

**NORTH VIKING GRABEN
GEOCHEMICAL STUDY**

GC-MS ANALYSIS

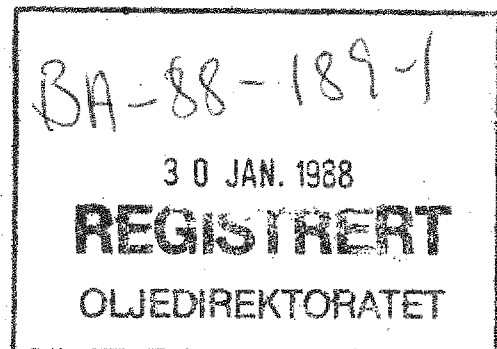
Well no. 31/4-3 NOCS

Client: Fina Exploration Norway

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RESULTS AND DISCUSSION

Five samples in this well were analysed by GC - MS. These includes: one from the "Intra Sand" in the Heather Fm. (2083 - 2092 m), three from the Dunlin Gr (2476 - 2495 m, 2501 - 2520 m and 2686 - 2705 m) and one from the Statfjord Fm. (2813 - 2828 m).

"INTRA SAND"

Saturated Fraction

Terpanes:

The analysed sample was picked medium dark grey to black shales over the interval 2083 - 2092 m. The hydrocarbons found in the extract from this sample are believed to be indigenous to the organic matter in the sample and not migrated hydrocarbons.

The M/Z 163 fragmentogram shows only one peak, which is due to a contaminant (believed to come from the septa on the sample flasks). The M/Z 177 and 191 fragmentograms show the same feature. The M/Z 191 fragmentogram was divided into two sections, so that one shows mainly the tricyclic and tetracyclic terpanes and the other shows the pentacyclic triterpanes. The M/Z 191 fragmentogram shows an unusual pattern with a very low abundance of triterpanes in which there is an almost equal abundance of $\alpha\beta$ norhopane and $\alpha\beta$ hopane. The rest of the triterpanes are virtually absent. The tricyclic and tetracyclic terpanes, especially the C₂₃ and C₂₄ tricyclic terpanes are prominent, together with another compound which elutes where the C₂₆ compounds would elute. This may be another contaminant peak.

The M/Z 205 fragmentogram shows only background noise. The fragmentograms of the molecular ions are not very helpful for this sample due to the low signal to noise ratio for the different fragmentograms representing terpanes.

Steranes:

The M/Z 149 fragmentogram shows one large peak at a retention time of approximately 30 minutes. This peak has not been identified. It is also seen in the M/Z 189 fragmentogram, which only shows a doublet consisting of the unknown discussed above and another at nearly the same intensity with a retention time of approximately 31.5 minutes. These two peaks were not observed in the M/Z 259 fragmentogram, which shows only traces of the rearranged steranes.

The M/Z 217 fragmentogram shows that there are mostly regular steranes present in the sample. The rearranged steranes, if present, are only minor components.

The M/Z 218 fragmentogram shows mostly noise and an evaluation is therefore not possible. The fragmentograms of the molecular ions show a very low signal to noise ratio and further evaluation was therefore not possible.

Bicyclanes:

The fragmentograms of the different bicyclanes are poor with a low signal to noise ratio and are therefore difficult to interpret. The M/Z 193 fragmentogram shows the C₁₅ bicyclanes are present.

Aromatic Fraction

Thiophenes:

The M/Z 84 fragmentogram shows that thiophene is quite prominent. The fragmentogram also shows a series of peaks, which appear to be n-alkanes and isoprenoids. The GC of the aromatic fraction does not show any signs of saturated compounds, and these are probably contaminants.

The M/Z 98 fragmentogram shows a similar series of peaks probably from the same contaminants, while the M/Z 112 and 126 fragmentograms do not show any peaks. The series of peaks seen in the M/Z 84 and 98 fragmentograms is also seen in the M/Z 140 fragmentogram.

Alkyl-substituted Benzenes:

The M/Z 106 fragmentogram shows the typical pattern of doublets seen in most of the other analysed samples. The M/Z 134 fragmentogram shows a distinct pattern of five peaks with a short retention time and six peaks with a longer retention time. The peaks with the shortest retention time have not normally been seen, while those with the longer retention time have been seen in other samples from the Heather Fm. and Dunlin Gr.

The M/Z 148 fragmentogram representing C₅-substituted alkylbenzenes also shows a group of peaks with short retention times and another group with longer retention times. The peak with short retention times have not been identified, while the group with longer retention times is the typical group of complex peaks found in most samples.

Naphthalenes:

The M/Z 142 fragmentogram shows the typical doublet for the methylnaphthalenes. The 1-methyl to 2-methylnaphthalenes ratio is far larger in this sample than is normally found in wells from the Bergen High.

The M/Z 156 fragmentogram shows the normal pattern of peaks for the C₂-naphthalenes, while the M/Z 170 fragmentogram shows the normal complex pattern for the C₃-naphthalenes. There are no special comments to add for these compounds.

Benzothiophenes and Dibenzothiophenes:

The M/Z 162 fragmentogram for methylbenzothiophenes does not show any peaks, while the M/Z 176 fragmentogram shows one peak presently not identified, but is certainly not a dimethylbenzothiophene.

The M/Z 184 fragmentogram shows only the single peak for dibenzothiophene, while the M/Z 198 fragmentogram shows the typical triplet for methyldibenzothiophenes. In this sample 4-methyldibenzothiophene is the largest peak, while in all the samples from well 31/4-2, 1-methyldibenzothiophene was the largest peak. The M/Z 212 fragmentogram shows the typical pattern for C₂-substituted dibenzothiophenes.

Phenanthrenes:

The M/Z 178 fragmentogram shows only the single peak for phenanthrene. There is no indication that anthracene is present in the sample. The M/Z 192 fragmentogram shows the two doublets for methylphenanthrenes, while the M/Z 206 fragmentogram shows the typical pattern for C₂-substituted phenanthrenes. The M/Z 220 fragmentogram for C₃-substituted phenanthrenes does not show any peaks.

Aromatic Steranes:

The M/Z 253 fragmentogram shows that the monoaromatic steranes are quite abundant in this sample. The two peaks representing C₂₈ monoaromatic steranes are most prominent which is different to that normally found for samples on the Bergen High.

The M/Z 231 fragmentogram does not show any distinctive peaks which indicates that this sample does not contain any triaromatic steranes.

DUNLIN GROUP

Saturated Fraction

Terpanes:

The M/Z 163 fragmentogram of the top two samples from the Dunlin Gr. is dominated by the contaminant peak discussed above. When the fragmentogram divided into two the sample from 2476 - 2495 m (2495 m) can be seen to have a very low abundance of steranes/triterpanes. One peak in the front section still dominates the fragmentogram. This peak was not identified and might be another contamination peak. The contamination peak is less prominent in the sample from 2501 - 2520 m (2520 m) and the section covering the triterpanes shows the fragmentogram is dominated by the $\alpha\beta$ hopane. There is no evidence that 25, 28, 30 trisnorhopane is present in the sample. The sample from 2686 - 2705 m (2705 m) does not contain any of the contamination peaks. The fragmentogram shows $\alpha\beta$ hopane is the dominant peak with $\alpha\beta$ norhopane as second largest peak. Again, there is no evidence that the sample contains any 25,28,30 trisnorhopane.

The M/Z 177 fragmentogram of the sample from 2495 m is dominated by the contamination peaks. The sample from 2520 m shows the $\alpha\beta$ and $\beta\alpha$ norhopane peaks are dominant, but there is also a fair abundance of steranes. The sample from 2705 m, is completely dominated by the $\alpha\beta$ and $\beta\alpha$ norhopanes and steranes are only minor components.

The M/Z 191 fragmentograms are affected by the contamination peaks as discussed above for the M/Z 163 fragmentograms. This makes it difficult to discuss these fragmentograms and especially in evaluation and comparison between the tricyclic and tetracyclic terpanes and the pentacyclic triterpanes. Tricyclic terpanes appear to be more abundant in the samples

from 2495 m and 2520 m than the sample from 2705 m. The pentacyclic compounds are dominated by $\alpha\beta$ hopane in the samples from 2495 m and 2520 m, while the sample from 2705 m has on almost equal abundance of $\alpha\beta$ norhopane and $\alpha\beta$ hopane; the 17 α trisnorhopane is only slightly smaller. The T_M/T_S ratio is very large for this sample, which also has a relatively large abundance of the $\beta\alpha$ compounds. The latter compounds are normally only found at low maturity levels, but here is also due to a difference in organic matter.

The M/Z 205 show the $\alpha\beta$ homohopane is the dominant peak in all three samples and only minor variations were observed. The fragmentograms of the molecular ions verify what has been discussed above. The variation in some fragmentograms for the sample from 2705 m compared to the other two samples is not so distinct in the molecular ion fragmentograms.

Steranes:

In the M/Z 149 fragmentograms two unknown peaks are the largest peaks in the sample from 2495 m, while one of these is the largest in the sample from 2520 m. It is difficult to evaluate the steranes due to the presence of these peaks, but the C_{29} regular steranes appear to dominate the fragmentograms. This is also the situation for the sample from 2705 m, in which another unidentified compound is the largest peak in the fragmentogram.

The M/Z 189 fragmentograms show the two peaks that were dominant in the sample from 2092 are dominant in the sample from 2495 m. The relative peak heights in the sample from 2495 m are opposite to that in the sample from 2092 m. The two peaks are also present (but in lower concentration) in the sample from 2520 m.

The M/Z 189 and 259 fragmentograms shows the C_{27} and C_{29} rearranged steranes are of similar abundance in these

samples, while the C₂₈ rearranged steranes are abundant.

The M/Z 217 and 218 fragmentograms show that the regular steranes are more abundant than the rearranged steranes in all three samples. The C₂₇ and C₂₉ compounds regular steranes are particularly abundant. The fragmentograms of the molecular ions indicate that the differences in the relative amounts of the regular and rearranged steranes is not as distinct and in fact the amount of regular and rearranged steranes is approximately the same.

Bicyclanes:

The bicyclanes are difficult to evaluate since all the M/Z 123, 179 and 193 fragmentograms show that either they have been lost during preparation of the samples, or they are not present in the samples.

Aromatic Fraction

Thiophenes:

The M/Z 84 fragmentograms show that thiophene is present in all the samples. A complex series of peaks with retention times between 23 and 27 minutes are also present in all the samples. The relative distributions of these peaks vary for the three different samples.

The M/Z 98 fragmentograms show all three samples contain one large unknown peak.

The M/Z 112 and 126 fragmentograms which represent C₂- and C₃-thiophenes show only background material, while the M/Z 140 representing C₄-thiophenes show a low signal to noise ratio for the sample from 2495 m, while the samples

from 2520 m and 2705 m show a complex pattern, which has been seen in a number of other samples from the Bergen High area. There is only minor variation between the two samples.

Alkyl-substituted Benzenes

The M/Z 106 fragmentograms representing the C₂-substituted benzenes show the typical pattern of doublets found in most of the samples from the Bergen High area. Some variation, especially for the peaks with higher retention time, is seen between the three samples. It is, however, difficult to evaluate this variation, which could be due to a variation in the organic matter.

The M/Z 134 fragmentograms representing the C₄-substituted benzenes show a significant variation in the three samples. It is believed that this variation is due to differences in the organic matter and these compounds appear to be very sensitive to such variation.

The M/Z 148 fragmentograms show mainly a large unresolved envelope with some small peaks. It is therefore difficult to evaluate the variation and these compounds are therefore not very useful for correlation purposes.

Naphthalenes:

The typical doublet for methylnaphthalenes is seen in all the samples. It is, however, affected by the work up of the samples and evaluation of the ratio between 2-methyl- and 1-methylnaphthalenes is therefore invalid.

The M/Z 156 fragmentograms show the typical pattern for the C₂-naphthalenes. The sample from 2495 m shows a loss of those compounds with shortest retention times. The sample has lost these compounds during preparation of the sample.

The other two samples show almost identical patterns.

Benzothiophenes and Dibenzothiophenes:

The M/Z 162 and 176 fragmentograms for C₂- and C₃-benzothiophenes show only background material, while the M/Z 104 fragmentograms show only the single peak for dibenzothiophene.

The M/Z 198 fragmentograms show the typical triplet for the methyl dibenzothiophenes. The ratio between 4-methyl- and 1-methyl dibenzothiophene is lower in the samples from 2520 m and 2705 m, than in the sample from 2495 m. The ratio between 1-methyl- and 3+2-methyl dibenzothiophene is approximately the same in all three samples.

The M/Z 212 fragmentograms for C₂-dibenzothiophenes show a low signal to noise ratio and further discussion is therefore not undertaken.

Phenanthrenes:

The M/Z 178 fragmentograms show only the single peak from phenanthrene, while the M/Z 192 fragmentograms show the two doublets from the methylphenanthrenes. The ratio between the two doublets varies slightly for the three samples. The ratio of 3+2-methylphenanthrenes to 9+1-methylphenanthrene is larger in the sample from 2495 m than in the other two samples. The typical pattern for C₂-phenanthrenes is found in the M/Z 206 fragmentograms for all three samples. Slight variations are seen between the three samples, but the peak shape indicates that this variation might be due to the variation in chromatographic conditions. The M/Z 220 fragmentograms for the C₃-phenanthrenes shows only background.

Aromatic Steranes:

The M/Z 253 fragmentograms of all three samples indicate the presence of monoaromatic steranes. There is less of the C₂₈ compounds in the sample from 2495 m when compared with the sample from the shale in the "Intra sand" which indicates a difference in organic matter. The other two samples have a low signal to noise ratio and also poorer separation. Discussion of these samples is therefore not undertaken. The M/Z 231 fragmentograms show only background material and none of these samples contain any triaromatic steranes.

STATFJORD FORMATION

Saturated Fraction

Terpanes:

The M/Z 163 fragmentogram shows a peak with a short retention time is the dominant. It is therefore difficult to evaluate the pattern in this fragmentogram, but the triterpanes appear to be more abundant than the steranes. The M/Z 177 show the $\alpha\beta$ and $\beta\alpha$ norhopane are the largest peaks in this fragmentogram similar to that found for the sample from 2705 m in the Dunlin Gr. The M/Z 191 fragmentogram also has a pattern similar to that seen in the sample from 2705 m. The only difference is that the abundance of 17 α trisnorhopane relative to the $\alpha\beta$ hopane is less in this sample than in the sample from 2705 m.

The M/Z 205 fragmentogram is very similar to those found for the Dunlin Gr. samples in this well. The fragmentograms of the molecular ions show the same as discussed above for the other terpene fragmentograms.

Steranes:

The M/Z 149 fragmentogram of the sample from the Statfjord Fm. show a distribution similar to that seen in the sample from 2705 m in the Dunlin Gr. This is also the situation for the M/Z 189 and 259 fragmentograms for the rearranged steranes and the M/Z 217 and 218 fragmentograms for the steranes. The different fragmentograms for the molecular ions support these observations.

Bicyclanes:

As with the other samples from this well it is difficult to evaluate the bicyclanes, but the M/Z 193 fragmentogram indicates that the C₁₅ bicyclanes are present in the sample.

Aromatic Fraction

Thiophenes:

The M/Z 84 fragmentogram shows the peaks with retention times between 23 and 27 minutes are quite abundant. The pattern is slightly different to that of the Dunlin Gr. shales.

The M/Z 98 fragmentogram shows a complex pattern of peaks that is similar to that of the sample from 2705 m.

The M/Z 112 fragmentogram shows only background material, while the M/Z 126 and M/Z 140 fragmentograms show the same pattern as found for the M/Z 98.

Alkyl-substituted Benzenes:

The M/Z 106 fragmentogram shows a larger abundance of the compounds with higher retention time than was seen in The Dunlin Gr. samples, while the M/Z 134 fragmentogram shows a completely different pattern to that found for the Dunlin Gr. samples. The peaks that were dominant in the samples from the Dunlin Gr. are also present in the sample from the Statfjord Fm., but they are not as dominant. A large number of background peaks are nearly as large in this sample as the other peaks. This suggest a change in organic matter. A similar situation is also found for the M/Z 148 fragmentogram.

Naphthalenes:

The M/Z 142 fragmentogram is dominated by the doublet from the methylnaphthalenes where 2-methylnaphthalene is slightly larger than 1-methylnaphthalene. The M/Z 156 fragmentogram shows the typical pattern for the C₂-substituted naphthalenes. The relative intensity of the 2,6+2,7-dimethylnaphthalene and 1,5+2,3+2,4-dimethylnaphthalene is changed in this sample compared with the samples from the Dunlin Gr.

Benzothiophenes and Dibenzothiophenes:

The M/Z 162 fragmentogram shows the typical triplet for the C₂-benzothiophenes. These peaks were not recorded for any of the other samples from this well. The M/Z 176 fragmentogram shows one peak that was not identified and therefore not discussed further.

The M/Z 184 fragmentogram shows the single peak for dibenzothiophene, while the M/Z 198 fragmentogram shows the typical triplet for the methyldibenzothiophenes. The 4-methyldibenzothiophene is the largest peak, while the 1-methyldibenzothiophene is the smallest. The pattern is different than that found for the samples from the Dunlin Gr., which is probably due to an increase in the maturity. The M/Z 212 fragmentogram shows a good signal to noise ratio for the C₂-dibenzothiophenes. It is difficult to compare the pattern found here to that found for the other samples in this well, due to the relatively poor signal to noise ratio, but the pattern is different to that found for other samples of younger formations on the Bergen High. This is probably due to a change in the organic matter in the samples.

Phenanthrenes:

The M/Z 178 fragmentogram shows the single peak from phenanthrene, while the M/Z 192 fragmentogram shows the two doublets for the methylphenanthrenes. The pattern is different than was found for the other samples from this well. The doublet of 3+2-methylphenanthrene is now larger than the doublet of 9+1-phenanthrenes. This is not only caused by increased maturity, but is also probably due to a change in the organic matter, which is so clearly seen by other parameters.

The M/Z 206 fragmentogram shows the typical pattern for C₂-phenanthrenes. There are only minor differences for this sample than was found for samples from the Dunlin Gr. The M/Z 220 fragmentogram shows some peaks from C₃-phenanthrenes, but the signal to noise ratio is so low that further discussion will not be undertaken.

Aromatic Steranes:

The M/Z 253 fragmentogram shows signals from the monoaromatic steranes. The separation is, however, poor and further discussion is therefore not undertaken. The M/Z 231 fragmentogram shows only noise which indicates that this sample does not contain triaromatic steranes.

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°C to 150°C at 35°C/min. at which point the programme rate was 4°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°C at 5°C/min. and held isothermally at 280_oC 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 C₂₇, C₂₈, C₂₉, C₃₀ and C₃₁ 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 C₂₇, C₂₈, C₂₉ and C₃₀ 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 C₁₄ and C₁₅ bicyclanes respectively.

Aromatic Fractions:

Alkyl-substituted Benzenes:

The M/Z 106 fragmentation 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 C₄-alkylbenzenes, but benzothiophene will also give a signal with this fragmentation. M/Z 148 can be used for the detection of C₅-alkylbenzenes, but will also give signals for methyl-substituted benzothiophenes.

Naphthalenes:

Methylnaphthalenes are normally detected by the M/Z 142 fragmentation while C₂-naphthalenes are detected by M/Z 156 and C₃-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 fragmentations are used for methyl-substituted dibenzothiophenes and dimethyl-substituted dibenzothiophenes respectively.

Phenanthrenes:

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

Aromatic Steranes:

Monoaromatic steranes are detected using the M/Z 253 fragmentation while the triaromatic steranes are detected using the M/Z 231 fragmentation.

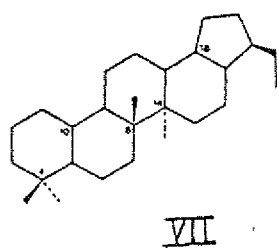
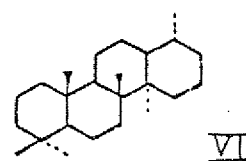
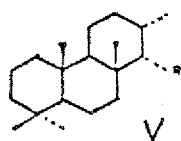
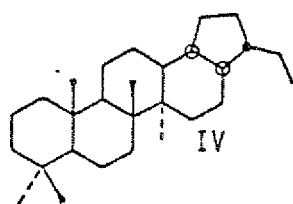
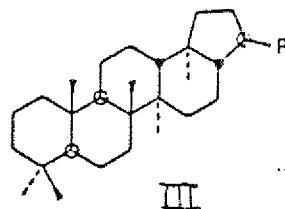
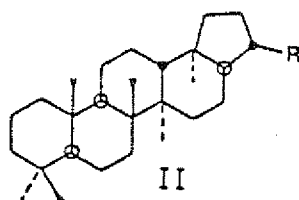
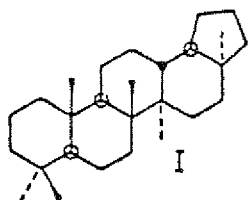
2a. Mass Fragmentograms representing Terpanes

(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 terpene	$C_{23}H_{42}$	(V, R= $i-C_4H_9$)
Q.	Tricyclic terpene	$C_{24}H_{44}$	(V, R= $i-C_5H_{11}$)
R.	Tricyclic terpene (17R, 17S)	$C_{25}H_{66}$	(V, R= $i-C_6H_{13}$)
S.	Tetracyclic terpene	$C_{24}H_{42}$	(VI)
T.	Tricyclic terpene (17R, 17S)	$C_{26}H_{48}$	(V, R= $i-C_7H_{15}$)
N.	Tricyclic terpene	$C_{21}H_{38}$	(V, R= C_2H_5)
O.	Tricyclic terpene	$C_{22}H_{40}$	(V, R= C_3H_7)
Y.	25,28,30 trisnorhopane/moretane	$C_{27}H_{46}$	(VII)
X.	Unknown triterpene	$C_{30}H_{52}$	

STRUCTURES REPRESENTING TERPANES



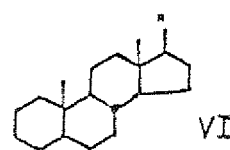
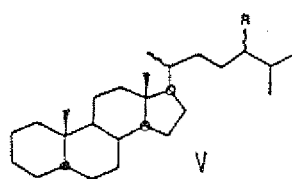
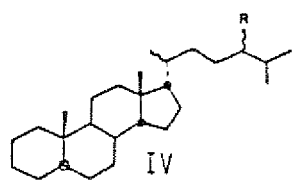
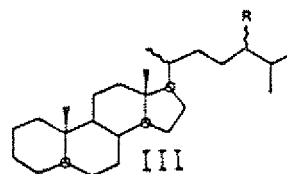
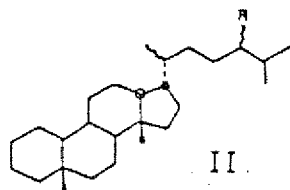
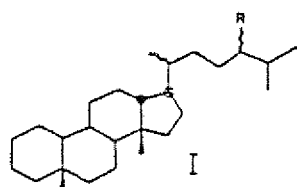
2b. Mass Fragmentograms representing Steranes

(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 methyl diacholestane	$C_{28}H_{50}$	(I, R=CH ₃)
f.	20R $\beta\alpha$ 24 methyl diacholestane	$C_{28}H_{50}$	(I, R=CH ₃)
g.	20S $\alpha\beta$ 24 methyl diacholestane + 20S $\alpha\alpha\alpha$ cholestane	$C_{28}H_{50}$ $C_{27}H_{48}$	(II, R=CH ₃) (III, R=H)
h.	20S $\beta\alpha$ 24 ethyl diacholestane + 20R $\alpha\beta\beta$ cholestane	$C_{29}H_{52}$ $C_{27}H_{48}$	(II, R=C ₂ H ₅) (IV, R=H)
i.	20S $\alpha\beta\beta$ cholestane + 20R $\alpha\beta$ 24 methyl diacholestane	$C_{27}H_{48}$ $C_{28}H_{50}$	(IV, R=H) (II, R=CH ₃)
j.	20R $\alpha\alpha\alpha$ cholestane	$C_{27}H_{48}$	(III, R=H)
k.	20R $\beta\alpha$ 24 ethyl diacholestane	$C_{29}H_{52}$	(I, R=C ₂ H ₅)
l.	20S $\alpha\beta$ 24 ethyl diacholestane	$C_{29}H_{52}$	(II, R=C ₂ H ₅)
m.	20S $\alpha\alpha\alpha$ 24 methyl cholestane	$C_{28}H_{50}$	(III, R=CH ₃)
n.	20R $\alpha\beta\beta$ 24 methyl cholestane + 20R $\alpha\beta$ 24 ethyl diacholestane	$C_{28}H_{50}$ $C_{29}H_{52}$	(IV, R=CH ₃) (II, R=C ₂ H ₅)
o.	20S $\alpha\beta\beta$ 24 methyl cholestane	$C_{28}H_{50}$	(IV, R=CH ₃)
p.	20R $\alpha\alpha\alpha$ 24 methyl cholestane	$C_{28}H_{50}$	(III, R=CH ₃)
q.	20S $\alpha\alpha\alpha$ 24 ethyl cholestane	$C_{29}H_{52}$	(III, R=C ₂ H ₅)
r.	20R $\alpha\beta\beta$ 24 ethyl cholestane	$C_{29}H_{52}$	(IV, R=C ₂ H ₅)
s.	20S $\alpha\beta\beta$ 24 ethyl cholestane	$C_{29}H_{52}$	(IV, R=C ₂ H ₅)
t.	20R $\alpha\alpha\alpha$ 24 ethyl cholestane	$C_{29}H_{52}$	(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

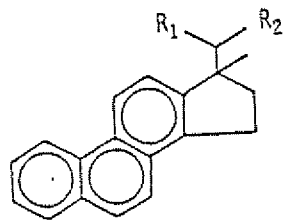
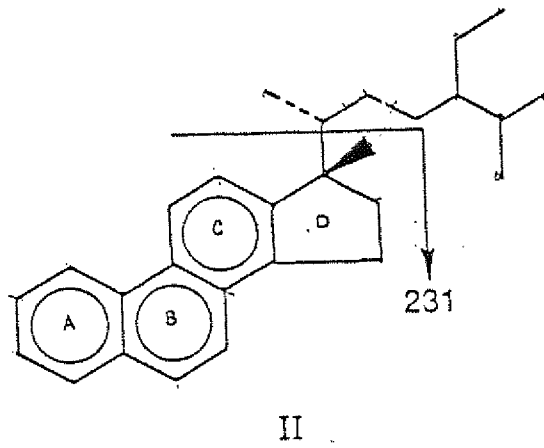


Mass Fragmentograms representing Triaromatic Steranes
 (M/Z 231)

Description of ABC-ring triaromatic steroid hydrocarbons

Peak	Substituents		Abbreviation of Compound
	R ₁	R ₂	
a1	CH ₃	H	C ₂₀ TA
b1	CH ₃	CH ₃	C ₂₁ TA
c1	S(CH ₃)	C ₆ H ₁₃	SC ₂₆ TA
d1	R(CH ₃)	C ₆ H ₁₃	RC ₂₆ TA
	S(CH ₃)	C ₇ H ₁₅	SC ₂₇ TA
e1	S(CH ₃)	C ₈ H ₁₇	SC ₂₈ TA
f1	S(CH ₃)	C ₇ H ₁₅	RC ₂₇ TA
g1	R(CH ₃)	C ₈ H ₁₇	RC ₂₈ TA

STRUCTURES REPRESENTING TRIAROMATIC STERANES:



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	β(H)	CH ₃	S(CH ₃)	H	βSC ₂₇ MA
	CH ₃	H	S(CH ₃)	H	SC ₂₇ DMA
D1	β(H)	CH ₃	R(CH ₃)	H	βRC ₂₇ MA
	CH ₃	H	R(CH ₃)	H	RC ₂₇ DMA
	α(H)	CH ₃	S(CH ₃)	H	αSC ₂₇ MA
E1	β(H)	CH ₃	S(CH ₃)	CH ₃	βSC ₂₈ MA
	CH ₃	H	S(CH ₃)	CH ₃	SC ₂₈ DMA
F1	α(H)	CH ₃	R(CH ₃)	H	αRC ₂₇ MA
	α(H)	CH ₃	S(CH ₃)	CH ₃	αSC ₂₈ MA
	β(H)	CH ₃	R(CH ₃)	CH ₃	βRC ₂₈ MA
G1	CH ₃	H	R(CH ₃)	CH ₃	RC ₂₈ DMA
	β(H)	CH ₃	S(CH ₃)	C ₂ H ₅	βSC ₂₉ MA
	CH ₃	H	S(CH ₃)	C ₂ H ₅	SC ₂₉ DMA
H1	α(H)	CH ₃	R(CH ₃)	CH ₃	αRC ₂₈ MA
	β(H)	CH ₃	R(CH ₃)	C ₂ H ₅	βRC ₂₉ MA
	CH ₃	H	R(CH ₃)	C ₂ H ₅	RC ₂₉ DMA
I1	α(H)	CH ₃	R(CH ₃)	C ₂ H ₅	αRC ₂₉ MA

STRUCTURES REPRESENTING MONOAROMATIC STERANES:

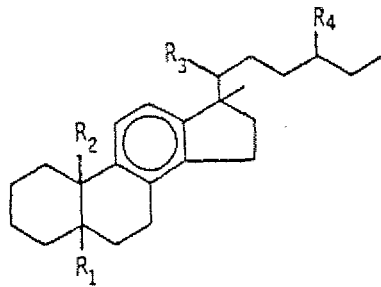
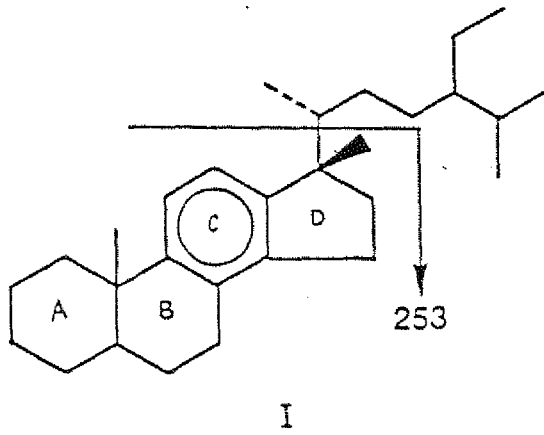


Table 1: Variation in Triterpane Distribution for Well NOCS 31/4-3

Depth unit of measure: m

Depth	Lithology	B/A	B/B+A	B		C/E	C/C+E	X/E	Z/E	Z/C	Z/Z+E	Q/E	E/E+F	C+D		J1		Sample
				B+E+F										C+D+E+F	D+F/C+E	J1+J2%		
2092.00	bulk	0.79	0.44	0.25	0.85	0.46	-	-	-	-	-	0.92	0.48	0.13	59.57	271-0		
2495.00	bulk	5.96	0.86	0.30	0.61	0.38	0.04	0.10	0.17	0.09	0.05	0.83	0.38	0.23	52.38	274-0		
2520.00	bulk	6.02	0.86	0.31	0.58	0.37	0.07	0.08	0.13	0.07	0.05	0.82	0.37	0.24	53.90	275-0		
2705.00	bulk	11.05	0.92	0.34	0.89	0.47	0.04	0.11	0.13	0.10	0.04	0.76	0.47	0.31	57.52	278-0		
2828.00	bulk	5.55	0.85	0.30	0.88	0.47	0.04	0.06	0.07	0.06	0.07	0.77	0.47	0.30	55.71	280-0		

Table 2: Variation in Sterane Distribution for Well NOCS 31/4-3

Depth unit of measure: m

<u>Depth</u>	<u>Lithology</u>	<u>Ratio1</u>	<u>Ratio2</u>	<u>Ratio3</u>	<u>Ratio4</u>	<u>Ratio5</u>	<u>Ratio6</u>	<u>Ratio7</u>	<u>Sample</u>
2092.00	bulk	0.51	79.25	77.06	1.48	0.68	0.20	0.08	271-0
2495.00	bulk	0.31	24.33	51.62	0.76	0.69	0.09	0.07	274-0
2520.00	bulk	0.35	24.14	50.29	0.77	0.68	0.08	0.07	275-0
2705.00	bulk	0.29	24.91	47.20	0.68	0.64	0.10	0.08	278-0
2828.00	bulk	0.29	26.62	53.54	0.71	0.68	0.13	0.10	280-0

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 31/4-3

Depth unit of measure: m

<u>Depth</u>	<u>Lithology</u>	<u>Ratio1</u>	<u>Ratio2</u>	<u>Sample</u>
2092.00	bulk	1.00	-	271-0
2495.00	bulk	1.00	-	274-0
2520.00	bulk	0.61	1.00	275-0
2705.00	bulk	0.84	1.00	278-0
2828.00	bulk	0.60	1.00	280-0

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

$$\text{Ratio2: } \text{g1} / \text{g1} + \text{I1}$$

Table 4: Variation in Triaromatic Sterane Distribution for Well NOCS 31/4-3

Depth unit of measure: m

<u>Depth</u>	<u>Lithology</u>	<u>Ratio1</u>	<u>Ratio2</u>	<u>Ratio3</u>	<u>Ratio4</u>	<u>Ratio5</u>	<u>Sample</u>
2092.00	bulk	-	-	-	-	-	271-0
2495.00	bulk	-	-	-	-	-	274-0
2520.00	bulk	0.79	0.52	0.28	0.46	0.40	275-0
2705.00	bulk	0.90	0.72	0.69	0.80	0.81	278-0
2828.00	bulk	0.75	0.41	0.33	0.47	0.51	280-0

Ratio1: $a1 / a1 + g1$

Ratio2: $b1 / b1 + g1$

Ratio3: $a1 + b1 / a1 + b1 + c1 + d1 + e1 + f1 + g1$

Ratio4: $a1 / a1 + e1 + f1 + g1$

Ratio5: $a1 / a1 + d1$

Table 5: Variation in Monoaromatic Sterane Distribution for Well NOCS 31/4-3

Depth unit of measure: m

<u>Depth</u>	<u>Lithology</u>	<u>Ratio1</u>	<u>Ratio2</u>	<u>Ratio3</u>	<u>Ratio4</u>	<u>Sample</u>
2092.00	bulk	0.17	0.17	0.09	0.09	271-0
2495.00	bulk	0.36	0.26	0.17	0.14	274-0
2520.00	bulk	0.28	0.17	0.14	0.11	275-0
2705.00	bulk	0.15	0.13	0.07	0.08	278-0
2828.00	bulk	0.26	0.17	0.14	0.13	280-0

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