NORTH VIKING GRABEN

GEOCHEMICAL STUDY

GC-MS ANALYSIS

Well no. 31/4-2 NOCS

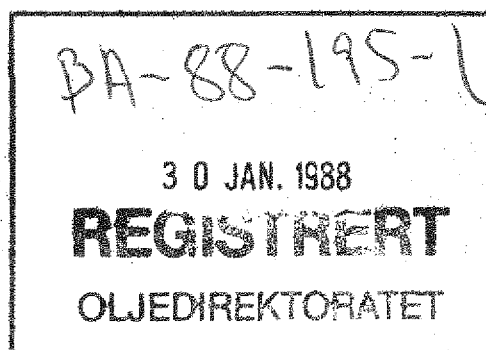Client: Fina Exploration Norway

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Steranes:

The M/Z 149 fragmentogram shows similar features to those found in other immature Draupne Fm. samples with the C_{27} compounds being particularly abundant. The M/Z 189 and 259 fragmentograms show that the C_{27} compounds are the most abundant of the rearranged steranes. The M/Z 217 and 218 fragmentograms show that the C_{29} steranes are as abundant as the C_{27} rearranged steranes. It is not usual to have such a large abundance of C_{29} regular steranes in Draupne Fm. samples and this could indicate that this Draupne Fm. sample has a larger input of terrestrial material than what is normally found for the Draupne Fm. The fragmentograms of the molecular ions verify what has been discussed above.

Bicyclanes:

In the M/Z 123, 179 and 193 fragmentograms the C_{16} compounds are dominant, while the C_{14} compounds are almost none existant. This might be due to a loss of the lighter molecular weight material during the work up of the samples.

Aromatic Fraction

Thiophenes:

The M/Z 84 fragmentogram shows thiophene as the largest peak. The series of peaks between retention time 23 and 27 minutes found for other Draupne Fm. samples are present also for this sample. The M/Z 98 fragmentogram shows a number of peaks that were not identified. These peaks have been found in a number of Draupne Fm. samples and could therefore be good indicators for correlation purposes.

The M/Z 112 fragmentogram shows a few peaks with a long

retention time, while the M/Z 126 fragmentogram shows some peaks with retention times between 24 and 33 minutes together with two single peaks with a longer retention time. The M/Z 140 fragmentogram, representing the C_4-substituted thiophenes, shows a doublet and a more complex series of peaks. These have been found in a number of samples and could be useful compounds for correlation purposes.

Alkyl-substituted Benzenes:

The M/Z 106 fragmentogram shows the typical series of doublets for C_2-substituted benzenes, while the M/Z 134 fragmentogram representing C_4-substituted benzenes shows a complex series of peaks found in other Upper Jurassic samples on the Bergen High. This is also the situation for the M/Z 148 fragmentogram representing the C_5-substituted benzenes.

Naphthalenes:

The M/Z 142 fragmentogram shows the normal doublet for the methylnaphthalenes with an almost equal abundance of 1- and 2-methylnaphthalenes. The M/Z 156 fragmentogram shows the typical pattern for the C_2-substituted naphthalenes and the M/Z 170 fragmentogram shows the typical pattern for the C_3-naphthalenes.

Benzothiophenes and Dibenzothiophenes:

The M/Z 162 fragmentogram shows the triplet for the C_2-substituted benzothiophenes as minor peaks while a series of peaks with longer retention time dominates the fragmentogram. The M/Z 176 fragmentogram shows some small C_3-substituted benzothiophene peaks, together with a large single peak with a retention time of 30 minutes. The M/Z 184

fragmentogram shows the single peak from dibenzothiophene, while the M/Z 198 fragmentogram shows the triplet of methyldibenzothiophenes. 1-methyldibenzothiophene is by far the largest peak, clearly showing that the sample is immature. The C_2-dibenzothiophenes are not as abundant in this sample, which can be seen by the M/Z 212 fragmentogram.

Phenanthrenes:

The M/Z 178 fragmentogram shows only the single peak from phenanthrene. There is no indication of anthracene in the sample. The M/Z 192 fragmentogram shows the two doublets from the methylphenanthrenes with a ratio between the first and second doublets similar to that found in other Draupne Fm. samples. The M/Z 206 fragmentogram shows the complex pattern for C_2-substituted phenanthrenes that is seen for all the other Draupne Fm. samples on the Bergen High, while the M/Z 220 fragmentogram shows only noise, which indicates that this sample does not contain C_3-substituted phenanthrenes.

Aromatic Steranes:

The M/Z 253 fragmentogram shows the typical pattern for monoaromatic steranes with C_{27} and C_{28} as the dominant compounds. The relatively low abundance of C_{21} and C_{22} monoaromatic steranes shows the sample is immature. The M/Z 231 fragmentogram shows the typical pattern for triaromatic steranes in a number of immature samples in the Bergen High areas.

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HEATHER FORMATION

Saturated Fraction

Terpanes:

The M/Z 163 fragmentogram of the sample from the Heather Fm., 2236 - 2324 m (2324 m), shows a pattern similar to the Draupne Fm. sample. The same situation is also found for the M/Z 177 fragmentogram and the M/Z 191 fragmentogram, while only minor differences are seen for the M/Z 205 fragmentogram. The fragmentograms of the molecular ions show the same as discussed above, i.e. the Heather Fm. and the Draupne Fm. samples have similar pattern, indicating the organic matter in these samples to be similar. There are no indications from other analyses that the Heather Fm. samples are caved, and these results would therefore indicate that the Draupne Fm. and Heather Fm. have similar organic matter.

Steranes:

The various fragmentograms representing different steranes show the same as seen for the terpanes, i.e. similar patterns between the Draupne Fm. and Heather Fm. samples showing the organic matter to be similar.

Bicyclanes:

The M/Z 123, 179 and 193 fragmentograms representing the various bicyclanes, show some differences between the Draupne Fm. and the Heather Fm. samples, indicating that these compounds are more sensitive to changes in the organic matter than the steranes and terpanes.

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Aromatic Fraction

Thiophenes:

The M/Z 84 fragmentogram show strong differences between the Draupne Fm. and the Heather Fm. samples. The difference is, due to the abundance of thiophene which is larger in the Heather Fm. sample with the result that the peak height of the compounds with retention times between 23 - 27 minutes are smaller. This could be due to losses caused by evaporation during sample preparation. The M/Z 98 fragmentogram shows basically the same as discussed for the M/Z 84 fragmentogram. The M/Z 112, 126 and 140 fragmentograms show that there are only minor differences between the Heather Fm. and Draupne Fm. samples.

Alkyl-substituted Benzenes:

The M/Z 106 fragmentogram shows only minor differences in the general pattern for the C_2-substituted benzenes between the Heather Fm. and Draupne Fm. samples. Small differences are also seen in the M/Z 134 fragmentograms for the C_4-substituted benzenes. These differences are small and might be due to the sample preparation technique. The M/Z 148 fragmentogram also shows only minor differences between the two samples.

Naphthalenes:

The two methylnaphthalenes in the M/Z 142 fragmentogram shows a slight difference in peak height to the Draupne Fm. sample, while the M/Z 156 fragmentogram for the C_2-substituted naphthalenes shows a completely different pattern for the two samples. The M/Z 170 fragmentogram shows some small differences between the two samples, mainly an

increase in the relative abundance of the peaks with shortest retention times in the sample from the Heather Fm.

Benzothiophenes and Dibenzothiophenes:

The M/Z 162 fragmentogram for C_2-benzothiophenes shows a similar pattern in the Heather Fm. sample as in the Draupne Fm. sample this is also the situation for the M/Z 176 fragmentograms. M/Z 184 fragmentogram shows only the single peak for dibenzothiophene, while the M/Z 198 shows the triplet for methyldibenzothiophenes. The pattern for the triplet is similar to that found in the Draupne Fm. samples. The M/Z 212 fragmentogram for C_2-dibenzothiophenes has a low signal to noise ratio and further discussion is not possible.

Phenanthrenes:

The M/Z 178 fragmentogram shows the single peak for phenanthrene, while the M/Z 192 fragmentogram shows the two doublets for methylphenanthrenes. The 3+2-methyl-phenanthrene doublet has the same peak height as the 1+9 doublet in this sample, while the former is smaller in the sample from the Draupne Fm. The M/Z 206 fragmentogram shows a pattern similar to that found in the Draupne Fm. sample for the C_2-phenanthrenes. This is also the situation for the M/Z 220 fragmentogram for the C_3-phenanthrenes.

Aromatic Steranes:

The M/Z 253 fragmentogram for monoaromatic steranes and M/Z 231 fragmentogram for triaromatic steranes are similar in the Heather Fm. to that in the Draupne Fm. sample.

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DUNLIN GROUP

Saturated Fraction

Terpanes:

The M/Z 163 fragmentograms vary somewhat for the five
samples from the Dunlin Gr. The samples from 2360 - 2378 m
(2378 m), 2378 - 2390 m (2390 m) and 2456 - 2474 m (2474 m)
show a pattern similar to that found in the Draupne Fm. and
Heather Fm. samples, while the sample from 2432 - 2456 m
(2456 m) has a very low amount of triterpanes, especially
$\alpha\beta$ hopane and $\alpha\beta$ norhopane. The sample from 2556 - 2566 m
(2566 m) has a large unresolved envelope, making it
difficult to evaluate the data, but it looks as if the ratio
of steranes to triterpanes is lower than is found in the
other samples.

The M/Z 177 fragmentograms show even larger differences
between the various samples than the M/Z 163 fragmentograms,
particularly in the sterane distribution and in the relative
abundance of steranes and triterpanes. The samples from
2378 m and 2390 m show some resemblance to the Heather Fm.
samples, while the other three are completely different. The
sample from 2456 m has very low amounts of triterpanes,
while the sample from 2474 m has large amounts. This
increases even further in the sample from 2566 m.

The M/Z 191 fragmentograms show the two samples from 2378 m
and 2390 m have a distribution similar to that found in the
Heather Fm. samples, while the sample from 2456 m shows a
strange distribution. 17 α trisnorhopane is the largest
compound and $\alpha\beta$ norhopane and $\alpha\beta$ hopane are only minor
compounds. The distribution changes again for the sample
from 2474 m, with a large increase in the relative abundance
of $\alpha\beta$ norhopane, which is now of almost the same abundance

as the αβ hopane. The relative abundance of tricyclic and tetracyclic terpanes is also larger than found in the Heather Fm. samples. The changes recorded for the sample from 2474 m, compared to the samples from the Heather Fm. and the top of the Dunlin Gr. are increased for the sample from 2568 m. In this sample the αβ norhopane peak is the largest peak in the fragmentogram. The M/Z 205 fragmentograms show relatively large variations in the five Dunlin Gr samples, which agree well with the variation discussed above for other terpane fragmentograms. The various molecular ion fragmentograms show considerable degree of variation, both between the different Dunlin Gr. samples, and compared to the Heather Fm. samples. The terpane data indicate that there is a significant variation in the organic matter in the Dunlin Gr. samples and also that there is a difference compared with the Heather Fm.

Steranes:

The M/Z 149 fragmentograms of the samples from 2378 m and 2390 m resemble those from the Heather Fm., while the sample from 2456 m is completely different. There are also some differences in the sample from 2474 m, especially the decrease in rearranged steranes compared to triterpanes. This is even more accentuated in the sample from 2566 m. The M/Z 189 and 259 fragmentograms for the rearranged steranes do not show the same large variation between the various samples as seen in the terpanes. There is some variation, but it is by no means as large as that discussed above. The variation is stronger in the M/Z 217 and M/Z 218 fragmentograms. The fragmentograms for the samples from 2370 m and 2390 m are similar to the Heather Fm. sample, while the sample from 2456 m is completely different, especially in the loss of C_{29} regular steranes compared to other compounds. This is again changed in the samples from 2474 m and 2566 m, which show similarities with the two samples from higher up in the Dunlin Gr.. The fragmentograms

of the different sterane molecular ions show only minor
differences for the C_{27} and C_{28} compounds except for the
sample from 2456 m. The C_{29} fragmentograms show that there
is a considerable decrease in regular steranes compared to
the rearranged steranes for the samples from 2474 m and
2566 m.

On the whole, the sterane distribution does not distinguish
as clearly between the various samples from the Dunlin Gr.
as do the triterpanes. For these samples, the triterpanes
allow a far better separation between the different samples.

Bicyclanes:

The fragmentograms of the different bicyclanes (M/Z 123, 179
and 193) show strong variations between the different
samples. Some of these variations could be due to
evaporation during the sample preparation, while others are
quite clearly due to variation in the samples. The amount of
the different C_{15} compounds is quite high as can be seen in
the M/Z 193 fragmentogram.

Aromatic Fraction

Thiophenes:

The M/Z 84 fragmentograms show that all the samples contain
thiophene but in variable abundance, probably due to
evaporation during sample preparation. There is some
variation in the pattern of the peaks with retention times
between 23 and 27 minutes. This variation is insignificant.
All the samples also contain a peak with longer retention
time. The relative abundance of this peak varies somewhat
between the different Dunlin Gr. samples. The M/Z 98
fragmentograms vary considerably. The signal to noise ratio

is low for the sample from 2378 m similar to that in the Heather Fm. sample, while the signal strength is good for the other samples. Most of the variation might be due to loss of material during sample preparation.

The samples show some variations in their M/Z 112 fragmentograms. The samples from 2378 m, 2390 m and 2456 m, show a similar pattern of groups as the Heather Fm. and Draupne Fm. samples, except for an increase of the abundance of the peaks between 24 and 26 minutes with increasing depth. The samples from 2474 m and 2568 m show a decrease in the abundance of these peaks together with a decrease in the abundance of the group of peaks with retention time between 41 and 43 minutes. The M/Z 126 fragmentograms also show variations between the different samples. The samples from 2378 m and 2474 m, show a similar pattern to the Heather Fm. and Draupne Fm. samples, while the rest of the samples show a large abundance of peaks with a lower retention time.

The M/Z 140 fragmentograms for the C_4-thiophenes show good signal to noise ratio for all the samples. Apart from loss of the lighter component in some of the samples, there are many similarities between the different Dunlin Gr. samples.

Alkyl-substituted Benzenes:

The M/Z 106 fragmentograms for the C_2-substituted benzenes have a similar pattern for the four uppermost samples, while the sample from 2568 m is completely different with a large abundance of compounds with a longer retention time. A similar situation is also found for the M/Z 134 for the C_4-alkylbenzenes. Here the samples from 2474 m and 2568 m also show a slight increase in the abundance of compounds with a longer retention time. This feature is even more pronounced in the M/Z 148 fragmentograms for the C_5-substituted alkylbenzenes.

Naphthalenes:

The M/Z 142 fragmentograms show that the methylnaphthalenes show some variation in the ratio of 2-methylnaphthalene/ 1-methylnaphthalene. The variation is small and not systematic, and probably represents small variations in the organic matter in the samples. The M/Z 156 fragmentograms show the normal pattern for the C_2-naphthalenes. There are some minor variation in the relative height of the different peaks for the various samples. The variation is not regular and could be due to variation in the organic matter in the samples. The M/Z 170 fragmentograms for the C_3-naphthalenes show a distribution similar to that in the Heather Fm. sample.

Benzothiophenes and Dibenzothiophenes:

The M/Z 162 fragmentograms for the C_2-benzothiophenes show the typical triplet together with a large number of peaks with a longer retention time. The relative peak height of the triplet vary somewhat from sample to sample, but in an irregular manner. This is probably due to a variation in the organic matter in the samples. There are also significant variations both in abundance and pattern for the peaks with long retention times.

The M/Z 176 fragmentograms shows a complex group for the C_3-benzothiophenes pluss a single peak with retention time approximately 30 minutes. The group of peaks shows only minor variation for the different samples and this parameter is therefore not as sensitive to variation in organic matter as those discussed above. The abundance of the group of peaks relative to the single peak with a retention time of 30 minutes vary significantly for the different samples. The M/Z 184 fragmentogram show the normal single peak, representing dibenzothiophene for all the analysed samples, while the M/Z 198 fragmentogram show the triplet for the

methyldibenzothiophenes. There is very little variation in the pattern for the methyldibenzothiophenes and the large relative abundance of 1-methyldibenzothiophene shows the low maturity of all these samples. The M/Z 212 fragmentograms show the typical pattern for the C_2-dibenzothiophenes. The four uppermost analysed samples in the Dunlin Gr. show only minor variations, while the sample from 2568 m shows a significant variation with a large increase in the relative abundance of one peak. This is most probably due to a variation in the abundance of organic matter and could be significant for correlation purposes.

Phenanthrenes:

The M/Z 178 fragmentograms show only the single peak for phenanthrene. There is no indication of anthracene in the sample. The M/Z 192 fragmentograms show the two doublets for methylphenanthrenes with hardly any variation in the ratio between the different peaks. The M/Z 206 fragmentograms show the complex pattern for the C_2-phenanthrenes and as with the methylphenanthrenes, hardly any variation is found between the different samples from the Dunlin Gr. The M/Z 220 fragmentograms show the typical pattern for C_3-phenanthrenes for all the Dunlin Gr. samples. There are only minor variations between the five samples.

Aromatic Steranes:

The M/Z 253 fragmentograms show a good signal to noise ratio for all the samples and all have abundant monoaromatic steranes. As with the samples from higher up in the well, the C_{28} compounds are most abundant. Some variation is seen between the different samples, but most of this could be due to variation in chromatographic conditions, giving slightly better separation in some samples than in others. The M/Z 231 fragmentograms show a relative good signal to noise

ratio for all the samples. The C_{27} 20S triaromatic sterane
is the largest peak for all the samples.

Experimental, combined gas chromatography – mass spectrometry (GC-MS)

The GC-MS analyses were performed on a VG TS250 system interfaced to a Hewlett Packard 5890 gas chromatograph. The GC was fitted with a fused silica OV-1 capillary column (25m x 0.22 mm i.d.) directly into the ion source. Helium (10psi) was used as carrier gas and the injections were performed in splittless mode. The GC oven was programmed from $50^{O}C$ to $150^{O}C$ at $35^{O}C$/min. at which point the programme rate was $4^{O}C$/min up to 280° where the column was held isothermally for 37 min. For the aromatic hydrocarbons, the GC oven was programmed from 50oC to $280^{O}C$ at $5^{O}C$/min. and held isothermally at $280_{O}C$ for 22 min. The mass spectrometer was operated in electron impact (EI) mode at 70 eV electron energy, a trap current of 500 uA and a source temperature of 220°C. The instrument resolution was 2500 (10% valley) for most of the samples, but had to be decreased to 1000 for some samples to improve the sensitivity of some mass fragmentograms.

The datasystem used was a VG PDP11/73 system. The samples were analysed in multiple ion detection mode (MID) at a scan cycle time of approximately 1,8 sec.

Calculation of peak ratios was done from peak height in the appropriate mass fragmentograms.

In the discussion of the GC-MS data, the results will be
discussed by area. The wells within an area will be
discussed separately. In the discussion, samples within one
formation are discussed together. The discussion is further
divided into types of compounds as follows:

Saturated Fractions:

Terpanes:

The most commonly used fragmentions for detection of
terpanes are M/Z 163 for detection of 25,28,30 trisnor-
moretane or 25,28,30 trisnorhopane, M/Z 177 for detection of
demethylated hopanes or moretanes, M/Z 191 for detection of
tricyclic, tetracyclic- and pentacyclic terpanes and M/Z 205
for methylated hopanes or moretanes. The molecular ions
M/Z 370, 384, 398, 412 and 426 are also recorded for
identification of C_{27}, C_{28}, C_{29}, C_{30} and C_{31} triterpanes
respectively.

Steranes:

The most commonly used fragmentions for detection of
steranes are M/Z 149 to distinguish between 5 α and
5 β steranes, M/Z 189 and 259 for detection of rearranged
steranes, M/Z 217 for detection of rearranged and normal
steranes and M/Z 218 for detection of 14 β (H), 17 β (H)
steranes. The molecular ions M/Z 372, 386, 400 and 414 are
also recorded for identification of C_{27}, C_{28}, C_{29} and C_{30}
steranes respectively.

Bicyclanes:

The fragmentions M/Z 123, 179 and 193 are normally used for

the detection of the bicyclanes (sesquiterpanes and diterpanes). M/Z 123 will detect all bicyclanes while M/Z 179 and 193 will show the C_{14} and C_{15} bicyclanes respectively.

Aromatic Fractions:

Alkyl-substituted Benzenes:

The M/Z 106 fragmentions is often used to detect the alkyl-substituted benzenes. It is especially useful for the detection of di-substituted benzenes. M/Z 134 can also be used for the detection of C_4-alkylbenzenes, but benzothiophene will also give a signal with this fragmention. M/Z 148 can be used for the detection of C_5-alkylbenzenes, but will also give signals for methyl-substituted benzothiophenes.

Naphthalenes:

Methylnaphthalenes are normally detected by the M/Z 142 fragmention while C_2-naphthalenes are detected by M/Z 156 and C_3-naphthalenes by M/Z 170.

Benzothiophenes and Dibenzothiophenes:

Benzothiophene can be detected, as mentioned above, by M/Z 134. The M/Z 198 and M/Z 212 fragmentions are used for methyl-substituted dibenzothiophenes and dimethyl-substituted dibenzothiophenes respectively.

Phenanthrenes:

Phenanthrene is detected using the M/Z 178 fragmention. Anthracene will, if present also give a signal in the M/Z 178 fragmention. Methyl-substituted phenanthrenes give signals in the M/Z 192 fragmention while the M/Z 206 fragmention shows the dimethyl-substituted phenanthrenes.

Aromatic Steranes:

Monoaromatic steranes are detected using the M/Z 253 fragmention while the triaromatic steranes are detected using the M/Z 231 fragmention.
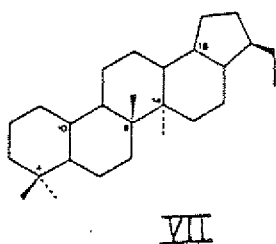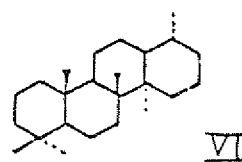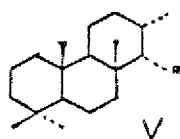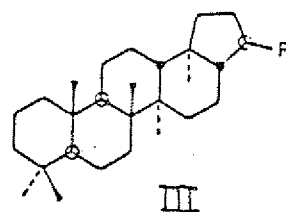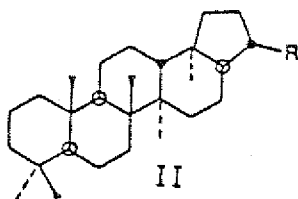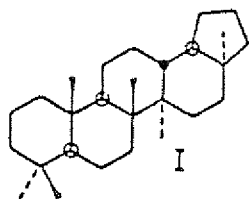
2a. Mass Fragmentograms representing Terpanes
(M/Z 163, 177, 191, 205, 370, 384, 398, 412 and 426)

Peak identification. (α and β refer to hydrogen atoms at C-17 and C-21 respectively unless indicated otherwise).

A.	18 α trisnorneohopane (T_S)	$C_{27}H_{44}$	(I)
B.	17 α trisnorhopane (T_M)	$C_{27}H_{46}$	(II, R=H)
Z.	Bisnorhopane	$C_{28}H_{48}$	(IV)
C.	$\alpha\beta$ norhopane	$C_{29}H_{50}$	(II, R=C_2H_5)
D.	$\beta\alpha$ norhopane	$C_{29}H_{50}$	(III, R=C_2H_5)
E.	$\alpha\beta$ hopane	$C_{30}H_{52}$	(II, R=i-C_3H_7)
F.	$\beta\alpha$ hopane	$C_{30}H_{52}$	(III, R=i-C_3H_7)
G.	22S $\alpha\beta$ homohopane	$C_{31}H_{54}$	(II, R=i-C_4H_9)
H.	22R $\alpha\beta$ homohopane	$C_{31}H_{54}$	(II, R=i-C_4H_9)
I.	$\beta\alpha$ homomoretane	$C_{31}H_{54}$	(III, R=i-C_4H_9)
J.	22S $\alpha\beta$ bishomohopane	$C_{32}H_{56}$	(II, R=i-C_5H_{11})
	22R $\alpha\beta$ bishomohopane	$C_{32}H_{56}$	(II, R=i-C_5H_{11})
K.	22S $\alpha\beta$ trishomohopane	$C_{33}H_{58}$	(II, R=i-C_6H_{13})
	22R $\alpha\beta$ trishomohopane	$C_{33}H_{58}$	(II, R=i-C_6H_{13})
L.	22S $\alpha\beta$ tetrakishomohopane	$C_{34}H_{60}$	(II, R=i-C_7H_{15})
	22R $\alpha\beta$ tetrakishomohopane	$C_{34}H_{60}$	(II, R=i-C_7H_{15})
M.	22S $\alpha\beta$ pentakishomohopane	$C_{35}H_{62}$	(II, R=i-C_8H_{17})
	22R $\alpha\beta$ pentakishomohopane	$C_{35}H_{62}$	(II, R=i-C_8H_{17})
P.	Tricyclic terpane	$C_{23}H_{42}$	(V, R=i-C_4H_9)
Q.	Tricyclic terpane	$C_{24}H_{44}$	(V, R=i-C_5H_{11})
R.	Tricyclic terpane (17R, 17S)	$C_{25}H_{66}$	(V, R=i-C_6H_{13})
S.	Tetracyclic terpane	$C_{24}H_{42}$	(VI)
T.	Tricyclic terpane (17R, 17S)	$C_{26}H_{48}$	(V, R=i-C_7H_{15})
N.	Tricyclic terpane	$C_{21}H_{38}$	(V, R=C_2H_5)
O.	Tricyclic terpane	$C_{22}H_{40}$	(V, R=C_3H_7)
Y.	25,28,30 trisnorhopane/moretane	$C_{27}H_{46}$	(VII)
X.	Unknown triterpane	$C_{30}H_{52}$	

STRUCTURES REPRESENTING TERPANES
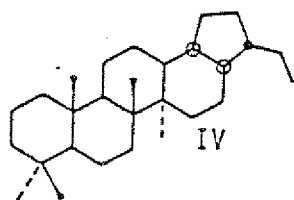
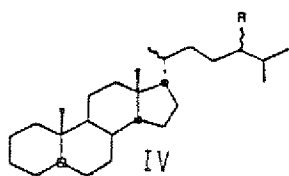
2b. Mass Fragmentograms representing Steranes
   (M/Z 149, 189, 217, 218, 259, 372, 386, 400 and 414)

Peak identifications. (α and β refer to hydrogen atoms at C-5, C-14 and C-17 in regular steranes and at C-13 and C-17 in diasteranes).

a.	20S $\beta\alpha$ diacholestane	$C_{27}H_{48}$	(I, R=H)
b.	20R $\beta\alpha$ diacholestane	$C_{27}H_{48}$	(I, R=H)
c.	20S $\alpha\beta$ diacholestane	$C_{27}H_{48}$	(II, R=H)
d.	20R $\alpha\beta$ diacholestane	$C_{27}H_{48}$	(II, R=H)
e.	20S $\beta\alpha$ 24 methyldiacholestane	$C_{28}H_{50}$	(I, R=CH$_3$)
f.	20R $\beta\alpha$ 24 methyldiacholestane	$C_{28}H_{50}$	(I, R=CH$_3$)
g.	20S $\alpha\beta$ 24 methyldiacholestane	$C_{28}H_{50}$	(II, R=CH$_3$)
	+ 20S $\alpha\alpha\alpha$ cholestane	$C_{27}H_{48}$	(III, R=H)
h.	20S $\beta\alpha$ 24 ethyldiacholestane	$C_{29}H_{52}$	(II, R=C$_2$H$_5$)
	+20R $\alpha\beta\beta$ cholestane	$C_{27}H_{48}$	(IV, R=H)
i.	20S $\alpha\beta\beta$ cholestane	$C_{27}H_{48}$	(IV, R=H)
	+20R $\alpha\beta$ 24 methyldiacholestane	$C_{28}H_{50}$	(II, R=CH$_3$)
j.	20R $\alpha\alpha\alpha$ cholestane	$C_{27}H_{48}$	(III, R=H)
k.	20R $\beta\alpha$ 24 ethyldiacholestane	$C_{29}H_{52}$	(I, R=C$_2$H$_5$)
l.	20S $\alpha\beta$ 24 ethyldiacholestane	$C_{29}H_{52}$	(II, R=C$_2$H$_5$)
m.	20S $\alpha\alpha\alpha$ 24 methylcholestane	$C_{28}H_{50}$	(III, R=CH$_3$)
n.	20R $\alpha\beta\beta$ 24 methylcholestane	$C_{28}H_{50}$	(IV, R=CH$_3$)
	+ 20R $\alpha\beta$ 24 ethyldiacholestane	$C_{29}H_{52}$	(II, R=C$_2$H$_5$)
o.	20S $\alpha\beta\beta$ 24 methylcholestane	$C_{28}H_{50}$	(IV, R=CH$_3$)
p.	20R $\alpha\alpha\alpha$ 24 methylcholestane	$C_{28}H_{50}$	(III, R=CH$_3$)
q.	20S $\alpha\alpha\alpha$ 24 ethylcholestane	$C_{29}H_{52}$	(III, R=C$_2$H$_5$)
r.	20R $\alpha\beta\beta$ 24 ethylcholestane	$C_{29}H_{52}$	(IV, R=C$_2$H$_5$)
s.	20S $\alpha\beta\beta$ 24 ethylcholestane	$C_{29}H_{52}$	(IV, R=C$_2$H$_5$)
t.	20R $\alpha\alpha\alpha$ 24 ethylcholestane	$C_{29}H_{52}$	(III, R=C$_2$H$_5$)
u.	5 α sterane	$C_{21}H_{36}$	(VI, R=C$_2$H$_5$)
v.	5 α sterane	$C_{22}H_{38}$	(VI, R=C$_3$H$_7$)

STRUCTURES REPRESENTING STERANES

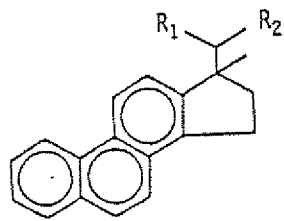

I

II

III

IV

V

VI
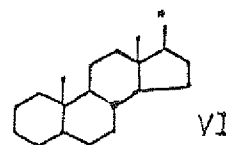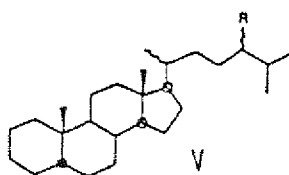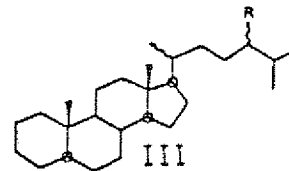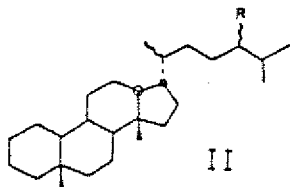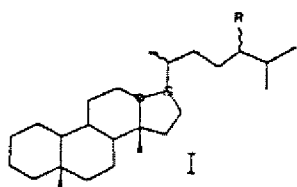
Mass Fragmentograms representing Triaromatic Steranes
(M/Z 231)

Description of ABC-ring triaromatic steroid hydrocarbons

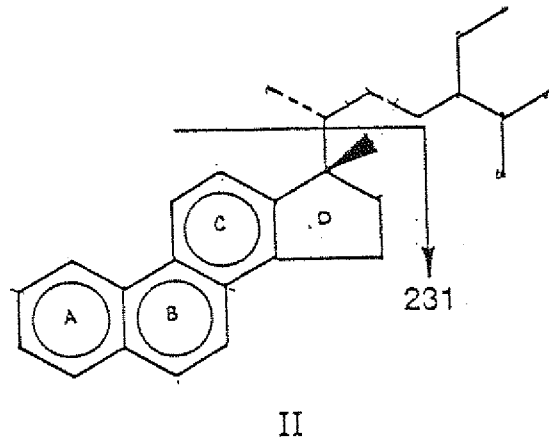| Peak | Substituents | | Abbreviation |
	R_1	R_2	of Compound
a1	CH_3	H	$C_{20}TA$
b1	CH_3	CH_3	$C_{21}TA$
c1	$S(CH_3)$	C_6H_{13}	$SC_{26}TA$
d1	$R(CH_3)$	C_6H_{13}	$RC_{26}TA$
	$S(CH_3)$	C_7H_{15}	$SC_{27}TA$
e1	$S(CH_3)$	C_8H_{17}	$SC_{28}TA$
f1	$S(CH_3)$	C_7H_{15}	$RC_{27}TA$
g1	$R(CH_3)$	C_8H_{17}	$RC_{28}TA$

STRUCTURES REPRESENTING TRIAROMATIC STERANES:

II

Mass Fragmentograms representing Monoaromatic Steranes
(M/Z 253)

Description of C-ring monoaromatic steroid hydrocarbons

Peak	Substituents				Abbreviation of Compound
	R_1	R_2	R_3	R_4	
A1					$C_{21}MA$
B1					$C_{22}MA$
C1	$\beta(H)$	CH_3	$S(CH_3)$	H	$\beta SC_{27}MA$
	CH_3	H	$S(CH_3)$	H	$SC_{27}DMA$
	$\beta(H)$	CH_3	$R(CH_3)$	H	$\beta RC_{27}MA$
D1	CH_3	H	$R(CH_3)$	H	$RC_{27}DMA$
	$\alpha(H)$	CH_3	$S(CH_3)$	H	$\alpha SC_{27}MA$
E1	$\beta(H)$	CH_3	$S(CH_3)$	CH_3	$\beta SC_{28}MA$
	CH_3	H	$S(CH_3)$	CH_3	$SC_{28}DMA$
F1	$\alpha(H)$	CH_3	$R(CH_3)$	H	$\alpha RC_{27}MA$
	$\alpha(H)$	CH_3	$S(CH_3)$	CH_3	$\alpha SC_{28}MA$
	$\beta(H)$	CH_3	$R(CH_3)$	CH_3	$\beta RC_{28}MA$
G1	CH_3	H	$R(CH_3)$	CH_3	$RC_{28}DMA$
	$\beta(H)$	CH_3	$S(CH_3)$	C_2H_5	$\beta SC_{29}MA$
	CH_3	H	$S(CH_3)$	C_2H_5	$SC_{29}DMA$
	$\alpha(H)$	CH_3	$R(CH_3)$	CH_3	$\alpha RC_{28}MA$
H1	$\beta(H)$	CH_3	$R(CH_3)$	C_2H_5	$\beta RC_{29}MA$
	CH_3	H	$R(CH_3)$	C_2H_5	$RC_{29}DMA$
I1	$\alpha(H)$	CH_3	$R(CH_3)$	C_2H_5	$\alpha RC_{29}MA$

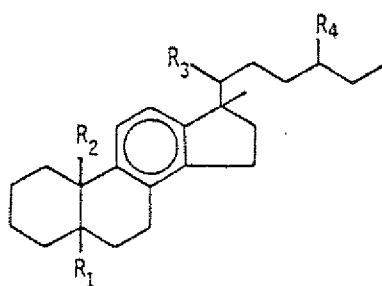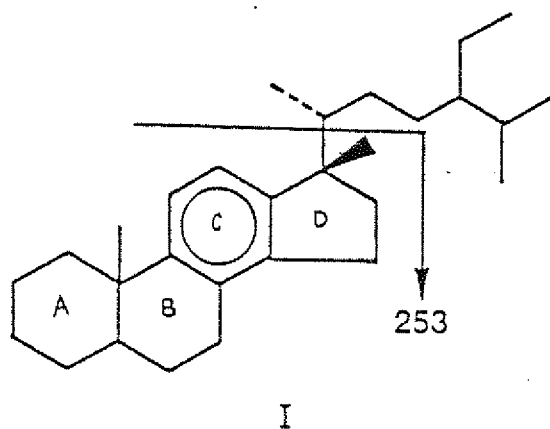STRUCTURES REPRESENTING MONOAROMATIC STERANES:

I

Table 1: Variation in Triterpane Distribution for Well NOCS 31/4-2

Depth unit of measure: m

Depth	Lithology	B/A	B/B+A	B/B+E+F	C/E	C/C+E	X/E	Z/E	Z/C	Z/Z+E	Q/E	E/E+F	C+D/C+D+E+F	D+F/C+E	J1/J1+J2%	Sample
2172.00	bulk	11.99	0.92	0.28	0.59	0.37	0.06	–	–	–	0.04	0.84	0.39	0.24	43.89	133-0
2324.00	bulk	2.46	0.71	0.28	0.62	0.38	0.05	–	–	–	0.06	0.85	0.40	0.21	45.59	134-0
2378.00	bulk	3.02	0.75	0.28	0.58	0.37	0.05	0.15	0.26	0.13	0.03	0.82	0.40	0.28	43.54	137-0
2390.00	bulk	2.84	0.74	0.27	0.52	0.34	0.05	0.11	0.20	0.10	0.03	0.84	0.37	0.25	43.91	138-0
2456.00	bulk	2.17	0.68	0.73	0.73	0.42	0.03	0.32	0.44	0.24	0.30	0.83	0.40	0.17	45.31	141-0
2474.00	bulk	2.34	0.70	0.33	0.89	0.47	0.04	0.11	0.12	0.10	0.05	0.87	0.47	0.16	49.77	142-0
2566.00	bulk	2.93	0.75	0.38	1.18	0.54	0.04	0.14	0.12	0.12	0.09	0.87	0.54	0.14	53.84	143-0

Table 2: Variation in Sterane Distribution for Well NOCS 31/4-2

Depth unit of measure: m

Depth	Lithology	Ratio1	Ratio2	Ratio3	Ratio4	Ratio5	Ratio6	Ratio7	Sample
2172.00	bulk	0.36	21.08	54.27	1.02	0.74	0.16	0.12	133-0
2324.00	bulk	0.34	19.09	50.49	1.04	0.73	0.14	0.11	134-0
2378.00	bulk	0.34	19.26	54.89	0.84	0.76	0.14	0.11	137-0
2390.00	bulk	0.37	18.66	53.08	1.10	0.75	0.16	0.13	138-0
2456.00	bulk	0.42	36.67	60.52	1.35	0.68	0.36	0.26	141-0
2474.00	bulk	0.33	21.84	55.19	0.76	0.74	0.56	0.48	142-0
2566.00	bulk	0.34	–	59.44	0.79	1.00	0.90	0.85	143-0

Ratio1: $a / a + j$
Ratio2: $q / q + t * 100\%$
Ratio3: $2(r + s)/(q + t + 2(r + s)) * 100\%$
Ratio4: $a + b + c + d / h + k + l + n$

Ratio5: $r + s / r + s + q$
Ratio6: $u + v / u + v + q + r + s + t$
Ratio7: $u + v / u + v + i + m + n + q + r + s + t$

Table 3: Aromatisation of Steranes for Well NOCS 31/4-2

Depth unit of measure: m

Depth	Lithology	Ratio1	Ratio2	Sample
2172.00	bulk	0.63	0.45	133-0
2324.00	bulk	0.64	0.44	134-0
2378.00	bulk	0.64	0.49	137-0
2390.00	bulk	0.64	0.44	138-0
2456.00	bulk	0.64	0.48	141-0
2474.00	bulk	0.63	0.54	142-0
2566.00	bulk	0.60	0.50	143-0

$$\text{Ratio1:} \quad \frac{C1+D1+E1+F1+G1+H1+I1}{C1+D1+E1+F1+G1+H1+I1 + c1+d1+e1+f1+g1}$$

Ratio2: $g1 / g1 + I1$

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Table 4: Variation in Triaromatic Sterane Distribution for Well NOCS 31/4-2

Depth unit of measure: m

Depth	Lithology	Ratio1	Ratio2	Ratio3	Ratio4	Ratio5	Sample
2172.00	bulk	0.72	0.59	0.23	0.35	0.30	133-0
2324.00	bulk	0.70	0.58	0.23	0.34	0.29	134-0
2378.00	bulk	0.69	0.55	0.24	0.37	0.32	137-0
2390.00	bulk	0.72	0.59	0.24	0.37	0.31	138-0
2456.00	bulk	0.60	0.49	0.21	0.28	0.28	141-0
2474.00	bulk	0.70	0.59	0.27	0.37	0.35	142-0
2566.00	bulk	0.56	0.46	0.19	0.26	0.27	143-0

Ratio1: a1 / a1 + g1   Ratio4: a1 / a1 + e1 + f1 + g1
Ratio2: b1 / b1 + g1   Ratio5: a1 / a1 + d1
Ratio3: a1 + b1 / a1 + b1 + c1 + d1 + e1 + f1 + g1

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Depth unit of measure: m

Depth	Lithology	Ratio1	Ratio2	Ratio3	Ratio4	Sample
2172.00	bulk	0.20	0.22	0.12	0.12	133-0
2324.00	bulk	0.21	0.23	0.13	0.12	134-0
2378.00	bulk	0.21	0.25	0.12	0.13	137-0
2390.00	bulk	0.21	0.22	0.13	0.12	138-0
2456.00	bulk	0.25	0.25	0.15	0.12	141-0
2474.00	bulk	0.17	0.18	0.09	0.09	142-0
2566.00	bulk	0.20	0.16	0.11	0.08	143-0

Ratio1: A1 / A1 + E1
Ratio2: B1 / B1 + E1

Ratio3: A1 / A1 + E1 + G1
Ratio4: A1+B1 / A1+B1+C1+D1+E1+F1+G1+H1+I1

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