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SOURCE ROCK ANALYSIS AND PETROLEUM GEOCHEMISTRY, PELICAN-5, T-22-P, BASS BASIN R210/86

Amoco Australian Petroleum Company

F3/786/0-F6416/86(Part 7) October 1986

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24 October 1986

F 3/786/0-F6416/86 - Part 7 (Final)

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Attention: C.W. Waring/K. Grant

REPORT F 6416/86 - Part 7 (Final)

YOUR REFERENCE: LPO's 985 and 1259

TITLE: Source rock analysis and petroleum geochemistry, Pelican-5, T-22-P, Bass Basin

MATERIAL: Canned cuttings (131 samples). Sidewall cores (34 samples). Gilsonite (1 sample). Condensate (1 sample).

LOCALITY: PELICAN-5

IDENTIFICATION: As in Tables 1, 5 and 6 of report

DATE RECEIVED: 13 February, 8 April and 5 May, 1986

WORK REQUIRED: Source Rock Analysis: Headspace gas (131 samples). Total organic carbon (103 samples). Rock-Eval pyrolysis (103 samples).
Petroleum Geochemistry: Hand-picking of cuttings (4 samples). Solvent extraction of residual oil (2 samples). MS-PONA analysis of condensate (1 sample). Topping condensate to 210°C (1 sample). Deasphaltening and liquid chromatography (6 samples). GC of saturates (6 samples). Isolation and GC-MS of naphthenes (3 samples). Methylphenanthrene index (MPI) by GC-MS of aromatics (1 sample). Interpretation.

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1. INTRODUCTION

Canned cuttings (131 samples), sidewall cores (34 samples), a condensate and a gilsonite mud additive from Pelican-5 were submitted for organic geochemical analysis.

The aims of the study were threefold:

1) to assess the hydrocarbon source potential of the Eastern View Coal Measures below 1776 metres depth in Pelican-5,

2) to determine the type, source affinity, maturity and degree of post-pooling alteration (water washing, biodegradation) of condensate recovered from an Eocene reservoir during RFT 3 (2788 metres); and

3) to evaluate the significance of live oil and/or bitumen noted during organic petrological examination of cuttings from 2169-2178, 2790-2799 and 2961-2970 metres depth (Watson, 1986).

A previous study of Pelican-5 (Watson, 1986) provided vitrinite reflectance data and descriptions of the dispersed organic matter (DOM) in selected samples from the interval 1851-4247 metres depth.

Preliminary headspace gas, total organic carbon (TOC) and Rock-Eval pyrolysis data on the cuttings and sidewall cores, and compositional data on the condensate, bitumen and gilsonite were facsimilied to S. Bane/G. Kjellgren on 14, 18 March, 1, 18, 23 April, 16, 20 May and 2 June 1986; and formally presented in several interim reports (McKirdy, 1986 a,b; McKirdy and O'Leary, 1986; McKirdy and Watson, 1986 a). These geochemical data are collated and interpreted in the present report.

A companion report (McKirdy and Watson, 1986 b) contains the results of a detailed comparison of the hydrocarbon source potential of coal/shale pairs from the Eocene, Paleocene and Cretaceous sections in Pelican-5.

2. ANALYTICAL PROCEDURE

Details of the analytical methods are given in Appendix 1.

3. RESULTS

Analytical data are summarised and presented herein as follows:

	Table	Figure	Appendix
Source Rock Analysis			
Headspace gas	1,2	1-4	-
Total organic carbon	3-5	-	-
Rock-Eval pyrolysis	4,5	5-7	-
Vitrinite reflectance	-	-	2
Condensate Analysis			
Gasoline-range (C_5-C_7) analysis	6,7	8,9	3
C_{12+} bulk composition	8	10	-
C_{12+} saturates (alkanes)	8	11	-
GC-MS of naphthenes	10,11	14-16,20,21	4
GC-MS of aromatics	12	22	-

Bitumen, Residual Oil Analysis	Table	Figure	Appendix
C_{15+} bulk composition	9	11	-
C_{15+} saturates (alkanes)	9	12,13	-
GC-MS of naphthenes	10,11	17-21	4

4. SOURCE ROCK ANALYSIS

4.1 Maturity

The vitrinite reflectance versus depth profile for Pelican-5 (Appendix 2) indicates that the Eocene section of the Eastern View Coal Measures above 1900 metres depth is thermally immature (VR <0.5%). However, generation of light oil from sediments of such low rank may occur where the DOM is rich in resinite (Snowdon and Powell, 1982; Powell, 1985), as appears to be the case at Pelican-5 (Watson, 1986).

Eocene sediments within the interval 1900-2780 metres depth are marginally mature (VR = 0.5-0.7%). The presence of exsudatinite in coals and oil in sandstones and siltstones from this part of the section (Watson, *op. cit.*) suggests that mobilisation of liquid hydrocarbons has commenced.

The rank threshold for significant gas generation from terrestrial (woody-herbaceous) organic matter (VR = 0.55% : Monnier *et al.*, 1983) occurs at 2160 metres depth, coinciding with a five-fold increase in cuttings gas (C_1-C_4) yield between 2000 and 2200 metres depth in the Eocene sequence (Fig. 1).

Oil generation from resinite-poor terrestrial organic matter commences at VR = 0.7% (Powell, 1985). Thus, the top of the oil window in Pelican-5 is located at approximately 2775 metres depth, still within the Eocene. The base of the oil window (VR = 1.35%) is reached at about 3975 metres depth in the Cretaceous portion of the Eastern View Coal Measures.

Headspace gas data delineate the same trend of increasing maturity with depth that is evident from the vitrinite reflectance profile (Appendix 2). In particular,

1. total gas (C_1-C_4) reaches a maximum at approximately 2700 metres depth and declines sharply over the interval 3600-4000 metres depth (Fig. 1);

2. percent wet gas values in excess of 50% occur between 2600 and 3700 metres depth (Fig. 2B); and

3. the $\underline{n}$-C_4/$\underline{n}$-C_4 (Fig. 3) and $\underline{i}$-C_5/$\underline{n}$-C_5 (Fig. 4) isomeric ratios respond in textbook fashion to increasing maturity (cf. Alexander *et al.*, 1983).

Rock-Eval Tmax values agree reasonably well with measured vitrinite reflectance (Figs. 5-7). Low Tmax values and high production indices (PI = 0.35-0.54) were obtained from several SWC samples of the Cretaceous sequence (Table 5, Fig. 7B). These anomalous values are due to a combination of instrumental errors in handling small ill-defined S_2 peaks, and the effects of staining by migrated hydrocarbons (Peters, 1986) or contamination from mud invasion of the sidewall core.

Another maturation parameter, the Rock-Eval production index increases from PI = 0.04-0.10 in immature Eocene sediments to PI = 0.20-0.35 in the mature Paleocene and Cretaceous sections of the Eastern View Coal Measures. Cuttings from the Cretaceous section gave lower PI values than did sidewall cores. This is believed due to the presence of caved coal in the cuttings (Watson, 1986).

4.2 Source Richness

The Eastern View Coal Measures has good to very good gas richness (C_1-C_4 = 10000-180000 ppm) throughout the interval sampled, but particularly between 2100 and 3600 metres depth (Eocene-Paleocene) where yields commonly exceed 50000 ppm (Fig. 1). Wet gas (C_{5+}) yields in excess of 1000 ppm occur at two levels which produced hydrocarbons on test:

Depth m	C_{5+} Yield ppm	Test
2709-2817	1000-2300	1) DST 6, 2786-2790 m, gas @ 3.5 MMCFD and condensate @ 400 BPD
		2) RFT 3, 2788 m, condensate
3150-3645 (Paleocene)	1300-15900	DST 4, 3143-3162.5 m, gas @ 300 MCFD and trace oil

Total organic carbon values (Tables 4, 5) decrease with increasing depth in the Eastern View Coal Measures, thus:

	TOC Range %	TOC Mean %	n
Eocene	1.10-79.2	16.1	57
Paleocene	0.96-47.0	10.4	27
Cretaceous	0.82-13.7	3.1	19

The Eocene and Paleocene mean values, although well above average for clastic sediments, are heavily influenced by abundant coal in the sequence. Both TOC and Rock-Eval data for the cuttings may also be affected by contamination over those intervals where gilsonite was employed as a mud additive (cf. Peters, 1986).

The presence of coal complicates the assessment of *source richness*. Potential hydrocarbon yields (oil and gas) are very high for the Eocene and Paleocene (S_1+S_2 > 6-366 kg hydrocarbons/tonne : Tables 4, 5). However, much (if not most) of this genetic potential is likely to be for gas and condensate. [Note: Rock-Eval pyrolysis is a bulk-flow technique which is incapable of discriminating between C_1-C_4 (gas) and C_{5+} (oil, condensate) compounds in the kerogen pyrolysate, i.e. the S_2 peak].

Cuttings from the Cretaceous are contaminated by up-hole cavings. Apart from one carbonaceous claystone at 3846 metres depth (S_1+S_2 = 24 kg hydrocarbons/tonne), *sidewall core* data (Table 5) indicate poor source richness for the Cretaceous section (S_1+S_2 < 2 kg hydrocarbons/tonne).

Cuttings and SWC samples from the following intervals display the best source richness for hydrocarbons:

Age	Depth m	S_1+S_2 kg h'c/tonne	PC %	TOC %
Eocene	*1999	192	16.0	60.7
	*2039	204	17.0	65.0
	*2223	200	16.7	69.6
	*2298.5	245	20.4	68.8
	2332	22	21.5	4.45
	*2365	26	2.13	8.00
	2583	31	2.55	8.45
	2790	22	1.99	39.4
	*2794	366	30.5	79.2
	*2970.5	259	21.6	72.4
Paleocene	3132	59	4.92	15.7
	3168	34	2.84	9.00
	3204	171	14.2	47.0
	3240	64	5.36	21.0
	3258	74	6.20	22.7
	3276	78	6.51	18.4
	3294	45	3.78	13.4
	3312	23	1.90	7.15
	3366	80	6.64	23.1
	3384	40	3.35	8.35
	3420	64	5.29	17.4

*SWC sample; remainder cuttings.

4.3 Source Quality and Kerogen Type

Eocene

Although coal is the dominant carbonaceous lithofacies, hydrogen index values extend over a wide range (HI = 30-430 mg S_2/g TOC : Tables 4,5) at maturation levels of VR = 0.5-0.85%.

Two main types of Eocene organic matter can be recognised (Fig. 5A, B):

1) good quality oil and gas-prone Type II-III kerogen
   - HI = 150-430 mg S_2/g TOC
   - rich in vitrinite (45-85%) and exinite (10-40%) (Watson, 1986)
   - major exinites are resinite and suberinite, both thermally labile and therefore potentially generative at maturities as low as VR = 0.45% (main oil generation range, VR = 0.5-0.8%: Cook, 1986)

2) poor quality dry gas-prone Type IV kerogen
   - HI = 30-120 mg S_2/g TOC
   - mainly siltstone rich in inertinite

Paleocene

Hydrogen index values (HI = 55-360 mg S_2/g TOC: Tables 4, 5) reflect the presence of somewhat more mature oil and gas-prone Type II-III kerogen (Fig. 6A, B). Coal is less abundant in this part of the sequence which occupies the main zone of oil generation for resinite/suberinite-poor terrestrial organic matter (VR = 0.85-1.15%: Appendix 2).

Coal and carbonaceous shale/siltstone display systematic differences in maceral abundance, although exinite contents are similar (Watson, 1986):

	V	I	E
		%	
Coal	75-80	5-10	15-20
Shale/Siltstone	25-60	15-65	10-20

The major exinite in both cases is sporinite.

Cretaceous

The advanced maturity of the Cretaceous sediments (VR = 1.15-1.7%: Appendix 2) is apparent in their uniformly low hydrogen indices (HI = 40-175 mg S_2/g TOC: Tables 4, 5). Shale appears to be the most common organic-rich rock type.

Many shales are exceptionally rich in exinite (up to 85% of DOM, mostly micrinitised bituminite). Since the oil deadline for bituminite is VR = 0.9% (Cook, 1986), these Cretaceous shales are now spent (post-mature). However, at an earlier stage of their burial/maturation history, they were probably prolific sources of liquid hydrocarbons.

5. PETROLEUM GEOCHEMISTRY

5.1 Bulk Composition

The Pelican-5 condensate (RFT 3, 2788.2 m, Eocene) has a *paraffinic* C_{12+} bulk composition which differs markedly from the *aromatic-asphaltic* compositions of bitumen hand-picked from cuttings (2790-2799 metres), and gilsonite mud additive (Fig. 10).

The "residual oil" extracts of cuttings (2169-2178 and 2961-2970 metres) also have an aromatic-intermediate to aromatic-asphaltic composition (Table 9).

The gasoline-range (C_5-C_7) composition of the condensate (Tables 6, 7) displays no evidence of *in situ* alteration by water washing or biodegradation (Fig. 9).

5.2 Source Affinity

Condensate (RFT 3, 2788.2 metres)

The alkane composition (Fig. 8) and high aromatics content (9.2%: Table 6) of the C_5-C_7 hydrocarbon fraction of the Pelican-5 condensate reflect its derivation from land-plant organic matter.

Likewise, aspects of the C_{12+} composition of the condensate attest to its terrestrial source affinity. These include the dominance of C_{29} homologues in its C_{27}-C_{29} sterane and diasterane distributions (parameters 1-3, Table 10; Fig. 20). High pristane/phytane and pristane/n-heptadecane ratios (pr/ph = 7.7; pr/n-C_{17} = 1.4: Fig. 11) indicate that the primary terrigenous organic matter was exposed to oxic conditions en route to its final site of accumulation in a peat swamp environment (Fig. 21) where it was reworked by anaerobic acidophilic bacteria.

Bacteria were the precursors of the C_{15} and C_{16} drimanes (m/z 123), C_{27}-C_{35} hopanes (m/z 191) and (in lesser concentration) methylhopanes (m/z 205) found in the condensate (Fig. 15, Appendix 4).

Regular (head-to-tail) acyclic isoprenoids up to C_{40} have been tentatively identified in the Pelican-5 condensate (m/z 183, Fig. 15). This isoprenoid distribution differs in detail from those found in oils generated from source rocks deposited under stable *anoxic* conditions, and therefore attributed to methanogenic archaebacteria (McKirdy *et al.*, 1984, 1986). The higher isoprenoids (C_{21+}) in this crude are more likely to be derived from long-chain oligoterpenyl alcohols which occur in higher plants (Philp and Gilbert, 1986).

The m/z 123 and 259 mass fragmentograms of the Pelican-5 condensate (retention time 25-30 mins.: Fig. 14) confirm the presence of the tetracyclic diterpanes, phyllocladane, beyerane and kaurane. These particular C_{20} hydrocarbons are biological markers of conifer leaf resins (Noble *et al.*, 1985). Other conifer resin biomarkers present in the condensate are the C_{19} and C_{20} isopimaranes (Table 11, Fig. 14) which are particularly abundant in Mesozoic oils from the Gippsland Basin. It is noteworthy that resinite is a volumetrically significant component of coals in the Eastern View organic facies of both the Bass and Gippsland Basins (Smith and Cook, 1984; Shanmugam, 1985; Watson, 1986).

Bitumen (2790-2799 and 2961-2970 metres)

The compositions of the two bitumens and the gilsonite sample are nearly identical. This is evident from their respective C_{12+} alkane chromatograms (Figs. 12, 13) and biomarker distributions (Figs. 17-19). Although likewise of land plant/bacterial origin (Fig. 21), the bitumens and gilsonite differ in detail from the heavy ends of the condensate (see in particular biomarker parameters 1-3, 9, 14, 16, 18 and 21: Tables 10, 11; Fig. 20).

We conclude that these and other bitumens visible in cuttings from Pelican-5 (Watson, 1986) are not indigenous to the Eastern View Coal Measures, but rather are artefacts of the mud system.

Residual Oil (2169-2178 and 2961-2970 metres)

The C_{12+} alkane patterns of two of the cuttings extracts illustrated in Figure 13A, C are typical of immature to marginally mature terrestrial geolipids. Notice, in particular, the high pristane/n-heptadecane (pr/n-C_{17} >>1) and pristane/phytane (pr/ph = 7-10) ratios, and the high proportion of waxy (C_{23+}) n-alkanes with a marked odd/even carbon number predominance. The first of these patterns (Fig. 13A) is not oil-like, whereas the second (Fig. 13C) bears some similarity to that of the RFT 3 condensate (Fig. 11).

The one hour extract of the Eocene coal cuttings from 2961-2970 metres depth (Table 9) has a more oil-like C_{12+} alkane distribution (Fig. 13B) characterised by a lower pristane/n-heptadecane ratio (pr/n-C_{17} = 0.86) and a much reduced proportion of C_{23+} n-alkanes. This extract is likely to be more representative of any residual oil observed in these cuttings (Watson, 1986) than is the subsequent 5 hour extract. A combination of these two C_{12+} alkane patterns (Fig. 13B, C), without the major (but as yet unidentified) component eluting immediately before n-C_{20}, would produce a chromatogram which closely resembles that of the RFT 3 condensate (Fig. 11).

5.3 Maturity and Migration

Gasoline-range maturity parameters (Table 7, Fig. 9) and a high pristane/n-heptadecane ratio (pr/n-C_{17} >1: Tables 9, 10) suggest that the RFT 3 condensate is relatively *immature*. This is confirmed by its triaromatic hydrocarbon distribution (Fig. 22). The crude's methylphenanthrene index (MPI = 0.49: Table 7) converts to a calculated source maturity of VR = 0.69%.

This maturity coincides exactly with the maturation level of the Eocene reservoir sand which hosts the condensate (VR = 0.70%: Appendix 2). An *in situ* origin from Eocene coal is implied.

Biomarker-based maturation indices (parameters 4-6, 8-12:Table 10) demonstrate that sterane and triterpane isomerisation is complete in the condensate, although its trisnorhopane isomeric ratio (Tm/Ts = 2) is still greater than unity. These same biomarker ratios suggest that the condensate is substantially more mature than the bitumen/gilsonite (Table 10).

6. CONCLUSIONS

1. Non-marine sediments of the Eastern View Coal Measures above 1900 metres depth in Pelican-5 are thermally immature (VR <0.5%). Nevertheless the presence of abundant resinite and suberinite in low rank Eocene coals (VR = 0.45-0.85%) imparts potential for the generation of light oil.

2. Maturation limits for the onset and cessation of hydrocarbon generation from resinite-poor terrestrial organic matter are located at the following depths in Pelican-5 sequence:

	VR %	Depth m
top of gas window	0.55	2160 (Eocene)
top of oil window	0.70	2775 (Eocene)
base of oil window	1.35	3975 (Cretaceous)

3. Good quality, mature, oil and gas-prone Type II-III kerogen is present in the Eocene and Paleocene sections of the Eastern View Coal Measures, as follows:

Age/Principal Lithofacies	S_1+S_2 kg h'c/t	HI mg S_2/g TOC	VR %
Eocene/coal	6-366	150-430	0.5-0.85
Paleocene/coal and carbonaceous shale	6-171	100-360	0.85-1.15

The major exinites are resinite and suberinite (Eocene) and sporinite (Paleocene).

4. Although now post-mature for oil generation (HI = 55-175 mg S_2/g TOC; VR = 1.15-1.7%), Cretaceous shales are rich in micrinitised bituminite (up to 85% of DOM) and therefore were important potential sources of liquid hydrocarbons at an earlier stage of their burial history.

5. Paraffinic condensate recovered on test from an Eocene reservoir (2786-2790 metres depth) is relatively immature (source VR = 0.69%), and originated from adjacent coals.

6. Bitumen reported in cuttings from 2300-2800 metres depth was derived from a gilsonite mud additive. On the other hand, trace amounts of oil observed throughout the Eocene-Cretaceous section examined are (like the condensate) expulsion products of indigenous hydrogen-rich exinite macerals.

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TABLE 1

AMDEL HEADSPACE GAS ANALYSIS

Client AMOCO

Well PELICAN 5

RESULTS IN PPM

DEPTH (m)	METHANE	ETHANE	PROPANE	I-BUTANE	N-BUTANE	I-PENTANE	N-PENTANE	HEXANE	HEPTANES
1776-85	11	0	29	43	14	20	5	15	18
1799-03	90	33	177	188	105	60	19	24	18
1812-21	1258	221	836	642	307	119	26	40	43
1830-39	81	45	311	317	152	82	19	41	36
1848-57	7871	1635	1537	799	111	172	23	63	32
1866-75	953	424	901	547	152	125	20	52	30
1902-11	11710	3555	2613	835	260	122	19	41	21
1920-29	570	699	909	284	164	67	23	55	15
1938-47	60	215	721	398	310	128	53	69	18
1956-65	17	25	86	73	60	40	19	29	20
1974-83	111	133	376	169	137	66	30	45	21
1992-01	63	8	5	1	1	2	2	10	0
2010-19	1959	1963	2258	486	285	86	31	49	24
2046-55	10374	4721	2188	588	122	63	12	34	18
2064-73	36557	13057	4359	1228	214	123	20	43	18
2082-91	1222	52	39	17	5	4	2	11	0
2100-09	4056	1585	707	221	51	37	8	26	15
2118-27	66026	9337	2719	878	135	79	14	32	15
2136-45	6429	2699	1903	751	135	74	13	34	17
2154-63	2655	1684	1544	560	94	59	10	31	17
2172-81	74505	10468	3121	786	108	61	10	20	9
2190-99	78797	19077	3717	1311	138	98	16	28	15
2208-17	35929	4192	986	366	49	39	7	18	16
2226-35	44973	5487	1494	675	82	74	13	32	43
2242-51	38891	5390	1349	523	64	57	10	26	40
2260-69	6359	2373	969	460	59	58	10	34	42
2278-87	93644	10347	2996	947	139	80	19	36	34
2296-05	121532	11884	3406	1149	161	101	19	33	31
2314-23	53164	7992	2855	1062	158	118	21	40	40
2332-41	25822	4883	2187	989	159	150	25	63	43
2350-59	82100	12652	3516	1149	190	143	24	50	35
2368-77	62820	20202	6831	2588	428	243	33	34	6
2403-12	58717	18416	3895	1054	93	45	5	7	3
2421-30	1683	459	235	97	23	23	4	12	7
2448-57	98713	11788	4618	1355	295	119	19	17	4
2475-84	21414	8249	5701	2989	766	577	95	139	51
2493-02	11989	1417	952	383	104	55	12	28	6
2511-20	60380	11305	6880	2708	789	481	75	108	45
2529-38	44544	10779	6023	1855	496	249	39	60	25
2565-74	38759	13044	11920	4342	1396	630	99	126	47
2583-92	127448	15991	6692	1653	663	260	58	75	32
2601-10	1806	1743	1675	520	215	104	28	50	34
2619-28	15659	6030	3713	851	373	151	40	68	35
2637-48	57712	55735	26188	4709	2036	648	144	153	52
2655-64	7493	6311	6306	1592	857	303	87	114	54
2709-18	62198	56875	20065	4017	2595	906	324	314	108
2727-36	109444	42204	22843	5074	3196	1140	474	484	203
2745-54	105718	31450	13157	2210	1379	504	169	242	135
2763-72	22771	11866	6180	1138	717	241	88	125	63

TABLE 1 contd.

AMDEL HEADSPACE GAS ANALYSIS

Client AMOCO

Well PELICAN 5

RESULTS IN PPM

DEPTH (m)	METHANE	ETHANE	PROPANE	I-BUTANE	N-BUTANE	I-PENTANE	N-PENTANE	HEXANE	HEPTANES
2790-99	96815	32443	8376	872	784	157	85	76	36
2808-17	67212	32296	15714	3803	2604	980	404	366	155
2826-35	690	2092	1910	387	319	102	49	73	43
2844-53	6929	5002	3257	684	494	178	76	98	50
2862-71	32465	3513	1546	207	129	39	19	22	17
2880-89	4072	1751	916	122	95	32	16	21	21
2898-07	12639	5954	2874	494	380	150	68	107	68
2916-25	52075	14190	4100	465	386	122	55	101	64
2934-43	3332	2505	970	154	130	51	29	40	41
2952-61	690	602	397	56	52	18	9	15	34
2970-79	89754	40318	14294	2367	1295	317	116	104	51
2988-97	78265	38941	13122	2281	1168	297	103	95	43
3006-15	10818	5486	2910	765	380	149	58	85	51
3024-33	1554	878	731	89	85	28	17	27	26
3042-51	6127	3263	1791	253	204	67	36	64	41
3060-69	45529	14075	4050	649	456	183	78	118	59
3078-87	1491	2753	1220	211	122	54	19	35	20
3096-05	409	1106	749	136	124	65	34	64	36
3114-23	21687	11309	5306	755	675	162	75	100	53
3132-41	17853	9134	3980	520	500	151	81	139	94
3150-59	20047	8298	4470	1091	1409	1121	868	2020	1406
3168-77	16956	8675	3955	860	865	711	597	2692	3284
3186-95	4810	1683	803	110	143	64	55	402	1322
3204-13	72243	12114	2748	398	346	150	93	493	1318
3222-31	32104	10772	3067	328	390	116	75	268	873
3240-49	103746	18051	3421	456	439	177	106	328	896
3258-67	52484	14050	3275	395	425	163	98	277	883
3276-85	94559	26151	12392	4631	5851	4416	3188	5071	3188
3294-33	9880	3701	1804	369	531	381	283	774	1112
3312-21	26850	9515	3777	726	769	471	301	709	757
3330-39	6749	2212	1465	377	508	359	281	693	796
3348-57	60	322	265	47	72	44	38	156	463
3366-75	36627	10630	3289	594	643	405	248	618	683
3384-93	24206	11456	7189	2056	2607	1592	1197	2072	1572
3402-11	67444	23946	7909	1508	1536	868	515	1052	927
3420-29	31733	10527	4044	990	1127	799	547	1102	905
3438-47	17670	6422	2864	739	868	649	466	1112	1091
3456-65	1283	889	455	64	91	52	41	149	313
3474-83	28196	8915	2756	442	561	351	241	601	596
3492-01	67478	57921	15308	3796	2929	1905	882	1642	1024
3510-19	88992	35452	6491	564	596	218	97	279	371
3528-37	74228	22706	5106	538	614	238	153	396	497
3546-55	98275	40866	9434	1316	1040	433	170	374	391
3564-73	117780	35334	7665	686	779	192	123	222	255
3582-91	1158	5715	4107	786	1111	719	485	1450	1367
3600-09	1110	3703	2578	505	800	640	490	1647	1536
3618-27	7490	10441	3230	402	421	217	136	577	882
3636-45	11426	21240	6852	927	944	377	199	497	727
3654-63	1097	546	183	25	31	12	10	23	114

TABLE 1 contd.

AMDEL HEADSPACE GAS ANALYSIS

Client AMOCO

Well PELICAN 5

RESULTS IN PPM

DEPTH (m)	METHANE	ETHANE	PROPANE	I-BUTANE	N-BUTANE	I-PENTANE	N-PENTANE	HEXANE	HEPTANES
3672-81	6195	2583	758	123	108	49	27	50	71
3690-99	12660	6644	1247	120	119	40	24	41	64
3708-17	26945	10420	1859	154	183	50	38	58	69
3726-35	7255	3998	1105	97	120	35	25	48	60
3744-53	9889	2208	519	62	83	33	27	50	56
3762-71	3244	2082	556	47	65	21	16	34	37
3780-89	3668	2156	512	47	56	27	17	52	65
3798-07	20412	9922	1796	113	130	32	19	39	44
3816-25	7448	2897	793	70	90	34	22	52	57
3834-43	7666	2848	894	101	114	47	30	65	61
3852-61	2728	1074	305	33	41	19	13	35	42
3870-79	1319	1211	377	31	32	12	6	16	21
3888-95	875	755	245	31	31	14	8	25	38
3906-15	4129	1150	390	50	50	27	15	43	50
3924-33	40	88	65	6	10	4	3	8	18
3942-51	849	867	251	26	27	13	7	24	34
3960-69	8884	3309	644	81	64	37	16	55	62
3978-87	8925	3002	525	61	52	26	12	37	45
3996-05	171	447	91	9	10	5	2	14	45
4014-23	11370	2971	452	39	44	20	11	39	50
4032-41	1517	1147	250	28	30	18	10	33	43
4050-59	1123	623	160	20	24	15	10	38	57
4068-77	7954	3925	700	97	83	52	25	96	56
4086-95	10818	4364	614	45	37	18	7	30	41
4104-13	4779	1926	334	39	37	23	12	47	52
4122-31	3788	2087	340	24	27	11	6	23	31
4140-49	14457	5904	823	55	52	23	11	38	58
4158-67	7040	3338	530	37	38	17	9	31	47
4176-85	2172	1037	215	27	29	17	11	41	51
4194-03	7074	2823	614	159	112	73	30	75	11
4212-21	4992	1759	359	76	60	49	23	68	57
4230-39	33030	8660	958	198	91	88	25	105	79
4248-57	9955	3515	627	161	99	104	42	171	115

TABLE 2

454019

AMDEL HEADSPACE GAS ANALYSIS

Client AMOCO

Well PELICAN 5

DEPTH m	WET GAS %	iC4/nC4	iC5/nC5	TOTAL GAS ppm	C5+ ppm
1776-85	88.7	3.12	4.00	96	58
1799-03	84.9	1.79	3.22	593	121
1812-21	61.5	2.09	4.57	3264	229
1830-39	91.0	2.09	4.25	906	177
1848-57	34.2	7.18	7.35	11954	290
1866-75	68.0	3.60	6.11	2977	227
1902-11	38.3	3.21	6.27	18975	203
1920-29	78.3	1.73	2.85	2625	160
1938-47	96.5	1.29	2.43	1704	268
1956-65	93.5	1.21	2.10	262	108
1974-83	88.0	1.24	2.18	927	162
1992-01	19.1	0.99	0.98	78	13
2010-19	71.8	1.71	2.75	6952	191
2046-55	42.3	4.84	5.09	17991	127
2064-73	34.0	5.73	6.05	55416	205
2082-91	8.5	3.11	2.80	1335	16
2100-09	38.7	4.31	4.59	6621	87
2118-27	16.5	6.51	5.80	79095	139
2136-45	46.1	5.55	5.74	11918	137
2154-63	59.4	5.96	5.85	6537	117
2172-81	16.3	7.27	5.91	88988	99
2190-99	23.5	9.50	6.16	103041	157
2208-17	13.5	7.45	5.32	41524	81
2226-35	14.7	8.20	5.75	52712	162
2242-51	15.8	8.21	5.55	46216	133
2260-69	37.8	7.79	5.67	10220	144
2278-87	13.4	6.81	4.27	108073	168
2296-05	12.0	7.12	5.23	138131	185
2314-23	18.5	6.71	5.76	65231	219
2332-41	24.1	6.21	6.13	34041	281
2350-59	17.6	6.04	5.89	99607	252
2368-77	32.4	6.05	7.38	92870	315
2403-12	28.5	11.35	9.48	82175	60
2421-30	32.6	4.23	5.32	2497	47
2448-57	15.5	4.59	6.41	116769	143
2475-84	45.3	3.90	6.04	39118	863
2493-02	19.2	3.69	4.48	14846	101
2511-20	26.4	3.43	6.39	82061	710
2529-38	30.1	3.74	6.37	63697	373
2565-74	44.2	3.11	6.34	69461	903
2583-92	16.4	2.49	4.47	152448	426
2601-10	69.7	2.42	3.68	5958	217
2619-28	41.2	2.28	3.79	26627	294
2637-48	60.6	2.31	4.50	146381	997
2655-64	66.8	1.86	3.46	22560	558
2709-18	57.3	1.55	2.79	145750	1653
2727-36	40.1	1.59	2.41	182761	2301
2745-54	31.3	1.60	2.98	153914	1050
2763-72	46.6	1.59	2.74	42673	517

TABLE 2 contd.

454020

AMDEL HEADSPACE GAS ANALYSIS

Client AMOCO

Well PELICAN 5

DEPTH m	WET GAS %	iC4/nC4	iC5/nC5	TOTAL GAS ppm	C5+ ppm
2790-99	30.5	1.11	1.85	139291	353
2808-17	44.7	1.46	2.42	121629	1905
2826-35	87.2	1.21	2.06	5398	267
2844-53	57.7	1.39	2.35	16365	402
2862-71	14.2	1.60	2.09	37860	97
2880-89	41.5	1.28	1.98	6957	91
2898-07	43.4	1.30	2.21	22341	392
2916-25	26.9	1.21	2.21	71215	343
2934-43	53.0	1.19	1.76	7090	162
2952-61	61.6	1.08	1.87	1796	76
2970-79	39.4	1.83	2.74	148028	587
2988-97	41.5	1.95	2.90	133777	538
3006-15	46.9	2.01	2.57	20360	343
3024-33	53.4	1.05	1.63	3337	98
3042-51	47.4	1.24	1.85	11639	208
3060-69	29.7	1.42	2.36	64759	438
3078-87	74.3	1.74	2.86	5797	127
3096-05	83.8	1.09	1.89	2522	199
3114-23	45.4	1.12	2.16	39732	390
3132-41	44.2	1.04	1.86	31987	465
3150-59	43.2	0.77	1.29	35315	5416
3168-77	45.8	0.99	1.19	31311	7284
3186-95	36.3	0.77	1.16	7549	1842
3204-13	17.8	1.15	1.62	87849	2054
3222-31	31.2	0.84	1.55	46662	1332
3240-49	17.7	1.04	1.66	126113	1507
3258-67	25.7	0.93	1.66	70630	1421
3276-85	34.1	0.79	1.39	143584	15863
3294-03	39.3	0.69	1.35	16285	2550
3312-21	35.5	0.94	1.57	41637	2238
3330-39	40.3	0.74	1.28	11310	2128
3348-57	92.2	0.65	1.18	766	701
3366-75	29.3	0.92	1.63	51783	1954
3384-93	49.1	0.79	1.33	47514	6432
3402-11	34.1	0.98	1.68	102343	3362
3420-29	34.5	0.88	1.46	48421	3353
3438-47	38.1	0.85	1.39	28563	3318
3456-65	53.9	0.70	1.29	2782	556
3474-83	31.0	0.79	1.46	40868	1790
3492-01	54.2	1.30	2.16	147432	5453
3510-19	32.6	0.95	2.24	132094	965
3528-37	28.1	0.88	1.56	103192	1284
3546-55	34.9	1.27	2.55	150931	1367
3564-73	27.4	0.88	1.56	162244	793
3582-91	91.0	0.71	1.48	12877	4020
3600-09	87.2	0.63	1.31	8695	4313
3618-27	65.9	0.96	1.60	21983	1812
3636-45	72.4	0.98	1.89	41388	1800
3654-63	41.7	0.80	1.21	1883	159

TABLE 2 contd.

AMDEL HEADSPACE GAS ANALYSIS

Client AMOCO

Well PELICAN 5

DEPTH m	WET GAS %	iC4/nC4	iC5/nC5	TOTAL GAS ppm	C5+ ppm
3672-81	36.6	1.14	1.79	9768	197
3690-99	39.1	1.01	1.67	20790	170
3708-17	31.9	0.84	1.31	39561	215
3726-35	42.3	0.81	1.42	12574	167
3744-53	22.5	0.75	1.22	12762	165
3762-71	45.9	0.72	1.33	5994	108
3780-89	43.0	0.84	1.57	6440	162
3798-07	36.9	0.86	1.66	32373	134
3816-25	34.1	0.78	1.52	11299	164
3834-43	34.0	0.88	1.57	11623	204
3852-61	34.8	0.82	1.52	4182	110
3870-79	55.6	0.95	2.11	2970	55
3888-95	54.8	1.02	1.66	1937	86
3906-15	28.4	1.01	1.85	5768	135
3924-33	80.9	0.63	1.37	210	33
3942-51	58.0	0.97	1.88	2020	78
3960-69	31.6	1.25	2.29	12983	170
3978-87	29.0	1.18	2.19	12565	120
3996-05	76.5	0.90	1.93	728	66
4014-23	23.6	0.90	1.78	14877	121
4032-41	48.9	0.94	1.70	2971	104
4050-59	42.4	0.82	1.47	1950	120
4068-77	37.7	1.17	2.08	12759	229
4086-95	31.9	1.22	2.47	15878	95
4104-13	32.8	1.06	1.92	7116	134
4122-31	39.5	0.89	1.79	6265	71
4140-49	32.1	1.06	2.04	21290	130
4158-67	35.9	0.97	1.94	10983	103
4176-85	37.6	0.92	1.55	3480	120
4194-03	34.4	1.42	2.43	10783	189
4212-21	31.1	1.26	2.09	7246	197
4230-39	23.1	2.16	3.48	42937	297
4248-57	30.7	1.63	2.47	14357	432

454022

TABLE 3: TOTAL ORGANIC CARBON CONTENTS OF CANNED CUTTINGS (HEADSPACE C_1-C_4 >15000 PPM), PELICAN-5

Depth m	TOC %	Depth m	TOC %	Depth m	TOC %
1902-11	17.8	2637-46	11.1	3258-67	22.7
2046-55	12.2	2655-64	2.52	3276-85	18.4
2064-73	18.1	2709-18	3.46	3294-03	13.4
2118-27	27.8	2727-36	3.68	3312-21	7.15
2172-81	19.8	2745-54	2.46	3366-75	23.1
2190-99	26.7	2763-72	4.50	3384-93	8.35
2208-17	12.2	2790-99	39.4	3402-11	5.30
2226-35	5.35	2808-17	2.04	3420-29	17.4
2242-51	4.10	2844-53	3.64	3438-47	1.56
2278-87	30.7	2862-71	18.6	3474-83	4.30
2296-05	15.6	2898-07	1.76	3492-01	4.55
2314-23	24.9	2916-25	4.20	3510-19	5.90
2332-41	4.45	2970-79	17.8	3528-37	3.42
2350-59	15.6	2988-97	20.6	3546-55	2.10
2368-77	21.7	3006-15	6.25	3564-73	7.10
2403-12	6.30	3060-69	26.4	3618-27	3.82
2448-57	16.4	3114-23	17.8	3636-45	5.40
2475-84	2.94	3132-41	15.7	3690-99	5.05
2511-20	4.65	3150-59	2.90	3708-17	10.0
2529-38	3.32	3168-77	9.00	3798-07	5.75
2565-74	3.02	3204-13	47.0	4086-95	3.64
2583-92	8.45	3222-31	22.8	4140-49	3.42
2619-28	2.84	3240-49	21.0	4230-39	4.80

ROCK-EVAL PYROLYSIS 30/05/86

Client AMOCO

Well PELICAN-5 Cuttings

DEPTH	T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
EOCENE											
1902.00	428	0.78	16.11	0.74	16.89	0.05	21.77	1.40	17.80	90	4
2046.00	424	0.35	7.15	0.58	7.50	0.05	12.32	0.62	12.20	58	4
2064.00	424	0.71	15.36	0.67	16.07	0.04	22.92	1.33	18.10	84	3
2118.00	424	0.43	11.47	0.53	11.90	0.04	21.64	0.99	27.80	41	1
2172.00	426	0.37	7.77	0.45	8.14	0.05	17.26	0.67	19.80	39	2
2190.00	427	0.59	12.50	0.47	13.09	0.05	26.59	1.09	26.70	46	1
2208.00	426	0.34	9.15	0.51	9.49	0.04	17.94	0.79	12.20	75	4
2226.00	427	0.53	8.63	0.65	9.16	0.06	13.27	0.76	5.35	161	12
2242.00	425	0.59	11.48	0.89	12.07	0.05	12.89	1.00	4.10	280	213
2278.00	428	0.65	14.97	0.51	15.62	0.04	29.35	1.30	30.70	48	1
2296.00	428	0.59	10.78	0.55	11.37	0.05	19.60	0.94	15.60	69	3
2314.00	429	1.32	11.38	0.48	12.70	0.10	23.70	1.05	24.90	45	1
2332.00	423	2.50	19.03	0.84	21.53	0.12	22.64	1.79	4.45	427	18
2350.00	428	1.04	13.44	0.48	14.48	0.07	28.00	1.20	15.60	86	3
2368.00	428	0.66	9.63	0.40	10.29	0.06	24.07	0.85	21.70	44	1
2403.00	430	0.72	13.91	0.62	14.63	0.05	22.43	1.21	6.30	220	9
2448.00	429	0.83	13.28	0.45	14.11	0.06	29.51	1.17	16.40	80	2
2475.00	422	0.86	8.17	1.13	9.03	0.10	7.23	0.75	2.94	277	38
2511.00	427	2.36	16.74	0.90	19.10	0.12	18.60	1.59	4.65	360	19
2529.00	427	2.48	12.90	0.62	15.38	0.16	20.80	1.28	3.32	388	18
2565.00	424	1.86	9.19	0.72	11.05	0.17	12.76	0.92	3.02	304	23
2583.00	432	5.14	25.50	0.63	30.64	0.17	40.47	2.55	8.45	301	7
2619.00	425	1.32	9.25	0.75	10.57	0.12	12.33	0.88	2.84	325	26
2637.00	434	0.92	12.40	0.33	13.32	0.07	37.57	1.11	11.10	111	2
2655.00	426	0.82	5.37	1.18	6.19	0.13	4.55	0.51	2.52	213	46
2709.00	434	1.02	11.49	0.49	12.51	0.08	23.44	1.04	3.46	332	14
2727.00	433	1.27	11.01	0.74	12.28	0.10	14.87	1.02	3.68	299	20
2745.00	431	0.70	5.37	0.82	6.07	0.12	6.54	0.50	2.46	218	33
2763.00	434	1.52	14.24	0.71	15.76	0.10	20.05	1.31	4.50	316	16
2790.00	435	3.20	18.76	0.38	21.96	0.15	49.36	1.99	39.40	48	1
2808.00	435	0.75	3.89	0.94	4.64	0.16	4.13	0.38	2.04	191	50
2844.00	431	2.30	13.09	0.89	15.39	0.15	14.70	1.28	3.64	360	24
2862.00	428	2.47	15.22	0.71	17.69	0.14	21.43	1.47	18.60	82	4
2898.00	433	0.69	4.01	0.94	4.70	0.15	4.26	0.39	1.76	228	53
2916.00	433	1.21	16.08	0.85	17.29	0.07	18.91	1.44	4.20	383	20
2970.00	440	1.84	14.76	0.30	16.60	0.11	49.20	1.55	17.80	83	2
2988.00	437	0.62	6.70	0.22	7.32	0.08	30.45	0.71	20.60	33	1
3006.00	439	1.63	9.66	1.04	11.29	0.14	9.28	0.94	6.25	155	17
3060.00	439	1.87	9.49	0.46	11.36	0.16	20.63	0.94	4.50	36	2
3114.00	442	1.33	10.02	0.33	11.35	0.12	30.36	0.94	17.80	56	2

TABLE 4

AMDEL

ROCK-EVAL PYROLYSIS

30/05/86

Client AMOCO

Well PELICAN-5 Cuttings

DEPTH	T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
PALEOCENE											
3132.00	444	8.82	50.26	1.81	59.08	0.15	27.76	4.92	15.70	320	11
3150.00	440	0.52	5.72	0.71	6.24	0.08	8.05	0.63	2.90	197	24
3168.00	444	4.44	29.75	0.90	34.19	0.13	33.05	2.84	9.00	330	10
3204.00	447	18.91	151.63	2.60	170.54	0.11	58.31	14.21	47.00	322	5
3222.00	444	10.70	78.83	2.32	89.53	0.11	33.97	7.41	22.80	345	10
3240.00	446	5.25	59.09	2.22	64.34	0.08	26.61	5.36	21.00	281	10
3258.00	442	8.72	65.68	2.35	74.40	0.12	27.94	6.20	22.70	289	10
3276.00	442	11.69	66.46	1.49	78.15	0.15	44.60	6.51	18.40	361	8
3294.00	442	5.88	39.55	2.05	45.43	0.13	19.29	3.78	13.40	295	15
3312.00	443	3.07	19.73	0.74	22.80	0.13	26.66	1.90	7.15	275	10
3366.00	442	11.30	68.40	2.60	79.70	0.14	26.30	6.64	23.10	296	11
3384.00	434	10.31	29.95	1.82	40.26	0.26	16.45	3.35	8.35	358	21
3402.00	446	2.15	11.69	0.74	13.84	0.16	15.79	1.15	5.30	220	13
3420.00	446	8.86	54.67	1.61	63.53	0.14	33.95	5.29	17.40	314	9
3438.00	442	0.64	2.87	0.52	3.51	0.18	5.51	0.30	1.56	183	33
3474.00	445	1.79	9.36	0.64	11.15	0.16	14.62	0.92	4.30	217	14
3492.00	443	1.98	11.37	0.51	13.35	0.15	22.29	1.11	4.55	249	11
3510.00	452	1.38	10.00	0.84	11.38	0.12	11.90	0.94	5.90	169	14
3528.00	448	0.90	4.66	0.69	5.56	0.16	6.75	0.46	3.42	136	20
3546.00	452	0.31	1.82	0.88	2.13	0.15	2.06	0.19	2.10	86	41
3564.00	456	2.50	12.04	0.90	14.54	0.17	13.37	1.21	7.10	169	12
3618.00	457	0.86	4.12	0.60	4.98	0.17	6.86	0.43	3.82	107	15
3636.00	458	1.39	6.73	1.30	8.12	0.17	5.17	0.67	5.40	124	24
3690.00	443	0.98	5.82	3.16	6.80	0.14	1.84	0.56	5.05	115	62
CRETACEOUS											
3708.00	460	2.56	14.92	3.00	17.48	0.15	4.97	1.45	10.00	149	30
3798.00	465	1.80	7.28	1.41	9.08	0.19	5.16	0.78	5.75	126	24
4086.00	461	0.52	3.32	1.11	3.84	0.14	2.99	0.35	3.64	91	30
4140.00	456	0.34	2.10	0.95	2.44	0.14	2.21	0.23	3.42	61	27
4230.00	442	0.91	3.81	1.68	4.72	0.19	2.26	0.41	4.80	79	35

TABLE 5

AMDEL

ROCK-EVAL PYROLYSIS

17/07/86

Client AMOCO

Well PELICAN-5 Sidewall cores

DEPTH	T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
1933.0	425	0.56	4.56	0.62	5.12	0.11	7.35	0.42	1.92	237	32
1999.0	424	8.04	184.48	4.25	192.52	0.04	43.40	16.04	60.70	304	7
2036.0	426	0.75	14.86	0.40	15.61	0.05	37.15	1.30	3.55	419	11
2039.0	423	8.58	195.07	3.50	203.65	0.04	55.73	16.97	65.00	300	5
2223.0	428	7.33	192.57	2.85	199.90	0.04	67.56	16.65	69.60	277	4
2298.5	429	12.04	233.06	2.24	245.10	0.05	104.04	20.42	68.80	339	3
2365.0	434	1.70	23.88	0.43	25.58	0.07	55.53	2.13	8.00	299	5
2451.0	428	1.02	16.18	0.44	17.20	0.06	36.77	1.43	4.70	344	9
2464.0	436	0.38	3.92	0.17	4.30	0.09	23.05	0.35	3.50	112	5
2517.5	438	0.35	1.78	0.19	2.13	0.17	9.36	0.17	0.69	258	28
2557.0	428	0.77	7.45	1.57	8.22	0.09	4.74	0.68	2.85	261	55
2794.0	441	27.01	338.76	4.43	365.77	0.07	76.46	30.48	79.20	428	6
2937.0	436	0.82	2.52	1.61	3.34	0.25	1.56	0.27	1.10	229	146
2970.5	442	23.37	235.34	4.06	258.71	0.09	57.96	21.55	72.40	325	6
2978.5	440	1.06	3.85	1.17	4.91	0.22	3.29	0.40	1.56	247	75
2991.0	442	0.72	3.86	2.23	4.58	0.16	1.73	0.38	2.00	193	111
3042.5	441	0.52	2.38	0.94	2.90	0.18	2.53	0.24	2.00	119	47
3139.0	447	0.30	1.08	1.59	1.38	0.22	0.67	0.11	1.00	108	159
3169.0	447	0.24	0.63	1.65	0.87	0.28	0.38	0.07	0.96	66	172
3653.0	455	0.37	0.60	2.17	0.97	0.39	0.27	0.08	1.09	55	199
3710.0	461	0.57	1.06	1.14	1.63	0.35	0.92	0.13	1.48	72	77
3741.3	458	0.33	0.69	2.42	1.02	0.32	0.28	0.08	0.96	72	252
3778.1	465	0.62	2.03	1.70	2.65	0.23	1.19	0.22	2.10	97	81
3846.0	468	3.08	23.95	1.39	27.03	0.11	17.23	2.25	13.70	175	10
3875.0	520	0.43	1.07	1.76	1.50	0.29	0.60	0.12	1.23	87	143
3907.0	458	0.45	0.68	0.82	1.13	0.40	0.82	0.09	1.08	63	76
3941.0	438	0.25	0.47	0.85	0.72	0.35	0.55	0.06	0.61	77	139
3976.5	461	0.44	1.06	1.57	1.50	0.29	0.67	0.12	1.92	55	82
4057.0	434	0.31	0.44	1.37	0.75	0.42	0.32	0.06	0.82	54	167
4085.0	476	0.28	0.62	0.91	0.90	0.31	0.68	0.07	1.34	46	68
4106.5	483	0.33	0.65	1.36	0.98	0.34	0.47	0.08	1.46	45	93
4130.0	490	0.24	0.70	2.20	0.94	0.26	0.31	0.07	1.74	40	126
4216.0	418	0.81	0.70	2.51	1.51	0.54	0.27	0.12	1.40	50	179
4247.0	491	0.26	0.99	7.48	1.25	0.21	0.13	0.10	2.45	40	305

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

	PARAMETER	SPECIFICITY
T max	position of S_2 peak in temperature program (°C)	Maturity/Kerogen type
S_1	kg hydrocarbons (extractable)/tonne rock	Kerogen type/Maturity/Migrated oil
S_2	kg hydrocarbons (kerogen pyrolysate)/tonne rock	Kerogen type/Maturity
S_3	kg CO_2 (organic)/tonne rock	Kerogen type/Maturity*
S_1+S_2	Potential Yield	Organic richness/Kerogen type
PI	Production Index ($S_1/S_1 + S_2$)	Maturity/Migrated oil
PC	Pyrolysable Carbon (wt. percent)	Organic richness/Kerogen type/Maturity
TOC	Total Organic Carbon (wt. percent)	Organic richness
HI	Hydrogen Index (mg h'c (S_2)/g TOC)	Kerogen type/Maturity
OI	Oxygen Index (mg CO_2(S_3)/g TOC)	Kerogen type/Maturity*

*Also subject to interference by CO_2 from decomposition of carbonate minerals.

TABLE 6

AMDEL

GASOLINE-RANGE ANALYSIS

BASS BASIN

GASOLINE-RANGE (C5-C7)

SAMPLE: PELICAN-5 RFT 3 (2788.2 M)

	%			
COMPOUND	NORMAL	BRANCHED	CYCLIC	AROMATIC
2-METHYLBUTANE		4.18		
N-PENTANE	5.27			
2,2-DIMETHYLBUTANE		.25		
CYCLOPENTANE			.71	
2-METHYLPENTANE		5.61		
3-METHYLPENTANE		3.17		
N-HEXANE	9.50			
METHYLCYCLOPENTANE			5.43	
2,4-DIMETHYLPENTANE		.56		
BENZENE				.76
CYCLOHEXANE			6.64	
2-METHYLHEXANE		3.41		
2,3-DIMETHYLPENTANE		1.00		
1,1-DIMETHYLCYCLOPENTANE			.83	
3-METHYLHEXANE		3.21		
CIS-1,3-DIMETHYLCYCLOPENTANE			1.63	
TRANS-1,3-DIMETHYLCYCLOPENTANE			1.74	
TRANS-1,2-DIMETHYLCYCLOPENTANE			2.56	
3-ETHYLPENTANE		.16		
N-HEPTANE	10.93			
METHYLCYCLOHEXANE			23.95	
TOLUENE				8.47
TOTAL PERCENTAGES	25.70	21.55	43.52	9.23

TABLE 7

GASOLINE-RANGE PARAMETERS

BASS BASIN

SAMPLE	GASOLINE YIELD,%	1	2	3	4	5	6	7	8	9
PELICAN-5 RFT 3	-	1.75	.45	4.15	8.68	2.82	.79	.33	1.11	19.48

KEY TO PARAMETERS

Parameter	Derivation	Specificity
1	n-hexane/methylcyclopentane	mat/biodeg
2	n-heptane/methylcyclohexane	mat/biodeg
3	3-methylpentane/benzene	water washing
4	cyclohexane/benzene	water washing
5	methylcyclohexane/toluene	water washing
6	isopentane/normal pentane	mat/biodeg
7	3-methylpentane/n-hexane	biodegradation
8	isoheptane value	maturity
9	heptane value	maturity

(Parameters 8 and 9 from Thompson, 1983)

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AMDEL

OIL ANALYSIS

WELL: PELICAN-5

SAMPLE: RFT 3

OIL COMPOSITION (C-12 PLUS FRACTION)

n+iso PARAFFINS	52.3
NAPHTHENES	14.8
AROMATICS	12.5
RESINS	20.3
ASPHALTENES	.1

N-ALKANE DISTRIBUTION IN SATURATES

C-NO.	%	C-NO.	%	C-NO.	%	C-NO.	%	C-NO.	%
12	1.9	17	5.8	22	6.1	27	4.3	32	.0
13	5.3	18	5.9	23	6.5	28	2.1	33	.0
14	7.4	19	6.6	24	6.8	29	1.7	34	.0
15	7.5	20	6.0	25	6.8	30	.8	35	.0
16	6.8	21	5.8	26	5.5	31	.6	36	.0

ODD EVEN PREDOMINANCE

O.E.P. C-17 = .96
O.E.P. C-19 = 1.08
O.E.P. C-25 = 1.04
O.E.P. C-27 = 1.12

ISOPRENOID RATIOS

TMTD/pristane ratio	.33
norpristane/pristane ratio	.20
pristane/phytane ratio	7.73
pristane/C-17 ratio	1.39
phytane/C-18 ratio	.18

TABLE 9: BITUMEN, GILSONITE AND RESIDUAL OIL ANALYSES, PELICAN-5

Sample	Depth m	C_{15+} Composition					Alkane Ratios				
		N+Iso %	Naph %	Arom %	Res %	Asph %	TMTD/Pr	Np/Pr	Pr/Ph	Pr/n-C_{17}	Ph/n-C_{18}
Bitumen[1]	2790-2799	3.9	5.8	3.0	29.5	57.8	0.18	0.25	4.7	0.84	0.15
Bitumen[1]	2961-2970	——17.4——		3.4	21.4	57.7	0.44	0.34	4.9	0.87	0.17
Gilsonite	mud additive	6.2	6.7	2.4	20.0	64.7	0.24	0.29	4.6	0.90	0.18
Residual oil[2]	2169-2178	——10.9——		11.1	37.8	40.2	-	0.12	9.8	4.8	0.60
Residual oil[3]	2961-2970 (a)	——19.9——		14.3	22.5	43.3	-	0.19	5.5	0.86	0.12
	(b)	——14.9——		20.4	16.3	48.4	-	0.12	7.5	2.5	0.25

N+Iso = normal + iso-alkanes
Naph = naphthenes
Arom = aromatic hydrocarbons
Res = resins
Asph = asphaltenes

TMTD = 2,6,10-trimethyltridecane
Np = norpristane
Pr = pristane
Ph = phytane
n-C_{17} = n-heptadecane
n-C_{18} = n-octadecane

1. Hand-picked from cuttings
2. Sandstone, siltstone cuttings (23.27 g) extracted for 6 hr (yield 3911 ppm)
3. Coal cuttings (4.95 g) extracted for (a) 1 hr (yield 13394 ppm)
(b) 5 hr (yield 4465 ppm)

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TABLE 10: BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION IN CONDENSATE, BITUMEN AND GILSONITE FROM PELICAN-5

AMDEL Sample No.	Sample	Depth m	Steranes							Terpanes						Acyclic Alkanes			
	Parameter*		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MS-277	Condensate RFT 3	2788	29:19:52	1.8	4.7	1.1	1.4	1.5	1.1	0.11	2.0	0.10	1.5	0.14	0.02	7.7	0.33	1.4	0.18
MS-279	Bitumen in cuttings	2790-2799	12:44:44	3.6	1.5	0.64	1.3	0.46	0.10	-	13	0.02	1.2	0.26	<0.01	4.7	0.18	0.84	0.15
MS-280	Gilsonite mud additive	-	11:49:40	3.7	2.7	0.66	1.8	0.36	0.09	-	40	0.03	1.3	0.27	<0.01	4.6	0.24	0.90	0.18

*See key (next page) for derivation and specificity of each parameter.

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KEY TO BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION

Parameter	* Derivation	Specificity
1	C_{27} : C_{28} : C_{29} 5α(H)14α(H)17α(H) 20R steranes	Source
2	C_{29} 5α(H)14α(H)17α(H) 20R sterane / C_{27} 5α(H)14α(H)17α(H) 20R sterane	Source
3	C_{29} 13β(H)17α(H) 20R diasterane / C_{27} 13β(H)17α(H) 20R diasterane	Source
4	C_{29} 5α(H)14α(H)17α(H) 20S sterane / C_{29} 5α(H)14α(H)17α(H) 20R sterane	Maturity, Biodegradation
5	C_{27} 13β(H)17α(H) 20S diasterane / C_{27} 13β(H)17α(H) 20R diasterane	Maturity
6	C_{29} 5α(H)14β(H)17β(H) 20R sterane / C_{29} 5α(H)14α(H)17α(H) 20R sterane	Maturity, Migration
7	C_{29} 13β(H)17α(H) 20R+20S diasteranes / C_{29} 5α(H) steranes	Migration, Source
8	C_{30} pentacyclic terpane/C_{30} 17α(H)21β(H) hopane	Source
9	C_{27} 17α(H)-22,29,30-trisnorhopane / C_{27} 18α(H)-22,29,30-trisnorhopane (T_m/T_s)	Maturity, Source
10	T_s / C_{30} 17α(H)21β(H) hopane	Maturity
11	C_{32} 17α(H)21β(H) 22S homohopane / C_{32} 17α(H)21β(H) 22R homohopane	Maturity
12	C_{30} 17β(H)21α(H) moretane / C_{30} 17α(H)21β(H) hopane	Maturity
13	C_{29} 17α(H)-25-norhopane / C_{29} 17α(H)-30-norhopane	Biodegradation
14	pristane / phytane	Source
15	2,6,10-trimethyltridecane / pristane	Maturity
16	pristane / n-heptadecane	Source, Biodegradation, Maturity
17	phytane / n-octadecane	Source, Biodegradation, Maturity

* Ratios calculated from peak areas as follows:

Parameters 1-6 m/z = 217 mass fragmentogram
Parameter 7 m/z = 217, 259 mass fragmentograms
Parameters 8-13 m/z = 191 mass fragmentogram
Parameters 14-17 capillary gas chromatogram of alkanes or whole oil/extract

TABLE 11: SUPPLEMENTARY SOURCE-DEPENDENT BIOMARKER RATIOS IN CONDENSATE, BITUMEN AND GILSONITE FROM PELICAN-5

AMDEL Sample No.	Sample	C_{30} Hopane / C_{29} Steranes	C_{31} Me Hopane / C_{30} Hopane	C_{24} Tetracyclic / C_{30} Hopane	16βH-Phyll / C_{30} Hopane	*ent*-Bey:16βH-Phyll:*ent*-16βH-Kaur
MS-277	Condensate RFT 3, 2788 m	3.8	0.07	0.10	0.45	13:69:18
MS-279	Bitumen in cuttings 2790-2799 m	7.3	0.01	0.03	0.01	25:59:16
MS-280	Gilsonite mud additive	8.7	0.01	0.03	0.02	28:55:17
*Parameter		18	19	20	21	22

*Measured from mass fragmentograms as follows:

Parameter 18 m/z 191, 217
Parameter 19 m/z 191, 205
Parameter 20 m/z 191
Parameter 21 m/z 123, 191
Parameter 22 m/z 259

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TABLE 12: SOURCE ROCK MATURITY OF CONDENSATE BASED ON METHYLPHENANTHRENE DISTRIBUTION*, PELICAN-5

AMDEL Sample No.	Test & Depth	Formation & Reservoir Age	MPI	MPR	VR_{calc} (a)	VR_{calc} (b)
MS-278	RFT 3 2788 m	Eastern View Coal Measures Eocene	0.49	0.68	0.69 ✓	2.01

*Methylphenanthrene index (MPI) and VR_{calc} are derived from the following equations (after Radke and Welte, 1983):

$$MPI = \frac{1.5\ (2\text{-}MP + 3\text{-}MP)}{P + 1\text{-}MP + 9\text{-}MP}$$

$$VR_{calc}\ (a) = 0.6\ MPI + 0.4\ (\text{for } VR < 1.35\%)$$

$$VR_{calc}\ (b) = -0.6\ MPI + 2.3\ (\text{for } VR > 1.35\%)$$

where P = phenanthrene
1-MP = 1-methylphenanthrene
2-MP = 2-methylphenanthrene
3-MP = 3-methylphenanthrene
9-MP = 9-methylphenanthrene

Peak areas measured from m/z 178 (phenanthrene) and m/z 191+192 (methylphenanthrenes) mass fragmentograms of total aromatic hydrocarbon fraction (Fig. 22).

Methylphenanthrene ratio (MPR) is defined as follows:

$$MPR = \frac{2\text{-}MP + 3\text{-}MP}{1\text{-}MP}$$

✓ = preferred value

FIGURE 1

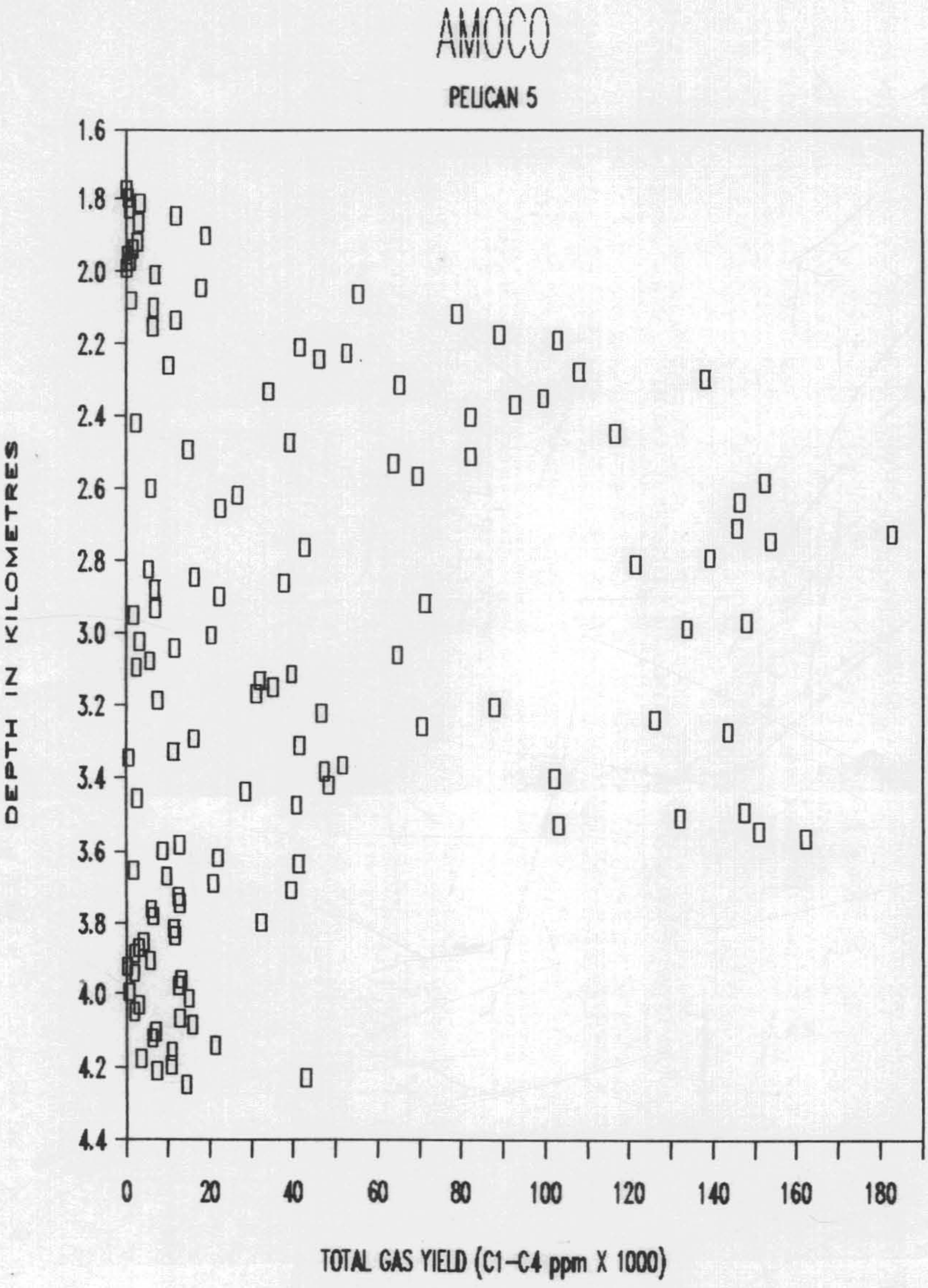

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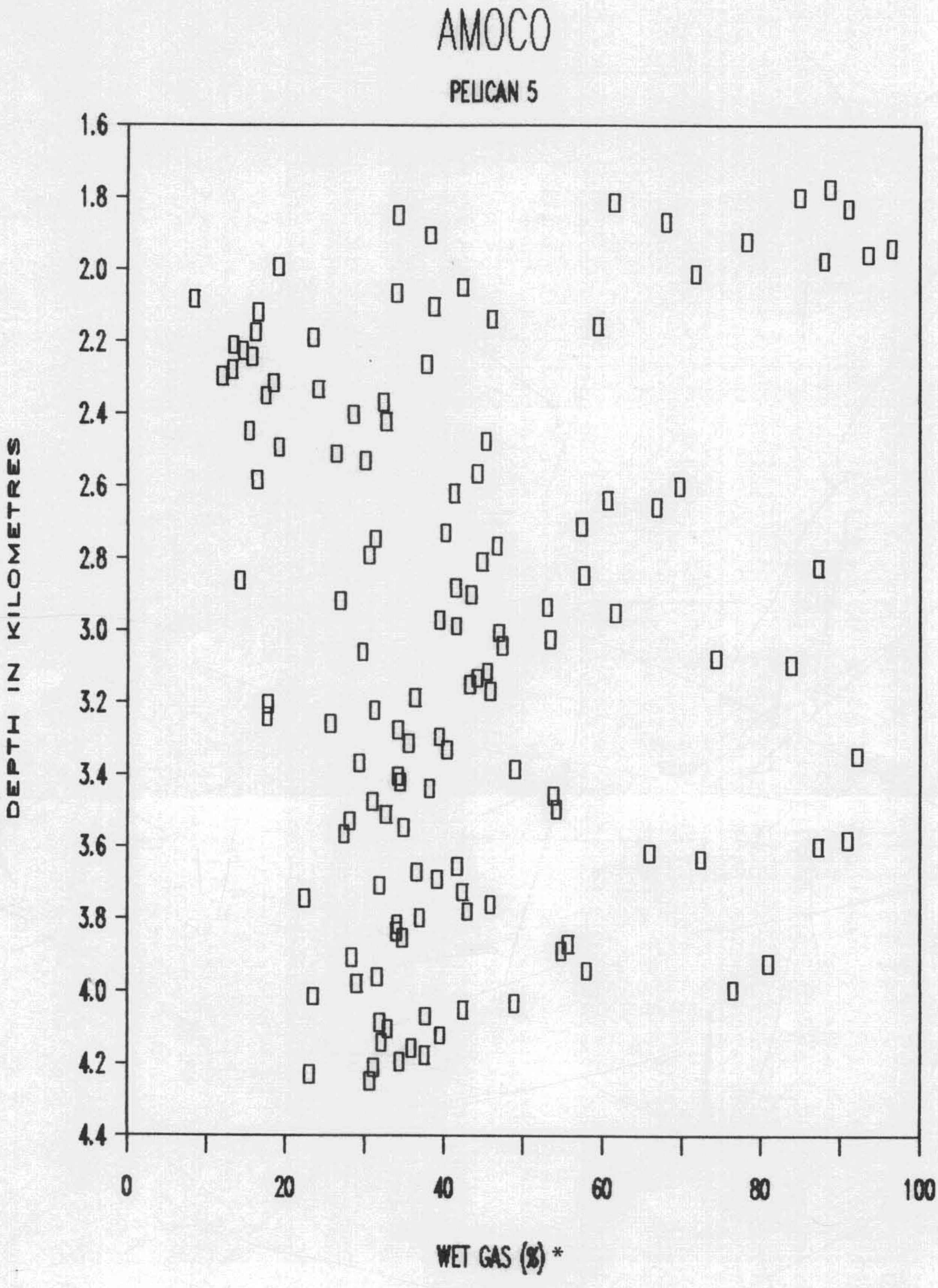
FIGURE 2A



* All samples

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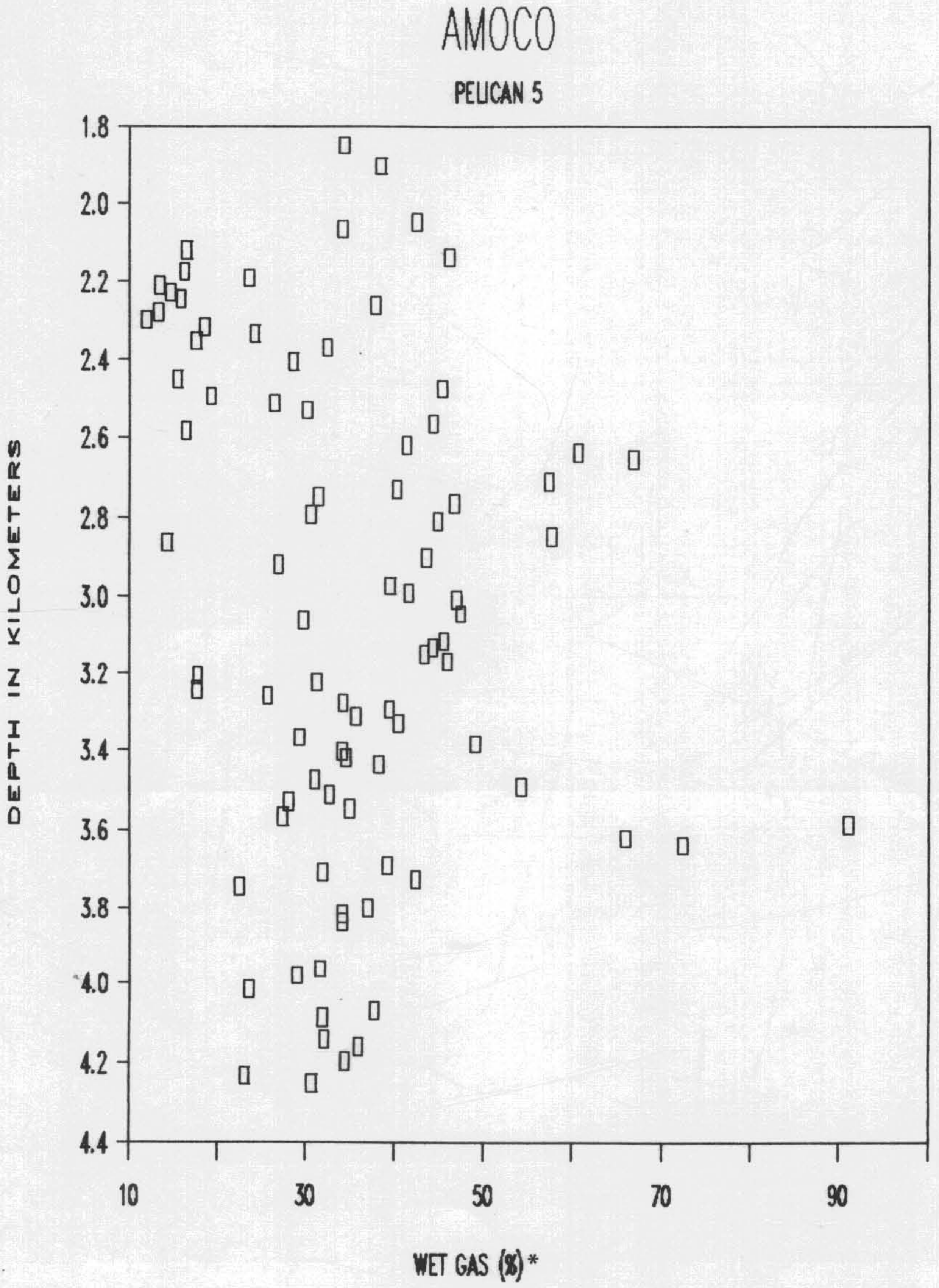
FIGURE 2B



* Samples yielding >10,000 ppm C_1-C_4

5 cm

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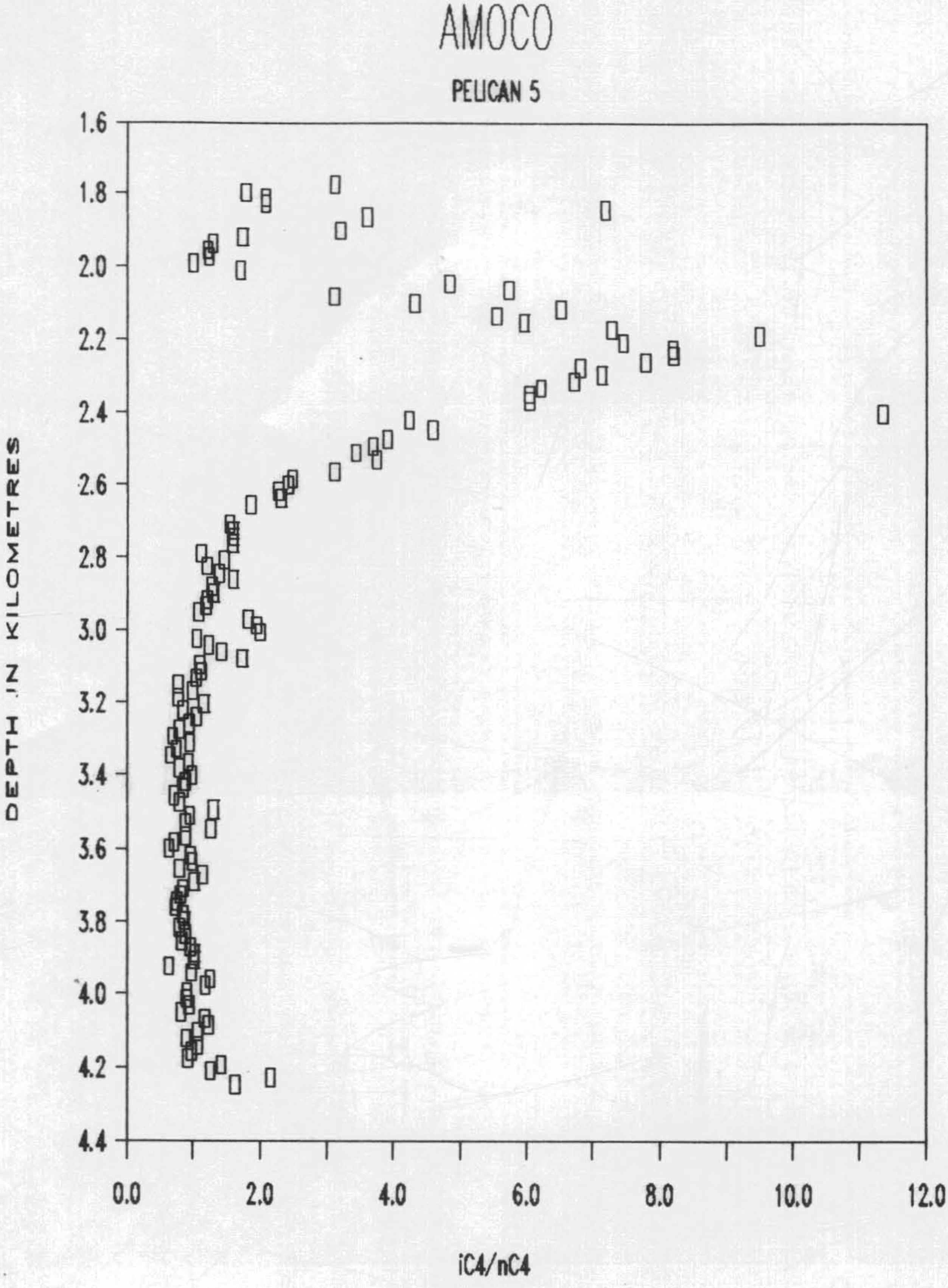
FIGURE 3



5 cm

amdel

FIGURE 4

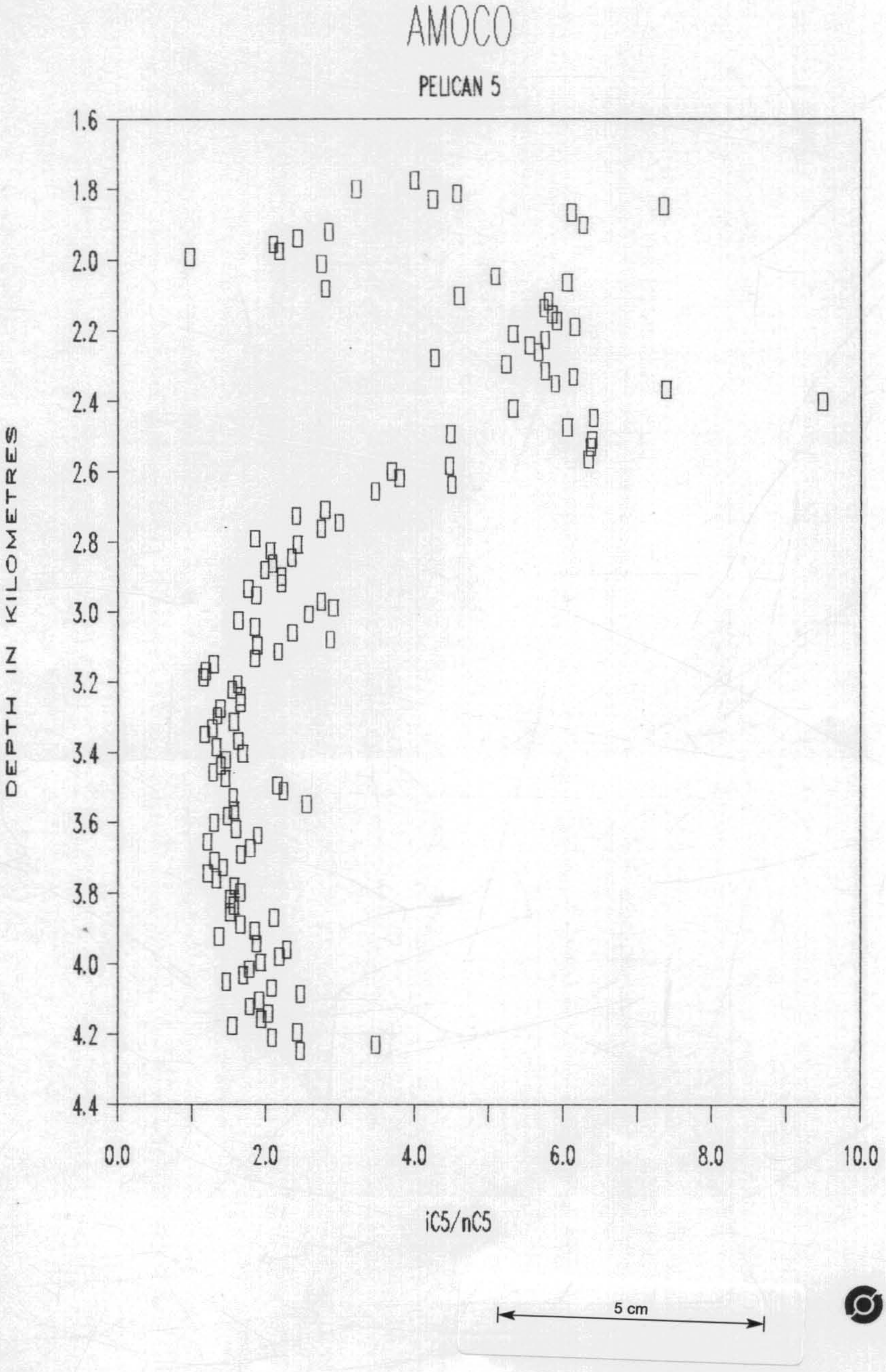
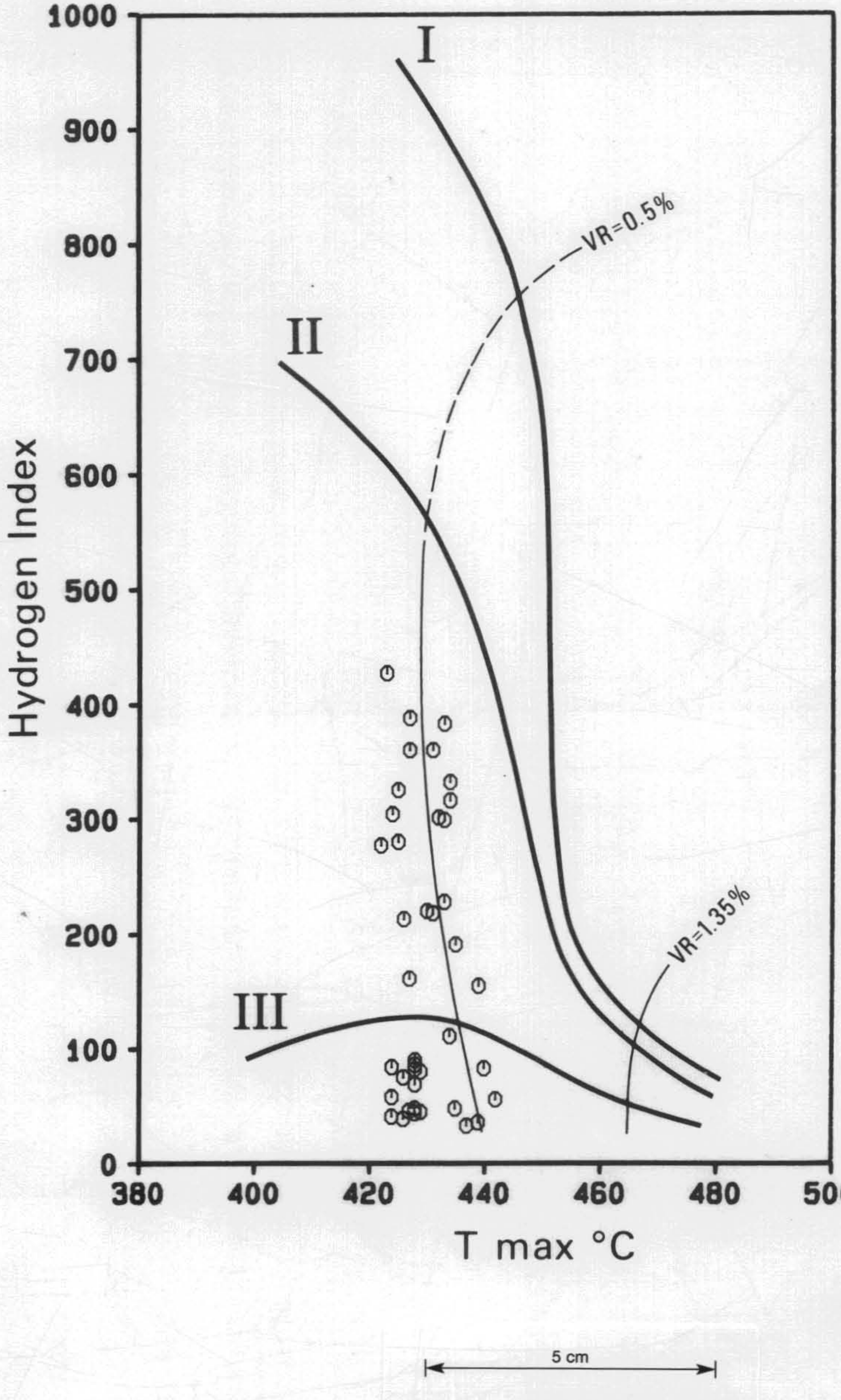

AMOCO
PELICAN 5
DEPTH IN KILOMETRES
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
0.0
2.0
4.0
6.0
8.0
10.0
iC5/nC5
5 cm

FIGURE 5A

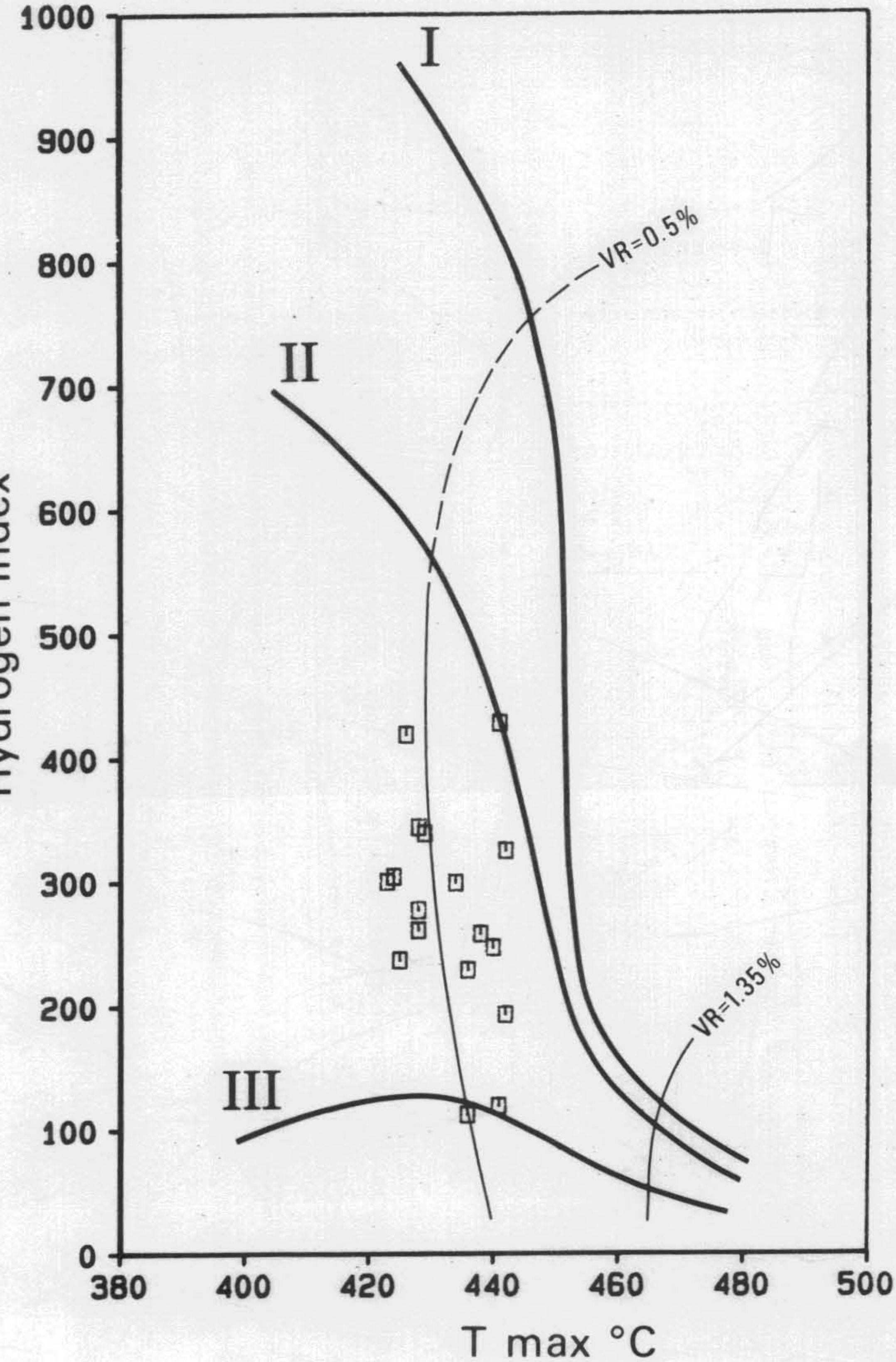
Client : DELHI PETROLEUM
Well Name : PELICAN-5
Interval : EOCENE CUTTINGS



amdel

FIGURE 5B

Client : AMOCO
Well name : PELICAN-5
Interval : EOCENE SIDEWALL CORES

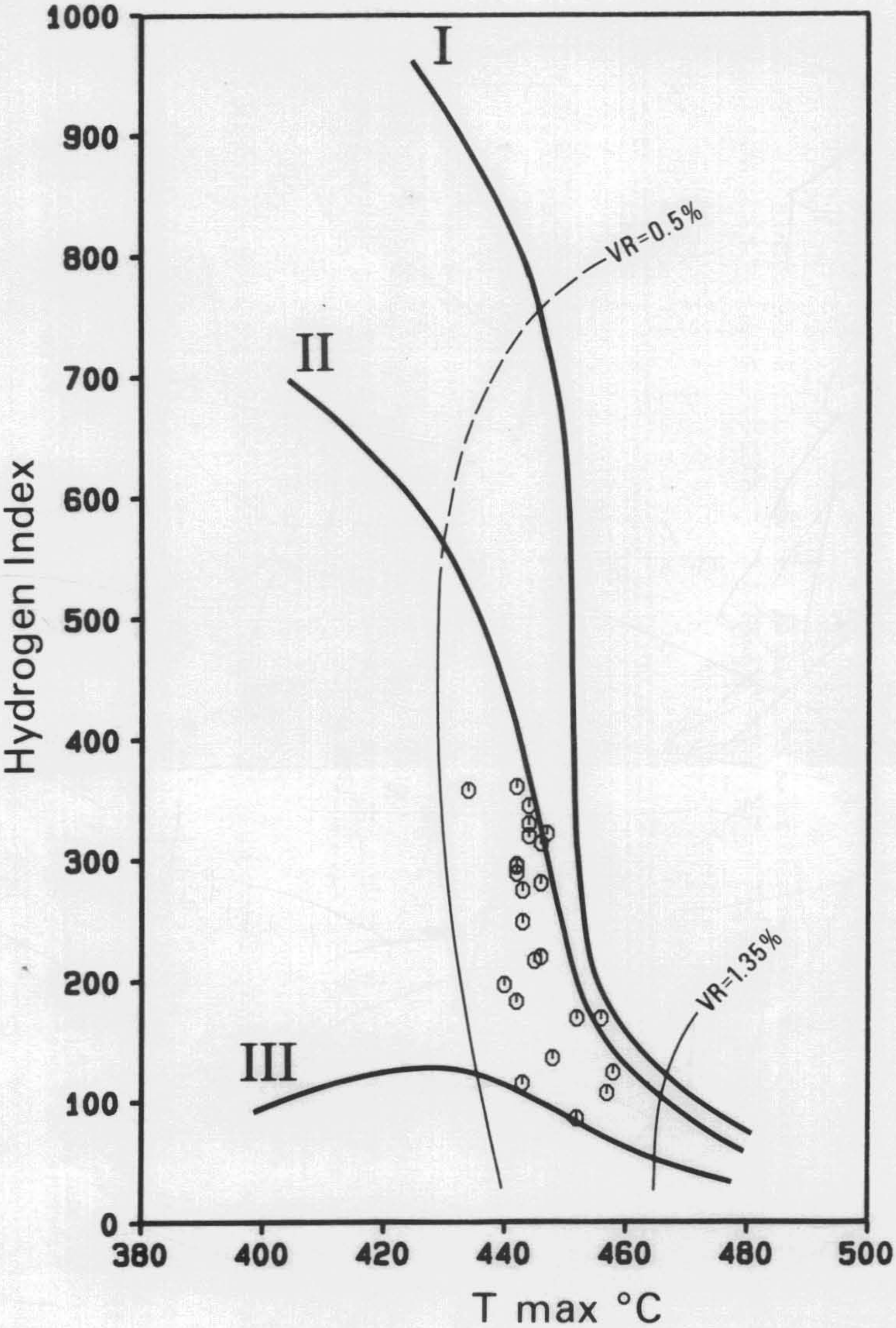


amdel

5 cm

FIGURE 6A

Client : DELHI PETROLEUM
Well Name : PELICAN-5
Interval : PALEOCENE CUTTINGS



amdel

5 cm

FIGURE 6B

Client : AMOCO
Well name : PELICAN-5
Interval : PALEOCENE SIDEWALL CORES

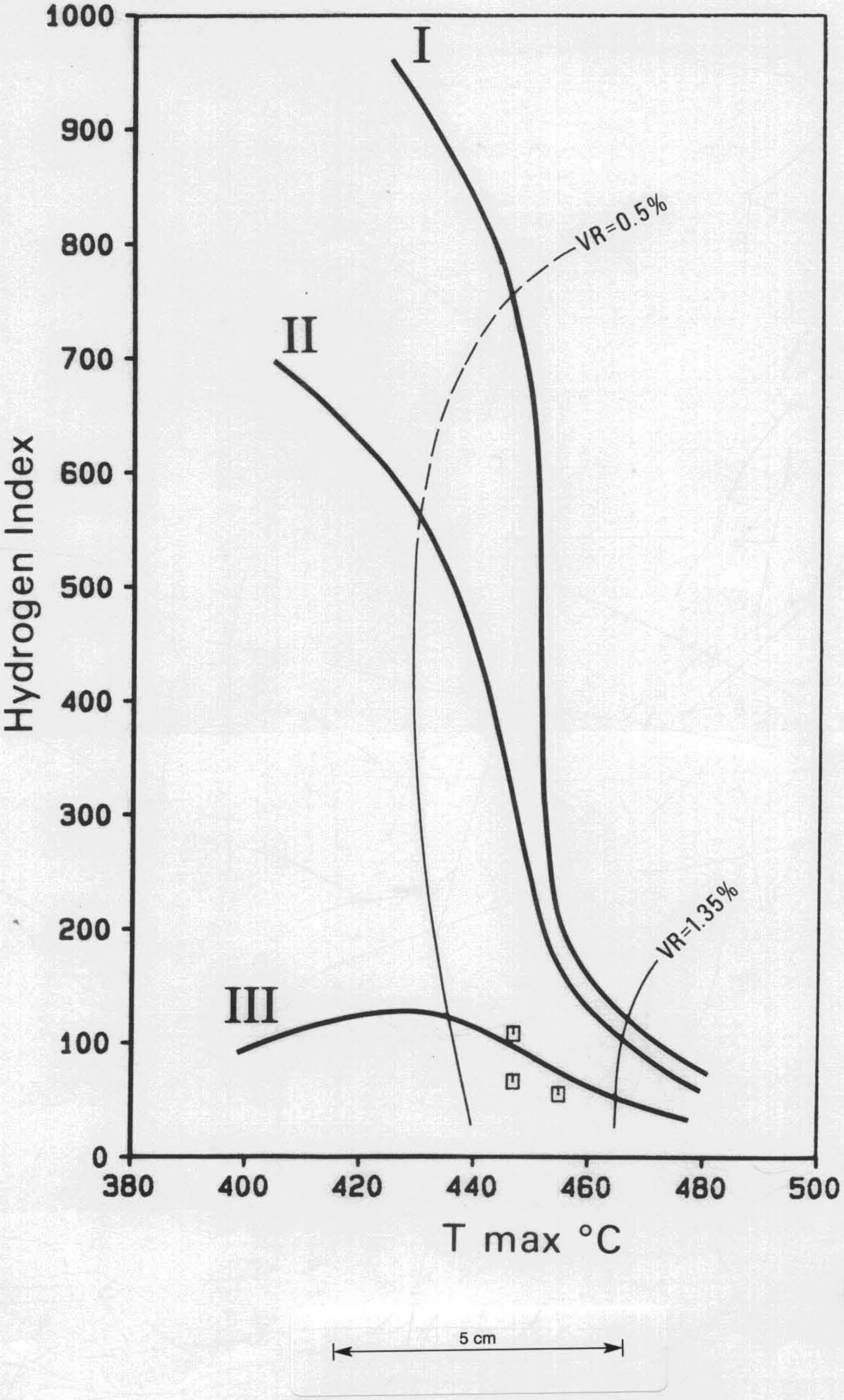
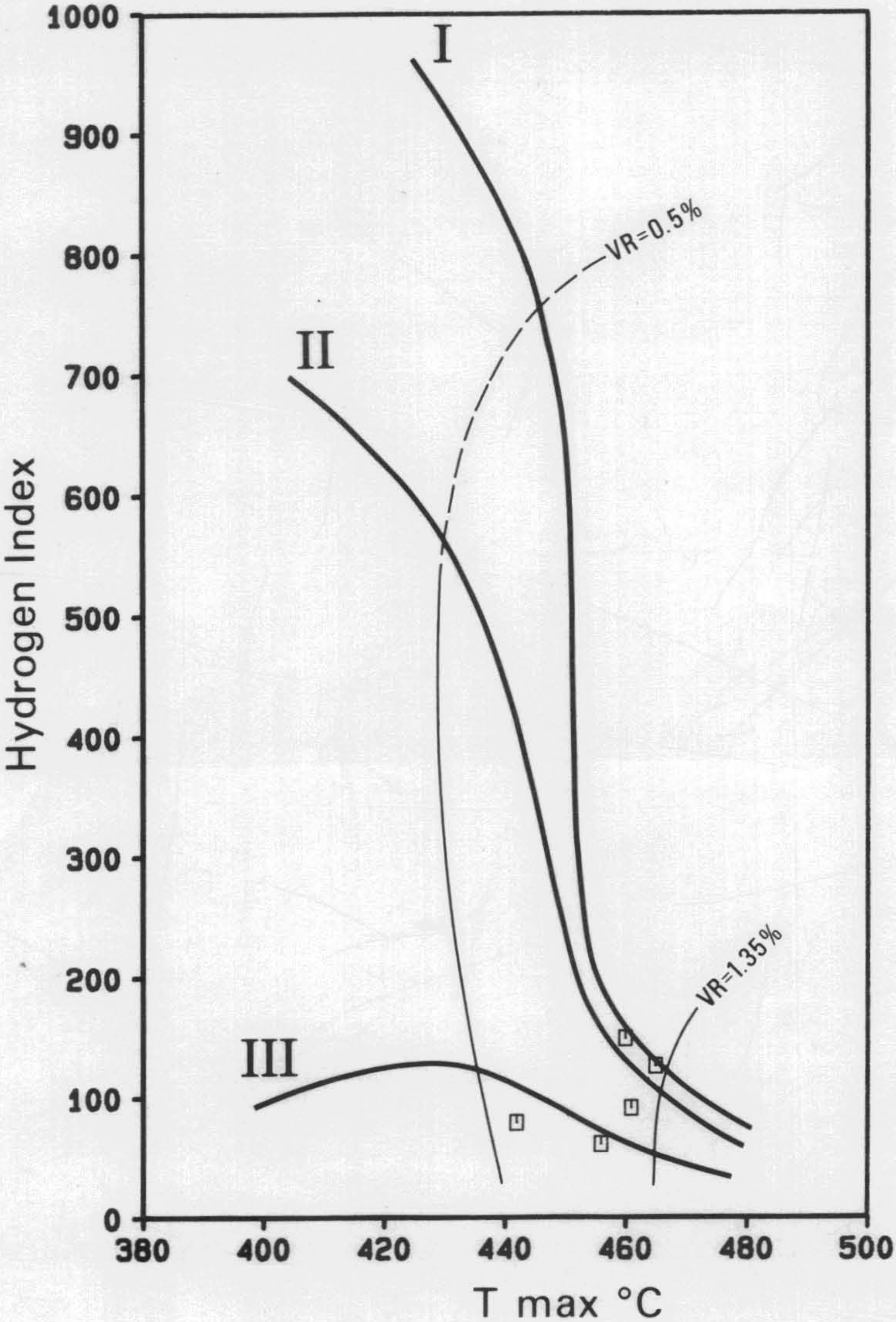


FIGURE 7A

454044

Client : DELHI PETROLEUM
Well Name : PELICAN-5
Interval : CRETACEOUS CUTTINGS

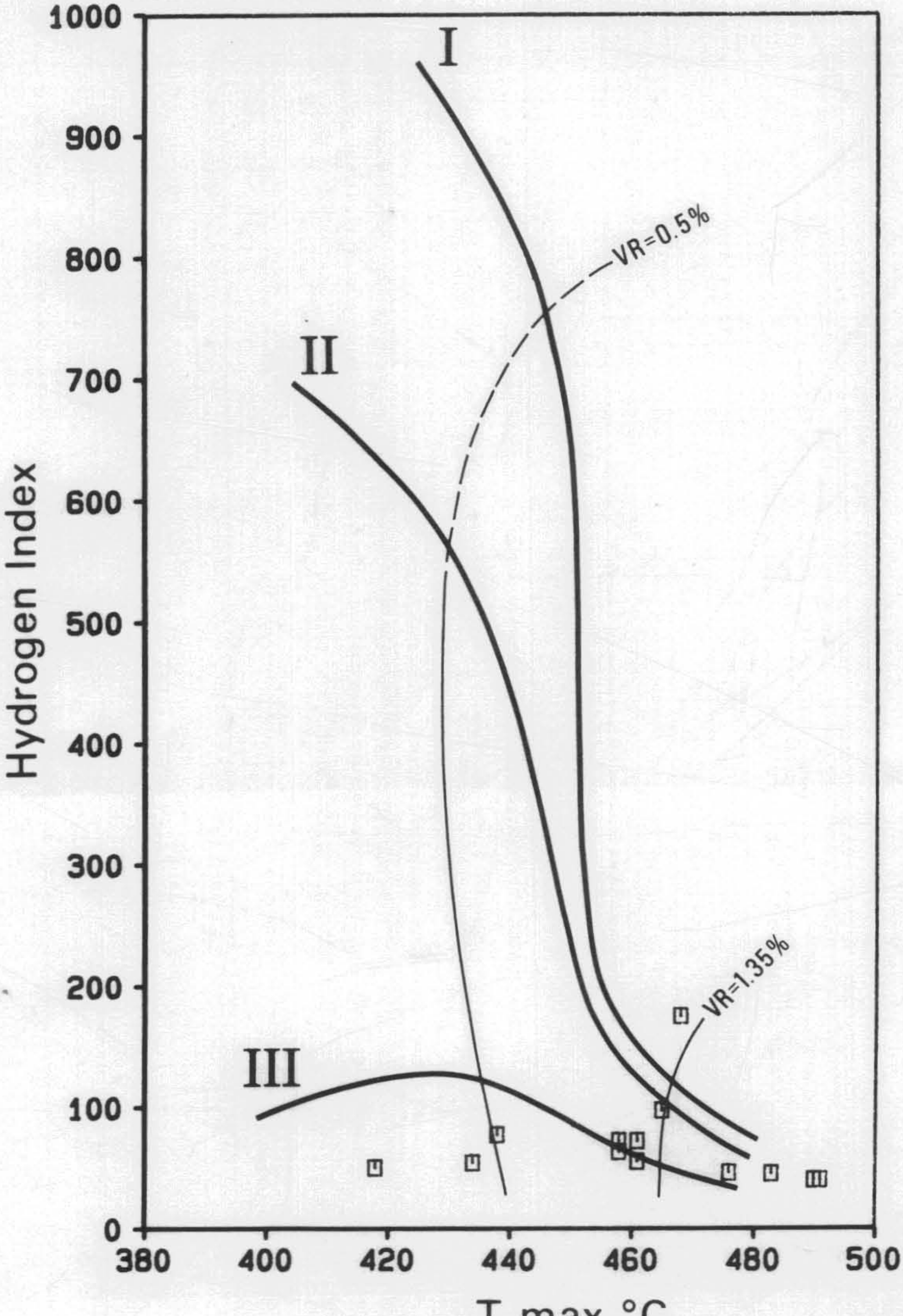


5 cm

FIGURE 7B

454045

Client : AMOCO
Well name : PELICAN-5
Interval : CRETACEOUS SIDEWALL CORES



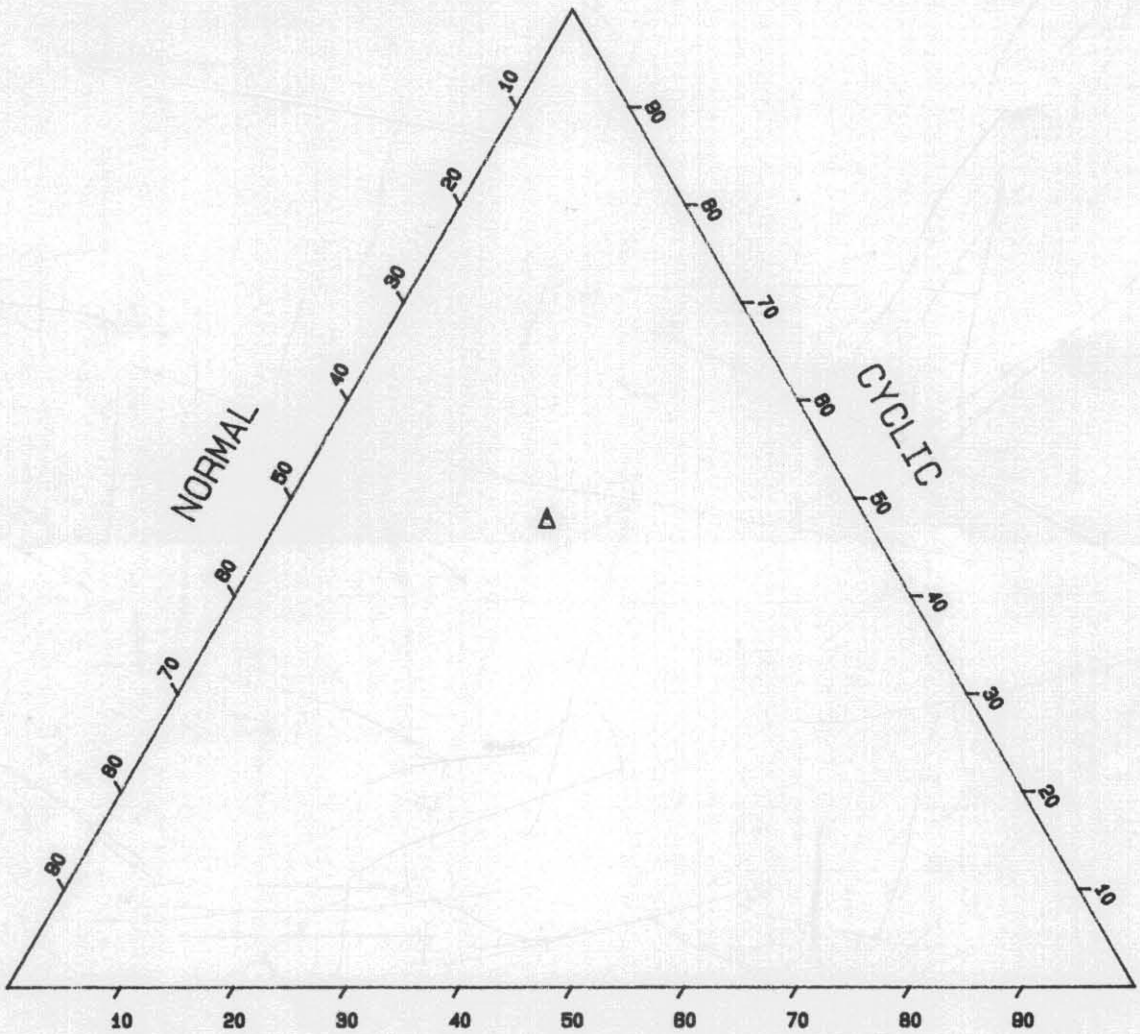
amdel

5 cm

FIGURE 8

454046

SOURCE AFFINITY BASED ON C5-C7 ALKANES
PELICAN-5, BASS BASIN



SOURCE CHARACTER BASED ON C_5-C_7 ALKANES

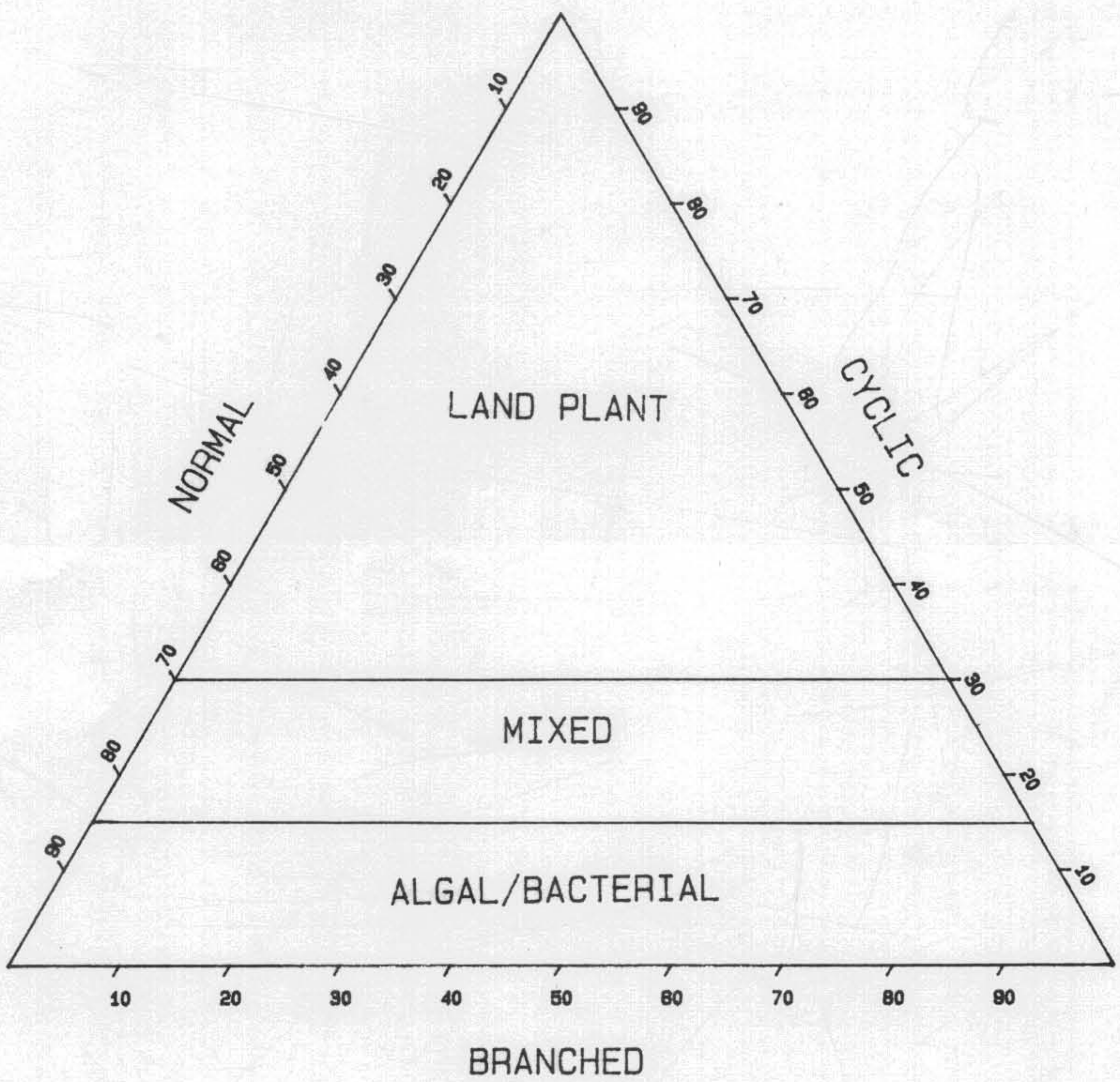


FIGURE 9
454048

OIL MATURITY AND ALTERATION
PELICAN-5, BASS BASIN

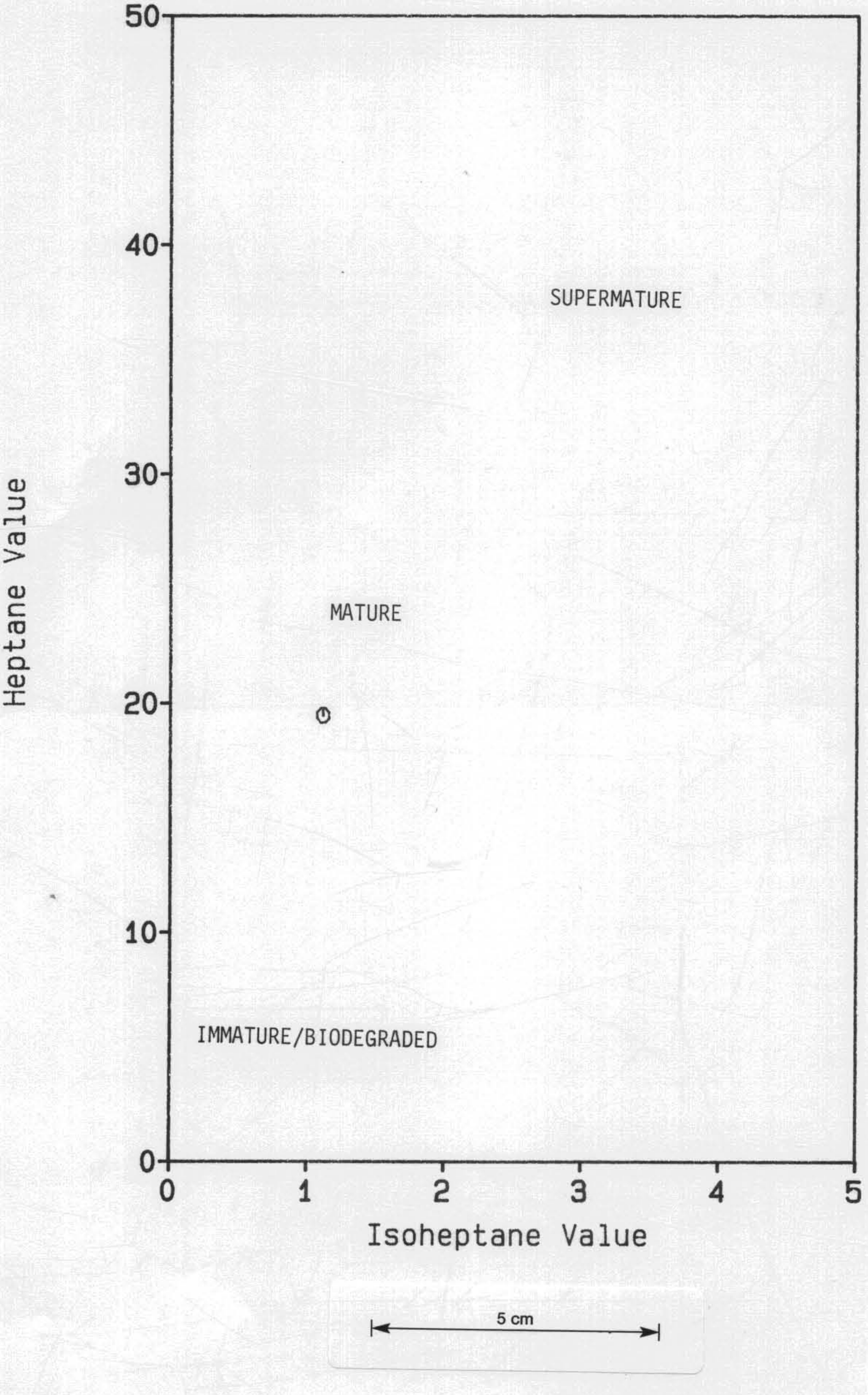
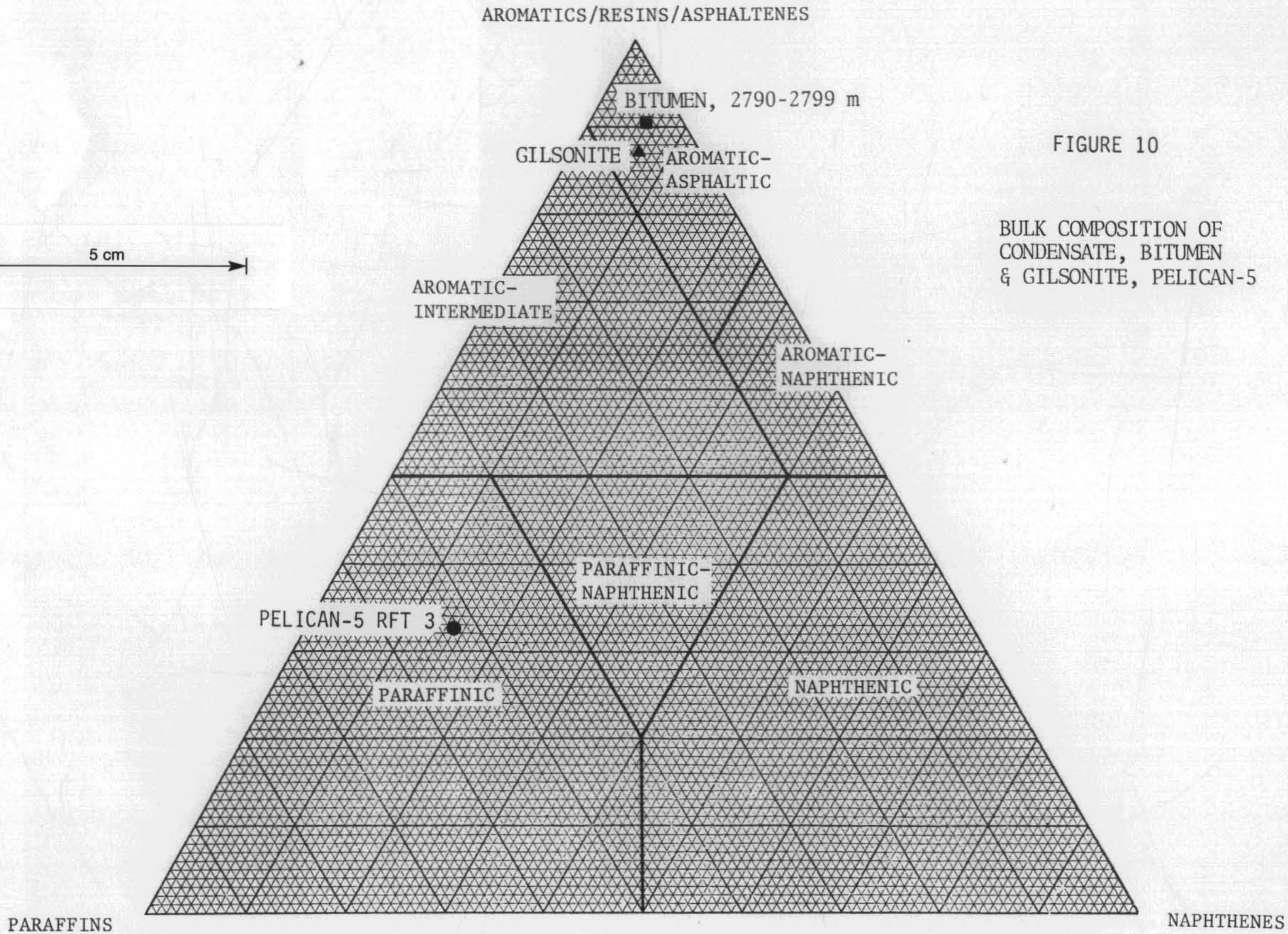


FIGURE 10

BULK COMPOSITION OF CONDENSATE, BITUMEN & GILSONITE, PELICAN-5



5 cm

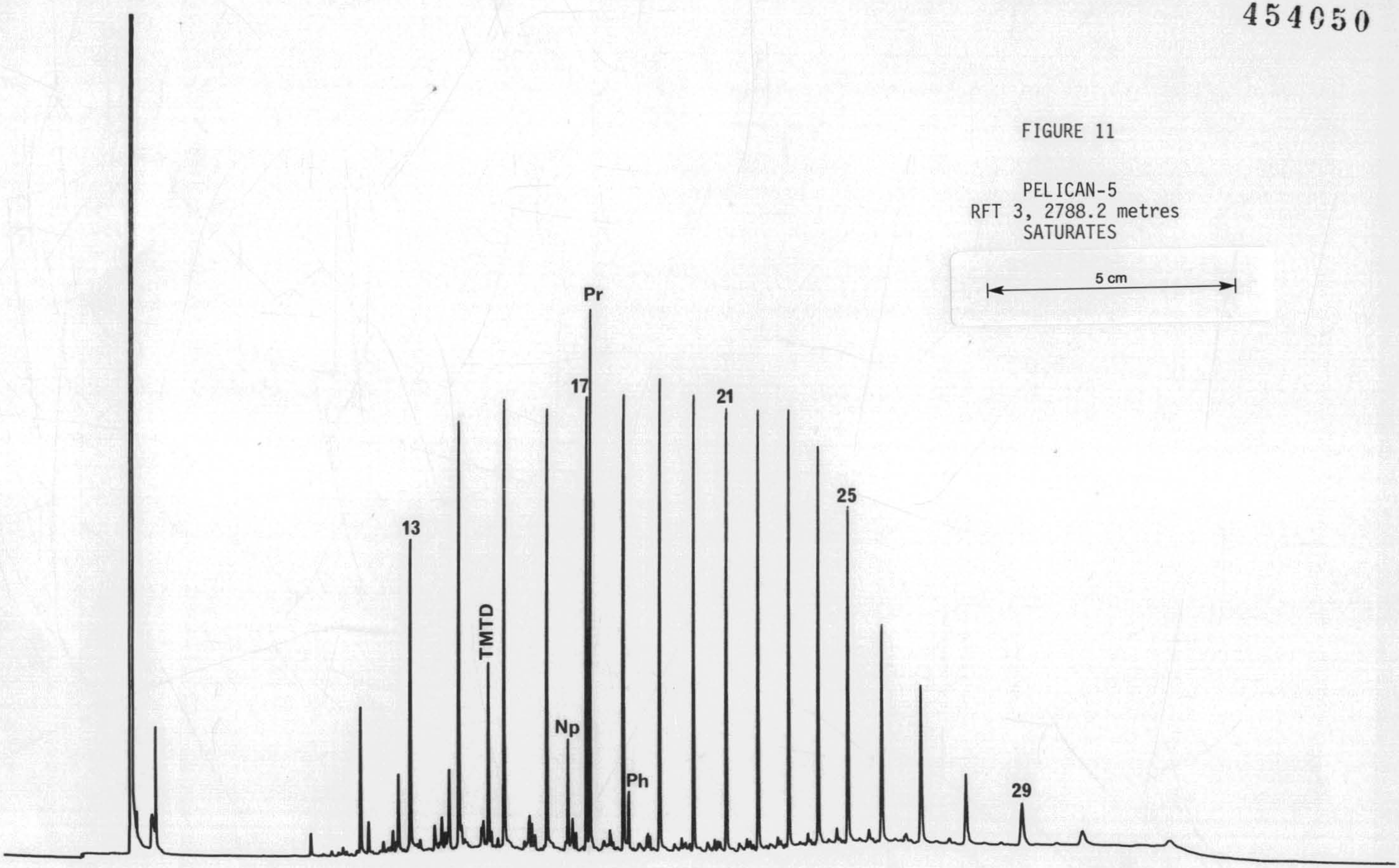
454049

amdel

454050

FIGURE 11

PELICAN-5
RFT 3, 2788.2 metres
SATURATES

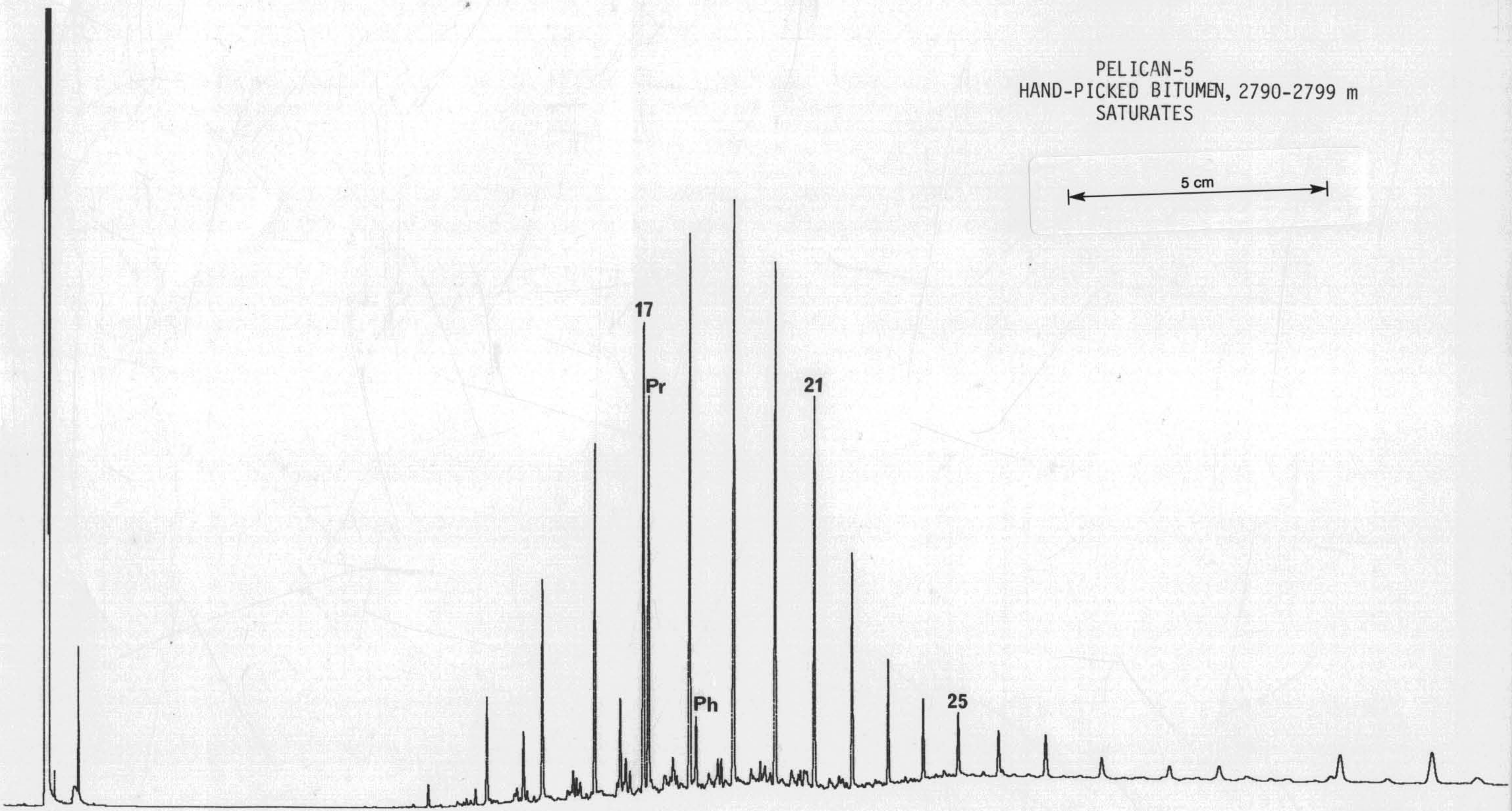


amdel

454051

FIGURE 12A

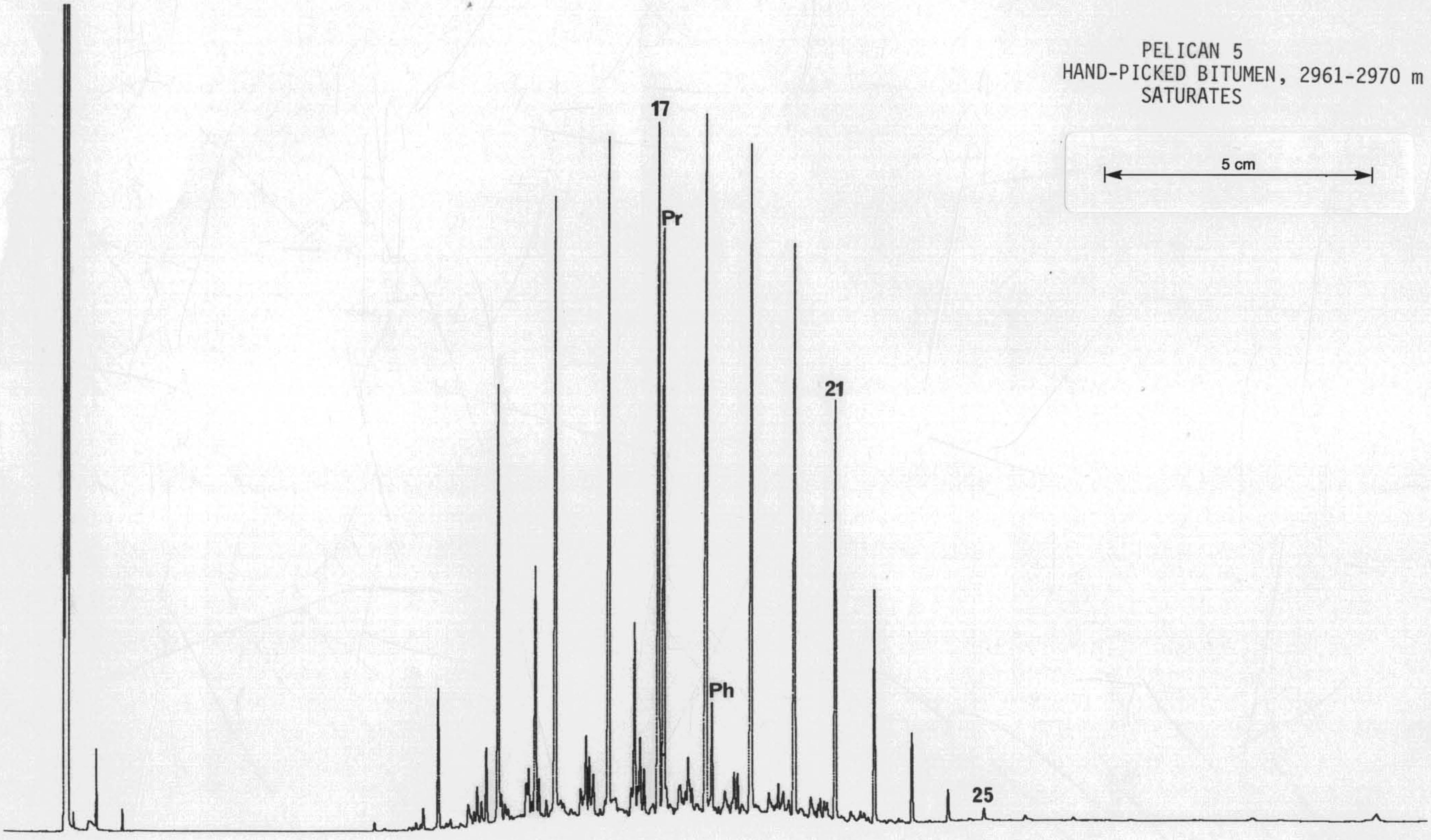
PELICAN-5
HAND-PICKED BITUMEN, 2790-2799 m
SATURATES



454052

FIGURE 12B

PELICAN 5
HAND-PICKED BITUMEN, 2961-2970 m
SATURATES

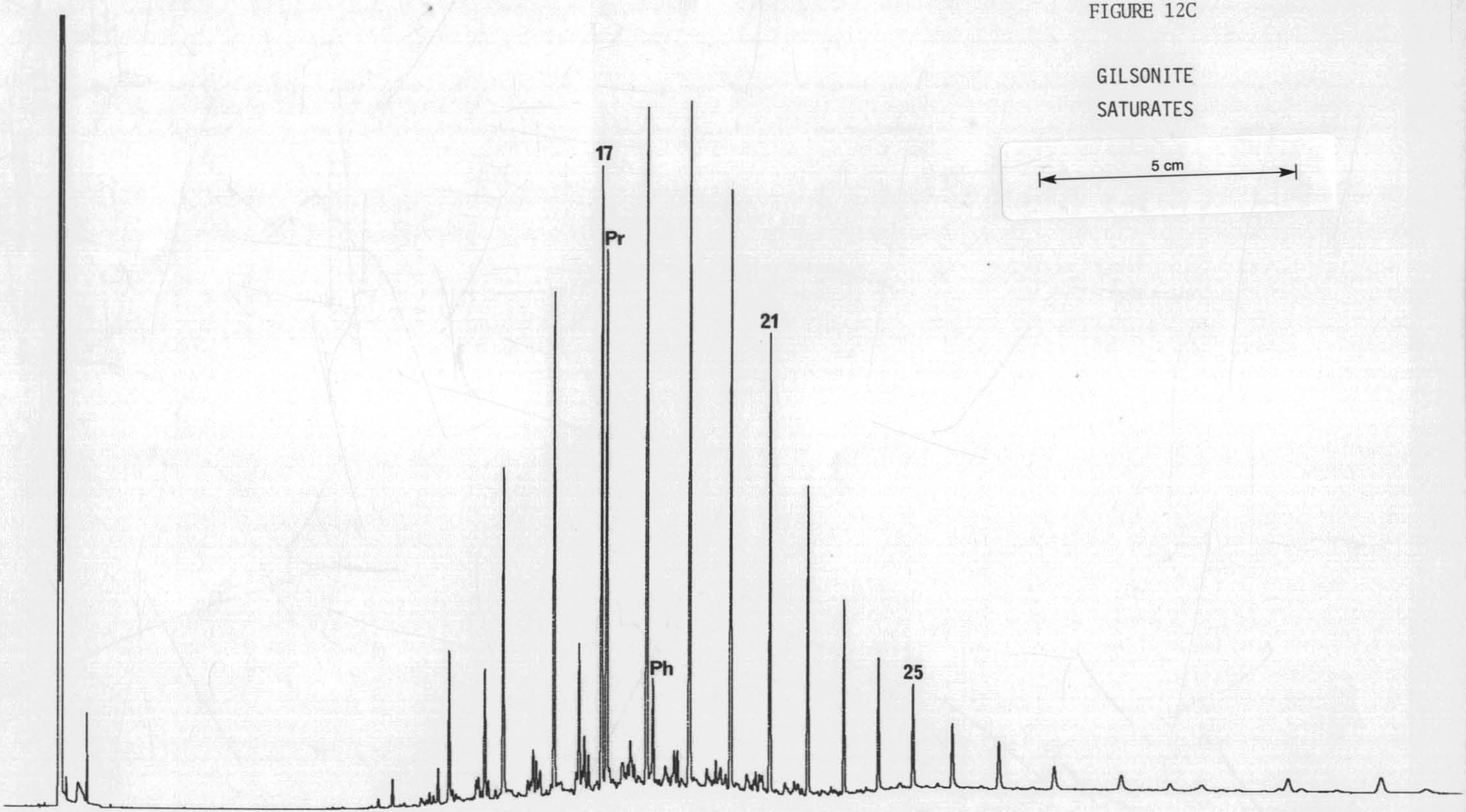


amdel

454053

FIGURE 12C

GILSONITE
SATURATES



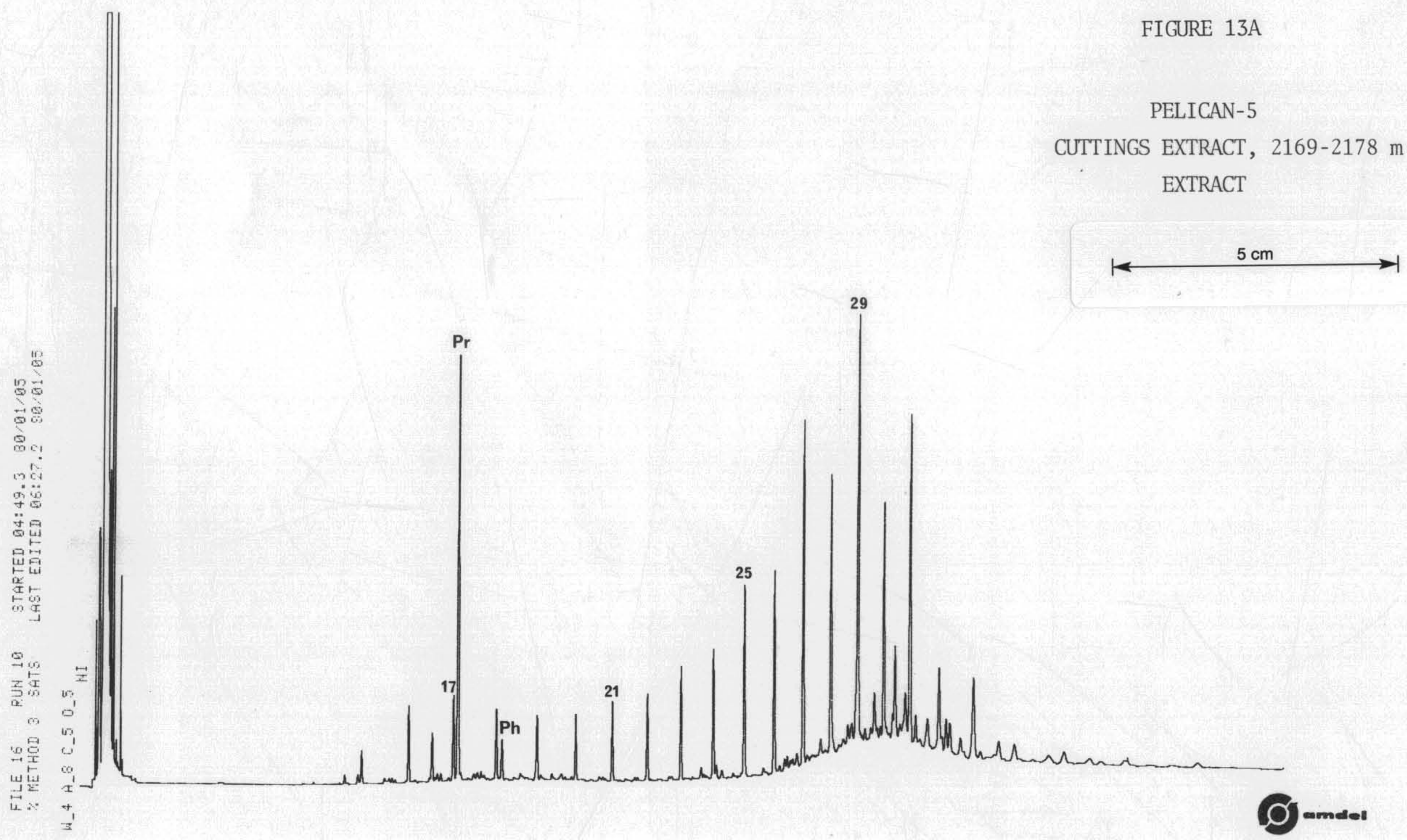
454054

FIGURE 13A

PELICAN-5

CUTTINGS EXTRACT, 2169-2178 m

EXTRACT



454055

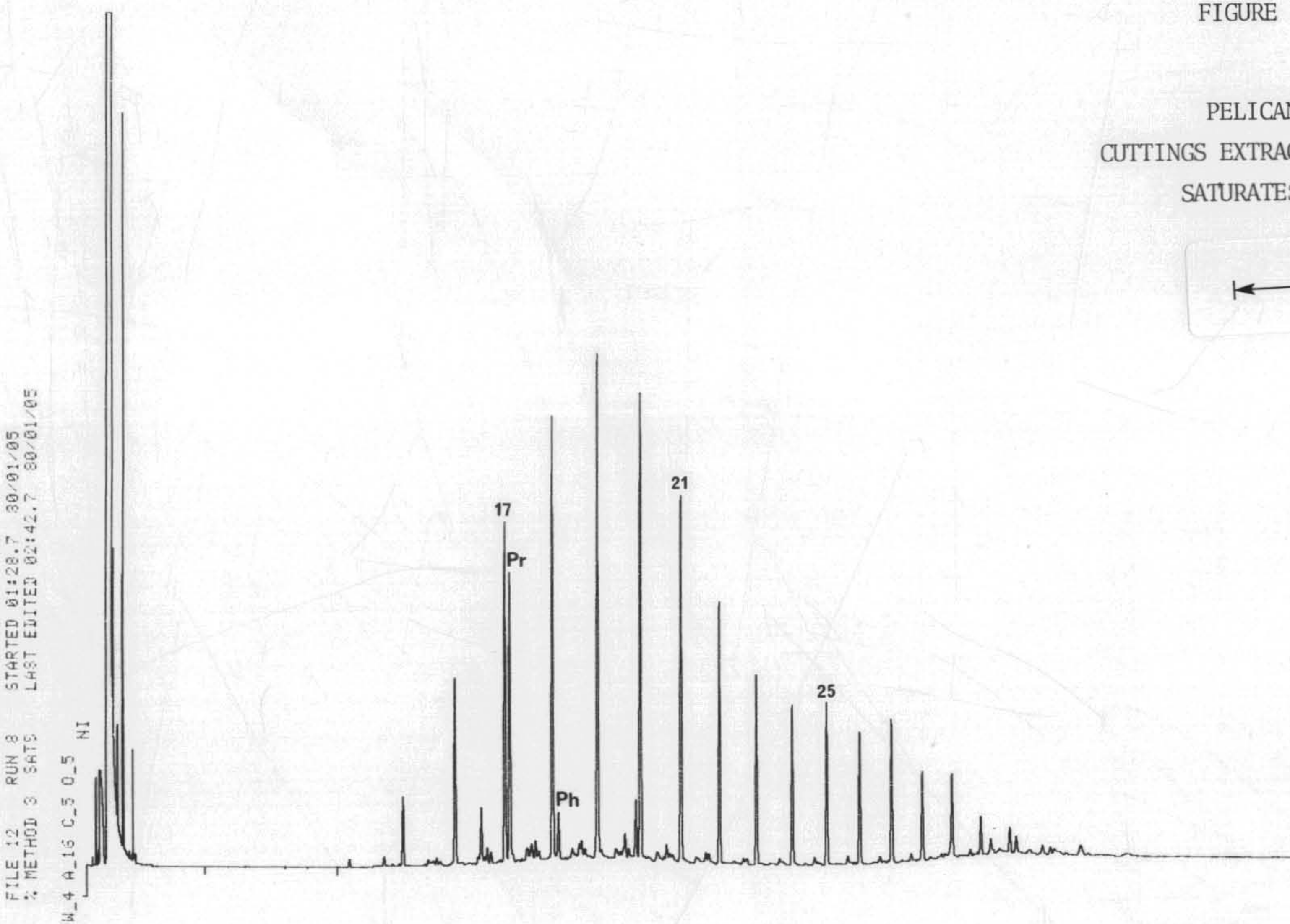


FIGURE 13B

PELICAN-5

CUTTINGS EXTRACT, 2961-2970 m

SATURATES (1 HR)

5 cm

amdel

454056

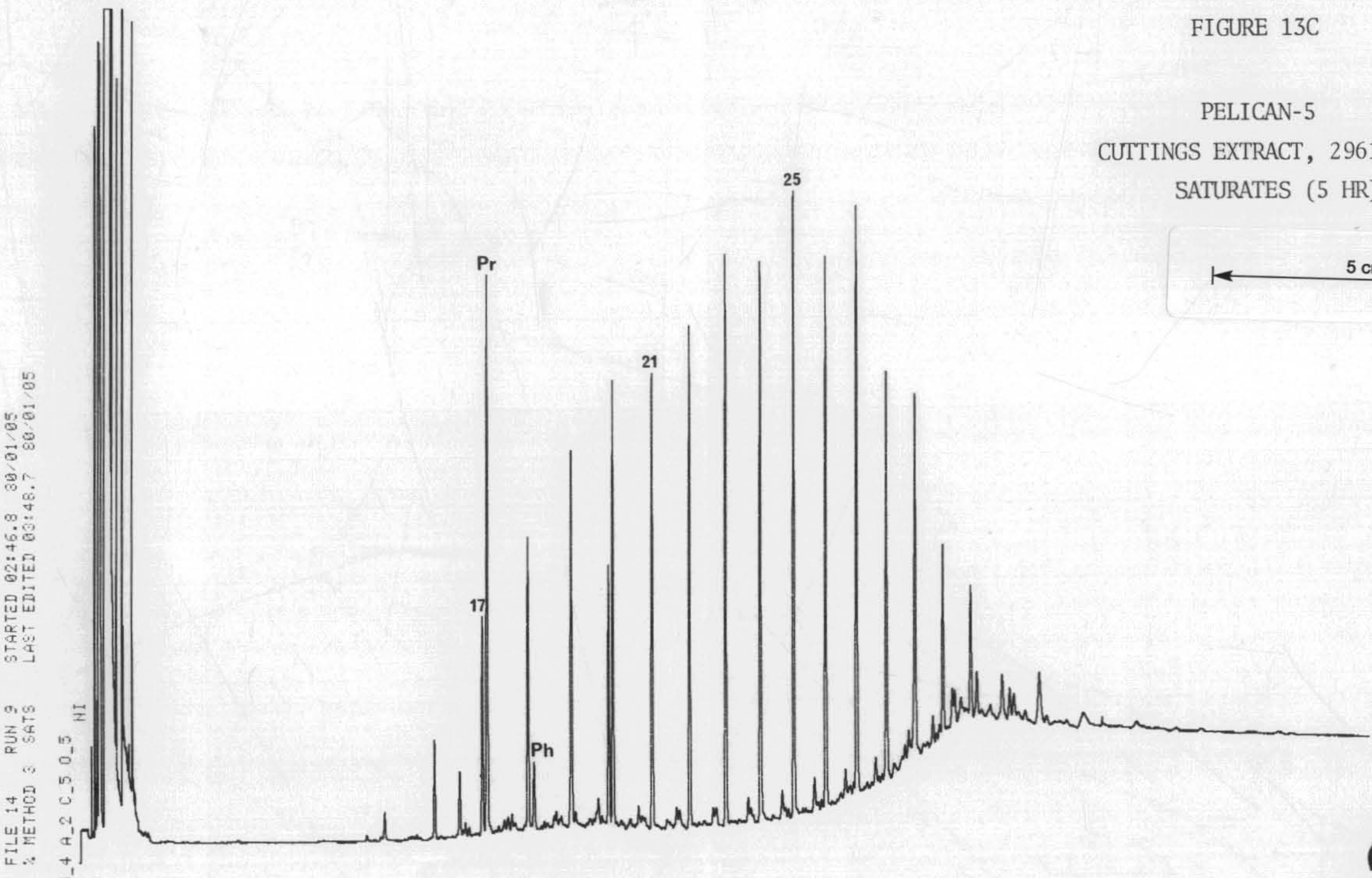
FIGURE 13C

PELICAN-5

CUTTINGS EXTRACT, 2961-2970 m

SATURATES (5 HR)

5 cm



amdel

FIGURES 14-16

MASS FRAGMENTOGRAMS OF NAPHTHENES IN CONDENSATE, RFT 3, PELICAN-5

Fig. 14	:	m/z 123, 259	tetracyclic diterpanes
Fig. 15	:	m/z 183	acyclic isoprenoid alkanes
		m/z 191	triterpanes (incl. hopanes, moretanes)
Fig. 16	:	m/z 217, 218	steranes

KEY TO MASS FRAGMENTOGRAMS

m/z 123, 259 (diterpanes)

1	C_{19}	isopimarane
2	C_{20}	ent-beyerane
3	C_{20}	isopimarane
4	C_{20}	16β(H)-phyllocladane
5	C_{20}	ent-16β(H)-kaurane
6	C_{20}	16α(H)-phyllocladane
7	C_{20}	ent-16α(H)-kaurane

m/z 183 (acyclic isoprenoid alkanes)

15-40	numbers indicate number of carbon atoms in compound
*	irregular (head-to-head)

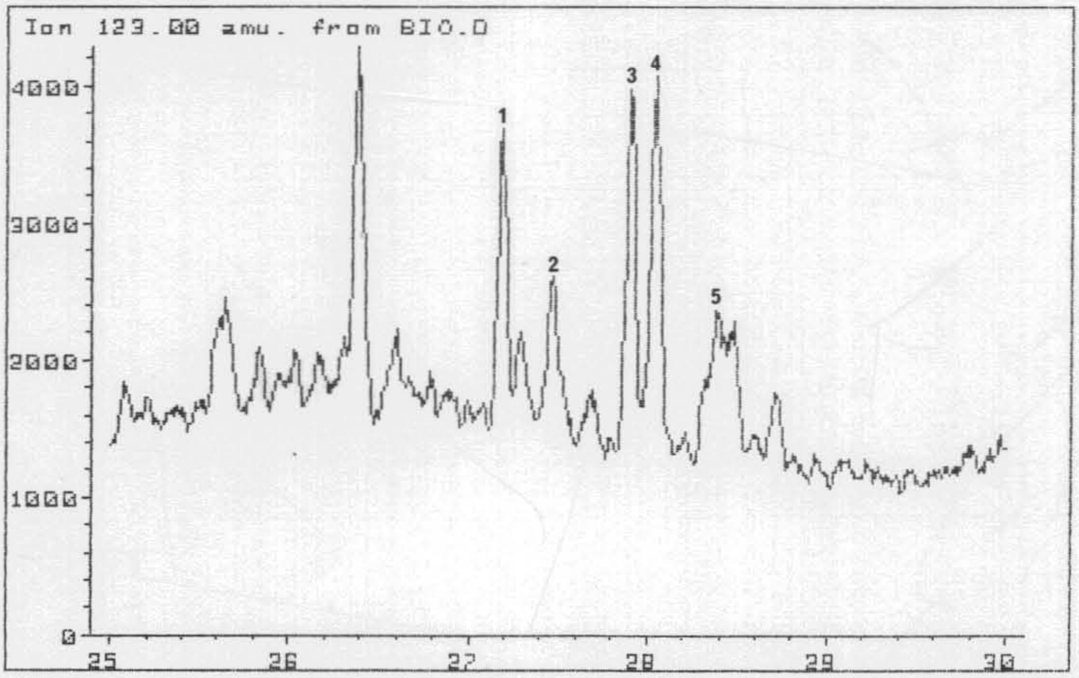
m/z 191 (terpanes)

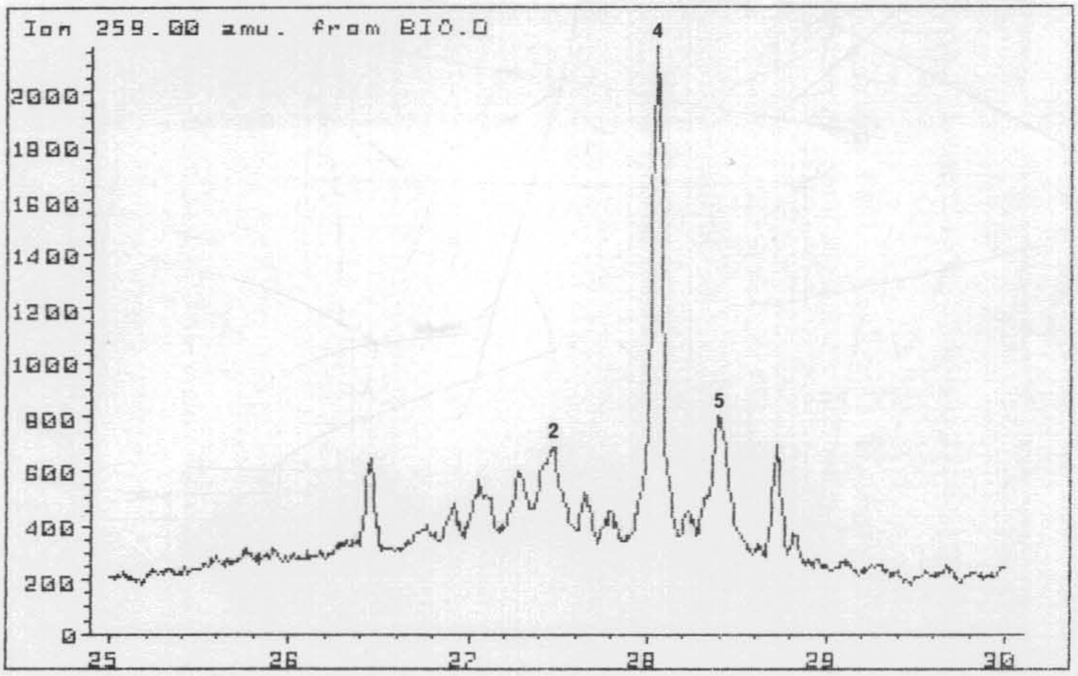
1-6	C_{20}-C_{25}	tricyclic terpanes
7	C_{24}	tetracyclic terpane
8	C_{26}	tricyclic terpane
9	C_{27}	18α(H)-22,29,30-trisnorhopane (Ts)
10	C_{27}	17α(H)-22,29,30-trisnorhopane (Tm)
11	C_{28}	17α(H)-28,30-bisnorhopane
12	C_{29}	17α(H)-25-norhopane
13	C_{29}	17α(H)21β(H) norhopane
14	C_{30}	pentacyclic terpane
15	C_{29}	17β(H)21α(H) moretane
16	C_{30}	17α(H)21β(H) hopane
17	C_{30}	17β(H)21α(H) moretane
18-22	C_{31}-C_{35}	17α(H)21β(H) 22S (left) and 22R (right) homohopanes

m/z 217, 218, 259 (steranes, diasteranes)

1	C_{21}	sterane
2	C_{22}	sterane
3&4	C_{27}	20S and 20R diasteranes
5&8	C_{27}	5α(H)14α(H)17α(H) 20S and 20R steranes
6	C_{27}	5α(H)14β(H)17β(H) 20R sterane
7	C_{27}	5α(H)14β(H)17β(H) 20S sterane + C_{29} 20S diasterane
9	C_{29}	20R diasterane
10&13	C_{28}	5α(H)14α(H)17α(H) 20S and 20R steranes
11&12	C_{28}	5α(H)14β(H)17β(H) 20R and 20S steranes
14&17	C_{29}	5α(H)14α(H)17α(H) 20S and 20R steranes
15&16	C_{29}	5α(H)14β(H)17β(H) 20R and 20S steranes

FIGURE 14

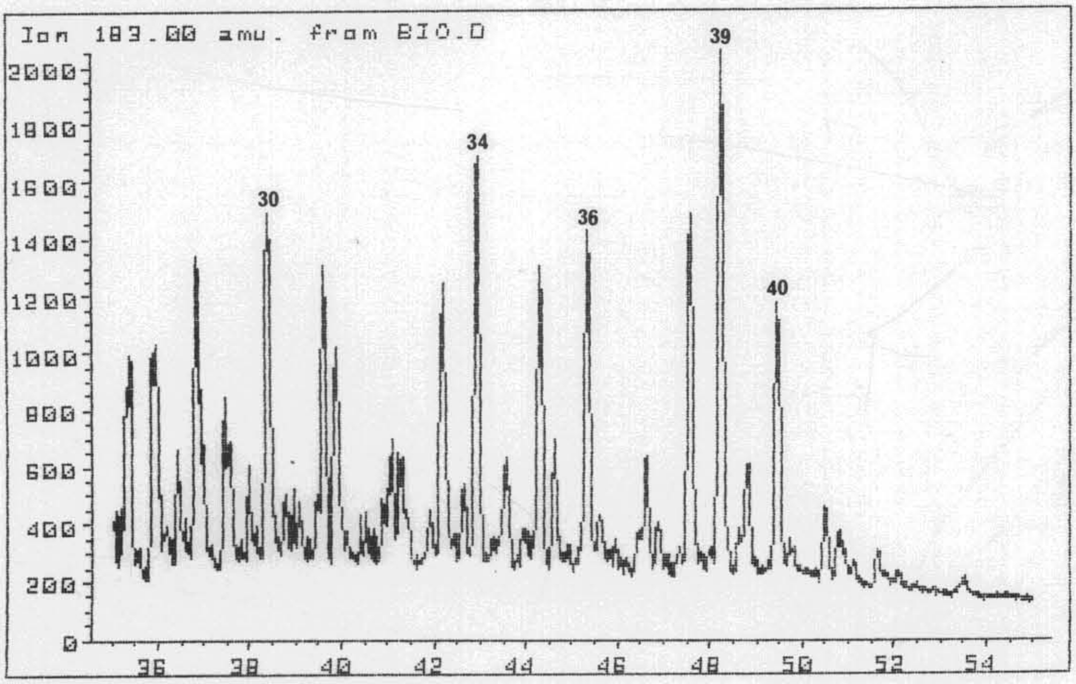


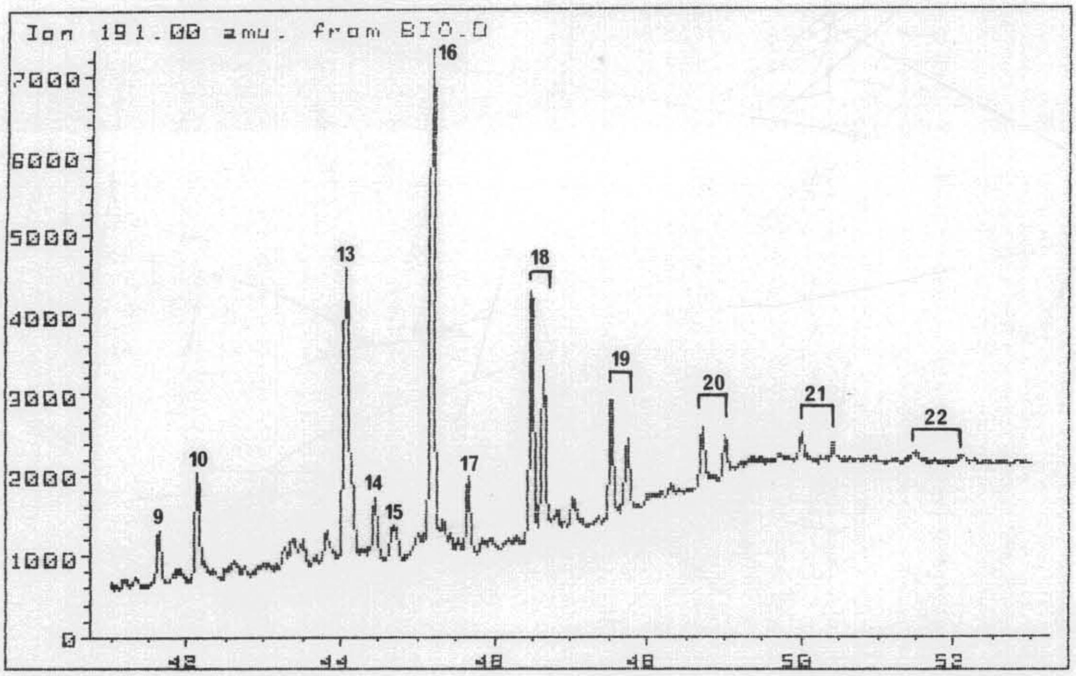


5 cm

454060

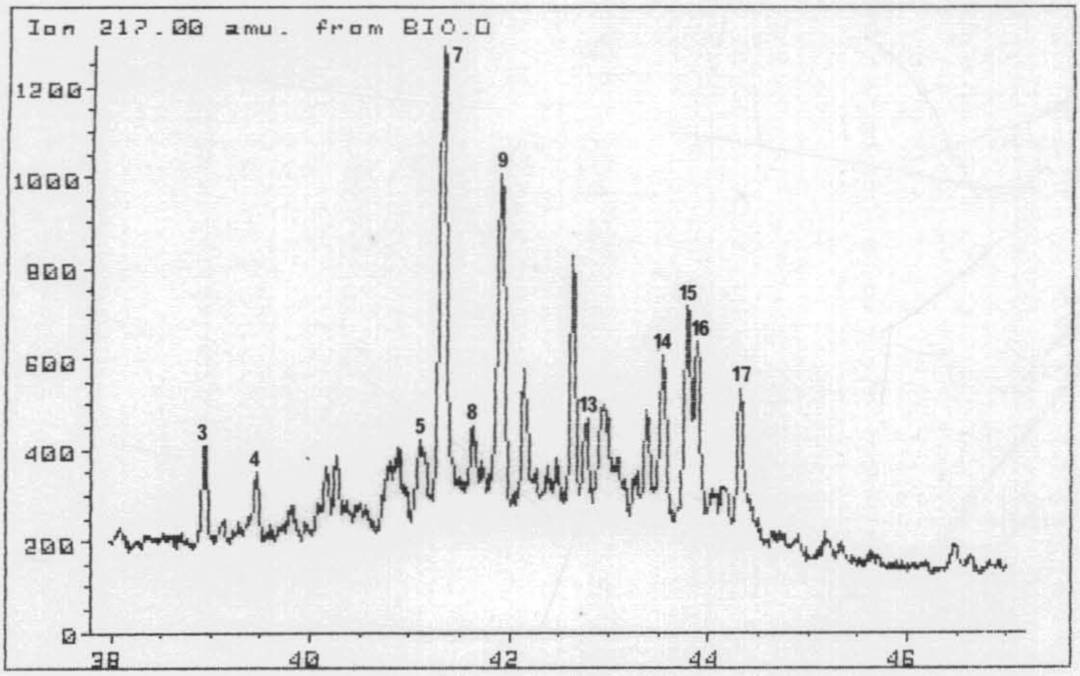
FIGURE 15

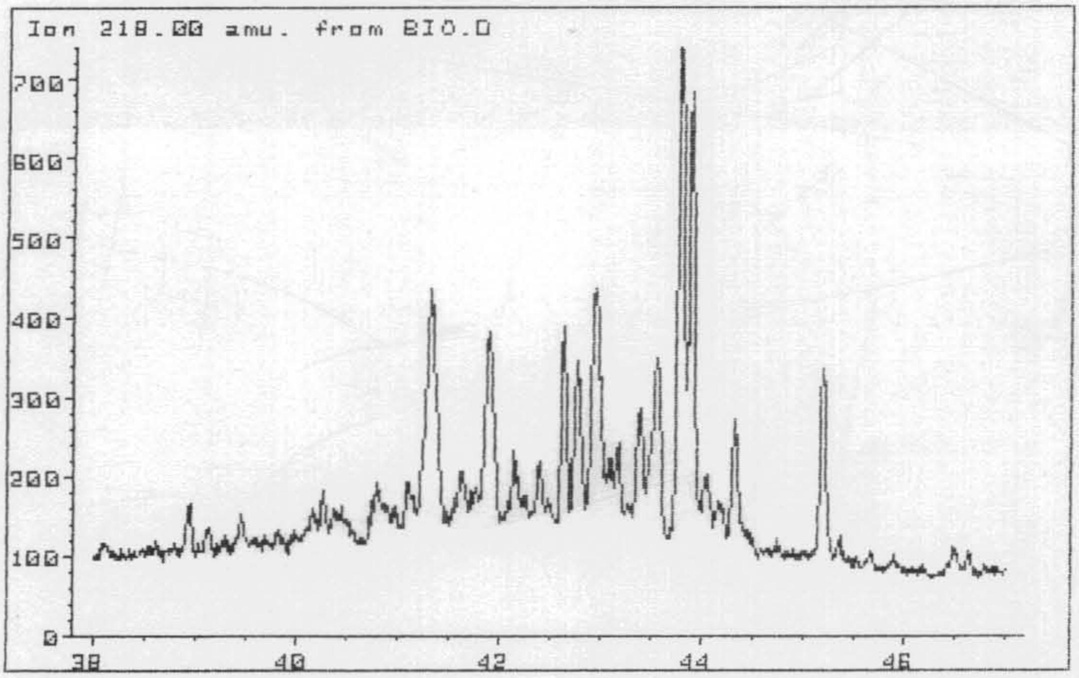




5 cm

FIGURE 16





5 cm

amdel

FIGURES 17-19

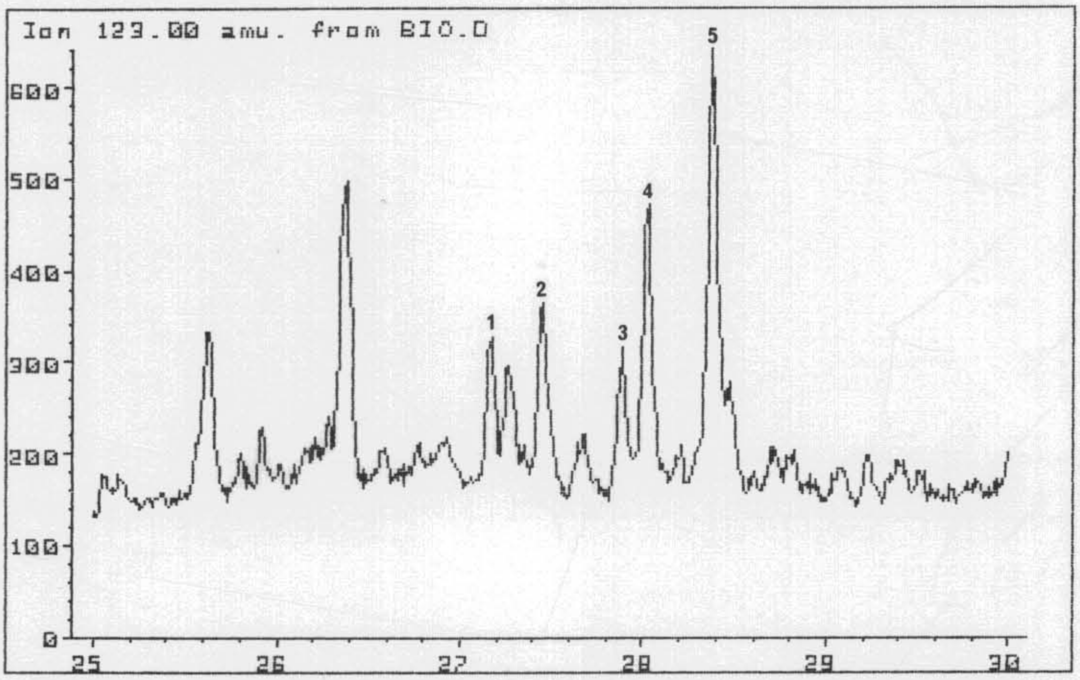
MASS FRAGMENTOGRAMS OF NAPHTHENES IN BITUMEN AND GILSONITE, PELICAN-5

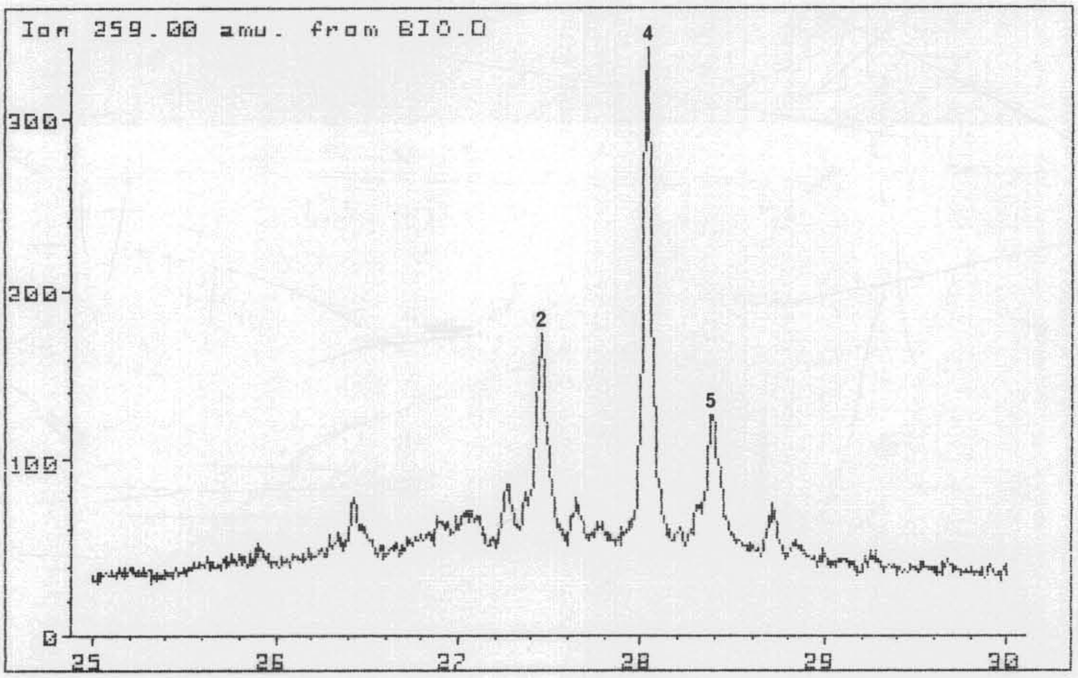
Fig. 17	:	m/z 123, 259	tetracyclic diterpanes
Fig. 18	:	m/z 183	acyclic isoprenoid alkanes
		m/z 191	triterpanes (incl. hopanes, moretanes)
Fig. 19	:	m/z 217, 218	steranes

A. Bitumen in cuttings, 2790-2799 m

B. Gilsonite mud additive

FIGURE 17A

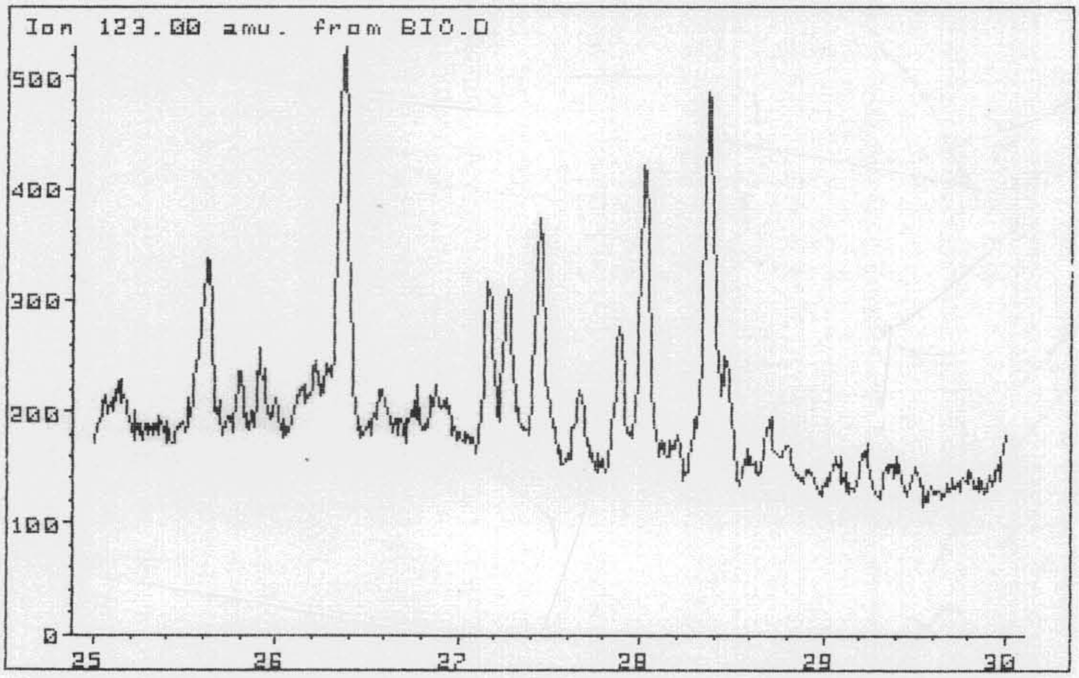


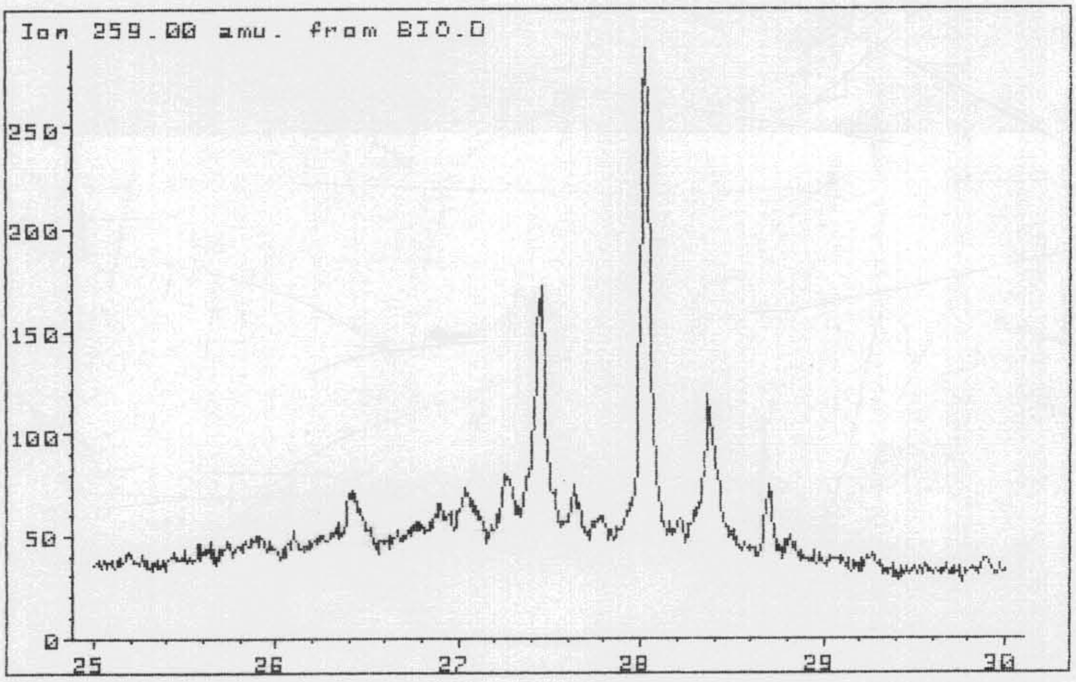


5 cm

FIGURE 17B

454064



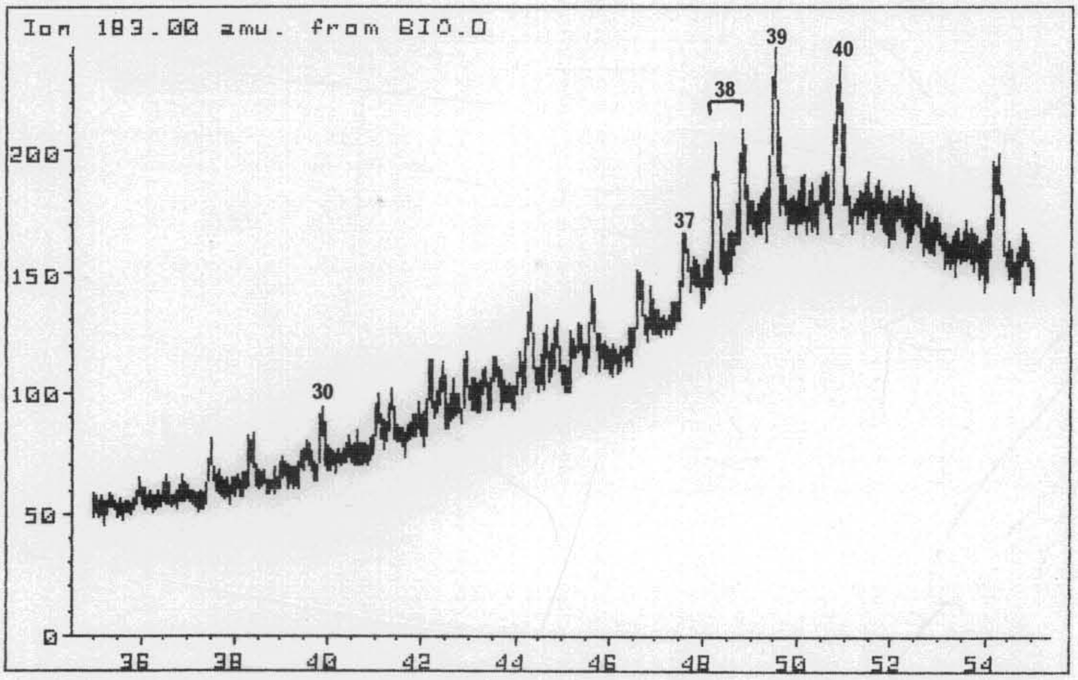


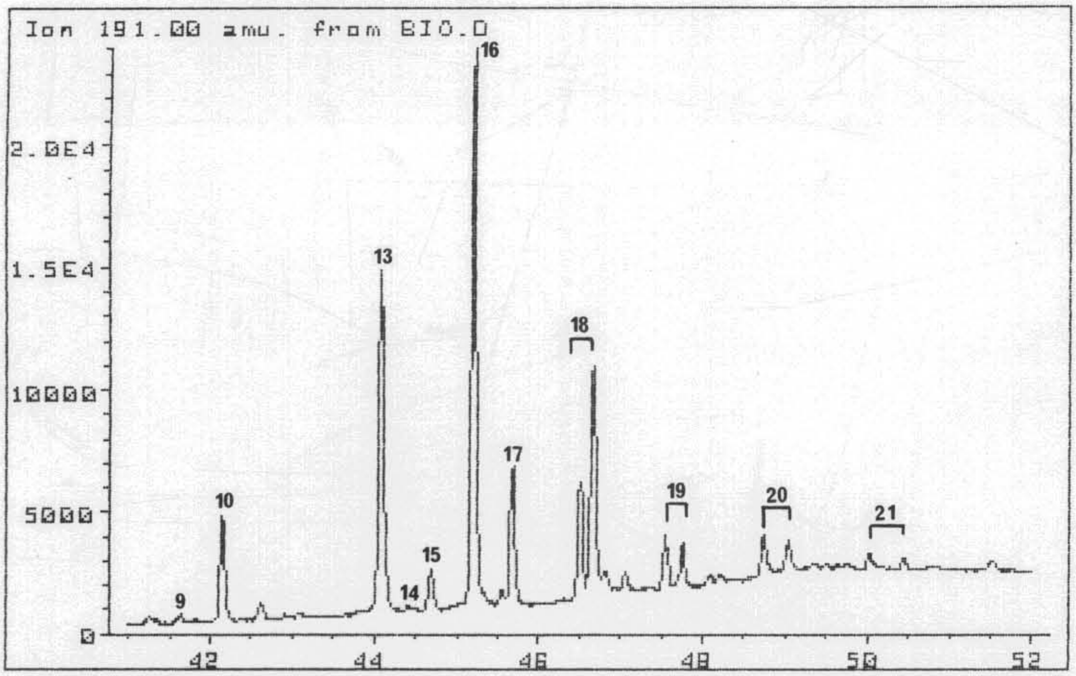
5 cm

amdel

FIGURE 18A

454065

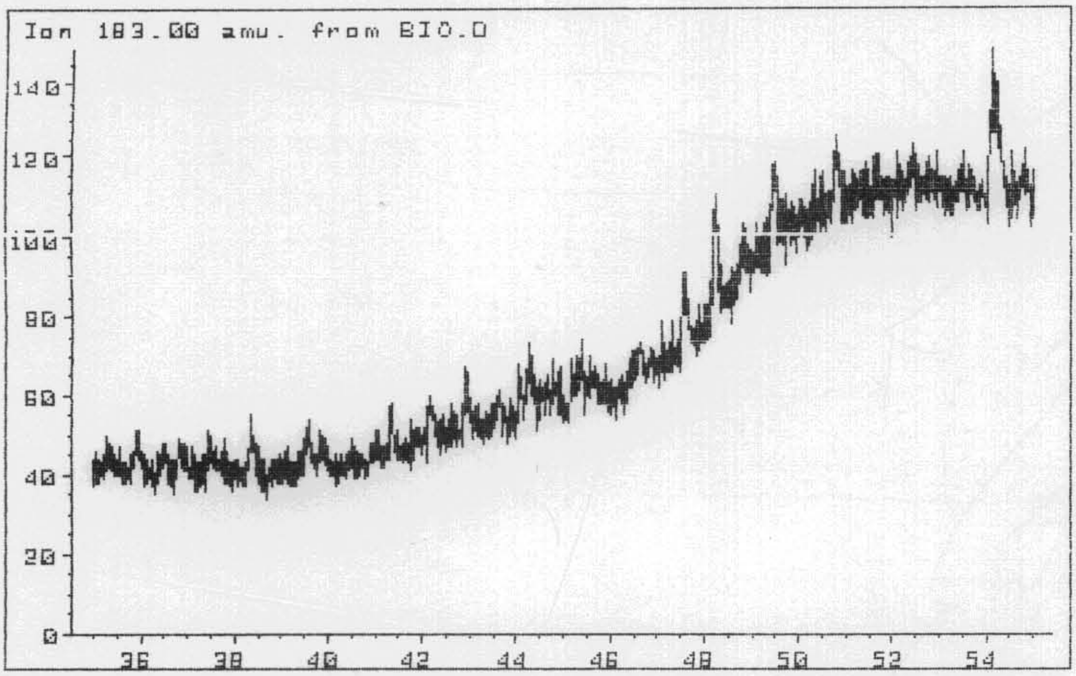


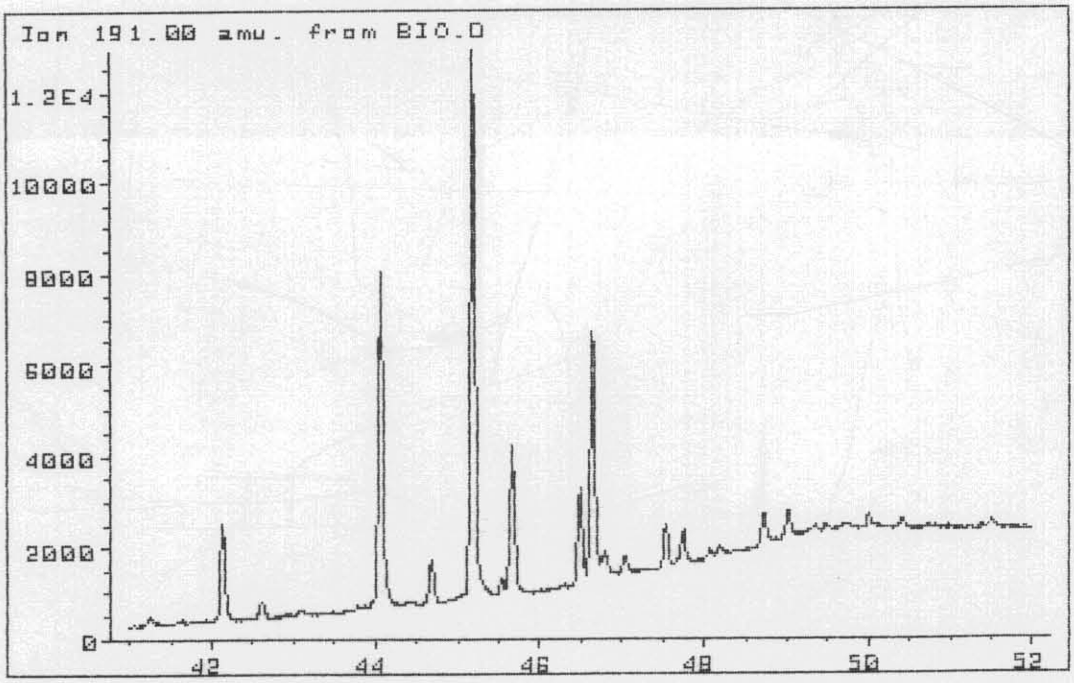


5 cm

FIGURE 18B

454066

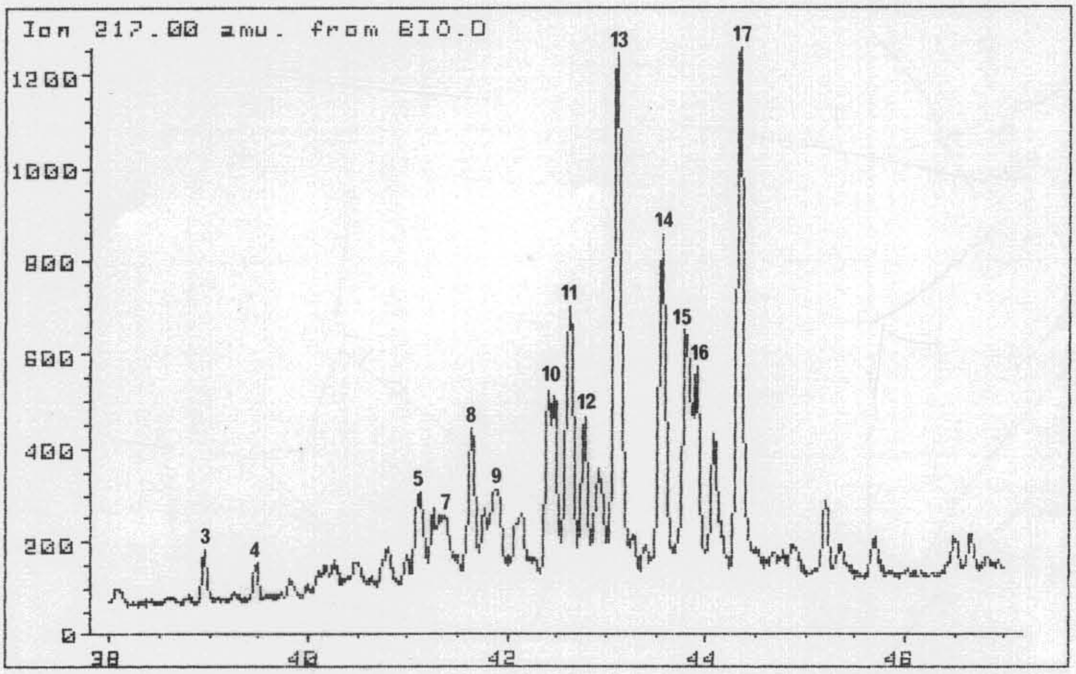


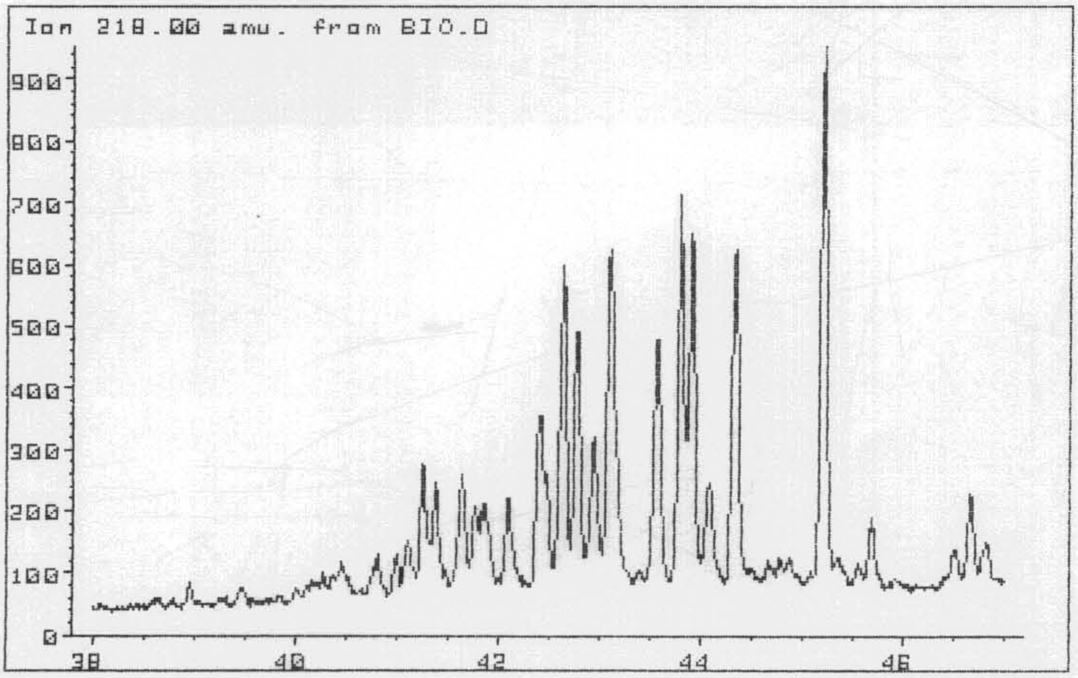


5 cm

amdel

FIGURE 19A
454067

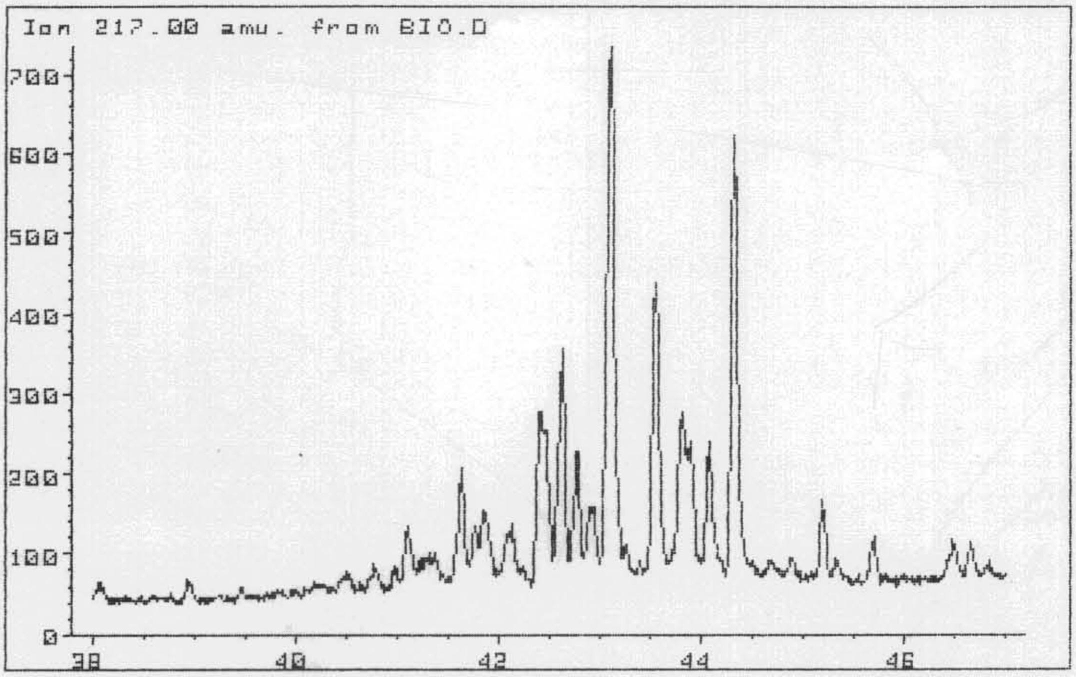


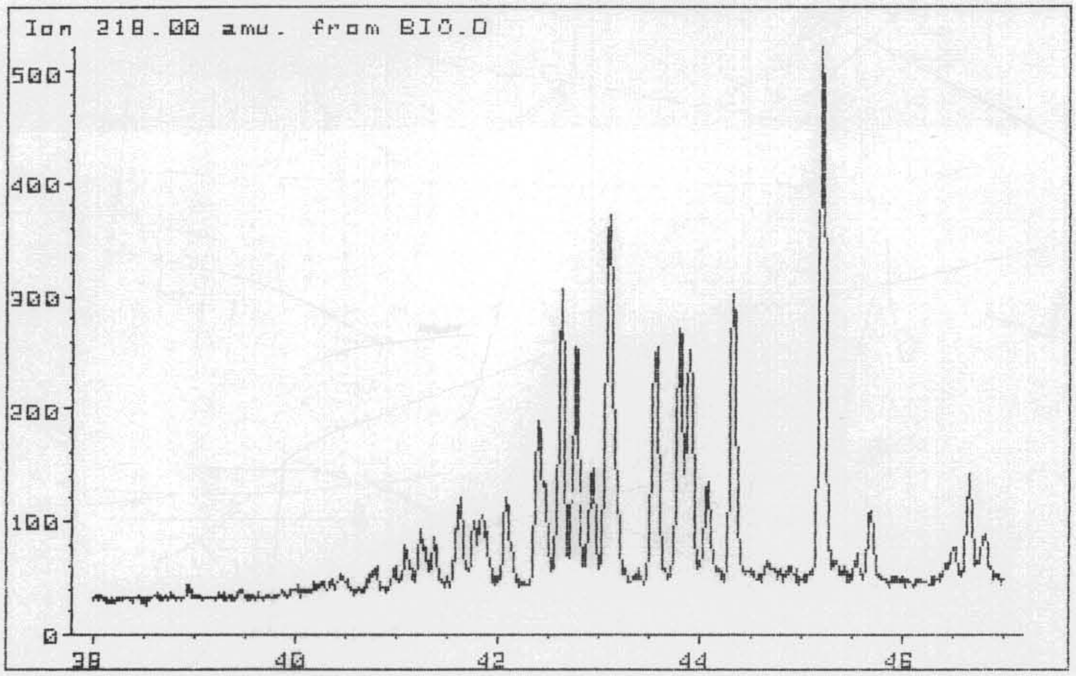


5 cm

FIGURE 19B

454068





5 cm

amdel

FIGURE 20

454069

C27-C29 STERANE DISTRIBUTIONS OF CONDENSATE AND BITUMEN/GILSONITE, PELICAN-5, BASS BASIN

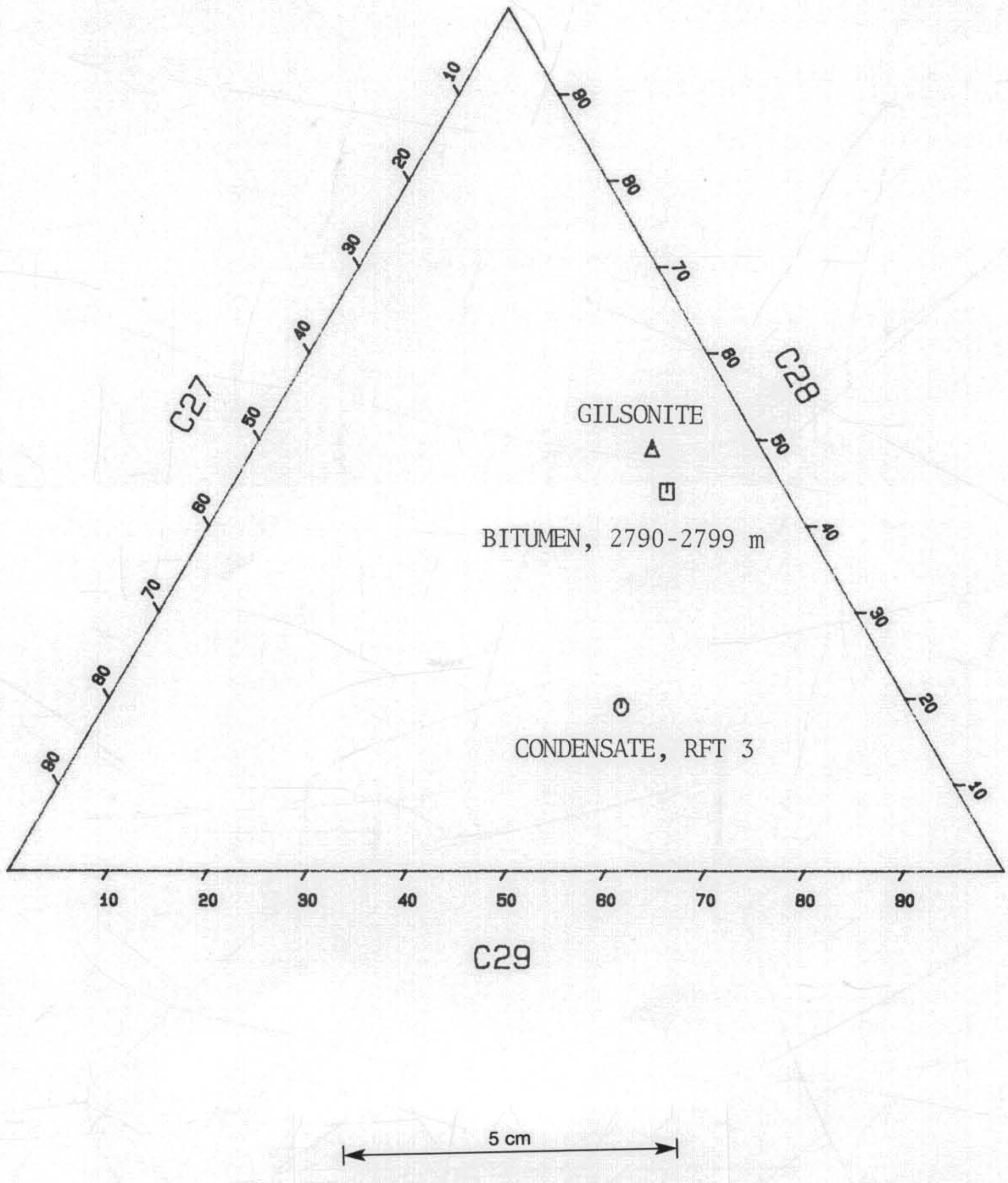
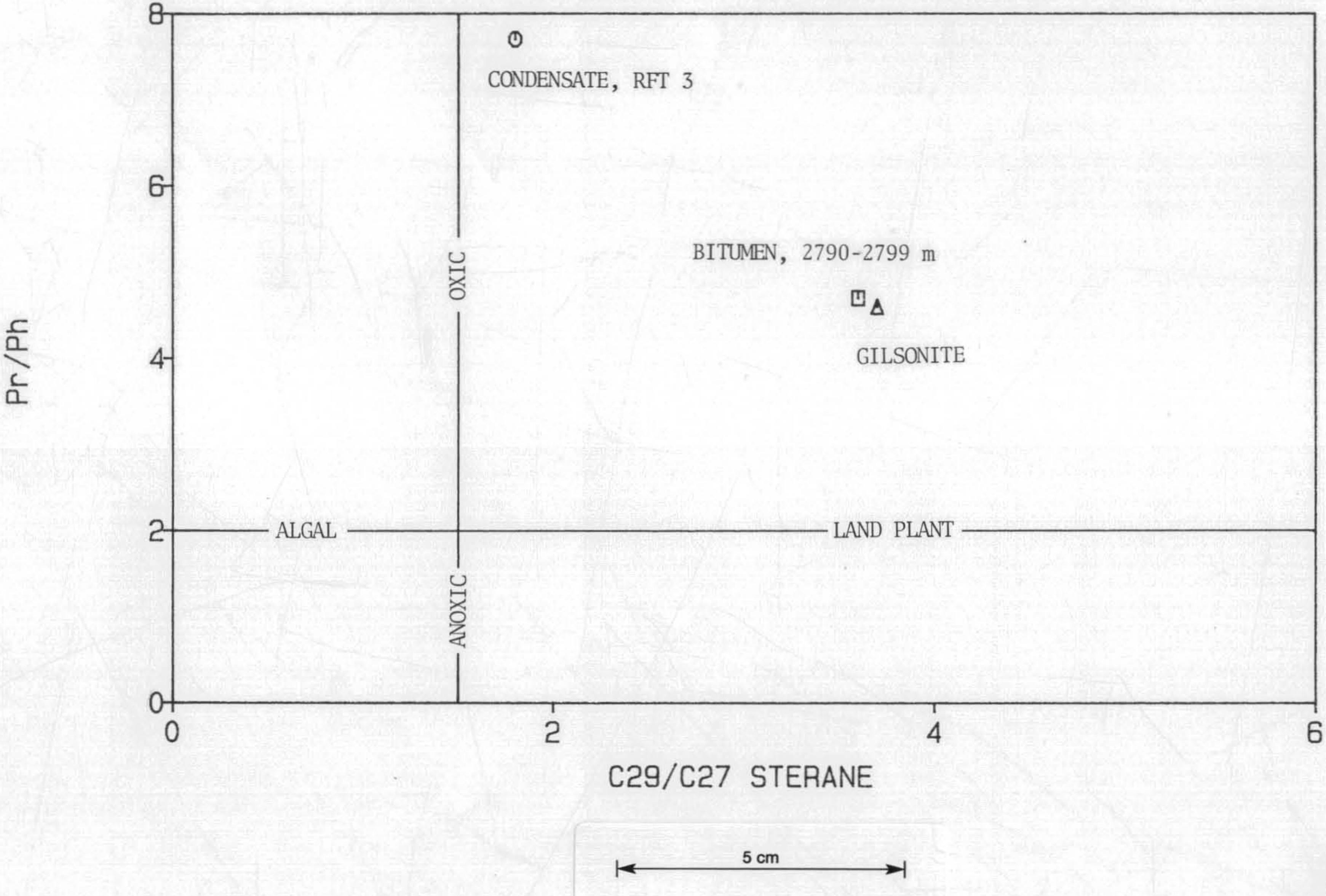


FIGURE 21

SOURCE AFFINITY OF CONDENSATE AND BITUMEN/GILSONITE, PELICAN-5, BASS BASIN



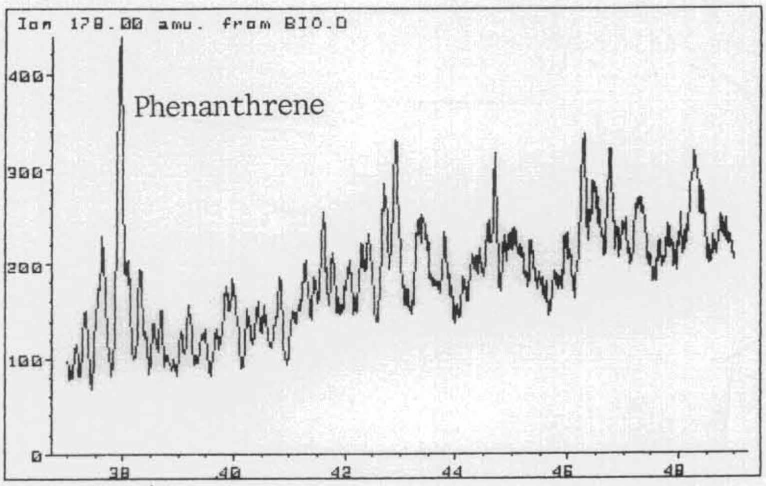
45470

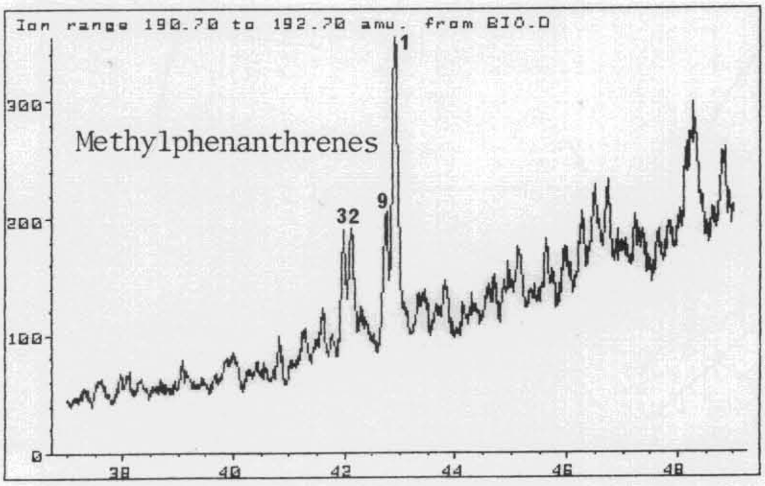
FIGURE 22

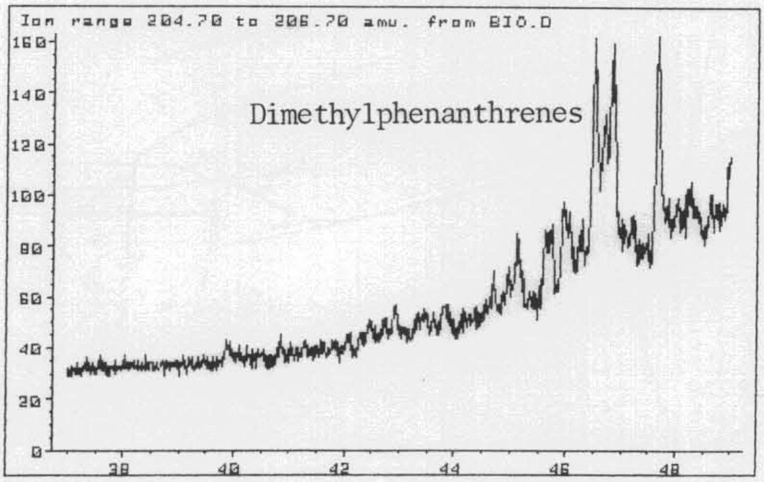
MASS FRAGMENTOGRAMS OF AROMATIC HYDROCARBONS
IN CONDENSATE, RFT 3, PELICAN-5

m/z 178	phenanthrene
m/z 191+192	methylphenanthrenes
m/z 205+206	dimethylphenanthrenes

FIGURE 22







5 cm

APPENDIX 1

MS-PONA ANALYSIS OF CONDENSATE
RFT 3, 2788.2 m, PELICAN-5

AMDEL MS-PONA ANALYSIS

454074

Sample :PELICAN 5

Components were separated on a Hewlett-Packard PONA column and quantified using a flame ionisation detector. Area counts were used directly to compute weight percentages. Components were identified by retention time comparison with a reference oil derived by pooling oils from several basins. Components in the reference oil were identified by computerised GC-MS and by comparison with retention time data supplied by HP.

Component		Weight %	Liquid vol %
1	C 3	0.055	0.081
2	i C 4	0.242	0.328
3	n C4	0.617	0.794
4	22 DMC 3	0.012	0.014
5	i C 5	1.866	2.242
6	n C 5	2.352	2.798
7	22 DMC 4	0.113	0.130
8	CYC 5	0.318	0.318
9	23 DMC 4	0.483	0.544
10	2 MC 5	2.502	2.852
11	3 MC 5	1.415	1.586
12	n C 6	4.239	4.781
13	22 DMC 5	0.128	0.141
14	M CYC 5	2.420	2.407
15	24 DMC 5	0.250	0.276
16	223 TMC 4	0.037	0.040
17	BZ	0.372	0.315
18	33 DMC 5	0.078	0.084
19	CYC 6	2.961	2.833
20	2 MC 6	1.523	1.671
21	23 DMC 5	0.447	0.479
22	11 DMCYC 5	0.372	0.366
23	3 MC 6	1.432	1.555
24	t 13 DMCYC 5	0.774	0.779
25	c 13 DMCYC 5	0.728	0.729
26	3 EC 5	0.072	0.077
27	t 12 DMCYC 5	1.144	1.154
28	n C 7	4.874	5.310
29	MCYC 6	10.681	10.339
30	22 DMC 6	0.382	0.410
31	ECYC 5	0.443	0.431
32	25 DMC 6	0.209	0.225
33	24 DMC 6	0.233	0.249
34	tc 124 TMCYC 5	0.354	0.346
35	234 TMC 5	0.085	0.089
36	tc 123 TMCYC 5	0.281	0.272
37	233 TMC 5	0.015	0.015
38	TOL	4.088	3.512
39	23 DMC 6	0.291	0.304
40	2 M 3 EC 5	0.000	0.000
41	2 MC 7	1.352	1.442
42	4 MC 7	0.380	0.402
43	34 DMC 6	0.035	0.036
44	tt 124 TMCYC 5	0.053	0.053
45	3 MC 7	0.969	1.021
46	1 M 2 ECYC 5	2.434	2.421
47	t 14 DMCYC 6	1.094	1.069
48	C 8-N	0.283	0.271

Component		Weight %	Liquid vol %
49	C 8-P	0.024	0.026
50	C 8-N	0.139	0.133
51	C 8-N	0.129	0.123
52	c 1 M 3 ECYC 6	0.182	0.179
53	C 8-P	0.040	0.042
54	t 12 DMCYC 6	0.951	0.889
55	n C 8	4.822	5.111
56	C 8-N	0.026	0.025
57	unk	0.020	-
58	C 9-P	0.030	0.031
59	unk	0.022	-
60	C 9-P	0.073	0.076
61	C 9-P	0.325	0.337
62	n C 3 CYC 5	1.970	1.890
63	N	0.012	0.011
64	113 TMCYC 6	0.273	0.260
65	C 9-P	0.452	0.468
66	C 9-P	0.043	0.045
67	N	0.030	0.029
68	N	0.051	0.048
69	N	0.016	0.015
70	E BZ	0.637	0.547
71	114 TMCYC 6	0.255	0.246
72	unk	0.000	-
73	unk	0.020	-
74	m+p XYL	6.623	5.746
75	C 9-P	0.018	0.019
76	23 DMC 7	0.012	0.012
77	C 9-P	0.178	0.184
78	4 MC 8	0.321	0.332
79	2 MC 8	0.548	0.574
80	C 9-P	0.104	0.108
81	3 MC 8	0.553	0.572
82	N	0.024	0.023
83	o XYL	1.454	1.230
84	unk	0.000	-
85	unk	0.000	-
86	1 M 2 PCYC 5	0.095	0.090
87	t 1 M 4 ECYC 6	0.522	0.488
88	c 1 M 4 ECYC 6	0.320	0.305
89	N	0.000	0.000
90	N	0.000	0.000
91	N	0.064	0.062
92	n C 9	3.394	3.522
93	1 M 1 ECYC 6	0.291	0.275
94	C 9-N	0.108	0.102
95	i PBZ	0.111	0.096
96	C 10-P	0.035	0.036
97	C 9-N	0.196	0.185
98	C 9-N	0.194	0.183
99	C 10-P	0.121	0.124
100	C 10-P	0.137	0.140
101	unk	0.029	-
102	C 10-P	0.163	0.167
103	s BCYC 5	0.546	0.515
104	C 10-P	0.140	0.143
105	C 10-P	0.154	0.157
106	3 MC 9	0.355	0.363

Component		Weight %	Liquid vol %
107	C 10-P	0.111	0.113
108	unk	0.000	–
109	unk	0.060	–
110	n PBZ	0.358	0.309
111	N	0.265	0.247
112	unk	0.043	–
113	unk	0.029	–
114	m E TOL	1.013	0.873
115	p E TOL	0.568	0.491
116	135 TM BZ	1.354	1.166
117	N	0.000	0.000
118	C 10-N	0.183	0.171
119	C 10-P	0.359	0.362
120	2 MC 9	0.404	0.413
121	o E TOL	0.258	0.218
122	C 10-P	0.036	0.036
123	36 DMC 8	0.435	0.445
124	N	0.116	0.108
125	C 10-N	0.029	0.027
126	124 TM BZ	1.774	1.508
127	C 10-N	0.113	0.106
128	N	0.105	0.098
129	C 10-N	0.199	0.185
130	N	0.000	0.000
131	N	0.000	0.000
132	N	0.028	0.026
133	C 10-P	0.119	0.121
134	n C 10	2.598	2.656
135	unk	0.023	–
136	unk	0.004	–
137	123 TM BZ	0.595	0.496
138	unk	0.000	–
139	unk	0.000	–
140	unk	0.098	–
141	unk	0.046	–
142	C 10-A	0.060	0.052
143	C 10-N	0.492	0.459
144	C 11-P	0.051	0.051
145	unk	0.123	–
146	C 10-N	0.274	0.256
147	unk	0.000	–
148	unk	0.000	–
149	C 10-A	0.000	0.000
150	C 10-A	0.240	0.209
151	C 10-A	0.000	0.000
152	unk	0.213	–
153	C 10-A	0.368	0.319
154	unk	0.000	–
155	unk	0.000	–
156	unk	0.000	–
157	unk	0.000	–
158	C 10-A	0.360	0.313
159	C 11-P	0.117	0.118
160	C 11-P	0.044	0.044
161	C 11-P	0.302	0.304
162	C 10-A	0.315	0.274
163	C 11-P	0.242	0.244

Component		Weight %	Liquid vol %
164	C 10-A	0.322	0.280
165	unk	0.215	-
166	unk	0.092	-
167	unk	0.000	-
168	C 10-A	0.217	0.188
169	n C 11	1.791	1.805
170	unk	0.000	-
171	C 10-A	0.000	0.000
172	unk	0.000	-
173	C 10-A	0.000	0.000
174	unk	0.000	-
175	unk	0.000	-
176	unk	0.000	-
177	unk	0.000	-
178	unk	0.000	-
179	C 12-P	0.000	0.000
180	unk	0.000	-
181	unk	0.000	-
182	unk	0.000	-
183	unk	0.000	-
184	C 11-A	0.000	0.000
185	unk	0.000	-
186	C 12-P	0.000	0.000
187	C 11-A	0.000	0.000
188	unk	0.000	-
189	n C 12	0.000	0.000
	0.000	-	

A value of 0.000 signifies <0.005%

The weight percentages of the compound types are as follows:-

Paraffins 45.340
Naphthenes 32.539
Aromatics 21.088
Unknowns 1.034

Average molecular weight of identified components: 107.2
Average specific gravity of identified components: 0.746

ABBREVIATIONS:
D = di; T = tri; M = methyl; E = ethyl; P = propyl; B = butyl;
CYC = cyclo; BZ = benzene; TOL = toluene; XYL = xylene; unk = unknown.
PREFIXES:
i = iso; n = normal; s = secondary; o = ortho; m = meta; p = para
c = cis; t = trans.
SUFFIXES:
A = aromatic; N = naphthene; P = paraffin.

APPENDIX 2

OTHER NAPHTHENE MASS FRAGMENTOGRAMS OF CONDENSATE, BITUMEN AND GILSONITE, PELICAN-5

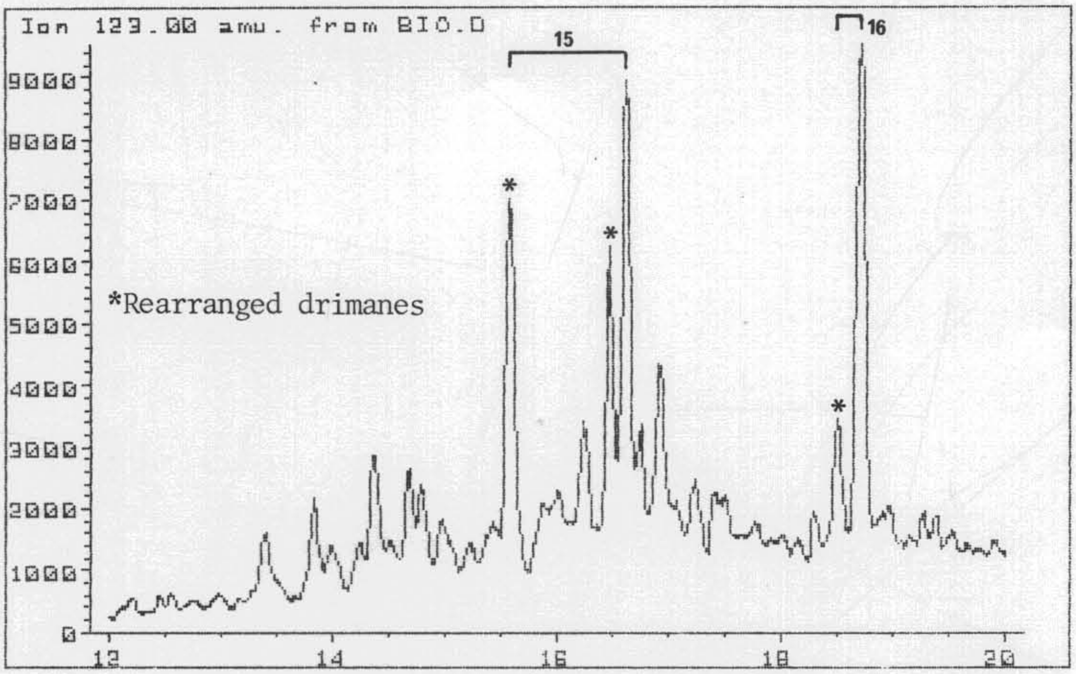
m/z 123	drimanes
m/z 177	hopanes, demethylated hopanes
m/z 205	methylhopanes
m/z 231	4-methylsteranes
m/z 259	diasteranes

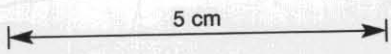
454079

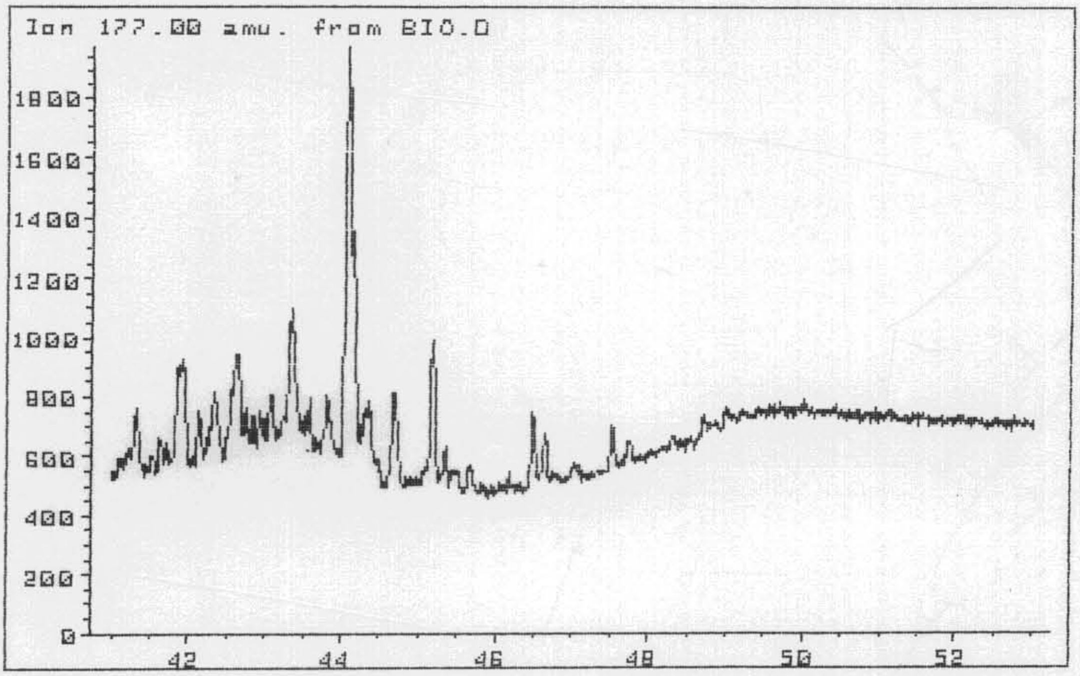
CONDENSATE

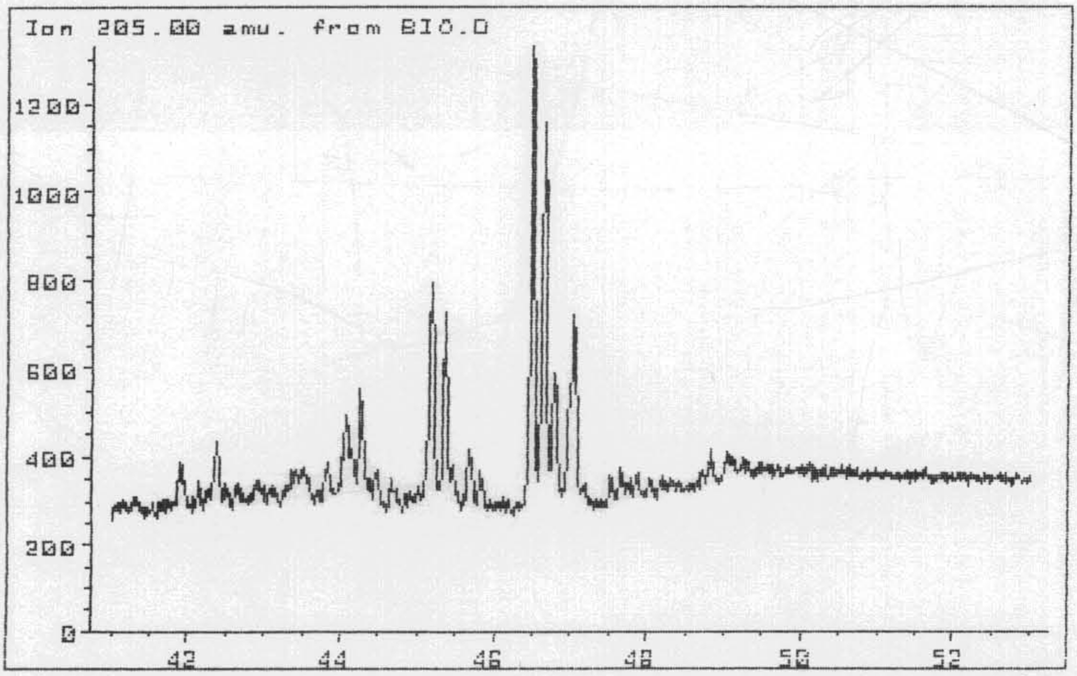
RFT 3, 2788.2 m, PELICAN-5

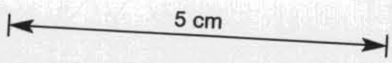
(AMDEL Sample MS-277)


Ion 123.00 amu. from BIO.D
15
16
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
*Rearranged drimanes
12
14
16
18
20


5 cm

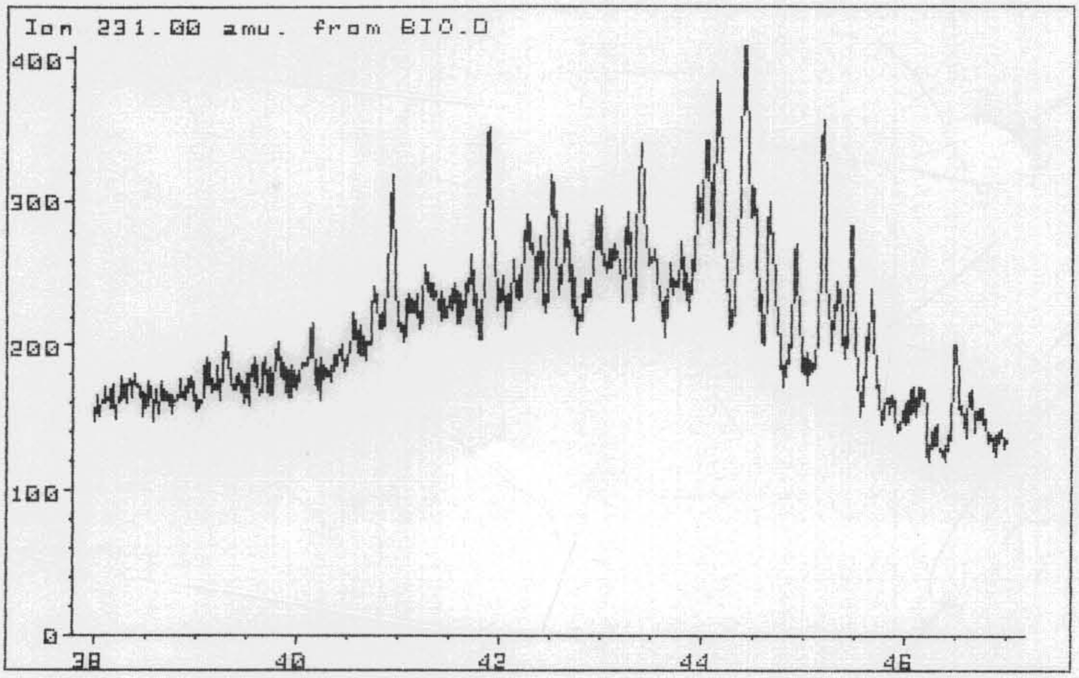

Ion 177.00 amu. from BIO.D
1800
1600
1400
1200
1000
800
600
400
200
0
42
44
46
48
50
52

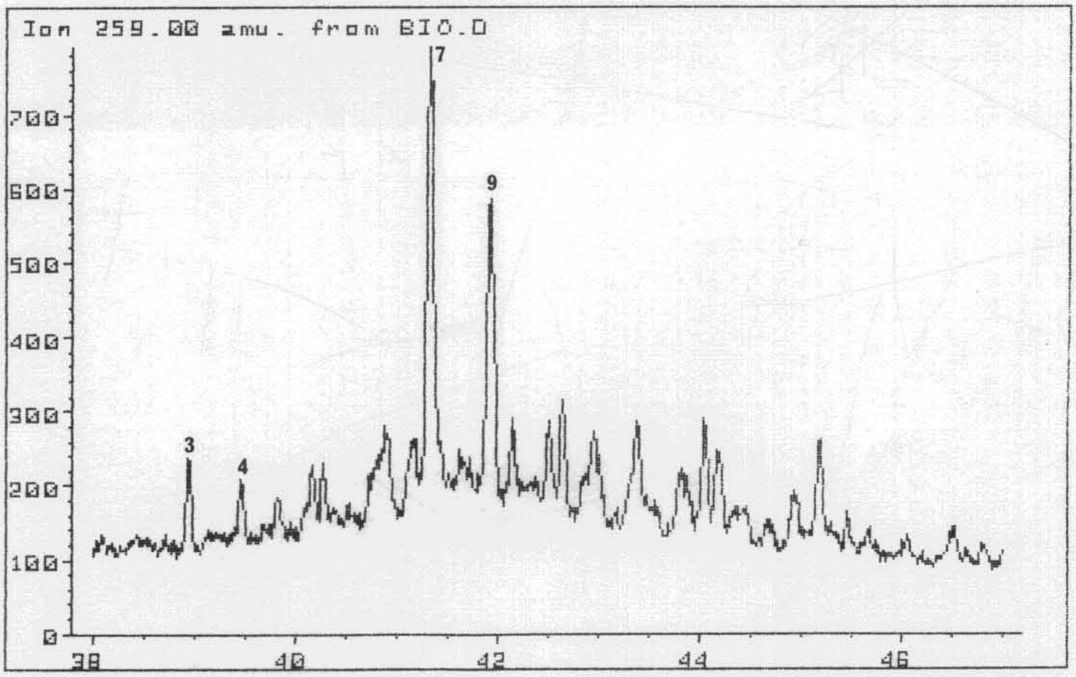

Ion 205.00 amu. from BIO.D
1200
1000
800
600
400
200
0
42
44
46
48
50
52


5 cm

amdel

454082


Ion 231.00 amu. from BIO.D
400
300
200
100
0
38
40
42
44
46


Ion 259.00 amu. from BIO.D
700
600
500
400
300
200
100
0
3
4
7
9
38
40
42
44
46

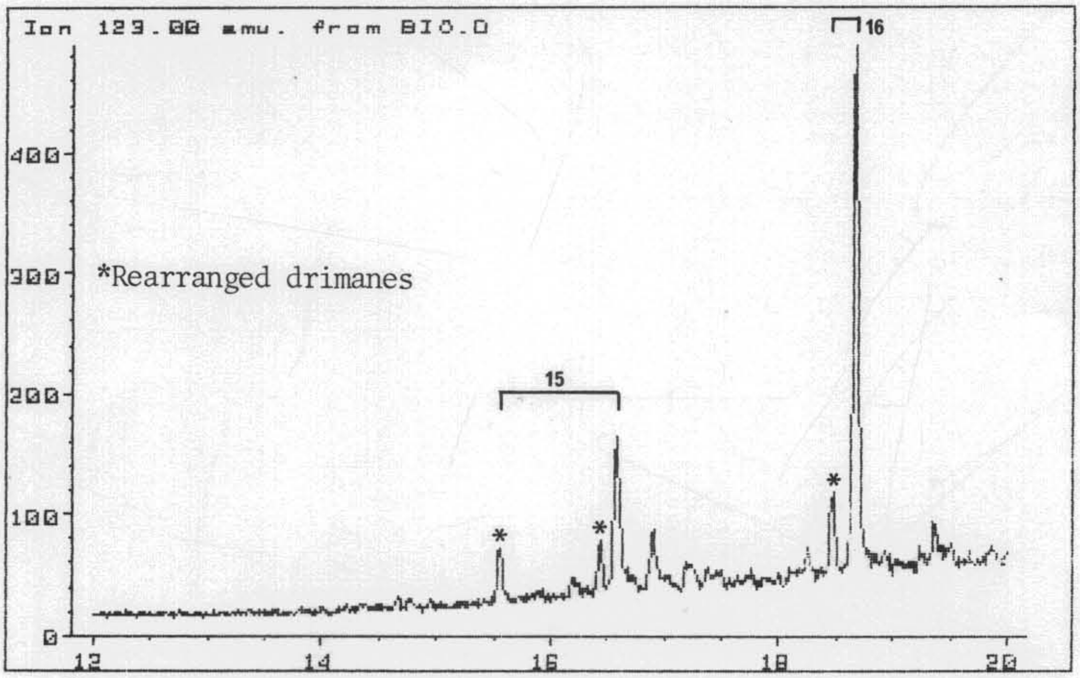
5 cm

454083

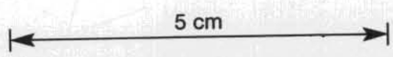
BITUMEN IN CUTTINGS

2790-2799 m, PELICAN-5

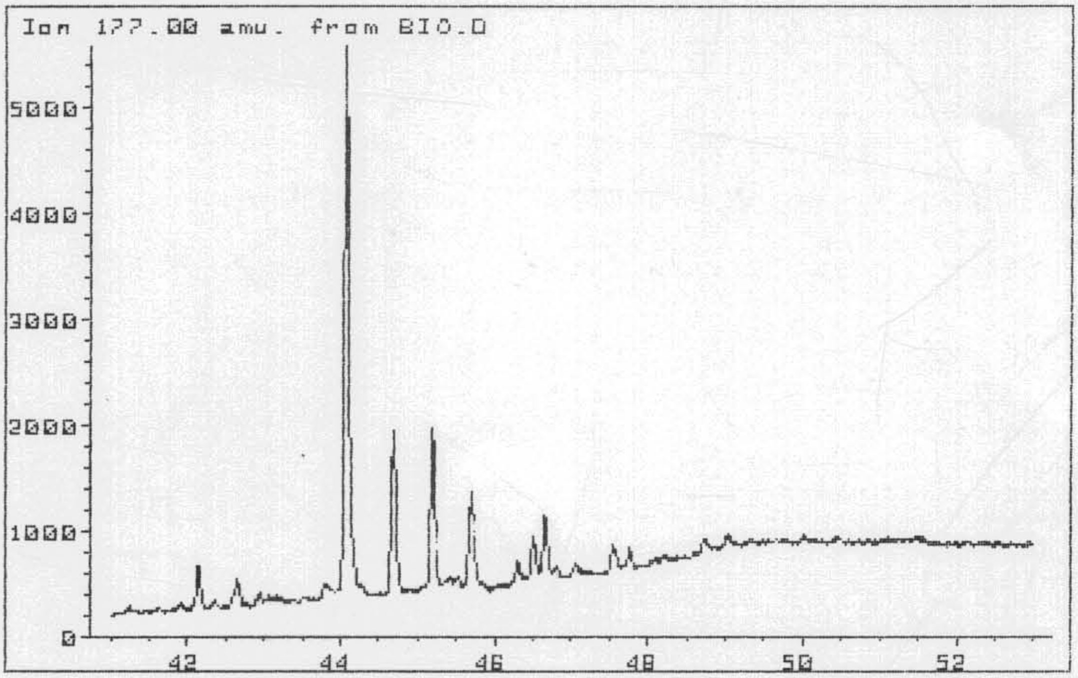
(AMDEL Sample MS-279)

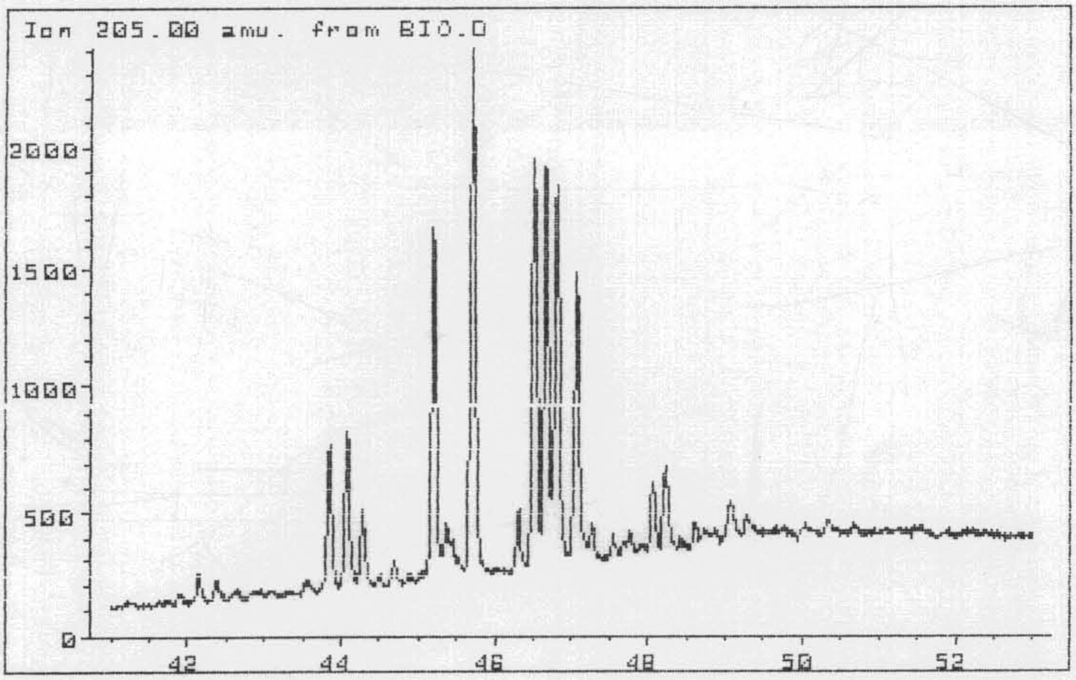


Ion 123.00 amu. from BIO.D
16
15
*Rearranged drimanes
0
100
200
300
400
12
14
16
18
20

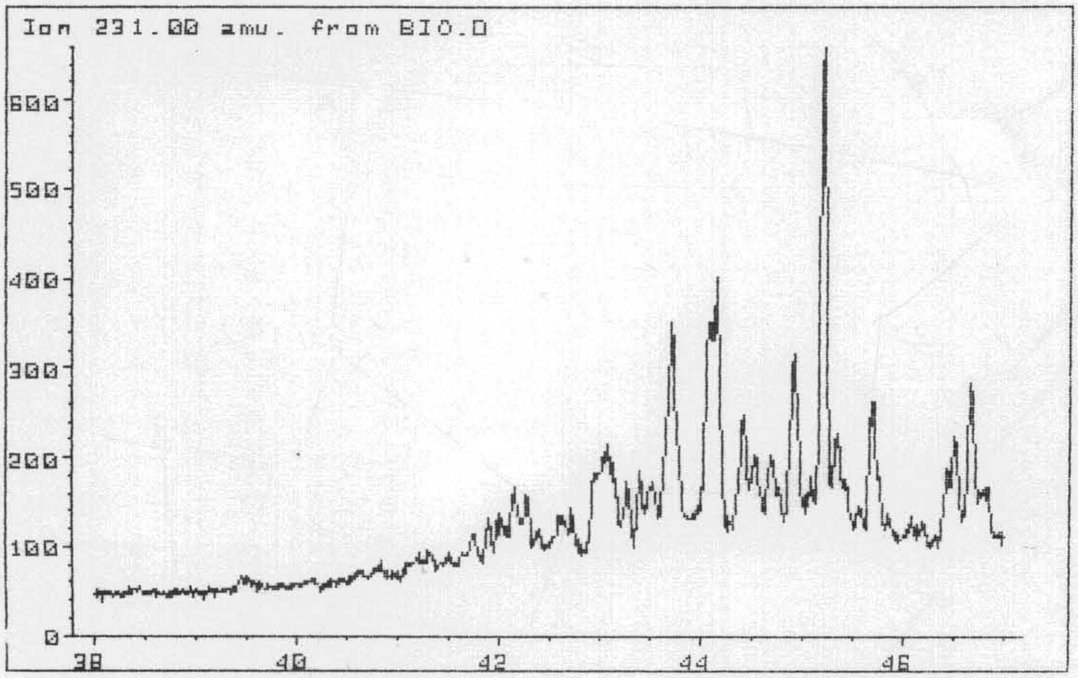


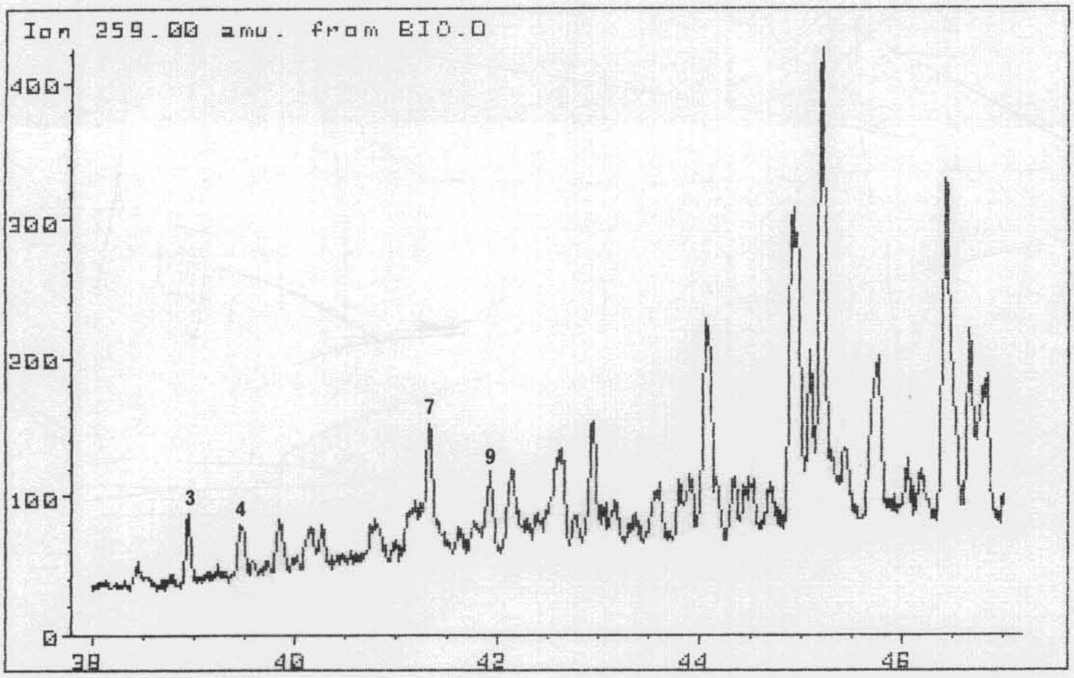
5 cm


Ion 177.00 amu. from BIO.D
5000
4000
3000
2000
1000
0
42
44
46
48
50
52


Ion 205.00 amu. from BIO.D
2000
1500
1000
500
0
42
44
46
48
50
52

5 cm


Ion 231.00 amu. from BIO.D
600
500
400
300
200
100
0
38
40
42
44
46


Ion 259.00 amu. from BIO.D
400
300
200
100
0
38
40
42
44
46
3
4
7
9

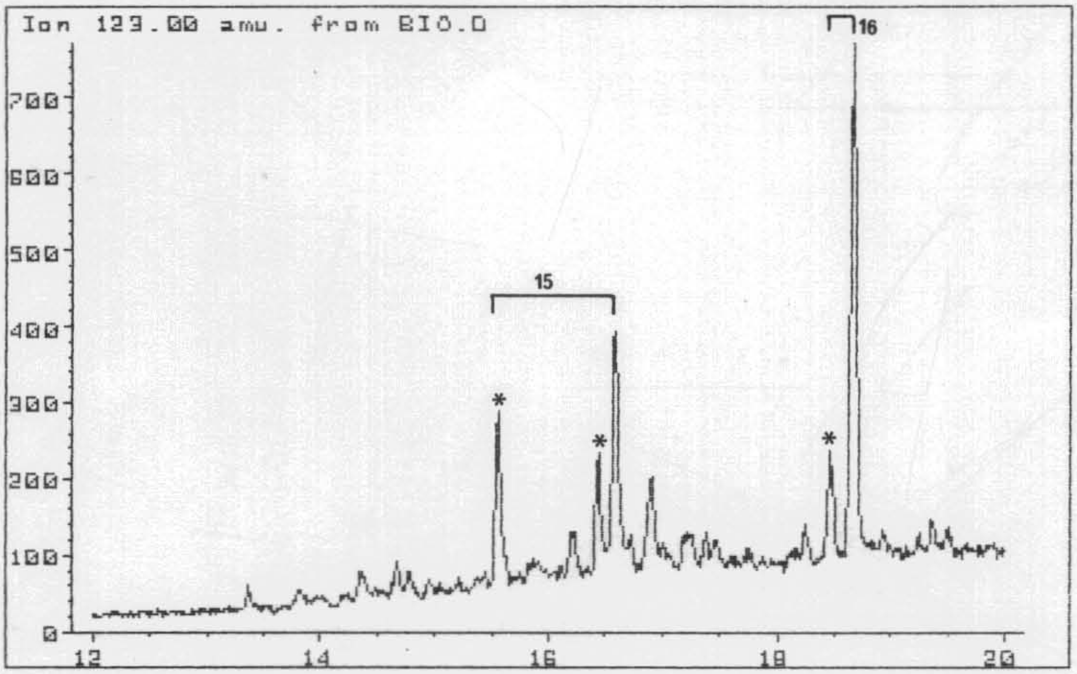
5 cm

amdel

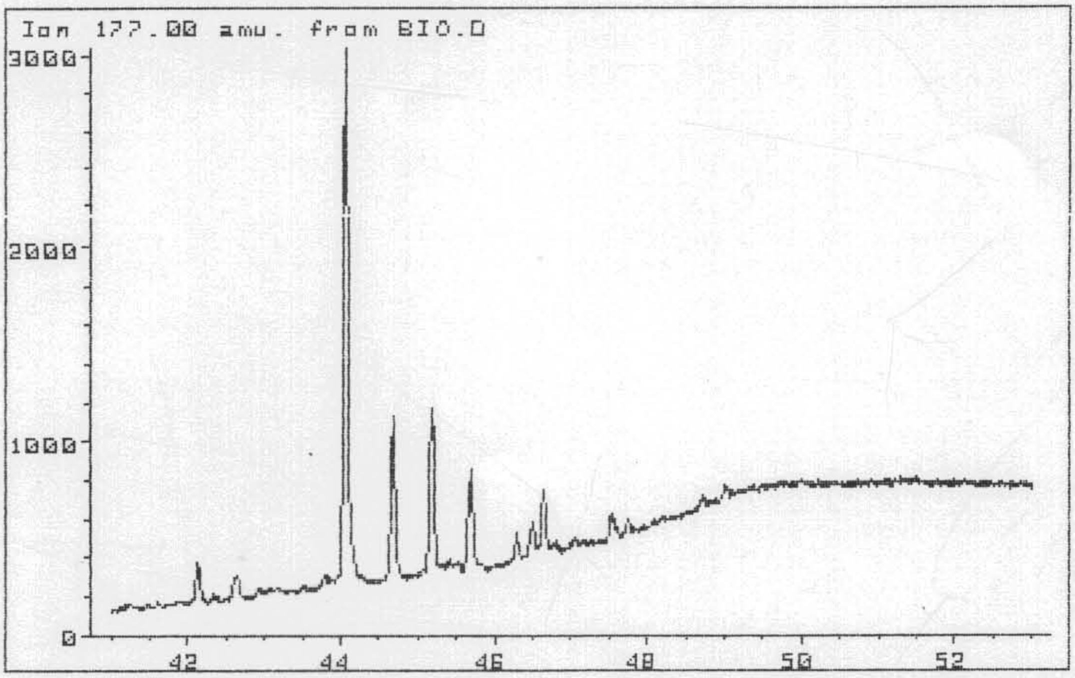
GILSONITE

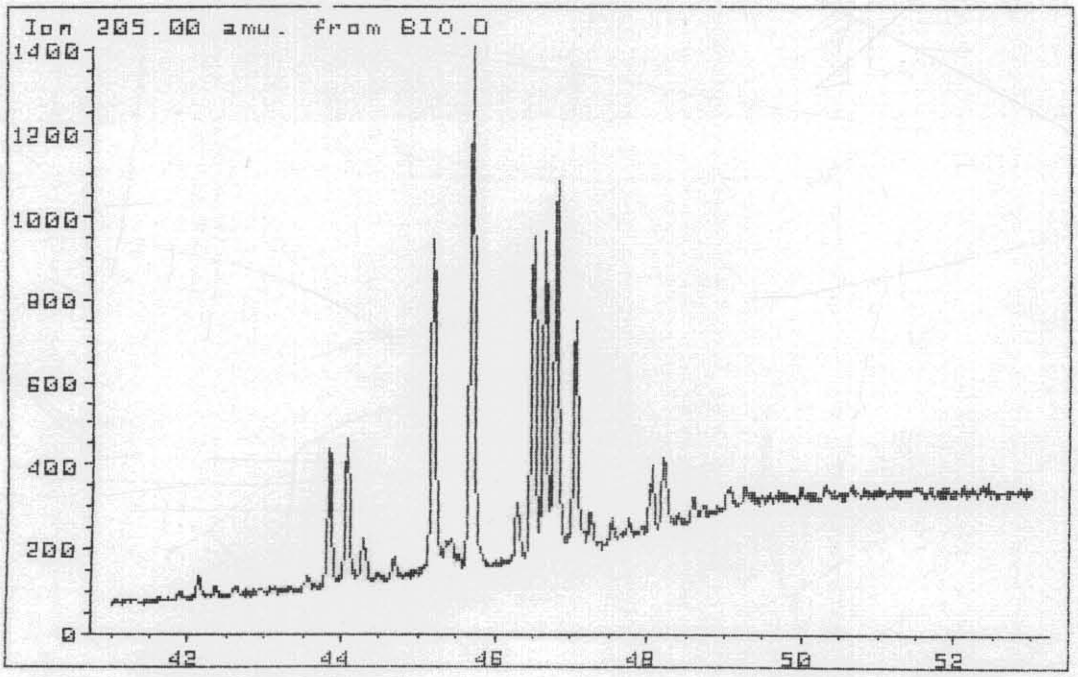
MUD ADDITIVE, PELICAN-5

(AMDEL Sample MS-280)


Ion 123.00 amu. from BIO.D
700
600
500
400
300
200
100
0
12
14
16
18
20
15
16
*
*
*

5 cm

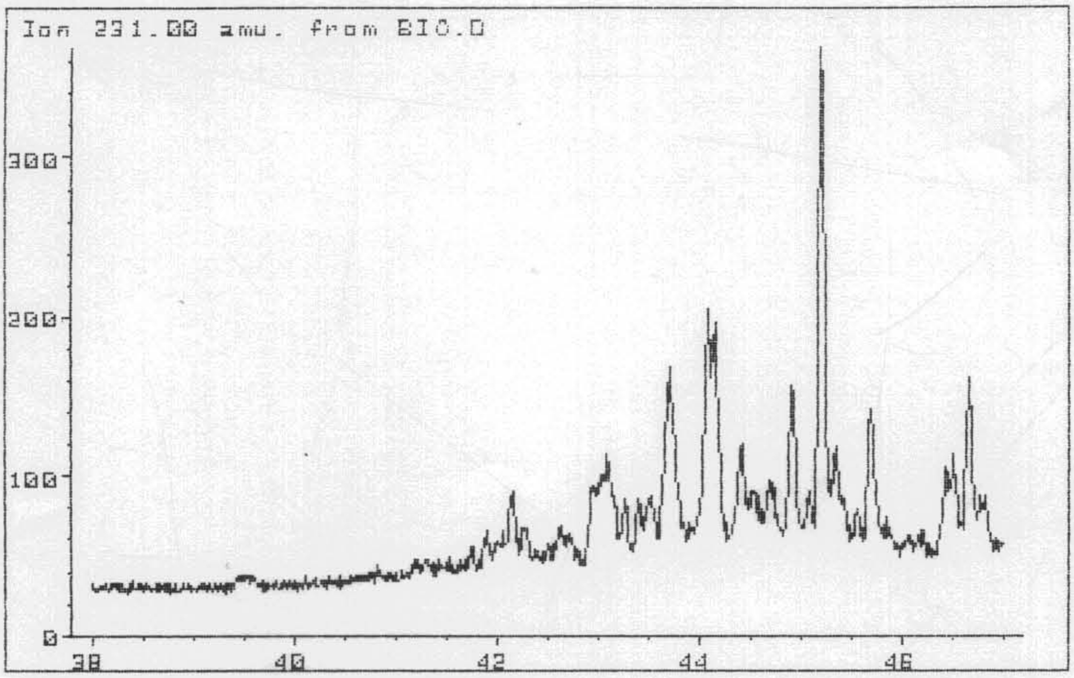

Ion 177.00 amu. from BIO.D
3000
2000
1000
0
42
44
46
48
50
52

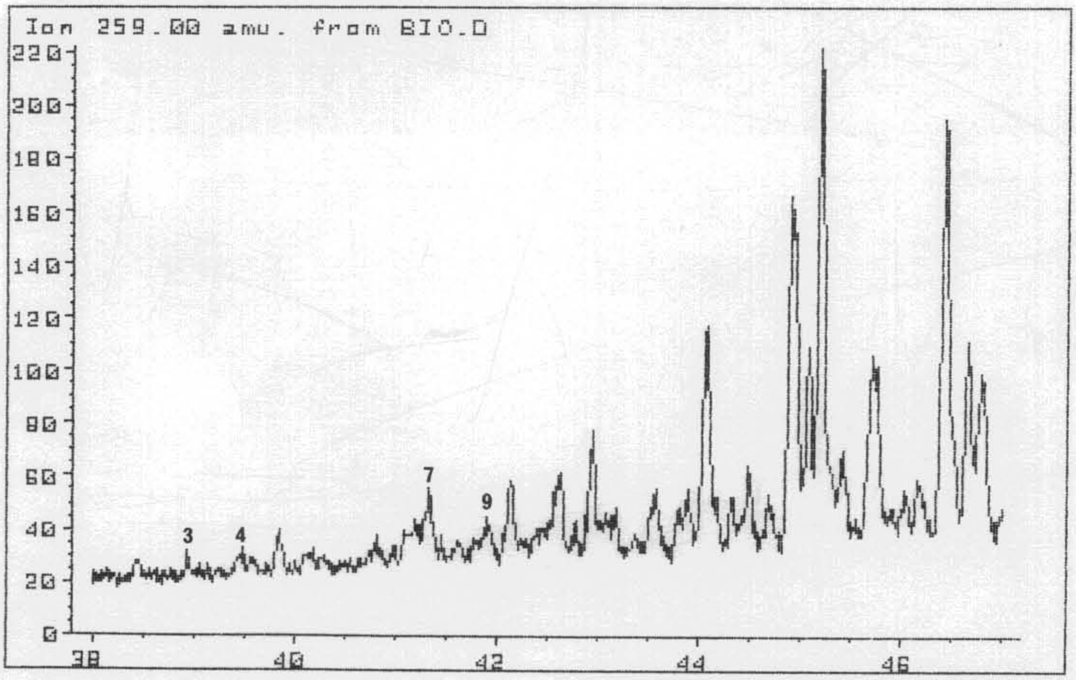

Ion 205.00 amu. from BIO.D
1400
1200
1000
800
600
400
200
0
42
44
46
48
50
52

5 cm

amdel

454090





5 cm

amdel

APPENDIX 3

ANALYTICAL METHODS

1. HEADSPACE GAS (C_1-C_{5+})

A silicone rubber septum was glued to the lid of each can. The lid was punctured through the septum and a 5 ml sample of headspace gas withdrawn with a gas-tight syringe. Cans were not shaken prior to sampling. The sample was analysed by gas chromatography using the following instrumental parameters:

Gas chromatograph:	Perkin Elmer Sigma 2 fitted with flame ionisation detector
Column:	6′ × ⅛" i.d. copper packed with activated alumina (80-100 mesh)
Column temperature:	40-275°C at 15° per minute
Carrier gas:	N_2
Quantitation:	Peak areas integrated with Perkin Elmer Sigma 10 Data System. Peak areas calibrated against a standard mixture comprising 100 ppm of each of methane, ethane, propane, n-butane, n-pentane and n-hexane in N_2.

Cuttings gas (C_1-C_4) yields are expressed as ppm by volume of headspace.

$$\text{Percent wet gas} = \frac{C_2-C_4}{C_1-C_4} \times 100\%$$

Also determined from headspace analysis were total C_{5+} hydrocarbon yield (ppm by volume) and i-pentane/n-pentane ratio.

2. SAMPLE PREPARATION

Cuttings were washed in water to remove mud and lost circulation material and then air-dried at 60°. Clean dry cuttings and sidewall cores (scraped free of mud cake) were ground in a Siebtechnik mill for 20-30 secs. In the case of the samples selected for bitumen and for residual oil analysis, aliquots of intact cuttings were set aside for hand-picking and solvent extraction.

3. TOTAL ORGANIC CARBON (TOC)

Total organic carbon was determined by digestion of a known weight (≃0.2 g) of powdered rock in 50% HCl to remove carbonates, followed by combustion in oxygen in the induction furnace of a Leco IR-12 Carbon Determinator and measurement of the resultant CO_2 by infra-red detection.

4. ROCK-EVAL ANALYSIS

A 100 mg portion of powdered rock was analysed by the Rock-Eval pyrolysis technique (Girdel IFP-Fina Mark 2 instrument; operating mode, Cycle 1).

5. BITUMEN AND RESIDUAL OIL ANALYSIS

Hand-picked cuttings (5-23 g) were extracted with dichloromethane in Soxhlet apparatus for 1-6 hours. Removal of solvent by careful rotary evaporation gave the crude extract (nominally C_{15+} EOM).

6. ISOLATION OF C_4-C_{12+} FRACTIONS

The condensate was topped to 210°C by distillation. The fraction boiling below 210°C was collected and retained for MS-PONA analysis.

7. MS-PONA ANALYSIS

C_4-C_{12} hydrocarbons were separated on a Hewlett-Packard PONA column and quantified using a flame ionisation detector. Area counts were used directly to compute weight percentages. Components in the reference oil were identified by computerised GC-MS and by comparison with retention time data supplied by HP.

For gasoline-range (C_5-C_7) data reported in Tables 6 and 7, areas of peaks corresponding to aromatic hydrocarbons were multiplied by appropriate response factors.

8. LIQUID CHROMATOGRAPHY

Asphaltenes were precipitated from the topped condensate, bitumen or cuttings extract by refluxing with petroleum ether prior to liquid chromatography. The asphaltene-free fraction was separated into hydrocarbons (saturates and aromatics) and polar compounds (resins) by liquid chromatography on activated alumina (sample: adsorbent ratio = 1:100). Hydrocarbons were eluted with petroleum ether/dichloromethane (50:50) and resins with methanol/dichloromethane (65:35). The saturated and aromatic hydrocarbons were then separated by liquid chromatography on activated silica gel (sample: adsorbent ratio = 1:100) eluting in turn with petroleum ether and petroleum ether/dichloromethane (91:9).

9. GAS CHROMATOGRAPHY

The saturated hydrocarbons (alkanes) were examined by gas chromatography using the following instrumental parameters:

Gas chromatograph:	Perkin Elmer Sigma 2 fitted with on-column injector
Column:	25 m x 0.3 mm fused silica, SGE QC3/BP1
Detector temperature:	300°C
Column temperature:	100-290°C at 5° per minute and held at 290°C until all peaks eluted
Quantification:	Relative concentrations of individual normal and isoprenoid alkanes obtained by measurement of peak areas with a Perkin Elmer LCI 100 integrator

10. GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS)

Naphthenes (branched/cyclic alkanes) were isolated from the condensate and bitumen by urea adduction of its saturates.

GC-MS analysis of the naphthenes (urea non-adduct) was undertaken in the selected ion detection (SID) mode. The instrument and its operating parameters were as follows:

System:	Hewlett Packard (HP) 5790 GC coupled with a HP5970A mass selective detector and HP9816S data system
Column:	25 m x 0.34 mm i.d. HP Ultra Performance cross-linked methyl-silicone phase fused silica, interfaced directly to source of mass spectrometer
Injector:	Carlo Erba on-column injector
Carrier gas:	He at 0.2 kg/cm^2 head pressure
Column temperature:	35-280°C at 5°/min
Mass spectrometer conditions:	70 eV; 9-ion selected ion monitoring, 50 millisec dwell time for each ion

The following mass fragmentograms were recorded:

m/z	Compound Type
123	sesquiterpanes (incl. drimanes), diterpanes
177	demethylated triterpanes
183	acyclic alkanes (incl. isoprenoids)
191	triterpanes (incl. hopanes, moretanes)
205	methyl triterpanes
217	steranes
218	steranes
231	4-methyl steranes
259	diasteranes, diterpanes

Integration of the m/z 191 and 217 mass fragmentograms allowed calculation of the biomarker ratios in Tables 10 and 11.

The aromatic hydrocarbon fraction isolated from the deasphaltened condensate by liquid chromatography was also analysed by GC-MS.

Instrumental conditions employed for the SID GC-MS of the aromatics are described above, except that a HP Ultra 2 cross-linked phenylmethylsilicone phase fused column was used.

The following mass fragmentograms were recorded:

m/z	Compound Type
178	phenanthrene
191+192	methylphenanthrenes
205+206	dimethylphenanthrenes

454095

APPENDIX 4

VITRINITE REFLECTANCE PROFILE, PELICAN-5
(after Watson, 1986)

VITRINITE REFLECTANCE Vs. DEPTH PLOT, PELICAN-5