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GEOCHEMICAL INVESTIGATION OF EIGHT CORE SAMPLES AT  
3947.0-4149.4 M FROM WELL 15/3-1, NORWAY

by

J.M.A. Buiskool Toxopeus & J. Posthuma

Investigation 9.5.3264

With cooperation from Ms. A. Faber

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GEOCHEMICAL INVESTIGATION OF EIGHT CORE SAMPLES AT  
3947.0-4149.4 M FROM WELL 15/3-1, NORWAY

1. RESULTS AND DISCUSSION

A geochemical investigation has been carried out on eight core samples (3947.0, 3950.5, 4088.0, 4089.0, 4089.5, 4146.0, 4147.3 and 4149.4 m) from the Upper Jurassic Kimmeridge clay Fm. in well 15/3-1, Norway. The results are shown in Tables 1-4 and in Figures 1-14 and indicate the following:

- 1.1. All investigated samples are fairly good to excellent source rocks for oil (and gas) (SRI values between 135 and 725 units; organic carbon contents; extract/carbon ratios; maceral descriptions, Fig. 14; 'kerogenous to mainly kerogenous' type of organic matter).
- 1.2. Samples 3947 and 3950.5 m show a just-mature hydrocarbon distribution (relatively high phytane/n-C<sub>18</sub> ratios; C<sub>30</sub> region of gas chromatograms, Figs. 1-2). All other samples show a mature character (gas chromatograms, Figs. 3-8; lower phytane/n-C<sub>18</sub> ratios).
- 1.3. The source rock extracts were derived from structureless organic matter - SOM - (shape of the gas chromatograms, Figs. 1-8). The sterane/triterpane fragmentograms indicate that the type of SOM is of bacterially reworked phytoplanktonic origin (C<sub>27</sub>-C<sub>29</sub> distribution of the sterane fragmentograms, Figs. 10-13). No significant amount of landplant-derived organic matter could be detected in the extracts.
- 1.4. Although the gas chromatograms and the sterane/triterpane fragmentograms of the core samples are very similar, slight differences between samples 3947, 3950.5 m (interval 3947.0-3950.5 m?) and the other samples (interval 4086.0-4149.4 m?) could be detected. Apart from a difference in maturity between the two intervals, the following differences could be detected:

- carbon isotope values:  $-29.3$  to  $-30.1^{\circ}/\text{oo}$  (3947-3950.5 m) and  $-26.8$  to  $-27.2^{\circ}/\text{oo}$  (4088-4149.4 m);
- percentage saturates per original organic carbon content (= generation potential): 2.27-3.64% (3947-3950.5 m)

The differences in carbon isotope values and percentages saturates per percent original organic carbon between the samples from interval 4088-4149.4 m and the samples 3947-3950.5 m may be indicative for variations in type of organic matter and/or environment of deposition. It appears that the generation potential of the lower interval (4086.0-4149.4 m) is significantly lower compared with the upper part (3947.0-3950.5 m).

## 2. CONCLUSIONS

Eight core samples from the Upper Jurassic Kimmeridge clay Fm. of well 15/3-1, Norway, are just mature (3947.0 and 3950.5 m) and mature (4088.0, 4089.0, 4089.5, 4146.0, 4147.3 and 4149.4 m) fairly good to excellent source rocks for oil (and gas). The extracts of the samples are derived from predominantly structureless organic matter (bacterially reworked phytoplankton). No significant amounts of landplant-derived organic matter could be detected in the samples. Although, apart from differences in maturity, most geochemical parameters of the core samples are very similar, differences in carbon isotope values and in generation capacity could be detected between samples 3947.0 and 3950.5 m (= core 1) and the other samples (cores 2 and 3). The slightly less negative carbon isotope values ( $-26.8$  to  $-27.2^{\circ}/\text{oo}$ ) and the much reduced generation potential of the samples from cores 2 and 3 may be indicative for a somewhat different type of organic matter and/or environment of deposition.

TABLE 1 - GEOCHEMICAL DATA OF EXTRACTS

Sample	Norway 15/3-1 3947 m core-1	Norway 15/3-1 3950.5 m core-1
% ethyl acetate extract	0.90	0.62
% organic carbon after ethyl acetate	8.4	7.1
% sulphur	0.9	1.2
ppm V as metals	39	-
ppm Ni as metals	7	-
pristane/phytane	1.3	1.3
pristane/nC17	0.9	0.7
pristane/nC18	0.7	0.6
C <sub>15</sub> distribution		
1-ring	36	41
2-ring	42	39
3-ring	22	20
C <sub>30</sub> distribution		
3-ring	18	21
4-ring	52	52
5-ring	30	27
C <sub>29</sub> DOM	63	63
% saturates*	34	26
% aromatics	49	48
% heterocompounds	17	26
$\delta^{13}C/_{\text{oo}}$	-29.3	-30.1
extract/carbon	0.11	0.09
% saturates per original organic carbon	3.64	2.27

\* determined by thin-layer chromatography

TABLE 2 - GEOCHEMICAL DATA OF EXTRACTS

Sample	Norway 15/3-1 4088 m core-2	Norway 15/3-1 4089 m core-2
% ethyl acetate extract	0.30	0.32
% organic carbon after ethyl acetate	8.0	4.9
% sulphur	-	-
ppm V as metals	-	-
ppm Ni as metals	-	-
pristane/phytane	1.4	1.8
pristane/nC17	0.4	0.6
pristane/nC18	0.3	0.4
C <sub>15</sub> distribution		
1-ring	51	53
2-ring	30	33
3-ring	20	14
C <sub>30</sub> distribution		
3-ring	21	24
4-ring	49	48
5-ring	29	28
C <sub>29</sub> DOM	67	67
% saturates*	19	23
% aromatics	66	55
% heterocompounds	15	22
$\delta^{13}\text{C}/\text{oo}$	-27.0	-27.2
extract/carbon	0.04	0.07
% saturates per original organic carbon	0.71	1.50

\* determined by thin-layer chromatography

TABLE 3 - GEOCHEMICAL DATA OF EXTRACTS

Sample	Norway 15/3-1 4089.5 m core-2	Norway 15/3-1 4146 m core-3
% ethyl acetate extract	0.34	0.31
% organic carbon after ethyl acetate	8.1	9.2
% sulphur	-	1.34
ppm V as metals	-	-
ppm Ni as metals	-	-
pristane/phytane	1.4	1.3
pristane/nC17	0.4	0.4
pristane/nC18	0.3	0.3
C <sub>15</sub> distribution		
1-ring	55	<i>nd</i>
2-ring	37	<i>nd</i>
3-ring	11	<i>nd</i>
C <sub>30</sub> distribution		
3-ring	19	23
4-ring	48	47
5-ring	33	29
C <sub>29</sub> DOM	67	65
% saturates*	21	18
% aromatics	63	64
% heterocompounds	16	18
$\delta^{13}C^o/oo$	-27.1	-27.0
extract/carbon	0.04	0.03
% saturates per original organic carbon	0.88	0.61

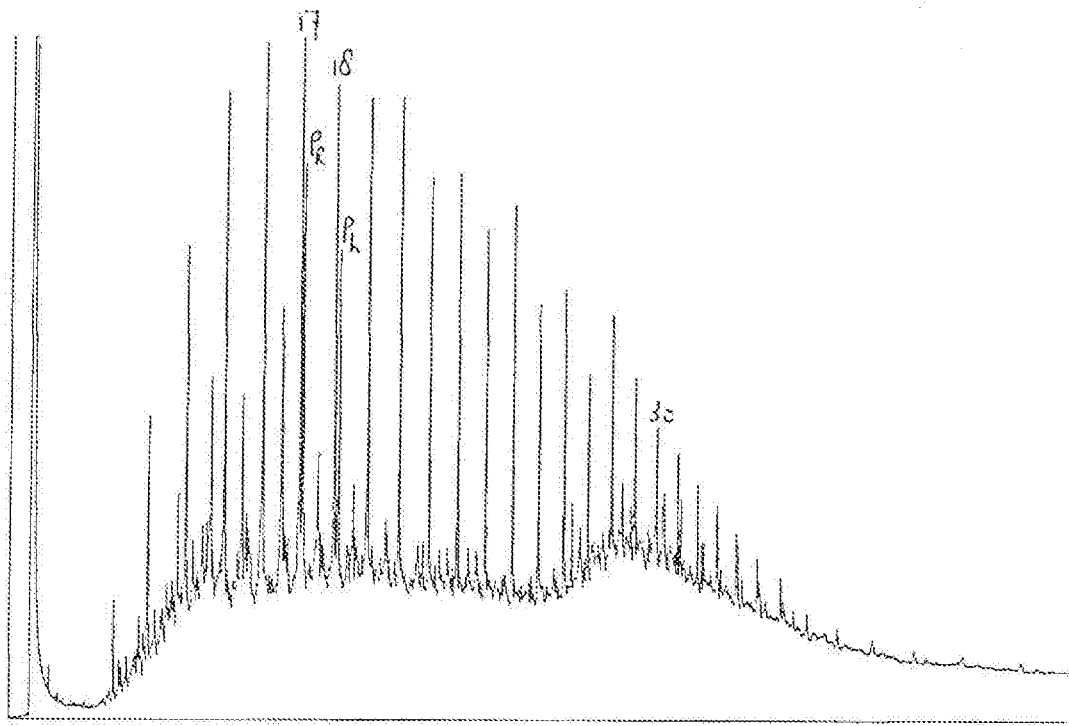
\* determined by thin-layer chromatography

TABLE 4 - GEOCHEMICAL DATA OF EXTRACTS

Sample	Norway 15/3-1 4147.3 m core-3	Norway 15/3-1 4149.4 m core-3
% ethyl acetate extract	0.32	0.34
% organic carbon after ethyl acetate	8.3	10.4
% sulphur	-	-
ppm V as metals	-	-
ppm Ni as metals	-	-
pristane/phytane	1.4	1.3
pristane/nC17	0.4	0.4
pristane/nC18	0.3	0.3
C <sub>15</sub> distribution		
1-ring	44	58
2-ring	31	28
3-ring	24	14
C <sub>30</sub> distribution		
3-ring	22	22
4-ring	44	49
5-ring	34	29
C <sub>29</sub> DOM	67	66
% saturates*	17	17
% aromatics	65	64
% heterocompounds	18	19
$\delta^{13}\text{C}/\text{‰}$	-26.8	-26.8
extract/carbon	0.04	0.03
% saturates per original organic carbon	0.66	0.56

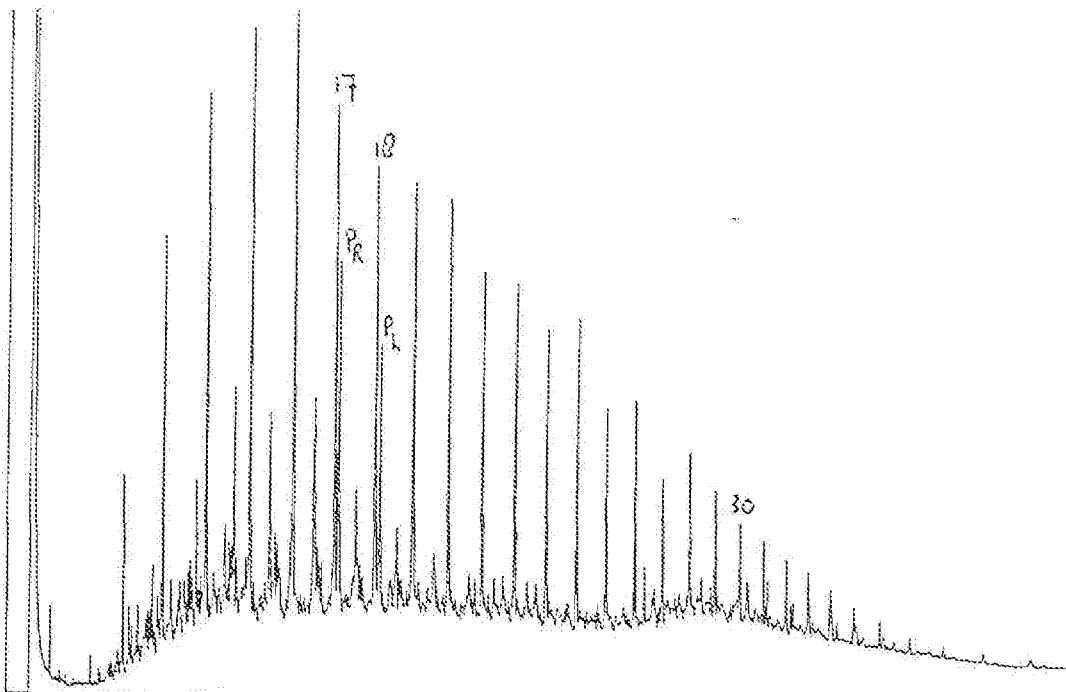
\* determined by thin-layer chromatography





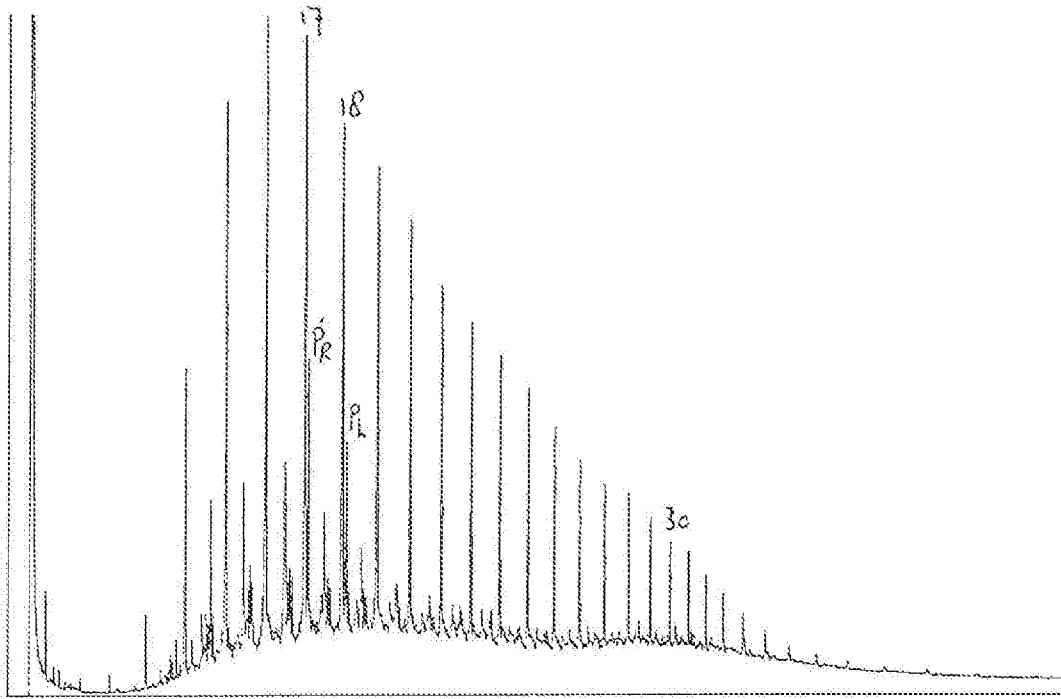
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 1. NORWAY: 15/3-1 3947M CORE-1



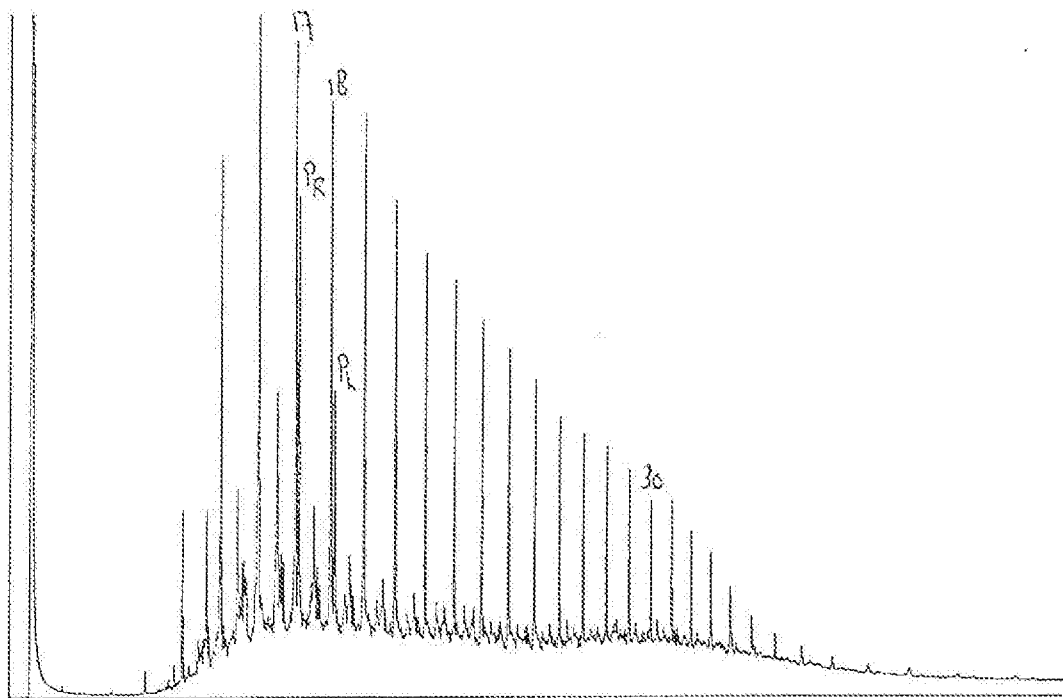
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 2. NORWAY: 15/3-1 3950.5M CORE-1



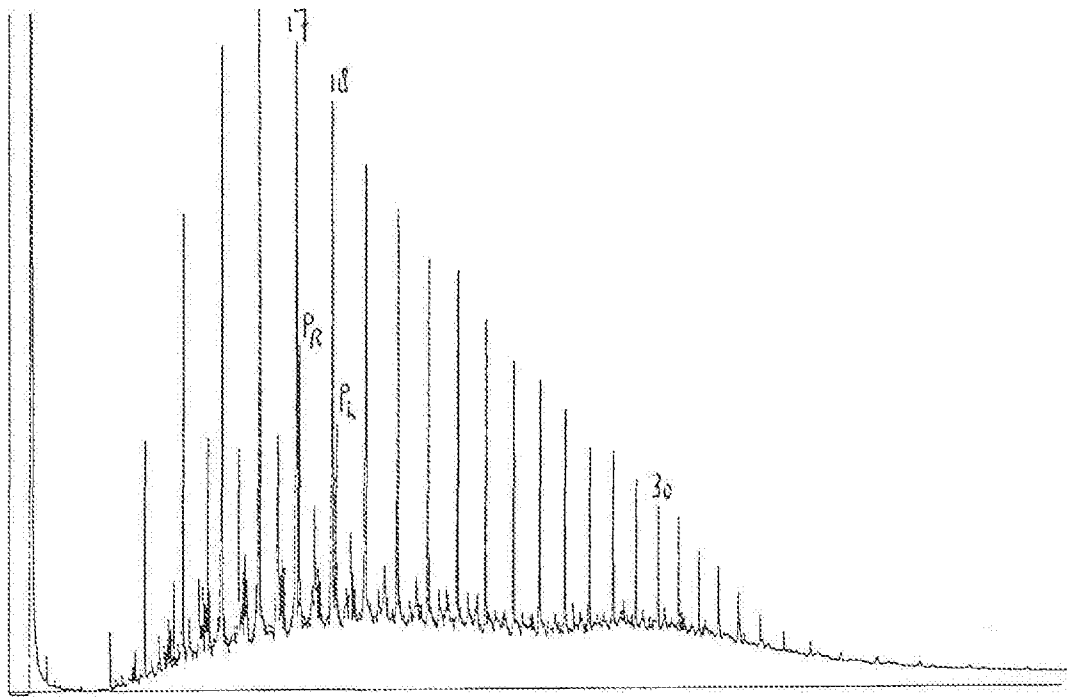
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 3, NORWAY, 15/3-1 4088M CORE-2



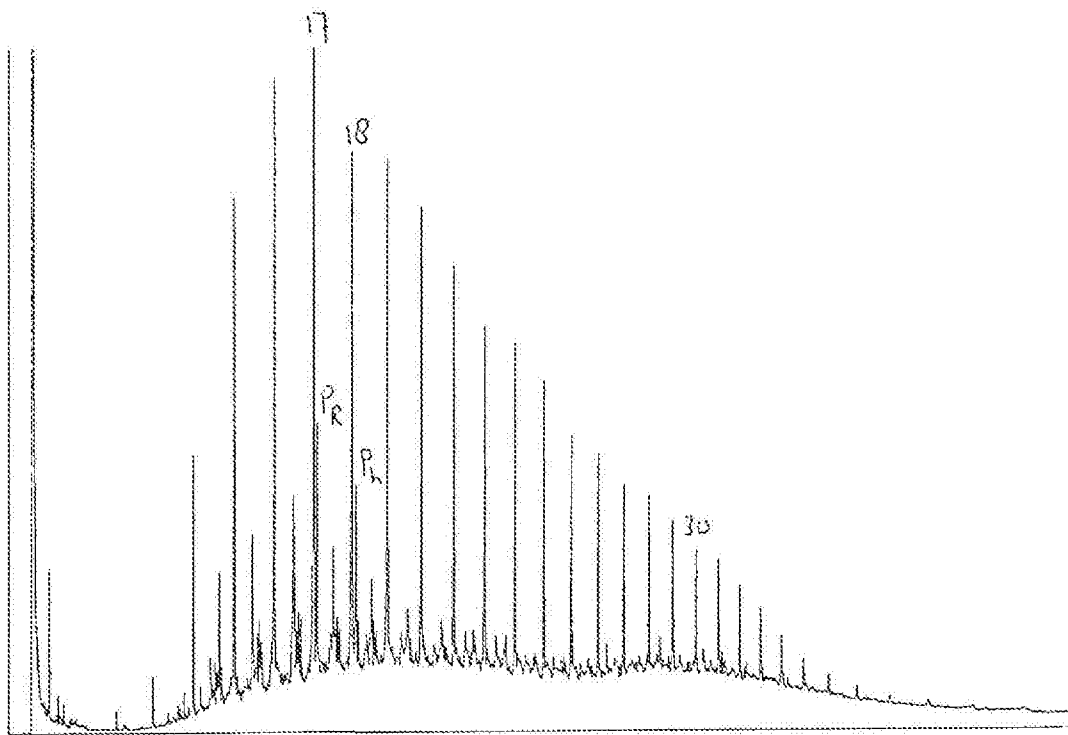
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 4, NORWAY, 15/3-1 4089M CORE-2



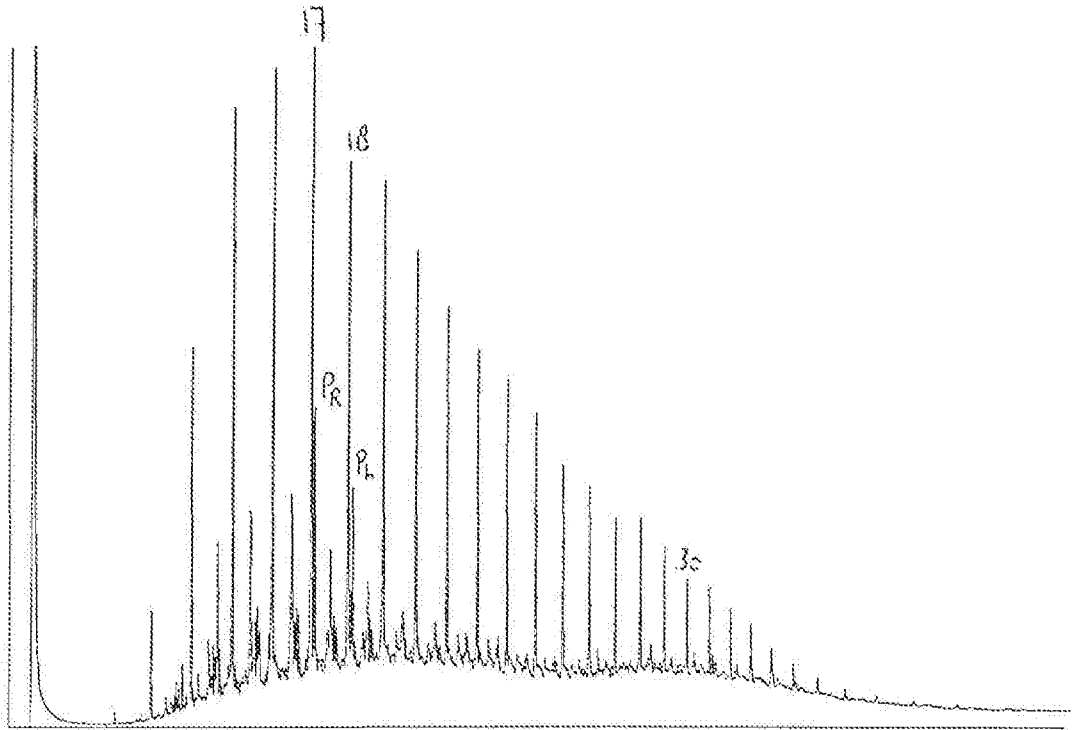
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 5. NORWAY: 15/3-1 4089.5M CORE-2



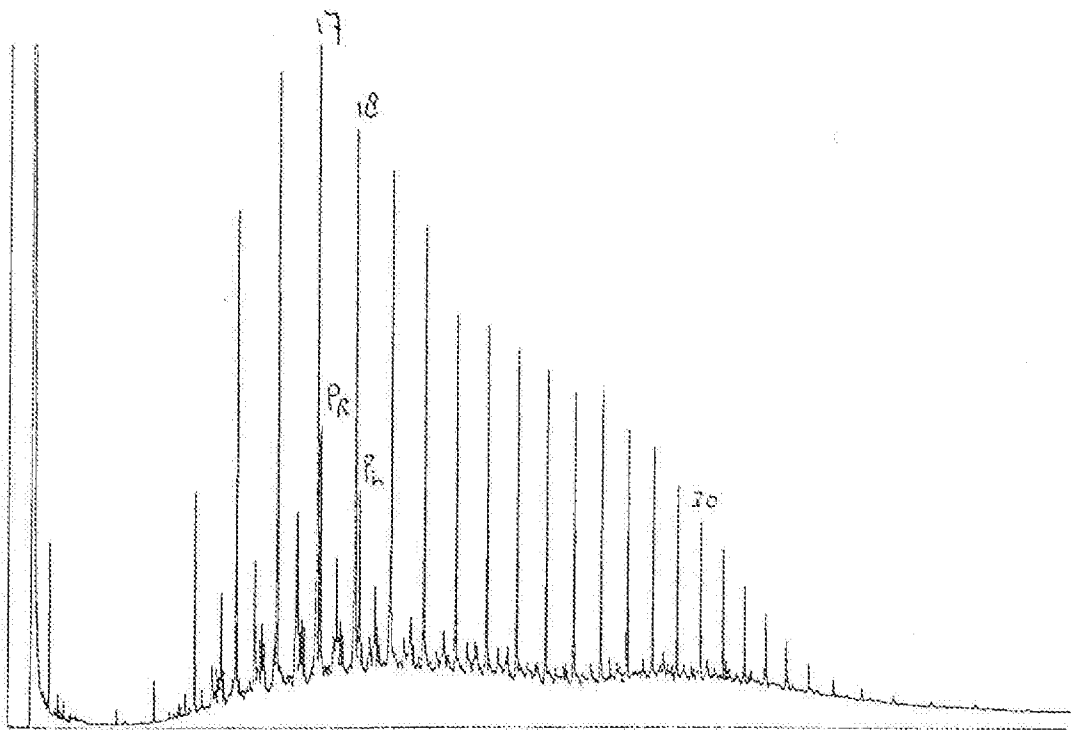
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 6. NORWAY: 15/3-1 4146M CORE-3



GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

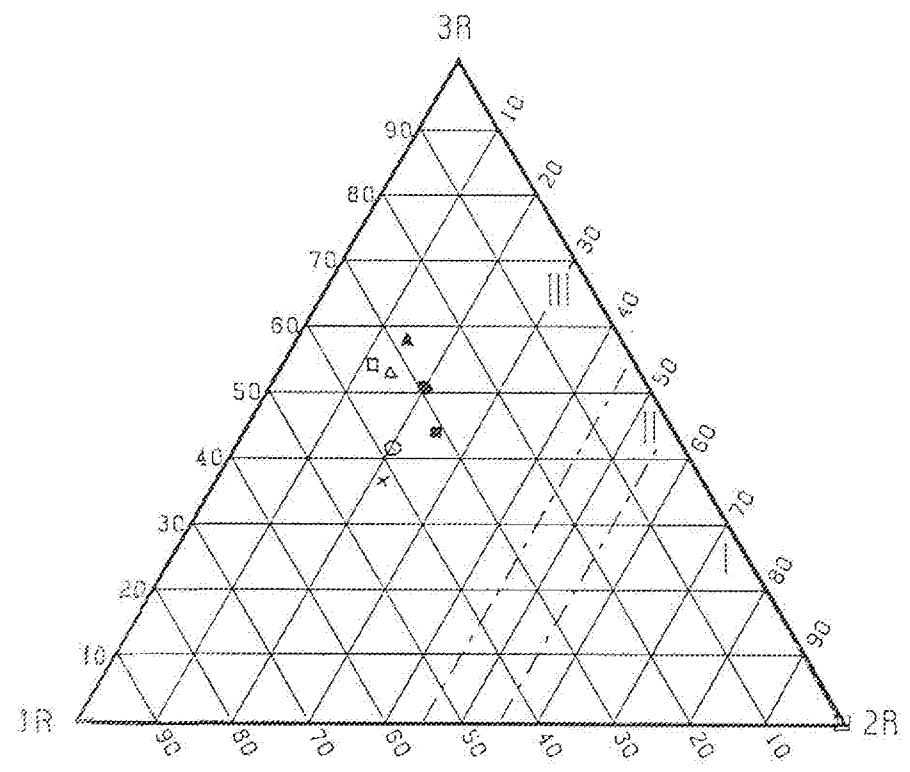
FIG. 7. NORWAY: 15/3-1 4147.3M CORE-3



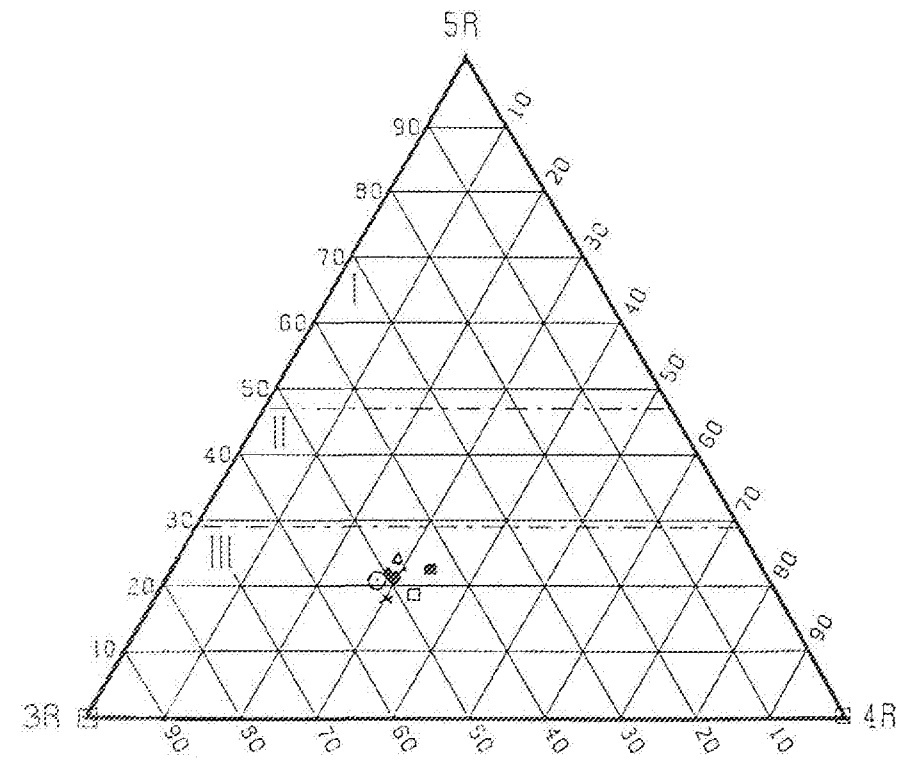
GAS CHROMATOGRAM OF SATURATED HYDROCARBONS

FIG. 8. NORWAY: 15/3-1 4149.4M CORE-3

# C<sub>15</sub>-RING DISTRIBUTION



# C<sub>30</sub>-RING DISTRIBUTION



- I LANDPLANT-DERIVED CRUDES WITH SUBSTANTIAL RESIN CONTRIBUTION TO SOURCE MATTER
- II CRUDES OF MIXED ORIGIN
- III CRUDES DERIVED FROM SOM AND/OR ALGAL MATTER

LEGEND	
□	

- x 3947 m
- 3950.5 m
- 4088 m
- △ 4089 m
- ◻ 4089.5 m
- 4146 m
- ◻ 4147.3 m
- ▲ 4149.4 m

FIG. 9

FIG. 10. GC-MS analysis 15/3-1, 3947 m.

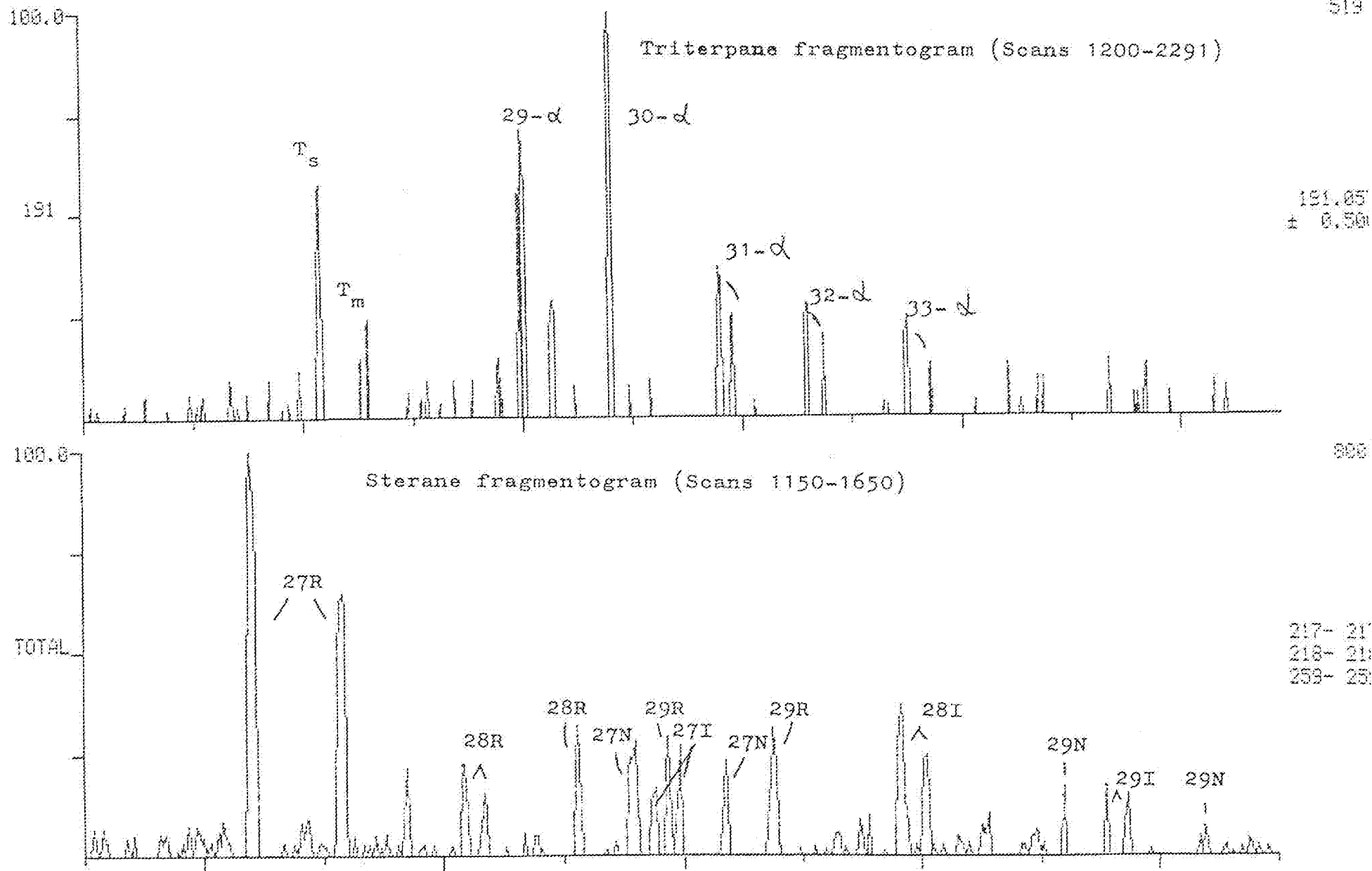


FIG. 11. GC-MS analysis 15/3-1, 4088 m.

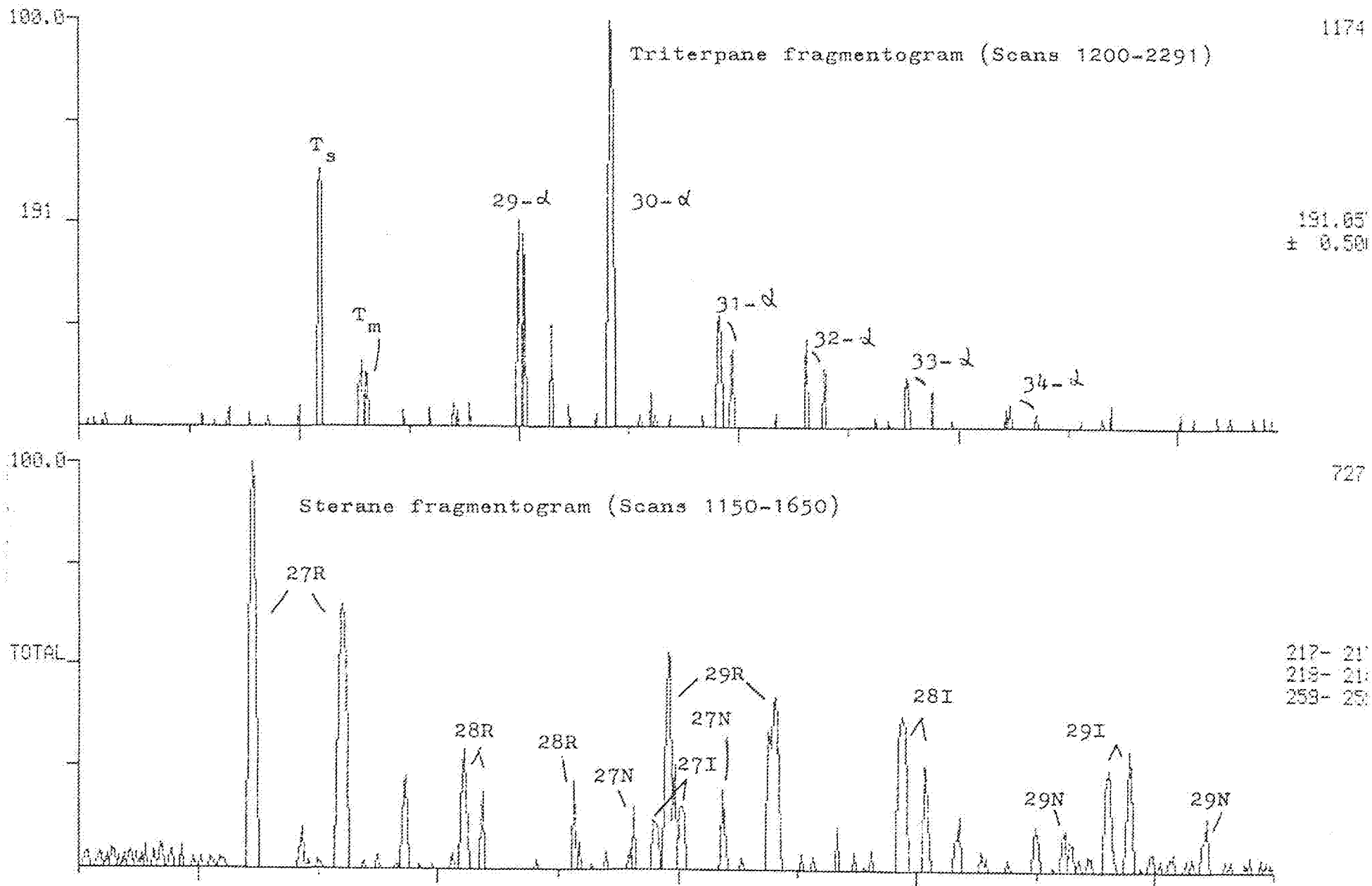


FIG. 12. GC-MS analysis 15/3-1, 4146 m.

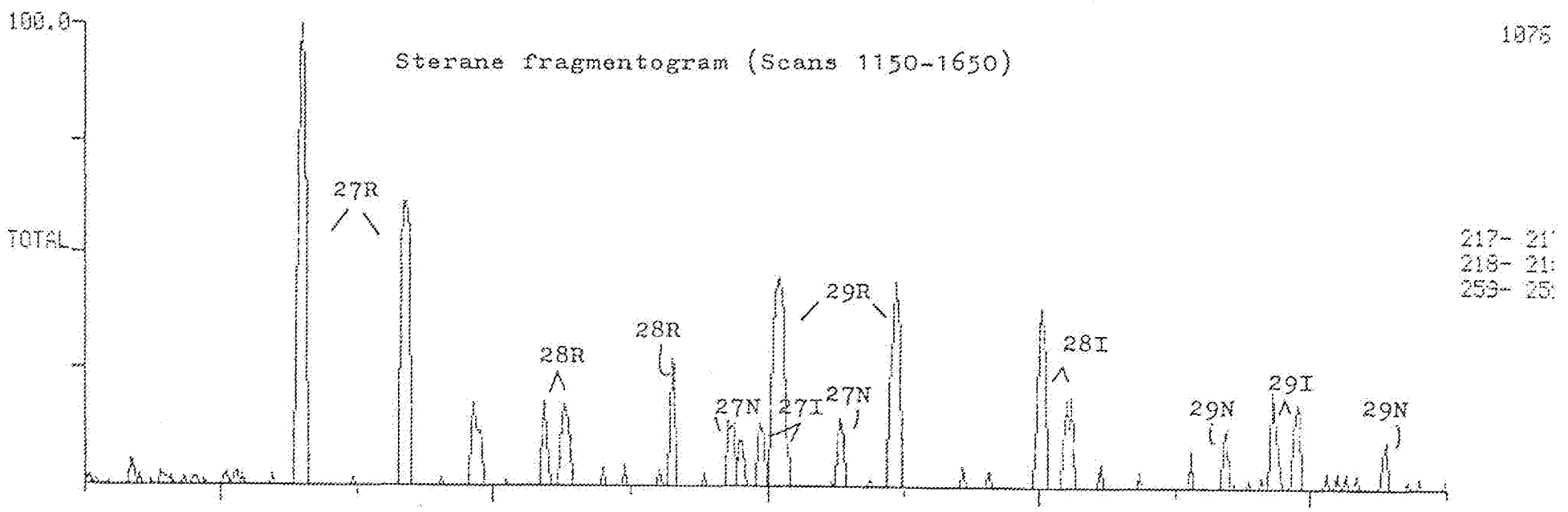
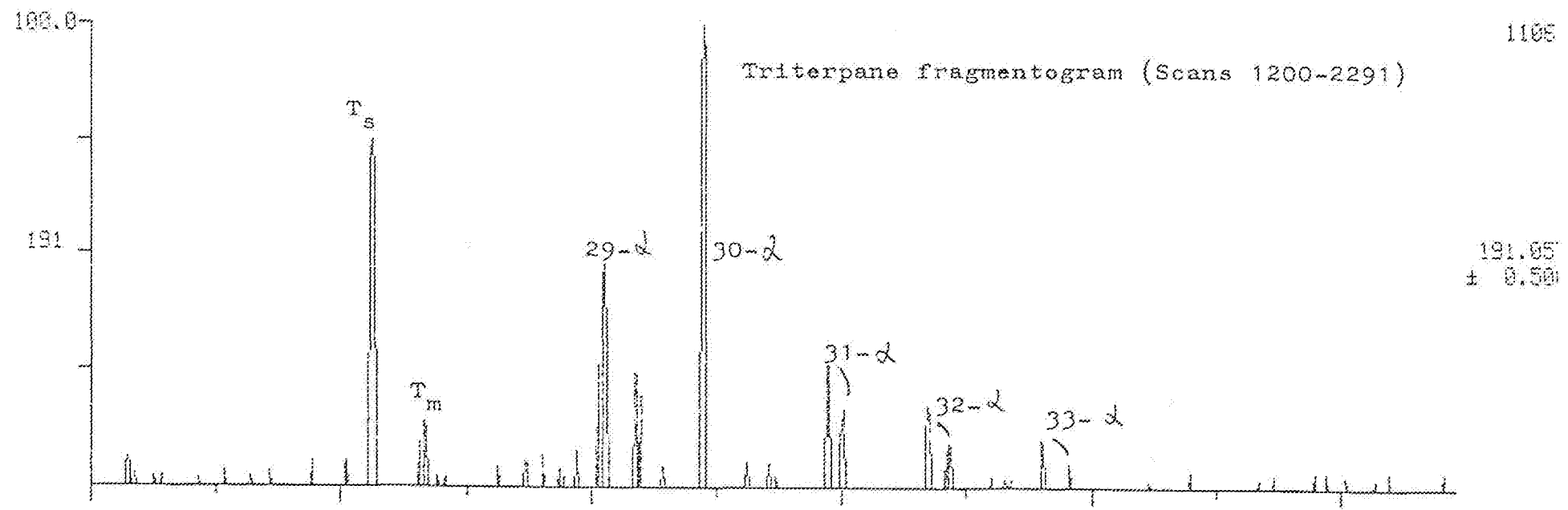
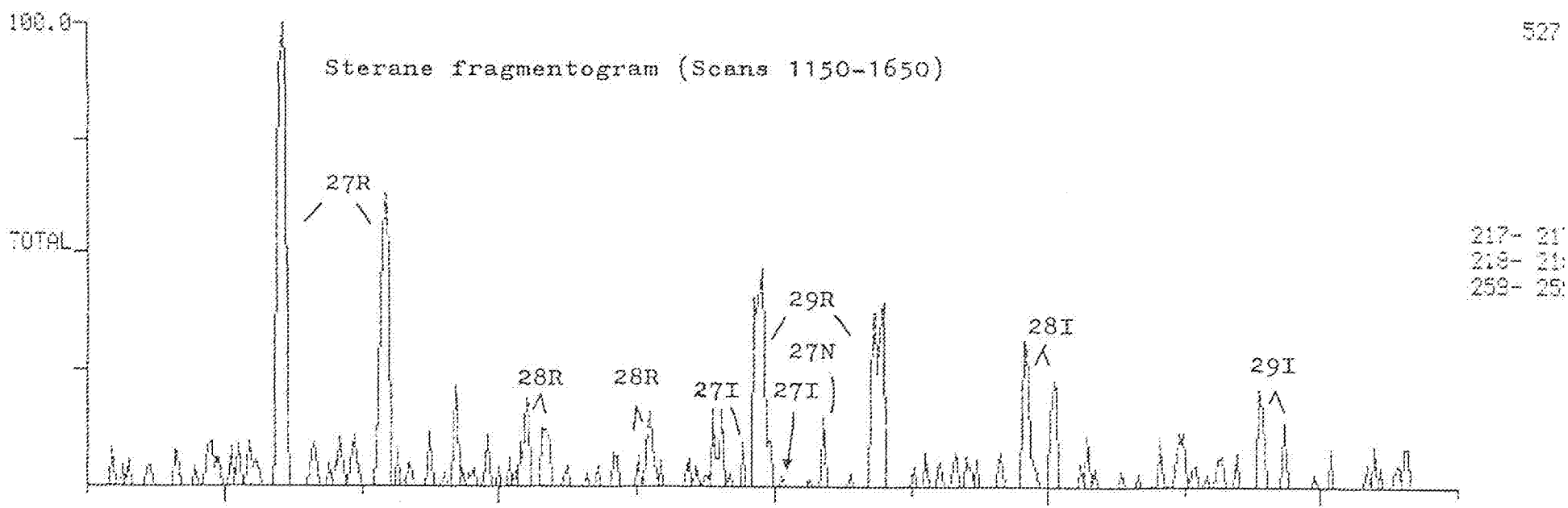
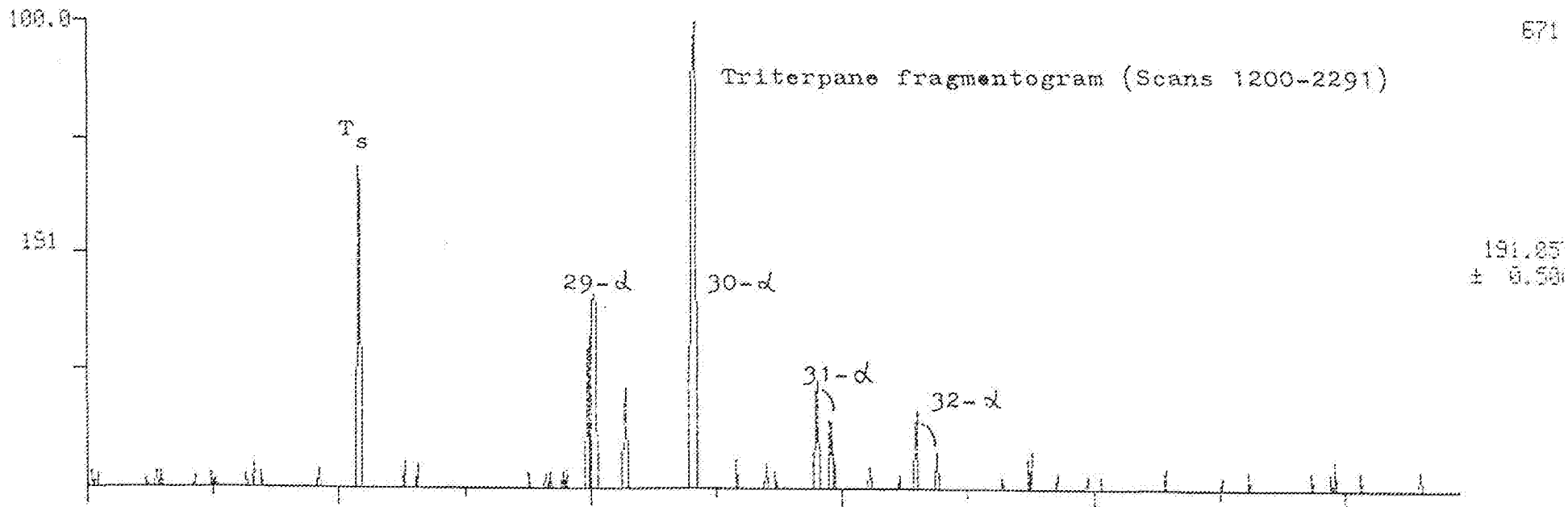




FIG. 13. GC-MS analysis 15/3-1, 4149.4 m.



# MACERAL DESCRIPTION OF 20 SAMPLES FROM WELL 15/3-1, NORWAY

DEPTH IN M	SAMPLE TYPE
---------------	----------------

	ORGANIC											INORG.								
	VITR.	LIPIDINITE						INERT.												
				ALGAE																
SAPROPELIC ORG. MATTER	TELOCOLLINITE	TELINITE	DESMOCOLLINITE	SPORINITE	CUTINITE	RESINITE	LIPTODETRINITE	BOTRYOCOCCUS	TASMANITES	OTHER ALGAE	MICROPLANKTON	EXUDATINITE	SCLEROTINITE	FUSINITE	MACRINITE	MICRINITE	UNDEFINED MINERALS	FRAGMENTAL PYRITE	AGGREGATES OF PYRITE	CRYSTALS OF PYRITE

3947.0	CORE	+		-	-		+	+	/	/	/	/	-		+	*	+	/	-
3948.0	CORE	+		-	-		+	/	/	/	/	/	/		+	*	+	/	/
3949.0	CORE	+		-	-		+	/	/	/	/	/	-		+	*	+	/	-
3950.0	CORE	/		-	-		+	/	/	/	/	/	/		+	*	+	/	-
3950.5	CORE	+		-	-		+	/	/	/	/	/	/		+	*	+	+	/
4086.0	CORE	+		-	-		-	-	-	+	/	/	/		+	*	+	-	/
4087.2	CORE	+		-	-		-	-	-	/	/	/	/		+	*	+	/	-
4088.0	CORE	+		-	-		/	/	/	/	/	/	/		+	*	+	/	-
4089.0	CORE	+		-	-		-	-	-	/	/	/	/		+	*	+	/	-
4089.5	CORE	+		-	-		/	/	/	/	/	/	/		+	*	+	+	-
4090.0	CORE	+		-	-		/	/	/	-	/	/	/		+	*	+	/	-
4090.4	CORE	+		-	-		/	/	/	/	/	/	/		+	*	+	/	-
4145.0	CORE	/		-	-		-	-	-	+	/	/	/		+	*	+	/	/
4146.0	CORE	+		-	-		+	/	/	/	/	/	/		+	*	+	+	/
4146.5	CORE	+		-	-		+	/	/	/	/	/	/		+	*	+	/	-
4146.8	CORE	+		-	-		+	/	/	/	/	/	/		+	*	+	+	-
4147.0	CORE	+		-	-		+	/	/	/	/	/	/		+	*	+	/	-

LEGEND	
*	ABUNDANT
+	COMMON
/	FEW
-	RARE

FIG. 14

DEPTH IN M	SAMPLE TYPE
---------------	----------------

4147.3	CORE
4149.2	CORE
4149.4	CORE

	ORGANIC											INORG.		
	VITR.		LIPIDINITE						INERT.					
			ALGAE											
SARCOPELIC ORG. MATTER														
TELOCOLLINITE														
TELINITE														
DESMACOLLINITE														
SERANITE														
CUTINITE														
RESINITE														
LIPIDETRAINITE														
BOTRYOCOCCUS														
TASMANITES														
OTHER ALGAE														
MICROPLANKTON														
EXSUDINITE														
SCLEROTINITE														
FUSINITE														
MAGRINITE														
MICRINITE														
UNDEFINED MINERALS														
FRAGMENTAL PYRITE														
AGGREGATES OF PYRITE														
CRYSTALS OF PYRITE														

+															
+															
+															

L E G E N D	
*	ABUNDANT
+	COMMON
/	FEW
-	RARE

FIG. 14

GENERAL DATA			CHEMICAL ANALYSIS DATA											
SAMPLE DEPTH (METRES)	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	PYROLYSIS					SOLVENT EXTRACTION					
				TEMPERATURE °C	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD (ppm)	TOTAL EXTRACT (ppm)	HYDRO-CARBONS (ppm)	EXTRACT % OF ORGANIC CARBON	HYDROCARBONS		
												mg/g OF ORGANIC CARBON	% OF EXTRACT	ALKANES % OF HYDRO-CARBONS
3947	Core	SH, gy-blk	6.32	439	670	17	.12	42400						
	"	After extraction	5.65	436	591	6	.00	33450						
	"	After decarbonation	6.28	436	535	6	.01	33640						
3948	"	A/a	6.47	436	570	12	.13	36910						
	"	After extraction	5.67	438	523	6	.00	29700						
	"	After decarbonation	6.21	435	570	4	.01	35410						
3949	"	A/a	10.15	438	775	9	.09	78670						
	"	After extraction	9.51	439	729	3	.00	69390						
	"	After decarbonation	10.42	441	772	3	.00	80460						
3950	"	A/a	6.96	438	648	6	.09	45120						
	"	After extraction	5.79	439	646	5	.00	37460						
	"	After decarbonation	7.15	440	584	6	.02	41770						
3950.5	"	A/a	7.73	440	584	4	.10	45160						
	"	After extraction	7.19	437	590	4	.00	42450						
	"	After decarbonation	7.97	438	676	1	.01	53950						
4086	"	SH, gy-blk, micr	4.85	443	88	13	.27	4280						
	"	After extraction	4.34	442	111	9	.02	4850						
	"	After decarbonation	4.30	440	124	10	.05	5370						
4087.2	"	A/a	6.67	437	106	5	.22	7130						
	"	After extraction	6.41	439	89	6	.02	5760						
	"	After decarbonation	6.58	436	153	5	.04	10100						
4088	"	A/a	8.73	437	202	4	.14	17700						
	"	After extraction	8.41	440	160	4	.01	13460						
	"	After decarbonation	8.34	440	224	3	.02	18750						
4089	"	A/a	6.22	435	88	6	.25	5480						
	"	After extraction	6.04	440	79	5	.02	4770						
	"	After decarbonation	5.95	444	134	1	.03	7980						
4089.5	"	A/a	7.75	438	129	4	.19	10020						
	"	After extraction	7.45	437	95	5	.02	7080						
	"	After decarbonation	7.13	446	160	3	.03	11470						
4090	"	A/a	7.59	440	107	4	.22	8120						
	"	After extraction	7.57	437	98	5	.01	7490						
	"	After decarbonation	7.27	445	160	3	.03	11680						
4090.4	"	A/a	8.58	436	198	6	.12	17010						
	"	After extraction	8.75	440	172	5	.01	15130						
	"	After decarbonation	8.91	440	204	4	.01	18260						
4145	"	A/a	5.98	440	101	4	.17	6100						

TABLE 1A Chemical Analysis Data

GENERAL DATA			CHEMICAL ANALYSIS DATA												
SAMPLE DEPTH (METRES)	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	PYROLYSIS					SOLVENT EXTRACTION						
				TEMPERATURE °C	HYDROGEN INDEX	OXYGEN INDEX	PREHECTION INDEX	POTENTIAL YIELD (ppm)	TOTAL EXTRACT (ppm)	HYDRO-CARBONS (ppm)	EXTRACT % OF ORGANIC CARBON	HYDROCARBONS			
												% OF ORGANIC CARBON	% OF EXTRACT	ALKANES % OF HYDRO-CARBONS	
4145	Core	After extraction	5.67	442	64	5	.02	3630							
	"	After decarbonation	4.35	443	140	5	.03	6110							
4146	"	SH, gy-blk, mic +tr SST, yel-gy, lam	9.76	440	264	5	.10	25860							
	"	After extraction	9.51	440	236	3	.01	22480							
	"	After decarbonation	9.39	441	353	3	.01	33200							
4146.5	"	A/a	8.75	439	182	4	.11	15980							
	"	After extraction	8.94	439	160	4	.01	14360							
	"	After decarbonation	7.77	440	226	5	.02	17630							
4146.8	"	A/a	8.56	440	259	4	.09	22190							
	"	After extraction	8.66	438	259	5	.01	22480							
	"	After decarbonation	9.80	438	144	11	.02	14110							
4147	"	A/a	11.81	438	309	4	.08	36510							
	"	After extraction	10.63	439	296	6	.01	31510							
	"	After decarbonation	12.41	438	189	13	.03	23540							
4147.3	"	A/a	11.97	438	222	4	.10	26620							
	"	After extraction	10.48	436	264	5	.01	27700							
	"	After decarbonation	11.91	438	205	12	.02	24530							
4149.2	"	A/a	7.90	438	133	5	.17	10530							
	"	After extraction	6.68	439	150	7	.01	10030							
	"	After decarbonation	7.92	442	100	12	.05	7970							
4149.4	"	A/a	12.49	437	299	4	.08	37350							
	"	After extraction	10.32	441	316	4	.00	22640							
	"	After decarbonation	12.18	437	279	10	.03	34070							

TABLE 18 Chemical Analysis Data