U-652 .3

HYDRO

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E&P Research Centre

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Title
PETROLEUM GEOCHEMISTRY

WELL: 30/9-11

Summary/Conclusion//Recommendation

Source rocks analysed from well 30/9-11 include Heather Fm. shales, and coals from Tarbert and Ness Fms.

Analysis indicate that the Heather Fm. is a fair source rock with a potential mainly for gas generation. The Heather Fm.seems to have been deposited in a dysaerobic/aerobic environment.

The Tarbert Fm. coal shows a high Hydrogen Index, and this together with the Pyrolysis gas chromatography results indicate that this coal might have a potential for liquid hydrocarbon generation.

The coals from Ness Fm. are of Type III kerogen with a potential for gaseous hydrocarbon generation.

All samples analysed from Heather, Tarbert and Ness Fm. indicate maturity below the oil window.

Keywords
Source Rock Evaluation.

Pages-appendix	Amendment no.	Revision no.	Revision date

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1. INTRODUCTION.

Well 30/9-11 is located in the Oseberg J-East area. The well was spudded 27.10.90, and reached T.D at 2570m RKB in the Lower Jurassic Drake Fm. A map indicating the well location is given in Figure 1.1, and a well summary with formation tops is given in Figure 1.2.

The aim of this study was to identify and characterize possible source rocks in well 30/9-11.

This report comprises the results from petroleum geochemical analysis of 24 SWCs and CCs. A list of the samples investigated is given in Table 1.1.

All analytical work, interpretation of data and compilation of this report was undertaken by Norsk Hydro Research Center, Bergen Norway.

2. SOURCE ROCK EVALUATION WELL 30/9-11.

Source rock horizons have been identified using Rock Eval pyrolysis and total organic carbon (TOC) measurements. The composition of the organic matter in two selected samples have been characterized by pyrolysis gas chromatography, gas chromatography of saturated hydrocarbons and biomarker analysis.

2.1 Source rock screening data.

The results of RockEval/TOC analysis are listed in Table 2.1, and are plotted versus depth in Figure 2.1. A crossplot between Hydrogen Index and T_{max} is given in Figure 2.2.

The SWC samples of the Heather Fm. claystones/siltstones have an average S_2 value of 4.2 kg/tonne suggesting a fair source potential. The average Hydrogen Index is 197 mgHC/gTOC indicating that the organic matter in this interval consists mainly of type III kerogen with a potential for generation of light molecular weight hydrocarbons, presumably gas.

One COCH sample from the Tarbert Fm. was analysed. This coal sample has a S_2 value of 133.5 kg/tonne and a Hydrogen Index of 352 mgHC/gTOC. The Hydrogen Index is very high for a coal sample and might indicate a potential for liquid hydrocarbon generation.

Coal samples from the Ness Fm. have average S_2 values of 150 kg/tonne and Hydrogen Indices ranging from 173-260 mgHC/gTOC. This suggests that the organic matter in this horizon is gas/condensate prone, type III kerogen.

T_{max} values for the sections analysed are around 430°C indicating low maturity.

2.2 Pyrolysis gas chromatography.

Programmed pyrolysis gas chromatography has been performed on extracted samples. The pyrolysis gas chromatograms are given in Appendix I.

Two of the samples from this well have been selected for closer examination. The richest sample from the Heather formation at 2365.5m, and the coal sample at 2388.4m in the Tarbert Fm. showing an unusually high Hydrogen Index.

The sample at 2365.5m show a homologous series of n-alkanes/alkenes extending up beyond n-C_{25}. Aromatics are abundant. This indicates an organic matter of mixed input, containing both terrestrially and liptinitic matter. Organic matter of this character has a potential for generation of condensate and gas.

The sample at 2388.4m shows a considerable amount of gaseous alkanes, which is typical for coaly material. The presence of homolouges of n-alkanes/alkenes beyond nC_{25} together with abundant aromatics indicates that the organic matter consists of liptinitic material mixed with material of a more terrogenous origin. This coal might have a potential for generation of liquid hydrocarbons.

2.3 Gas chromatography of saturated hydrocarbons.

The gas chromatograms of the saturated hydrocarbons are given in Appendix II. Molecular ratios are given in Table 2.2.

The gas chromatogram of the sample at 2365.5m in the Heather Fm. show abundant nC_{14} and $n\text{-}C_{15}$ alkanes, and have a slight bimodal n-alkane distribution. The Pristane/Phytane ratio is 4.1, this indicates an oxic environment at the time of deposition. The strong predominance of odd/even carbon numbered alkanes in the sample, with CPI indices of 1.8 suggests input off higher plant material and indicates a predominantly terrestrial origin for the organic matter.

The sample from Tarbert Fm. show abundant isoprenoides and has a Pristane/$n\text{-}C_{17}$ ratio of 30. Pristane/$n\text{-}C_{17}$ value in this order is typical for coals. The Pristane/Phytane ratio is 8.5 and this indicates that the organic matter was deposited in an oxic depositional environment.

2.4 Biological markers, saturated hydrocarbons.

The mass chromatograms of the terpanes (m/z 191) and the steranes (m/z 217) are given in Appendix III. Selected biomarker ratios are listed in Table 2.3.

The mass chromatogram (m/z 191) of the Heather Fm. sample show relatively abundant moretanes. This together with the results from calculated biomarker ratios indicates low maturity in this section. The high concentration of C_{31} hopanes and the rapid decrease in concentration of the extended hopanes suggest a dysaerobic/aerobic depositional environment. 28,30-bisnorhopane is absent.

In the m/z 217 mass chromatogram for this sample C_{29} steranes are dominant, suggesting input of terrestrial material to the organic matter. The presence of C_{27} and C_{30} steranes suggests presence of marine organic matter, and this indicates a mixed input with both marine and terrestrial organic matter for this sample. The 20S sterane isomerization is 20% indicating low maturity.

The distribution of terpanes in the m/z 191 mass chromatogram of the sample from Tarbert Fm. is different from that of the Heater Fm. This sample contains 28,30-Bisnorhopane, and fair amounts of Δ17,22 hopene. It also show abundant moretanes indicating low maturity.

The sterane mass chromatogram shows presence of almost exclusively C_{29} steranes, indicating that the organic material is predominantly terrestrially derived. This together with the high Hydrogen Index suggests that the organic matter is of herbaceous character, and possibly contains Sporinite and/or Cutinite which both are rich in hydrogen. The 20S sterane isomerization is 26% indicating low maturity for this section.

3. SUMMARY.

Source rocks analysed from well 30/9-11 include Heather Fm. shales, and coals from Tarbert and Ness Fms.

Analysis indicate that the Heather Fm. is a fair source rock with a potential mainly for gas generation. The Heather Fm.seems to have been deposited in a dysaerobic/aerobic environment.

The Tarbert Fm. coal shows a high Hydrogen Index, and this together with the Pyrolysis gas chromatography results indicate that this coal might have a potential for liquid hydrocarbon generation.

The coals from Ness Fm. are of Type III kerogen with a potential for gaseous hydrocarbon generation.

All samples analysed from Heather, Tarbert and Ness Fm. indicate maturity below the oil window. (Ro for this section would probably be around or below 0.5%).

Table 1.1 List of samples analysed.

	DEPTH, m	Type	Rock-Eval	TOC	PyGC	Extr.	Iatroscan	GCMSD-Sat
1	2297.8	SWC	*	*				
2	2308.8	SWC	*	*				
3	2316.6	SWC	*	*				
4	2326.1	SWC	*	*				
5	2334.0	SWC	*	*				
6	2339.8	SWC	*	*				
7	2343.8	SWC	*	*				
8	2351.7	SWC	*	*				
9	2358.0	SWC	*	*				
10	2360.4	SWC	*	*				
11	2365.5	SWC	*	*	*	*	*	*
12	2368.5	SWC	*	*				
13	2370.8	SWC	*	*				
14	2371.4	SWC	*	*				
15	2378.1	SWC	*	*				
16	2378.4	SWC	*	*				
17	2380.4	SWC	*	*				
18	2388.4	COCH	*	*	*	*	*	*
19	2389.8	COCH	*	*				
20	2390.8	COCH	*	*				
21	2391.5	COCH	*	*				
22	2455.5	COCH	*	*				
23	2456.9	COCH	*	*				
24	2498.8	COCH	*	*				

Table 2.1 Source rock screening data.

Table 2.1 **SOURCE ROCK SCREENING DATA WELL 30/9-11**

Petroleum Geochemistry Group
Research Centre Bergen
HYDRO

Depth (m)	Group/Fm.	%	Lithology	Type	S1 kg/t	S2 kg/t	TOC %	HI	PI	Tmax DegC	Company
2297.80	HEATHER		CLYST	SWC	0.86	3.66	2.5	146	0.19	430	F-BERGEN
2308.80	HEATHER		CLYST/SLST	SWC	0.77	5.72	3.0	191	0.12	430	F-BERGEN
2316.60	HEATHER		CLYST/TR SS	SWC	0.59	6.13	3.0	204	0.09	430	F-BERGEN
2326.10	HEATHER		SLST/TR SST	SWC	0.55	6.75	3.5	193	0.08	429	F-BERGEN
2334.00	HEATHER		CLYST/SLTY	SWC	0.59	5.00	2.5	200	0.11	428	F-BERGEN
2339.80	HEATHER		CLYST	SWC	1.33	2.68	1.4	191	0.33	430	F-BERGEN
2343.80	HEATHER		CLYST/SLST	SWC	0.59	5.24	2.6	202	0.10	430	F-BERGEN
2351.70	HEATHER		CLYST/SLST	SWC	0.43	3.53	1.7	208	0.11	424	F-BERGEN
2358.00	HEATHER		CLYST/TR SS	SWC	0.23	2.72	1.4	194	0.08	430	F-BERGEN
2360.40	HEATHER		CLYST	SWC	0.34	2.82	1.8	157	0.11	432	F-BERGEN
2365.50	HEATHER		CLYST	SWC	0.84	14.69	5.5	267	0.05	429	F-BERGEN
2368.50	HEATHER		CLYST/TS SS	SWC	0.09	1.07	0.7	153	0.08	438	F-BERGEN
2370.80	HEATHER		CLYST	SWC	0.35	1.43	0.7	204	0.20	445	F-BERGEN
2371.40	HEATHER		CLYST	SWC	0.13	1.99	0.8	249	0.06	439	F-BERGEN
2378.10	HEATHER		SLST	SWC	0.19	1.93	1.0	193	0.09	441	F-BERGEN
2380.40	HEATHER		SLST	SWC	0.21	2.06	0.9	229	0.09	436	F-BERGEN
2388.40	TARBERT		COAL	COCH	10.48	133.46	37.9	352	0.07	416	F BERGEN
2389.80	NESS		COAL	COCH	13.39	155.87	70.3	222	0.08	424	F BERGEN

Table 2.1 **SOURCE ROCK SCREENING DATA WELL 30/9-11**

Petroleum Geochemistry Group
Research Centre Bergen
HYDRO

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2308.80	HEATHER		CLYST/SLST	SWC	0.77	5.72	3.0	191	0.12	430	F-BERGEN
2316.60	HEATHER		CLYST/TR SS	SWC	0.59	6.13	3.0	204	0.09	430	F-BERGEN
2326.10	HEATHER		SLST/TR SST	SWC	0.55	6.75	3.5	193	0.08	429	F-BERGEN
2334.00	HEATHER		CLYST/SLTY	SWC	0.59	5.00	2.5	200	0.11	428	F-BERGEN
2339.80	HEATHER		CLYST	SWC	1.33	2.68	1.4	191	0.33	430	F-BERGEN
2343.80	HEATHER		CLYST/SLST	SWC	0.59	5.24	2.6	202	0.10	430	F-BERGEN
2351.70	HEATHER		CLYST/SLST	SWC	0.43	3.53	1.7	208	0.11	424	F-BERGEN
2358.00	HEATHER		CLYST/TR SS	SWC	0.23	2.72	1.4	194	0.08	430	F-BERGEN
2360.40	HEATHER		CLYST	SWC	0.34	2.82	1.8	157	0.11	432	F-BERGEN
2365.50	HEATHER		CLYST	SWC	0.84	14.69	5.5	267	0.05	429	F-BERGEN
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2378.10	HEATHER		SLST	SWC	0.19	1.93	1.0	193	0.09	441	F-BERGEN
2380.40	HEATHER		SLST	SWC	0.21	2.06	0.9	229	0.09	436	F-BERGEN
2388.40	TARBERT		COAL	COCH	10.48	133.46	37.9	352	0.07	416	F BERGEN
2389.80	NESS		COAL	COCH	13.39	155.87	70.3	222	0.08	424	F BERGEN

Table 2.1 **SOURCE ROCK SCREENING DATA WELL 30/9-11** (cont'd)

Depth (m)	Group/Fm.	%	Lithology	Type	S1 kg/t	S2 kg/t	TOC %	HI	PI	Tmax DegC		Company
2390.80	NESS		COAL	COCH	16.85	174.16	81.4	214	0.09	427	F	BERGEN
2391.50	NESS		COAL	COCH	12.26	200.56	77.2	260	0.06	425	F	BERGEN
2455.50	NESS		COAL	COCH	8.03	119.01	68.6	173	0.06	433	F	BERGEN
2456.90	NESS		COAL	COCH	4.00	66.47	35.7	186	0.06	433	F	BERGEN
2498.80	NESS		COAL	COCH	15.88	183.36	71.3	257	0.08	427	F	BERGEN

Table 2.2 Molecular ratios.

Table 2.2 **SATURATED FRACTION MOLECULAR RATIOS WELL 30/9-11**

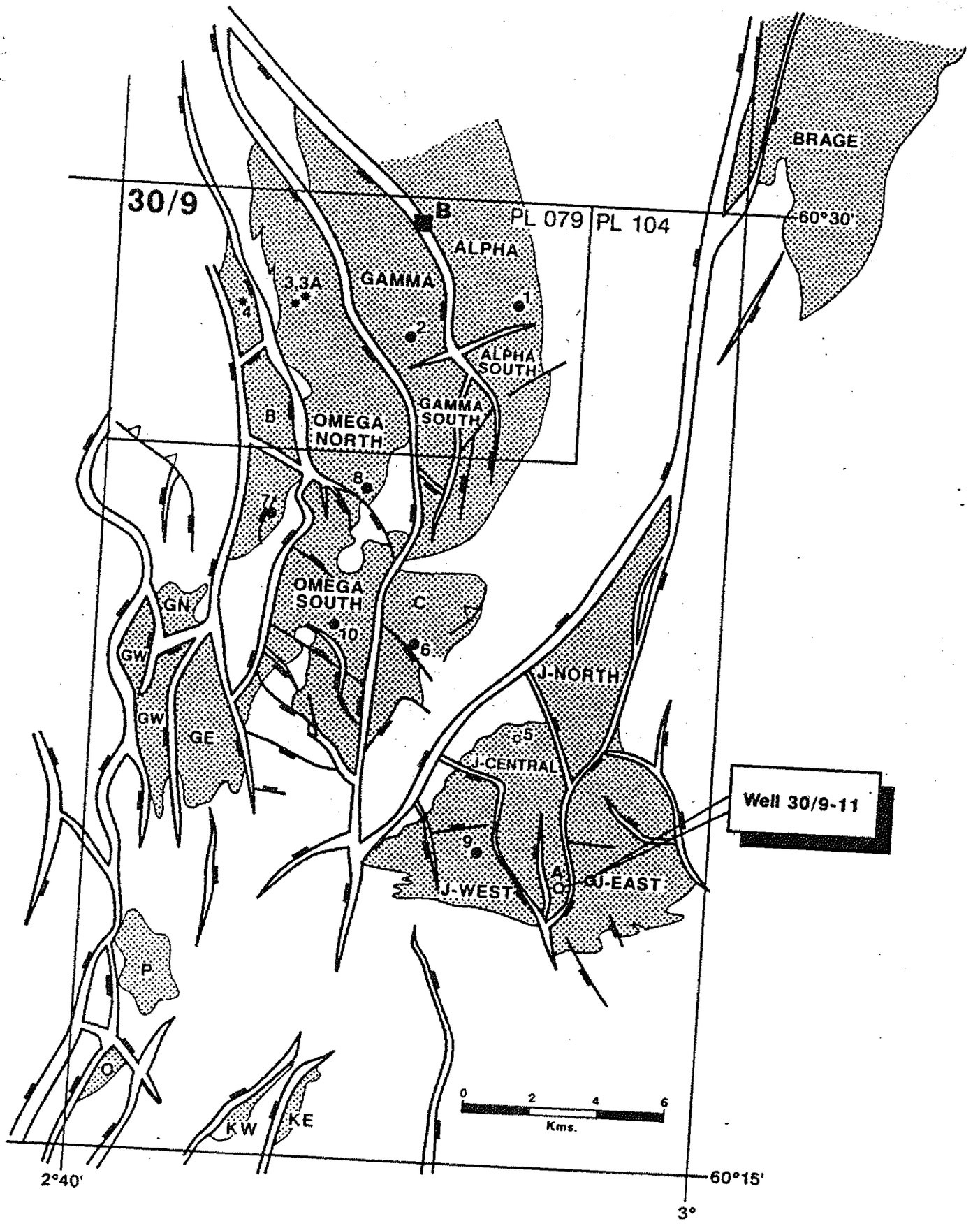
Petroleum Geochemistry Group
Research Centre Bergen
HYDRO

Depth	Group/Fm.	%	Lithology	Type	Pristane / nC17	Pristane / Phytane	CPI-I	CPI-II	nC15+ / Total	nC20 / nC25
2365.50	HEATHER		CLYST	SWC	2.91	4.07	1.78	1.76		
2388.40	TARBERT		COAL	COCH	30.38	8.50	1.06	0.91		

Table 2.3 Biomarker ratios.

DEPTH m	Ts/Tm	BNH/H	NH/H	MORETANE/ HOPANE	%20S	%abb
2365.5	0.07	0.01	0.6	0.4	20	35
2388.4	0.10	0.20	0.4	0.3	26	59

Figure 1.1 Well location map.



Location map, Well 30/9-11

HYDRO

TNI047/OH/BM/06.90

Figure 1.2 Well summary with formation tops.

HYDRO

WELL: 30/9-11

DEPTH RKB: ELEVATION KB: 25m NB! Not to scale All depth in meters

CHRONOSTRATIGRAPHY

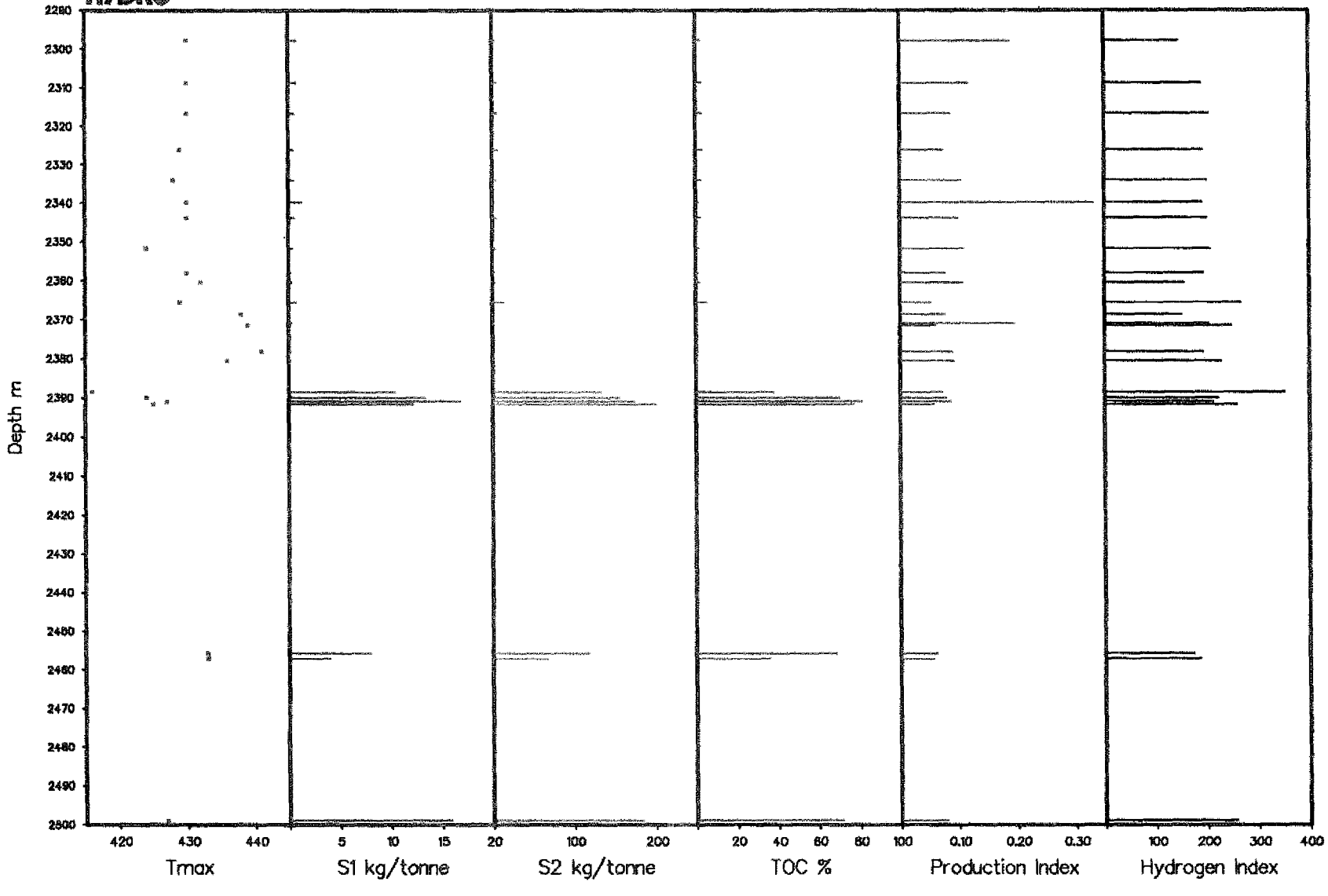
SYSTEM	SERIES/STAGE	DEPTH m	THICKNESS m
		134	
QUAT			180
		314	
TERTIARY			616
		930	
	Early Miocene		50
		980	
			10
		990	
	Late Oligocene		200
		1190	
			10
		1200	
	Early Oligocene		280
		1480	
			10
		1490	
	?Early Oligocene - Late Eocene		150
		1640	
			20
		1660	
	Late - ?Middle Eocene		60
		1720	
			10
		1730	
	Middle Eocene		160
		1890	
			10
		1900	
	Early Eocene		40
		1940	
			10
		1950	
	Late Paleocene		230
		2180	
	Early Paleocene	2200	40
CRET		2220	
	Early Maas - Late Campanian		62
		2282	
	Early Barremian	2290	15.6
		2297.6	
	Early Kimmeridgian		19
		2316.6	
	Early Kimmeridgian - Middle Oxfordian		48.9
		2365.5	
		2368.5	3
	Early Late Callovian - Late Bathonian		11.9
		2380.4	
	Early Bathonian - Late Bajocian	2382	21.4
		2401.8	
JURASSIC	Bajocian - Aalenian		108.4
		2510.2	
	Aalenian - Late Toarcian		9.8
		2520	
	Toarcian		50
		2570 (TD)	

LITHOSTRATIGRAPHY

GROUP	FORMATION/MEMBER	
	Seabed	
Nordland Group		651
	Utsira Fm.	829
Hordaland Group		1951
Rogaland Group	Balder Fm.	1975
	Sele Fm.	2050
	Lista Fm.	2188
	Våle Fm.	2193
Shetland Group		2286
Cromer Knoll Group		2291
Viking Group		2384
	Tarbert Fm.	2390
Brent Group	Ness Fm.	2507
	Etive/Rannoch Fm.	2514
	Oseberg Fm.	2516
Dunlin Group	Drake Fm.	2570 (TD)

Figure 2.1 Screening data versus depth.

Well: 30/9-11


HYDRO
Depth m
2280
2300
2310
2320
2330
2340
2350
2360
2370
2380
2390
2400
2410
2420
2430
2440
2450
2460
2470
2480
2490
2500
420
430
440
Tmax
5
10
15
S1 kg/tonne
20
100
200
S2 kg/tonne
20
40
60
80
TOC %
100
0.10
0.20
0.30
Production Index
100
200
300
400
Hydrogen Index

Well: 30/9-11 – Heather Fm.

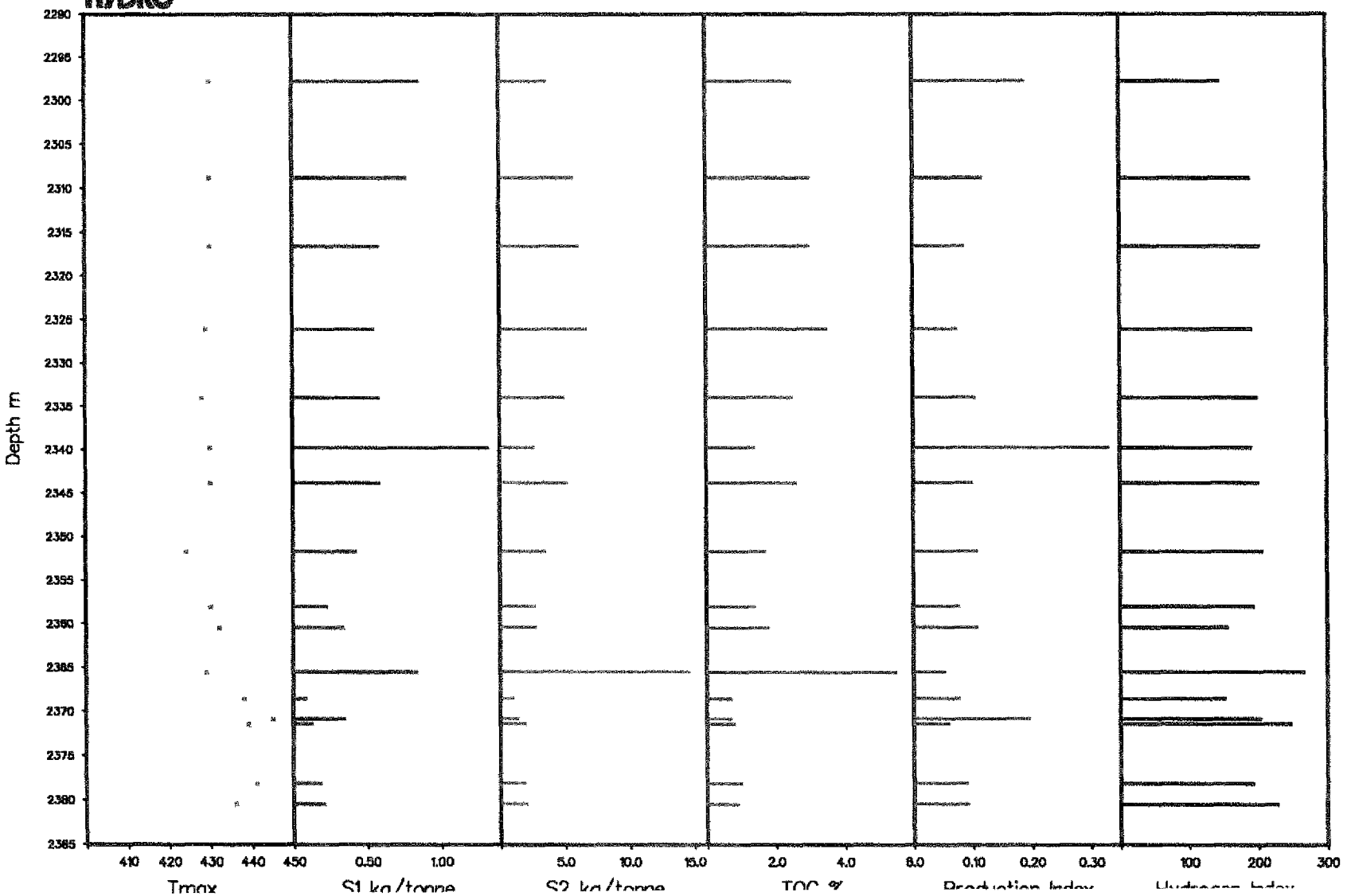
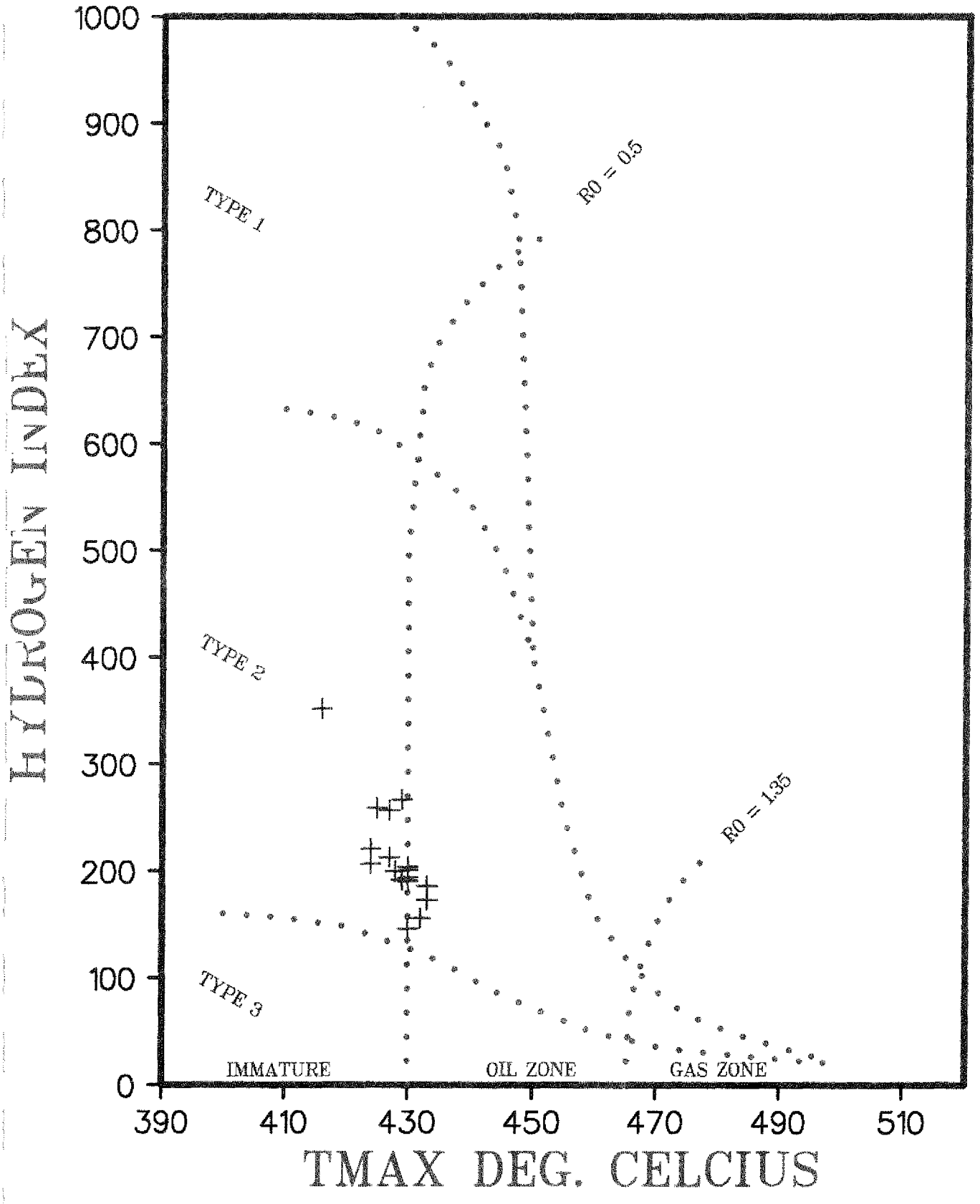


Figure 2.2 Hydrogen Index versus T_{max}.

Well: 30/9-11


HYDROGEN INDEX
1000
900
800
700
600
500
400
300
200
100
0
TYPE 1
TYPE 2
TYPE 3
R0 = 0.5
R0 = 1.35
IMMATURE
OIL ZONE
GAS ZONE
390
410
430
450
470
490
510
TMAX DEG. CELCIUS

APPENDIX I

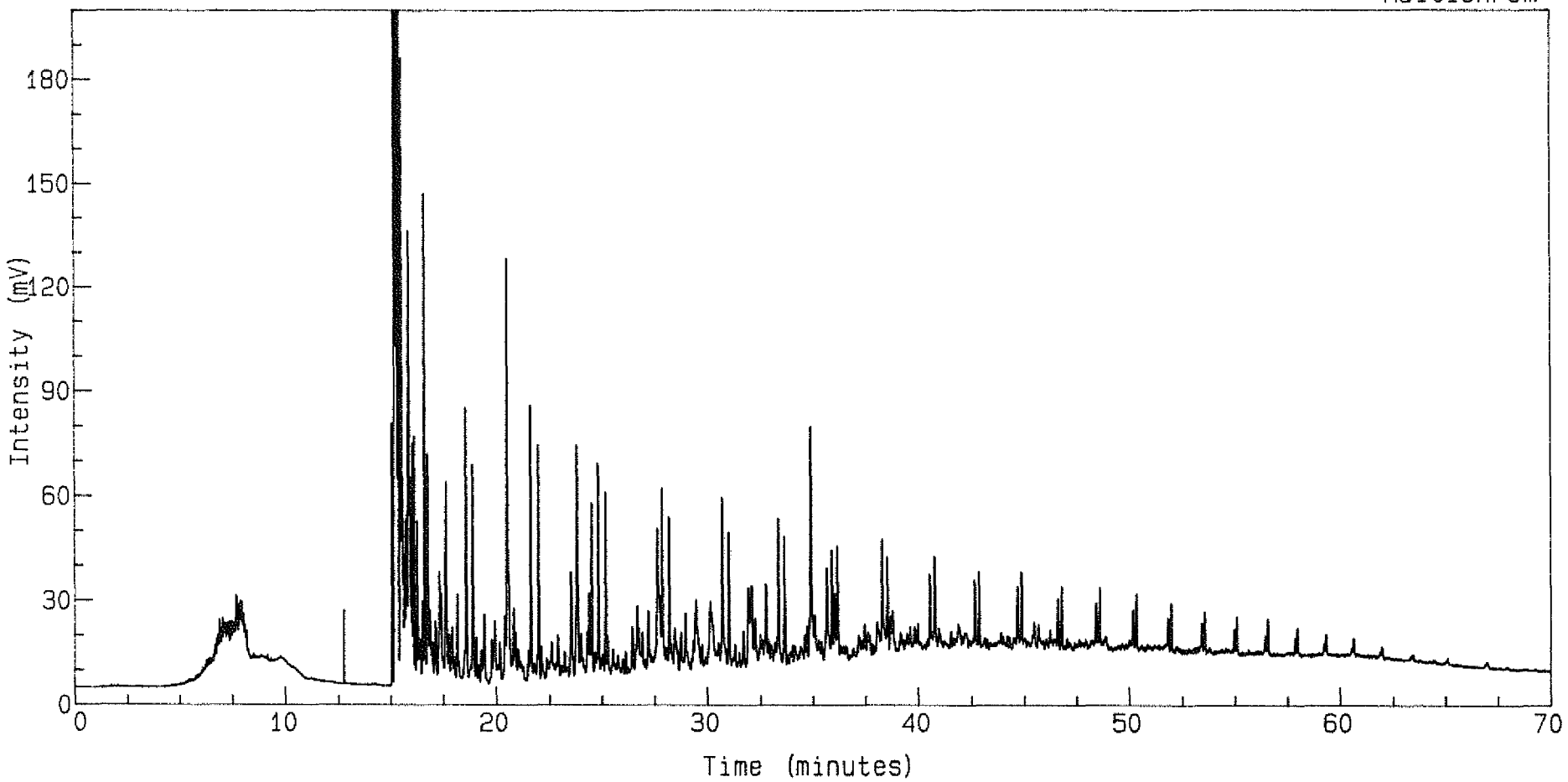
Pyrolysis Gas Chromatograms.

Analysis Name : [PETRO] 6 A390911P, 2, 1.

30/9-11 2365.5 M SWC Amount : 30.900

PROGRAMMED PYROLYSIS FID

Multichrom



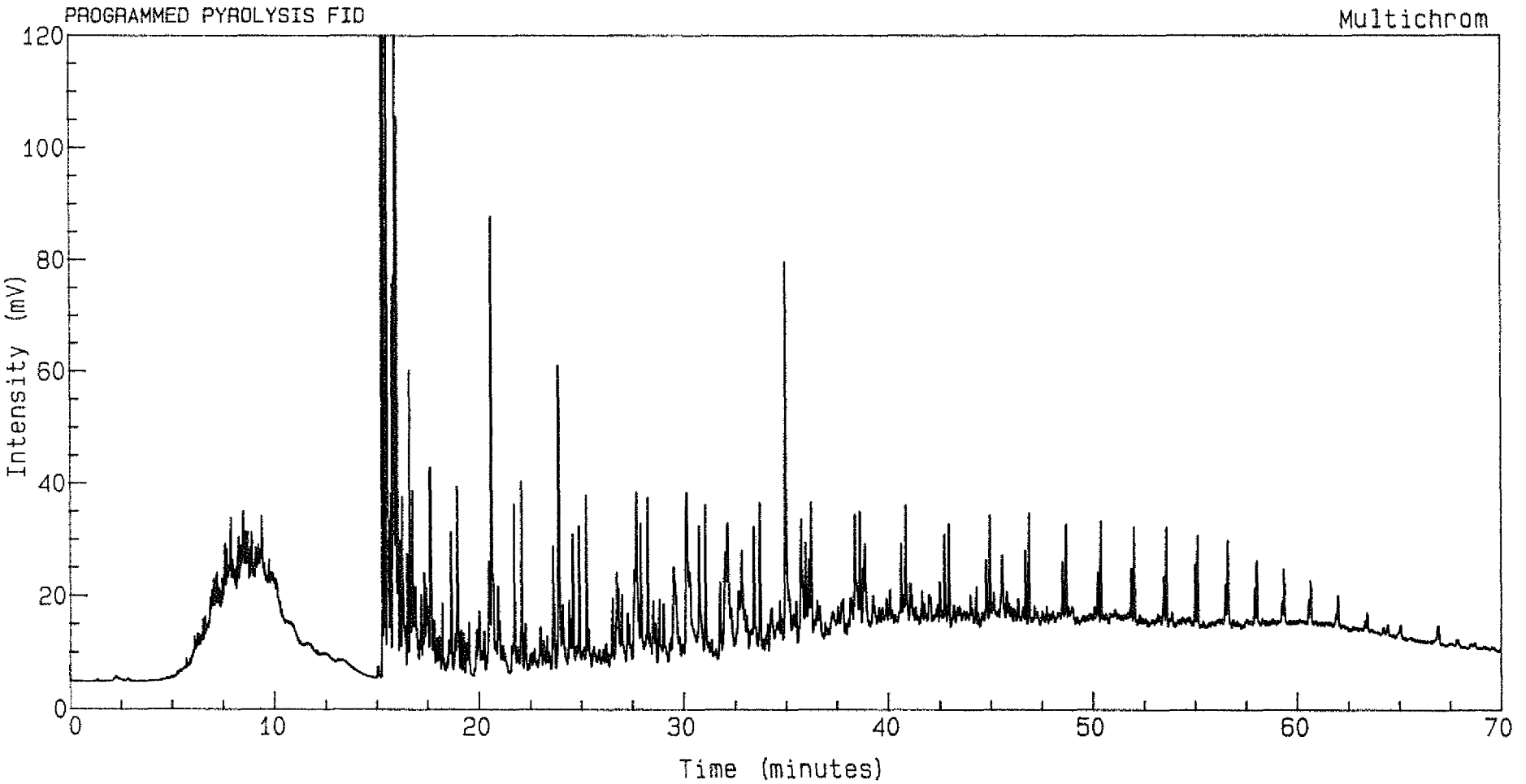
Instrument : V 3700
Channel Title : PYROLYSIS FID
Lims ID :
Acquired on 18-MAR-1991 at 15:02
Reported on 19-MAR-1991 at 12:12

Method : PYRO
Calibration : PYRO
Run Sequence : PYRO

Analysis Name : [PETRO] 6 A390911P, 3, 1.

30/9-11 2388.40 M COCH COAL Amount : 2.700

PROGRAMMED PYROLYSIS FID



Instrument : V 3700
Channel Title : PYROLYSIS FID
Lims ID :
Acquired on 18-MAR-1991 at 16:37
Reported on 19-MAR-1991 at 12:11

Method : PYRO
Calibration : PYRO
Run Sequence : PYRO

APPENDIX II

Gas Chromatograms of Saturated Hydrocarbons.

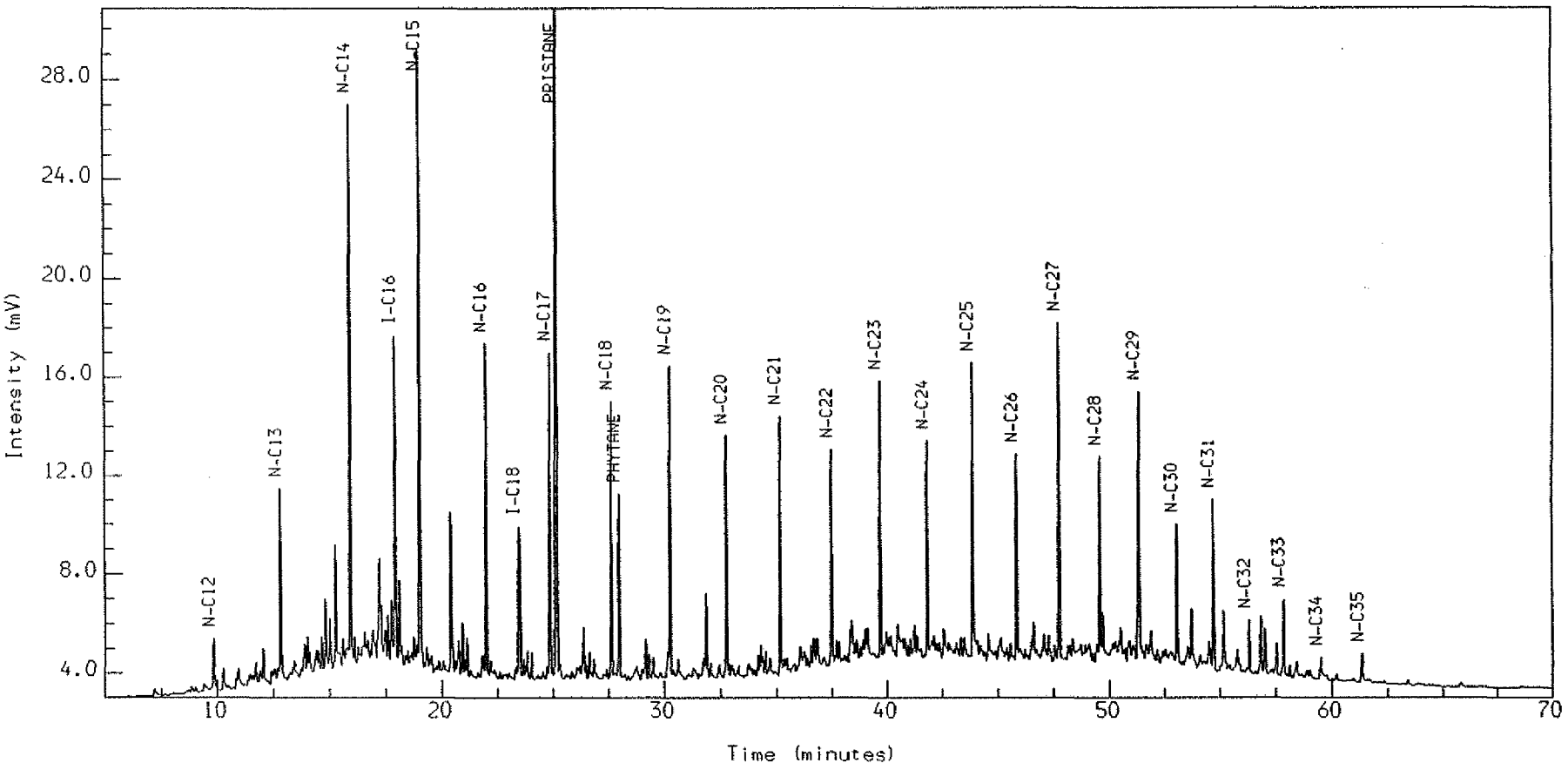
NORSK HYDRO RESEARCH CENTRE

Analysis Name : [PETRO] 7 w300911.9.1.

30/9-11 2365.5m

GC SATURATED HYDROCARBONS

Multichrom



Instrument : HP5890

Channel Title : MSD

Lims ID :

Acquired on 20-MAR-1991 at 04:20

Reported on 20-MAR-1991 at 05:42

Method : MSDS

Calibration : MSDS

Run Sequence : MSDS

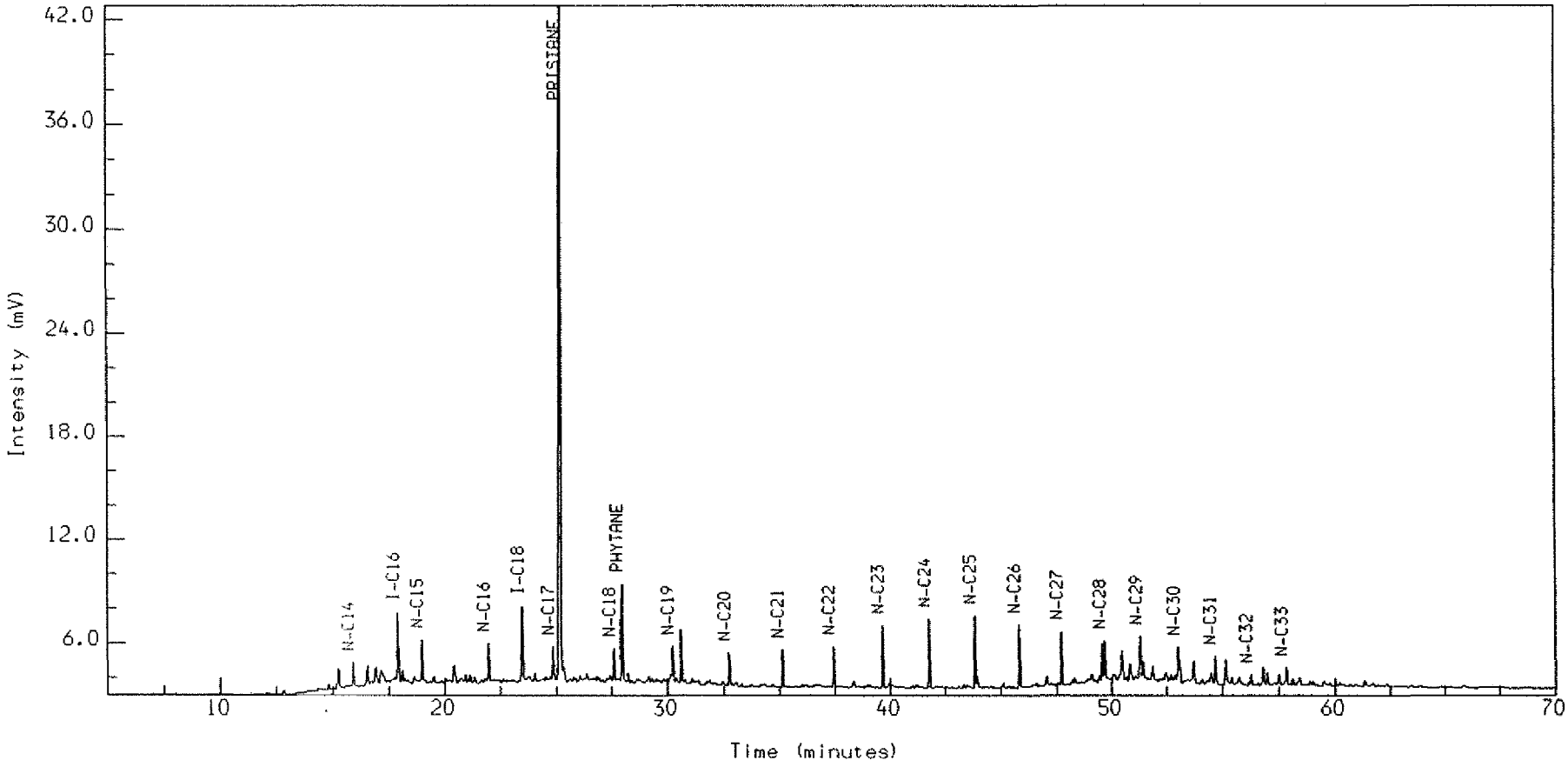
NORSK HYDRO RESEARCH CENTRE

Analysis Name : [PETRO] 7 w300911,10,1.

30/9-11 2388.4m

GC SATURATED HYDROCARBONS

Multichrom



Instrument : HP5890

Channel Title : MSD

Lims ID :

Acquired on 20-MAR-1991 at 05:52

Reported on 20-MAR-1991 at 07:13

Method : MSDS

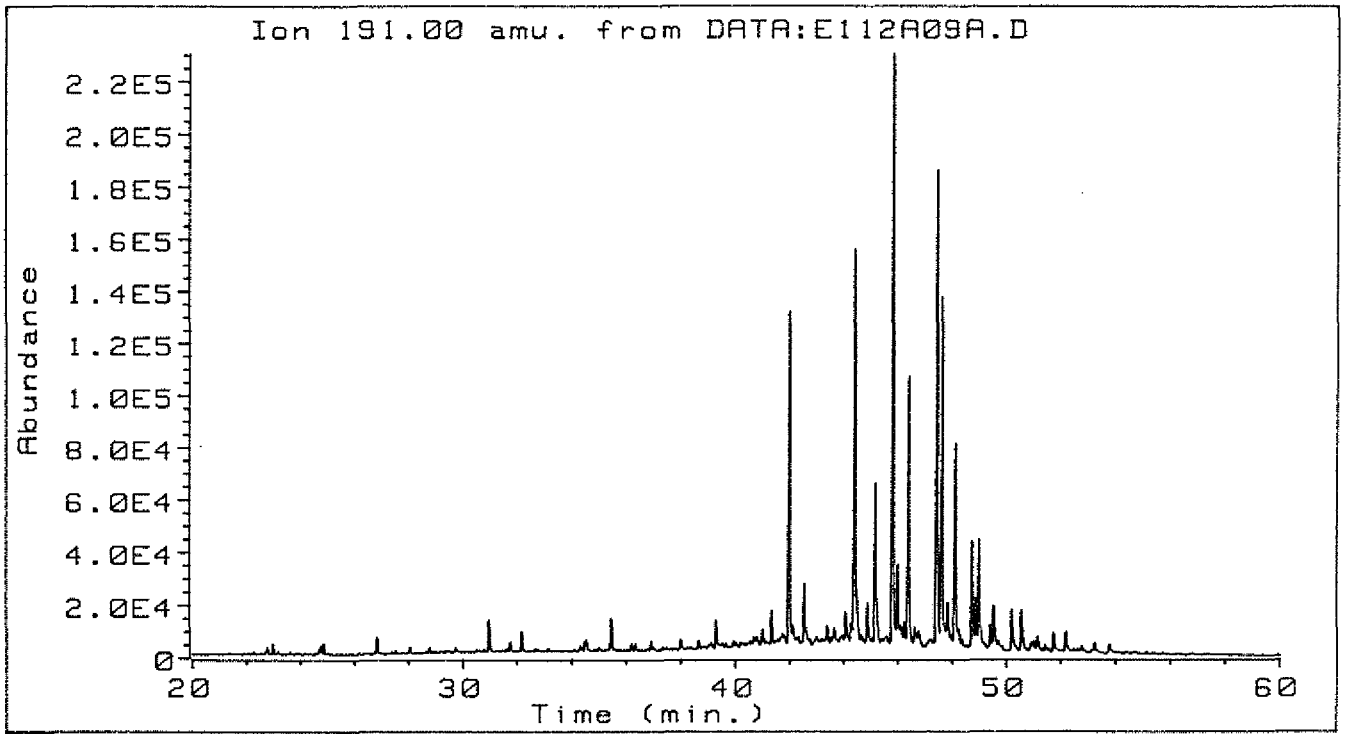
Calibration : MSDS

Run Sequence : MSDS

APPENDIX III

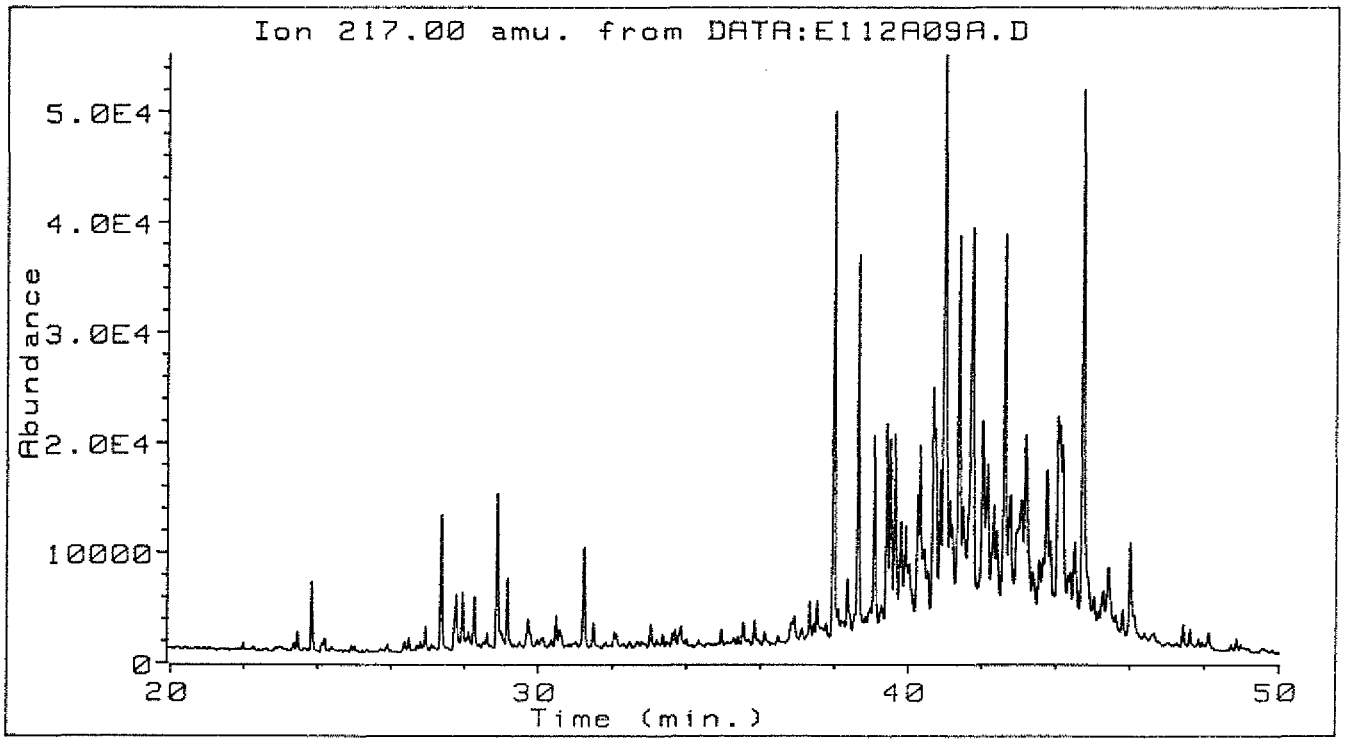
Fragmentograms of Terpanes, (Ion 191 m/z).

Fragmentograms of Steranes, (Ion 217 m/z).



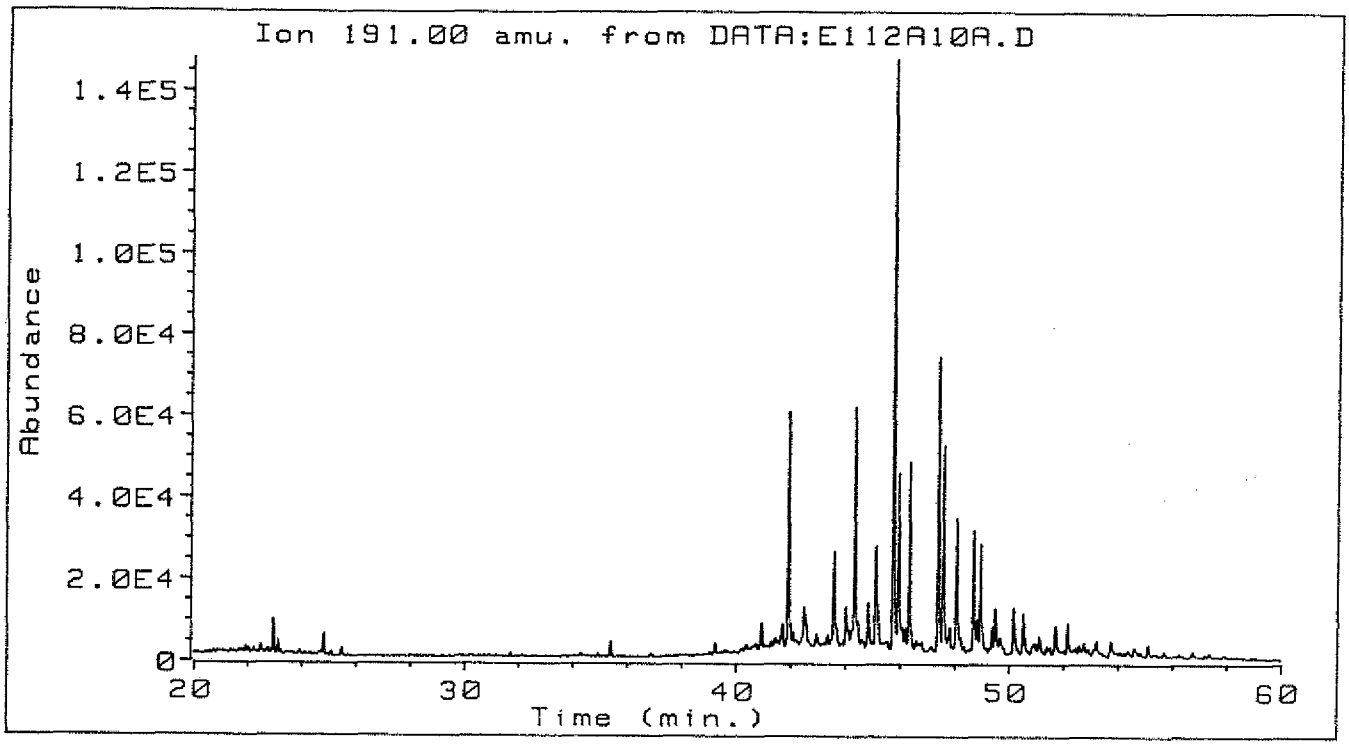
30/9-11

2365.5 M



30/9-11

2365.5 M



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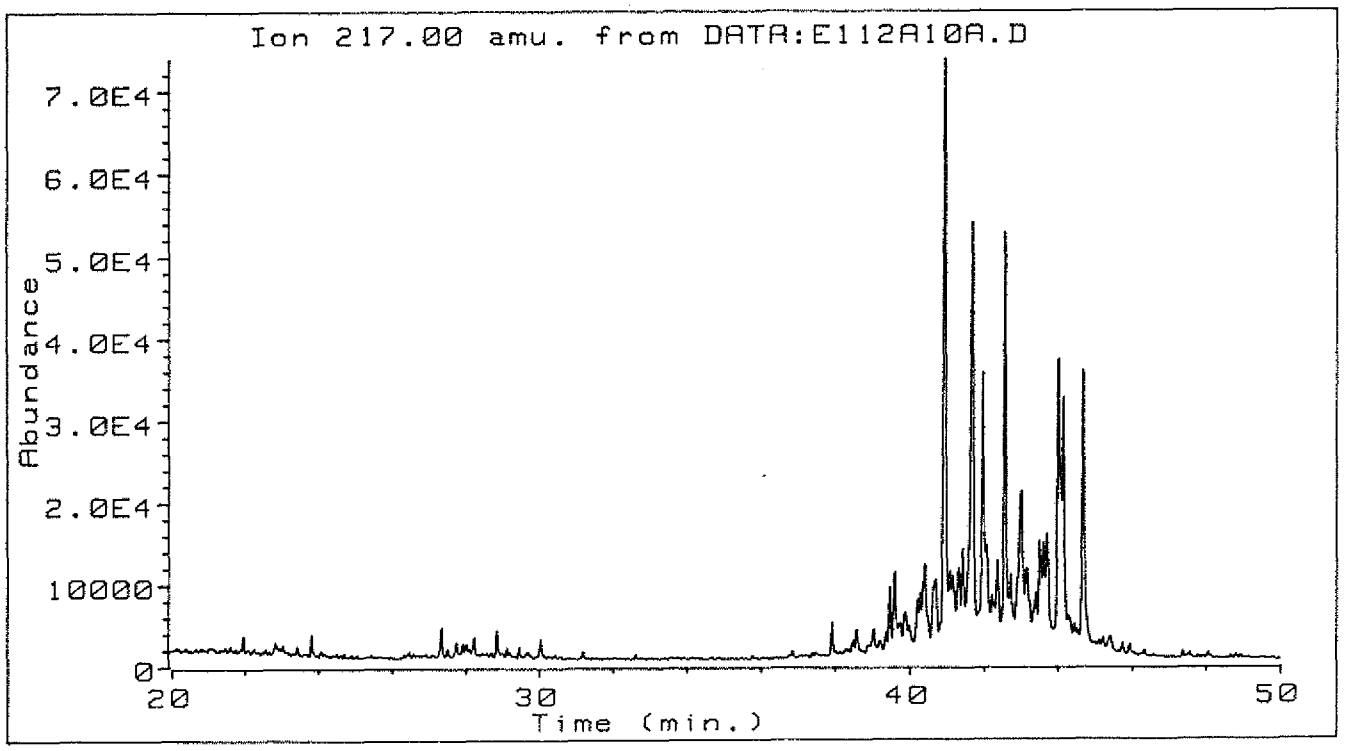
2388.4 M



30/9-11

2388.4 M