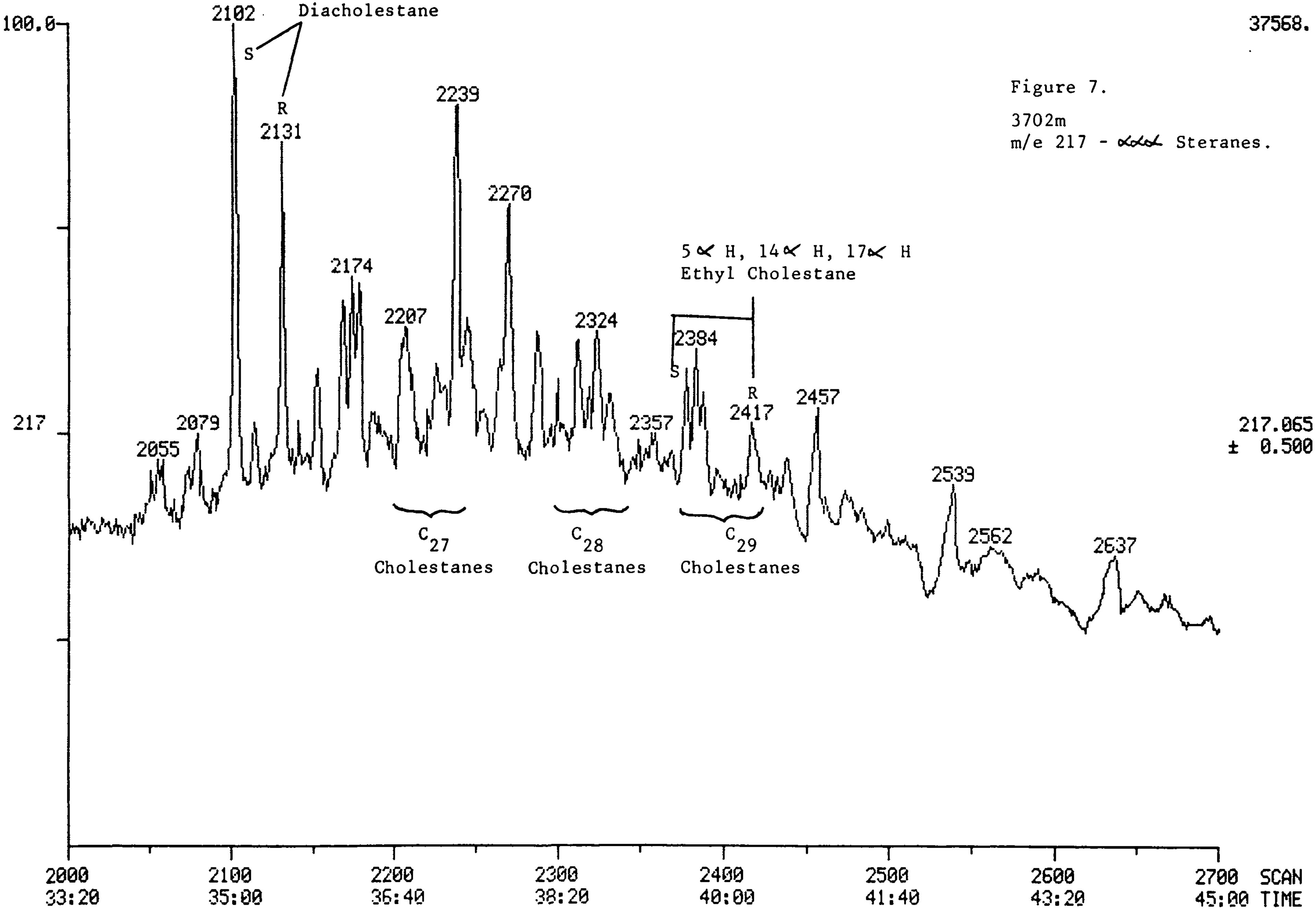


Figure 7.

3702m
m/e 217 - ααα Steranes.

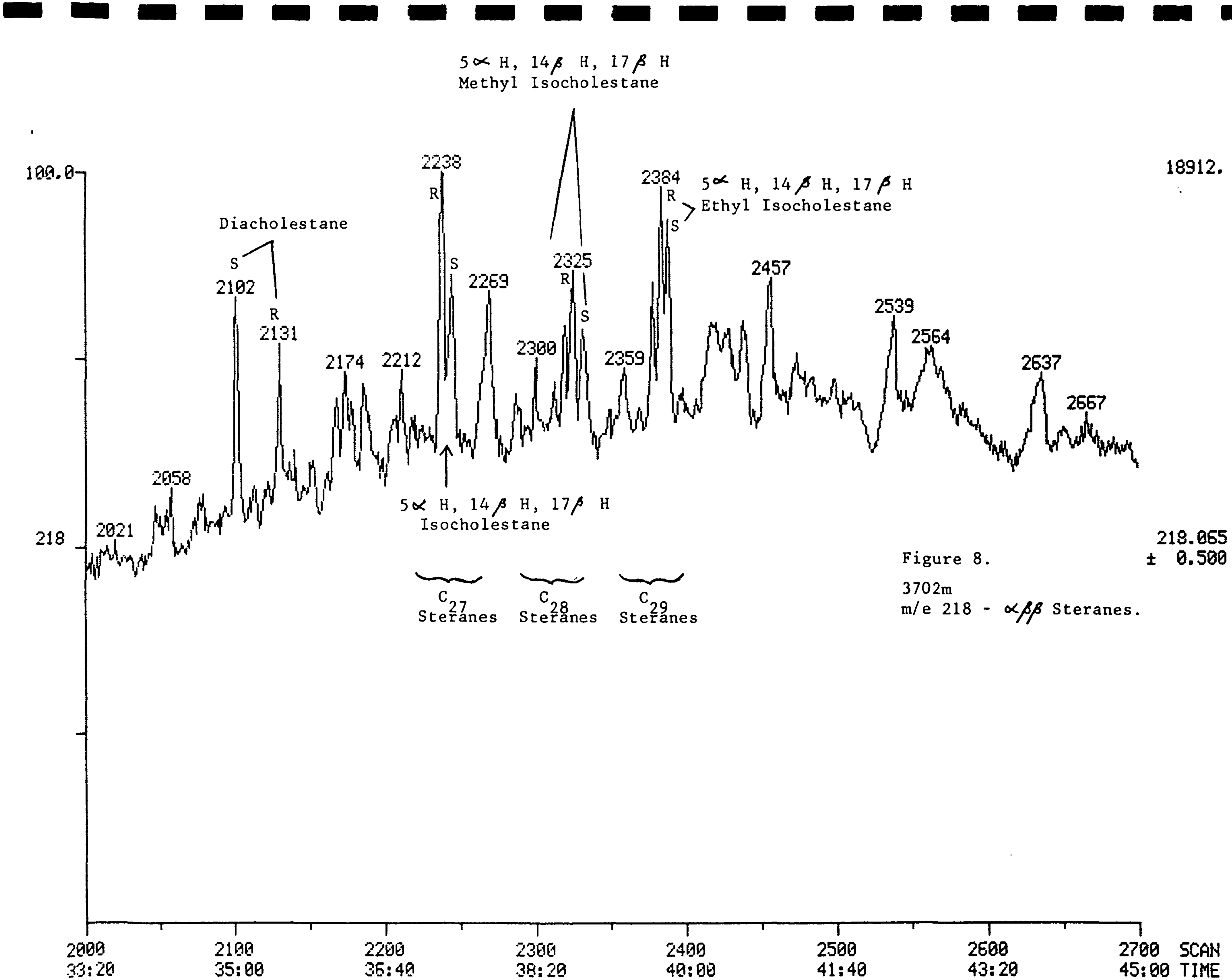


Figure 8.

3702m
m/e 218 - αββ Steranes.

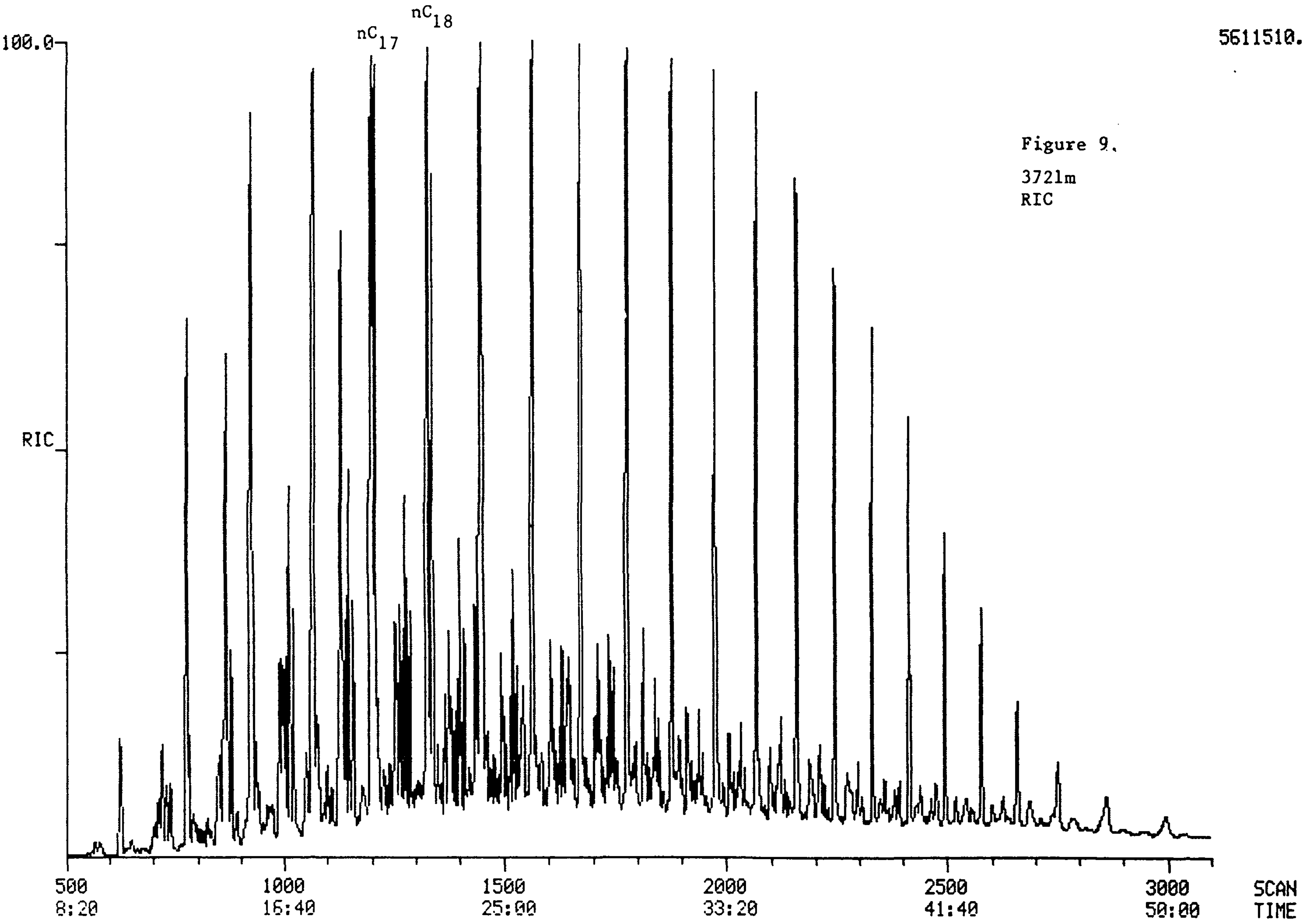


Figure 9.

3721m
RIC

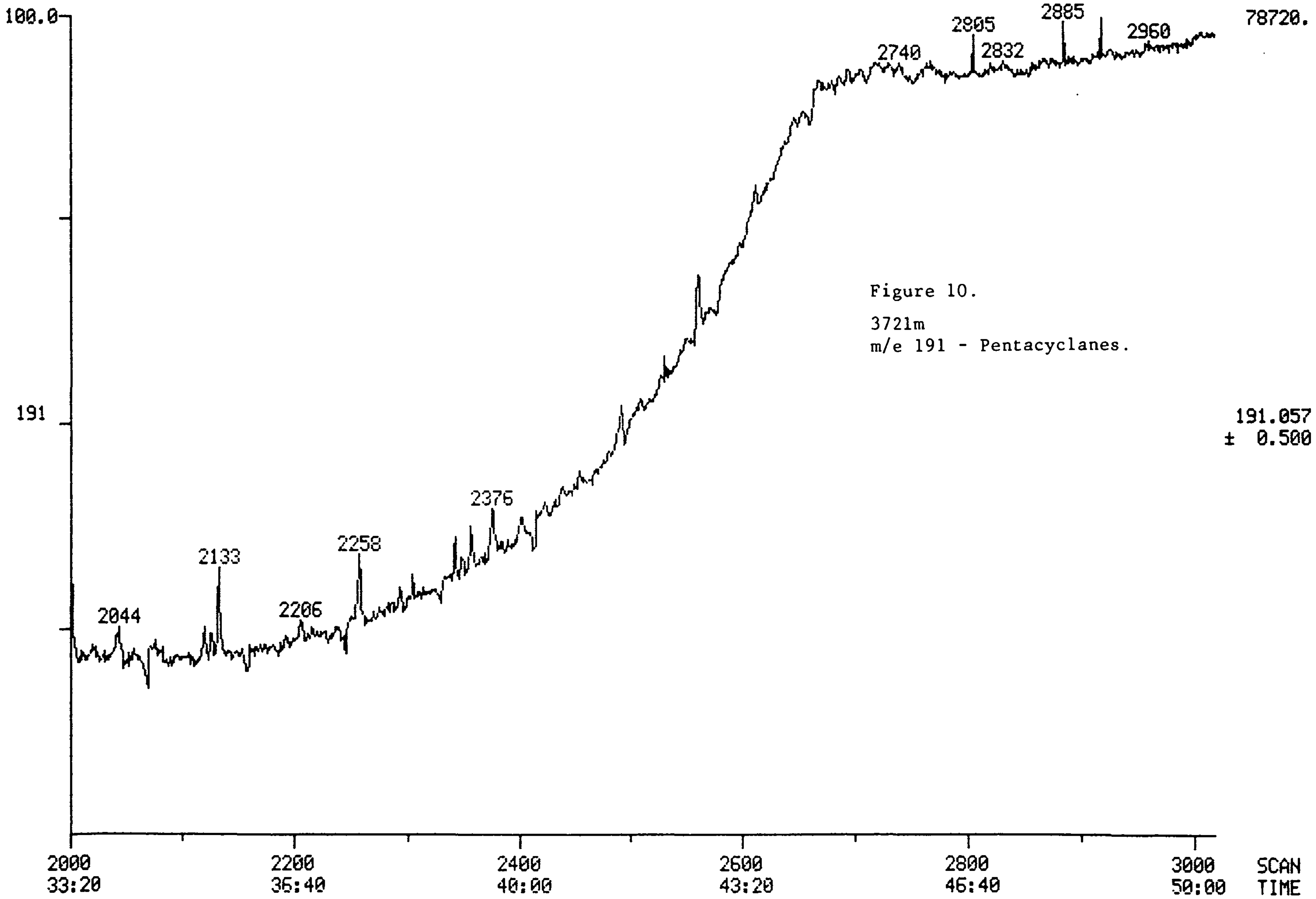


Figure 10.

3721m
m/e 191 - Pentacyclanes.

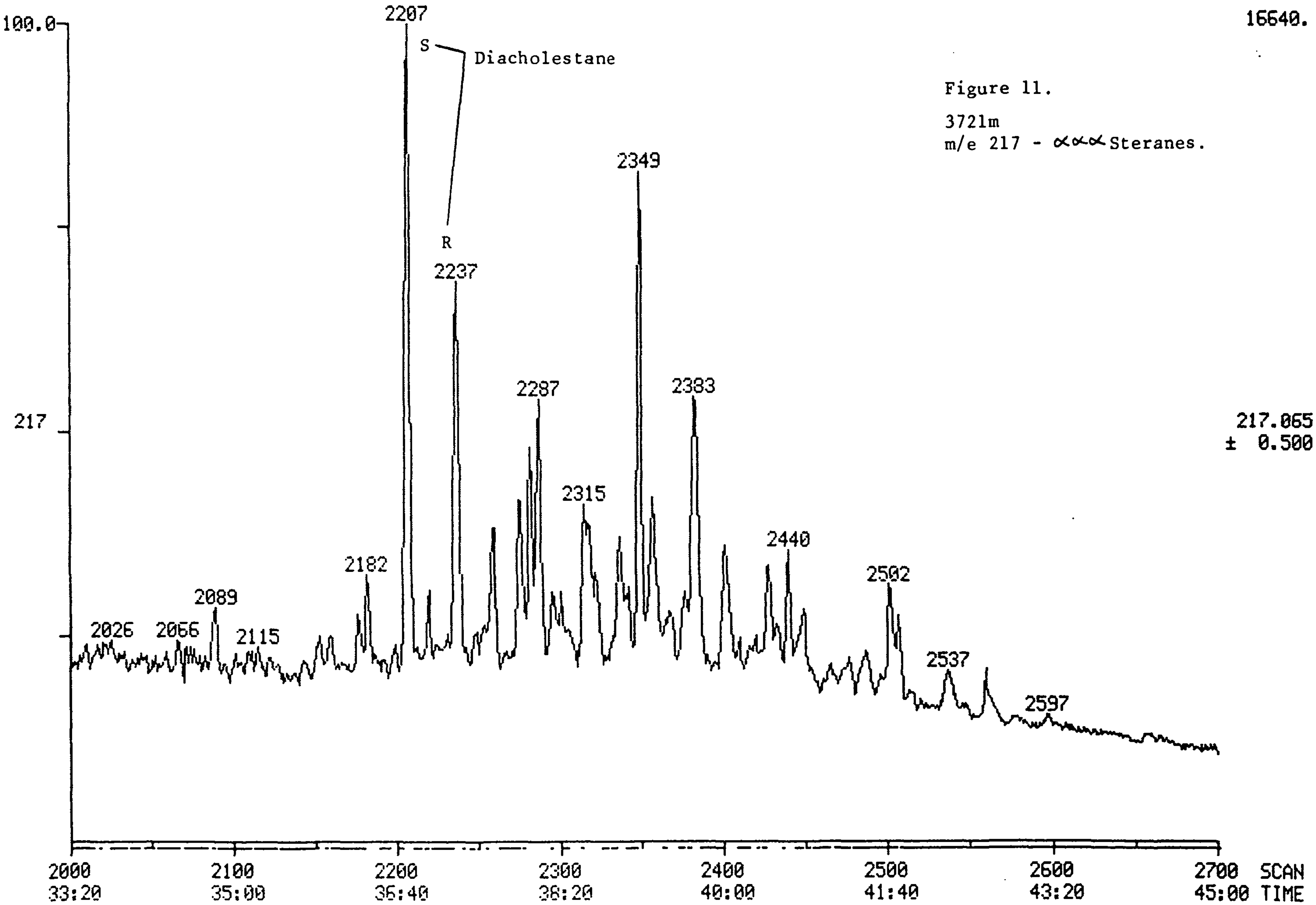


Figure 11.

3721m
m/e 217 - ααα Steranes.

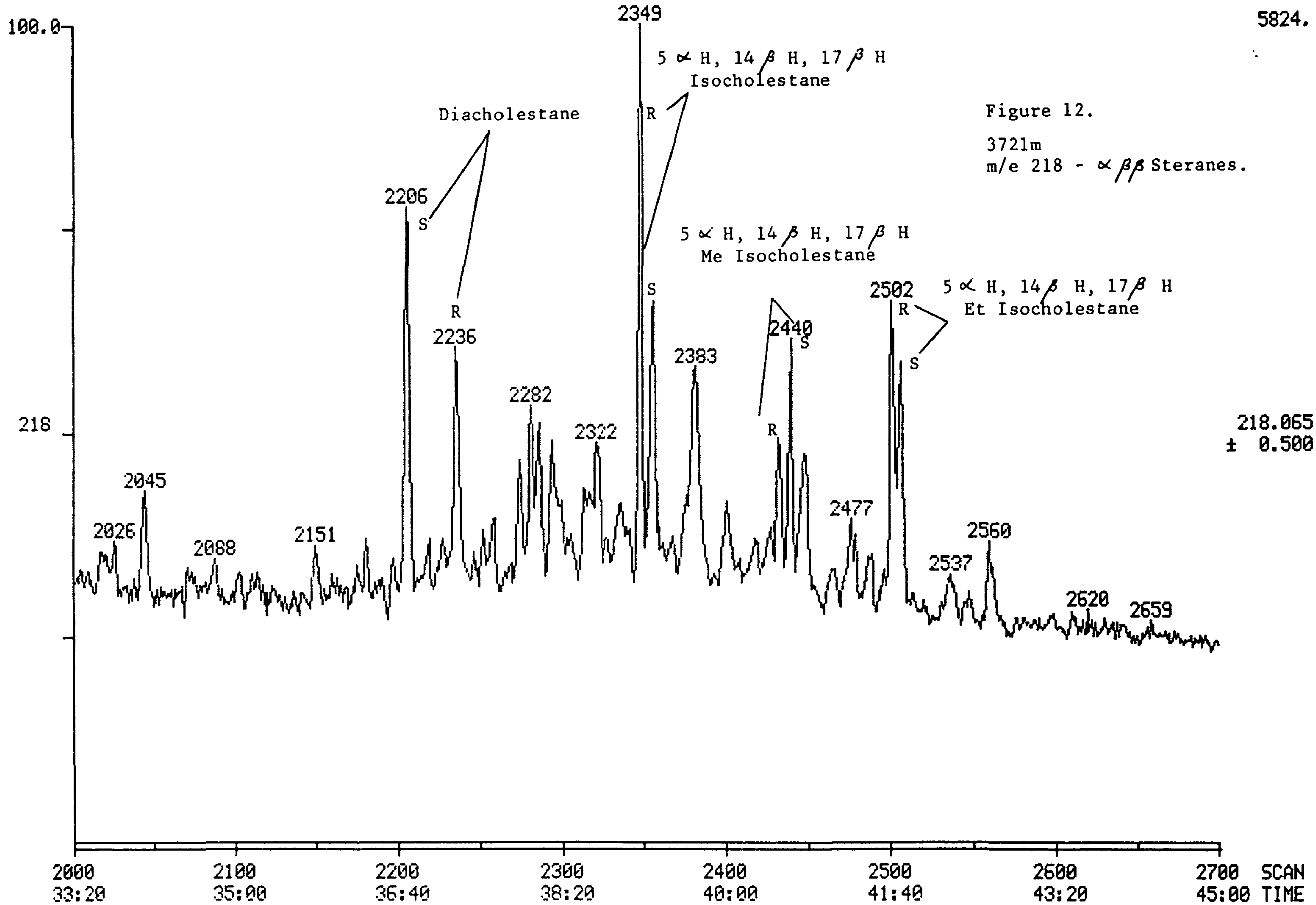


Figure 12.

3721m
m/e 218 - αββ Steranes.

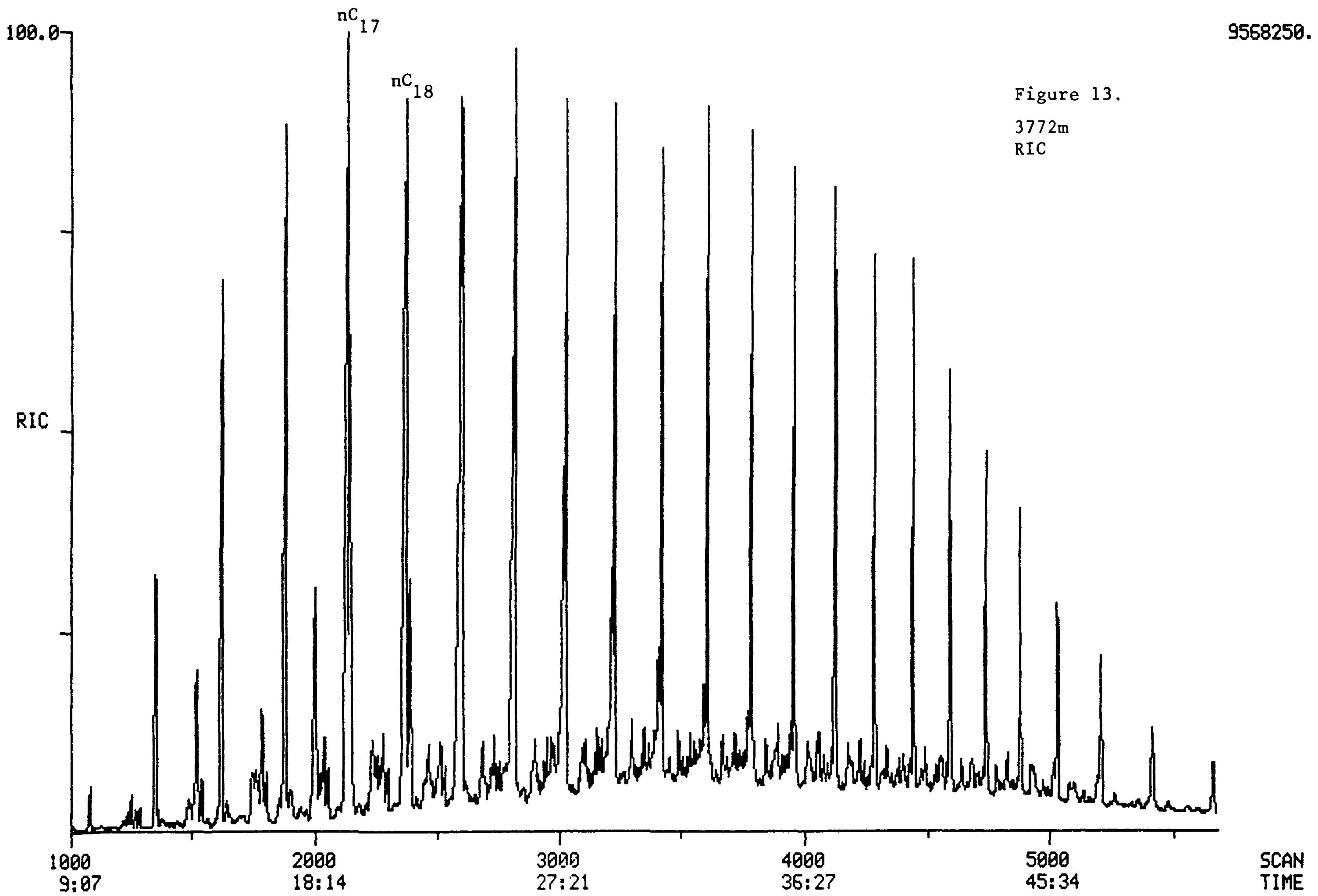


Figure 13.

3772m
RIC

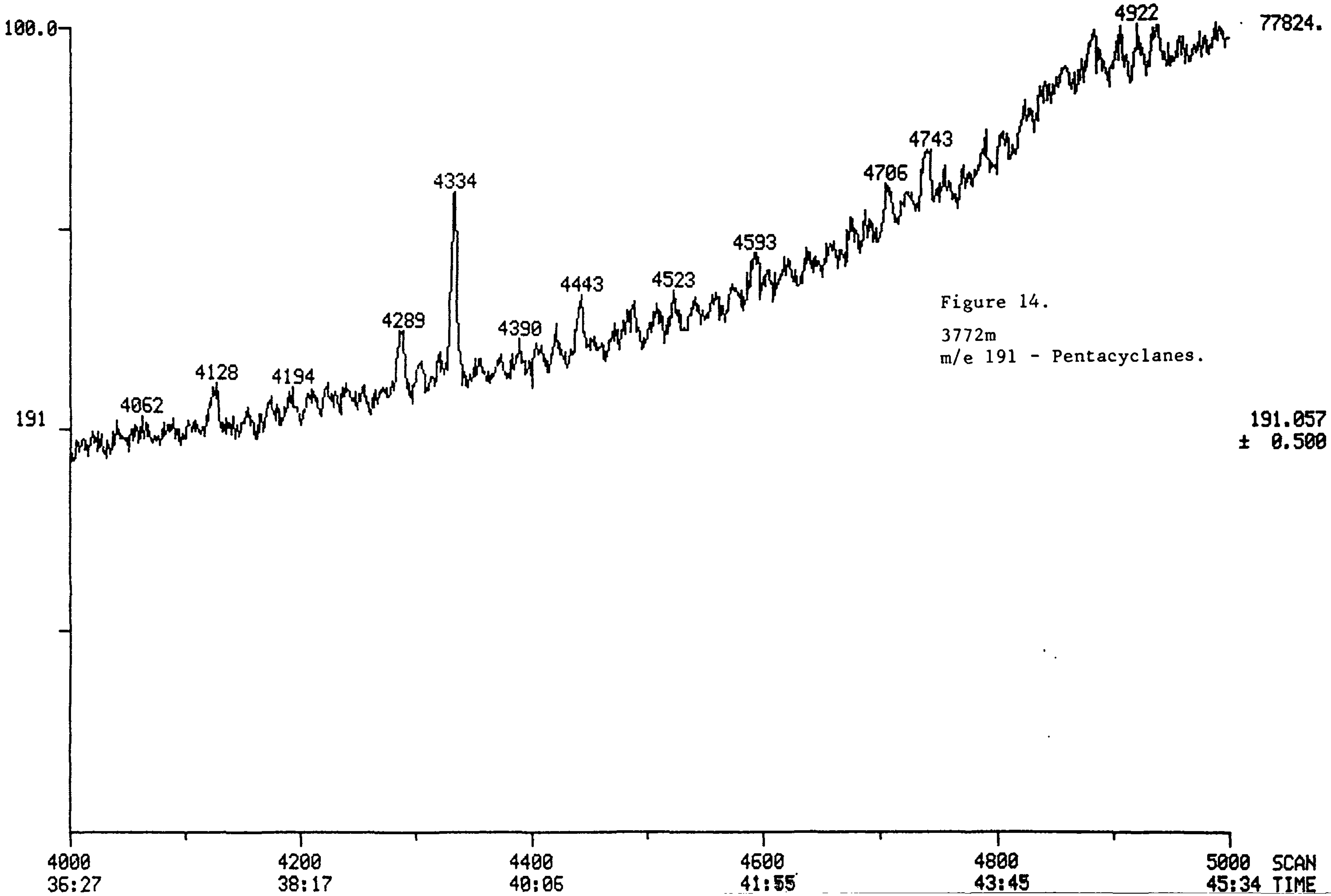


Figure 14.

3772m
m/e 191 - Pentacyclanes.

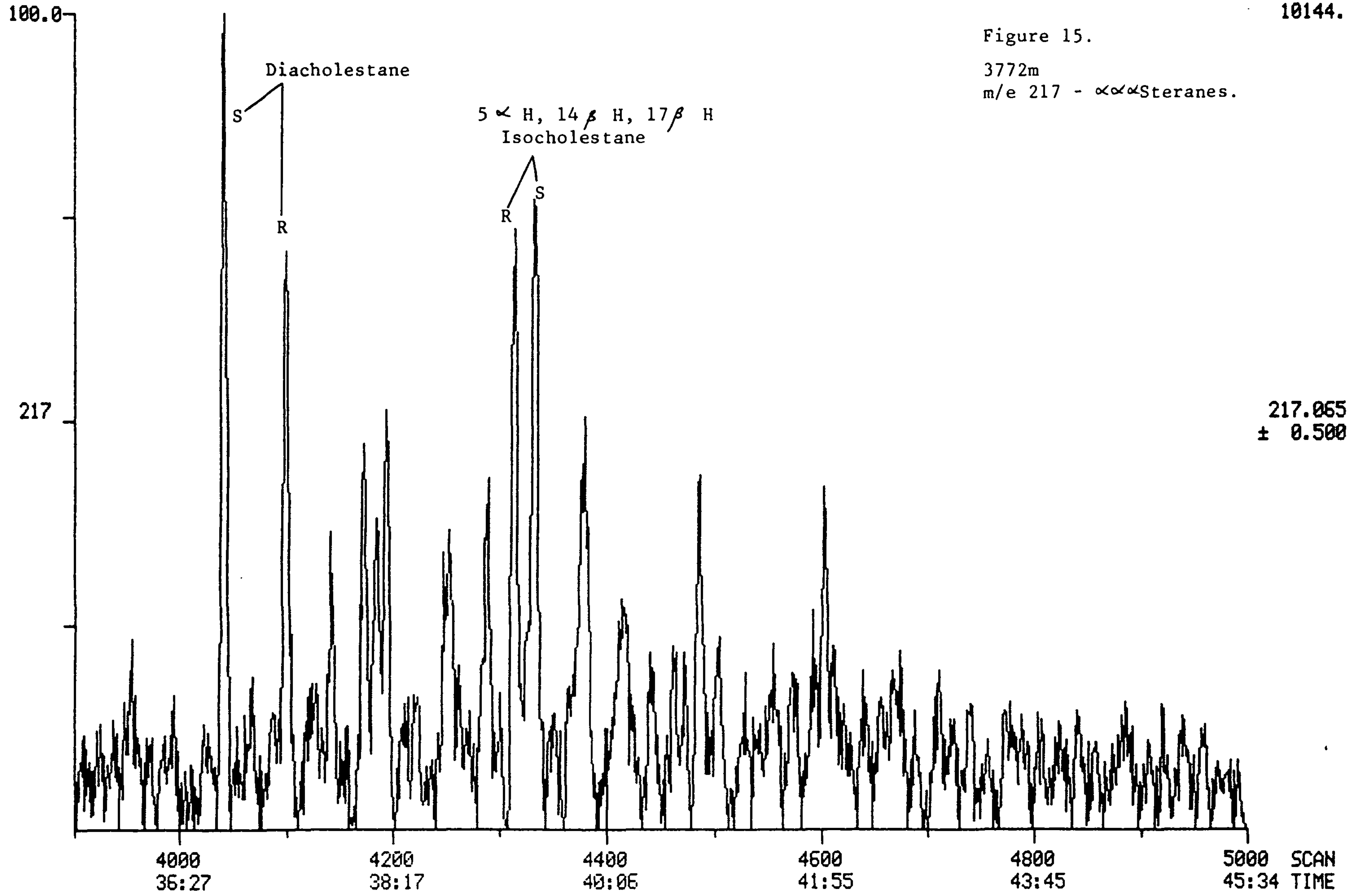


Figure 15.

3772m
m/e 217 - αααSteranes.

Figure 16.

3772m
m/e 218 - αββ Steranes.