

Petroleum Geochemistry: Cenomanian - Turonian succession of three core wells from the Cretaceous Western Interior Seaway, USA

Data report: USGS Escalante 1,
USGS Portland 1 and AMOCO
Rebecka C. Bounds 1 wells

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CENTUR - project data report

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Introduction

This report presents organic geochemical data on part of the Cretaceous age section in three fully cored wells that together represent a transect of the Cretaceous Western Interior Seaway (CWIS) of the USA. The wells are:

- USGS Escalante 1 well (Utah)
- USGS Portland 1 well (Colorado)
- AMOCO Rebecka C. Bounds 1 well (Kansas)

Location map is shown in fig. 1, for details of the well stratigraphy etc., the reader should consult Dean & Arthur (eds.) (1998).

The data comprise Rock-Eval/TOC screening data on all samples plus standard biological marker data on selected samples.

The data were produced by the Geological Survey of Denmark and Greenland (GEUS) as part of a research project on the distribution of petroleum source rocks in the Davis Strait region and in the Arctic in general. The WIS-wells are included in the study to serve as a basis for comparison with deposits of similar age in the Arctic, in order to allow assessment of the influence of paleolatitude on the organic geochemical characteristics and petroleum source rock potential of the deposits. A short commentary text is included for each well, but no detailed discussion has been attempted.

A CD-ROM containing data tables (MS Excel spreadsheets) and figures (MS Windows *.emf format) is enclosed.

Samples were kindly provided by United States Geological Survey (USGS), Federal Center, Denver, Colorado. The assistance of Drs. W. E. Dean, M. D. Lewan, and C. Barker, and Mr. B. Whitus is gratefully acknowledged.

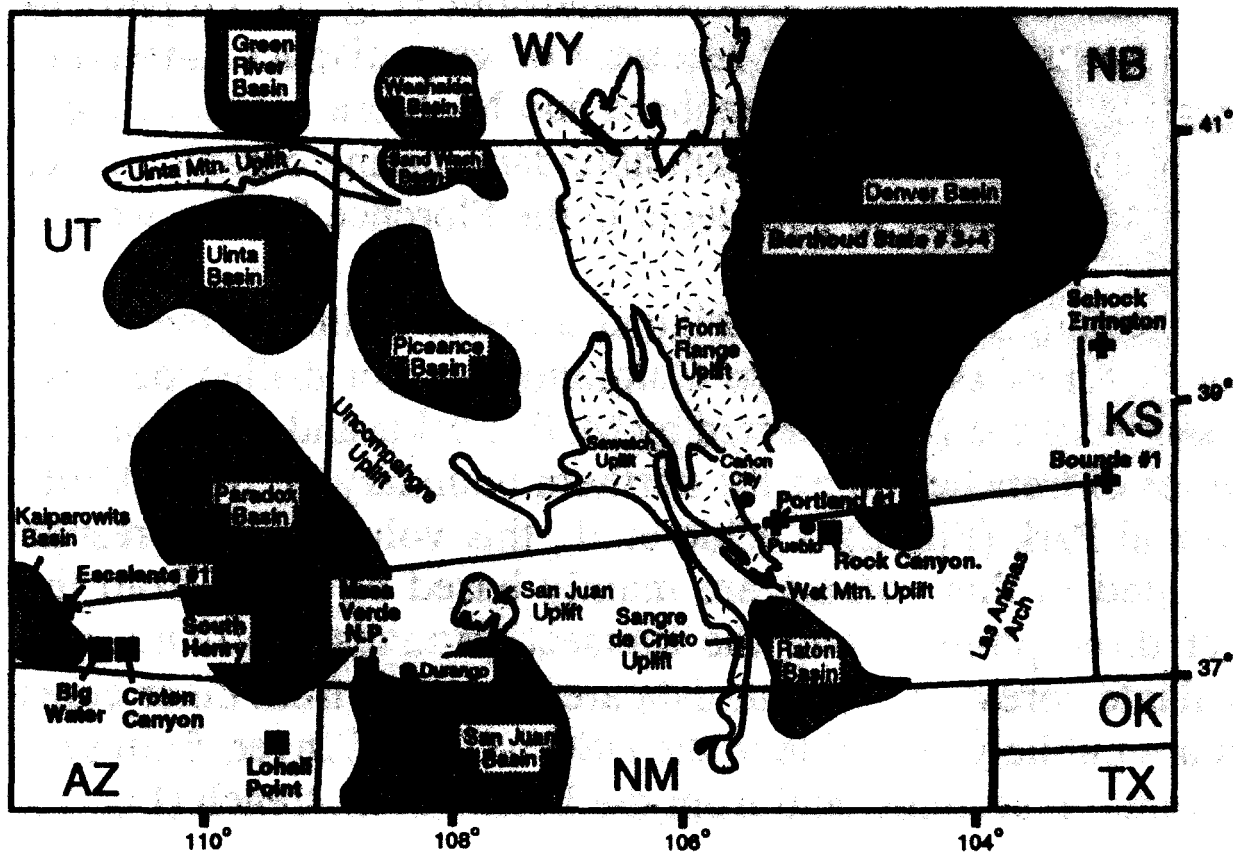


Fig. 1 Location map (from Dean & Arthur, 1988)

Methods

All samples are core chips that have been powdered in an agate mortar to attain a grainsize <250 μm prior to analysis.

Rock-Eval/TOC screening pyrolysis was carried out by means of a Rock-Eval 6 Turbo instrument using standard procedures. The instrument was calibrated using the GEUS inhouse Rock-Eval standard MS.15.05.1999, which in turn was calibrated against the commercially available IFP 55000 standard. The MS.15.05.1999 standard shows the following average parameter-values and acceptance limits:

TOC (%):	3.23 ± 0.55
Tmax ($^{\circ}\text{C}$):	417 ± 5
S2 (mg/g):	13.74 ± 0.92
S3 (mg/g):	0.94 ± 0.13

Sets of standard+blank were run for every 10 samples. In case such control-standards did not comply with the values and acceptance levels stated, 5 samples on both sides of the spurious standard+blank set were reanalysed.

Solvent extraction was carried out by means of a SoxtecTM instrument, using dichloromethane+methanol (93 + 7 vol. + vol.) as solvent. Asphaltenes were precipitated by addition of 40-fold excess of *n*-pentane. Maltenes were separated into saturated, aromatic and heteroatomic (NSO) fractions using MPLC, following procedures adapted from Radke et al. (1980).

Gas chromatographic analysis of saturated extract fractions was carried out by means of a Hewlett-Packard 5890 gas chromatograph, using splitless injection, a 25m HP-1 WCOT column and FID

Coupled gas chromatography – mass spectrometry of saturated biological markers was carried out by means of a Hewlett-Packard 5890 gas chromatograph, using splitless injection and a 30m ZB-5 WCOT column, connected to a Hewlett-Packard 5971 MSD. Analysis was carried out using selected ion monitoring (SIM).

USGS Escalante 1 well

Rock-Eval/TOC screening

The Escalante-1 well represents the westernmost part of the transect of the Cretaceous Western Interior Seaway defined by the three wells discussed herein. A total of 58 samples were analysed, covering the interval 79.90 m to 189.74 m (Table 1, Figure 2).

TOC contents are variable, 0.89% – 2.64%, averaging 1.56%, but showing an overall decreasing trend downwards through the succession. S2 pyrolysis yields are moderate, 1.08 – 10.54 mg/g, averaging 4.02 mg/g. Hydrogen Indices (HI) are variable 115 – 399 with an average of 240, showing a trend very similar to that of the TOC (Figs. 3 and 4). On average, the deposits show fair petroleum source potential.

The Production Index (PI) is low, invariably <0.1, and no signs of staining or contamination are observed.

Tmax shows a gradual increase from approximately 420 °C at the top of the studied succession, to approximately 428 °C at its base (Fig. 2). Hence, the succession is immature with respect to petroleum generation.

Solvent extract analysis

A total of six samples were analysed:

Lab. #	2001064-7257	D = 86.56 m	(Fig. 5)
Lab. #	2001064-7267	D = 103.63 m	(Fig. 6)
Lab. #	2001064-7275	D = 118.87 m	(Fig. 7)
Lab. #	2001064-7284	D = 139.0 m	(Fig. 8)
Lab. #	2001064-7296	D = 164.59 m	(Fig. 9)
Lab. #	2001064-7305	D = 183.79 m	(Fig. 10)

Compound identification key is shown in Appendix 1, key biomarker ratios are tabulated in Appendix 2.

All samples show very similar characteristics.

Gas chromatography data show strongly light-end skewed n-alkane distributions with poorly developed bi- or trimodality, comprising secondary/ternary maxima centred at approximately nC₂₃ and nC₂₉. The proportions of "Unresolved Complex Mixture" (UCM) are low, and acyclic isoprenoids, except for pristane and phytane, are not abundant. Pristane/phytane ratios are low, 0.63 – 1.06. Gas chromatographic data indicate kerogen derived predominantly from marine algal organic matter, with very limited terrestrial input, deposited in a oxygen-deficient shale/marl depositional environment. Due to low thermal maturity, biomarker data are not very informative. Triterpanes (m/z 191) are dominated by hopanes of the unstable ββ-configuration, and abundant 13(18)-hopene further testifies to the low maturity. Steranes (m/z 217 and m/z 218) show overwhelming predominance of moieties of the 20R-configuration and a near total absence of diasteranes. C₂₈ steranes are remarkably abundant.

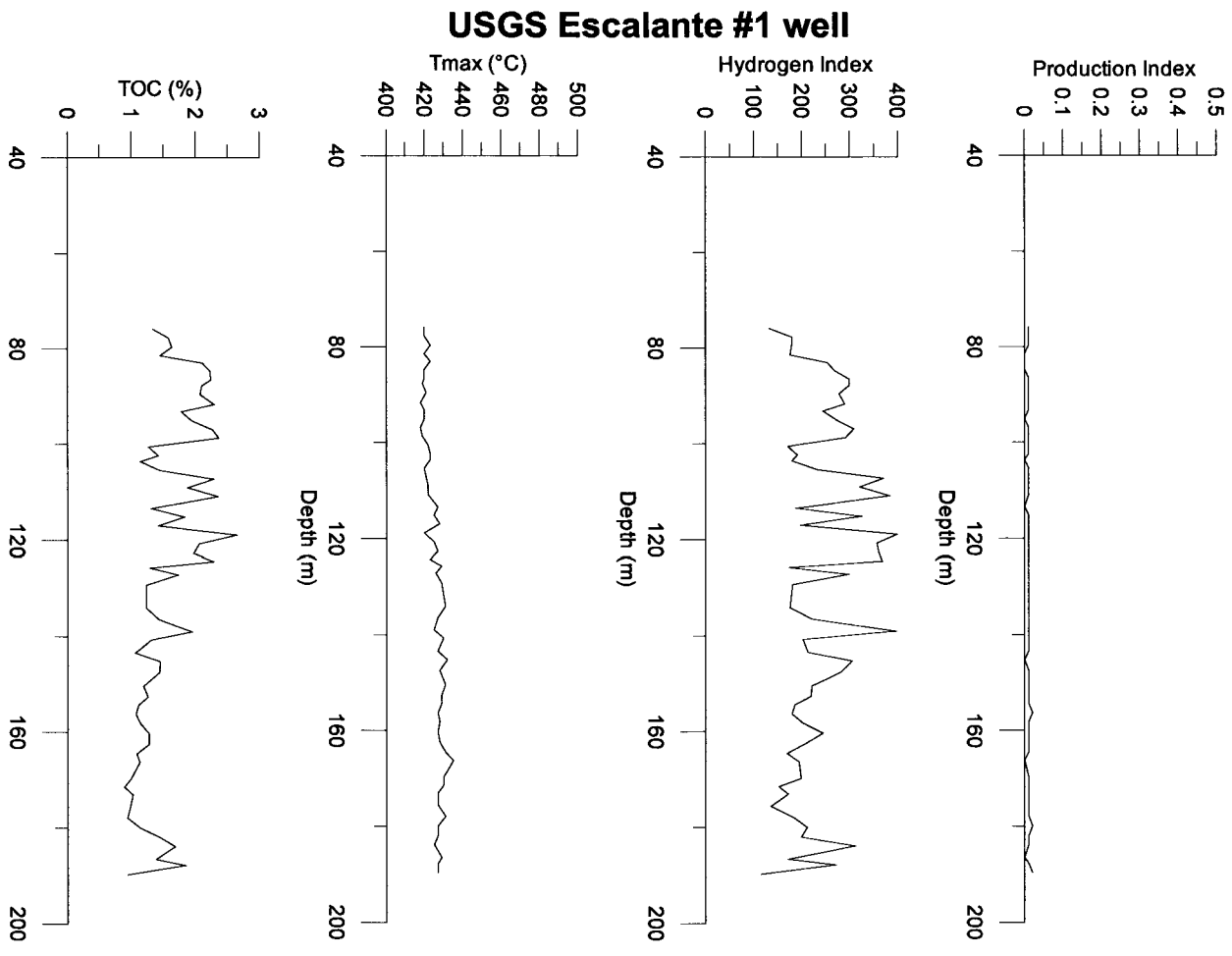


Fig. 2. Simple geochemical log, USGS Escalante-1 well

USGS Escalante #1 well

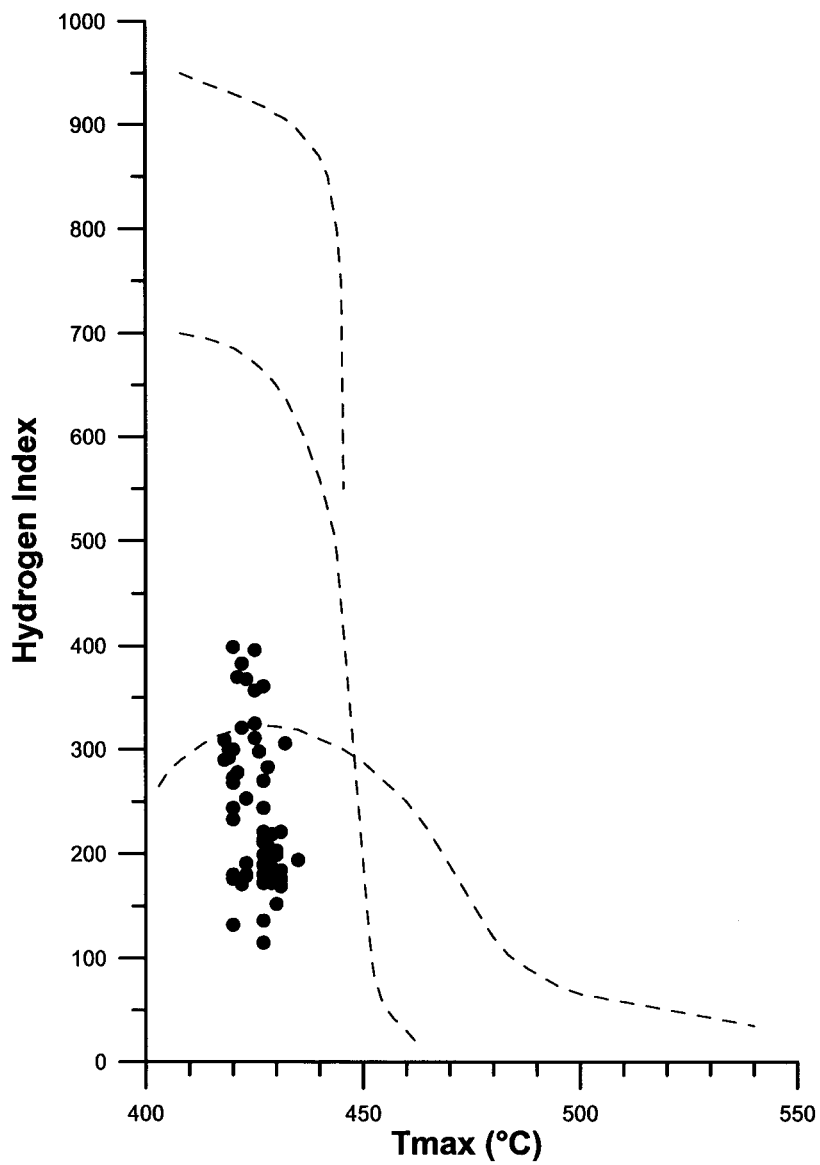


Fig. 3. USGS Escalante 1 well, all data

USGS Escalante #1 well

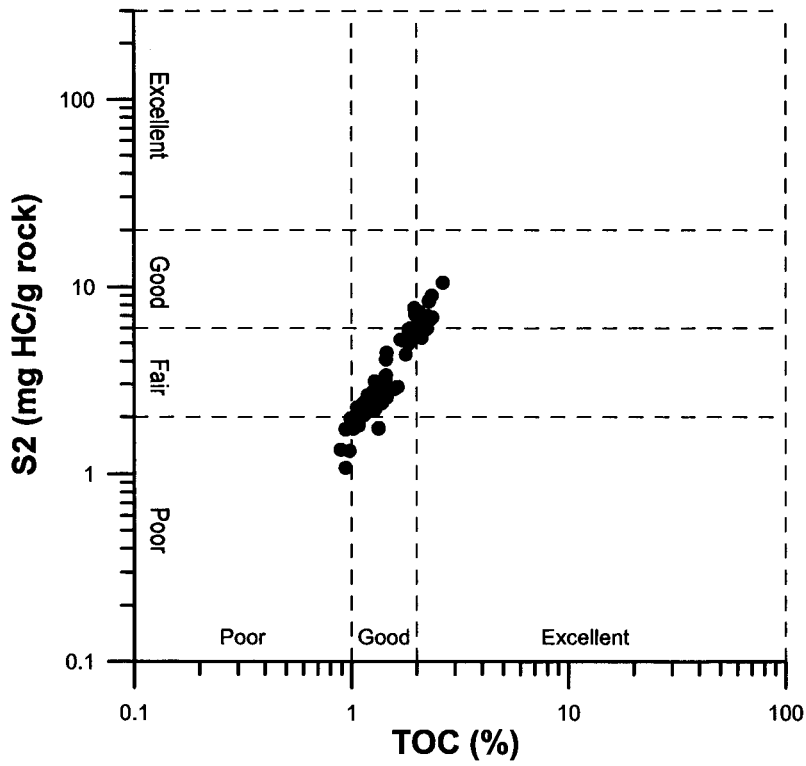
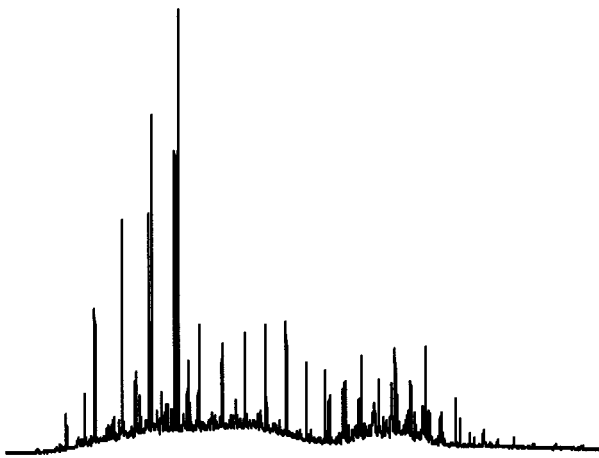


Fig. 4. USGS Escalante 1 well, all data

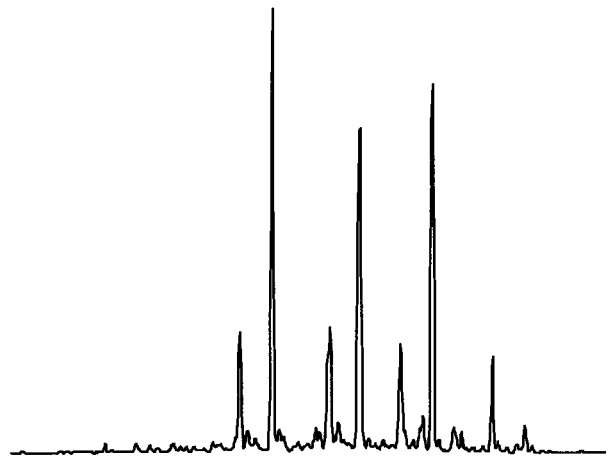
Table 1. USGS Escalante 1 well. Rock-Eval /TOC screening data

Lab (#)	Depth (meter)	TOC (wt-%)	Tmax (°C)	S1 (mg HC / g rock)	S2	S3	HI	OI	PI	PC
7251	75,90	1,33	420	0,01	1,75	0,59	132	44	0,01	0,15
7252	77,72	1,58	420	0,02	2,84	0,60	180	38	0,01	0,24
7253	79,71	1,63	423	0,02	2,91	0,53	179	33	0,01	0,24
7254	81,53	1,45	420	0,01	2,55	0,39	176	27	0,00	0,21
7255	83,06	2,11	423	0,01	5,34	0,60	253	28	0,00	0,44
7256	84,73	2,23	420	0,03	5,97	0,69	268	31	0,00	0,50
7257	86,56	2,24	420	0,04	6,73	0,66	300	29	0,01	0,56
7258	87,78	2,10	419	0,05	6,31	0,65	300	31	0,01	0,53
7259	89,61	2,07	421	0,03	5,75	0,62	278	30	0,01	0,48
7260	91,74	2,29	418	0,04	6,63	0,74	290	32	0,01	0,55
7261	93,27	1,78	420	0,03	4,34	0,62	244	35	0,01	0,36
7262	95,10	1,94	420	0,02	5,30	0,65	273	34	0,00	0,44
7263	96,93	2,26	418	0,04	6,98	0,79	309	35	0,01	0,58
7264	98,76	2,36	419	0,04	6,88	0,80	292	34	0,01	0,57
7265	100,58	1,27	422	0,02	2,17	0,42	171	33	0,01	0,18
7266	102,41	1,42	423	0,02	2,71	0,47	191	33	0,01	0,23
7267	103,63	1,14	423	0,01	2,05	0,32	180	28	0,00	0,17
7268	105,46	1,44	420	0,04	3,36	0,47	233	33	0,01	0,28
7269	107,29	2,28	421	0,05	8,44	0,66	370	29	0,01	0,70
7270	109,12	1,88	422	0,05	6,03	0,67	321	36	0,01	0,50
7271	110,95	2,35	422	0,07	8,99	0,97	383	41	0,01	0,75
7272	113,46	1,31	427	0,01	2,47	0,47	189	36	0,00	0,21
7273	115,21	1,83	425	0,08	5,94	0,68	325	37	0,01	0,50
7274	117,04	1,42	428	0,03	2,83	0,42	199	30	0,01	0,24
7275	118,87	2,64	420	0,11	10,54	1,00	399	38	0,01	0,88
7276	120,70	2,06	425	0,06	7,35	0,79	357	38	0,01	0,62
7277	122,68	1,97	427	0,10	7,12	0,62	361	31	0,01	0,60
7278	124,36	2,28	423	0,08	8,38	0,71	368	31	0,01	0,70
7279	125,65	1,29	429	0,02	2,23	0,36	173	28	0,01	0,19
7280	127,10	1,73	426	0,04	5,15	0,55	298	32	0,01	0,43
7281	129,24	1,24	429	0,02	2,24	0,40	181	32	0,01	0,19
7282	134,04	1,24	431	0,02	2,18	0,36	176	29	0,01	0,18
7283	136,40	1,43	427	0,03	3,16	0,41	221	29	0,01	0,26
7284	138,99	1,95	425	0,08	7,72	0,76	396	39	0,01	0,65
7285	140,74	1,31	430	0,03	2,66	0,49	203	37	0,01	0,22
7286	143,41	1,06	427	0,03	2,26	0,52	213	49	0,01	0,19
7287	145,24	1,45	432	0,02	4,44	0,65	306	45	0,00	0,37
7288	147,52	1,44	428	0,04	4,08	0,71	283	49	0,01	0,34
7289	150,42	1,19	431	0,02	2,63	0,48	221	40	0,01	0,22
7290	152,70	1,26	429	0,03	2,76	0,47	219	37	0,01	0,23
7291	154,38	1,11	429	0,03	2,07	0,43	186	39	0,01	0,17
7292	156,36	1,07	427	0,03	1,93	0,54	180	50	0,02	0,16
7293	158,19	1,14	428	0,03	2,30	0,51	202	45	0,01	0,19
7294	160,32	1,28	427	0,02	3,12	0,60	244	47	0,01	0,26
7295	162,53	1,28	428	0,02	2,65	0,58	207	45	0,01	0,22
7296	164,59	1,08	431	0,02	1,82	0,41	169	38	0,01	0,15
7297	166,27	1,13	435	0,01	2,19	0,49	194	43	0,00	0,18
7298	169,77	0,99	430	0,01	1,97	0,51	199	52	0,01	0,16
7299	171,45	0,89	430	0,01	1,35	0,37	152	42	0,01	0,11
7300	173,05	1,02	427	0,01	1,75	0,44	172	43	0,01	0,15
7301	175,56	0,98	427	0,02	1,33	0,54	136	55	0,01	0,11
7302	178,00	0,94	431	0,02	1,73	0,56	184	60	0,01	0,15
7303	179,98	1,13	427	0,04	2,38	0,72	211	64	0,02	0,20

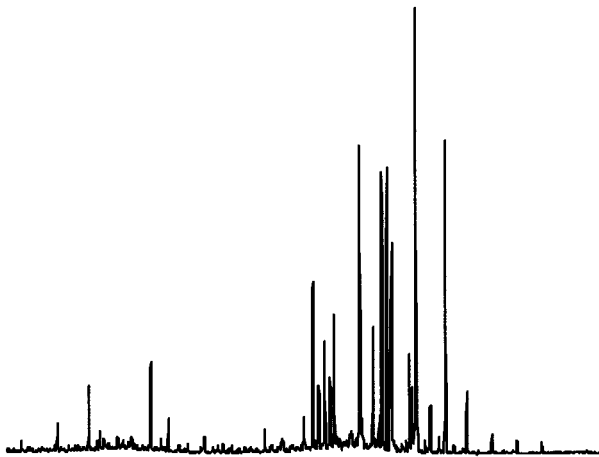
7304	181,97	1,45	427	0,02	2,89	0,63	199	43	0,01	0,24
7305	183,79	1,68	425	0,04	5,23	0,71	311	42	0,01	0,44
7306	186,54	1,38	429	0,01	2,38	0,59	172	43	0,00	0,20
7307	187,76	1,84	427	0,03	4,96	0,77	270	42	0,01	0,41
7308	189,74	0,94	427	0,02	1,08	0,59	115	63	0,02	0,09



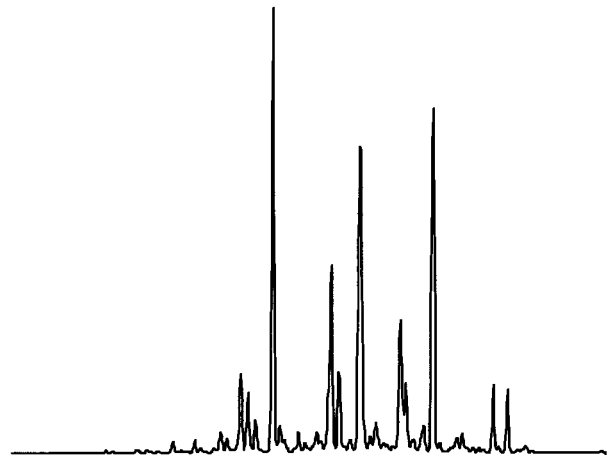
Gas Chromatogram



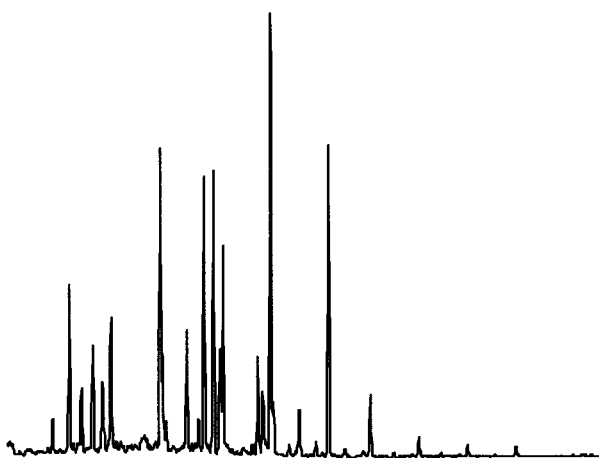
m/z 217



m/z 191 (full)



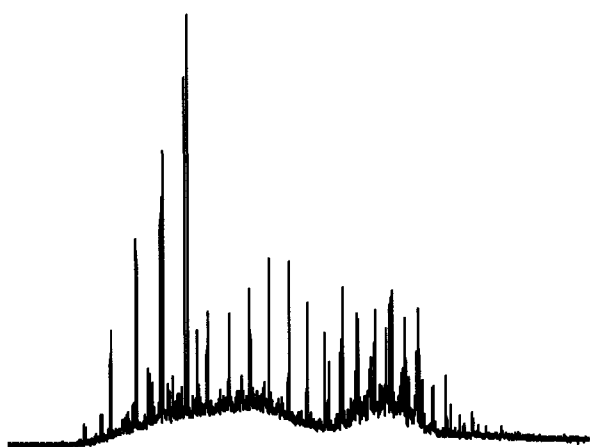
m/z 218



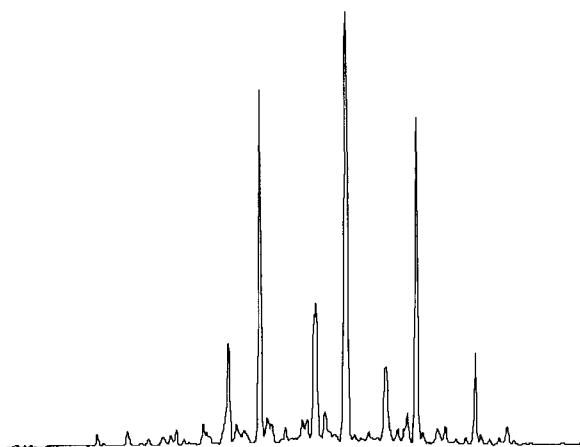
m/z 191 (partial)

USGS
Escalante 1 well
Utah, USA
Lab. # 2001064-7257
Core sample, D = 86.56 m

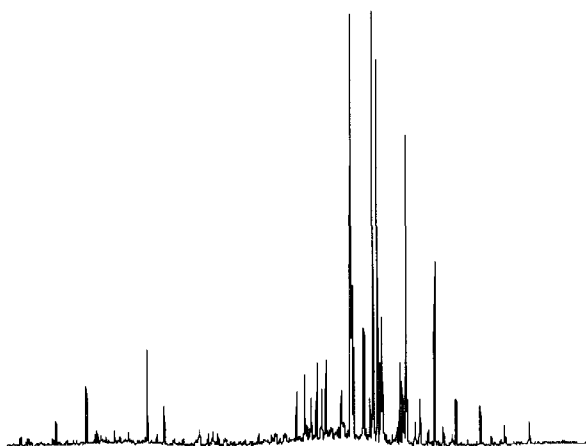
Fig. 5



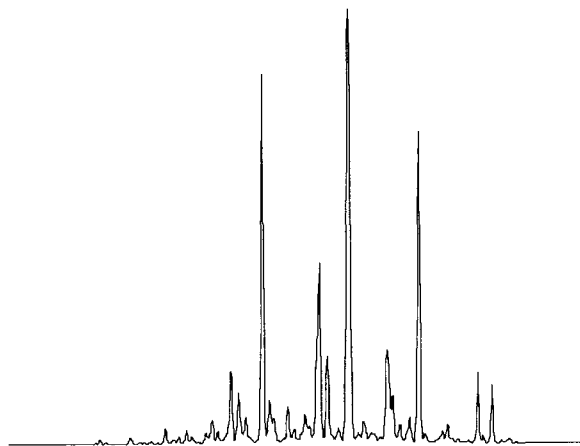
Gas Chromatogram



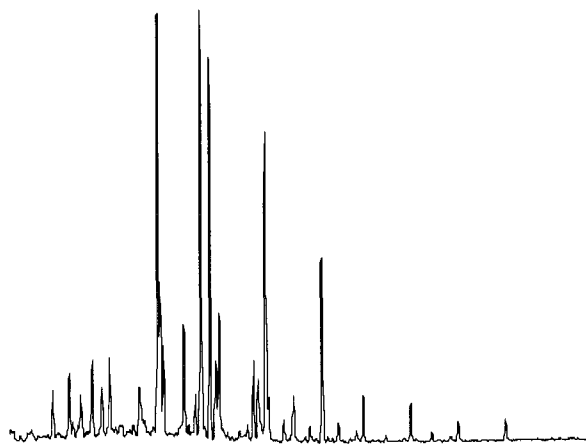
m/z 217



m/z 191 (full)



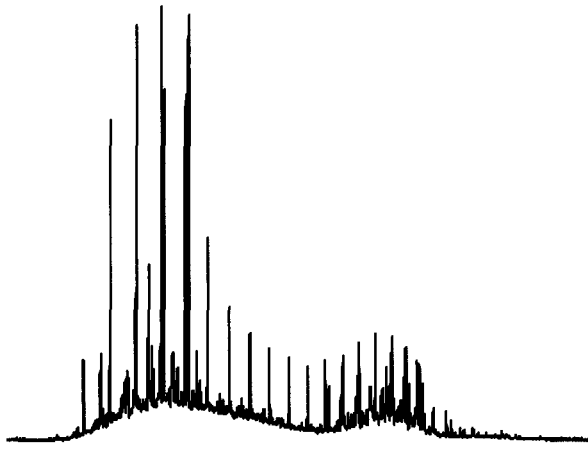
m/z 218



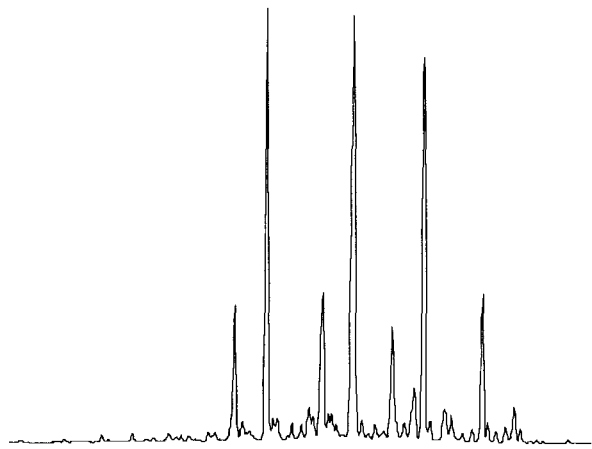
m/z 191 (partial)

USGS
Escalante 1 well
Utah, USA
Lab. # 2001064-7267
Core sample, D = 103.63 m

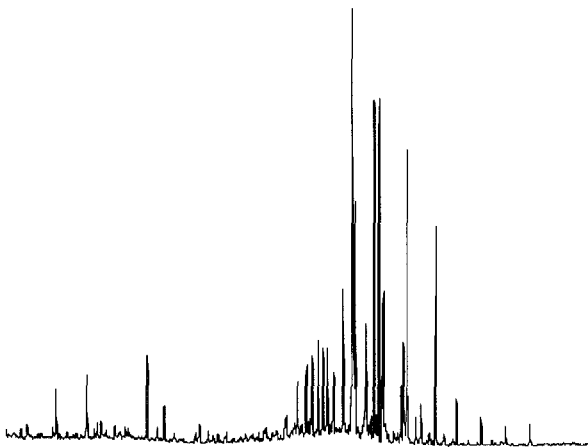
Fig. 6



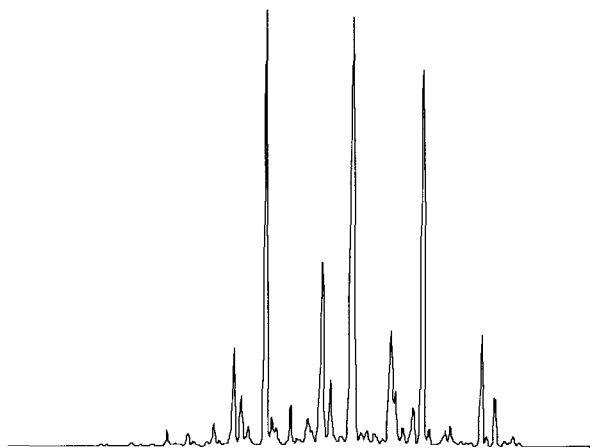
Gas Chromatogram



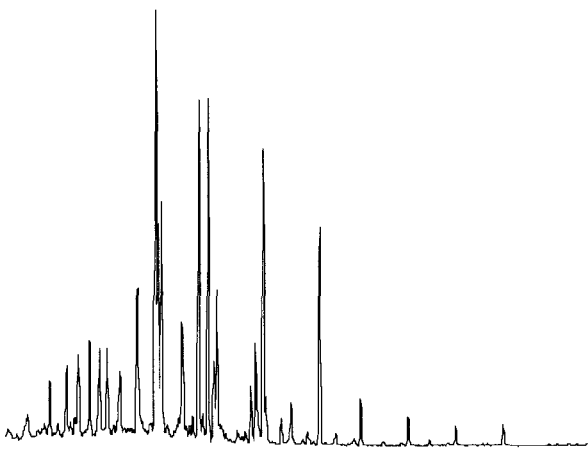
m/z 217



m/z 191 (full)



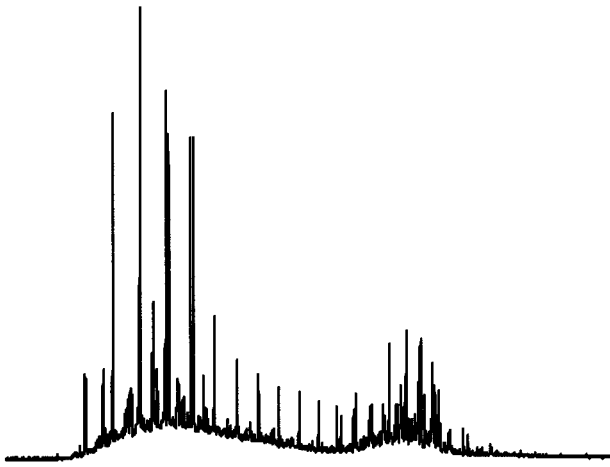
m/z 218



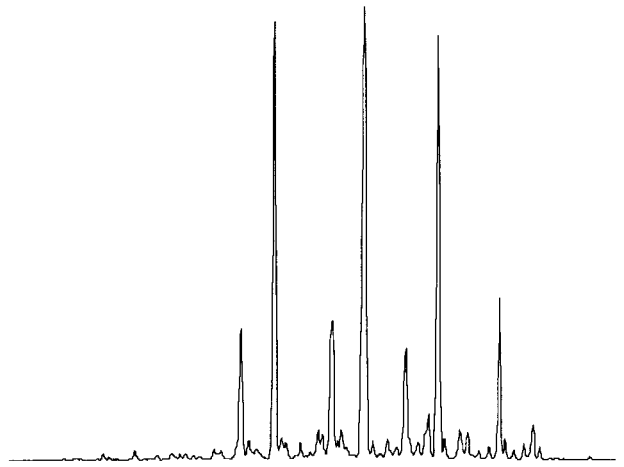
m/z 191 (partial)

**USGS
Escalante 1 well
Utah, USA
Lab. # 2001064-7275
Core sample, D = 118.87 m**

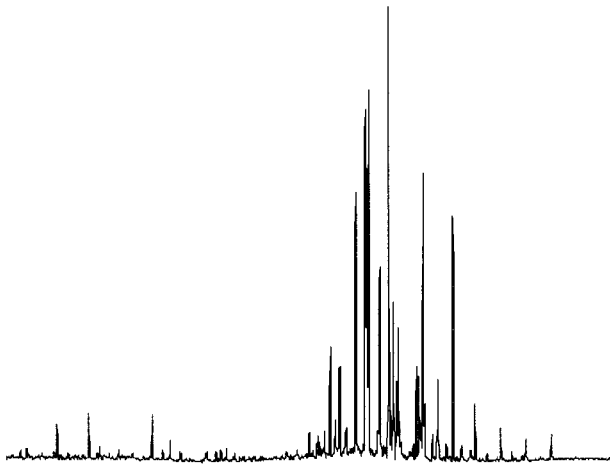
Fig. 7



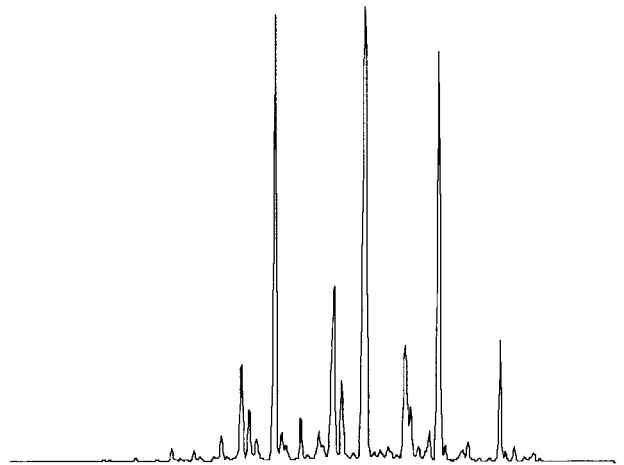
Gas Chromatogram



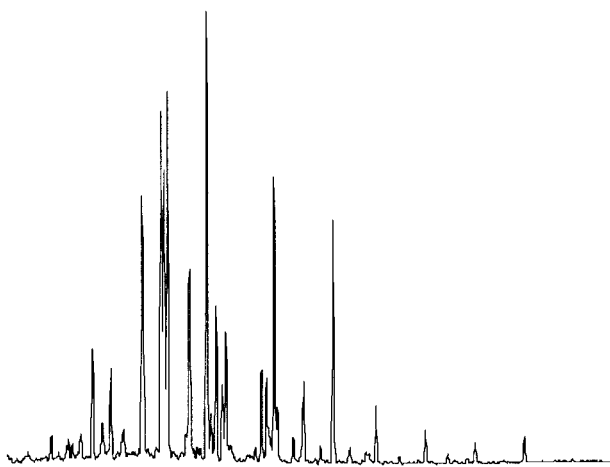
m/z 217



m/z 191 (full)



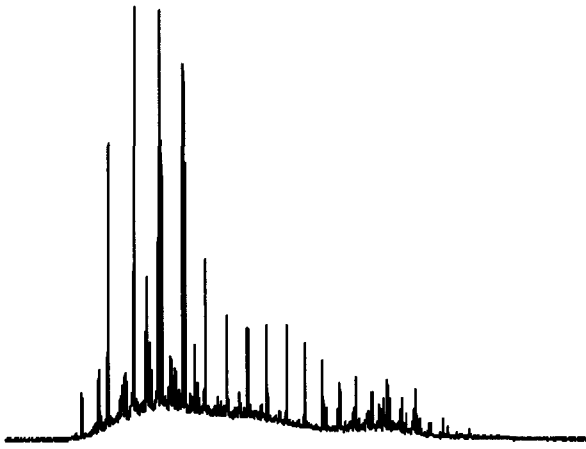
m/z 218



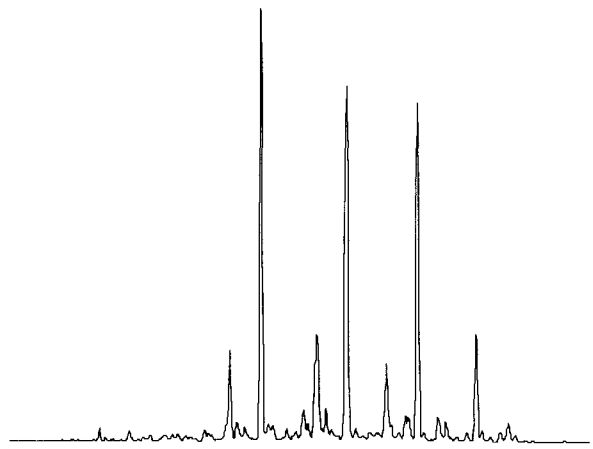
m/z 191 (partial)

USGS
Escalante 1 well
Utah, USA
Lab. # 2001064-7284
Core sample, D = 139 m

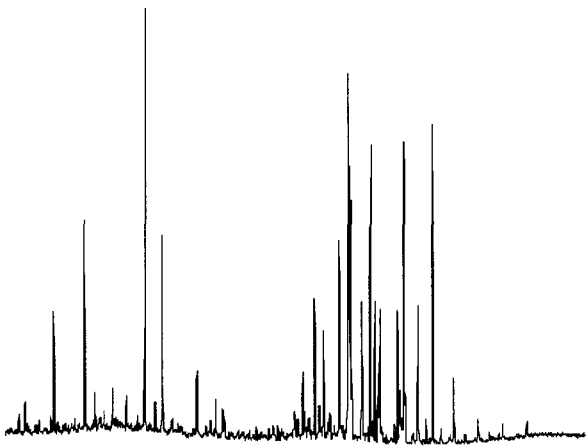
Fig. 8



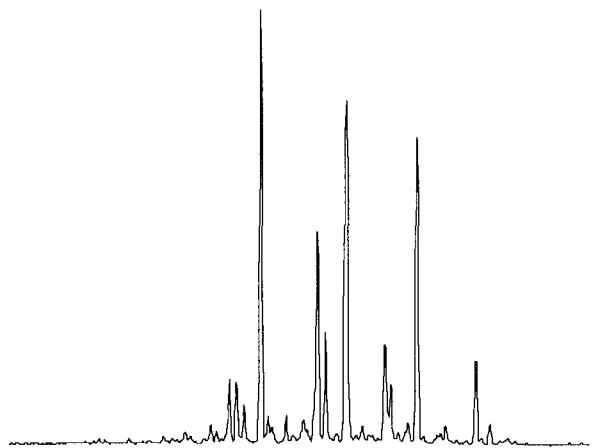
Gas Chromatogram



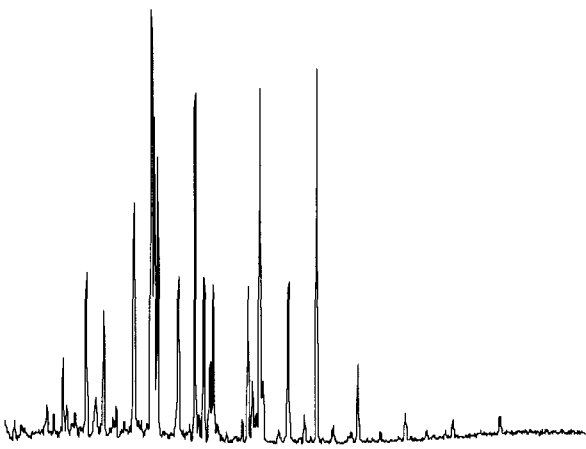
m/z 217



m/z 191 (full)



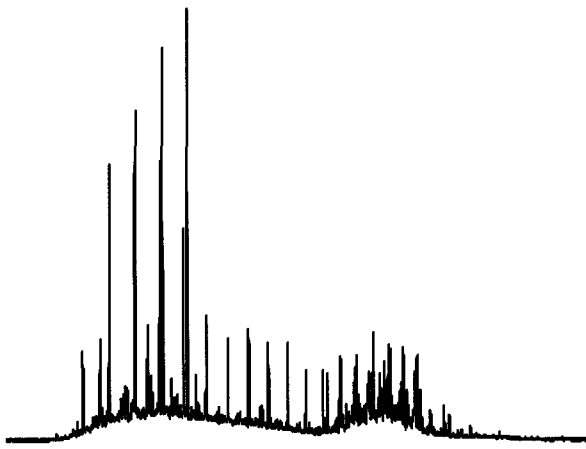
m/z 218



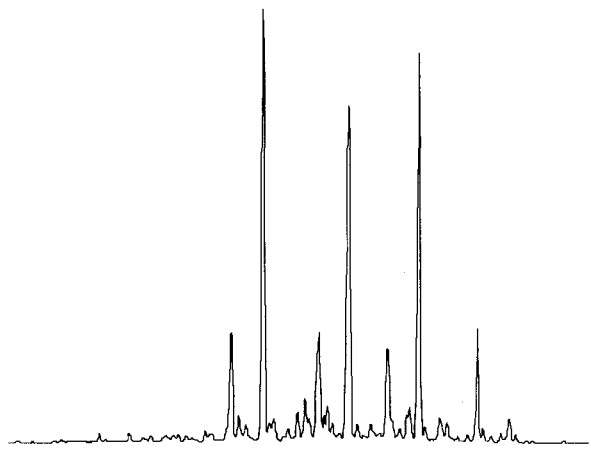
m/z 191 (partial)

USGS
Escalante 1 well
Utah, USA
Lab. # 2001064-7296
Core sample, D = 164.59 m

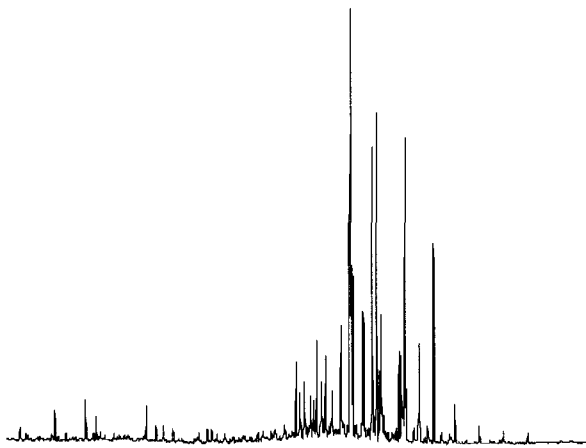
Fig. 9



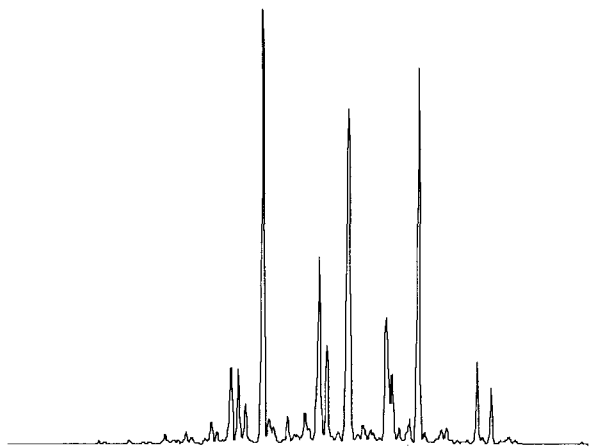
Gas Chromatogram



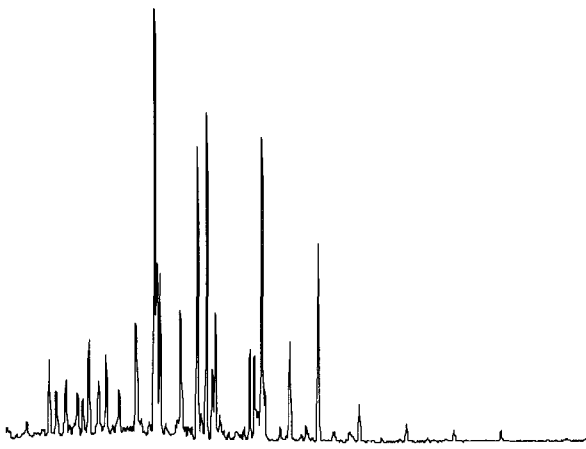
m/z 217



m/z 191 (full)



m/z 218



m/z 191 (partial)

USGS
Escalante 1 well
Utah, USA
Lab. # 2001064-7305
Core sample, D = 183.79 m

Fig. 10

USGS Portland 1 well

Rock-Eval/TOC screening

The Portland-1 well occupies an intermediate position in the transect of the Cretaceous Western Interior Seaway defined by the three wells discussed herein. A total of 38 samples were analysed, covering the interval 134.72 m to 174.96 m (Table 2, Figure 11).

TOC contents are variable, 0.39% – 4.88%, averaging 2.65%. S2 pyrolysis yields are variable, 0.49 – 27.46 mg/g, averaging 12.14 mg/g. Hydrogen Indices (HI) are variable 83 – 590 with an average of 418, showing a trend very similar to that of the TOC (Figs. 12 and 13). On average, the deposits show good petroleum source potential.

The Production Index (PI) is low, invariably <0.1, and no signs of staining or contamination are observed.

Tmax remains rather stable through the section, averaging 429 °C (Fig. 11). Hence, the succession is immature with respect to petroleum generation.

Solvent extract analysis

A total of six samples were analysed:

Lab. #	2001064-7312	D = 137.46 m	(Fig. 14)
Lab. #	2001064-7314	D = 138.91 m	(Fig. 15)
Lab. #	2001064-7320	D = 145.85 m	(Fig. 16)
Lab. #	2001064-7331	D = 156.97 m	(Fig. 17)
Lab. #	2001064-7334	D = 159.72 m	(Fig. 18)
Lab. #	2001064-7340	D = 167.64 m	(Fig. 19)

Compound identification key is shown in Appendix 1, key biomarker ratios are tabulated in Appendix 2.

All samples show rather similar characteristics.

Gas chromatography data show light-end skewed n-alkane distributions maximising at approximately nC₁₇ with poorly developed bi- or trimodality, comprising secondary/ternary maxima centred at approximately nC₂₁ and nC₂₇. The proportions of "Unresolved Complex Mixture" (UCM) are low. Acyclic isoprenoids are fairly abundant. Pristane/phytane ratios are rather high, 2.30 – 2.94. Gas chromatographic data indicate mixed kerogen derived from both marine algal/bacterial and terrestrial sources, deposited in a oxygen-restricted or suboxic depositional environment. Triterpanes (m/z 191) are poor in tricyclics, but comprise a full suite of regular hopanes, however with few rearranged (neo- and dia-hopanes) hopanes. Homohopane and bishomohopane 22S/(22S+22R) epimerisation ratios have reached equilibrium. Sterane distributions (m/z 217 and m/z 218) show some variation but are generally characterised by unusually high abundance of C₂₈ steranes. Diasteranes are present in appreciable proportions. Sterane 20S/(20S+20R)

epimerisation ratios are low testifying to the rather low (i.e. pre-oilwindow) level of thermal maturity.

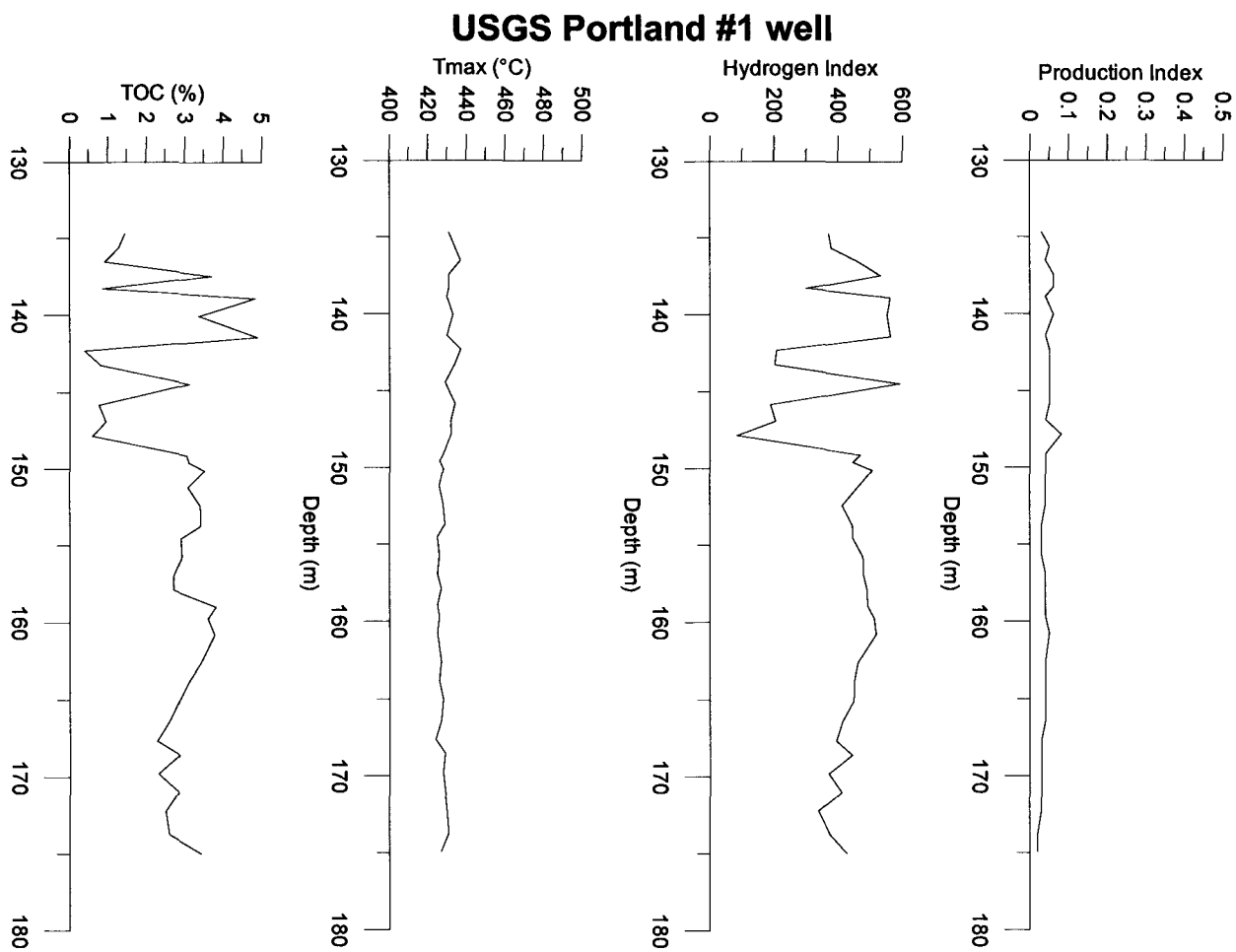


Fig. 11. Simple geochemical log, USGS Portland 1 well

USGS Portland #1 well

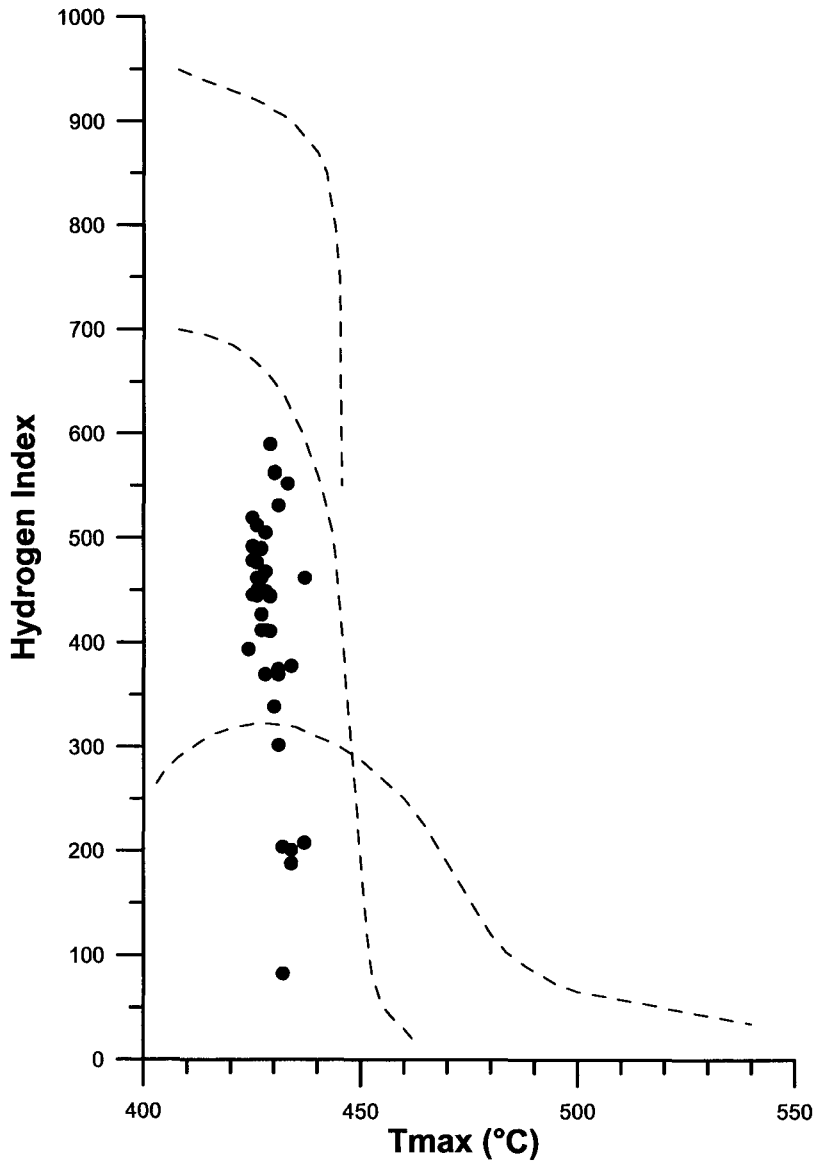


Fig. 12. USGS Portland 1 well, all data

USGS Portland #1 well

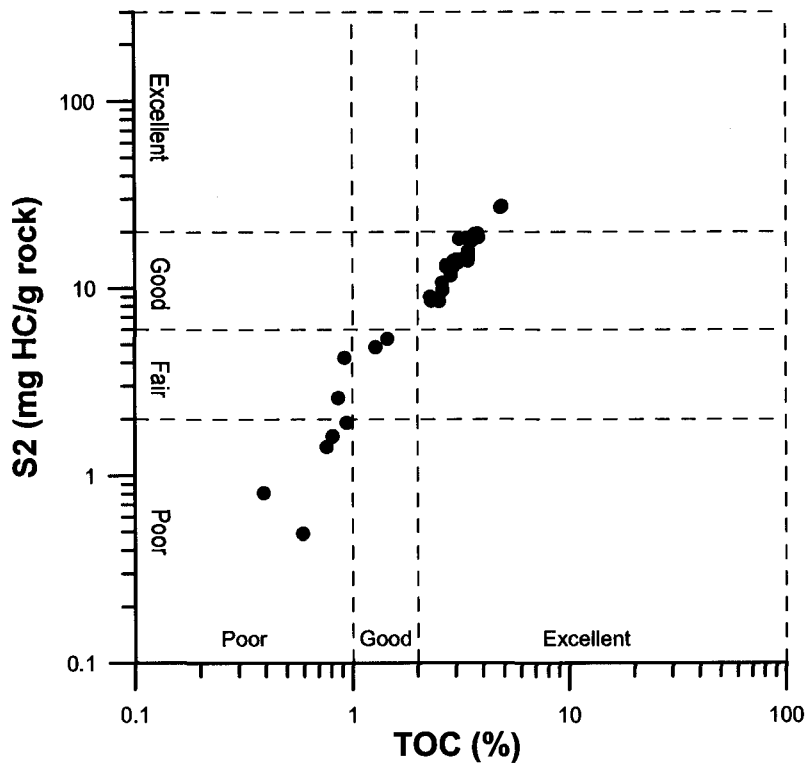
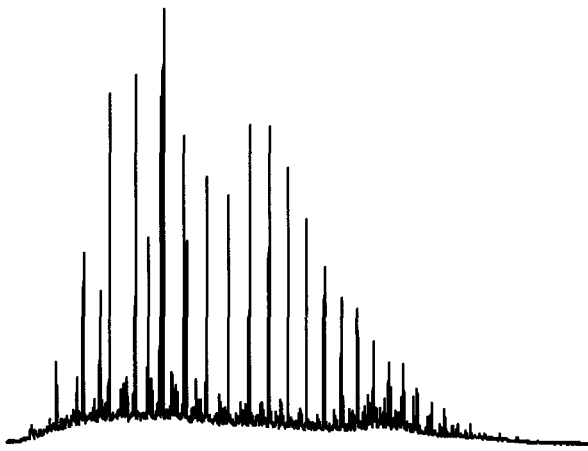


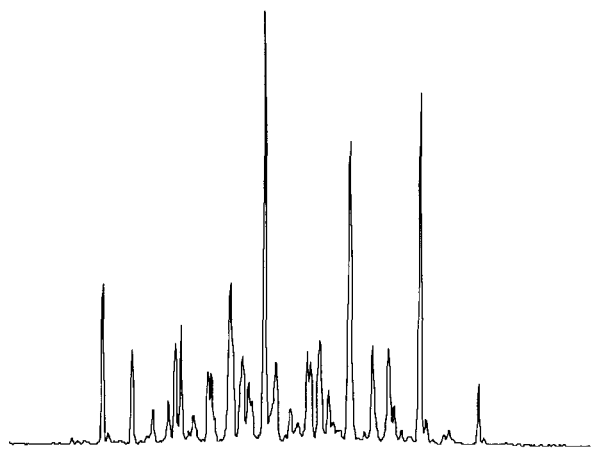
Fig. 13. USGS Portland 1 well, all data

Table 2. USGS Portland 1 well. Rock-Eval /TOC screening data

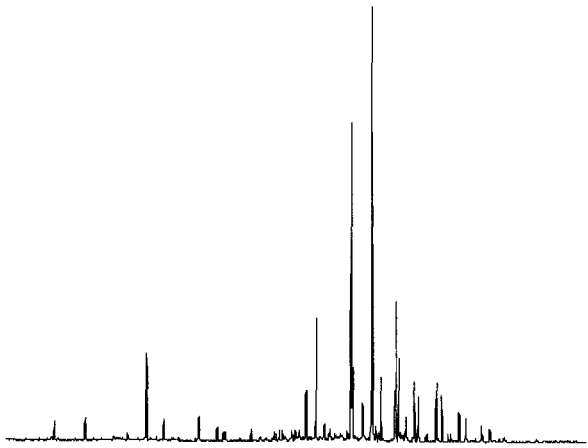
Lab #	Depth (m)	TOC (wt-%)	Tmax (°C)	S1 (mg HC/g rock)	S2	S3	HI	OI	PI	PC
7309	134,72	1,45	431	0,19	5,36	0,27	370	19	0,03	0,46
7310	135,64	1,28	434	0,23	4,84	0,31	378	24	0,05	0,42
7311	136,55	0,92	437	0,18	4,25	0,26	462	28	0,04	0,37
7312	137,46	3,67	431	1,16	19,48	0,04	531	1	0,06	1,71
7313	138,3	0,86	431	0,17	2,60	0,28	302	33	0,06	0,23
7314	138,91	4,82	430	1,20	27,07	0,66	562	14	0,04	2,35
7315	140,06	3,37	433	1,18	18,61	0,53	552	16	0,06	1,64
7316	141,43	4,88	430	1,24	27,46	0,72	563	15	0,04	2,38
7317	142,34	0,39	437	0,04	0,81	0,20	208	51	0,05	0,07
7318	143,26	0,81	434	0,09	1,63	0,25	201	31	0,05	0,14
7319	144,48	3,11	429	0,87	18,36	0,50	590	16	0,05	1,60
7320	145,85	0,76	434	0,07	1,43	0,18	188	24	0,05	0,12
7321	146,91	0,94	432	0,09	1,92	0,21	204	22	0,04	0,17
7322	147,83	0,59	432	0,04	0,49	0,15	83	25	0,08	0,04
7323	149,12	3,04	428	0,56	14,24	0,41	468	13	0,04	1,23
7324	149,58	3,10	426	0,58	13,80	0,39	445	13	0,04	1,19
7325	150,11	3,50	428	0,79	17,67	0,47	505	13	0,04	1,53
7326	151,18	3,08	426	0,64	14,24	0,40	462	13	0,04	1,24
7327	152,4	3,40	428	0,62	14,02	0,34	412	10	0,04	1,22
7328	153,7	3,41	429	0,55	15,19	0,42	445	12	0,03	1,31
7329	154,53	2,90	425	0,46	12,93	0,46	446	16	0,03	1,11
7330	155,75	2,93	426	0,47	13,99	0,37	477	13	0,03	1,20
7331	156,97	2,71	425	0,52	12,99	0,45	479	17	0,04	1,12
7332	157,89	2,71	427	0,50	13,27	0,42	490	15	0,04	1,14
7333	158,95	3,80	425	0,77	18,71	0,45	492	12	0,04	1,62
7334	159,72	3,60	426	0,78	18,42	0,49	512	14	0,04	1,59
7335	160,78	3,77	425	1,10	19,56	0,55	519	15	0,05	1,71
7336	162,61	3,41	427	0,59	15,74	0,47	462	14	0,04	1,36
7337	163,83	3,09	426	0,51	13,90	0,40	450	13	0,04	1,20
7338	165,05	2,85	428	0,52	12,81	0,33	449	12	0,04	1,11
7339	166,42	2,59	427	0,42	10,66	0,32	412	12	0,04	0,92
7340	167,64	2,28	424	0,29	8,99	0,34	394	15	0,03	0,77
7341	168,55	2,87	429	0,44	12,73	0,36	444	13	0,03	1,09
7342	169,77	2,31	428	0,24	8,54	0,30	370	13	0,03	0,73
7343	170,99	2,84	429	0,32	11,68	0,38	411	13	0,03	1,00
7344	172,21	2,51	430	0,25	8,51	0,22	339	9	0,03	0,73
7345	173,74	2,60	431	0,24	9,75	0,27	375	10	0,02	0,83
7346	174,96	3,42	427	0,37	14,59	0,31	427	9	0,02	1,24



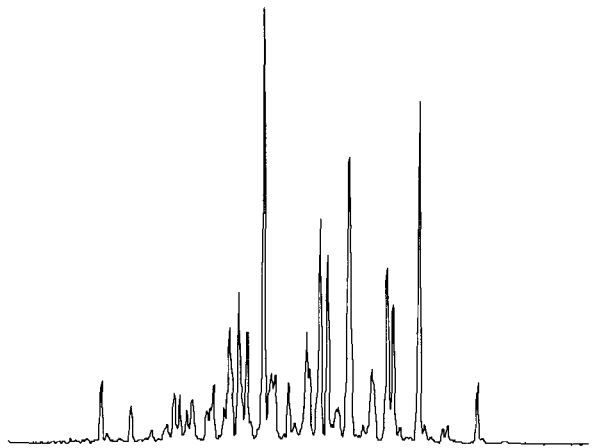
Gas Chromatogram



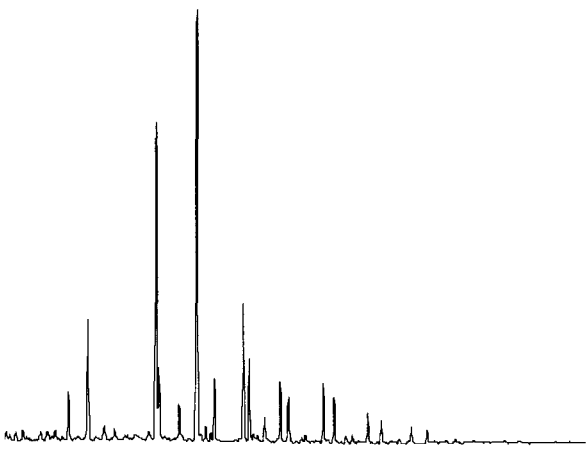
m/z 217



m/z 191 (full)



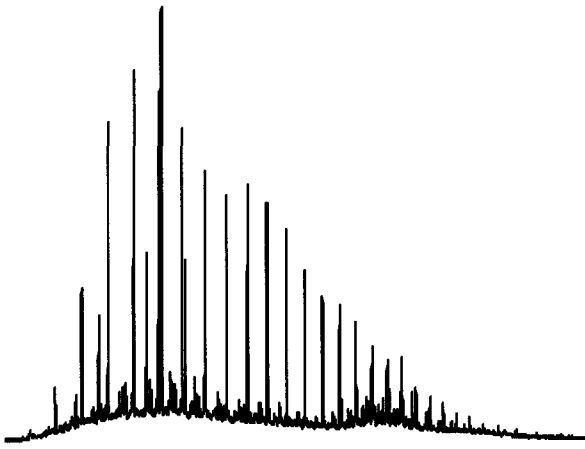
m/z 218



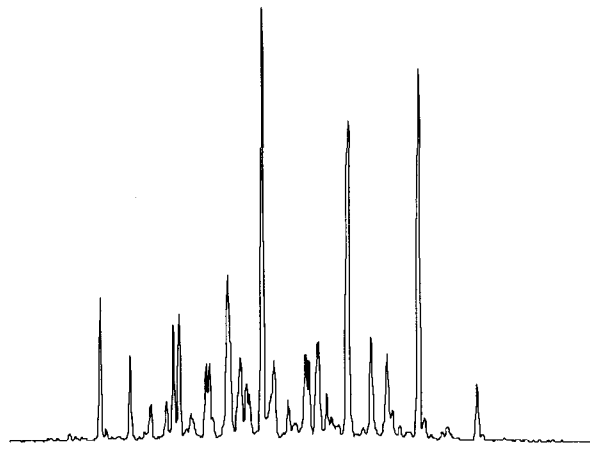
m/z 191 (partial)

USGS
Portland 1 well
Colorado, USA
Lab. # 2001064-7312
Core sample, D = 137.46 m

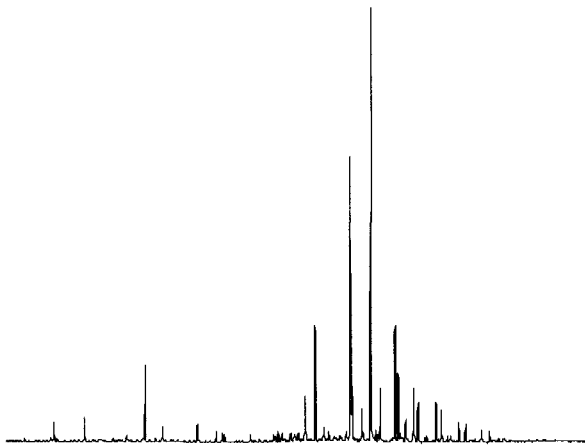
Fig. 14.



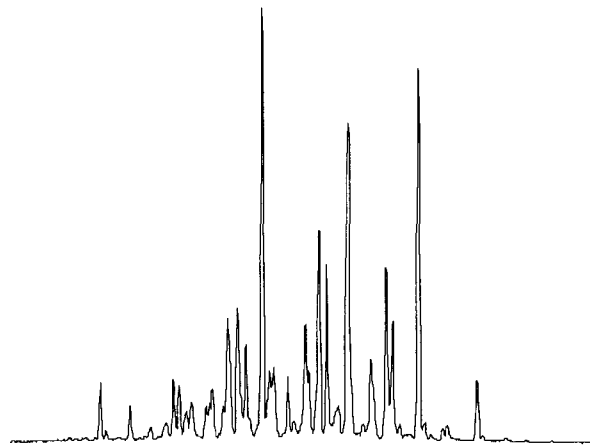
Gas Chromatogram



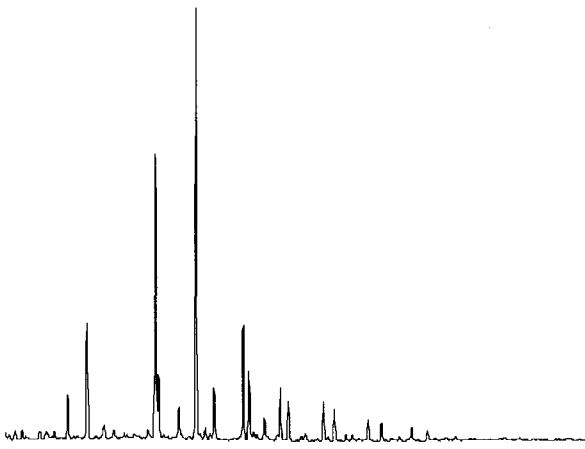
m/z 217



m/z 191 (full)



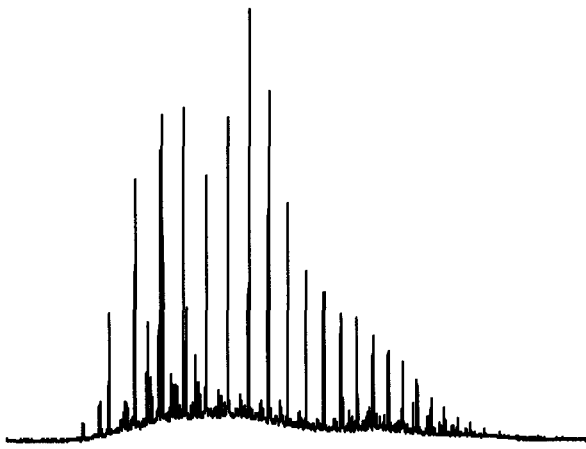
m/z 218



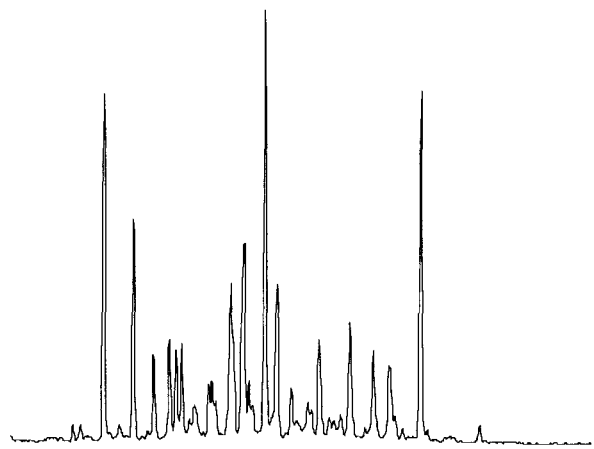
m/z 191 (partial)

USGS
Portland 1 well
Colorado, USA
Lab. # 2001064-7314
Core sample, D = 138.91 m

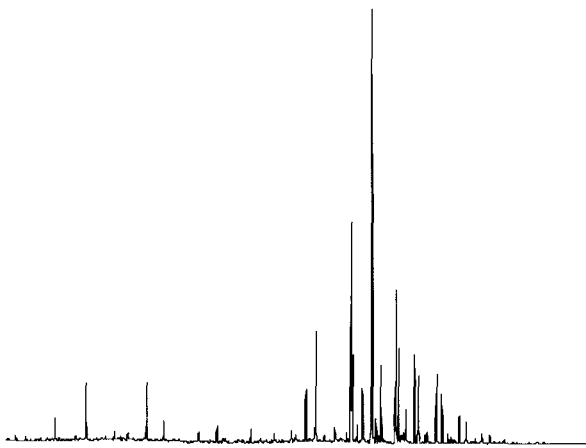
Fig. 15.



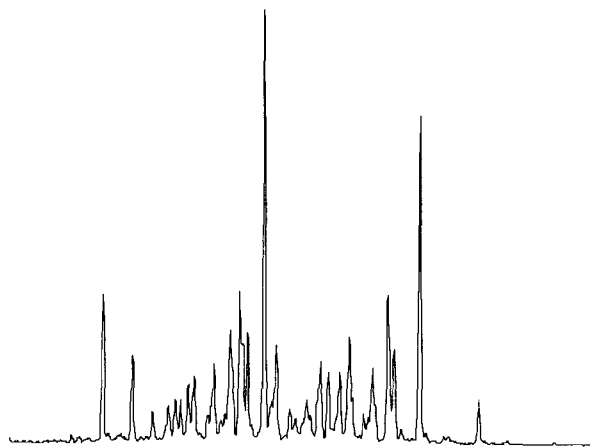
Gas Chromatogram



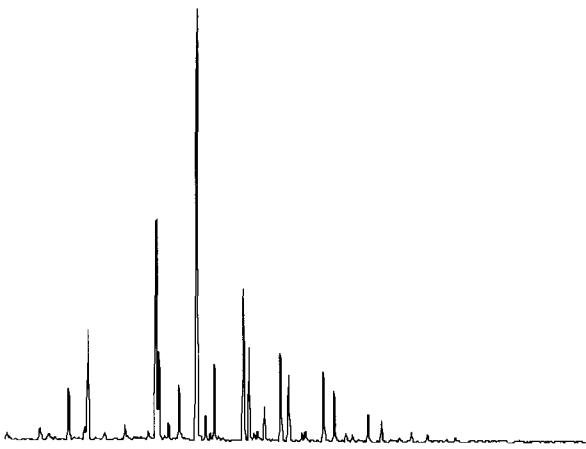
m/z 217



m/z 191 (full)



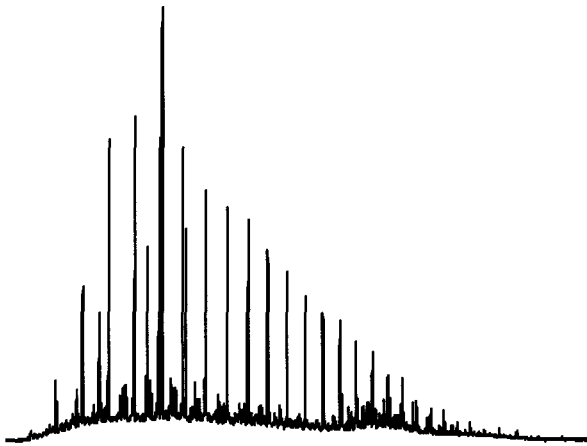
m/z 218



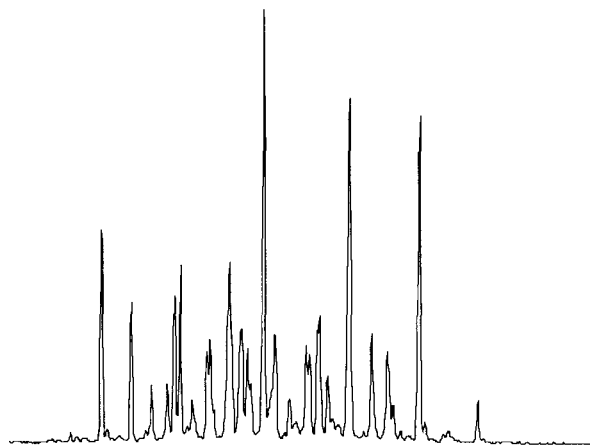
m/z 191 (partial)

USGS
Portland 1 well
Colorado, USA
Lab. # 2001064-7320
Core sample, D = 145.85 m

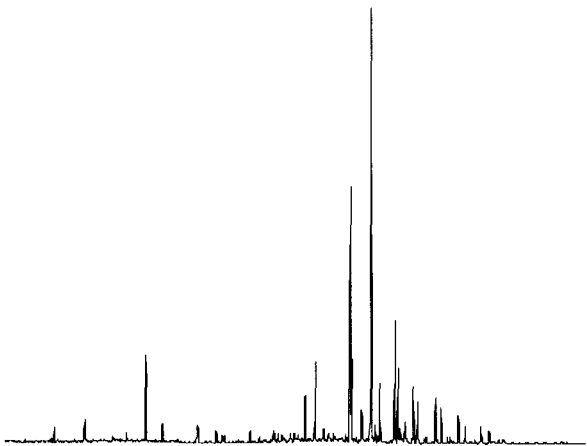
Fig. 16.



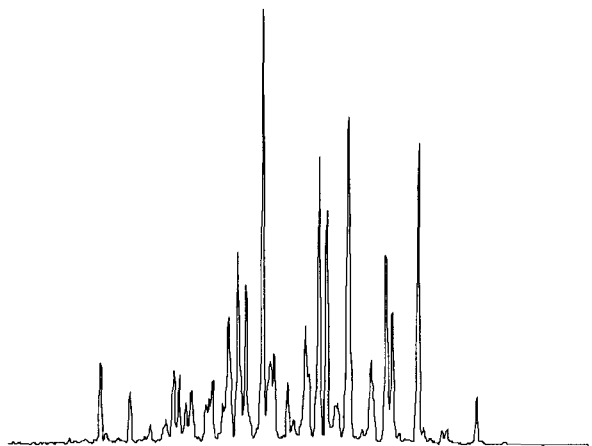
Gas Chromatogram



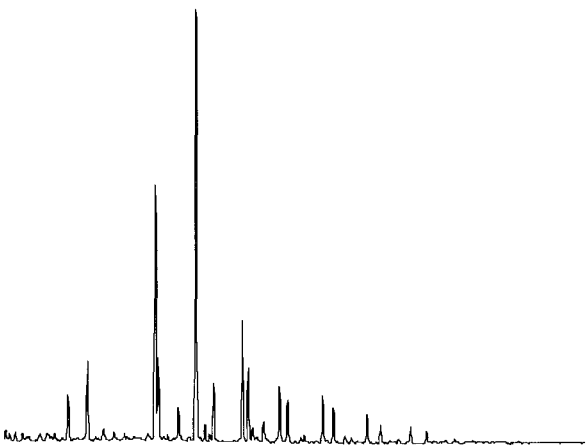
m/z 217



m/z 191 (full)



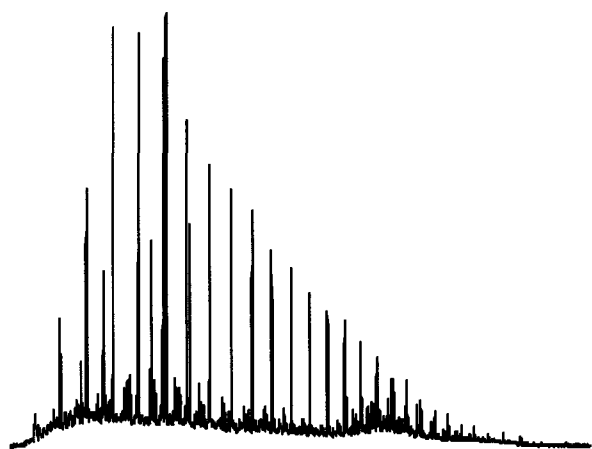
m/z 218



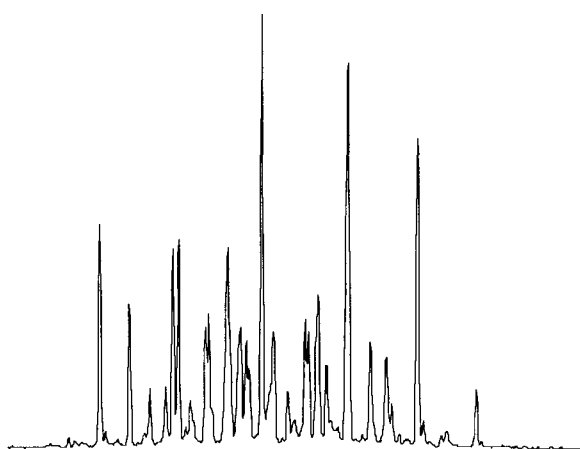
m/z 191 (partial)

USGS
Portland 1 well
Colorado, USA
Lab. # 2001064-7331
Core sample, D = 156.97 m

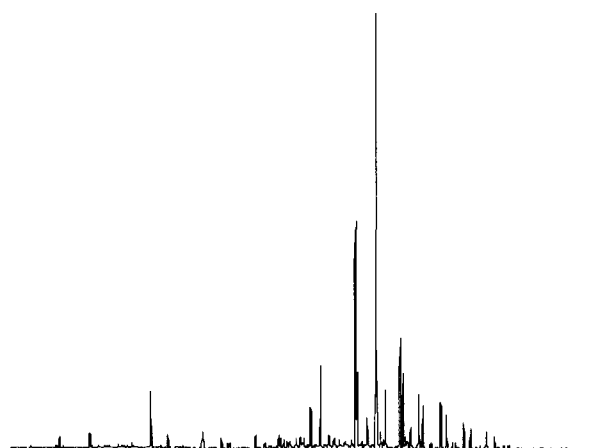
Fig. 17.



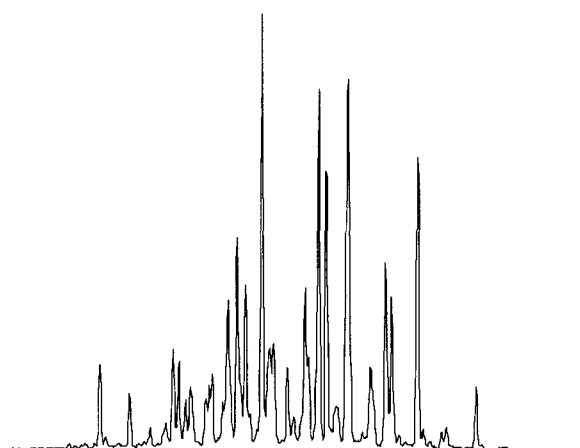
Gas Chromatogram



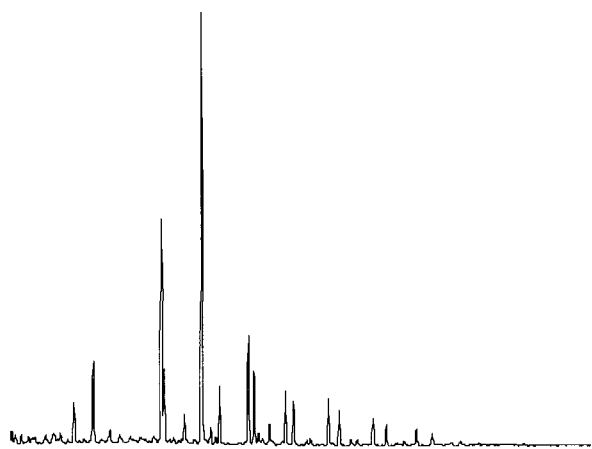
m/z 217



m/z 191 (full)



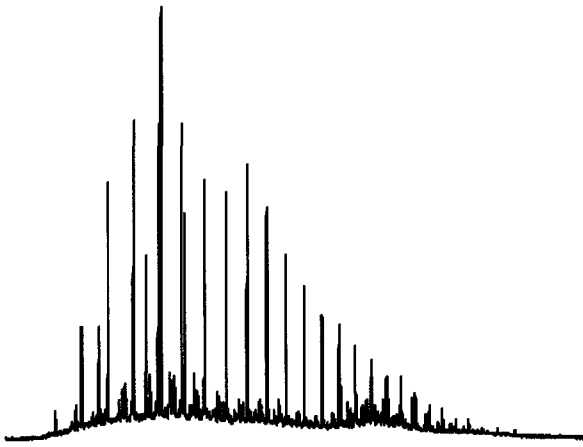
m/z 218



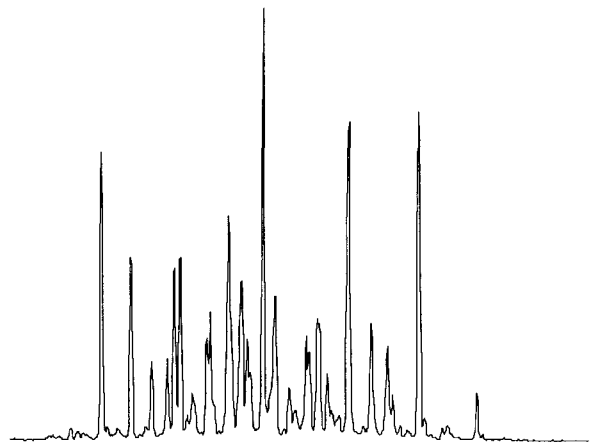
m/z 191 (partial)

USGS
Portland 1 well
Colorado, USA
Lab. # 2001064-7334
Core sample, D = 159.72 m

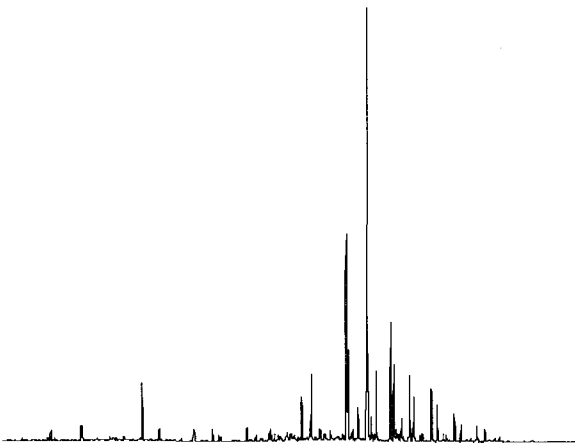
Fig. 18.



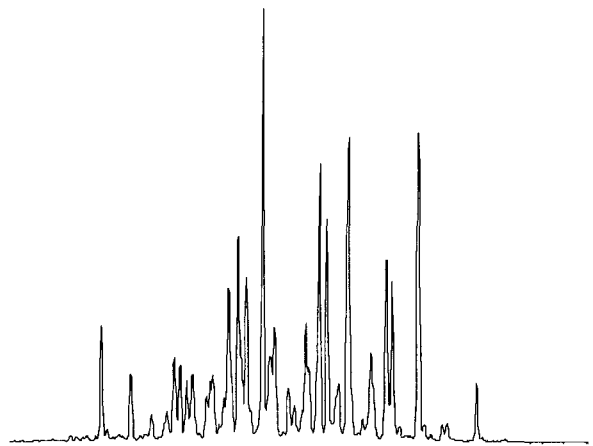
Gas Chromatogram



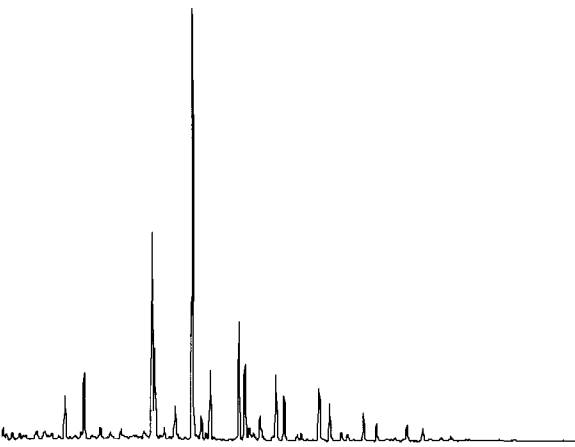
m/z 217



m/z 191 (full)



m/z 218



m/z 191 (partial)

USGS
Portland 1 well
Colorado, USA
Lab. # 2001064-7340
Core sample, D = 167.64 m

Fig. 19.

AMOCO Rebecka C. Bounds 1 well

Rock-Eval/TOC screening

The AMOCO Rebecka C. Bounds 1 well represents the easternmost position in the transect of the Cretaceous Western Interior Seaway defined by the three wells discussed herein. A total of 31 samples were analysed, covering the interval 275.23 m to 324.46 m (Table 3, Figure 20).

TOC contents are rather high, 2.28% – 7.42%, averaging 4.14%, showing an overall increasing trend downwards through the succession. S2 pyrolysis yields are high, 7.47 – 39.69 mg/g, averaging 19.26 mg/g. Hydrogen Indices (HI) are variable 314 – 551 with an average of 451 (Figs. 21 and 22). The deposits show good or even excellent petroleum source potential.

The Production Index (PI) is low, invariably <0.1, and no signs of staining or contamination are observed.

Tmax remains rather stable through the section, averaging 419 °C (Fig. 20). Hence, the succession is immature with respect to petroleum generation.

Solvent extract analysis

A total of seven samples were analysed:

Lab. #	2001064-7221	D = 277.06 m	(Fig. 23)
Lab. #	2001064-7223	D = 280.87 m	(Fig. 24)
Lab. #	2001064-7229	D = 293.22 m	(Fig. 25)
Lab. #	2001064-7233	D = 298.09 m	(Fig. 26)
Lab. #	2001064-7238	D = 306.55 m	(Fig. 27)
Lab. #	2001064-7243	D = 315.01 m	(Fig. 28)
Lab. #	2001064-7249	D = 323.24 m	(Fig. 29)

Compound identification key is shown in Appendix 1, key biomarker ratios are tabulated in Appendix 2.

All samples show rather similar characteristics.

Gas chromatography data show strongly light-end skewed n-alkane distributions maximising at approximately nC₁₇ with poorly developed bi- or trimodality, comprising secondary/ternary maxima centred at approximately nC₂₃ and nC₂₉. The proportions of "Unresolved Complex Mixture" (UCM) are low. Acyclic isoprenoids are fairly abundant. Pristane/phytane ratios are moderate, 1.44 – 2.33. Gas chromatographic data indicate mixed kerogen derived primarily from marine algal/bacterial sources with only minor terrestrial inputs, deposited in a oxygen-restricted or suboxic depositional environment. Triterpanes (m/z 191) are poor in tricyclics, but comprise a full suite of regular hopanes, including a high proportion of moretanes, but virtually without rearranged hopanes (neo- and dia-hopanes). Homohopane and bishomohopane 22S/(22S+22R) epimerisation ratios

are far below equilibrium, confirming the indication of low thermal maturity provided by Tmax data. Sterane distributions (m/z 217 and m/z 218) show little variation and are generally characterised by unusually high abundance of C₂₈ steranes. Diasteranes are present in small, but still approachable proportions. Sterane 20S/(20S+20R) epimerisation ratios are very low, testifying to the low level of thermal maturity.

Amoco Rebecka Bounds #1 well

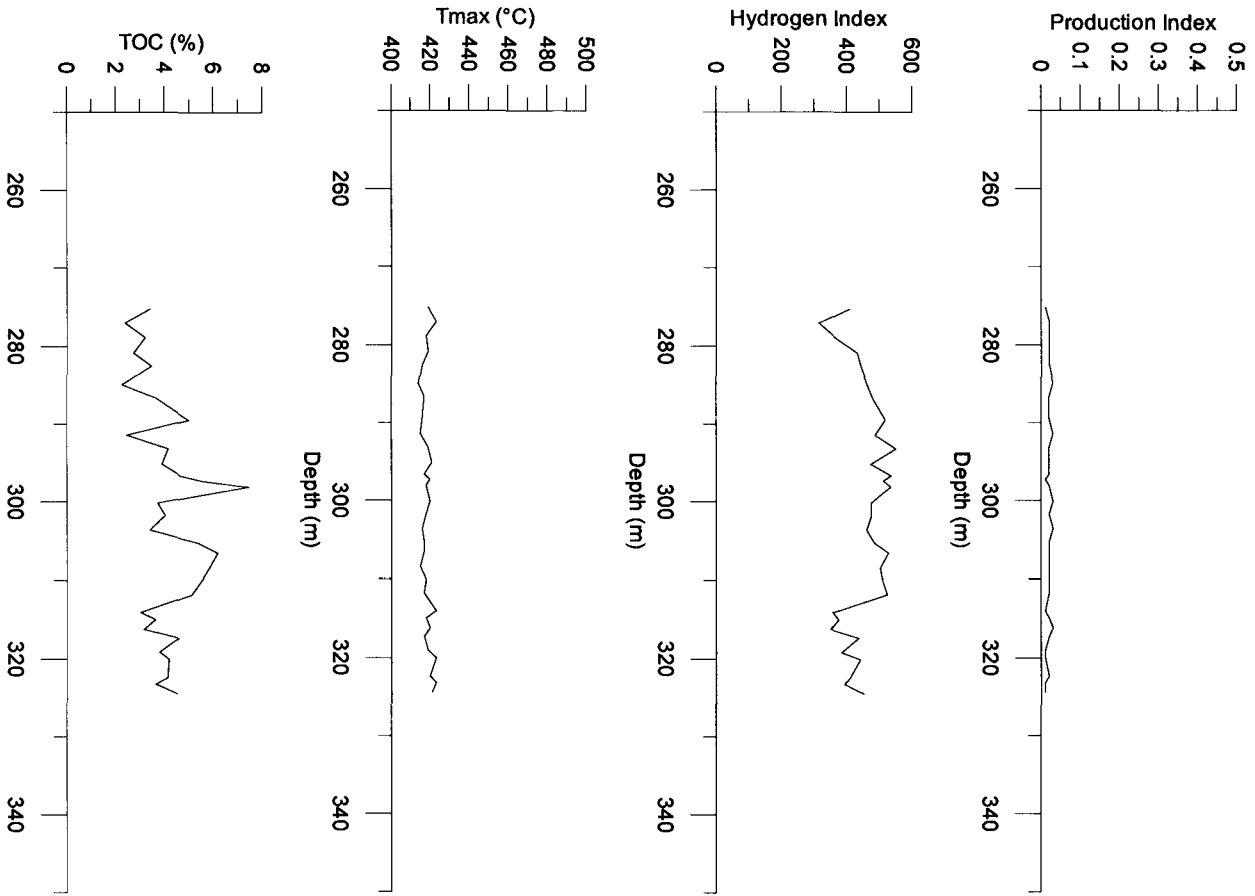


Fig. 20. Simple geochemical log, AMOCO Rebecka C. Bounds 1 well

Amoco Rebecka Bounds #1 well

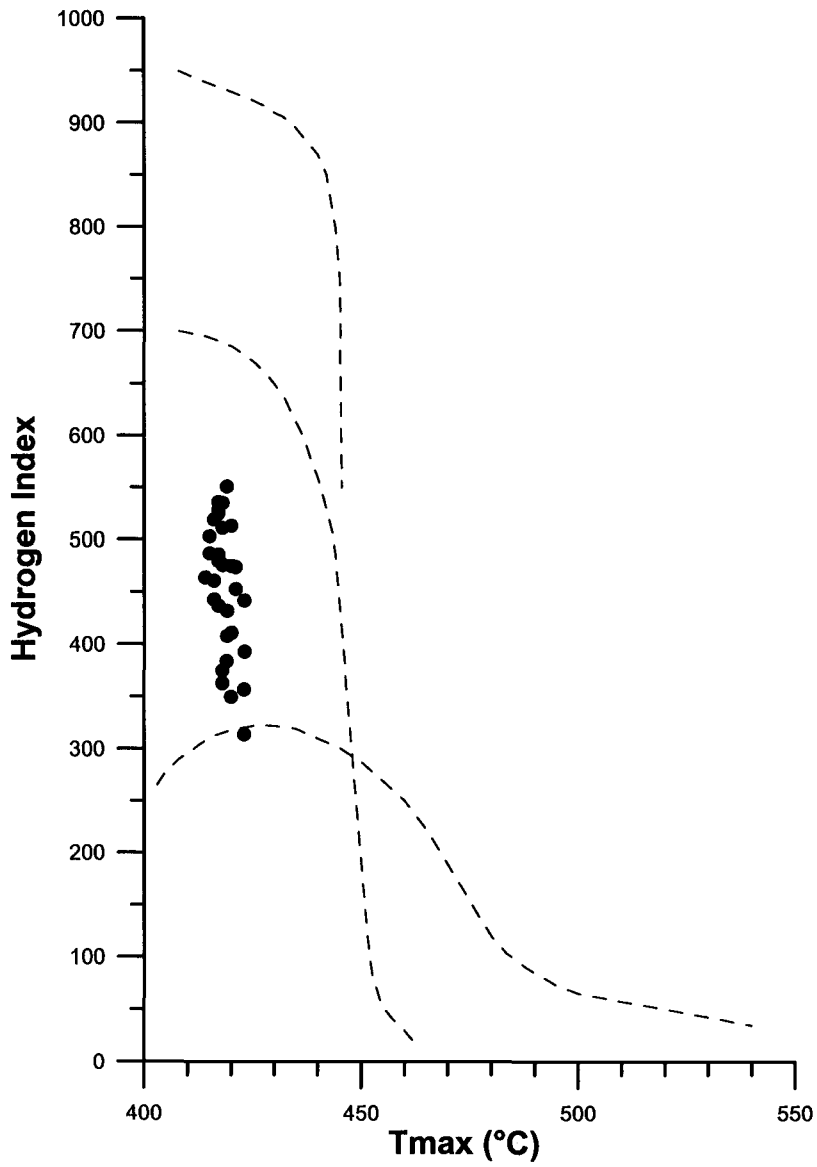


Fig. 21. AMOCO Rebecka C. Bounds 1 well, all data

Amoco Rebecka Bounds #1 well

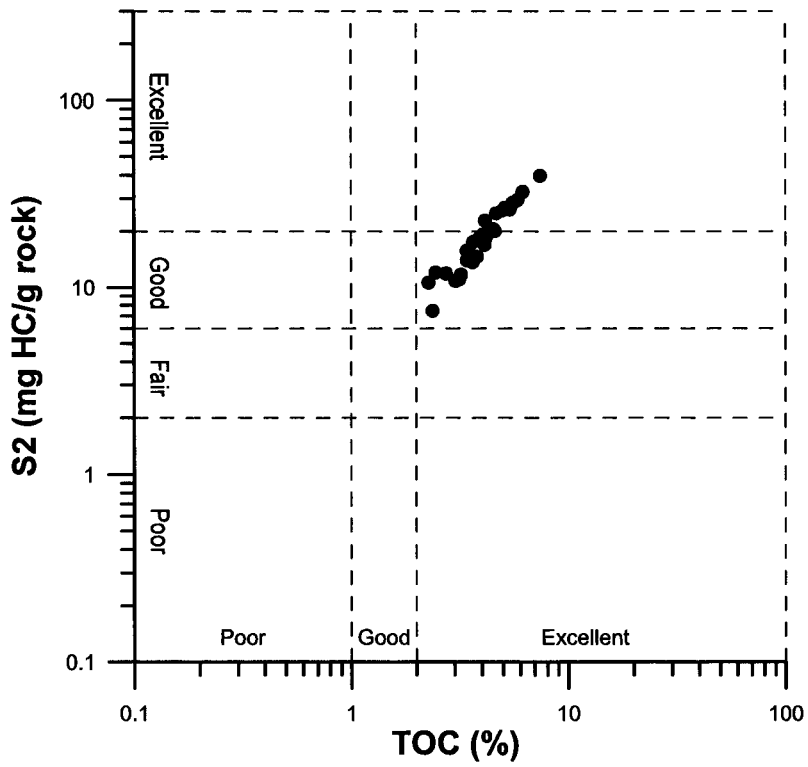
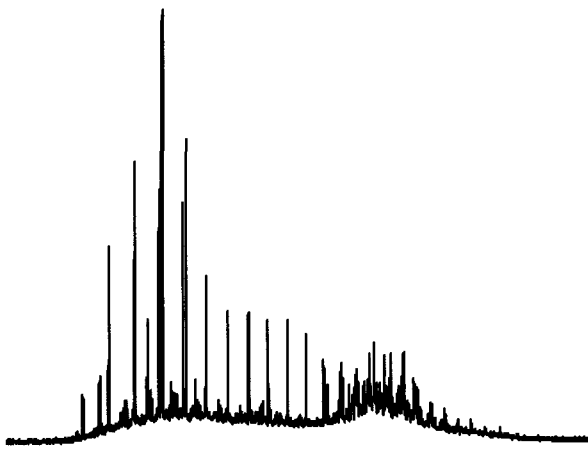


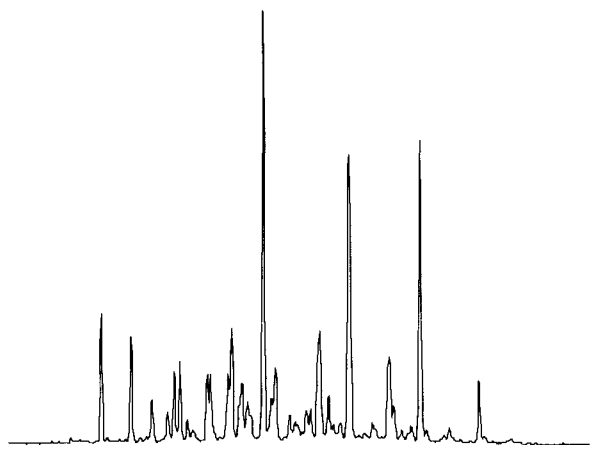
Fig. 22. AMOCO Rebecka C. Bounds 1 well, all data

Table 3. AMOCO Rebecka C. Bounds 1 well. Rock-Eval /TOC screening data

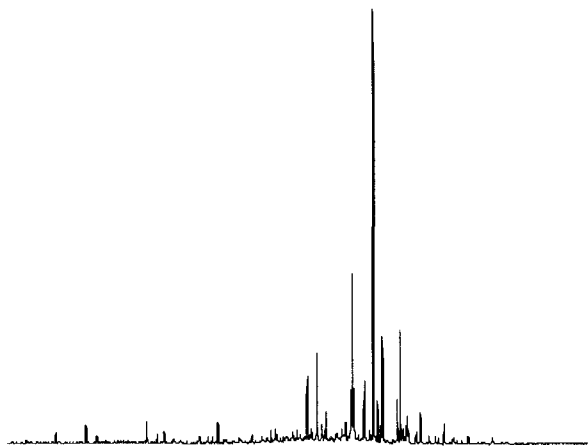
Lab (#)	Depth (meter)	TOC (wt-%)	Tmax (°C)	S1 (mg HC / g rock)	S2	S3	HI	OI	PI	PC
7220	275,23	3,42	419	0,21	13,94	1,14	408	33	0,01	1,17
7221	277,06	2,38	423	0,12	7,47	0,76	314	32	0,02	0,63
7222	278,89	3,21	418	0,18	11,65	1,05	363	33	0,02	0,98
7223	280,87	2,74	419	0,23	11,84	1,01	432	37	0,02	1,00
7224	282,55	3,46	416	0,24	15,34	1,08	443	31	0,02	1,29
7225	284,99	2,28	414	0,31	10,59	0,89	464	39	0,03	0,90
7226	286,66	3,66	417	0,34	17,55	1,08	480	30	0,02	1,48
7227	289,48	4,98	416	0,53	25,85	1,32	519	27	0,02	2,19
7228	291,47	2,46	415	0,34	11,99	1,07	487	43	0,03	1,02
7229	293,22	4,15	419	0,45	22,85	1,49	551	36	0,02	1,93
7230	295,20	3,91	421	0,33	18,52	1,05	474	27	0,02	1,56
7231	296,65	4,67	417	0,43	25,04	1,33	536	28	0,02	2,11
7232	297,33	5,55	420	0,40	28,45	1,20	513	22	0,01	2,39
7233	298,09	7,42	418	0,74	39,69	1,54	535	21	0,02	3,36
7234	300,15	3,73	420	0,56	17,73	1,26	475	34	0,03	1,52
7235	301,75	4,03	418	0,31	19,19	1,25	476	31	0,02	1,62
7236	303,58	3,41	416	0,52	15,71	1,44	461	42	0,03	1,35
7237	305,26	5,39	417	0,52	26,18	1,49	486	28	0,02	2,22
7238	306,55	6,18	417	0,69	32,63	1,70	528	28	0,02	2,77
7239	308,46	5,84	415	0,57	29,40	1,70	503	29	0,02	2,49
7240	310,13	5,51	418	0,64	28,18	1,52	511	28	0,02	2,39
7241	311,81	5,12	417	0,54	26,87	1,39	525	27	0,02	2,28
7242	314,10	3,03	423	0,16	10,83	0,79	357	26	0,01	0,91
7243	315,01	3,63	418	0,21	13,60	1,01	375	28	0,02	1,15
7244	316,23	3,15	420	0,29	11,03	0,82	350	26	0,03	0,94
7245	317,37	4,59	417	0,34	20,06	1,18	437	26	0,02	1,69
7246	319,13	3,80	419	0,19	14,59	0,82	384	22	0,01	1,23
7247	320,04	4,18	423	0,24	18,49	1,00	442	24	0,01	1,55
7248	322,40	4,13	420	0,37	16,96	0,90	411	22	0,02	1,44
7249	323,24	3,65	423	0,21	14,33	0,82	393	22	0,01	1,21
7250	324,46	4,53	421	0,30	20,50	0,96	453	21	0,01	1,73



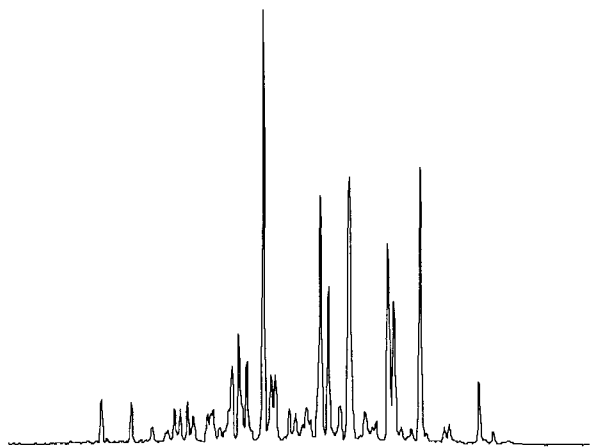
Gas Chromatogram



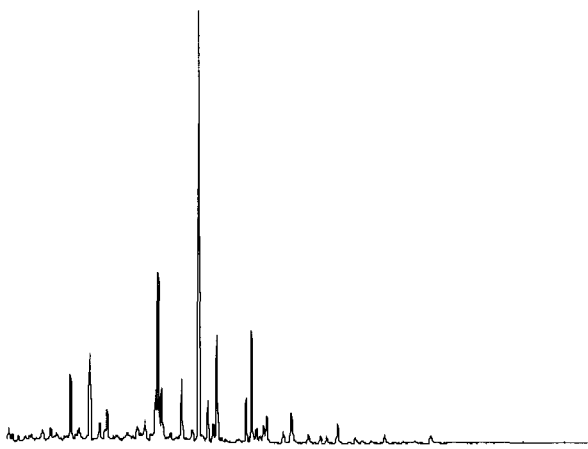
m/z 217



m/z 191 (full)



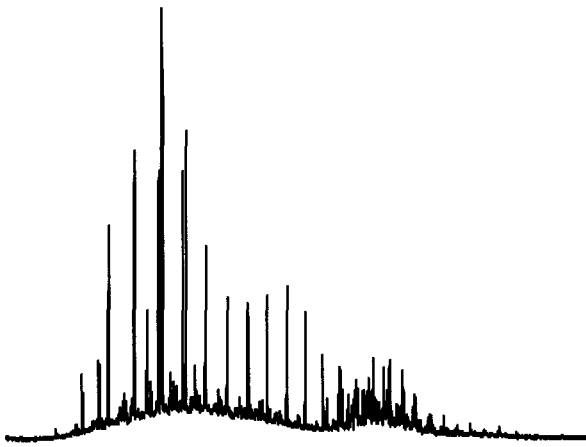
m/z 218



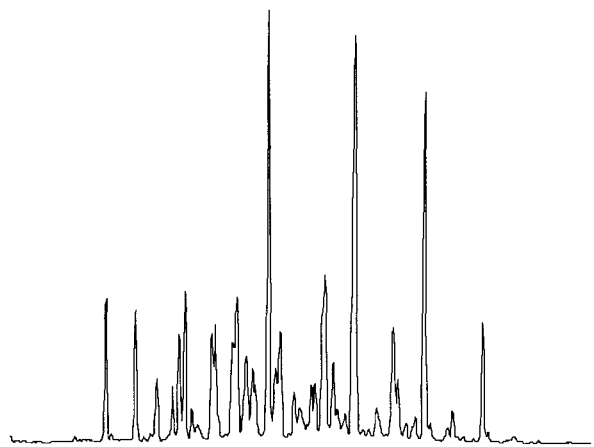
m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7221
Core sample, D = 277.06 m

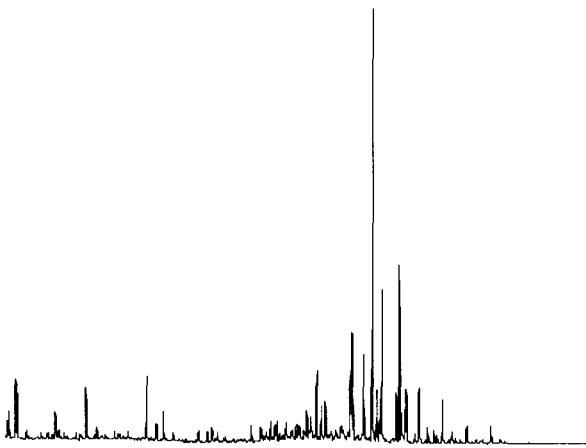
Fig. 23.



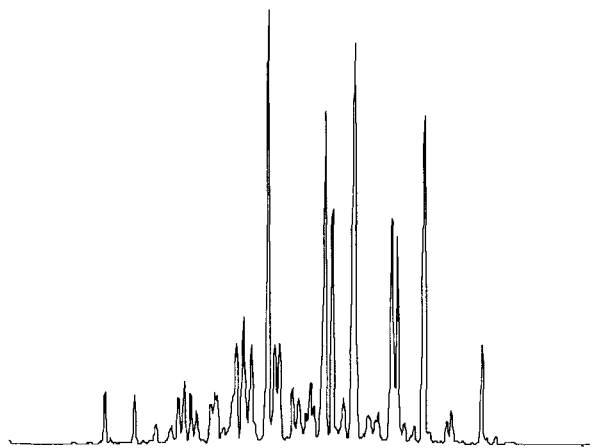
Gas Chromatogram



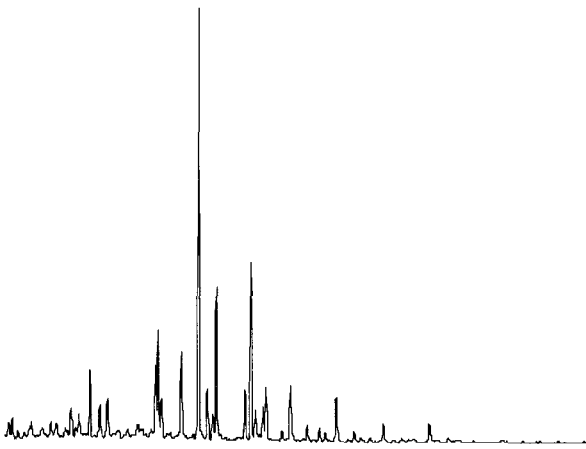
m/z 217



m/z 191 (full)



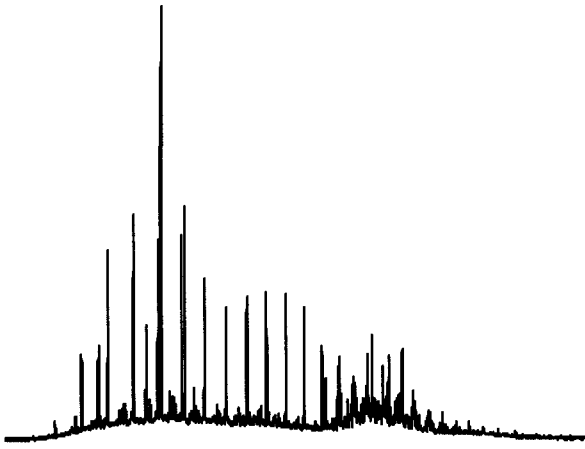
m/z 218



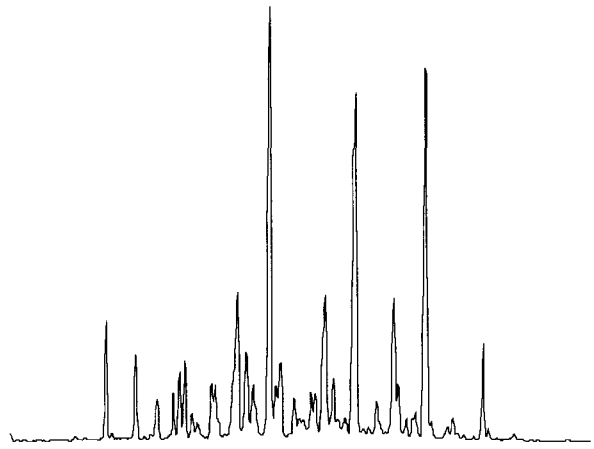
m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7223
Core sample, D = 280.87 m

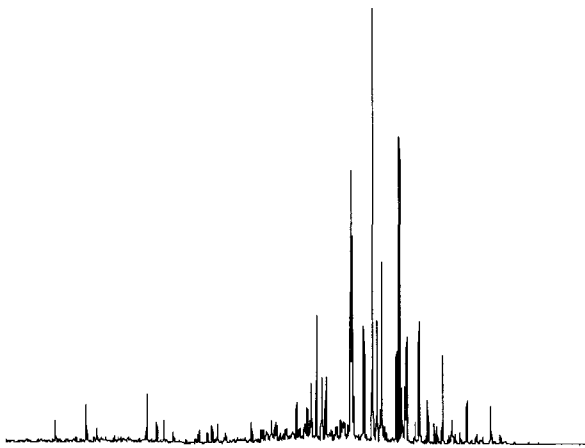
Fig. 24.



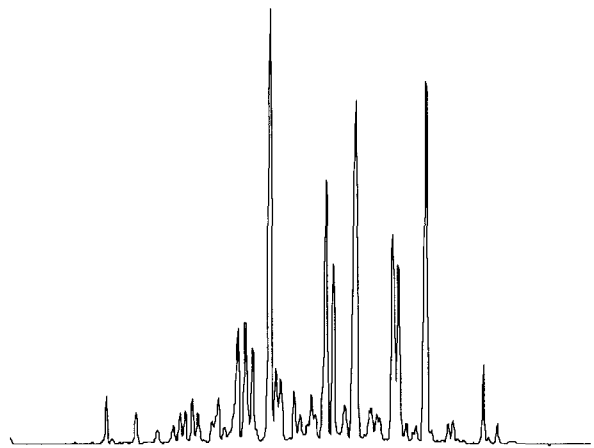
Gas Chromatogram



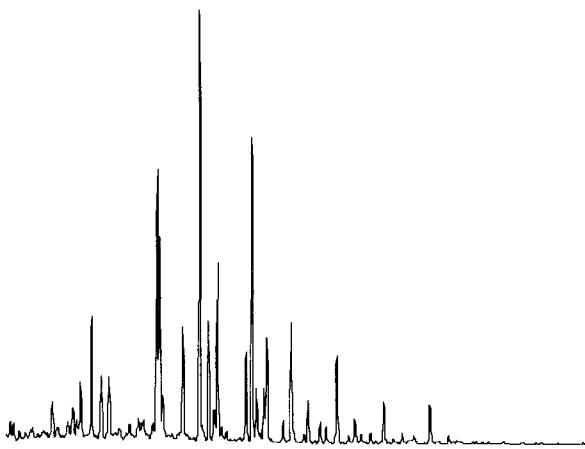
m/z 217



m/z 191 (full)



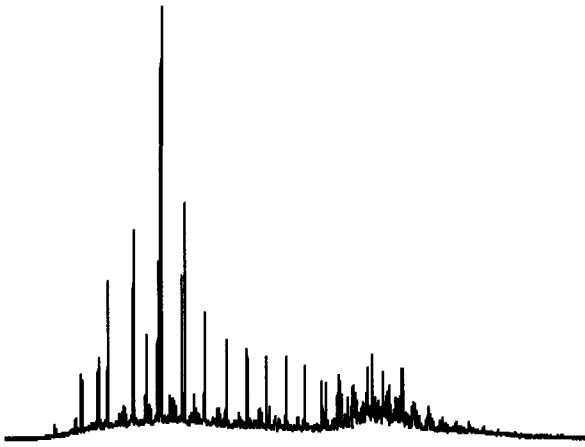
m/z 218



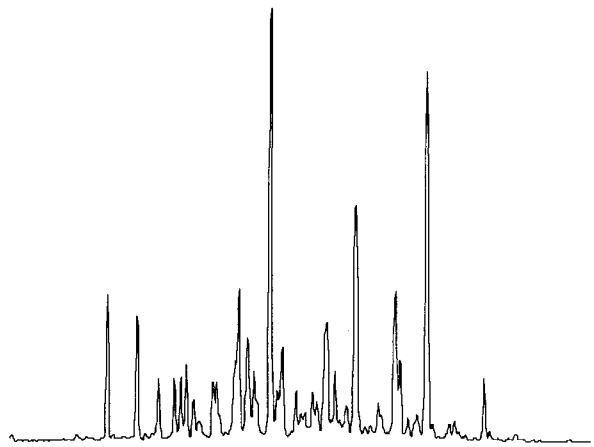
m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7229
Core sample, D = 293.22 m

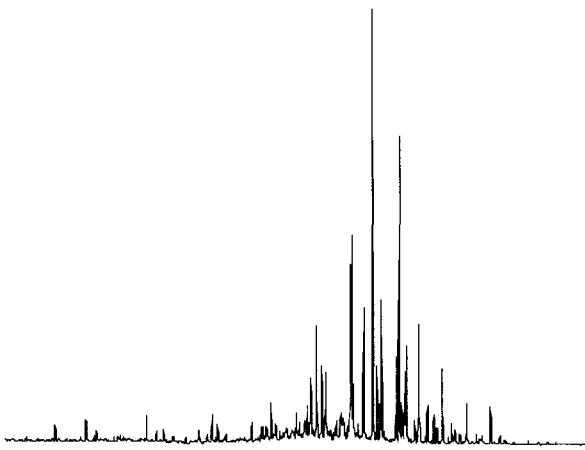
Fig. 25.



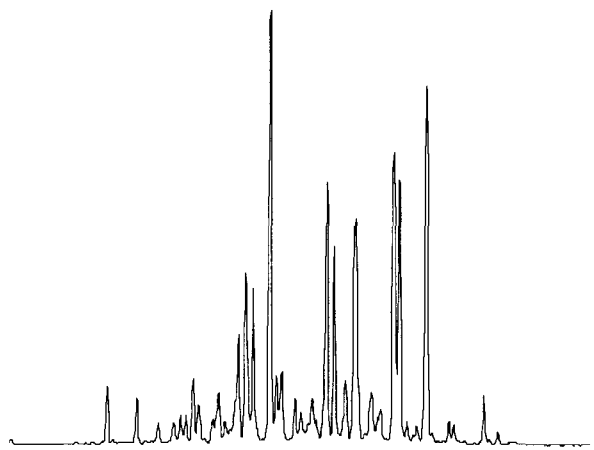
Gas Chromatogram



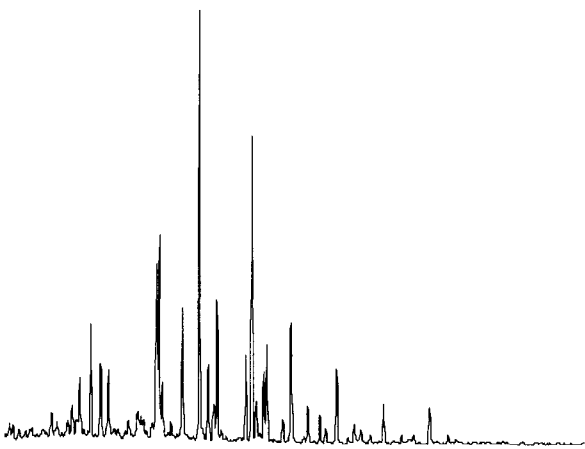
m/z 217



m/z 191 (full)



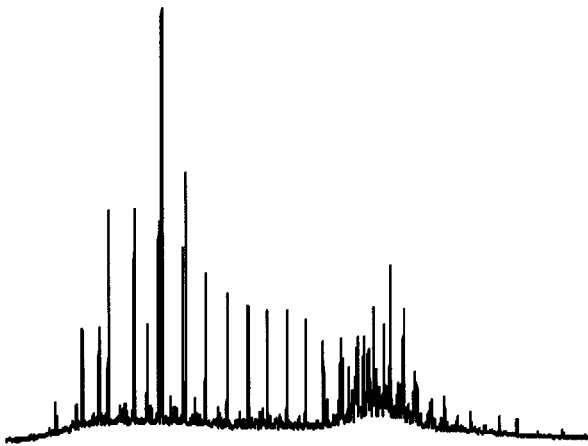
m/z 218



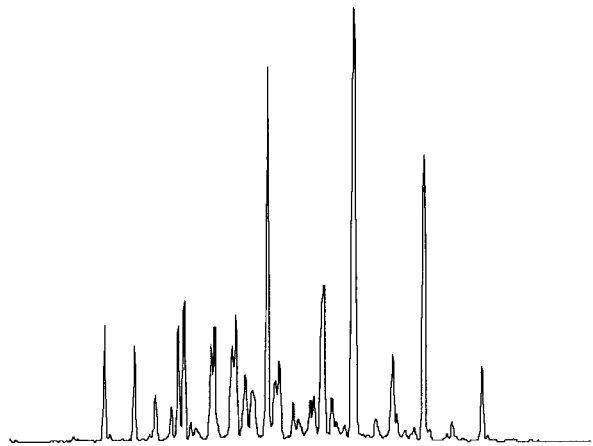
m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7233
Core sample, D = 298.09 m

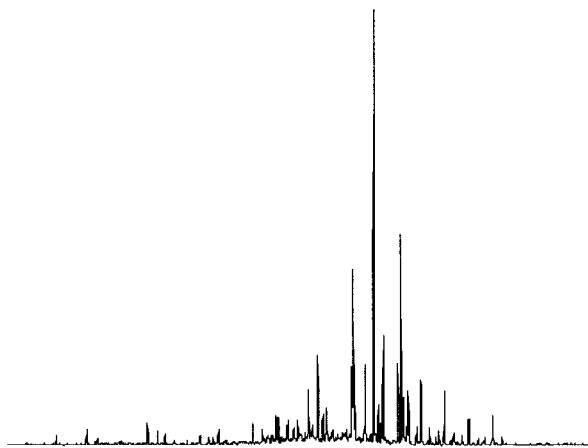
Fig. 26.



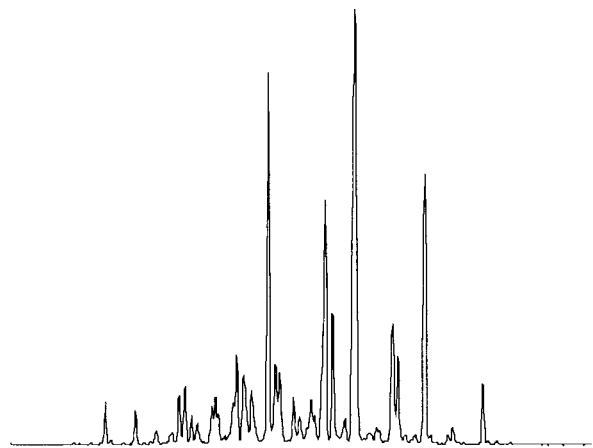
Gas Chromatogram



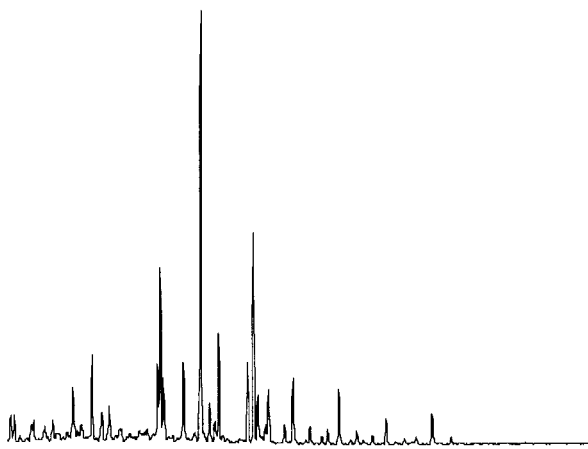
m/z 217



m/z 191 (full)



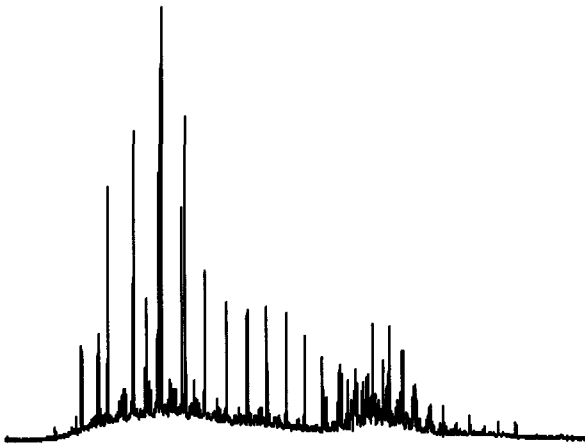
m/z 218



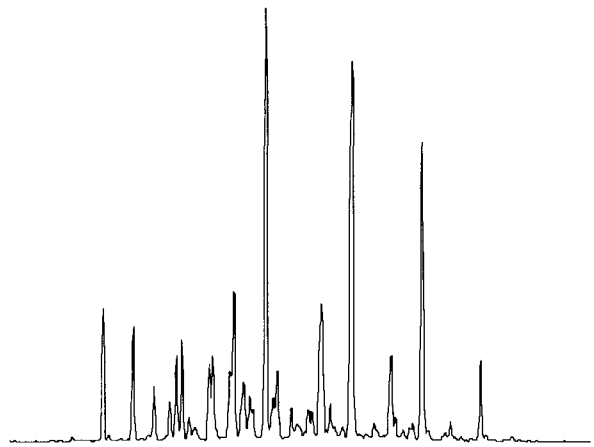
m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7238
Core sample, D = 306.55 m

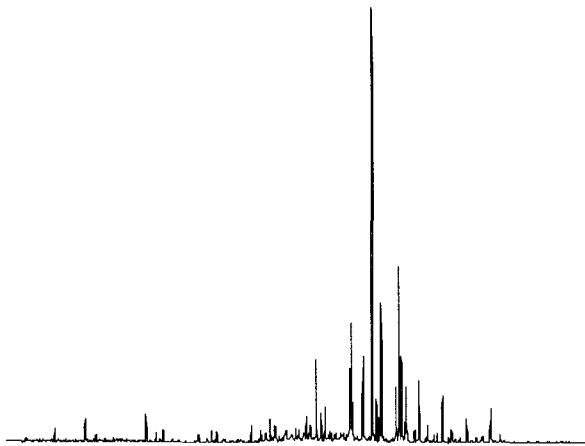
Fig. 27.



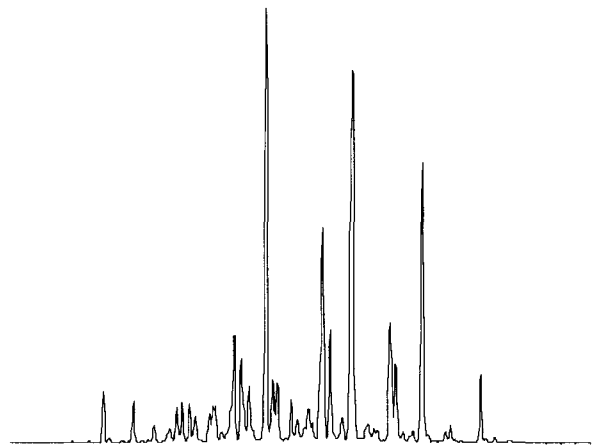
Gas Chromatogram



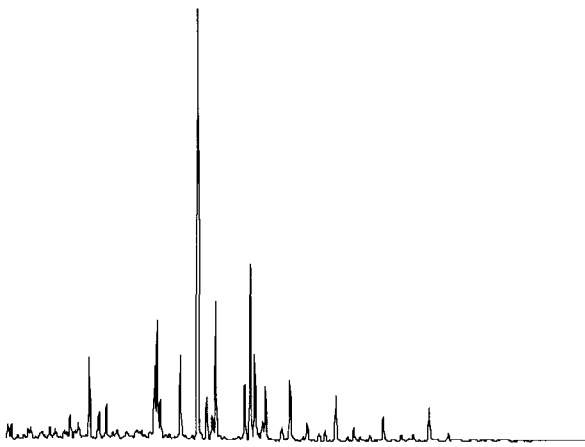
m/z 217



m/z 191 (full)



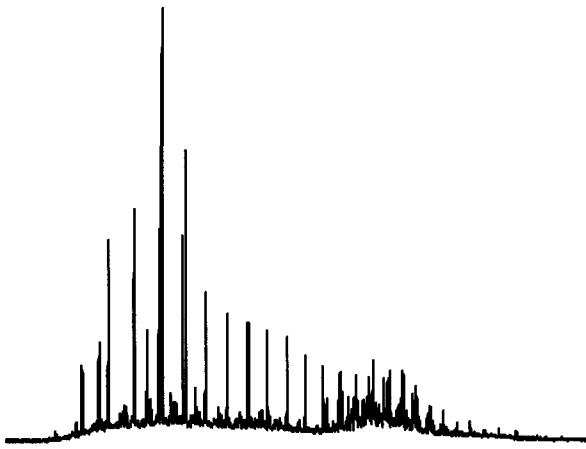
m/z 218



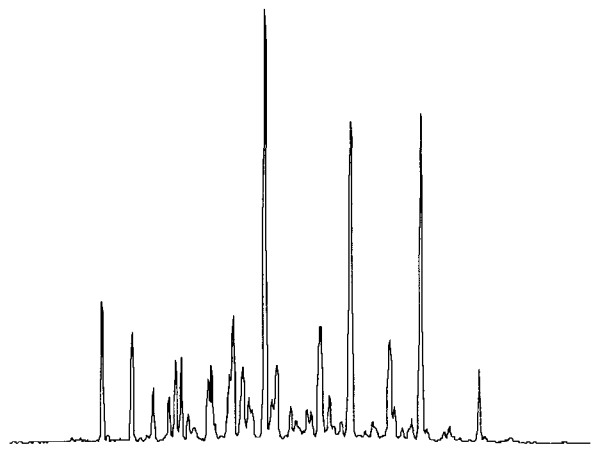
m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7243
Core sample, D = 315.01 m

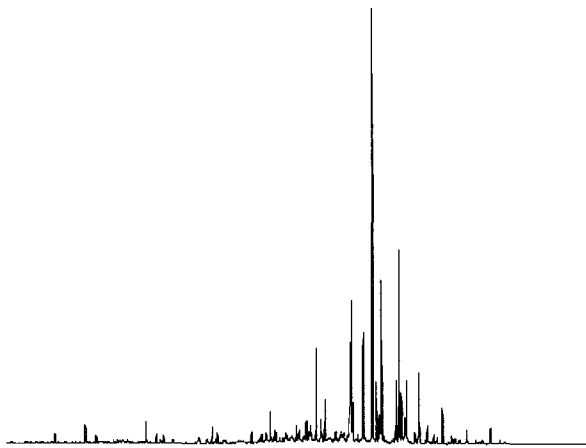
Fig. 28.



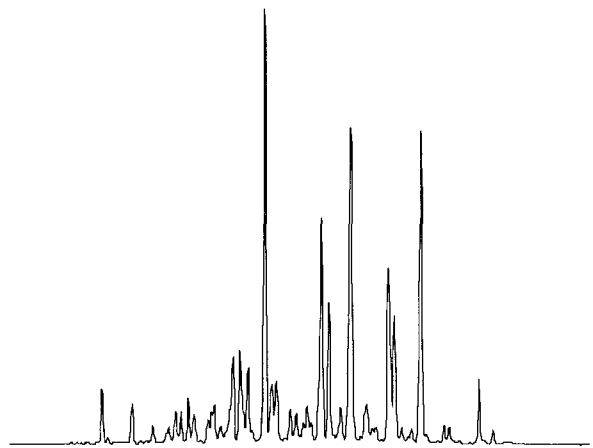
Gas Chromatogram



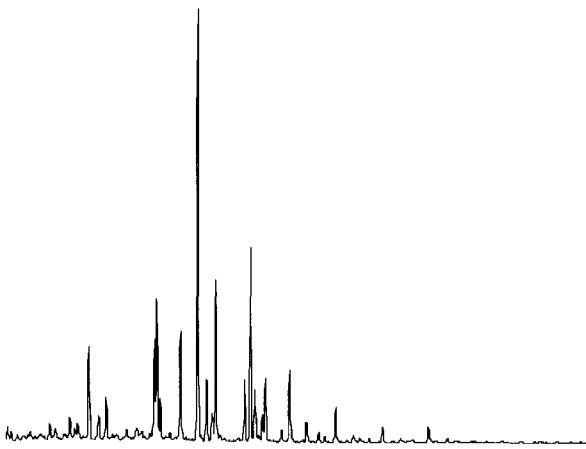
m/z 217



m/z 191 (full)



m/z 218



m/z 191 (partial)

AMOCO
Rebecka C. Bounds well
Kansas, USA
Lab. # 2001064-7249
Core sample, D = 323.24 m

Fig. 29.

References

Dean, W. E. & Arthur, M. A. (eds.) 1998, Stratigraphy and Paleoenvironments of the Cretaceous Wesyerb Interior Seaway, USA, SEPM concepts in Sedimentology and Paleontology No.6

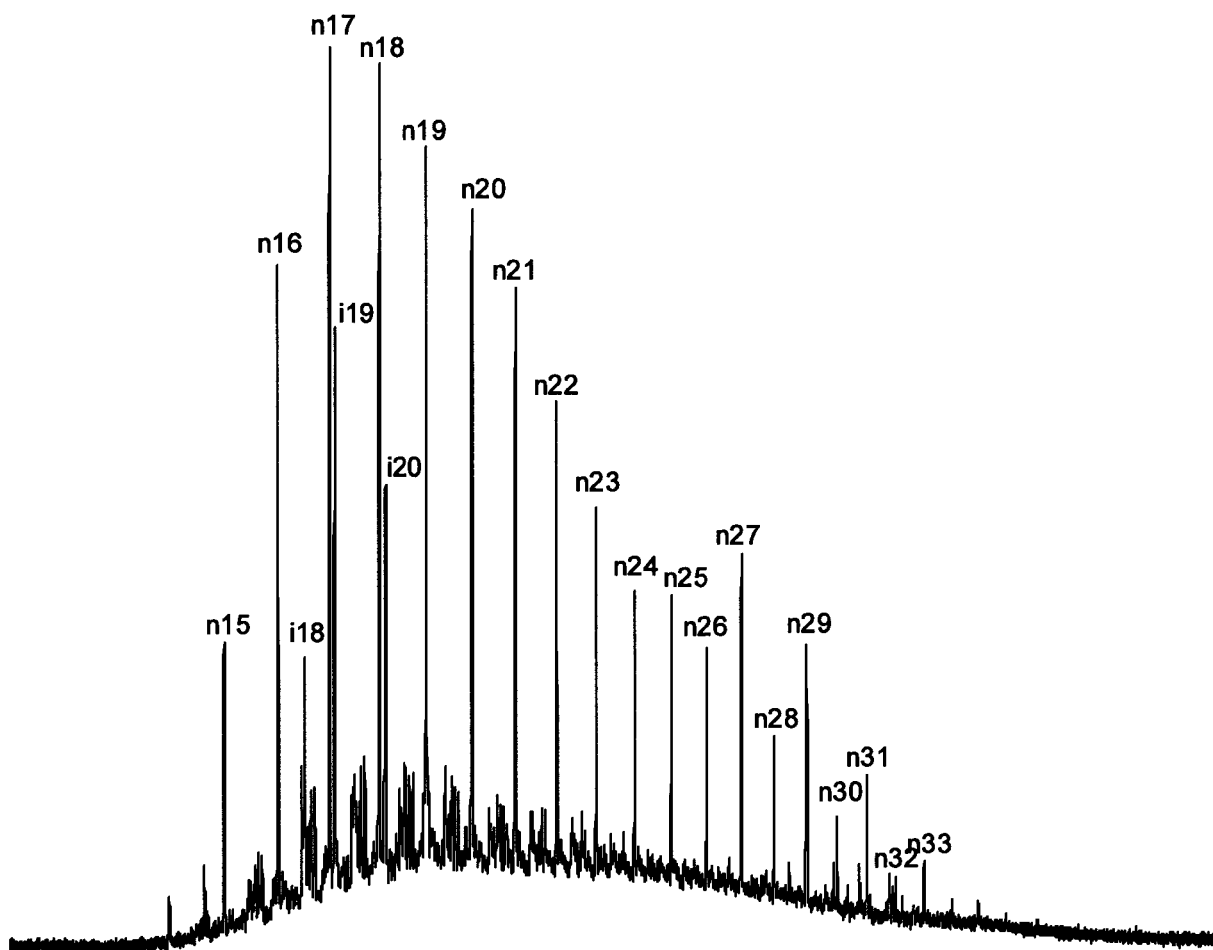
Radke, M., Willsch, H. & Welte, D. H. 1980. Preparative hydrocarbon group type determination by automated medium pressure liquid chromatography. Analytical Chemistry 52, 406-411

Appendix 1

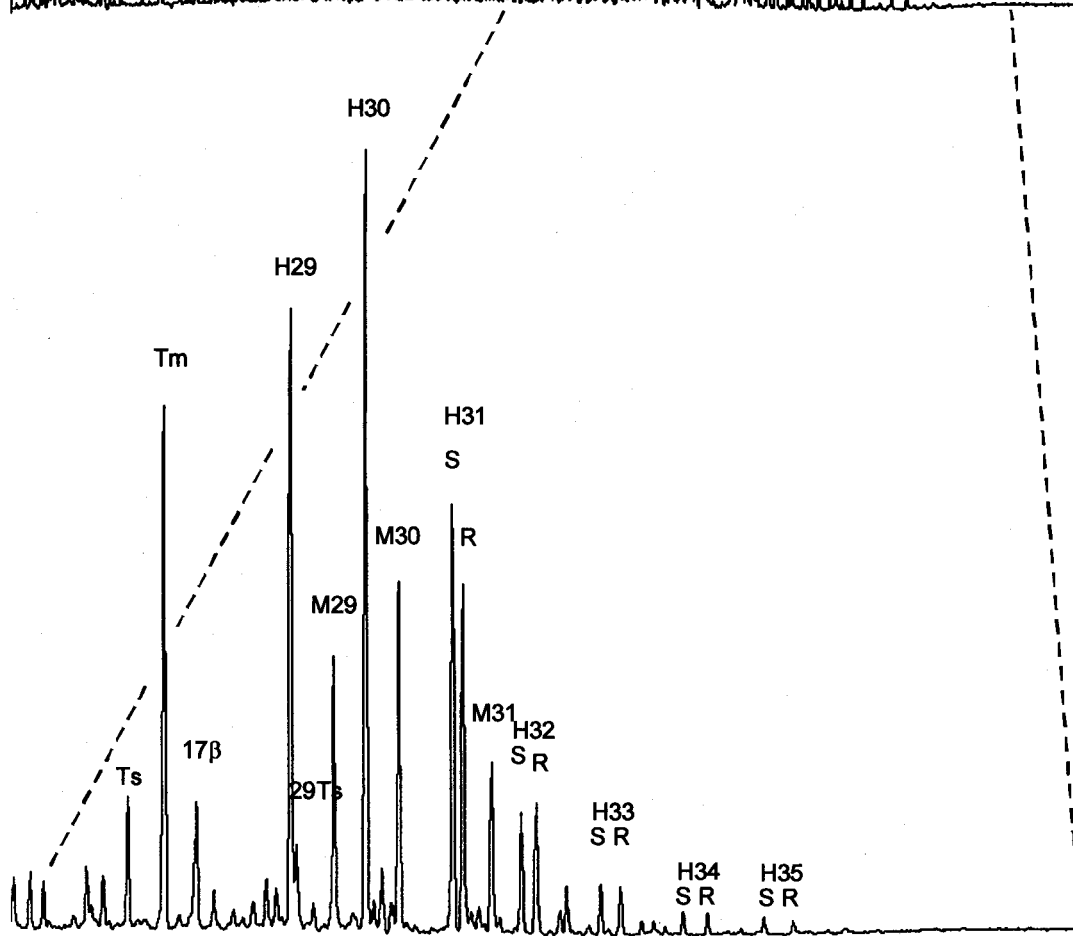
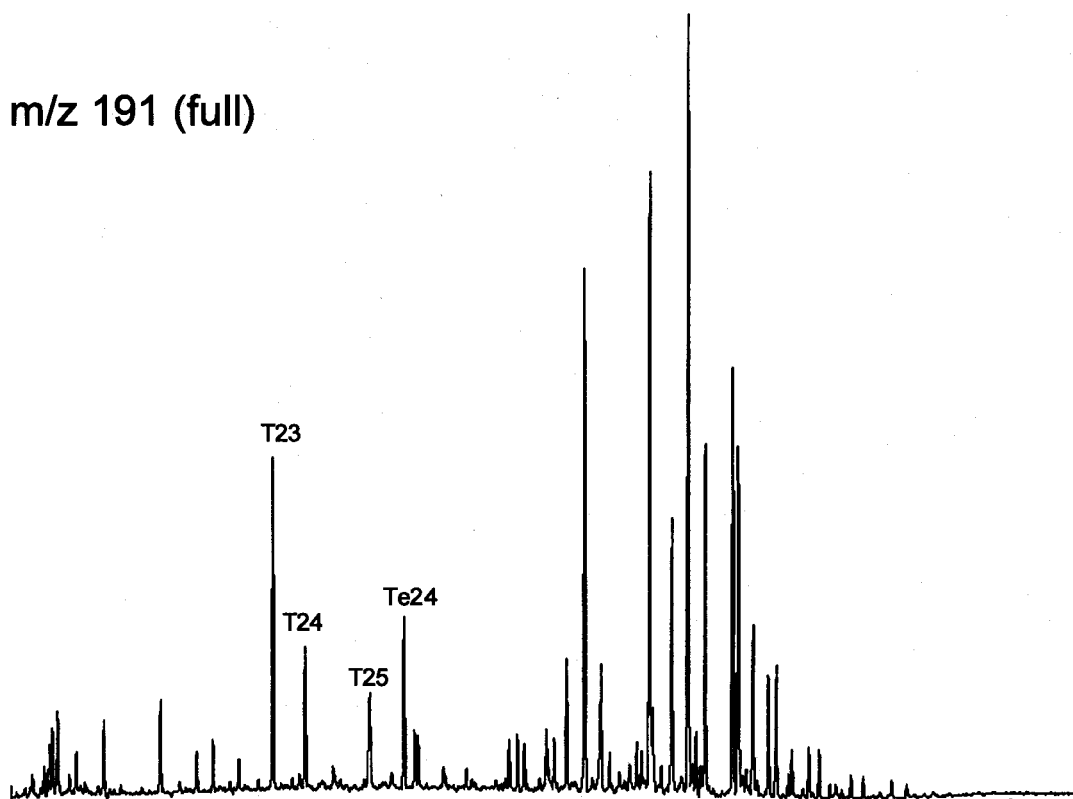
Compound identification key

n15	C ₁₅ normal alkane
n16	C ₁₆ normal alkane
i18	C ₁₈ acyclic isoprene
n17	C ₁₇ normal alkane
i19	C ₁₉ (=pristane) acyclic isoprene
n18	C ₁₈ normal alkane
i20	C ₂₀ (=phytane) acyclic isoprene
n19	C ₁₉ normal alkane
n20	C ₂₀ normal alkane
n21	C ₂₁ normal alkane
n22	C ₂₂ normal alkane
n23	C ₂₃ normal alkane
n24	C ₂₄ normal alkane
n25	C ₂₅ normal alkane
n26	C ₂₆ normal alkane
n27	C ₂₇ normal alkane
n28	C ₂₈ normal alkane
n29	C ₂₉ normal alkane
n30	C ₃₀ normal alkane
n31	C ₃₁ normal alkane
n32	C ₃₂ normal alkane
n33	C ₃₃ normal alkane
T23	C ₂₃ tricyclic triterpane
T24	C ₂₄ tricyclic triterpane
T25	C ₂₅ tricyclic triterpane 22R+22S coeluting
Te24	C ₂₄ tetracyclic terpane
Ts	C ₂₇ 18 α (H)trisorneohopane
Tm	C ₂₇ 17 α (H)trisorneohopane
17b	C ₂₇ 17 β (H)trisorneohopane
H29	C ₂₉ 30-norhopane
29Ts	C ₂₉ 18 α (H)norneohopane
M29	C ₂₉ normoretane
H30	C ₃₀ hopane
M30	C ₃₀ moretane
H31S	C ₃₁ homohopane 22S
H31R	C ₃₁ homohopane 22R
M31	C ₃₁ homomoretane, 22S+22R coeluting
H32S	C ₃₂ bishomohopane 22S
H32R	C ₃₂ bishomohopane 22R
H33S	C ₃₃ trishomohopane
H33R	C ₃₃ trishomohopane 22R
H34S	C ₃₄ tetrakishomohopane 22S
H34R	C ₃₄ tetrakishomohopane 22R

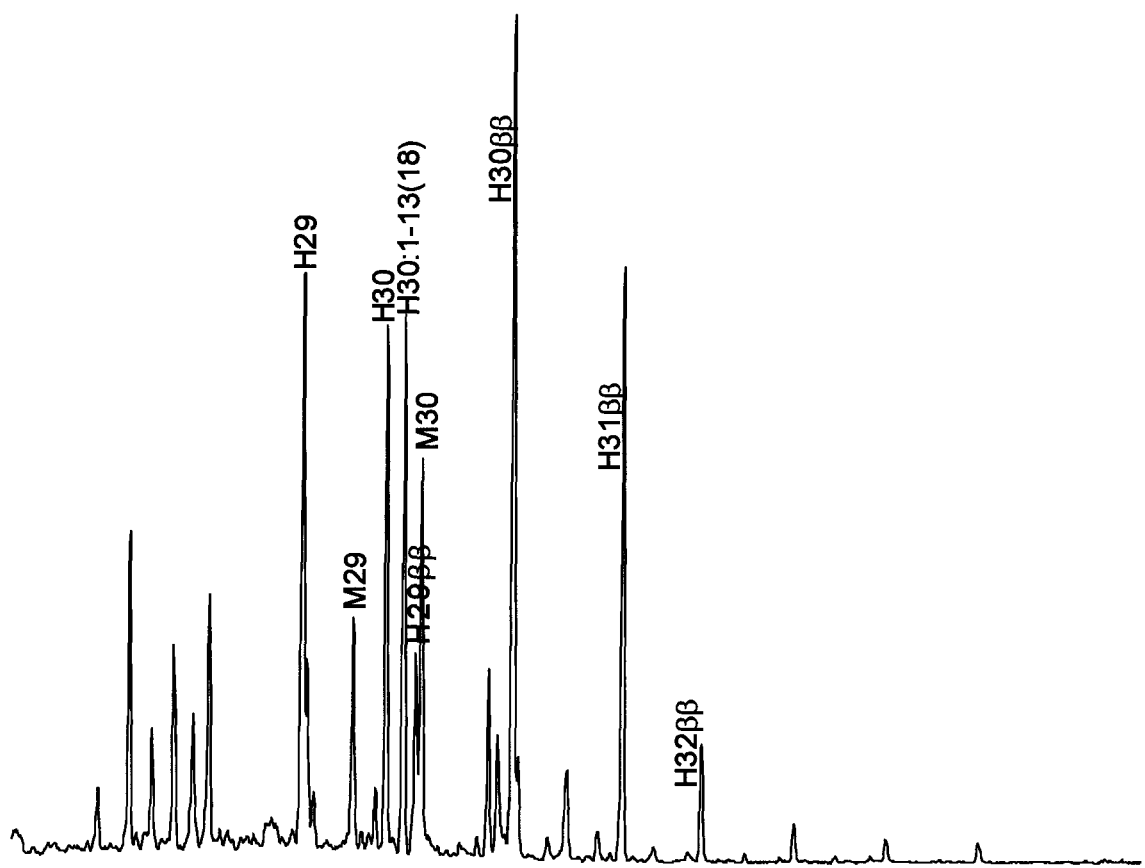
H35S	C ₃₅ pentakishomohopane 22S
H35R	C ₃₅ pentakishomohopane 22R
DS27	C ₂₇ diasterane, unknown isomer
RS29aS	C ₂₉ regular sterane, $\alpha\alpha\alpha$ -20S isomer
RS29bR	C ₂₉ regular sterane, $\alpha\beta\beta$ -20R isomer
RS29bS	C ₂₉ regular sterane, $\alpha\beta\beta$ -20S isomer
RS29aR	C ₂₉ regular sterane, $\alpha\alpha\alpha$ -20R isomer
RS27bR (m/z 218)	C ₂₇ regular sterane, $\alpha\beta\beta$ -20R isomer
RS27bS (m/z 218)	C ₂₇ regular sterane, $\alpha\beta\beta$ -20S isomer
RS28bR (m/z 218)	C ₂₈ regular sterane, $\alpha\beta\beta$ -20R isomer
RS28bS (m/z 218)	C ₂₈ regular sterane, $\alpha\beta\beta$ -20S isomer
RS29bR (m/z 218)	C ₂₉ regular sterane, $\alpha\beta\beta$ -20R isomer
RS29bS (m/z 218)	C ₂₉ regular sterane, $\alpha\beta\beta$ -20S isomer
RS30bR (m/z 218)	C ₃₀ regular sterane, $\alpha\beta\beta$ -20R isomer
RS30bS (m/z 218)	C ₃₀ regular sterane, $\alpha\beta\beta$ -20S isomer



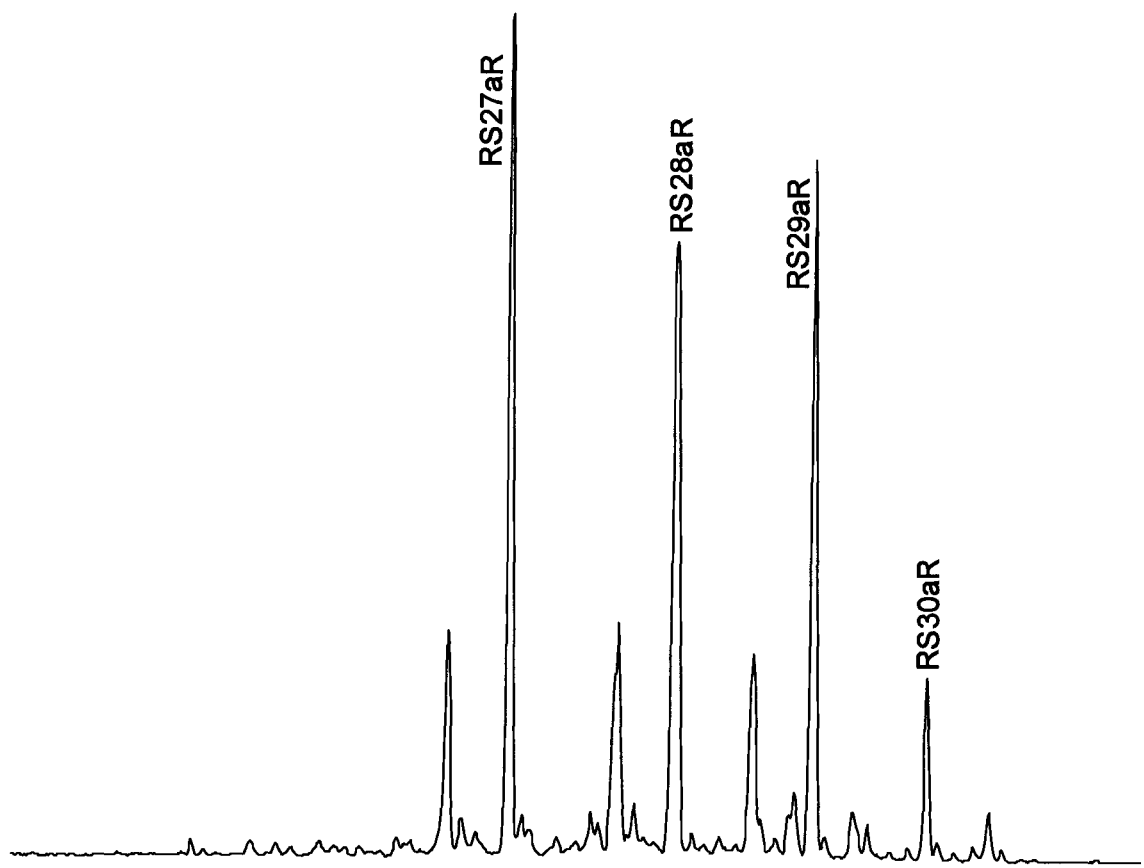
m/z 191 (full)



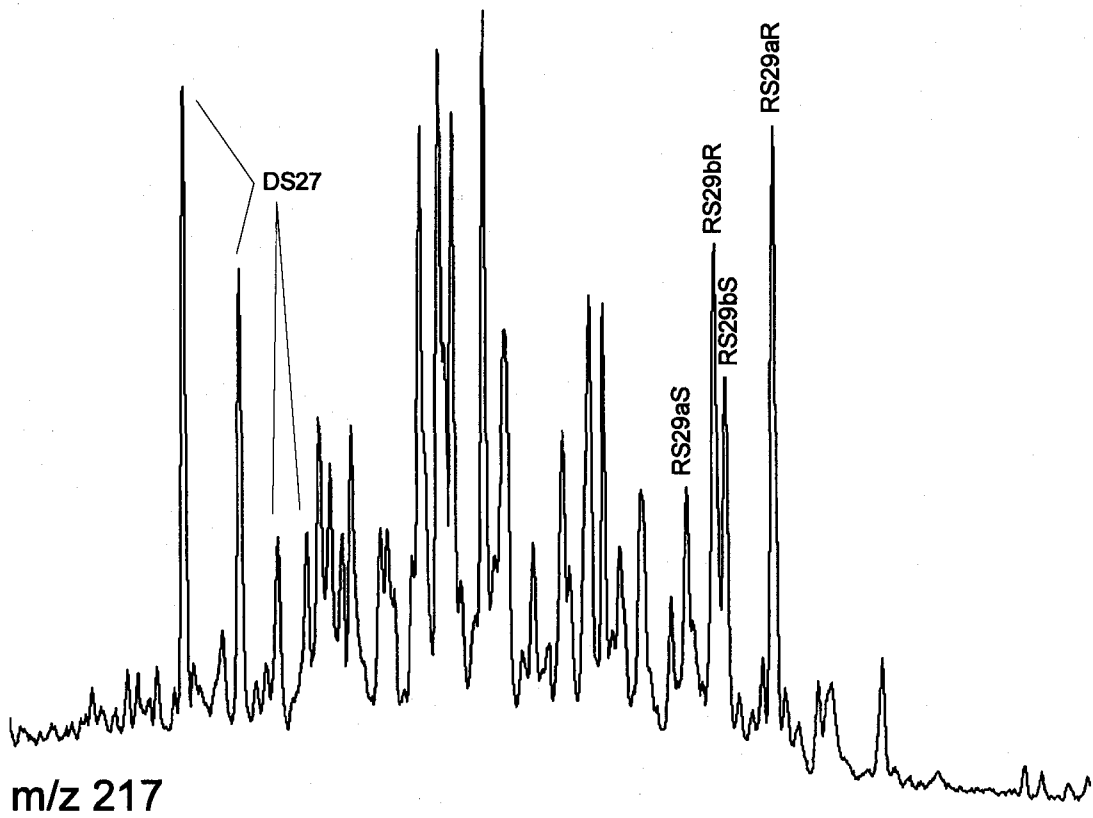
m/z 191 (partial)



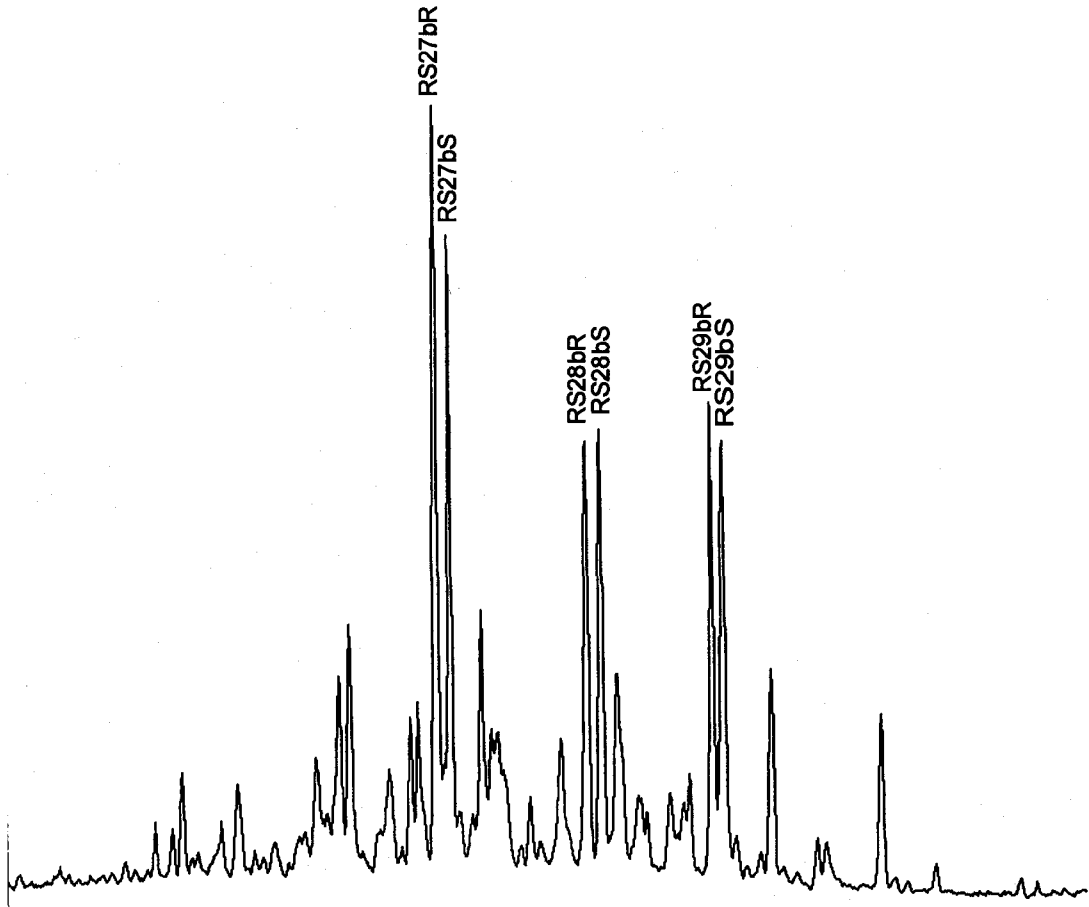
m/z 191(partial), low maturity sample



m/z 217, low maturity sample



m/z 217



m/z 218

Appendix 2

Gas Chromatography data

Lab #	Depth (m)	Location	Pr/Ph	Pr/n17	Ph/n18	i/n	bias	CPI
2001064-7221	277,06	Amoco Rebecka Bounds #1 well, Kansas	1,63	2,31	1,77	0,97	2,49	0,83
2001064-7223	280,87	Amoco Rebecka Bounds #1 well, Kansas	1,51	2,12	1,61	0,91	2,43	0,92
2001064-7229	293,22	Amoco Rebecka Bounds #1 well, Kansas	2,24	3,13	1,63	1,11	1,78	0,86
2001064-7233	298,09	Amoco Rebecka Bounds #1 well, Kansas	2,33	3,75	2,07	1,34	2,27	0,80
2001064-7238	306,55	Amoco Rebecka Bounds #1 well, Kansas	1,83	2,78	1,94	1,08	1,49	0,97
2001064-7243	315,01	Amoco Rebecka Bounds #1 well, Kansas	1,44	2,21	2,06	1,00	2,02	1,01
2001064-7249	323,24	Amoco Rebecka Bounds #1 well, Kansas	1,60	2,89	2,13	1,17	2,51	1,20
Average, Amoco Rebecka Bounds #1 well			1,77	2,70	1,88	1,08	2,09	0,94
2001064-7257	86,56	USGS Escalante #1 well, Utah	0,63	1,63	1,90	1,02	2,28	1,48
2001064-7267	103,63	USGS Escalante #1 well, Utah	0,67	1,36	1,25	0,75	1,19	0,96
2001064-7275	118,87	USGS Escalante #1 well, Utah	0,69	0,74	1,53	0,60	3,95	1,04
2001064-7284	138,99	USGS Escalante #1 well, Utah	1,04	0,91	1,08	0,54	2,84	0,89
2001064-7296	164,59	USGS Escalante #1 well, Utah	1,06	0,68	0,75	0,45	5,03	1,37
2001064-7305	183,79	USGS Escalante #1 well, Utah	0,85	1,60	2,70	0,94	2,17	0,82
Average, USGS Escalante #1 well			0,79	1,03	1,42	0,67	2,63	1,05
2001064-7312	137,46	USGS Portland #1 well, Colorado	2,75	1,63	0,79	0,71	2,11	0,99
2001064-7314	138,91	USGS Portland #1 well, Colorado	2,94	1,63	0,71	0,69	2,31	0,97
2001064-7320	145,85	USGS Portland #1 well, Colorado	2,87	1,42	0,44	0,45	2,54	0,95
2001064-7331	156,97	USGS Portland #1 well, Colorado	2,43	1,85	0,94	0,79	2,47	0,92
2001064-7334	159,72	USGS Portland #1 well, Colorado	2,30	1,50	0,86	0,69	2,94	0,97
2001064-7340	167,64	USGS Portland #1 well, Colorado	2,43	1,90	0,91	0,79	2,72	0,97
Average, USGS Portland #1 well			2,59	1,66	0,76	0,68	2,49	0,96

Pr/Ph : pristane/phytane

Pr/nC17: pristane/n-heptadecane

Ph/nC18: phytane/n-octadecane

i/n : C15-20 isoprenoids/c15-20 n-alkanes

bias : nC15-22/nC23-30

Biomarker Maturity

Lab #	Depth (m)	Location	H31 (S/S+R)	H32 (S/S+R)	RS29 (S/S+R)	RS29 ($\beta\beta/\alpha\alpha+\beta\beta$)	Ts/(Ts+Tm)
2001064-7221	277,06	Amoco Rebecka Bounds #1 well, Kansas	0,30	0,29	0,06	0,28	0,43
2001064-7223	280,87	Amoco Rebecka Bounds #1 well, Kansas	0,22	0,14	0,08	0,32	0,30
2001064-7229	293,22	Amoco Rebecka Bounds #1 well, Kansas	0,23	0,17	0,10	0,33	0,21
2001064-7233	298,09	Amoco Rebecka Bounds #1 well, Kansas	0,22	0,17	0,09	0,36	0,24
2001064-7238	306,55	Amoco Rebecka Bounds #1 well, Kansas	0,28	0,21	0,07	0,27	0,38
2001064-7243	315,01	Amoco Rebecka Bounds #1 well, Kansas	0,24	0,16	0,06	0,25	0,24
2001064-7249	323,24	Amoco Rebecka Bounds #1 well, Kansas	0,25	0,14	0,06	0,29	0,21
Average, Amoco Rebecka Bounds #1 well			0,25	0,18	0,07	0,31	0,29
2001064-7257	86,56	USGS Escalante #1 well, Utah	0,11	0,21	0,03	0,25	0,08
2001064-7267	103,63	USGS Escalante #1 well, Utah	0,18	0,33	0,04	0,21	0,18
2001064-7275	118,87	USGS Escalante #1 well, Utah	0,38	0,39	0,04	0,25	0,13
2001064-7284	138,99	USGS Escalante #1 well, Utah	0,17	0,25	0,04	0,23	0,14
2001064-7296	164,59	USGS Escalante #1 well, Utah	0,15	0,08	0,03	0,21	0,18
2001064-7305	183,79	USGS Escalante #1 well, Utah	0,14	0,13	0,04	0,21	0,11
Average, USGS Escalante #1 well			0,20	0,20	0,04	0,23	0,14
2001064-7312	137,46	USGS Portland #1 well, Colorado	0,61	0,58	0,23	0,25	0,29
2001064-7314	138,91	USGS Portland #1 well, Colorado	0,63	0,56	0,22	0,20	0,29
2001064-7320	145,85	USGS Portland #1 well, Colorado	0,62	0,57	0,21	0,19	0,34
2001064-7331	156,97	USGS Portland #1 well, Colorado	0,62	0,58	0,26	0,23	0,36
2001064-7334	159,72	USGS Portland #1 well, Colorado	0,59	0,56	0,26	0,25	0,34
2001064-7340	167,64	USGS Portland #1 well, Colorado	0,62	0,58	0,27	0,24	0,41
Average, USGS Portland #1 well			0,61	0,57	0,24	0,23	0,33

H31 (S/S+R): Homohopane 22S/(22S+22R) ratio

H32 (S/S+R): Bishomohopane 22S/(22S+22R) ratio

RS29 (S/S+R): C29 Regular sterane 20S/(20S+20R) ratio

RS29 ($\beta\beta/\alpha\alpha+\beta\beta$): C29 Regular sterane ($\beta\beta/\alpha\alpha+\beta\beta$) ratio

Sterane distribution

Lab #	Depth (m)	Location	% RS27 (m/z 218)	% RS28 (m/z 218)	% RS29 (m/z 218)	% RS30 (m/z 218)	DS27/R S27
2001064-7221	277,06	Amoco Rebecka Bounds #1 well, Kansas	19,69	41,85	34,77	3,69	0,48
2001064-7223	280,87	Amoco Rebecka Bounds #1 well, Kansas	17,73	44,21	33,81	4,26	0,55
2001064-7229	293,22	Amoco Rebecka Bounds #1 well, Kansas	20,00	40,83	35,56	3,61	0,40
2001064-7233	298,09	Amoco Rebecka Bounds #1 well, Kansas	23,57	33,26	40,31	2,86	0,53
2001064-7238	306,55	Amoco Rebecka Bounds #1 well, Kansas	13,42	52,81	29,87	3,90	0,42
2001064-7243	315,01	Amoco Rebecka Bounds #1 well, Kansas	26,02	43,90	26,83	3,25	0,50
2001064-7249	323,24	Amoco Rebecka Bounds #1 well, Kansas	20,76	41,52	33,91	3,81	0,52
Average, Amoco Rebecka Bounds #1 well			20,32	41,71	34,36	3,61	0,48
2001064-7257	86,56	USGS Escalante #1 well, Utah	16,06	44,56	34,20	5,18	0,00
2001064-7267	103,63	USGS Escalante #1 well, Utah	14,88	52,98	27,38	4,76	0,08
2001064-7275	118,87	USGS Escalante #1 well, Utah	25,00	40,82	28,06	6,12	0,04
2001064-7284	138,99	USGS Escalante #1 well, Utah	24,48	42,71	28,13	4,69	0,04
2001064-7296	164,59	USGS Escalante #1 well, Utah	20,47	50,23	24,65	4,65	0,05
2001064-7305	183,79	USGS Escalante #1 well, Utah	22,94	43,12	29,36	4,59	0,05
Average, USGS Escalante #1 well			20,81	45,60	28,60	4,99	0,04
2001064-7312	137,46	USGS Portland #1 well, Colorado	25,66	40,12	30,97	3,24	0,45
2001064-7314	138,91	USGS Portland #1 well, Colorado	24,84	40,45	31,21	3,50	0,42
2001064-7320	145,85	USGS Portland #1 well, Colorado	38,67	22,67	36,00	2,67	0,66
2001064-7331	156,97	USGS Portland #1 well, Colorado	28,68	42,64	26,43	2,24	0,58
2001064-7334	159,72	USGS Portland #1 well, Colorado	26,59	46,15	24,40	2,86	0,58
2001064-7340	167,64	USGS Portland #1 well, Colorado	29,76	40,00	27,32	2,93	0,69
Average, USGS Portland #1 well			28,45	40,07	28,59	2,89	0,58

DS27/RS27 : C27 diasterane/regular sterane, 4+4 isomers, m/z 217

Triterpanes

Lab #	Depth (m)	Location	SumT/ H30	H29/ H30	100*BNH/ H30	100*D30/ H30	HOPI
2001064-7221	277,06	Amoco Rebecka Bounds #1 well, Kansas	0,16	0,39	0,00	0,00	0,00
2001064-7223	280,87	Amoco Rebecka Bounds #1 well, Kansas	0,42	0,26	0,00	0,00	0,00
2001064-7229	293,22	Amoco Rebecka Bounds #1 well, Kansas	0,32	0,63	0,00	0,00	6,37
2001064-7233	298,09	Amoco Rebecka Bounds #1 well, Kansas	0,20	0,41	0,00	0,00	6,30
2001064-7238	306,55	Amoco Rebecka Bounds #1 well, Kansas	0,14	0,40	0,00	0,00	7,51
2001064-7243	315,01	Amoco Rebecka Bounds #1 well, Kansas	0,20	0,28	0,00	0,00	9,15
2001064-7249	323,24	Amoco Rebecka Bounds #1 well, Kansas	0,14	0,33	0,00	0,00	4,23
Average, Amoco Rebecka Bounds #1 well			0,22	0,39	0,00	0,00	5,51
2001064-7257	86,56	USGS Escalante #1 well, Utah	0,81	1,10	0,00	0,00	0,00
2001064-7267	103,63	USGS Escalante #1 well, Utah	0,51	0,99	0,00	0,00	0,00
2001064-7275	118,87	USGS Escalante #1 well, Utah	0,69	1,25	0,00	0,00	0,00
2001064-7284	138,99	USGS Escalante #1 well, Utah	0,33	0,78	0,00	0,00	0,00
2001064-7296	164,59	USGS Escalante #1 well, Utah	3,41	1,23	0,00	0,00	0,00
2001064-7305	183,79	USGS Escalante #1 well, Utah	0,45	1,45	0,00	0,00	0,00
Average, USGS Escalante #1 well			1,01	1,11	0,00	0,00	0,00
2001064-7312	137,46	USGS Portland #1 well, Colorado	0,43	0,74	0,00	0,00	6,18
2001064-7314	138,91	USGS Portland #1 well, Colorado	0,36	0,66	0,00	0,00	6,21
2001064-7320	145,85	USGS Portland #1 well, Colorado	0,40	0,51	3,50	4,20	3,52
2001064-7331	156,97	USGS Portland #1 well, Colorado	0,40	0,59	1,40	0,00	6,58
2001064-7334	159,72	USGS Portland #1 well, Colorado	0,27	0,52	1,40	1,40	6,62
2001064-7340	167,64	USGS Portland #1 well, Colorado	0,27	0,48	2,10	2,80	5,66
Average, USGS Portland #1 well			0,36	0,58	1,40	1,40	5,69

SumT/H30: Sum C20-25 tricyclic triterpanes/hopane

H29/H30: norhopane/hopane

100*BNH/H30: 100*28,30-bisnorhopane/hopane

100*D30/H30: 100* diahopane/hopane

HOPI: Homohopane Index