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GUMMY-1 (W1028)

SHELL AUSTRALIA E. & P. OIL AND GAS

SDA 976

GUMMY-1
WELL COMPLETION REPORT

VOLUME 2   01 FEB 1991

INTERPRETATIVE DATA

PETROLEUM DIVISION

by

EXO TEAM

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THE SHELL COMPANY OF AUSTRALIA LIMITED
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NE/NEW/119001NE.WP5:3

1. INTRODUCTION

Gippsland Basin permit VIC/P19 (Fig. 1) was originally awarded to a consortium of Shell (40%, operator), News Corporation (20%), TNT (20%), Crusader (15%) and Mincorp (now Petroz) (5%) in 1981. In 1985, the Joint Venture farmed-out 50% of its interest to Esso/BHPP. One graticular block containing the Basker and Manta discoveries (Basker/Manta Block) was retained by the original Joint Venture. The Gummy-1 exploration well was drilled in the Basker/Manta Block and represents drilling above commitment. The VIC/P19 Year 2 commitment well was fulfilled by Admiral-1, drilled in December 1989 at New Joint Venture cost. Due to non-participation by Petroz (5%) in the drilling of Gummy-1, Shell and Crusader increased their equity to 42.5% and 17.5% respectively.

Gummy-1 is located at SP 2201 on seismic line G88A-9191 in 156 m of water. The well's primary objective was to test coastal plain fluvial sands of the lower Latrobe Group and upper Golden Beach Group in a dip and fault-closed structure. A secondary objective was to test alluvial sands of the Golden Beach Group in a setting similar to the Manta gas/condensate discovery.

2. REGIONAL GEOLOGY

The stratigraphy of the offshore Gippsland Basin is summarised in Figure 2.

The Early Cretaceous Strzelecki Group represents the initial rift infill sequence, and its deposition can be correlated with the onset of the development of Southern Australia's rift valley system. The Group consists of non—marine greywackes, volcanoclastics, shales and minor coals, and is regarded as economic basement.

The Cenomanian to Late Campanian Golden Beach Group overlies Strzelecki Group sediments with angular unconformity (marking the onset of opening of the Southern Ocean), and represents a second phase of rift infill, associated with the development of the Tasman Sea rift. Where penetrated, sediments comprise dominantly immature non—marine sandstones, siltstones, shales and minor coals deposited in alluvial fan, braided stream, lacustrine and upper coastal plain environments. Basaltic volcanics are both stratigraphically and areally widespread. Continued subsidence, though with much reduced extension, resulted in growth on earlier faults during deposition of the Golden Beach Group. This was followed by a pronounced phase of tectonism and associated volcanism during the Campanian, which produced the major throws now seen on intra—Golden Beach Group faults. This "Intra—Campanian Unconformity" can be correlated with the onset of drift in the Tasman Sea (ca. 76 MABP), and marks the cessation of Golden Beach Group deposition.

From the late Campanian to Late Eocene the Latrobe Group was deposited as a non—marine to coastal marine sequence of sandstones, siltstones, shales and coals under the progressive influence of the opening Tasman Sea. As marine conditions encroached from southeast to northwest, a diachronous succession of laterally equivalent sedimentary facies was deposited comprising alluvial, upper coastal plain, lower coastal plain, estuarine, back barrier/lagoonal, coastal barrier, shoreface and offshore marine deposits. Latrobe Group deposition was characterised by slow subsidence and continued movement on earlier faults. The major basin bounding faults continued to exert a major influence on sedimentary patterns. Early to Late Eocene tectonic uplift of the northeastern part of the basin, in association with a series of sea level falls, led to submarine channelling of the Top Latrobe surface. Late Eocene deposition is recorded by a condensed glauconitic sequence known as the Gurnard Formation which, where preserved, marks the top of the Latrobe Group.

Convergent wrenching due to Southern Ocean spreading, and strike—slip movement along Tasman Sea fracture zones occurred during the latter part of Latrobe Group deposition. In the Late Eocene, this phase of activity terminated Latrobe Group deposition in the offshore basin and was responsible for strike—slip and reverse reactivation of many earlier normal faults and the formation/enhancement of the major anticlinal features in the basin. Thermal subsidence from the Oligocene to Recent resulted in the deposition of calcareous siltstones and marls of the Lakes Entrance Formation overlain by a marine, eastwards prograding sequence of calcarenites, calcilutites and marls of the Gippsland Limestone.

3. STRATIGRAPHY

The stratigraphic sequence in Gummy-1 is summarised in Figure 3 and Enclosure 1. Formation tops and ages are based on lithological, palynological (Appendix 1) and micropalaentological (Appendix 2) data from cuttings and sidewalls samples, together with wireline log characteristics. All depths are quoted in metres below derrick floor.

3.1 Gippsland Limestone (SEGL) : 184-1755m (1571m)

The Gippsland Limestone consists of interbedded calcarenite, calcilutite and marl, ranging in age from Middle Miocene (D1 Zone) to Recent. The calcarenites and calcilutites are off white to light grey and green grey, argillaceous in places, with trace amounts of glauconite, pyrite and carbonaceous detritus. These units also contain common to locally abundant fossils, including foraminifera, echinoderms and bryozoa. Calcarenite and calcilutite dominate the section, although increases in marl are evident between 820-965, 1190-1330, 1470-1555 and 1680-1755m. The marl is light (green) grey to off white, and often soft to sticky with trace amounts of glauconite, pyrite, carbonaceous detritus and foraminifera.

The carbonate depositional environment is interpreted as outer neritic (100-200m water depths) for much of the sequence and outer neritic-upper bathyal (200-500m water depths) for the basal 70m of the Gippsland Limestone.

3.2 Lakes Entrance Formation (SELE) : 1755-2081m (326m)

The Lakes Entrance Formation ranges in age from Early to Middle Miocene (H2-D1 Zones) and consists of dominantly marl in the upper section grading to calcareous claystone with depth. The marl is light to medium (green) grey, firm to hard, occasionally dispersive and contains trace to locally abundant fossils (foraminifera) and trace amounts of glauconite, pyrite and carbonaceous detritus.

Foraminiferal assemblages indicate that the Lakes Entrance Formation was deposited in an outer neritic to upper bathyal environment (200-500m water depths).

3.3 Latrobe Group (LA) : 2081-3035.5m (954m)

The Latrobe Group is subdivided into two main units: the Flounder Formation and the informal "Coarse Clastics" sequence. The "Coarse Clastics" have been further subdivided on the basis of palynological zonations where available.

3.3.1 Flounder Formation (LACH) : 2081-2137.5m (56.5m)

The Flounder Formation unconformably underlies the Lakes Entrance Formation and consists of strongly glauconitic siltstone and sandstone. The siltstone is yellow brown to medium and dark brown while the sandstone is yellow brown to light grey, silty and fine to very coarse

grained. Limonitic alteration is common in the upper Flounder Formation.

The unit represents the marine infilling stage of the Tuna-Flounder Channel complex during the Early Eocene (Lower M. diversus).

3.3.2   "Coarse Clastics": 2137.5–3035.5m (898m)

3.3.2.1   L. balmei Biozone (LALB) : 2137.5–2374m (236.5m)

The Paleocene L. balmei biozone unconformably underlies the Flounder Formation and consists wholly of marine sandstones and siltstones. The sandstones show both coarsening and fining upward cycles representing deposition in coastal barrier and transgressive shoreface environments. The blocky log character of the sandstone from 2281–2311m may indicate deposition as a tidal channel or current sandbody. The sands are quartzose, glauconitic in parts, fine to very coarse grained, moderately well sorted, generally disaggregated weakly cemented by silica and occasional pyrite cement. Good to excellent porosity is inferred. The siltstones are medium to dark (brown) grey, firm, non-calcareous, and contain trace to abundant amounts of glauconite, mica and carbonaceous detritus.

3.3.2.2   T. longus Biozone (LALO) : 2374–?2685m (311m)

The Maastrichtian T. longus biozone comprises sediments deposited in marine, coastal barrier, back barrier/lagoonal and lower coastal plain environments. From 2374–2460m, thinly interbedded sandstones, siltstones and mudstones were deposited in a predominantly back barrier/lagoonal setting. The sandstones are quartzose, medium to very coarse grained, generally disaggregated, subangular to subrounded and weakly cemented by silica. Pyrite aggregates are common and good porosity is inferred. The siltstones and mudstones are dark (grey) brown, carbonaceous, micaceous, laminated and firm to hard.

The coastal barrier sequence from 2460–2515m consists of fine to very coarse grained sandstone, moderately well sorted, subrounded, weak to strongly cemented by silica and pyrite bands. Minor amounts of glauconite and chert are present and visual porosity varies from fair to excellent. The barrier sequence grades up from a medium (brown) grey, glauconitic, micaceous marine siltstone at 2515–2532m.

Back barrier/lagoonal and lower coastal plain deposits of thinly interbedded sandstone, siltstone, mudstone and coal dominate the remainder of the biozone from 2532–2685m. The sandstones are quartzose, fine to very coarse grained, subangular to subrounded, moderately sorted and weak to moderately cemented by silica. Sandstone beds between 2629

and 2651m contain abundant dolomitic cement and are non-porous. The siltstone is light to medium (brown) grey, carbonaceous, micaceous and firm. The mudstone is light to dark (grey) brown, very carbonaceous and micaceous and firm to hard. The coal is black to dark brown, dull with occasional vitreous layers and grades to carbonaceous siltstone and mudstone.

3.3.2.3   T. lilliei Biozone (LALI) : ?2685-3035.5m (350.5m)

The late Campanian T. lilliei biozone is constrained only by correlation from the wells Basker-1 and Manta-1. No sidewall sampling or palynological interpretation was undertaken below 2631m. The sequence is dominated by interbedded sandstone, siltstone and coal, deposited in a lower coastal plain setting. The sands are quartzose, light grey to off white, predominantly fine to medium grained, subangular to rounded, moderately well sorted and weak to moderately cemented by silica and occasional siderite, pyrite and calcareous cement. The sands average 3m in thickness and contain trace to common amounts of mica. Lithics become more common with depth and visual porosity varies from poor to very good. The siltstone is light to dark (grey) brown, firm and contains common carbonaceous laminae and detritus, mica and minor disseminated pyrite. The coal is black to very dark brown, dull to vitreous in places and occasionally earthy.

3.4   Golden Beach Group (GB) : 3035.5-3563m (527.5m)

The Golden Beach Group has been differentiated on the basis of correlations from the wells Basker-1 and Manta-1 which indicate the penetrated section is likely to range from early to middle Campanian (N. senectus - T. lilliei) in age.

Weathered volcanic flows (average thickness 17m) dominate the section from 3035.5-3318m. These volcanics are interpreted as intermediate to basic in composition and described as pale to medium green and grey, off white, minor red brown, amygdaloidal, extensive clay alteration, siliceous groundmass in part, occasional pyrite and abundant dolomitic vein and fracture fill. Less altered volcanics are black, medium to dark green and grey with common glassy groundmass, aphanitic texture and are hard to very hard. The intervening sediments between 3035.5 and 3495m comprise thinly interbedded sandstones, siltstones and minor claystone, tuff and coal, deposited in an upper coastal plain environment. The sandstones are quartzose, off white to light grey, dominantly fine to medium angular to subrounded grains, poor to moderately sorted and cemented by weak to strong dolomitic and siliceous cement with trace to common pyrite cement. The sands average only 1m in thickness and contain common argillaceous matrix and lithics. Visual porosity is generally poor. The siltstones are generally light to medium brown grey, micaceous, tuffaceous in part, firm to hard with common carbonaceous laminae and detritus. The claystones are (light) to dark brown, very micaceous and carbonaceous, sub-indurated, firm to hard and grade to coal in

places. The tuffs are light brown to brown grey, argillaceous, siliceous in part, lithic, laminated, hard to very hard and occasionally soft.

The section between 3495 and 3563m comprises dominantly sandstone with thin interbeds of siltstone and claystone, deposited in a braided stream environment. The sandstones are off white to buff, fine to medium and occasionally coarse to very coarse grained, subangular to subrounded, poor to moderately sorted with common to abundant lithics, argillaceous and very fine sand matrix and moderately strong siliceous cement. Visual porosity ranges from poor to fair. The siltstone and claystone are as described above.

4. SEISMIC MARKERS AND STRUCTURE

4.1 Seismic Markers (Fig. 4)

A check-shot survey (WST) was included in the final logging suite at Gummy-1 (Appendix 4 – Volume 1). The synthetic seismogram provides a good match with seismic at the well location (Encl. 3). Comparison with pre-drill picks of the major seismic markers shows that in all cases the correct pick had been made. All tops were penetrated well within pre-drill error estimates. A summary of pre- and post-drill depths is given below in Table 1.

Table 1 : Pre-and post-drill depths to markers (see Fig. 5)

SEISMIC MARKER	PRE-DRILL DEPTH (mbsl)	ACTUAL DEPTH (mbsl)	DIFFERENCE (m)
Base Gippsland Limestone	1725	1727	– 2
Top Latrobe Group	2065	2053	+ 12
Top Golden Beach Group	3022	3007.5	+ 14.5

4.2 Structure

The structure tested by Gummy-1 is a downthrown fault trap formed due to intersection of the northeast-southwest trending Basker-Manta Nose by the northwest-southeast trending Gummy Fault. Closure was mapped at intra-Latrobe and Golden Beach Group levels, however it was recognised that the expression of the Gummy Fault changes along its length. In the west and east, the Gummy Fault is clearly expressed and has a very large throw, whereas in its eastern central portion it is very subtle. It is clearly present at the top of the Golden Beach Group and was interpreted as extending upward for at least 100m into the Latrobe Group. The well results confirm the existence of closure at pre-Intra-Campanian unconformity levels, however at the Intra-Latrobe level a trap may not exist. It is possible that the post-unconformity throw on the Gummy Fault diminishes to near zero at some point between seismic lines G88A-9191 and G81A-73 where the mapped throw is most subtle, or that throws larger than those mapped are necessary to adequately provide fault seal.

5. HYDROCARBON SHOWS

Sustained levels of background gas began at around 2650m in the Latrobe Group and continued to TD at levels of between 0.1 and 0.2% Total Gas. Encouraging gas shows were recorded from 2875–2921m (46m) within the Latrobe Group where Total Gas levels increased above background to around 3% and as high as 5%. Gas composition averaged 85% C1, 10% C2, 5% C3 and traces of i–C4. Traces of dull yellow natural fluorescence with very slow streaming cut were recorded from well cemented, very fine grained sandstones near the base of this interval. Petrophysical analysis of the sands indicate them to be water bearing (Appendix 3). Further isolated gas peaks of between 1 and 3% Total Gas within the Latrobe can be correlated with coal beds at 2715, 2812, 2845, 2965 and 2981m. Gas composition varies from 97% C1, 3% C2, tr C3 at shallower levels to 92% C1, 8% C2 and trace C3 at deeper levels. Further traces of dull to bright yellow natural fluorescence with associated weak slow streaming cut were recorded in tight, fine grained sandstones at 2937, 2967 and 3018m.

A significant increase in Total Gas levels above background began to be recorded from around 3190m in the Golden Beach Group and continued essentially to TD. The overall very low net:gross reservoir characteristics of the Golden Beach Group determines the spiky response of the gas curve and gas peaks in general correlate well to sands. Gas peaks range between 1 and 25% Total Gas, averaging 3–4% over the following zones: 3190–3210, 3244–3247, 3266–3285, 3325–3330, 3364–3382, 3410–3460 and 3473–3544m. Gas composition averages 95% C1, 4% C2, 1% C3, trace i–C4 & n–C4. Natural fluorescence was observed in zones of generally tight sandstone between 3204 and 3495m, occurring as trace to 70% dull to moderately bright green yellow and blue white fluorescence with milky white crush to moderate streaming cut. The presence of hydrocarbons in the Golden Beach Group interval was confirmed by petrophysical analysis (see Appendix 3). Evaluation of RFT pressures and samples (see Appendix 4) indicates the hydrocarbons to be primarily condensate–rich gas.

6. RESERVOIRS, SEALS AND SOURCE ROCKS

6.1 Reservoirs (Appendix 3)

Reservoir quality of the Latrobe Group fluvial, coastal barrier and marine sandstones (2137.5–3035.5m) is generally excellent. Log derived porosity ranges between 16 and 30%, averaging 20%. Net:gross ratio for the interval is 39%. The sandstones are quartzose, fine to coarse grained with weak to moderate siliceous cement, and in places sideritic, pyritic and calcareous cement. The sandstones are predominantly disaggregated at the surface and estimates of fair to excellent porosity are made aided by the penetration rate. Sandbodies in the objective lower coastal plain sequence comprise fluvial channel, point bar and crevasse splay deposits. They average around 3m thick and attain a maximum thickness of 8.5m. This sequence has a sand/shale ratio of 28%, net:gross of 24% and average log derived porosity of 18%. Analysis of dipmeter FMS data indicate a dominant southeasterly palaeoflow direction (SDA 989 – in prep.).

Reservoir quality of Golden Beach Group upper coastal plain fluvial and braided stream sandstones (3035.5–3563m) is generally poor. Log derived porosities range between 3 and 18%, averaging 13% for the net sand interval (10% porosity cut–off). The overall net:gross ratio for the interval is 10%. The Golden Beach Group is dominated by upper coastal plain facies (3097–3495m) which have a sand/shale (and volcanics) ratio of 19% and net:gross of 4%. The sandstones are quartzose, commonly lithic, fine to medium grained with weak to strong dolomitic and siliceous cement, trace pyrite cement and argillaceous matrix in parts. Fluvial sandbodies in this sequence average 1 to 2m in thickness and analysis of dipmeter FMS data indicates a dominantly south–southwesterly palaeoflow direction (SDA 989 – in prep.). This is consistent with a dip–fed rift valley system. Braided stream facies (3495–3563m) contain the majority of reserves at Gummy. The sequence has a sand/shale ratio of 74%, however poor reservoir quality accounts for a net:gross of only 32%. The sandstones are quartzose, fine to coarse grained, commonly lithic, with argillaceous matrix and moderate to strong siliceous cement. Log derived porosity for the net sand interval averages 11%.

6.2 Seals

The primary objective, Intra–Latrobe Group interval comprises a low sand/shale ratio (28%) sequence of lower coastal plain sediments with good potential for intra–formational top and lateral sealing. Sealing lithologies of overbank shales, siltstones and coals average around 7m thick, attaining maximum thicknesses greater than 20m in places.

The sealing capacity of the penetrated Golden Beach Group sequence is excellent. Low sand/shale ratio upper coastal plain facies dominate the section and, in combination with interbedded weathered volcanic flows and tuffs, provide good sealing potential. Volcanic flows vary between 5 and 30m thick, averaging around 17m. Clay smear potential is considered to be good and likely to enhance lateral sealing. Two gross hydrocarbon columns of 25m (3190–3215m) and 130m (3420–3550m) along with numerous individually sealed hydrocarbon bearing sands were intersected.

6.3   Source Rocks and Charge (Appendix 5)

Sampling for source potential and maturity was conducted between 2393.5 and 2619.5m in the Latrobe Group from predominantly back barrier/lagoonal mudstones and siltstones. Rock-Eval indicates genetic potentials ranging from marginal to good and likely to generate both oil and gas. The samples between 2393.5 and 2549m are immature while the deepest sample (2619.5m) may have just reached the oil window. The presence of strong gas shows and traces of fluorescence and cut within the intra-Latrobe may indicate the presence of migrating hydrocarbons or alternatively early in-situ generation.

Charge to the Golden Beach Group comprises condensate-rich gas. The GC trace of a condensate sample from 3201.5m characterises a typical mature condensate derived from terrestrial organic matter deposited under very oxic conditions. Sterane and triterpane parameters suggest a maturity level equivalent to approximately 1.1% VR for the condensate.

7. CONCLUSIONS AND CONTRIBUTIONS TO GEOLOGY

(a) The lithological and stratigraphical sequences encountered in Gummy–1 were essentially as anticipated from regional facies distribution mapping and nearby well control.

(b) The mapped seismic markers can be directly related to the well data.

(c) Gummy–1 is interpreted as an invalid test of the primary Intra–Latrobe Group objective. Although good hydrocarbon shows were encountered over a 46m zone (2875–2921m) near where Intra–Latrobe closure was expected to begin, petrophysical evaluation indicated the sands to be water bearing. It is now thought likely that the mapped, subtle post–Intra–Campanian throw on the Gummy Fault is not large enough to provide adequate fault seal and thus Intra–Latrobe closure does not exist.

(d) Gummy–1 successfully tested a valid hydrocarbon bearing trap at the secondary objective, intra–Golden Beach Group level. At least two significant condensate–rich gas columns (25 and 130m) were encountered along with numerous individual hydrocarbon–bearing sands.

(e) Reservoir quality of the Golden Beach Group upper coastal plain fluvial and braided stream sandstones is poor and as such contribute to the low (51% average) petrophysically determined hydrocarbon saturations. Permeabilities derived from RFT drawdown data are low and indicate likely poor deliverability.

8. REFERENCES

SDA 916 :   Exploration well proposal Gummy–A, Gippsland Basin Permit VIC/P19, Basker/Manta Block.

SDA 989 :   Gummy–1 FMS Interpretation.
(In prep.)

FIGURES

PE906847

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                       for Gummy-1
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(Inserted by DNRE - Vic Govt Mines Dept)

VICTORIA

STRZELECKI

WELLINGTON FAULT

LAKE

NORTHERN TERRACE

ROSEDALE FAULT

VIC/P11

VIC/P19

VIC/P22

VIC/P24

GUMMY-1 LOCATION

200m

100m

CENTRAL DEEP

VIC/P26

VIC/P1

VIC/P27

VIC/P20

200m

VIC/P23

VIC/P21

FOSTER FAULT

SOUTHERN PLATFORM

VIC/P25

BASSIAN RISE
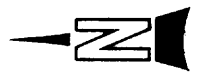
LIMIT OF LATROBE GROUP

◯ OIL

⬤ GAS

N

0 —— 20KM

PE906847

DEPT. NAT. RES & ENV

GIPPSLAND BASIN

LOCATION MAP - GUMMY-1

SHELL-AUSTRALIA
E.& P. OIL AND GAS

| Author: EXO | Report No.: SDA 976 | Date: **AUGUST 1989** | Drawing No.: 25523 |

Figure
1

Gippsland Basin — Offshore Stratigraphy

MA	PERIOD	EPOCH	AGE	SPORE-POLLEN ZONES (REGEO)		GIPPSLAND BASIN OFFSHORE STRATIGRAPHY	TECTONIC EVENTS
		PLIO-CENE (PL)		T. pleistocenicus		NW SE	
				M. lipsus		GIPPSLAND LIMESTONE	
10			L	C. bifurcatus			
		MIOCENE (MI)	M	T. bellus S980	U		
					L		
20			E			LAKES ENTRANCE FM	
		OLIGO-CENE (OL)	L	P. tuberculatus S970			SOUTHERN OCEAN OPENING / TASMAN SEA OPENING
30	NEOGENE (TU)		E				
			L	S9608	U	GURNARD FM	
40	TERTIARY (TT) / PALEOGENE (TL)	EOCENE (EO)	M	S9604	M	TURRUM FM	COMPRESSION
				N. asperus S960	L	FLOUNDER FM	
				S9602			
50			E	P. asperopolus S950			
				M. diversus S930	U / L		
		PALEO-CENE (PC)	L	L. balmei S920	L	LATROBE GROUP	
60			E				
70			MA	T. longus S890	L		
80	CRETACEOUS (KK)	KU	CA	T. lilliei S880			
				N. senectus S870		GOLDEN BEACH GROUP	GOLDEN BEACH RIFTING
		SENONIAN	SA	T. apoxyexinus S865			
			CO	P. mawsonii S860			
90			TR				
			CE	A. distocarinatus S850			
100			AB	P. pannosus S840			
				C. paradoxa S830			
110		KL	AP	C. striatus S820			
				C. hughesi S810		STRZELECKI GROUP	
			BR				
120		NEOCOMIAN	HT	F. wonthaggiensis S800			STRZELECKI RIFTING
			VA				
130			BE	C. australiensis S790			
	(JJ)		TI	R. watherooensis			

BASEMENT

MA	PERIOD	EPOCH	AGE	SPORE-POLLEN ZONES (REGEO)			FORMATION	DEPTH mbdf	THICKNESS m
	NEOGENE (ÏU)	PLIO-CENE (PL)		T. pleistocenicus	A1/A2/A3/A4		GIPPSLAND LIMESTONE	184	1571
			L	M. lipsus	B1				
10		MIOCENE (MI)		C. bifurcatus	B2				
			M	T. bellus S980	C	U		1755	
					D1/2	L	LAKES ENTRANCE FORMATION		326
20			E		E1/2				
	TERTIARY (TT)				F/G				
					H1/2			2081	
			L	P. tuberculatus S970	I1				
30		OLIGO-CENE (OL)			I UNDIFF				
			E						
	PALEOGENE (TL)		L	S9608	J1	U			
40		EOCENE (EO)		S9604	K	M			
			M	N. asperus S960		L			
				S9602					
50			E	P. asperopolus S950				2081	
				M. diversus S930	U/M/L/U		FLOUNDER FM		56.5
		PALEO-CENE (PC)	L	L. balmei S920	L			2137.5	
60			E				LATROBE GP "COARSE CLASTICS"		898
70	CRETACEOUS (KK)	KU	MA	T. longus S890	L				
				T. lilliei S880				3035.5	
80		SENONIAN	CA	N. senectus S870			GOLDEN BEACH GP	3035.5	527.5
			SA	T. apoxyexinus S865				3563 (TD)	
			CO	P. mawsonii S860					
90			TR						
			CE	A. distocarinatus S850					
100		KL	AB	P. pannosus S840					
				C. paradoxa S830					
				C. striatus S820					
110			AP	C. hughesi S810					
			BR						
120		NEOCOMIAN	HT	F. wonthaggiensis S800					
			VA	C. australiensis S790					
130			BE						
	(JJ)		TI	R. watherooensis					

GIPPSLAND BASIN

GUMMY-1 STRATIGRAPHIC TABLE

Figure 3

PE906102

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The enclosure PE906102 has the following characteristics:
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      ITEM_BARCODE = PE906102
 CONTAINER_BARCODE = PE902077
              NAME = Interpreted Seismic Line
             BASIN = GIPPSLAND
            PERMIT = VIC/P19
              TYPE = SEISMIC
           SUBTYPE = SECTION
       DESCRIPTION = Interpreted Seismic Line G88A-9191 with
                     Gummy-1.
           REMARKS =
      DATE_CREATED = 30/09/1989
     DATE_RECEIVED = 01/02/1991
              W_NO = W1028
         WELL_NAME = GUMMY-1
        CONTRACTOR =
      CLIENT_OP_CO = SHELL AUSTRALIA
```

(Inserted by DNRE - Vic Govt Mines Dept)

GUMMY-1

PREDICTED

ACTUAL

GIPPSLAND BASIN

GUMMY-1 PREDICTED vs ACTUAL STRATIGRAPHY

SHELL-AUSTRALIA
E.& P. OIL AND GAS

| Author: EXO | Report No.: SDA 976 | Date: DEC 1990 | Drawing No.: 26559 |

Figure
5

PE600934

This is an enclosure indicator page.
The enclosure PE600934 is enclosed within the
  container PE902077 at this location in this
  document.

The enclosure PE600934 has the following characteristics:
```
      ITEM_BARCODE = PE600934
 CONTAINER_BARCODE = PE902077
              NAME = Composite Well Log
             BASIN = GIPPSLAND
            PERMIT =
              TYPE = WELL
           SUBTYPE = COMPOSITE_LOG
       DESCRIPTION = Composite Well Log
           REMARKS =
      DATE_CREATED = 10/06/1990
     DATE_RECEIVED = 01/02/1991
              W_NO = W1028
         WELL_NAME = Gummy-1
        CONTRACTOR = Schlumberger
      CLIENT_OP_CO = Shell Australia
```

(Inserted by DNRE - Vic Govt Mines Dept)

PE600935

This is an enclosure indicator page.
The enclosure PE600935 is enclosed within the
  container PE902077 at this location in this
  document.

The enclosure PE600935 has the following characteristics:
      ITEM_BARCODE = PE600935
CONTAINER_BARCODE = PE902077
             NAME = Well Correlation Basker 1 to Manta 1
            BASIN = GIPPSLAND
           PERMIT =
             TYPE = WELL
          SUBTYPE = CROSS_SECTION
      DESCRIPTION = Well Correlation Basker 1 to Manta 1
          REMARKS =
     DATE_CREATED = 10/06/1990
    DATE_RECEIVED = 01/02/1991
             W_NO = W1028
        WELL_NAME = Gummy-1
       CONTRACTOR = Schlumberger
     CLIENT_OP_CO = Shell Australia

(Inserted by DNRE - Vic Govt Mines Dept)

PE600936

This is an enclosure indicator page.
The enclosure PE600936 is enclosed within the
  container PE902077 at this location in this
  document.

The enclosure PE600936 has the following characteristics:
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      ITEM_BARCODE = PE600936
 CONTAINER_BARCODE = PE902077
              NAME = Synthetic Siesmogram
             BASIN = GIPPSLAND
            PERMIT =
              TYPE = WELL
           SUBTYPE = SYNTH_SEISMOGRAM
       DESCRIPTION = Synthetic Siesmogram
           REMARKS =
      DATE_CREATED = 16/01/1991
     DATE_RECEIVED = 01/02/1991
              W_NO = W1028
         WELL_NAME = Gummy-1
        CONTRACTOR =
      CLIENT_OP_CO = Shell Australia
```

(Inserted by DNRE - Vic Govt Mines Dept)

Appendix 1
Palynology

INTRODUCTION

Fifteen sidewall core samples, representing the interval 2082.5 to 2619.5m in Gummy-1, were processed and examined for spore-pollen and dinoflagellates.

With the exception of the SWC at 2082.5m, yields and preservation were medium to high. Conversely, few samples yielded diagnostic species and the confidence of many age-determinations is low, particularly within the Tertiary interval.

Palynological determinations and interpreted lithological units are summarized below. Interpretative and basic data are given in Tables 1 and 2 respectively. Check lists of all species recorded are attached. Electric log data were unavailable.

SUMMARY

AGE	UNIT	ZONE	DEPTH RANGE (m)	ENVIRONMENT
Early Eocene	LATROBE GROUP	Lower M. diversus	2098.0	marginal marine
Paleocene	"	Upper L. balmei	2128.0-2199.5	marginal marine
"	"	Lower L. balmei	2259.0-2368.0	marginal marine
Maastrichtian	"	Upper T. longus	2423.5-2454.0	coastal plain
"	"	"	2525.0	marginal marine?
"	"	"	2549.0-2619.5	coastal plain

GEOLOGICAL COMMENTS

1. Although Gummy-1 contains a continuous sequence of
    palynological zones from the Maastrichtian, Upper T.
    longus Zone to the Early Eocene Lower M. diversus Zone,
    the palynological data imply that depositional rates
    were low. Alternatively the section analysed in this
    report comprises a number of thin [on-lapping?] units
    separated by long periods of erosion or non-deposition.

2. Intervals almost certainly representing condensed
    sequences are:

    (a) Glauconitic siltsones between 2082.5-2098.0m

        Because of very low recovery and recycling of
        palynomorphs at 2082.5m, it is not possible to date
        precisely the top of this unit which appears [hand-
        written SWC descriptions] to form the top coarse
        clastics in Gummy-1. However an Early Eocene date is
        likely based on the Lower M. diversus Zone
        palynoflora at 2098.0m

    (b) Siltstones and sandstones between 2128.0-2368.0m,

        The lack of a clear distinction between the Upper
        and Lower L. balmei Zone palynofloras is consistent
        with a condensed sequence, as is the presence of
        varying amounts of glauconite between 2279.0-2368.0.

        This boundary should be treated as provisional.
        Similarly the pick for the Upper L. balmei/Lower M.
        diversus is of low confidence due to the possibility
        of bioturbation of Early Eocene pollen indicators
        [see Biostratigraphy]

3. It is noted that the top of the Upper Cretaceous appears
    to be high relative to adjacent wells such as Grunter-1
    and ?Basker South-1. The Upper T. longus date at 2423.0m
    is considered to very reliable although a more confident
    pick will require palynological analysis of SWC 11 at
    2393.5m

4. On present indications, the lowest sample received [SWC
    3 at 2619.0m] is low within the Upper T. longus Zone. If
    correct, then the Upper Cretaceous unit may also be
    include condensed sequence above this depth.

PALAEOENVIRONMENTS

1.   With the possible exception of SWC 8 at 2525.0m, all
     Upper T. longus Zone samples represent a coastal plain
     environment. This included swamps and probably a lake
     containing anoxic bottom water - represented by a coal
     at 2605.0m [not analysed] and pyrite-scarred spore-
     pollen at 2619.0m respectively. The absence of dinocysts
     are against the latter sample representing a marginal
     marine environment.

2.. Marginal marine conditions were established at the well-
     site in the Paleocene, most probably before or during
     the E. crassitabulata marine transgression and certainly
     by the time of the A. homomorphum marine transgression.

     Similar conditions are represented by the Early Eocene,
     Lower M. diversus Zone sample at 2098.0m. The data are
     inadequate to determine when open marine conditions
     developed over the wellsite.

BIOSTRATIGRAPHY

Zone and age-determinations have been made using criteria
proposed by Stover & Partridge (1973), Helby et al. (1987)
and unpublished observations made on Gippsland Basin wells
drilled by Esso Australia Ltd. The informal subdivision of
the T. longus Zone proposed by Macphail (1983b: see Helby et
al., ibid p.58) is followed here. Zone names have not been
altered to conform with nomenclatural changes to nominate
species such as Tricolpites longus [now Forcipites longus:
see Dettman & Jarzen, 1988].

It is noted that published criteria for subdividing the
L. balmei Zone are unreliable although first appearances and
extinctions defining the zone overall are not. For example,
species whose first appearance are diagnostic of Upper L.
balmei Zone age, e.g. Cyathidites gigantis and Proteacidites
incurvatus, appear only towards the top of the zone whilst
others which are usually restricted to this zonule have been
recorded within the Lower L. balmei Zone, e.g. Malvacipollis
subtilis and Verrucosisporites kopukuensis. At present the
Proteacidites annularis is considered to range no lower than
the Upper L. balmei Zone. Similarly the typically Lower L.
balmei Zone species Proteacidites angulatus and
Tetracolporites verrucosus are known to range into the Upper
L. balmei Zone although only in trace numbers.

A few species appear to terminate within the Upper zonule and
therefore can be used to define an informal 'middle' L.
balmei zonule, e.g. Beaupreadites orbiculatus, Integricorpus
antipodus ms and Jaxtacolpus pieratus ms.

For present purposes, it is suggested that the Upper/Lower L.
balmei Zone boundary be treated as provisional in all
palaeontological reports unless supported by unequivocal
geological and dinoflagellate data.

Upper Tricolpites longus Zone 2423.5-2619.5m Maastrichtian

Samples within this interval are characterized by frequent to
abundant Gambierina rudata and Proteacidites spp. and lesser
numbers of Late Cretaceous species which range no higher than
the Upper T. longus Zone, e.g Proteacidites reticuloconcavus,
P. palisadus, P. otwayensis, Triporopollenites sectilis and
Tricolporites lilliei.

The lower boundary of the zone is provisionally placed at
2619.5m, a sample yielding Forcipites longus and Quadraplanus

brossus but not <u>Stereisporites</u> <u>punctatus</u>. Although the relative abundance of <u>Gambierina</u> makes an Upper <u>T. longus</u> Zone probable, the presence of an undescribed species of <u>Grapnelispora</u> with simple not bifurcating processes suggests a position relatively low in the zonule.

<u>Stereisporites</u> <u>punctatus</u> first appears at 2549.0m, associated with <u>Tricolporites</u> <u>lilliei</u> and abundant <u>Gambierina</u> <u>rudata</u>, and in association with <u>Forcipites</u> <u>longus</u> at 2454.0m. The latter palynoflora contains very rare Late Cretaceous occurrences of <u>Dryptopollenites</u> <u>semilunatus</u> and <u>Beaupreadites</u> sp. cf <u>B. verrucosus</u>. **Possible** fragments of the Maastrichtian dinoflagellate <u>Manumiella</u> <u>druggii</u> are present at 2525.0m and minor pyrite scarring of spore-pollen occurs at 2619.5m.

The upper boundary is tightly defined by the simultaneous occurrence of <u>Stereisporites</u> <u>punctatus</u>, <u>Forcipites</u> <u>longus</u>, <u>Quadraplanus</u> <u>brossus</u> and <u>Triporopollenites</u> <u>sectilis</u>.

Lower <u>Lygistepollenites</u> <u>balmei</u> Zone 2259.0-2368.0m Paleocene

SWCs within this interval and the overlying Upper <u>L. balmei</u> Zone are dominated by <u>Proteacidites</u> spp. and gymnosperm pollen: the latter group usually includes frequent numbers of <u>Lygistepollenites</u> <u>balmei</u> and more rarely <u>Araucariacites</u> <u>australis</u>.

Although a Paleocene age is certain, the Lower <u>L. balmei</u> Zone date for the interval 2259.0-2368.0m is based on negative evidence, viz. the absence of species ranging no lower than the Upper <u>L. balmei</u> Zone.

It is noted that two lines of evidence indicate a 'Middle' Paleocene position, i.e. all samples were deposited close to upper boundary of the zonule. Similarly the lower of the two samples assigned to the Upper <u>L. balmei</u> Zone [2199.0m] also may be 'Middle' Paleocene.

1.   The SWCs at 2318.5m, 2348.0m and 2368.0m contain a rare subspecies of the typically Upper <u>L. balmei</u> Zone dinoflagellate <u>Apectodinium</u> <u>homomorphum</u>. This form is characterized by short processes and, apart from having a narrow, high rather than low, wide archaeopyle, is virtually identical with the Late Eocene index species <u>Gippslandica</u> (<u>Vozzhenikovia</u>) <u>extensa</u>.

     Whilst it is possible that occurrences of <u>A. homomorphum</u> at 2368.0m are due to mud-contamination or caving [the dinocyst is caved into the Upper <u>T. longus</u> Zone at

2454.0m], the dinoflagellate is common-abundant at
2318.5m and 2348.0m and both samples are likely to
represent the same marine transgression. Interestingly,
the dinocyst flora at 2318.5m also includes <u>Alisocysta</u>
spp., including one cyst of <u>A. crassitabulata</u>, a species
diagnostic of the Lower <u>L. balmei</u>, <u>E. crassitabulata</u> Zone
(see Partridge, 1976).

Other dinoflagellates present in the interval include
<u>Deflandrea</u> sp. cf <u>D. delineata</u> and <u>Deflandrea medcalfii</u>
at 2318.5m and 2348.0m, and <u>Cordosphaeridium inodes</u> at
2348.0m and 2259.0m.

2. The palynoflora at 2318.5m includes <u>Verrucosisporites
    kopukuensis</u> and <u>Rotverrusporites stellatus</u>, spores more
    typically found no lower than the Upper <u>L. balmei</u> Zone
    whilst those at 2259.0m and 2259.0m include specimens of
    <u>Tetracolporites verrucosus</u>, a pollen rarely found above
    the Lower <u>L. balmei</u> Zone.

On present indications, the most probable explanation is that
the interval 2199.5-2368.0m is a condensed sequence [see
Geological Comments]. This explanation is supported by
occurrences of reworked Early and Late Cretaceous spore-
pollen, in particular at 2318.5m.

The upper boundary is provisionally picked at 2259.0m, a
sample yielding both <u>Tetracolporites verrucosus</u> and multiple
specimens of the typically Lower <u>L. balmei</u> Zone species,
<u>Proteacidites angulatus</u>.

Upper <u>Lygistepollenites balmei</u> Zone 2128.0-2199.5m   Paleocene

Two palynofloras are assigned to this zone. Both include
frequent to common <u>Deflandrea medcalfii</u> and low numbers of a
species resembling <u>D. flounderensis</u> but differ in terms of
the spore-pollen component.

The lower palynoflora, at 2199.5m includes frequent-common
<u>Lygistepollenites balmei</u> and <u>Australopollis obscurus</u>. In this
case the Upper <u>L. balmei</u> Zone is based on wholly on
<u>Proteacidites annulatus</u> (see above) and it is noted that the
relative abundance of <u>Proteacidites angulatus</u> in the same
sample is more typical of a Lower <u>L. balmei</u> Zone palynoflora.

Conversely <u>Lygisteopllenites balmei</u> is extremely rare in the
upper palynoflora [2128.0m]. Nevertheless the sample can be
confidently dated as Upper <u>L. balmei</u> Zone based on the
association of <u>Proteacidites annularis</u>, <u>P. differentipollis</u>,

frequent <u>P. grandis</u>, <u>Tricolporites moultonii</u>, <u>Banksieaeidites</u> <u>lunatus</u>, <u>Ischyosporites gremius</u>, <u>I. irregularis</u>, <u>Gambierina</u> <u>rudata</u>, and <u>Camarozonosporites bullatus</u>. <u>Proteacidites</u> <u>angulatus</u> and<u>Tricolpites confessus</u> are present.

Lower <u>Malvacipollis diversus</u> 2098.0m   Early Eocene

One sample is provisionally assigned to this zone, based on occurrences of <u>Spinizonocolpites prominatus</u> and frequent-common specimens of <u>Malvacipollis diversus</u> and <u>M. subtilis</u>. An Upper <u>L. balmei</u> Zone date is possible if the specimen of <u>Spinizonocolpites prominatus</u> is bioturbated downwards.

Otherwise the palynoflora closely resembles the sample [2128.0m] picked as the top of the Upper <u>L. balmei</u> Zone, e.g. in the relative abundance of <u>Proteacidites grandis</u> and <u>Deflandrea medcalfii</u>. <u>Gambierina edwardsii</u> implies that at least portion of the palynoflora may be recycled from the underlying Paleocene interval.

The highest sample received, SWC 20 at 2082.0m, yielded a very sparse palynoflora comprising a mixture of Paleocene-Upper Cretaceous spore-pollen species and caved, mostly Oligo-Miocene, dinoflagellates. The former include <u>Gambierina</u> <u>rudata</u> and <u>Triporopollenites sectilis</u>: the latter include <u>Phthanoperidinium</u> sp., <u>Pyxidinopsis pontus</u> and ?<u>Apectodinium</u> <u>hyperacantha</u>.

The palynoflora includes an as yet unexplained, perfect specimen of the Valanginian-Turonian dinoflagellate, <u>Cribroperidinium edwardsii</u>.

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PARTRIDGE, A.D. (1976). The geological expression of eustacy in the Early Tertiary of the Gippsland Basin. <u>APEA J.</u>, <u>16</u> : 73-79.

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TABLE 1: SUMMARY OF INTERPRETATIVE PALYNOLOGICAL DATA

SWC	DEPTH (m)	ZONE S-P	. DINO	CONF. RTG.	COMMENT
20	2082.5	Indet.	—	—	
19	2098.0	L. M.d.	—	2	S. prominatus
18	2128.0	U L.b.	—	1	C. bullatus
17	2199.5	U. L.b.		2	P. annularis
16	2259.0	L. L.b.		2	T. verrucosus
15	2279.0	L. L.b.	A. hom.	2	T. verrucosus
14	2318.5	L. L.b.	A. hom.	2	A crassitabulata
13	2348.0	L. L.b.	A. hom.?	2	C. inodes
12	2368.0	L. L.b.	A. hom.?	2	A. homomorpha
10	2423.5	U. T.l.	—	0	F. longus, S. punctatus
09	2454.0	U. T.l.	—	0	S. punctatus
08	2525.0	U. T.l.	—	2	S. punctatus
06	2549.0	U. T.l.	0	0	S. punctatus, T. lilliei
05	2577.0	U. T.l.	2	2	freq. Gambierina
03	2619.5	U. T.l.		1	Q. brossus, freq. Gambierina

TABLE 2: SUMMARY OF BASIC PALYNOLOGICAL DATA

SWC	DEPTH (m)	YIELD S-P	DINO	DIVERSITY S-P	DINO	PRES.	LITH.*
20	2082.5	negl	negl.	low	low	good	Slst., glc.
19	2098.0	high	med.	med.	med.	mod.	As above
18	2128.0	high	low	high	med.	mod.	Slst.
17	2199.5	high	low	med.	med.	poor	Slst.
16	2259.0	med.	low	med.	low	mod.	Slst.
15	2279.0	high	low	med.	low	mod.	Slst.
14	2318.5	high	med.	high	high	good	Ss., glc
13	2348.0	med.	med.	low	med.	mod.	Slst.
12	2368.0	med.	low	med.	low	mod.	Ss, glc
10	2423.5	med.	–	high	–	mod.	Slst.
09	2454.0	high	low#	high	low	good	Clyst.
08	2525.0	low	low?	med.	low	mod.	Slst., glc.
06	2549.0	med.	–	med.	–	mod.	Clyst.
05	2577.0	low	low#	med.	low	good	Ss.
03	2619.5	med.	–	high	–	mod.	Slst.

Caved Oligocene-Miocene species.

* Lithological descriptions [main rock type.qualifier] taken from hand-written sidewall core sample description sheets

FOSSIL NAMES \ DEPTHS (m)	2082.5	2098.0	2128.0	2199.5	2259.0	2279.0	2318.5	2348.0	2368.0	2423.5	2454.0	2525.0	2549.0	2577.0	2619.5
SAMPLE TYPE OR NO.	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
SPORE-POLLEN															
Alisporites grandis R														•	
Amosopollis cruciformis							•		•						
Araucariacites australis	•	•	•	•	•	•	•		•	•	•	•	•		•
Australopollis obscurus				•	•	•	•	•							
Baculatisporites comaumensis											•		•	•	
B. disconformis			•	•		•			•	•	•			•	
Banksieaeidites lunatus ms		•	•												
Beaupreadites orbiculatus											•	•	•	•	
B. elegansiformis [Late K var.]											•				
Basopollis mutabilis ms					•										
B. otwayensis ms		•			•	•	•		•		•				
Camarozonosporites australiensis			•									•		•	•
C. bullatus			•							•					
C. dumus ms											•	•		•	
C. heskermensis											•				
C. horrendus ms											•	•			
Ceratosporites equalis		•								•					
Cicatricosisporites australiensis										•	•	•		•	
Clavifera triplex			•			•					•				
Ccrollinia spp.							•								
Cyathidites australis	•		•	•	•		•		•		•			•	
C. minor		•	•	•							•	•		•	
C. splendens		•	•	•	•		•	•	•					•	
Dacrycarpidites australiensis					•										
Dicolpopollis sp.				•											
Dicotetradites meridianus	•	•	•								•				
Dilwynites granulatus		•	•					•			•				
D. tuberculatus		•	•				•				•				
Dryptopollenites semilunatus											•				
Forcipites longus										•	•		•	•	
Foveotriletes balteus			•												
Gambierina edwardsii		•				•		•	•		•				
G. rudata	•		•	•	•	•	•	•	•	•	•	•	•	•	•
Gleicheniidites spp.	•	•	•	•	•	•	•		•	•	•	•	•		
Grapnelispora [simple process sp.]														•	
Haloragacidites harrisii	•	•	•		•						C				
Herkosporites elliotii		•		•	•	•		•	•	•	•		•	•	
Ischyosporites gremius		•	•												
I. irregularis ms		•	•												
Jaxtacolpus pieratus ms				•	•						•			•	
Klukisporites scaberis R					•										
Kraeuselisporites linearis			•												
K. majus											•		•		
Laevigatosporites musca ms										?					
Laevigatosporites spp.	•	•	•	•	•	•	•	•	•	•	•	•		•	
Latrohosporites amplus	•			•	•			•	•	•	•	•		•	
L. crassus				•	•				•		•	•			
Leptolepidites verrucatus								•	•					•	
Liliacidites spp.			•							•	•	•			
Lygistepollenites balmei		•	•	•	•	•	•	•	•	•	•			•	
L. florinii		•	•	•	•	•	•	•		•		•	•	•	
Malvacipollis diversus		•	•												
M. subtilis		•	•	•											
Microalatidites palaeogenicus		•													
Microcachrydites antarcticus		•	•	•		•				•			•		

* C=CORE   S=SIDEWALL CORE
  T=CUTTINGS   J=JUNK BASKET

R = REWORKED SP.
C = CONTAMINANT

SAMPLE TYPE OR NO. *	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
FOSSIL NAMES \ DEPTHS (m)	2082.5	2098.0	2128.0	2199.5	2259.0	2279.0	2318.5	2348.0	2368.0	2423.5	2454.0	2525.0	2549.0	2577.0	2619.5
Myrtaceidites eucalyptoides			•												
M. parvus-mesonesus		•													
Myrtaceoipollenites australis		•													
Nothofagidites brachyspinulosus			•		•	•		•					•	•	
N. emarcidus-heterus		•			•	•				C		C			
N. endurus	•			•	•	•			•	•	•	•	•	•	•
N. flemingii		•	•				•			•	•				•
N. senectus											•				
Peninsulapollis gillii	•	•		•	•	•	•	•	•	•	•	•	•	•	•
Polyporopollenites demarcatus											•				
P. polyoratus		•	•	•	•	•	•		•						
Peromonolites densus		•			•	•									
Phyllocladidites mawsonii	•		•	•	•	•	•	•	•	•	•	•	•		•
P. reticulosaccatus				•	•	•	•	•		•			•	•	
P. verrucosus	•				•		•	•		•					
Podocarpidites exiguus					•								•		
Podocarpidites spp.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Podosporites microsaccatus		•	•	•	•	•	•		•	•		•	•	•	
Polypodiisporites s.p.			•												
Polycingutrilites pocockii										•					
Polycolpites langstonii			•												
Proteacidites adenanthoides		•							•	•	•	•	•		
P. amolosexinus											•	•		•	
P. angulatus	•		•	•	•	•	•		•						
P. annularis		•	•												
P. cleinei ms					•					•	•	•	•	•	
P. dierama ms											•				
P. differentipolis			•												
P. grandis		•	•												
P. latrobensis		•													
P. otwayensis ms										•				•	
P. palisadus										•	•	•		•	•
P. prepolus ms											•				
P. rectus			•				•								
P. reticuloconcavus ms										•	•	•	•		•
P. reticuloscabratus		•		•	•			•							
P. retiformis											•				
P. tenuiexinus		•									•				
P. wahooensis ms											•				
P. spp. indet./undescribed	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Quadraplanus brossus										•					•
Retitriletes australoclavatidites			•				•			•			•		•
R. circolumenus						•									
R. facetus								•							
R. spp. indet./undescribed	•			•	•						•			•	
Rhoipites sphaerica		•													
Rotverrusporites stellatus						•									
Rugulatisporites mallatus		•	•			•	•								
Spinizonocolpites prominatus		•													
Stereisporites australis f. crassa								•			•				
S. antiquisporites			•		•			•		•					
S. (Tripunctisporis) sp.	•		•			•		•	•	•	•				
S. regium													•	•	
S. spp. indet./undescribed	•	•	•	•	•			•	•	•	•	•	•	•	•
Tetracolporites multistrixus ms		•	•	•			•	•							
T. verrucosus					•	•				•	•				

* C=CORE   S=SIDEWALL CORE
  T=CUTTINGS   J=JUNK BASKET

R = REWORKED SP.
C = CONTAMINANT

SAMPLE TYPE OR NO. *	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
FOSSIL NAMES / DEPTHS (m)	2082.5	2098.0	2128.0	2199.5	2259.0	2279.0	2318.5	2348.0	2368.0	2423.5	2454.0	2525.0	2549.0	2577.0	2619.5
Tricolpites confessus			•	•			•			•	•		•	•	•
T. phillipsii						•									
T. waipawaensis										•	•				•
T. spp. indet./undescribed		•	•	•	•	•	•	•	•	•	•	•	•	•	•
Tricolporites lilliei	•									•	•		•	•	•
T. marginatus ms										•					
T. moultonii ms			•												
T. spp. indet./undescribed		•	•	•	•	•	•	•	•	•	•	•	•	•	•
TRILETE SPORES indet./undescribed		•	•	•	•	•	•	•	•	•	•	•			
Triletes tuberculiformis			•				•								
Triporoletes reticulatus										•		•			
Trisaccites spp.							•								
Triporopollenites sp. cf T. bellus			•												
T. scabratus															
T. sectilis	•						•			•	•	•	•	•	•
T. sp. indet./undescribed			•						•						
Verrucatosporites alienus			•												
Verrucosisporites kopukuensis		•	•			•	•								
Peromonolites vellosus															
Tetradopollis obscurus													•		
DINOFLAGELLATES															
Alisocysta (Eisenackia) crassitabulata							•								
A. sp. cf A. rugulolirata							•								
Apectodinium homomorphum (long processes)							•								
A. homomorphum (short processes)	•						•	•	•		C				
Cleistosphaeridium spp. C	•						•								
Delfandrea medcalfii			•	•	•		•	•							
D. sp. cf D. delineata			•	•	•		•								
Glaphyracysta retiintextum					•										
Lingulodinium machaerophorum C	•														
Spiniferites spp.	•	•	•					•			C				
Phthanoperidinium comatum C.	•														
Paralecaniella indentata	•														
Cordosphaeridium inodes		•	•		•		•								
Crassosphaera sp.															
Cribroperidinium edwardsii R	•														
Indet./undescribed spp.	•	•	•	•	•	•	•	•	•		C?		C		

C=CORE   S=SIDEWALL CORE
T=CUTTINGS   J=JUNK BASKET

R = REWORKED SP.
C = CONTAMINANT

PALYNOLOGICAL ANALYSIS, GUMMY-1

GIPPSLAND BASIN

by

M.K. MACPHAIL

Palaeontological report prepared 5 July 1990 for
The Shell Company of Australia Ltd.

Consultant Palynologist, 20 Abbey St., Gladesville, NSW 2111

Appendix 2

Micropaleontology

MICROPALAEONTOLOGICAL ANALYSIS, GUMMY-1, GIPPSLAND BASIN

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August, 1990.

C O N T E N T S

1. SUMMARY

Gummy-1 was drilled in offshore petroleum permit Vic P/19, Gippsland Basin to a depth of 3563mKB. Sidewall cores from 1215m to 2078m have been examined for foraminifera and calcareous nannoplankton. A summary of the biostratigraphic breakdown of the respective microfossil groups and environmental sub-division is given below:-

Planktonic Foraminiferal Subdivision

1215m & 1387m	:	Zone B2	mid-lower Late Miocene
1519m	:	Zones B2 & C	mid Late-upper Middle Miocene
1642m	:	Zones C & D1	upper-mid Middle Miocene
1749m & 1788m	:	Zone D1	mid Middle Miocene
1852m	:	Zone D2	lower Middle Miocene
1956m	:	Zone F	upper Early Miocene
2065m	:	Zone H1	basal Early Miocene
2078m	:	Zone H2	latest Late Oligocene

Calcareous Nannoplankton Subdivision

1215m	:	Zones NN14 to NN10	Early Pliocene-Late Miocene
1387m	:	Indeterminate	
1519m & 1642m	:	Zones NN9 to NN7	upper Middle Miocene
1749m-1852m	:	Zone NN6	mid Middle Miocene
1956m	:	Zones NN5 & NN4	lower Middle-upper Early Miocene
2065m & 2078m	:	Zones NN1 & NP25	lower Early Miocene-latest Late Oligocene

Environment of Deposition

| Samples 1215m-1642m inclusive | : | outer neritic |
| Samples 1749m-2078m inclusive | : | outer neritic-upper bathyal |

II. INTRODUCTION

A total of 10 sidewall cores have been scrutinized for foraminifera and calcareous nannoplankton from the interval 1215m to 2078m in Gummy-1. Fossil assemblages identified in the well section are provided in Appendix No. 2.

III. BIOSTRATIGRAPHIC ANALYSIS

The planktonic foraminiferal letter zonal scheme of Taylor (in prep.) and the NN/NP calcareous nannoplankton zonal scheme of Martini (1971) are used for biostratigraphic subdivision.

(A) Planktonic Foraminiferal Subdivision

1. 1215m & 1387m : Zone B2 (mid-lower Late Miocene)

Assignment to Zone B2 is based on the association of Globorotalia acostaensis and Globorotalia miotumida.

2. 1519m : Zones B2 & C (mid Late-upper Middle Miocene)

The occurrence of Globorotalia miotumida miotumida (few) indicates assignment to Zones B2 and C. The single recorded occurrence of Globorotalia acostaensis in the sample at 1519m indicates a possible Zone B2 age however an undifferentiated B2/C assignment is given a higher degree of confidence.

3. 1642m : Zones C & D1 (upper-mid Middle Miocene)

The low yielding and very poorly preserved planktonic foraminiferal fauna at 1642m includes single specimens of Globorotalia praescitula/G. scitula and Globorotalia aff. miotumida. These taxa suggest assignment to Zones C and D1.

4. 1749m & 1788m : Zone D1 (mid Middle Miocene)

Assignment to Zone D1 is based on the association of Globorotalia praescitula and Globorotalia miozea miozea.

5. 1852m : Zone D2 (lower Middle Miocene)

The sample at 1852m is assigned to Zone D2 on the basis of the association of Orbulina universa, Orbulina suturalis and Globigerinoides sicanus.

6. 1956m : Zone F (upper Early Miocene)

The occurrence of Globigerinoides sicanus (single specimen) and lack of the Orbulina/Praeorbulina group indicates assignment to Zone F.

7. 2065m : Zone H1 (basal Early Miocene)

The occurrence of Globigerina woodi connecta and lack of Globigerinoides trilobus indicates that the sample at 2065m is Zone H1 in age.

8. 2078m : Zone H2 (latest Late Oligocene)

Assignment to Zone H2 is based on the occurrence of Globigerina woodi woodi without Globigerina woodi connecta.

(B)   Calcareous Nannoplankton Sub-division

1.   1215m : Zones NN14 to NN10 inclusive (Early Pliocene-Late
                Miocene)

The high yielding nannoplankton asemblage at 1215m contains
frequent Sphenolithus abies and lacks Sphenolithus moriformis, and
on this basis is assigned to Zones NN14 to NN10 inclusive.

2.   1387m : Indeterminate

The impoverished and very poorly preserved calcareous
nannoplankton assemblage at 1387m lacks age-diagnostic taxa and no
zonal assignment is possible.

3.   1519m & 1642m : Zones NN9 to NN7 inclusive (upper Middle
                       Miocene)

The samples at 1519m and 1642m are assigned to Zones NN9 to NN7
inclusive on the basis of the occurrence of Sphenolithus
moriformis and lack of Cyclicargolithus floridanus.

4.   1749m-1852m : Zone NN6 (mid Middle Miocene)

The high yielding and moderately diverse nannoplankton assemblages
in the interval contain frequent to abundant Cyclicargolithus
floridanus, and lack Sphenolithus heteromorphous, and on this
basis are indicative of Zone NN6.

5.   1956m : Zones NN5 & NN4 (lower Middle-upper Early Miocene)

The diverse nannoplankton assemblage at 1956m is assigned to Zones
NN5 and NN4 on the basis of the occurrence of rare Sphenolithus
heteromorphous.

6.   2065m & 2078m : Zones NN1 & NP25 (lower Early Miocene-latest
                       Late Oligocene)

Assignment to Zones NN1 and NP25 is based on the association of
Zygrhablithus bijugatus (rare at 2065m), Dictyococcites aff.
bisectus (frequent at 2065m and rare at 2078m), Cyclicargolithus
abisectus (frequent at 2078m) and Sphenolithus cf. capricornatus
(rare at 2078m).

IV. ENVIRONMENT OF DEPOSITION

1. Samples 1215m-1642m inclusive : Outer neritic

The micritic limestones in the interval are interpreted to have been deposited in an outer neritic environment on the basis of containing the following bathymetrically-diagnostic taxa: Cassidulina delicata/laevigata (rare-frequent), Bulimina aff. aculeata (rare-few), Sphaeroidina bulloides (few-frequent) and Siphouvigerina proboscidea (rare-few). The foraminiferal faunas in the samples in the interval contain generally even numbers of planktonics and benthonics.

2. Samples 1749m-2078m inclusive : Outer neritic-upper bathyal

The rich foraminiferal faunas in the interval comprise 80-95% planktonics and the benthonic assemblages include : Pleurostomella (rare at 1749m), ?Osangularia (rare at 1788m and 2078m), Hyperammina (frequent at 1956m) and Cyclammina (few at 2065m). Deposition in an outer neritic to upper bathyal environment is envisaged.

V.   REFERENCES

MARTINI, E., 1971. Standard Tertiary and Quaternary calcareous
    nannoplankton zonation. In: A. Farinacci (ed.). Proc. II Plank.
    Conf., Roma, 1970, 2: 739-785.

TAYLOR, D.J., (in prep.). Observed Gippsland biostratigraphic
    sequences of planktonic foraminiferal assemblages.

APPENDIX NO. 1 : SUMMARY OF MICROPALAEONTOLOGICAL DATA, GUMMY-1

SAMPLE (mKB)	FORAM YIELD	FORAM PRESERV.	FORAM DIVERSITY	NANNO YIELD	NANNO PRESERV.	NANNO DIVERSITY
SWC, 1215	high	poor	high	high	poor	mod/low
SWC, 1387	high	poor	mod/high	v. low	v. poor	low
SWC, 1519	mod/high	v. poor	mod/high	moderate	poor	low
SWC, 1642	low	v. poor	mod/low	moderate	poor	low
SWC, 1749	high	poor	moderate	high	poor	moderate
SWC, 1788	high	mod/poor	moderate	high	poor	moderate
SWC, 1852	high	mod/poor	moderate	high	mod/poor	mod/high
SWC, 1956	mod/low	poor	moderate	high	moderate	high
SWC, 2065	high	mod/poor	mod/high	high	moderate	mod/high
SWC, 2078	high	mod/poor	moderate	high	moderate	mod/high

Appendix 3

Petrophysics

APPENDIX 3

GUMMY-1 PETROPHYSICAL ANALYSIS

1.0 WIRELINE LOGS (all depths are logging depths below RT)

The following wireline logs were run:

Date	Hole Size	Run	Interval	Type
19/5/90	12 1/4"	1	2639-1192.5	DLL/LSSL/LDL/CNL/MSFL/ CAL/GR/SP (CNL AND MSFL logged to 2030 m)
	13 3/8" csg.	1	1192.5-seabed	GR
	12 1/4"	2	2633.5-1215	CST/GR (30 fired, 29 recovered)
2/6/90	8 1/2"	1	3562.5-2634.5	DLL/LSSL/GR/MSFL/CAL
3/6/90	8 1/2"	2	3566.5-2634.5	LDL/CAL/CNL/GR
	9 5/8" csg	2	2634.5-2575	CNL/GR
	8 1/2"	3	3567-2634.5	SHDT/FMS/GR (FMS scan over 3480m to 3380m and 2950m to 2850m)
	open/cased hole	4	3563-1200	WSS (17 levels)
4-5/6/90	8 1/2 "	5	3555-2729m	RFT (66 pretests, 2 samples)

2.0 EVALUATION

2.1 General

Petrophysical evaluation indicates no net pay in the objective Latrobe Groups sandstones and 28m net gas pay (10% porosity and 40% S_H cutoffs) in low porosity sands of the Golden Beach Group (see Table 2 for detailed summary).

2.2 Wireline Log Acquisition/Quality

- The programmed logging suite in the 17 1/2" hole section was dropped on exploration department advice. The GR tool was subsequently run through 13 3/8" casing to seabed for correlation purposes.

- Numerous spikes in the LDT data occur throughout the 12 1/4" open hole section. This may have been a result of interference ("cross-talk") between the LSSL and LDT tools in the super-combo configuration. Schlumberger is

currently investigating and will report.

- Sonic cycle skipping is common in 12 1/4 and 8 1/2"
holes, particularly in washed out zones.

- The hole below the 9 5/8" casing shoe is badly washed out
through volcanic and shale/siltstone sections (hole in
gauge across sands).

- The sidewall core run in 8 1/2" hole was cancelled on
advice from exploration department.

- The 12 1/4" hole was logged with the super-combo
configuration, consequently a 23m hole section has an
incomplete suite of logs (2612-2635m BRT). The GR and CNL
tools were logged through 9 5/8" casing to 2575m BRT.

- Two conventional logging runs were required in 8 1/2"
hole to allow log acquisition over an interpreted
gas-bearing sand near TD.

2.3 <u>Petrophysical Parameters</u> (see Table 1)

2.3.1 <u>Reservoir Parameters</u>:

In the absence of any conventional core data from the
Gummy-1 well, the following reservoir parameters were
used in the evaluation:

- In the Latrobe Group, values of 0.85 for A and 2.08
for m were used. These parameters were derived from
core analysis of Intra-Latrobe sands at the nearby
Tuna-4 well. The saturation exponent n (1.83) and
RHO_{ma} (2.66 g/cc) were taken from analysis of
core plugs from the Intra-Latrobe at Basker-1.

- The Golden Beach reservoir parameters were default
values typical of low porosity sandstones (see
Table 1).

2.3.2 <u>Formation Water Resistivity (Rw)</u>:

- In the Latrobe Group, Rw was estimated by the Rwa
technique (porosity/resistivity crossplots) over
clean, low resistivity sands. Calculated values
ranged from 0.07 ohm.m in the upper Latrobe (50000
ppm NaCl equiv.) to 0.09 ohm.m in the lower Latrobe
(30000 ppm NaCl equiv.). These interpreted
formation water salinities are in general agreement
with that derived from the RFT pressure gradient
(0.445 psi/ft - 35000 ppm in the lower Latrobe at
Gummy-1. However it should be noted that these
salinities are twice those previously calculated
for an equivalent interval in nearby wells
(SDA 619).

- No thick sequence of clean, obviously water-bearing
sands can be identified in the Golden Beach
Formation. However, two RFT pretests (3063.5 and
3061.5 mBDF) in an apparently water-wet sand of the

uppermost Golden Beach fell on a gradient of 0.442 psi/ft (35000 ppm); a resistivity/porosity analysis in this zone substantiated this formation water salinity. An Rw of 0.07 ohm.m was therefore used for calculation of S_H in the lower Golden Beach section. It should be noted that this salinity is also higher than that previously calculated for this interval.

2.3.3 Shaley Sand Evaluation

- In the absence of Qv data both in the Latrobe and Golden Beach sections, the shaley sand Indonesia equation was used for calculation of hydrocarbon saturations.

TABLE 1 : PETROPHYSICAL PARAMETERS

INTERVAL (m BRT)

	2081-2374m Latrobe	2374-2612m Latrobe	2635-3035m Latrobe	3035-3558 Golden Beach
Hole size (inches)	12.25	12.25	8.5	8.5
GR_{ma} (API)	25	25	25	30
GR_{sh} (API)	150	150	150	145
R_m (OHMM)	0.09	0.09	0.085	0.069
R_{mc} (OHMM)	0.13	0.13	0.135	0.11
R_{sh} (OHMM)	15	16	20	12
R_w (OHMM)	0.07	0.085	0.09	0.07
A	0.85	0.85	0.85	1.00
m	2.08	2.08	2.08	2.00
n	1.83	1.83	1.83	2.00
RHO_{ma} (g/cc)	2.66	2.66	2.66	2.65
RHO_{mud} (g/cc)	1.08	1.08	1.09	1.09
RHO_{mf} (g/cc)	1.00	1.00	1.00	1.00
$NEUT_{ma}$ (p.u.)				0
$NEUT_{sh}$ (p.u.)				18
RHO_{hc} (g/cc)				0.23[*]

* Derived from PVT analysis of Manta-1 U3 sand gas (pressure and temperature corrected).

2.4   Evaluation Procedure

The following steps were used in the petrophysical evaluation of Gummy-1:

2.4.1 Preliminary Lithology Evaluation

- identify dolomitic sands (high MSFL, high density)

- identify volcanics in Golden Beach (low GR, washed out hole, high PE)

- correct GR for borehole effects

- calculate V_{sh} from GR

- apply cutoff for coal definition

    coal : Density $\leq$ 2.0 g/cc

2.4.2 Preliminary Rwa Calculations over Clean, Apparently Water-bearing Sandstones

- Correct DLL/DLS/MSFL for borehole effects

- Calculate DINV and RTRU

- Correct LDL for borehole effects

- Calculate porosity from density (Latrobe)

- Correct CNL for borehole effects and clay (upper Golden Beach)

- Calculate porosity from LDL/CNL crossplot (upper Golden Beach)

- Calculate Rwa from porosity and RTRU.

2.4.3 Calculation of Hydrocarbon Saturation

2.4.3.1   Latrobe Group (2081-3035m BDF):

- Environmental corrections for all curves and calculation of RTRU

- Hydrocarbon saturation calculated from the shaley sand Indonesia equation:

$$S_h = 1 - R_T^{-1/n} * \left[\frac{V_{sh}^{(1-Vsh/2)}}{R_{sh}^{\frac{1}{2}}} + \frac{POR^{m/2}}{(A*Rw)^{\frac{1}{2}}} \right]^{-2/n}$$

2.4.3.2   Golden Beach Group (3035-3558m BDF):

-    Environmental corrections for all curves and calculation of RTRU (except 3544-3558m BDF where MSFL curve not acquired)

-    Correction of CNL for clay.

-    Iteration procedure based on hydrocarbon (gas) effect correction of the LDL, calculation of porosity and hydrocarbon saturation in the invaded zone and correction of the CNL for excavation effect.

-    Calculation of hydrocarbon saturation in the virgin zone using the shaley sand Indonesia equation.

2.5   Evaluation Summary (Table 2 and Enclosures 1 and 2)

-    No net pay was identified from logs in the Latrobe Group sandstones (2081-3035m BDF).

-    A total of 28m of net gas pay (10% porosity and 40% S_G cutoffs) was interpreted in low porosity sands of the Golden Beach Group from 3200-3550.5 mBDF. Approximately half of this total (12m) occurs in individual sands less than 3m thick from 3200-3495 mBDF.

-    The massive sand between 3495 and 3556 mBDF contains approximately 16m of net gas pay, predominantly in its upper 33m.

-    A 23m thick transition zone (3527-3550.5) is evident on resistivity logs. Gas saturation in this interval decreases gradually from 60% at 3527m to the interpreted GWC at 3550.5 mBDF.

-    Hydrocarbons in Golden Beach identified as gas by RFT samples at 3201.5m and 3421.5 mBDF, pressure gradients from RFT (circa 0.14 psi/ft.) and by CNL/LDL crossover.

TABLE 2 - PETROPHYSICAL SUMMARY - GUMMY-1

INTERVAL m BDF	GROSS THICKNESS (m)	NET SST				NET RESERVOIR *				NET PAY **			
		h (m)	N/G	AVG Ø	AVG S_h	h (m)	N/G	AVG Ø	AVG S_h	h (m)	N/G	AVG Ø	AVG S_h
LATROBE (3081-3035)	954	375	.39	.20	.08	360	.38	.21	.08	-	-	-	-
GOLDEN BEACH (3035-3563)	528	141	.27	.09	.33	52	.10	.13	.37	27.8	.05	.12	.58
3035-3187	152	28	.18	.10	.10	13	.09	.15	.08	-	-	-	-
3187-3224	37	10	.27	.08	.29	3	.08	.11	.42	1.2	.03	.11	.51
3224-3420	196	25	.13	.08	.31	6	.03	.12	.38	4.3	.02	.12	.48
3420-3495	75	28	.37	.08	.43	8	.11	.13	.54	6.4	.09	.13	.58
3495-3550	55	43	.78	.10	.49	20	.36	.11	.55	15.9	.29	.12	.62

*   Porosity Cutoff : 10%
** S_G Cutoff : 40%

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PE600937

This is an enclosure indicator page.
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      DATE_RECEIVED = 01/02/1991
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          WELL_NAME = Gummy-1
         CONTRACTOR =
       CLIENT_OP_CO = Shell Australia

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PE600939

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The enclosure PE600939 is enclosed within the
   container PE902077 at this location in this
   document.

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           WELL_NAME = Gummy-1
          CONTRACTOR =
        CLIENT_OP_CO = Shell Australia

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Appendix 4
RFT Evaluation

APPENDIX 4

GUMMY-1 RFT EVALUATION

Introduction

A total of 66 pretest pressures and 2 samples were taken in the
Latrobe and Golden Beach Groups in the Gummy-1 well. A list of
pretest pressures is given in Appendix 1 with sample details
given in Appendix 2.

Plots of RFT pressures versus depth are given as Figure 1 and
Figure 2.

Discussion

Latrobe Interval (2081 - 3035m ahbdf)

A total of 6 pretests were taken in the water bearing Latrobe
sands.   These pressures all fall on a single line with an
equivalent gradient of 0.445 psi/ft. When converted to a
salinity (ca. 35000 ppm) this appears to be significantly more
saline than the water recovered from production tests of
Basker-1 and Bignose-1 (10000 ppm) across stratigraphically
similar intervals. It is however less than the equivalent
salinity originally used to evaluate the Basker-1 RFT plot (SDA
619, SDA 525) which assumed a gradient of 0.456 psi/ft
equivalent to a salinity of some 50000 ppm. Analysis of the RFT
drawdown data suggests generally good permeabilities consistent
with those observed in similar intervals in Basker and Manta
(Appendix 3).

Golden Beach Interval (3035 - 3563m ahbdf)

Some 60 pretests were taken. Pre-tests were attempted in 4
water-bearing sands at the top Golden Beach with successful
tests in two giving a water gradient of 0.442 psi/ft. However,
as these tests were taken within 2m of each other the actual
water gradient may vary considerably from this. Water collected
from production testing of the U3 sands at Manta-1 (16.5 bbls)
consisted of a 9000 ppm brine which is essentially fresh and
suggests that the calculated gradient (0.442 psi/ft) may be
high.

Two gas columns can be identified in interbedded sands between
3190 to 3215m and 3420 to 3550m.

In both intervals however, calculated gas gradients are high
(0.14 psi/ft). This would require a gas wetter than that
observed and tested in a similar interval in Manta (U3 sand).

A considerable amount of scatter is evident in the observed
pressures over the interval 3420-3550m. If viewed separately
the pretest pressures across the lowermost sand package
(3495-3556m) appear to fall on a gas gradient of 0.12 psi/ft
which is more consistant with the type of gas which occurrs in

the Manta U3 sand. A possible explanation for the high overall
gradient over the interval 3420 to 3550m is that two separate
columns have been tested.

Insufficient pressure points are available in the water-bearing
lower sands in the Golden Beach, to enable the drawing of a
water gradient and hence the calculation of accurate GWC's.

Extrapolation of the observed water gradient from the top Golden
Beach (see Fig. 1) would give GWC's of around 3260m and 3570m
for the two columns. However these do not agree with log
derived saturations which indicate that the free water levels
for each column are around 3215m and 3550m.

Pre-tests taken between 3280m and 3400m do not fall on any
recognizable common gradient. Log evaluation of these sands
indicates an average gas saturation of 31% and average porosity
of 8%. It is possible that each pre-test represents an
individual gas sand connected to the regional water gradient
which would require significant gas columns, however it is
considered more likely that a series of overpressured gas sands
of limited areal extent have been tested.

Permeabilities estimated from the RFT drawdowns in the Golden
Beach are low (Appendix 3) which is in agreement with
permeabilities derived from production testing the U3 sand in
Manta-1 (3.5mD).

Samples
Two samples were taken at 3201.5m and 3421.5m to confirm
fluid/gas content. Details of sample recovery are given in
Appendix 3.

Conclusion

Two gas columns have been identified within the interbedded gas
sands of the Golden Beach Group. In the absence of definitive
RFT data a GWC of around 3550m was identified from logs for the
lower sand package (3420-3550m).

069004jr.CWT/PROD/JR

Pretest Pressures

Depth (m ahbdf)	Minimum Flowing Pressure (psia)	Final Buildup Pressure(psia)	Test Time (sec)	
3555	1708	5144.2	357	
3554.5	13	<25		tight
3553	64	5119	335	
3553.5	3600	5120.3	200	
3548.5	3800	5118.7[+]	495	
3545	-	-	-	tight
3544	1650	5113.9	255	
3541	3430	5109.9	160	
3538	20	28	85	tight
3537	4632	5110.28	650	
3536	13	-	60	tight
3535.5	111	5110.1	320	
3535	18	-	62	tight
3527	4780	5100.2	160	
3523	5000	5102.4	681	
3522	4717	5100.2	190	
3517	4250	5101.2	789	
3508.5	5033	5097	474	
3508	14.5	-	-	tight
3501	4959	5095.3	698	
3497.5	5039	5093.2	790	
3487.3	4390	-	73	tight
3485.5	45	5096.6	466	
3475.5	32	-	-	tight
3475		5088.1	508	
3474.5	16.4	-	-	tight

+ still building at end of pretest.

069004jr.CWT/PROD/JR

Depth (m ahbdf)	Minimum Flowing Pressure (psia)	Final Buildup Pressure (psia)	Test Time (sec)	
3471.5	4980	5077.9	315	
3449.5	2530	5071.3	471	
3444	4860	5067.7	580	
3439	1200	5067.3	810	
3433	730	4960.1[+]	540	still building
3431.3	141	3423	210	tight
3425.5	805	5057.9	779	
3425.5	520	5057.6	865	
3421.5	4870	5050.9	426	
3421.5	4922	5052.6	789	
3420.6	5016	5053.1	930	
3420.5	5035	5052	1255	
3388.8	150	5019	515	
3387	46	70	110	tight
3383	36	5012.9	640	
3382	61	5010.7	270	
3351	4907	4942.6	395	
3351	4927	4943.2	130	
3349.7	3970	4914.6	–	
3349.5	29	4915.5	460	
3330.5	–	–	–	seal failure
3330	50	62	58	tight
3327	3410	4847.7	225	
3274.5	4680	4830.2	200	

Depth (m ahbdf)	Minimum Flowing Pressure (psia)	Final Buildup Pressure (psia)	Test Time (sec)	
3270.5	4600	4820.9	300	
3213.7	4180	4659.8	298	
3213.5	13	28	70	tight
3201.5	4444.2	4653.1	430	
3192	3800	4650.1	155	
3174.5	406	–	–	tight
3170.5	671	–	–	tight
3063.5	4381	4391.5	580	
3061.5	4382	4388.6	413	
2956.5	4184	4227.6	700	
2922	4160	4175.2	462	
2894	4126	4133.9	546	
2871.5	3691	4093.3	565	
2795	3947	3989.4	1213	
2729	3580	3893.2	608	

Sample Data

1. <u>3201.5m</u> (6 gallon chamber)
    Opening Pressure 2430 psi (9°C)

Gas	157.9	ft^3
Condensate	0.95 L	
Filtrate	2 L (Rm 0.25512 at 15°C cf 0.219 for mud filtrate)	

Gas Composition (%)		
	C_1	91.2
	C_2	5.9
	C_3	2.4
	iC_4	0.1
	nC_4	0.5

2. <u>3421.5</u>   (2.75 gallon chamber)
    Opening Pressure 550 psi (9°C)

Gas	0.75 ft^3	
Condensate	- light oil scum observed	
Filtrate	9.25L (Rm 0.212 at 15°C cf 0.219 for mud filtrate)	

Gas Composition (%)		
	C_1	83
	C_2	9.9
	C_3	5.6
	iC_4	0.5
	nC_4	0.9

Appendix 3

Permeabilities Derived from RFT Drawdown Data

Depth (m)	K/u (mD/Cp)	K water (mD)	K gas (mD)
2729	33	10	0.7
2795	60	18	1.3
2871.5	23	7	0.5
2894	428	128	9
2922	431	129	9
2956.5	152	46	3.2
3061.5	2709	813	5.7
3063.5	228	68	4.8
3192	13	4	0.3
3201.5	71	21	1.5
3213.7	28	8	0.6
3270.5	206	62	4.3
3274.5	63	19	1.3
3327	8	2	0.2
3351	582	175	2.2
3349.7	12	4	0.3
3349.5	1	0.03	0.02
3351	223	67	4.7
3382	1	0.3	0.02
3383	0.5	0.2	0.01
3388.8	1	0.03	0.02
3420.6	74	22	1.6
3425.5	1	0.03	0.02
3421.5	192	58	4.0
3420.5	190	57	4.0
3421.5	56	17	1.2
3425.5	1	0.03	0.02
3431.3	0.3	0.09	0.006
3433	0.1	0.03	0.002
3439	0.5	0.2	0.01
3444	40	12	0.8
3449.5	5	2	0.1
3471.5	131	39	2.8
3475.5	1	0.3	0.02
3485.5	1	0.3	0.02
3497.5	112	34	2.4
3501	49	15	1.0
3508.5	186	56	3.9
3517	14	4	0.3
3523	123	37	2.6
3527	40	12	0.8
3537	24	7	0.5
3553.5	1	0.3	0.02
3541	7	2	0.15
3544	3	1	0.06
3548.5	9	3	0.19
3553.5	8	2	0.17
3553	1	0.3	0.02
3555	3	1	0.06

DEPTH mbdf

TOP
GOLDEN
BEACH

TD 3563mdf

LATROBE WATER
GRADIENT

PRESSURE psia

	GIPPSLAND BASIN	Figure
SHELL-AUSTRALIA E.& P. OIL AND GAS	**GUMMY-1 RFT PRESSURE VS DEPTH**	1
Author: EE1	Report No.: SDA 976	Date: JUNE 1990	Drawing No.: 26185	

DEPTH mbdf

TD 3563mRT

LATROBE WATER
GRADIENT

PRESSURE psia

	GIPPSLAND BASIN			Figure
SHELL–AUSTRALIA E.& P. OIL AND GAS	**GUMMY RFT PLOT**			2
	Author: EE1	Report No.: SDA 976	Date: JUNE 1990	Drawing No.: 26184	

Appendix 5
Geochemistry

PETROLEUM GEOCHEMISTRY

GUMMY-1

Prepared for:
THE SHELL COMPANY OF AUSTRALIA   AUGUST 1990
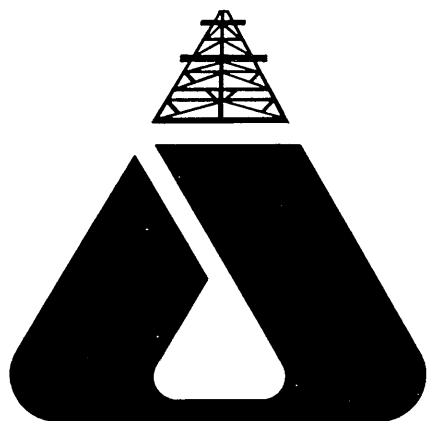
ANALABS

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HYDROCARBON CHARACTERISATION STUDY

GUMMY-1

Introduction

Potential source sediments and a condensate from the well Gummy-1, drilled by The Shell Company of Australia in permit Vic-P-19, were analysed geochemically.

The aim of this study was to assess the source potential of the interval between 2,393.5m and 2,619.5m and to characterise a condensate recovered from the well in terms of its source and maturity.

Analytical Procedure

Five (5) core samples ranging in depth from 2,393.5m down to 2,619.5m were air dried, hand-crushed and analysed for total organic carbon. All samples were subsequently submitted to Rock-Eval pyrolysis, and three sediments were selected for vitrinite reflectance measurement and maceral description.

The API gravity was determined for an RFT-1 condensate before the sample was submitted to liquid chromatography in order to separate saturate, aromatic and NSO compounds. Gas chromatography was performed on the saturate fraction, the branched and cyclic compounds of which were subsequently separated using a molecular sieve. GC-MS was then carried out on the branched and cyclics.

Analytical techniques applied are described in the "Theory and Methods" chapter in the back of this report.

Results obtained are presented in the following figures and tables:

Type of Analysis	Figure	Table
TOC and Rock-Eval pyrolysis	-	1
Physical properties and liquid chromatography	-	2
Gas chromatography	1	3
GC-MS	2,3,4	4,5
Vitrinite reflectance/maceral descriptions	-	6

General Information

Two copies of this report have been sent to Mr Malcolm King of The Shell Company of Australia. Any queries related to it may be directed to Dr Birgitta Hartung-Kagi of Analabs - Oil & Gas in Perth.

All data and interpretations in this study are proprietary to The Shell Company of Australia and regarded as highly confidential by all Analabs personnel.

RESULTS AND INTERPRETATION

A.   Source Rocks (Table 1)

The five sediment samples analysed contain between 0.70% and 3.10% TOC which characterises them as potentially fair to very good source rocks.

Genetical potentials (S1 + S2) between 0.70 and 8.96 range from poor to good, sample 2,525m being classified as poor, 2,619.5m as marginal, 2,292.5m and 2,549m as moderate and 2,454.0m as good. Samples 2,393.5m, 2,454m and 2,549m are characterised by fair (to good) levels of free hydrocarbons.

The top four samples (2,393.5m to 2,549m) are immature to date whereas the deepest sediment (2,619.5m) has probably just reached the oil window. All samples, except the purely gas-prone interval at 2,525m, are likely to generate gas together with oil upon further maturation.

B.   RFT-1 Condensate

The API gravity determined for RFT-1, 3,201.5m, is 48.6. The condensate is rich in saturates (82%) and contains only minor amounts of NSO compounds (3.3%; Table 2).

The overall picture of the GC trace obtained for the saturate fraction (Figure 1) characterises a typical mature condensate derived from probably terrestrial organic matter deposited under very oxic conditions.

This assessment is confirmed by GC-MS biomarker distributions. Low values for C27 to C29 sterane and diasterane ratios (0.28 and 0.75, respectively; Table 4) as well as a full range of bi-, tri- and tetracyclic diterpanes (Figure 2, m/z 123) indicate a source input from predominantly higher plants. 4-Methylsteranes, which occur in low concentrations in the Gummy-1 condensate, are often regarded as markers for dinoflagellates and thereby for lacustrine to marginally marine environments.

Mass fragmentograms m/z 191 is characterised by a suite of hopanes ranging from C27 to C31, low levels of moretanes and the unknown compounds Cy and Cz.

Both triterpane (Ts/Tm, hopane/moretane) and sterane (C29 20S/20R) parameters suggest a maturity level equivalent to approximately 1.1% V_R for the Gummy-1 condensate.

TABLE 1

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = GUMMY 1   DATE OF JOB = JUNE 1990

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
2393.5	429	0.21	3.73	0.27	3.94	13.81	0.05	0.33	1.85	201	14
2454.0	427	0.40	8.56	0.27	8.96	31.70	0.04	0.74	3.10	276	8
2525.0	424	0.07	0.63	0.66	0.70	0.95	0.10	0.06	0.83	75	79
2549.0	426	0.21	5.73	0.19	5.94	30.16	0.04	0.49	1.92	298	9
2619.5	432	0.08	1.63	1.21	1.71	1.35	0.05	0.14	0.70	232	172

TMAX = Max. temperature S2   S1 = Volatile hydrocarbons (HC)   S2 = HC generating potential
S1+S2 = Potential yield   S3 = Organic carbon dioxide   PI = Production index
PC = Pyrolysable carbon   TOC = Total organic carbon   HI = Hydrogen index
OI = Oxygen Index   nd = no data

TABLE 2

Summary of Physical Property and Sulphur Data

Date of Job: JULY 1990

Sample	API Gravity	%Sulphur(w/w)	Viscosity(25°C)	Viscosity(60°C)
GUMMY 1 RFT 1 3201.5	48.6	nd	nd	nd

TABLE 2

Summary of Liquid Chromatography(Compositional Data)

Date of Job: JULY 1990

Sample	-----Hydrocarbons-----			-----Nonhydrocarbons-----			SAT AROM	ASPH NSO	HC Non HC
	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's			
GUMMY 1 RFT 1 3201.5	82.1	14.6	96.7	3.3	nd	3.3	5.62	nd	29.1

na = not applicable   nd = no data

TABLE 3

Summary of Gas Chromatography Data

A. Alkane Compositional Data   Date of Job: JULY 1990

Sample	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
GUMMY 1 RFT 1 3201.5	7.09	.62	.09	1.07	1.05	5.68

TABLE 3

Summary of Gas Chromatography Data

B. n-Alkane Distributions   Date of Job: JULY 1990

Sample	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
GUMMY 1 RFT 1 3201.5	9.8	9.1	8.6	8.1	7.4	7.0	4.3	6.5	.6	6.2	5.6	5.2	4.7	4.1	3.6	3.0	2.2	1.8	1.1	.7	.3	.2

na = not applicable   nd = no data

TABLE 4

SELECTED PARAMETERS FROM GC/MS ANALYSIS

Sample: GUMMY 1, RFT 1

	Parameter	Ion(s)	Value
1.	18α(H)-hopane/17α(H)-hopane (Ts/Tm)	191	0.79
2.	C30 hopane/C30 moretane	191	8.03
3.	C31 22S hopane/C31 22R hopane	191	1.38
4.	C32 22S hopane/C32 22R hopane	191	1.31
5.	C29 20S ααα sterane/C29 20R ααα steranes	217	1.04
6.	C29 ααα steranes (20S / 20S+20R)	217	0.51
7.	$\dfrac{\text{C29 αββ steranes}}{\text{C29 ααα steranes + C29 αββ steranes}}$	217	0.59
8.	C27/C29 diasteranes	259	0.28
9.	C27/C29 steranes	217	0.75
10.	18α(H)-oleanane/C30 hopane	191	nd
11.	$\dfrac{\text{C29 diasteranes}}{\text{C29 ααα steranes + C29 αββ steranes}}$	217	0.72
12.	$\dfrac{\text{C30 (hopane + moretane)}}{\text{C29 (steranes + diasteranes)}}$	191/217	0.46
13.	C15 drimane/C16 homodrimane	123	0.57
14.	Rearranged drimanes/normal drimanes	123	0.66

nd = not detectable

TABLE 5

GC/MS AREA COUNTS

	STERANES C27				C28				C29			TRITERPANES C30		
SAMPLES	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)		(d)	(d)	(d)
WELL	normal	iso	rearranged	normal	iso	rearranged	normal	iso	rearranged		others	hopane	moretane
GUMMY 1 RFT 1	200	164	66	186	143	107	310	604	240			530	66

PERCENTAGES

	Steranes C27+C28+C29			Steranes C27	Steranes C28	C29	C27+C28+C29	Steranes C27+C28+C29	Triterpanes C30
SAMPLES WELL	normal	iso	rearranged	nor+is+re	nor+is+re	nor+is+re	iso	rearranged	sum
GUMMY 1 RFT 1	31.8%	47.0%	21.3%	22.2%	18.4%	59.5%	47.4%	21.5%	31.8%

KEY TO TABLE

(a) From m/z 217 mass fragmentograms using peaks from C27, C28 or C29
     normal steranes.

     NB. Because of co-elution with the C29 20S diasterane the C27 20S
         normal sterane peak area was calculated by equating the
         C29 20S/C29 20R diasterane ratio from m/z 259 to that in the
         m/z 217 mass fragmentogram and hence determining the contribution
         from C27 20S normal to the diasterane peak in the m/z 217
         mass fragmentogram.

(b) From m/z 218 mass fragmentograms using peaks from C27, C28 or C29
     isosteranes.

(c) From m/z 259 mass fragmentograms using peaks from C27, C28 or C29
     rearranged steranes (diasteranes).

(d) From m/z 191 mass fragmentograms using peaks from C30 triterpanes.

~   The value given is only approximate.

TABLE 6

GUMMY NO. 1

K.K. No.	Depth (m)	$\bar{R}_v$ max	Range	N	Description Including Liptinite (Exinite) Fluorescence
v2661	2393.5 SWC	0.40	0.29-0.50	27	Sparse cutinite and phytoplankton, greenish yellow to orange, rare sporinite and liptodetrinite, greenish yellow to orange. (Sandstone>siltstone>carbonate>coal. Coal rare to sparse, V>>I. Vitrite>>vitrinertite. Dom common, I>V>L. Inertinite and vitrinite common, liptinite sparse. Sparse bitumen, green to yellow. Rare to sparse glauconite. Iron oxide common. Pyrite sparse.)
v2662	2533 SWC	0.50	0.35-0.62	27	Rare cutinite, resinite, liptodetrinite and phytoplankton, yellow to orange. (Sandstone>coal>siltstone>carbonate. Coal major, I>V>L. Vitrinertite>inertite>vitrite. Dom abundant, I>V>L. Inertinite and vitrinite abundant, liptinite rare. Rare bitumen, green to yellow. Rare low rank coal cavings and glauconite. Iron oxide common. Pyrite sparse.)
v2663	2605 SWC	0.47	0.35-0.55	29	Abundant sporinite, cutinite and suberinite, yellow to dull orange and dull orange to brown. Common to abundant resinite, orange to dull orange, sparse to common liptodetrinite, yellow to orange, sparse exsudatinite, yellow. (Shaly coal abundant. The maceral composition of shaly coal;

Vitrinite = 41.0%
Inertinite = 4.0%
Sporinite = 8.0%
Cutinite = 6.0%
Resinite = 2.0%
Suberinite = 3.0%
Liptodetrinite = 0.5%
Exsudatinite = 0.2%
Bitumen = 0.3%
Mineral matter (clay + pyrite = 35.0%

Sparse greenish yellow fluorescence of bitumen and oil drops. Iron oxide sparse. Pyrite rare to sparse.)

Figure 1

GUMMY 1, RFT 1 3201.5m
Saturate Fraction
C_{12}^+ GLC
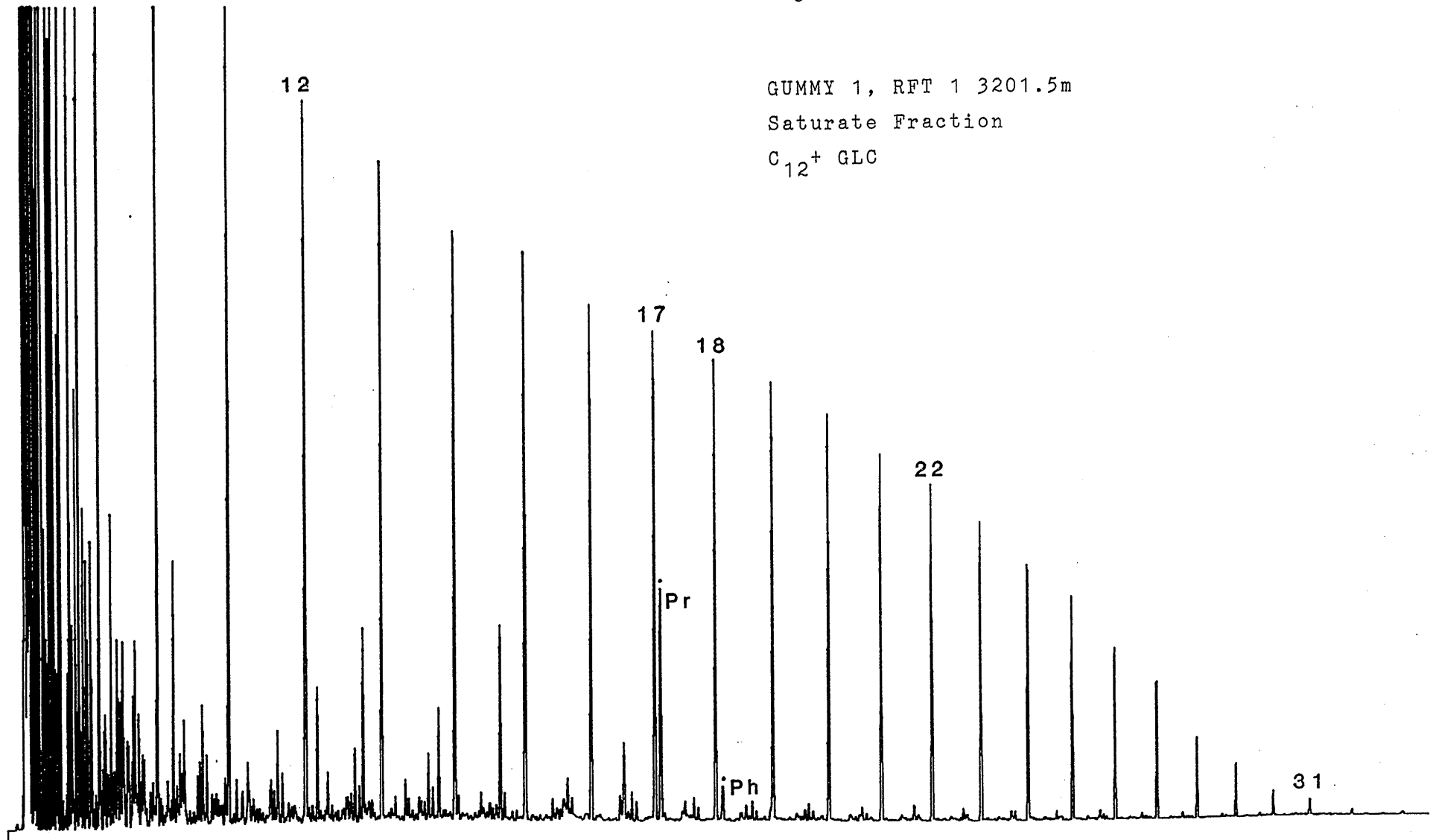
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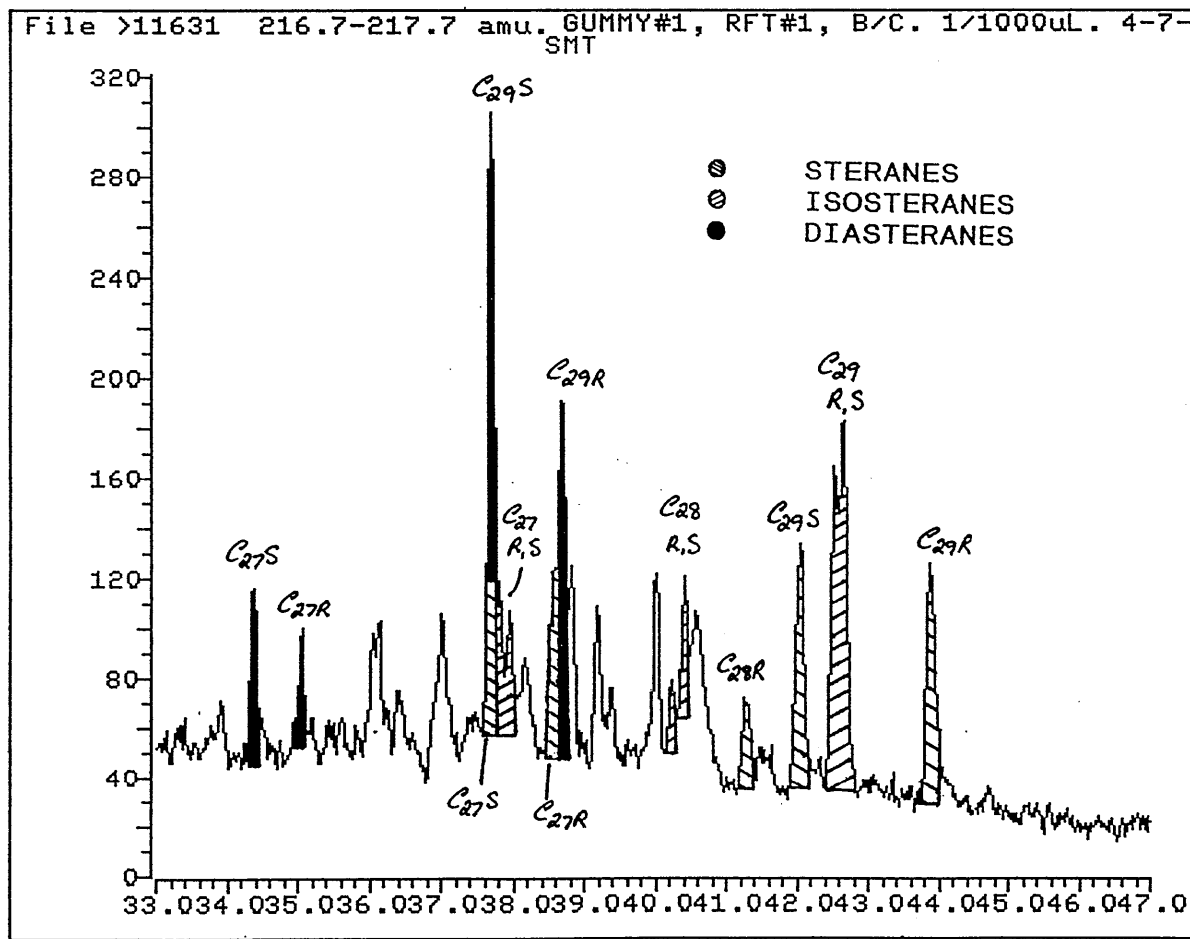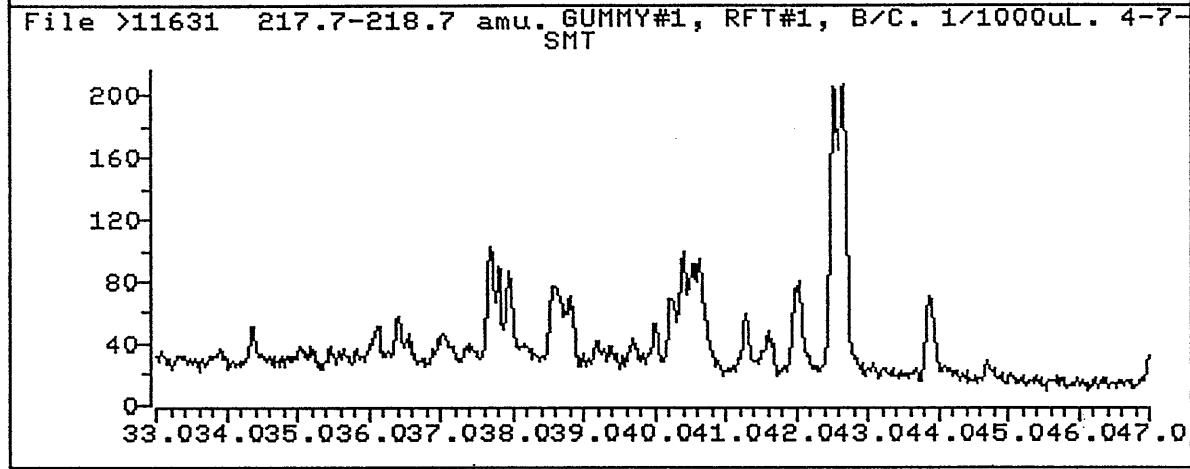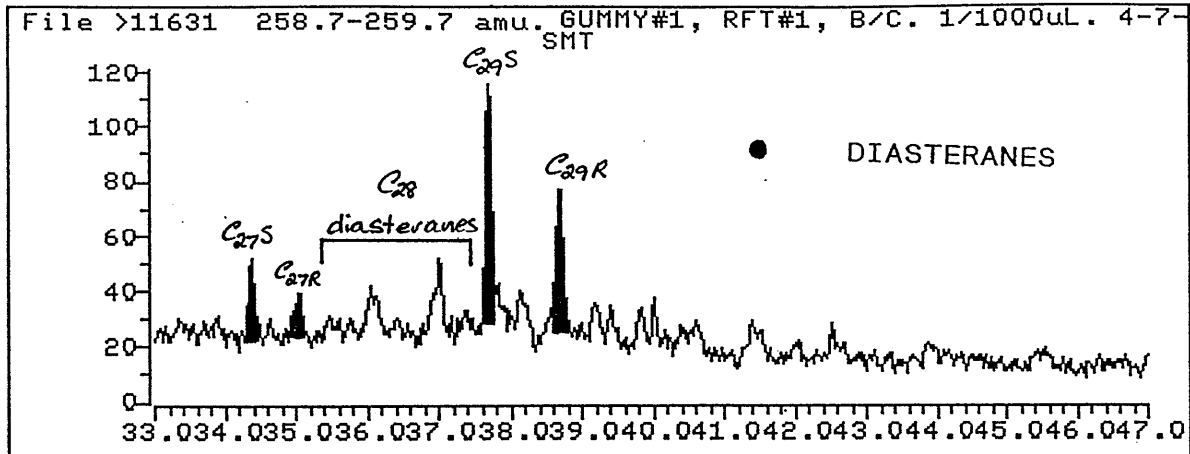
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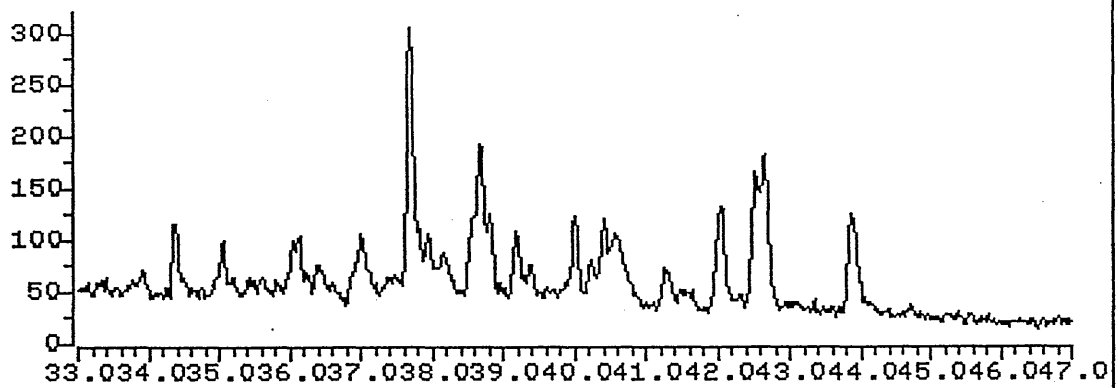
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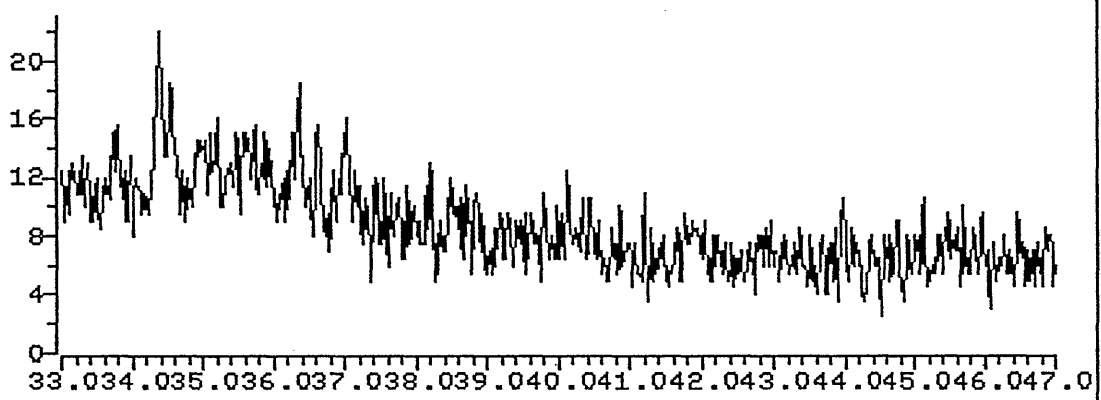
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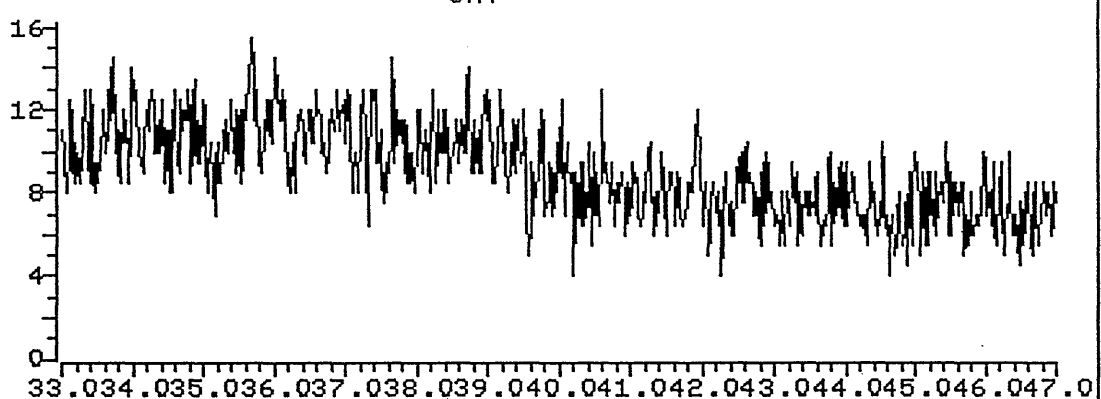
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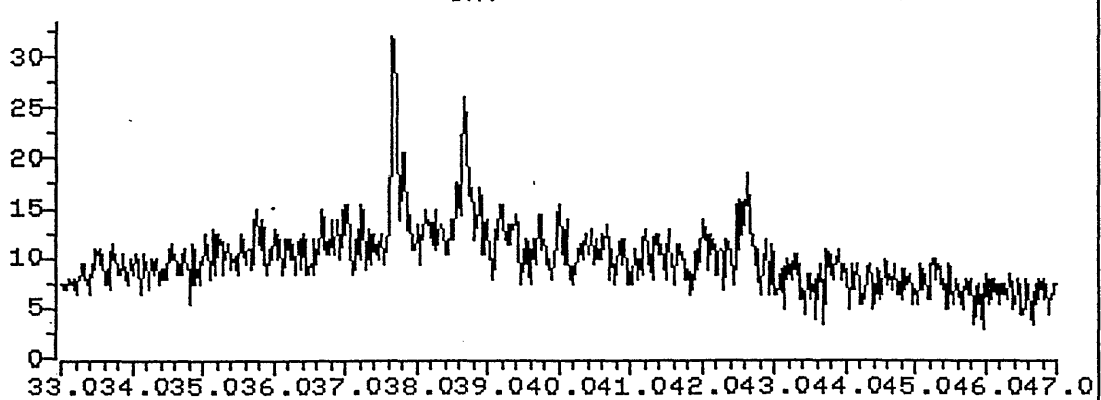
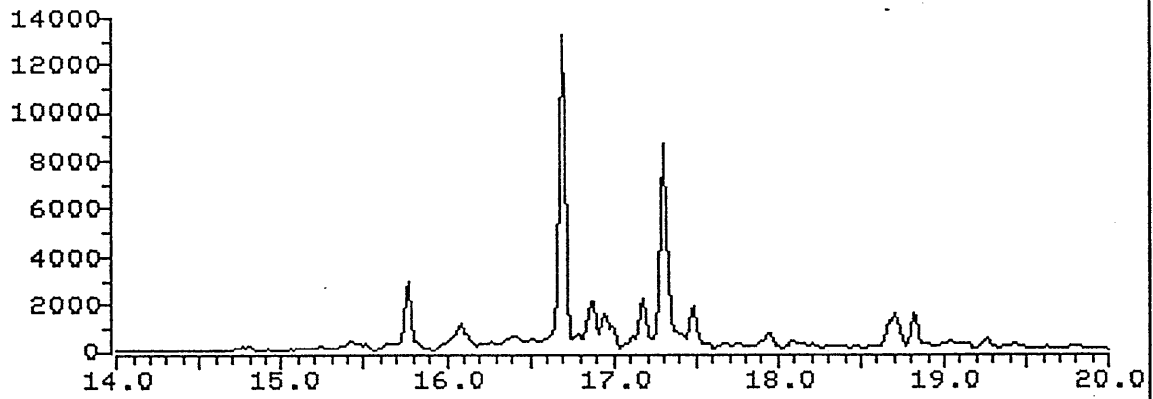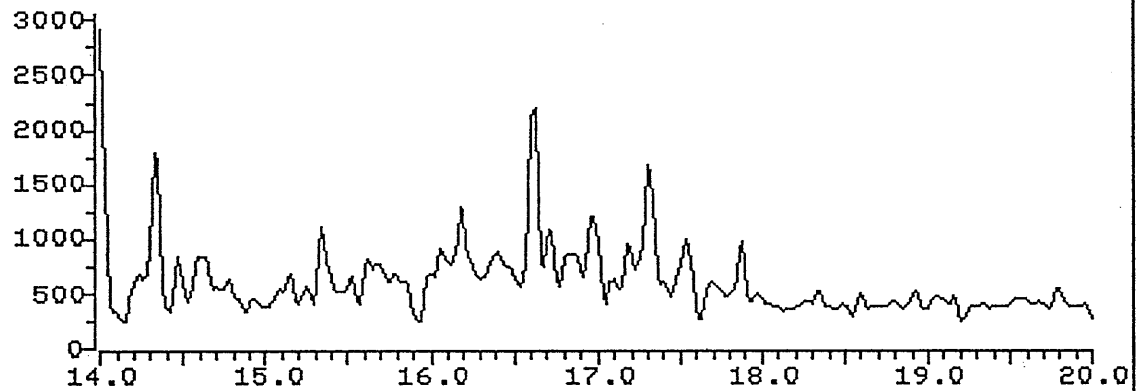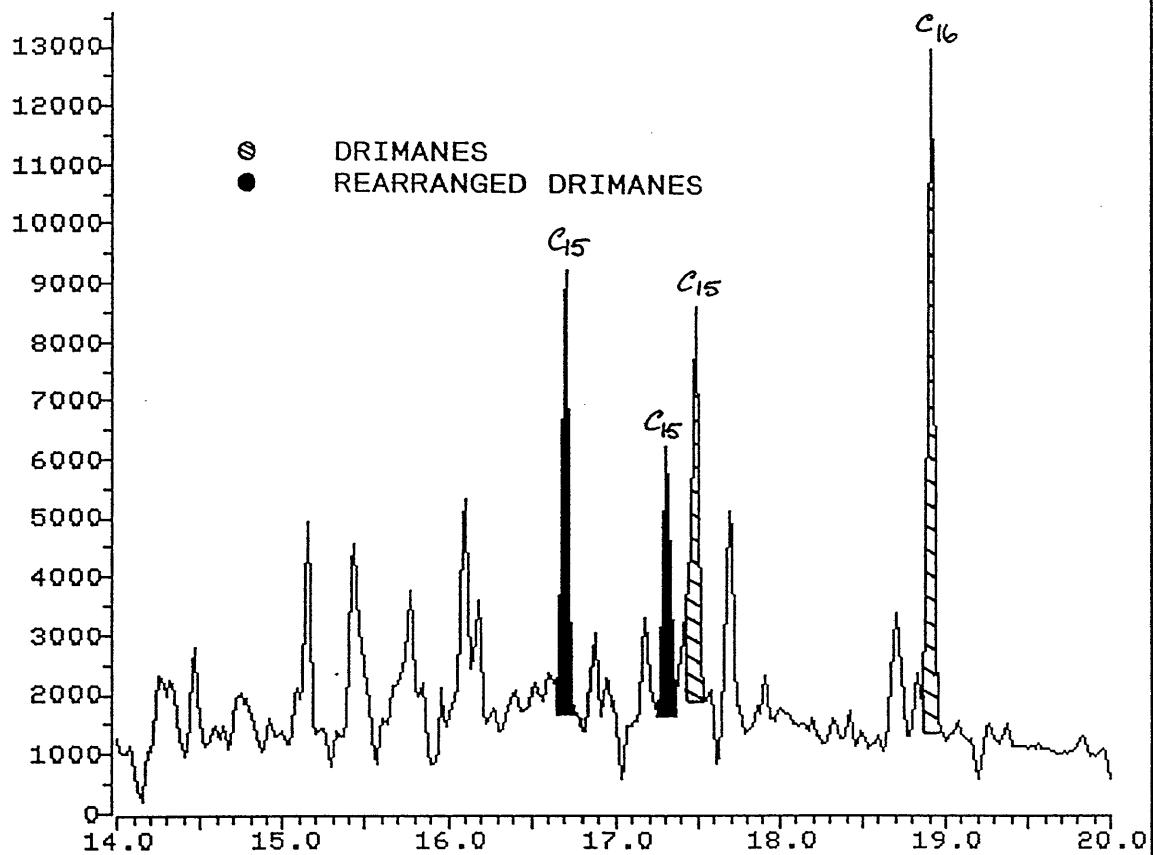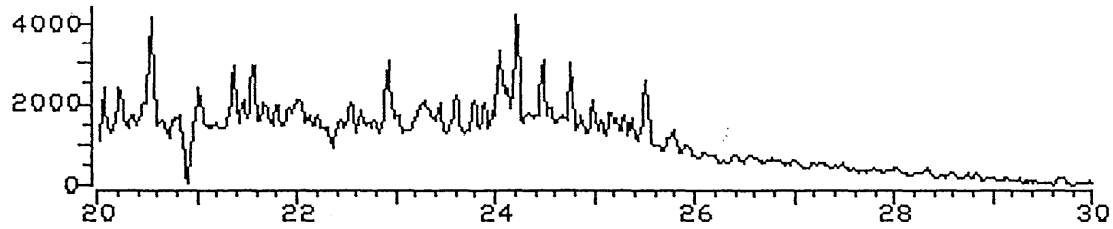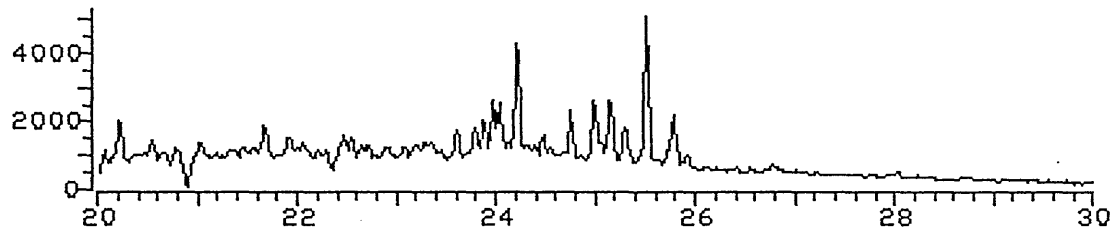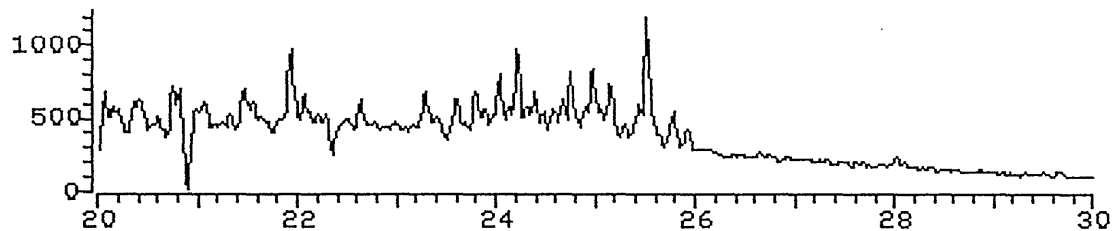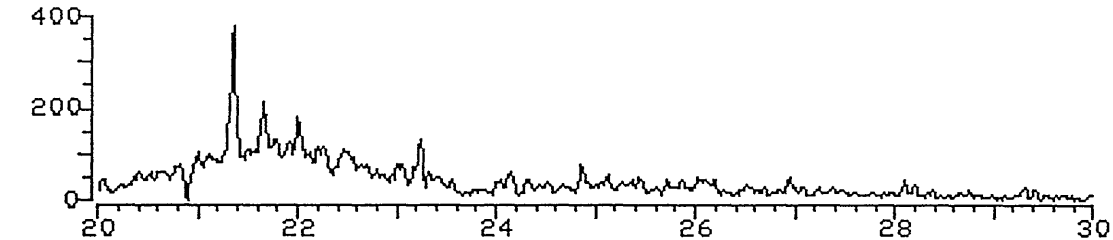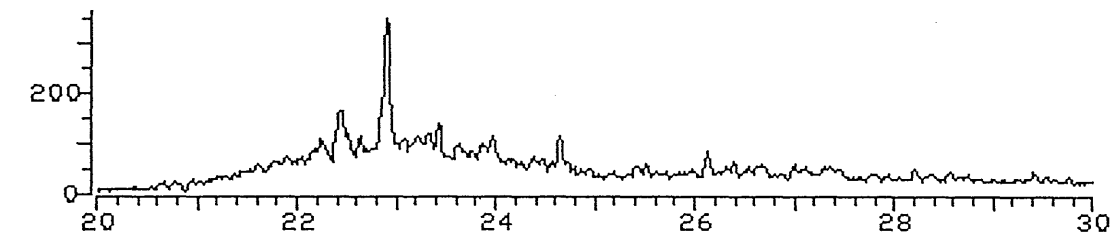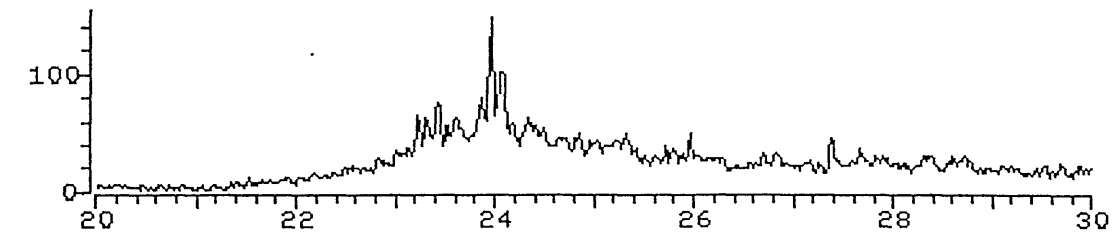File >11631   272.7-273.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
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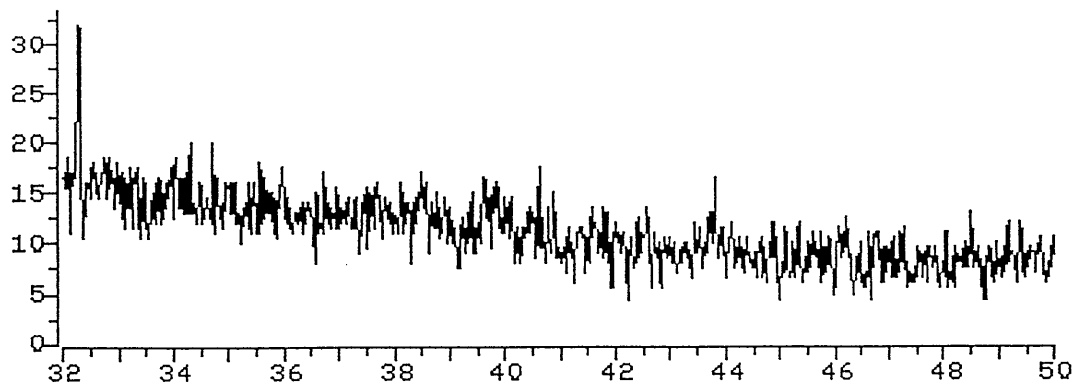
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SMT
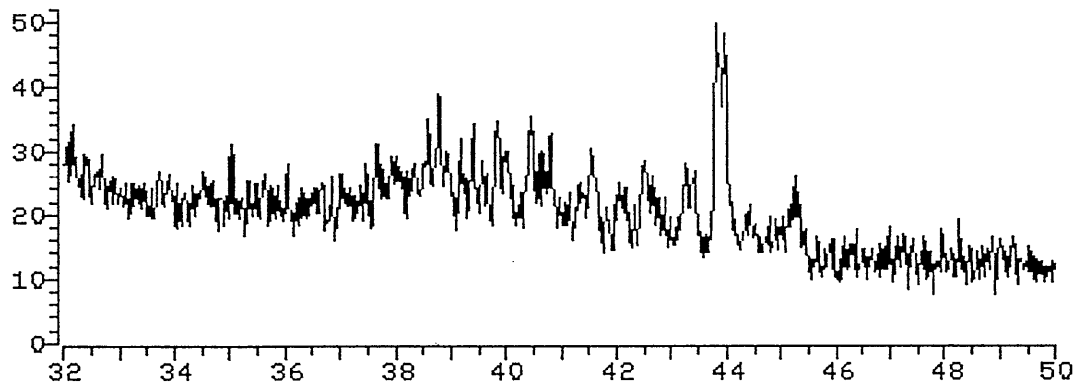
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SMT

4-METHYL STERANES

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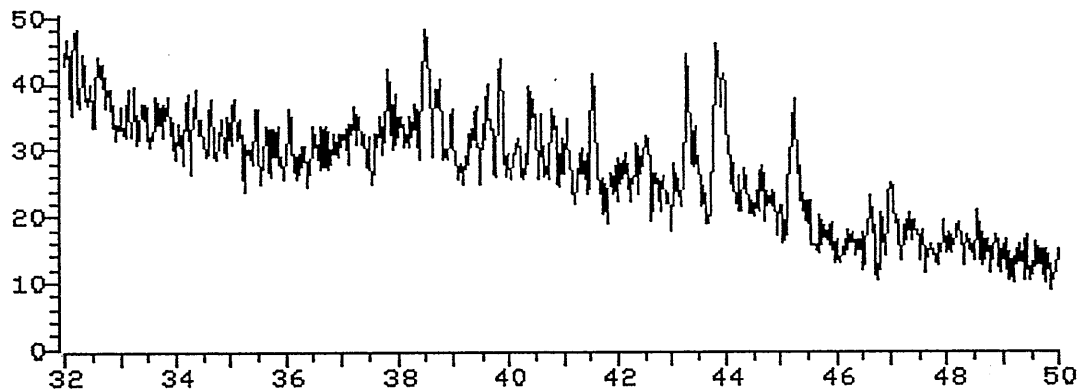
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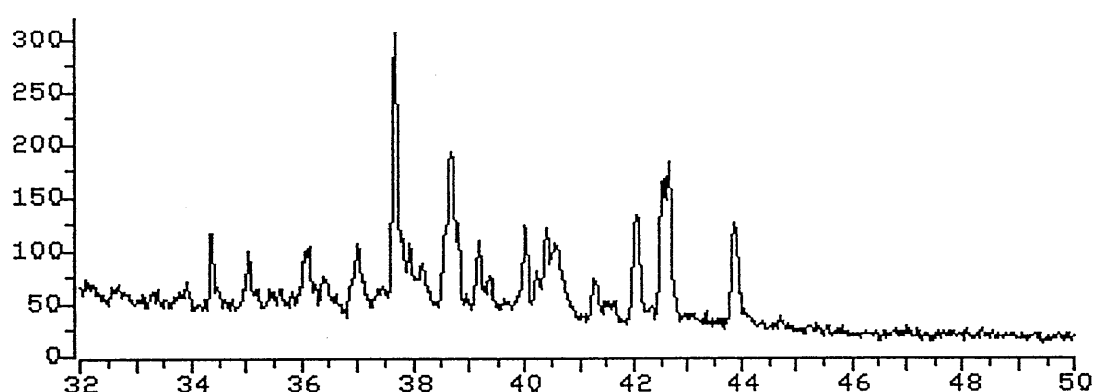
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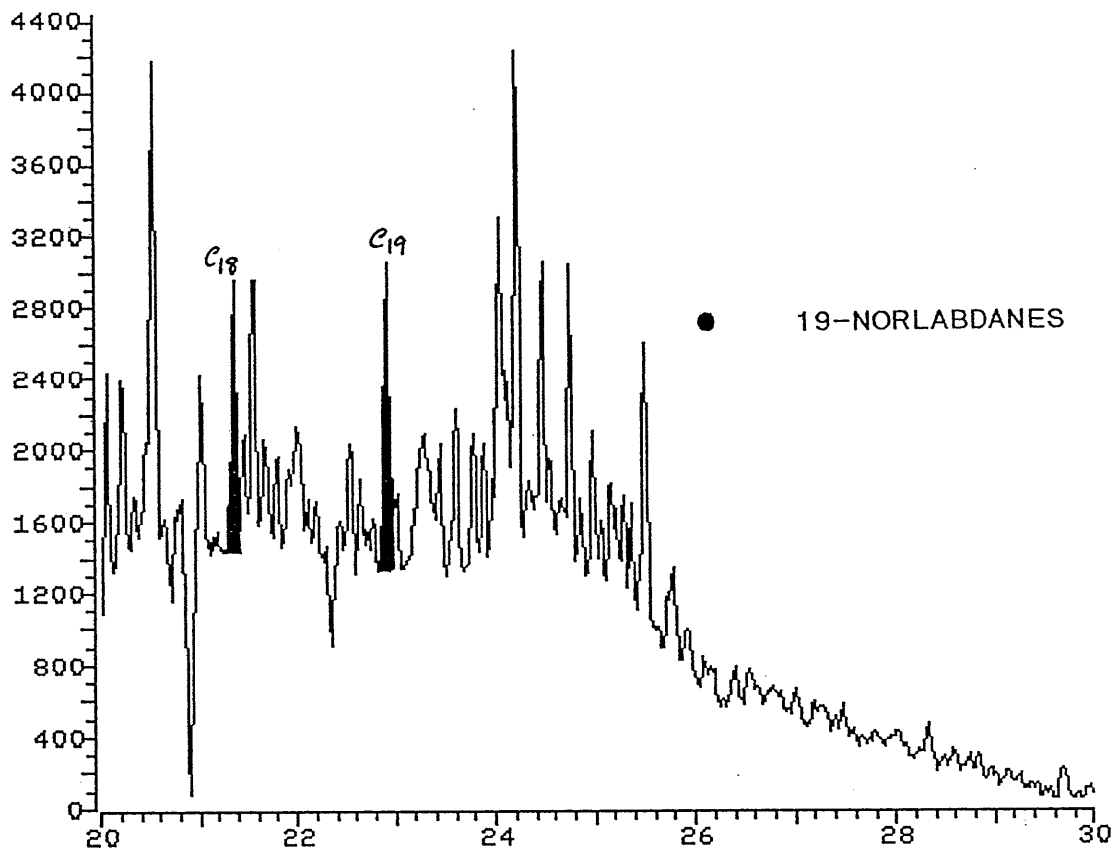SMT

STERANES

C_{21}
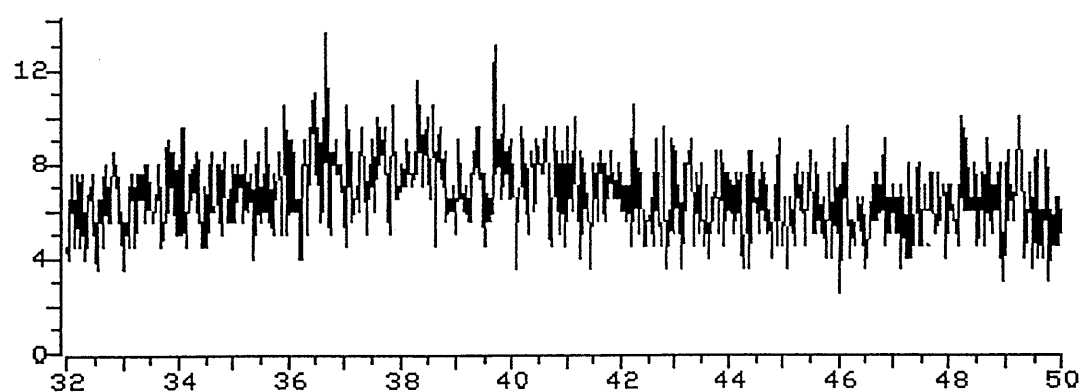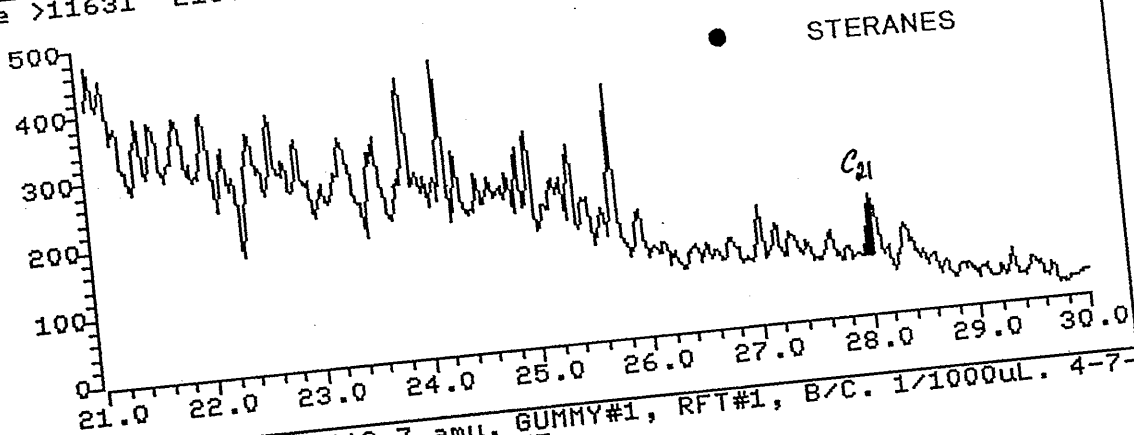
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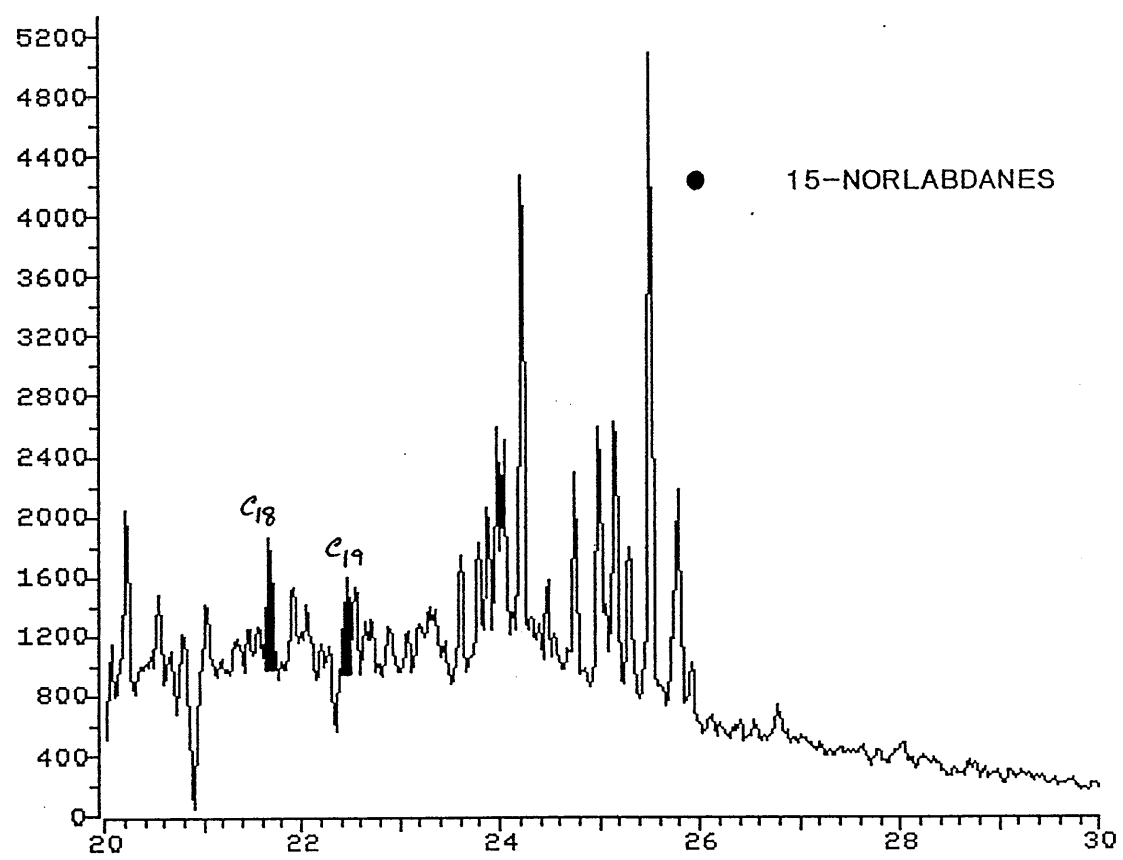SMT
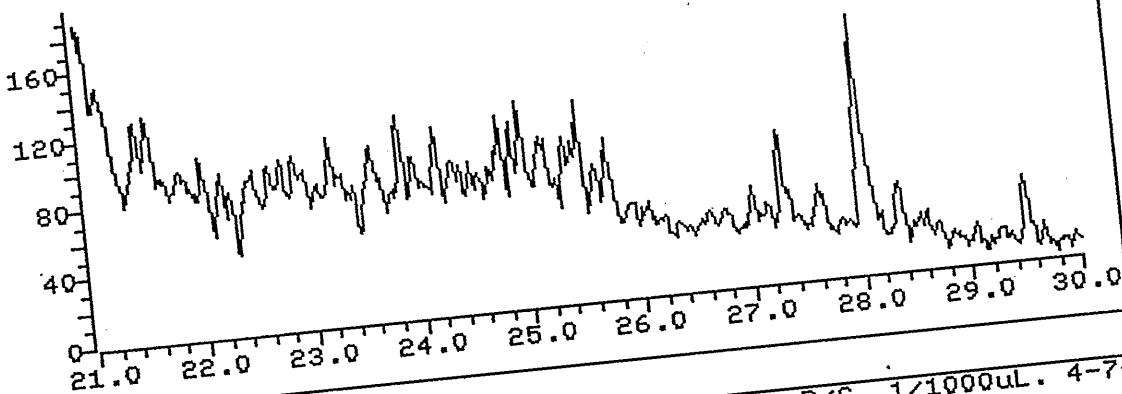
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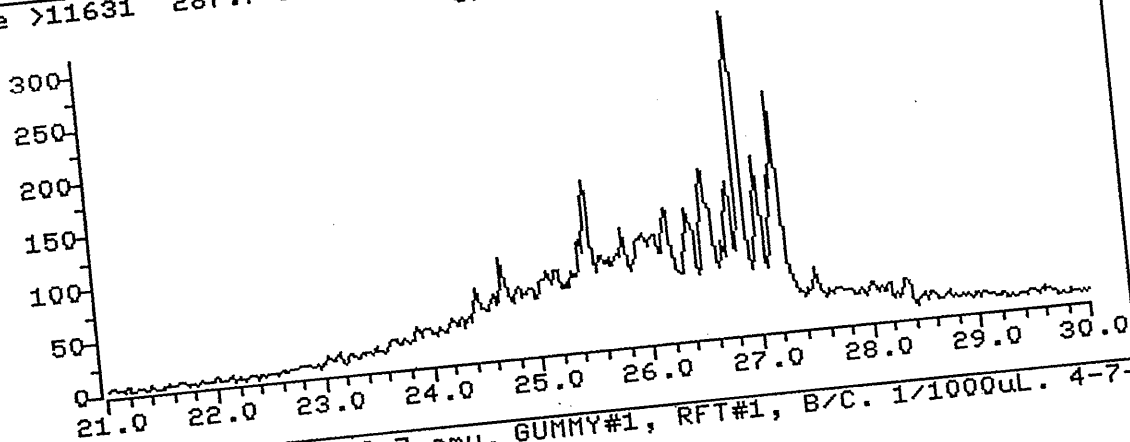
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SMT

File >11631   82.7-83.7 amu.   GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

ALKYLCYCLOHEXANES

C_{15}

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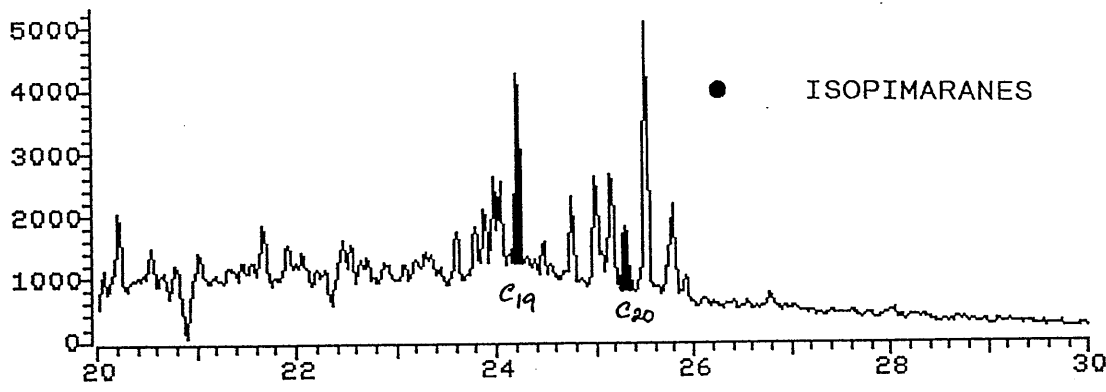
ISOPRENOIDS

Pr

Ph
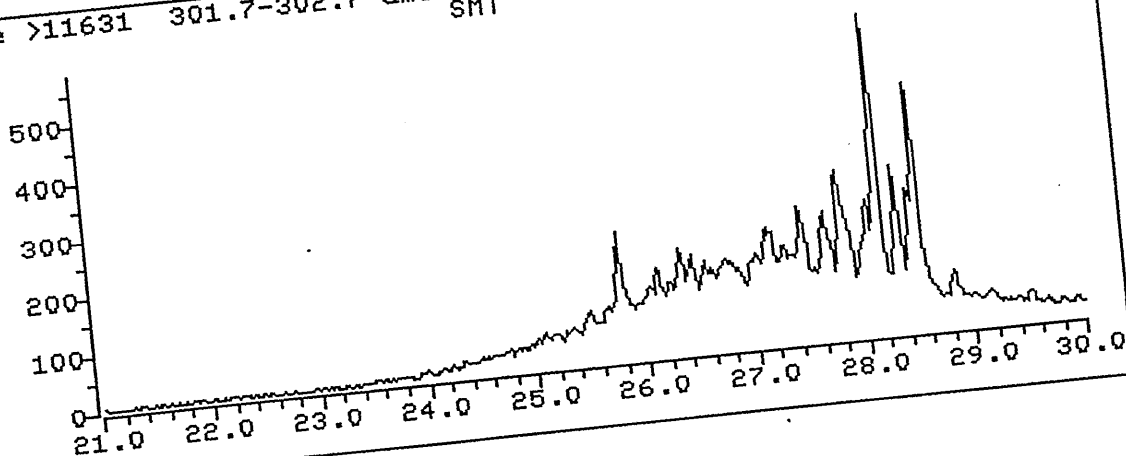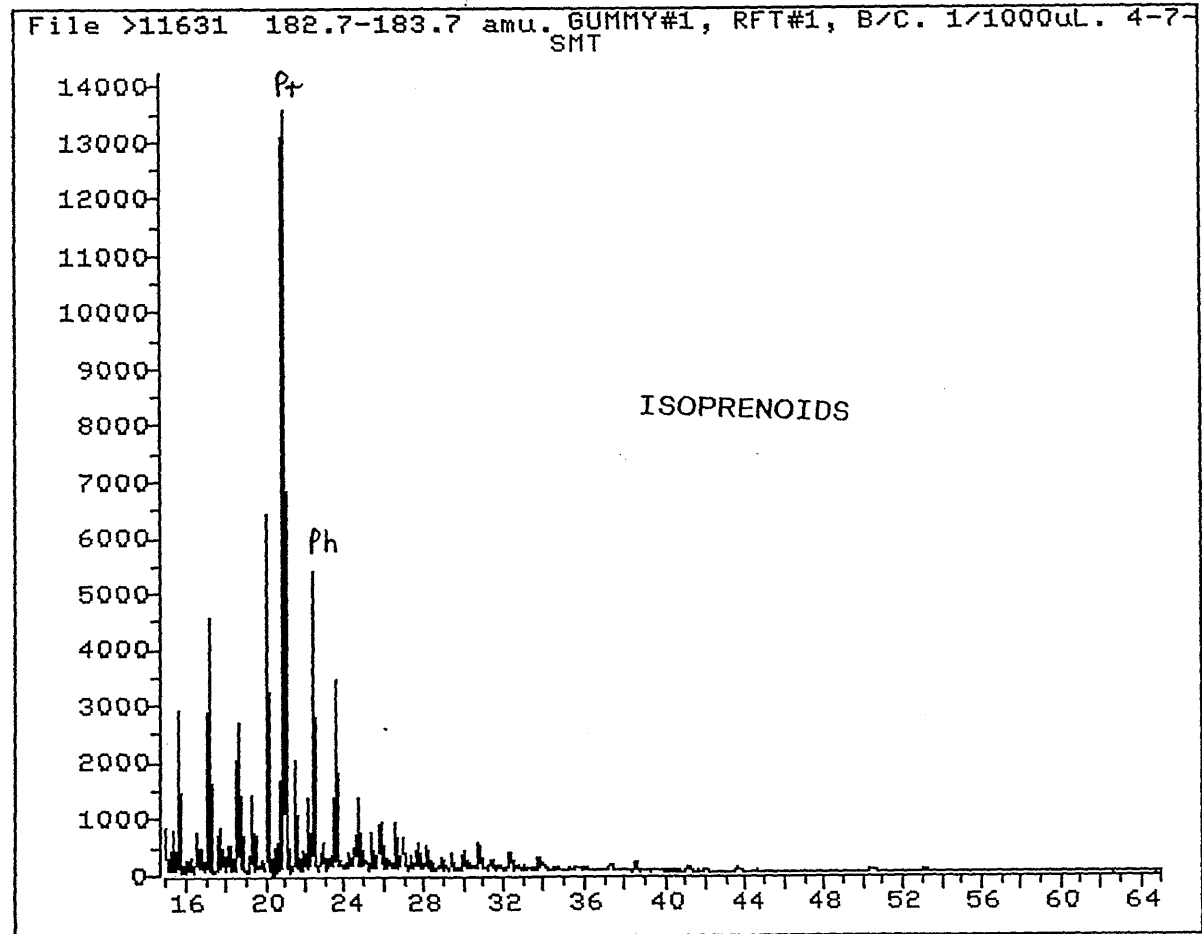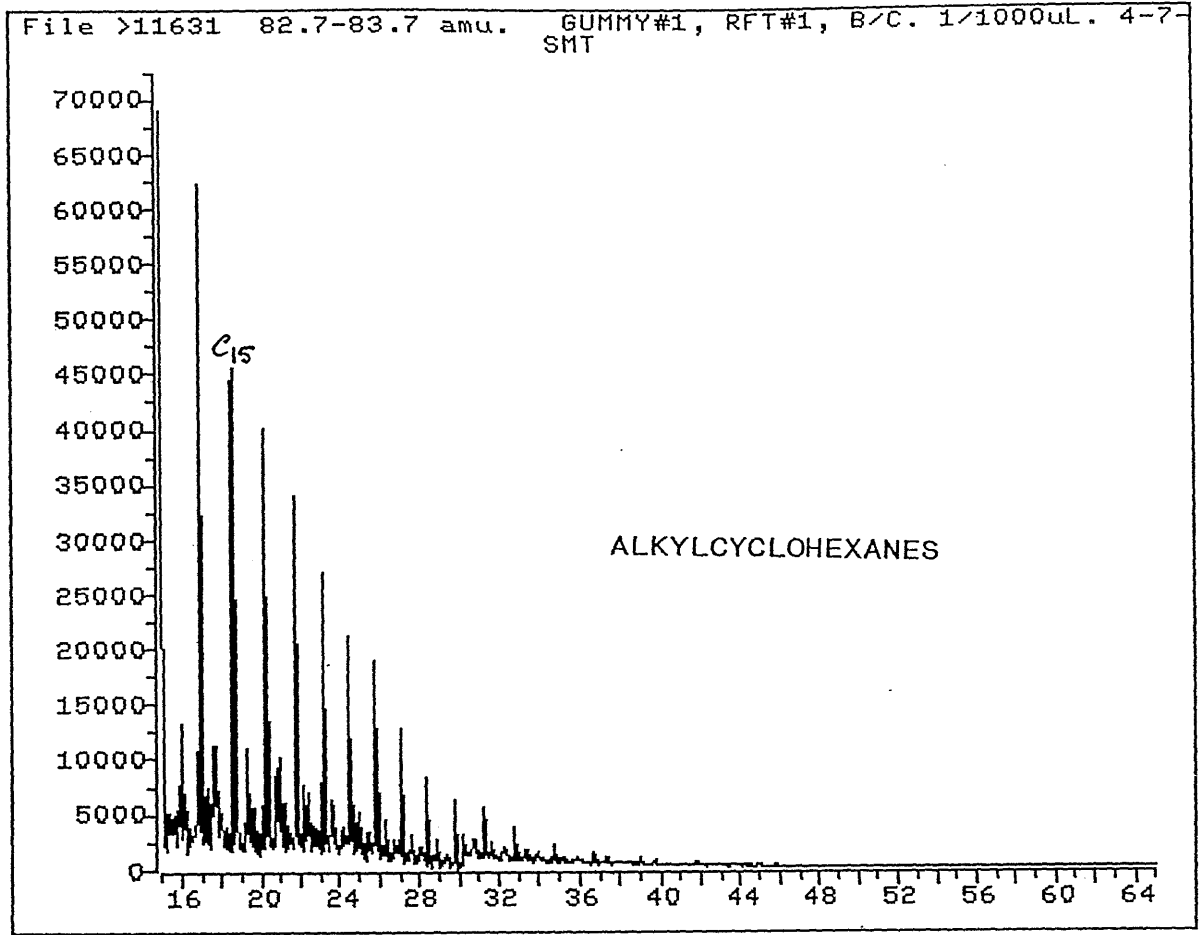
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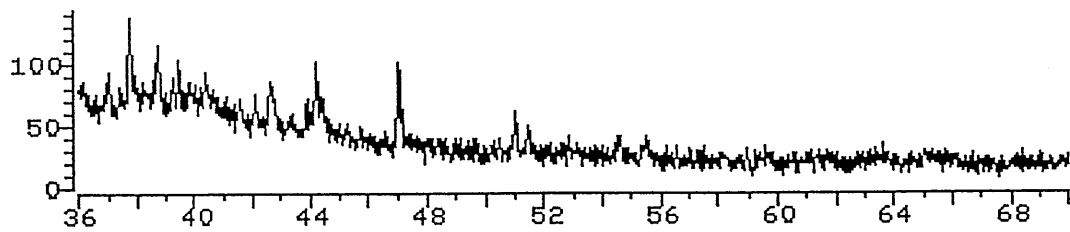
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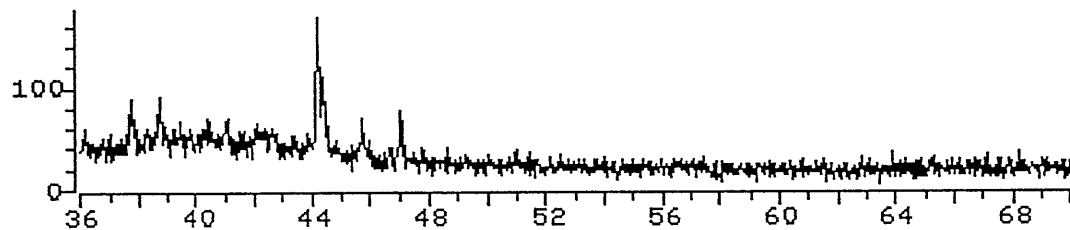
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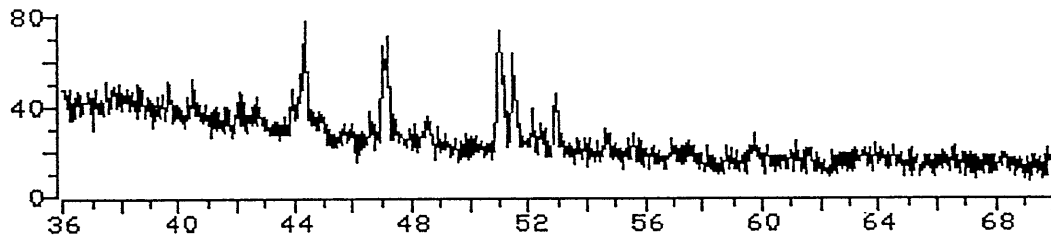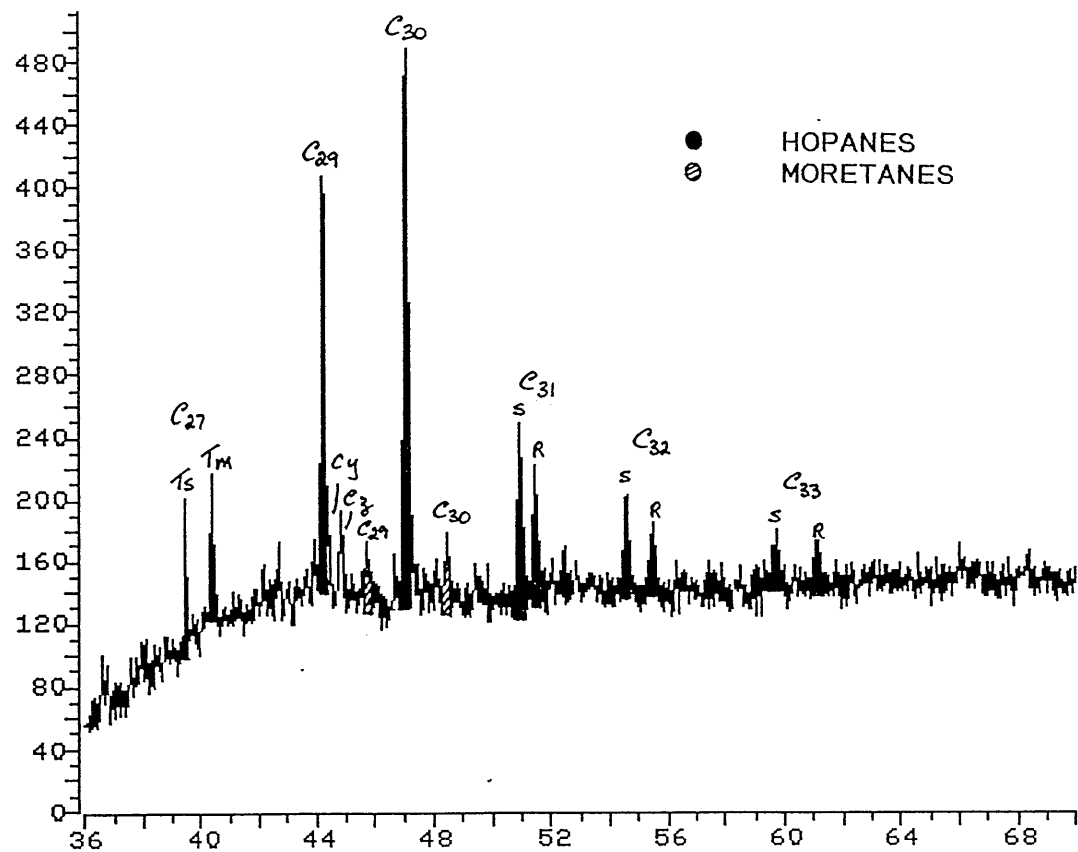
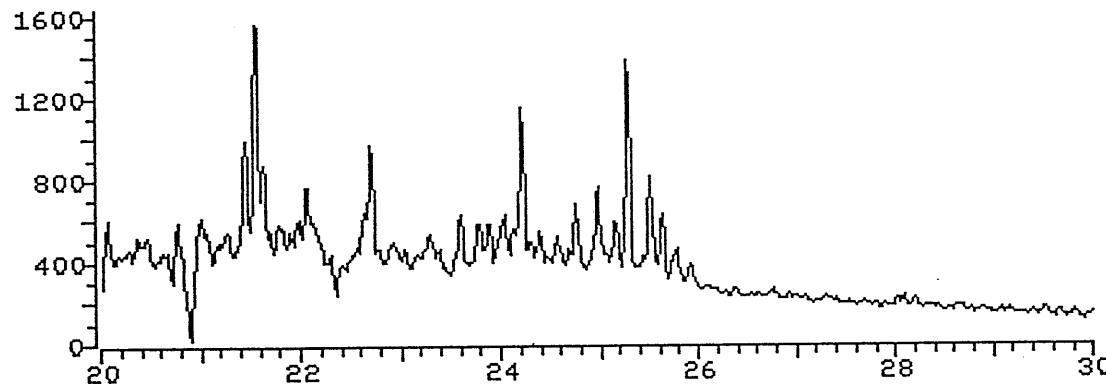File >11631   190.7-191.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

● HOPANES
Ө MORETANES

File >11631   258.7-259.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT
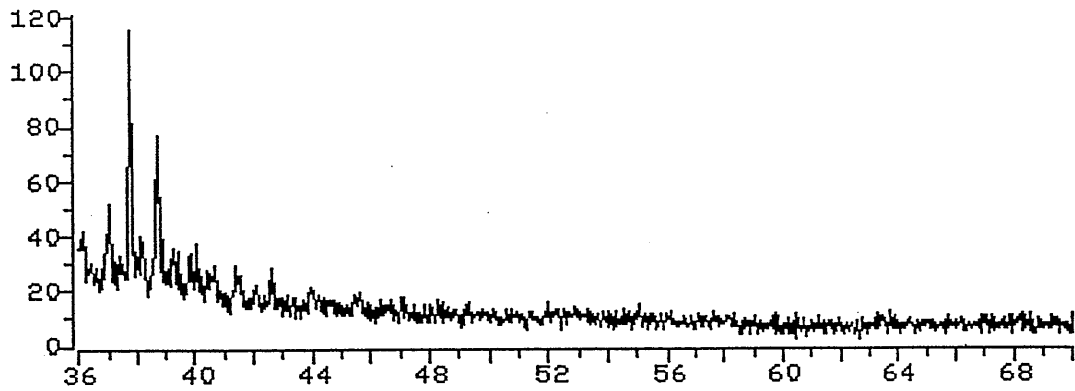
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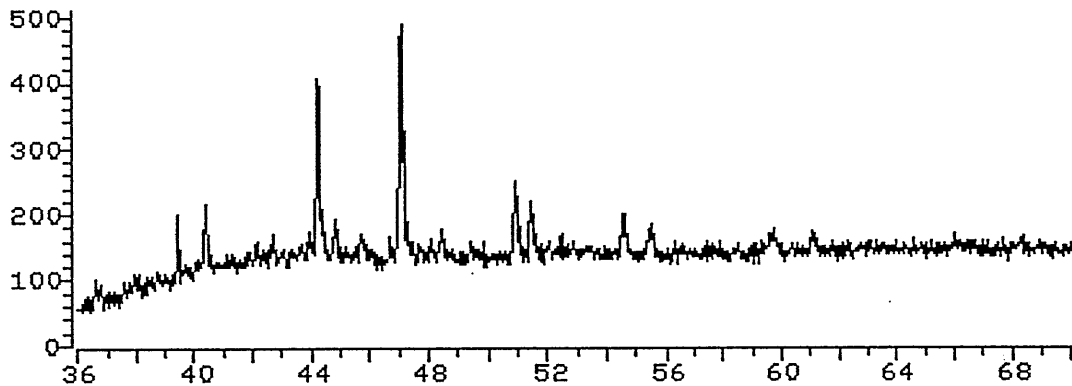
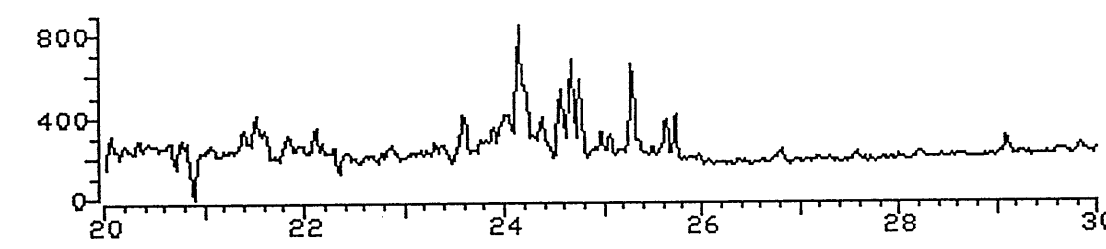File >11631   369.7-370.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT
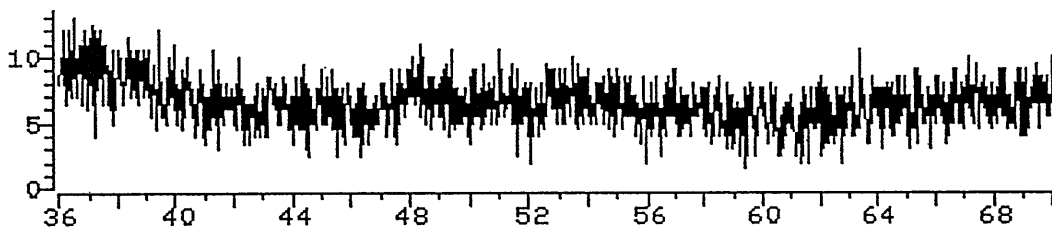
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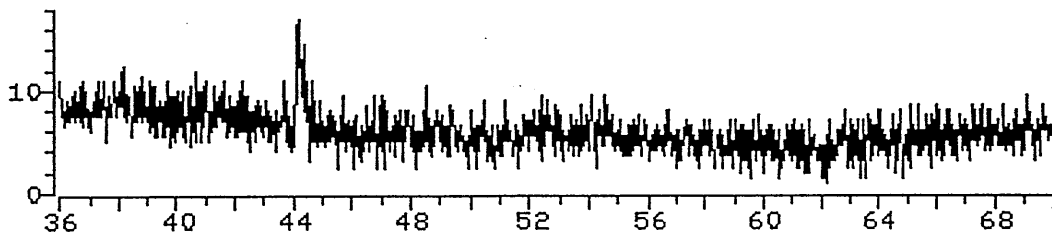
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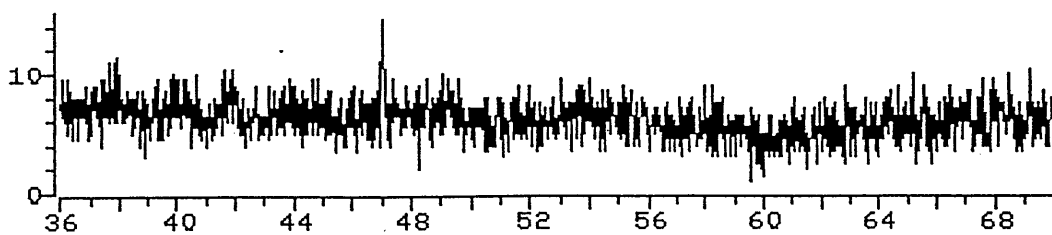
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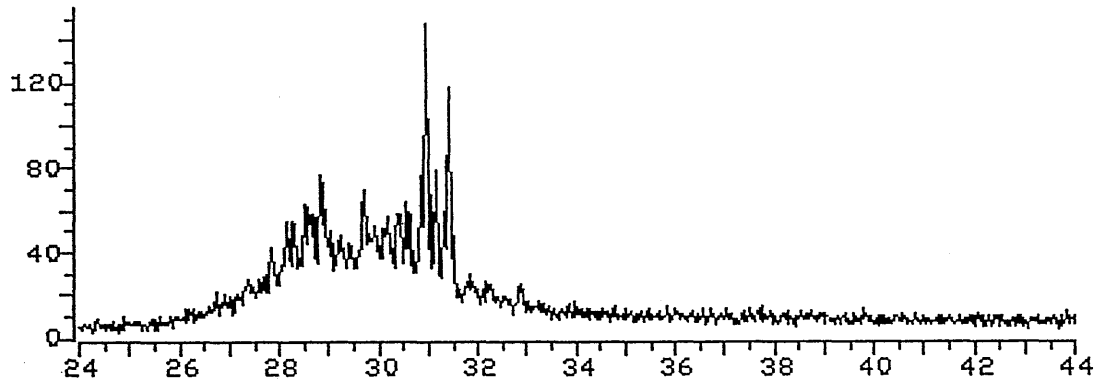
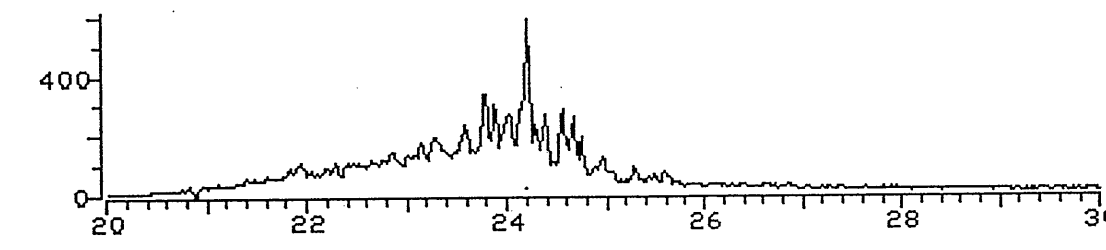File >11631   162.7-163.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT
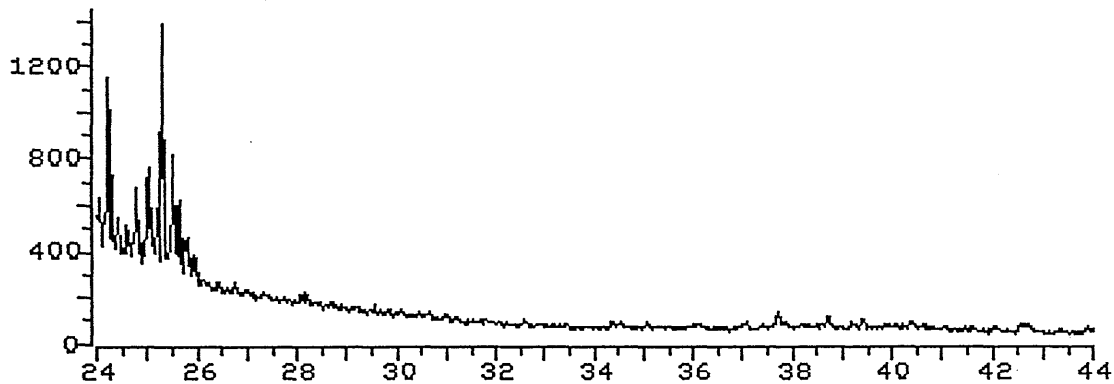
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⊘   HOMOLOGOUS TETRACYCLIC TERPANES

C_{24} Ts   Tm
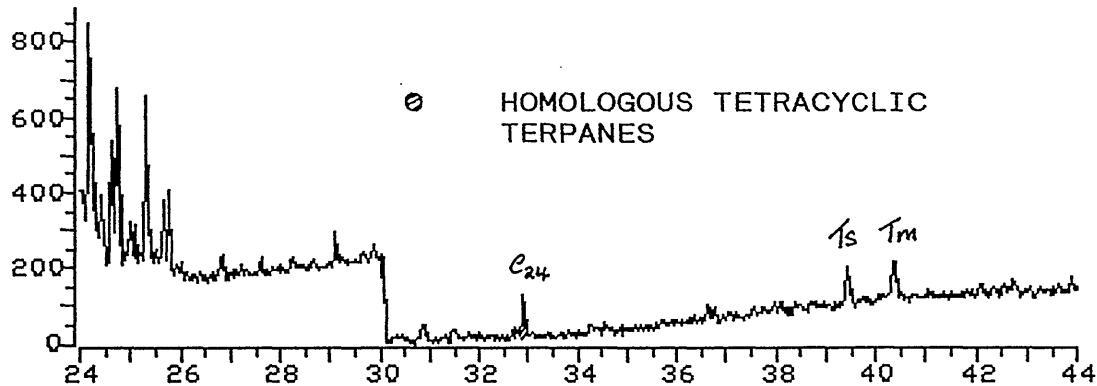
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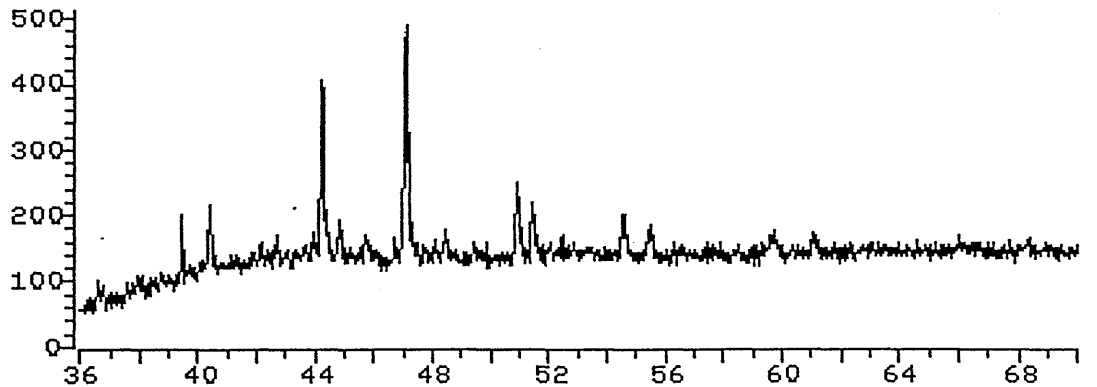
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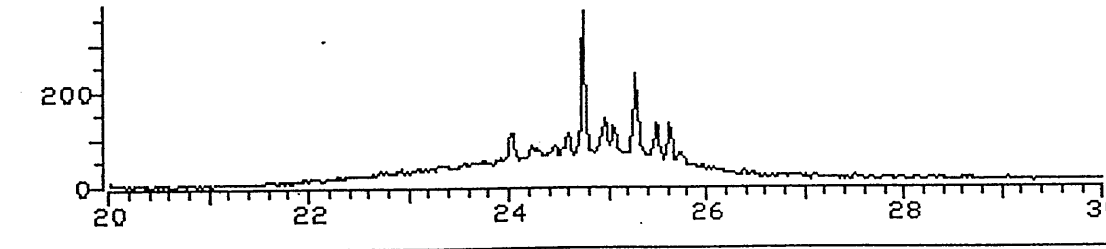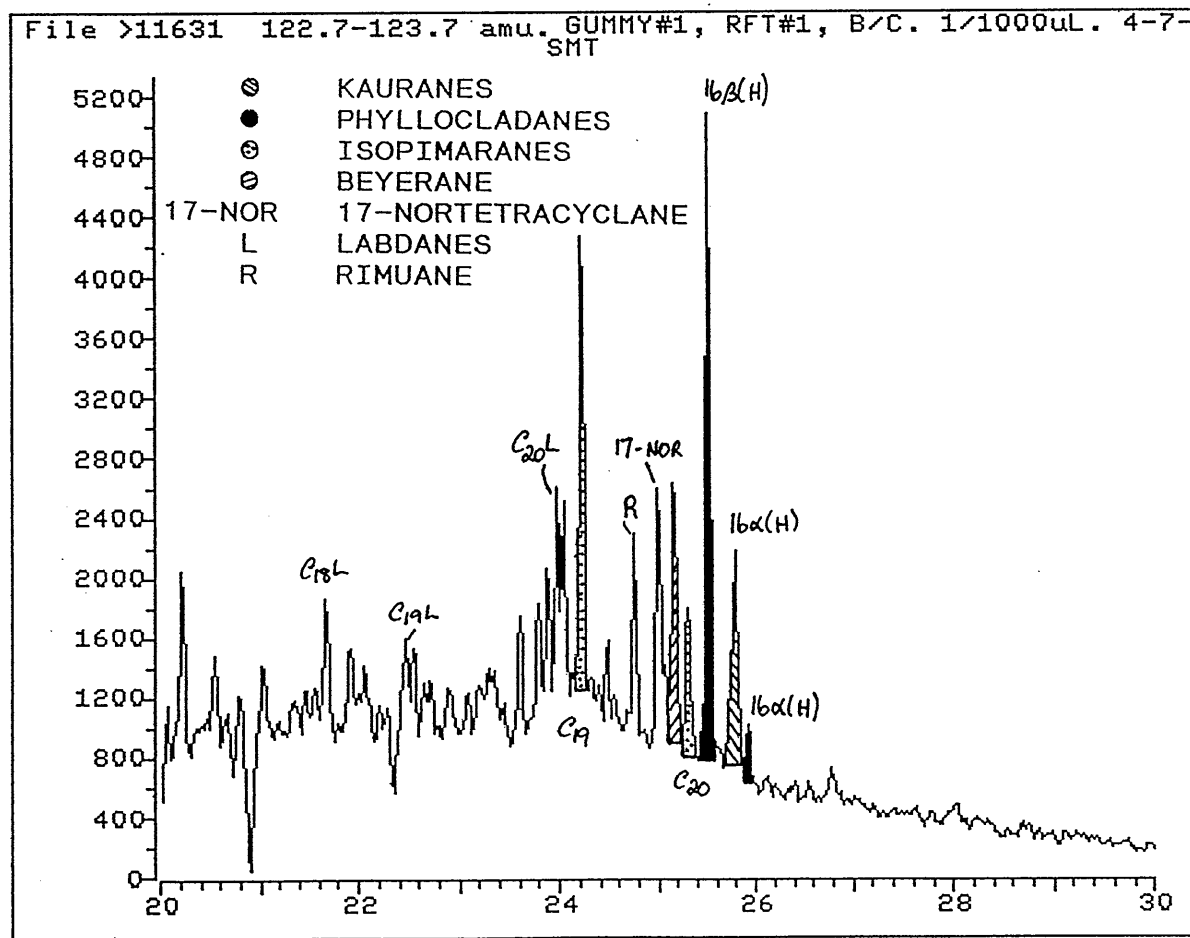File >11631   164.7-165.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

File >11631   122.7-123.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-

C_{16}

⊗   DRIMANES
●   REARRANGED DRIMANES

C_{15}

C_{15}

C_{15}

File >11631   108.7-109.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

File >11631   122.7-123.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

File >11631   148.7-149.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

File >11631   249.7-250.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

File >11631   263.7-264.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

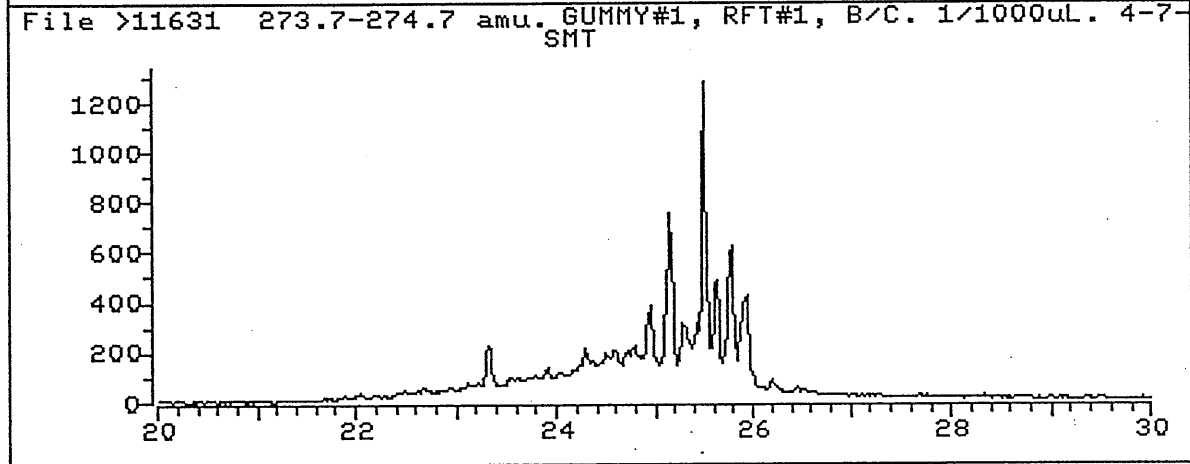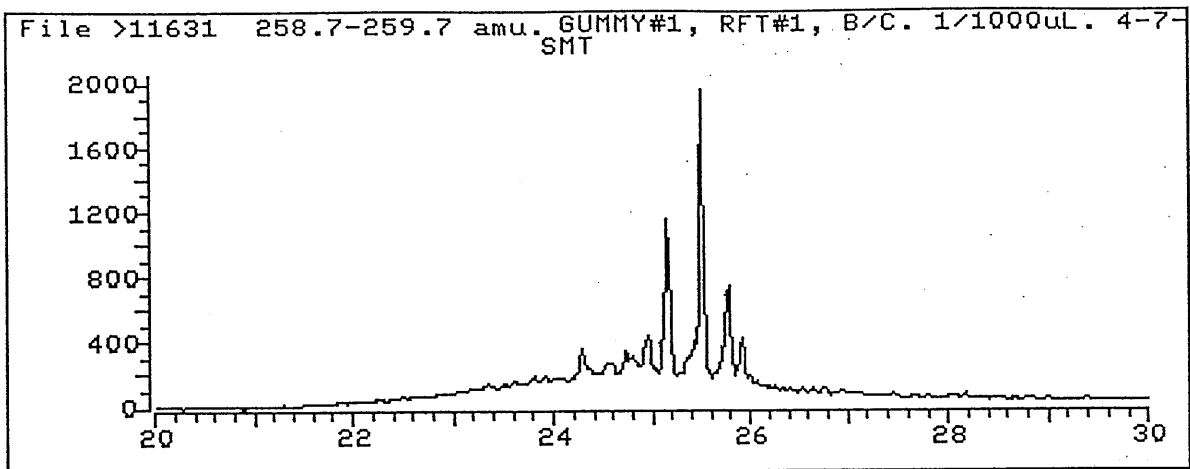File >11631   277.7-278.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-
SMT

File >11631   108.7-109.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

C_{18} C_{19}

● 19-NORLABDANES

File >11631   122.7-123.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

C_{18} C_{19}

● 15-NORLABDANES

File >11631   122.7-123.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

● ISOPIMARANES

C_{19} C_{20}

File >11631   162.7-163.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

File >11631   190.7-191.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

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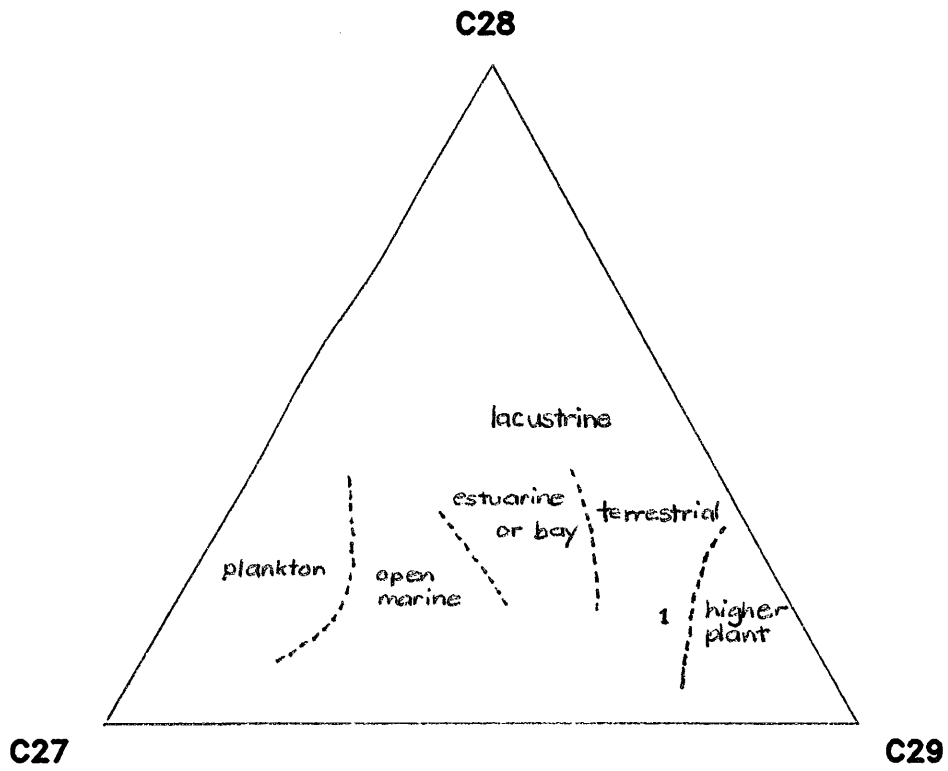File >11631   275.7-276.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

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File >11631   273.7-274.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

File >11631   122.7-123.7 amu. GUMMY#1, RFT#1, B/C. 1/1000uL. 4-7-SMT

⊘   KAURANES
●   PHYLLOCLADANES
⊕   ISOPIMARANES
⊘   BEYERANE
17-NOR   17-NORTETRACYCLANE
L   LABDANES
R   RIMUANE

FIGURE 3

RELATIONSHIP BETWEEN STEROL CARBON NUMBER AND ECOSYSTEM
(AFTER HUANG AND MEINSCHEIN, 1979)

GUMMY 1, RFT 1

FIGURE 4

ILLUSTRATION OF OXIC/ANOXIC CONDITIONS DURING SEDIMENTATION
(PR/PH) VERSUS THE TYPE OF
ORGANIC MATTER (C27/C29 20R$\alpha\alpha$STERANES)

GUMMY 1,RFT 1
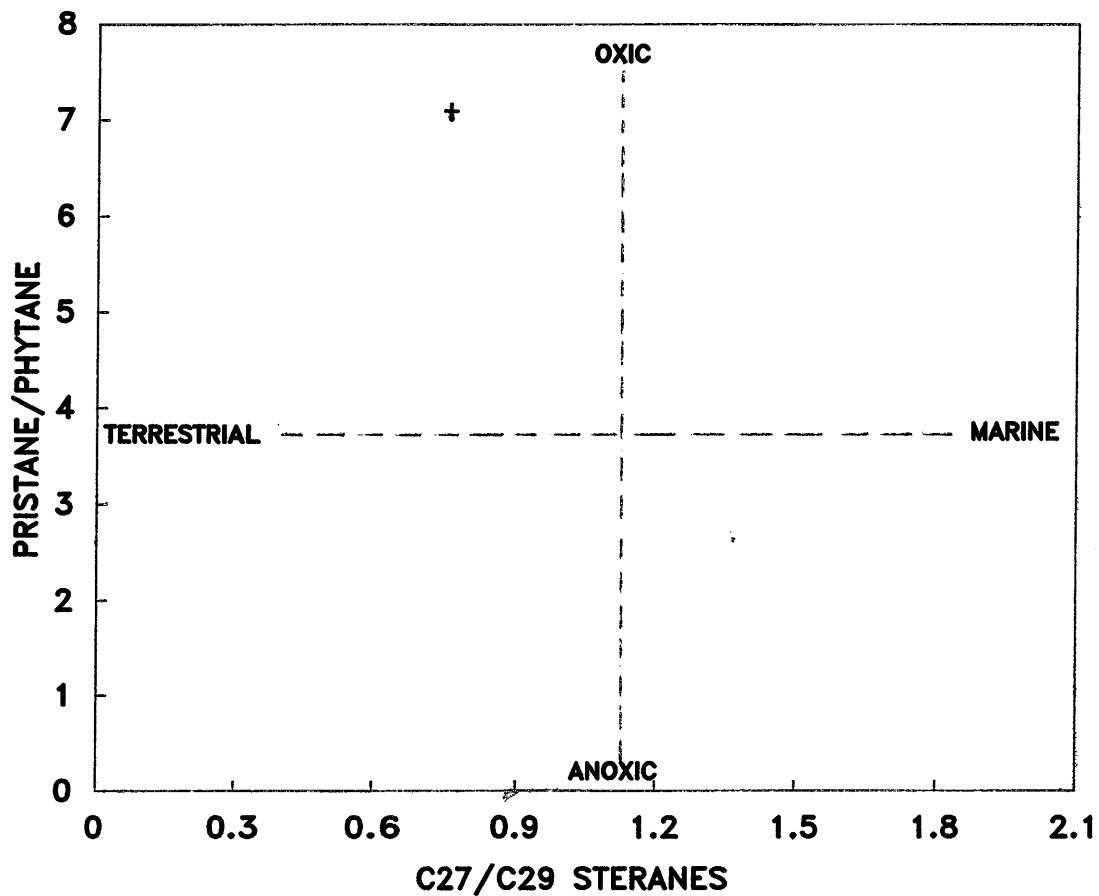
ANALABS—OIL & GAS

THEORY AND METHODS

This section details a series of geochemical methods which are commonly used in our laboratory, including those used to obtain the data presented in this report. Where applicable, the discussion is accompanied by a summary of the general theory used to interpret the data generated by each method.

1. SEDIMENTARY GAS ANALYSIS

a) Headspace Analysis
Headspace analysis is carried out using sealed containers (usually tinned cans) of wet cuttings. The containers are approximately three quarters filled with the cuttings and water to leave an appreciable headspace into which volatile hydrocarbons contained in the cuttings diffuse.

After covering about 1cm2 of the container lid with silicone and allowing the silicone to dry, the procedure involves placing a small hole in the lid through the silicone, then sampling an aliquot of the headspace gas with a gas injection syringe, and finally gas chromatographing this sample of gas under the following conditions: instrument = Shimadzu GC-8APF; column = 6' x 1/8" Chromosorb 102; column temperature = 110 Deg. C; carrier gas = nitrogen at 23mls/min; injector temperature = 120 Deg. C.; analysis cycle = C1-C4 components are flushed from the column in the forward direction and then the C5-C7 compounds are removed from the column by backflushing.

The integrated areas of peaks representing each of the C1-C7 components of the headspace gas are compared to the areas of corresponding components of a standard gas of known composition. The calculated amount of each component in the sample gas is adjusted for the total headspace volume and reported as ppm (parts of gas per million parts of sediment by volume).

Data from headspace analysis is commonly used to identify the zone of oil generation by plotting gas wetness (C2-C4/C1-C4) expressed as a % against sediment burial depth. Gas containing appreciable quantities of C2-C4 components, termed wet gas (Fuex, 1977), is generally considered to be gas associated with oil generation. In addition, the ratio of isomeric butanes can sometimes be used for assessment of sediment maturity (Alexander et. al., 1981). The amount of gas in sediments can be used to identify zones of significant gas generation and out-of-place gas (LeTran et. al., 1975).

b) Cuttings Gas Analysis
This analysis is the same as Headspace Analysis with the exception that instead of analysing the gas in the container headspace, a known volume of the wet cuttings are transferred to the blender bowl of a Kenwood electronic blender with the lid modified to incorporate a septum, water at 75 Deg. C is added to leave a headspace of 160ml, and the mixture is blended at maximum speed for 2 minutes. Following a 2 minute settling period 1ml of the blending bowl headspace gas is analysed as described in section 1a.

It is recommended that for the most meaningful gas data both headspace and cuttings gas analysis are carried out. In such cases we provide tabulations of the headspace, gas, and combined headspace/cuttings gas data. Normally, the combined data is used for plotting purposes.

2.   SAMPLE PREPARATION

a)   Cuttings
     Cuttings samples are inspected by our qualified geological staff and then water
     washed according to the drilling mud content and lithology. In special cases (e.g.
     diesel contamination) it is necessary to lightly solvent wash samples. After
     washing, the samples are air dried, either sieved or picked free of cavings, and
     crushed to 0.1mm using a ring pulveriser.

b)   Sidewall Cores
     Sidewall samples are freed of mud cake and any other visible contaminants, and are
     also inspected for lithologic homogeneity. For homogeneous samples, the minimum
     amount of material required for the requested analyses is air dried and handcrushed
     to 0.1mm. For non-homogeneous samples, the whole sample is air dried and handcrushed
     to 0.1mm.

c)   Conventional Core and Outcrop Samples
     These sample types are firstly inspected for visible contaminants, and where
     applicable, are freed of these contaminants to the best of our ability. Commonly,
     the surface of conventional core and outcrop samples are lightly solvent washed. The
     samples are then crushed to approximately 1/8" chips using a jaw crusher, air dried,
     and finally further crushed to 0.1mm using a ring pulveriser.

d)   Petroleum/Aqueous Mixtures
     The most common sample type in this category are RFT tests containing oil, water and
     mud. The mixture is placed in a separation funnel and allowed to stand for several
     hours which enables the petroleum and water/mud fractions to separate. The neat
     petroleum is isolated by removal of the lower layer (water/mud) from the funnel. To
     remove the last traces of water and mud, the neat petroleum is centrifuged at
     moderate speed.

     When the volume of petroleum accounts for only a very small part of the sample the
     method above is unsatisfactory and the petroleum is solvent extracted from the
     mixture with dichloromethane. The petroleum is recovered by careful evaporation of
     the solvent from the organic layer.

3.   TOTAL ORGANIC CARBON DETERMINATION

     The total organic carbon value (TOC) is determined on the unextracted sediment
     sample. The value is determined by treating a known weight of sediment with hot
     dilute HCl for 1 hour to remove carbonate minerals, and then heating the residue to
     1700 Deg. C (Leco Induction Furnace CS-044) in an atmosphere of pure oxygen. The
     carbon dioxide produced is transferred to an infra-red detector which has been
     calibrated with a series of standards, and the microprocessor of the Leco unit then
     automatically calculates the % TOC in the sample. To ensure reliable data a standard
     is run after every 10 samples, regular sample repeats are carried out, and at least
     one blank determination is carried out for each batch of samples.

     The following scales are normally used for source rock classification based on % TOC
     data:

Classification	Clastics	Carbonates
Poor	0.00 – 0.50	0.00 – 0.25
Fair	0.50 – 1.00	0.25 – 0.50
Good	1.00 – 2.00	0.50 – 1.00
Very Good	2.00 – 4.00	1.00 – 2.00
Excellent	> 4.00	> 2.00

4. ROCK-EVAL PYROLYSIS

Although a preliminary source rock classification is made using TOC data a more accurate assessment accounting for organic source type and maturity is made by pyrolysis analysis. Two types of Rock-Eval pyrolysis services are offered: "one run" which involves pyrolysis of the crushed but otherwise untreated sediment and "two run" which involves pyrolysis of both the crushed, untreated sediment and sediment which has been rendered free of carbonate minerals by treatment with hot dilute HCl. The two run service offers considerably more reliable S3 data.

The method involves accurately weighing approximately 100mg of the sample into a sintered steel crucible and subjecting it to the following pyrolysis cycle:

Stage (i)   –   Sample purged with helium for 3.5 minutes in unheated part of pyrolysis furnace;

Stage (ii)   –   Sample heated at 300 Deg. C for 3 minutes to liberate free petroleum (S1 peak);

Stage (iii) –   Sample heated from 300 Deg. C to 550 Deg. C at 25 Deg. C/minute to produce petroleum from kerogen (S2 peak). The furnace is maintained at 550 Deg. C for one minute. Carbon dioxide produced during this pyrolysis up to 390 Deg. C in the case of "one run" and 550 Deg. C for "two run" is absorbed on a molecular sieve trap;

Stage (iv)   –   During the cool down period the carbon dioxide produced during pyrolysis is measured (S3 peak).

The units used for Rock-Eval data are as follows:

S1, S2, S3   =   kg/tonne or mg/g of rock

Tmax   =   Deg. C

Hydrogen Index = $\dfrac{S2}{TOC}$ x $\dfrac{100}{1}$

Oxygen Index = $\dfrac{S3}{TOC}$ x $\dfrac{100}{1}$

Rock-Eval data is most commonly used in the following manner:

(i) S1   –   indicates the level of oil and or/gas already generated by the sample according to the following scale:

S1 (mg/g or kg/tonne)	Classification
0.00 - 0.20	Poor
0.20 - 0.40	Fair
0.40 - 0.80	Good
0.80 - 1.60	Very Good
> 1.60	Excellent

(ii) S1+S2   -   referred to as the genetic potential this parameter is used for source rock classification according to the following criteria:

S1+S2 (mg/g or kg/tonne)	Classification
0.00 - 1.00	Poor
1.00 - 2.00	Marginal
2.00 - 6.00	Moderate
6.00 - 10.00	Good
10.00 - 20.00	Very Good
> 20.00	Excellent

(iii) S1/(S1+S2)- this parameter is the production index (PI) which is a measure of the level of maturity of the sample. For oil prone sediments, values less than 0.1 are indicative of immaturity, the values increase from 0.1 to 0.4 over the oil window and values greater than 0.4 represent over maturity. For gas prone sediments, the PI data shows a relatively smaller change with increasing maturity.

(iv) Tmax   -   the temperature corresponding to the S2 maxima. This temperature increases with increasingly mature sediments. Values less than 430 Deg. C are indicative of immaturity while values from 430/435 to 460 Deg. C represent the maturity range of the oil window. Tmax values greater than 460 Deg. C are indicative of over maturity.

(v) HI, OI   -   the hydrogen ((S2 x 100)/TOC) and oxygen ((S3 x 100)/TOC) indices when plotted against one another provide information about the type of kerogen contained in the sample and the maturity of the sample. Both parameters decrease in value with increasing maturity. Samples with large HI and low OI are dominantly oil prone and conversely samples with low HI and large OI are at best gas prone.

5.   EXTRACTION OF SEDIMENT SAMPLES

Crushed sediment (maximum of 250g) and 300mls of purified dichloromethane are placed in a 500ml conical flask and are then blended for ten minutes with a Janke and Kunkel Ultra-Turrax T45/2G high efficiency disperser. After a ten minute settling period the solvent is separated from the sediment using a large Buchner filtration system. The extract is recovered by careful evaporation of the solvent on a steam bath and weighed. The weight of extract is used to calculate % EOM and ppm EOM using the following formulae:

$$\% \text{ EOM} = \frac{\text{Wt} \quad \text{EOM}}{\text{Wt Sediment Extracted (g)}} \times \frac{100}{1}$$

$$\text{ppm EOM} = \frac{\text{Wt} \quad \text{EOM (mg)}}{\text{Wt Sediment Extracted (kg)}}$$

The following scale is used to classify the source rock richness of samples based on C12+ extractables:

Classification	ppm Total Extract
Poor	0 - 500
Fair	500 - 1000
Good	1000 - 2000
Very Good	2000 - 4000
Excellent	> 4000

6. SEPARATION OF PETROLEUM INTO CONSTITUENT FRACTIONS

Sediment extracts and crude oil or condensate samples are separated into saturate, aromatic and NSO (asphaltenes plus resins) fractions by medium pressure liquid chromatography (MPLC). That part of the petroleum which is soluble in pentane is applied to the MPLC system via a sample loop and is then pumped using pentane to a partially activated silicic acid pre-column which prevents further movement of the non-hydrocarbon compounds. The hydrocarbon components are pumped further to a Merck Si60 column where the saturate fraction is obtained by forward flushing and the aromatic fraction is recovered by reverse flushing. This separation procedure is monitored using a refractive index detector. To complete the separation the pre-column is removed from the MPLC system and flushed with dichloromethane: methanol (1:10). This non-hydrocarbon fraction is combined with the pentane insoluble material which is not applied to the MPLC system, and is labelled as the NSO fraction. The neat fractions are recovered by careful removal of the solvent by distillation and are weighed.

The weight of each fraction is used to calculate the % of each fraction in the sediment according to the following formulas:

$$\% \text{ Fraction} = \frac{\text{Wt Fraction}}{\text{Wt all Fractions}} \times \frac{100}{1}$$

$$\text{ppm Fraction} = \frac{\text{Wt Fraction (mg)}}{\text{Wt Sediment Extracted (kg)}}$$

The ppm hydrocarbon (saturates and aromatics) and ppm saturate values can be used to classify source rock richness and oil source potential respectively according to the following criteria:

v

Classification	ppm Hydrocarbon	ppm Saturates
Poor	0 – 300	0 – 200
Fair	300 – 600	200 – 400
Good	600 – 1200	400 – 800
Very Good	1200 – 2400	800 – 1600
Excellent	> 2400	> 1600

The composition of the extracts can also provide information about their levels of maturity and/or source type (LeTran et. al., 1974; Philippi, 1974). Generally, marine extracts have relatively low concentrations of saturated and NSO compounds at low levels of maturity, but these concentrations increase with increased maturation. Terrestrially derived organic matter often has a low level of saturates and large amount of aromatic and NSO compounds irrespective of the level of maturity.

N.B.   If requested by a client the NSO fraction is separated into asphaltenes and resins by conventional methods.

7.   EXTRACTABLE/TOTAL ORGANIC CARBON RATIOS

The ratios of EOM(mg)/TOC(g) and SAT(mg)/TOC(g) are determined from the appropriate data. The EOM(mg)/TOC(g) ratio can be used as a maturation indicator, especially if the parameter is plotted against depth for a given sedimentary sequence. In an absolute sense it is less reliable as a maturation indicator, although previous work (Tissot et. al., 1971; LeTran et. al., 1974) suggests that the following criteria can be used to determine maturity with this parameter.

$$< \ 50 \qquad \text{Low maturity}$$
$$50 - 100 \qquad \text{Moderate maturity}$$
$$> 100 \qquad \text{High maturity}$$

The ratios of EOM(mg)/TOC(g) and SAT(mg)/TOC(g) can be used collectively to provide information about source type. For example, if SOM(mg)/TOC(g) is > 100, suggesting a high level of maturity, but the SAT(mg)/TOC(g) < 20 it is very likely that the organic matter is gas prone. Conversely, the same EOM(mg)/TOC(g) value with a SAT(mg)/TOC(g) value > 40 suggests oil prone source type.

8.   PYROLYSIS GAS CHROMATOGRAPHY

Pyrolysis-gas chromatography (PGC) incorporates a Chemical Data System Pyroprope 150 flash pyrolysis unit interfaced with a capillary gas chromatograph. A sample (5-10mg) of extracted sediment is placed in a quartz tube inside the element coil of the pyrolysis probe and is then heated to 610 Deg. C in a few milliseconds, and is maintained at this temperature for 20 seconds. Products generated from the pyrolysis are swept onto the bonded phase capillary column of the gas chromatograph and are chromatographed from −20 Deg. C (isothermal for two minutes) to 280 Deg. C at 4 Deg. C/minute. The product distribution is dominated by the nature of the kerogen from which it is derived.

9.   C12+ GAS CHROMATOGRAPHY

C12+ gas chromatography is commonly carried out on the saturate fraction but in certain instances is carried out on neat oil, condensate or extract. The analysis is carried out under the following conditions: instrument = Shimadzu GC-9A;   column = 50m x 0.2mm ID OV101 vitreous silica;   column temperature = programmed from 60 Deg. C

to 280 Deg. C at 4 Deg. C/min; injection system = Grob splitless using a 30 second dump time and split ratio of 25:1, carrier gas = hydrogen at 2mls/min; sample = 1µ 1 of 0.5% soln in pentane.

The following information is commonly obtained from C12+ gas chromatographic analysis:

(a)   n-Alkane Distribution - The C12-C31 n-alkane distribution is determined from the area under peaks representing each of these n-alkanes. This distribution can yield information about both the level of maturity and the source type (LeTran et. al., 1974).

(b)   Carbon Preference Index - Two values are determined:

$$CPI\ (1)\ =\ \frac{(C23 + C25 + C27 + C29)\ Wt\% + (C25 + C27 + C29 + C31)\ Wt\%}{2 \times (C24 + C26 + C28 + C30)\ Wt\%}$$

$$CPI\ (2)\ =\ \frac{(C23 + C25 + C27)\ Wt\% + (C25 + C27 + C29)\ Wt\%}{2 \times (C24 + C26 + C28)\ Wt\%}$$

The CPI is believed to be a function of both the level of maturity (Cooper and Bray, 1963; Scalan and Smith, 1970) and the source type (Tissot and Welte, 1978). Marine extracts tend to have values close to 1.0 irrespective of maturity whereas values for terrestrial extracts decrease with maturity from values as high as 20 but do not usually reach a value of 1.0

(c)   (C21+C22)/(C28+C29) - This parameter provides information about the source of the organic matter (Philippi, 1974). Generally, terrestrial source material gives values <1.2 whereas a aquatic source material results in values >1.5.

(d)   Pristane/Phytane Ratio - This value was determined from the areas of peaks representing these compounds. The ratio renders information about the depositional environment according to the following scale (Powell and McKirdy, 1975):

    < 3.0   Relatively reducing depositional environment
    3.0-4.5   Reducing/oxidizing depositional environment
    >4.5   Relatively oxidizing depositional environment

(e)   Pristane/n-C17 Ratio - This ratio was determined from the areas of peaks representing these compounds. The value can provide information about both the depositional environment and the level of maturation (Lijmbach, 1975). Very immature crude oil has a pristane/n-C17 ratio >1.0, irrespective of the depositional environment. However, the following classification can be applied to mature crude oil:

    <0.5   Open water depositional environment
    0.5-1.0   Mixed depositional environment
    >1.0   Peat-swamp depositional environment

In the case of sediment extracts these values are significantly higher and the following classification is used:

<1.0	Open water depositional environment
1.0-1.5	Mixed depositional environment
>1.5	Peat-swamp depositional environment

(f) Phytane/n-C18 Ratio – This ratio was determined from the areas of peaks representing these compounds.   The value usually only provides information about the level of maturity of petroleum.   The value decreases with increased maturation.

(g) Relative Amounts of n-Alkanes and Naphthenes – Since n-alkanes and naphthenes are the two dominant classes of compounds in the saturate fraction, a semi-quantitative estimate of the relative amounts of these compounds can be made from saturate GLC's.   This information can be used to assess the degree of maturation and/or the source type of the petroleum (Philippi, 1974; Tissot and Welte, 1978). Very immature petroleum has only small proportions of n-alkanes, but as maturity increases the relative amount of n-alkanes increases.   In addition, terrestrial petroleum has a greater proportion of high molecular weight naphthenes than petroleum comprising aquatic source material.

10. API/SPECIFIC GRAVITY

A specific gravity (SG) bottle was accurately weighed, then filled with crude oil at 60 Deg. F and finally reweighed. The weight difference was divided by the weight of an equal volume of water at 60 Deg. F to obtain the specific gravity. The following formula was then used to calcuate the API gravity:

$$API\ Gravity\ =\ \left[\frac{141.5}{SG\ (60\ Deg.\ F)}\right]\ -\ 131.5$$

The reported gravity value is the average of duplicate determinations.

11. SULPHUR DETERMINATION

The % sulphur by weight is determined by dissolving 0.5g of the petroleum in 50mls kerosene and then analysing this mixture with an inductively coupled plasma (ICP) instrument which has been calibrated with a series of sulphur standards.

This parameter is influenced by the nature of the source material from which a crude is derived, the depositional environment of the source rocks, and reservoir alteration processed such as bacterial alteration.

12. C1-C31 WHOLE SAMPLE GAS CHROMATOGRAPHY

This method of analysis is normally only applied to oil or condensate samples.   The technique provides a "picture" of the sample which shows good resolution of the low, medium and high molecular weight components.   Whole sample GC data is considered to be more useful than C12+ saturate fraction GC data for oil or condensate samples.

The analysis is carried out under the same conditions as for the C12+ GC analysis with the following exceptions: column temperature = programmed from -20 Deg. C to 280 Deg. C at 4 Deg. C/min (uses cryogenic mode); injection is carried out in split mode; sample = 0.1 µl of neat petroleum.

Cl-C31 analysis data can be used to obtain the same information as that obtained from Cl2+ GC but further provides detailed compositional data on the Cl-Cll fraction and enables calculation of the distillation range of the sample.

13. MOLECULAR SIEVE EXTRACTION

This technique is used to isolate the branched/cyclic alkanes from the saturate fraction for gas chromatography/mass spectometry analysis. A mixture of saturates: 5A molecular sieves: purified benzene in the proportions 1:5:12 by weight is placed in a 100ml round bottom flask and refluxed for 24 hours. After cooling, the seives are filtered from the liquid phase and are washed with 4 x 10ml aliquots of benzene. The liquid phase plus washing are freed of benzene by distillation yielding the branched/cyclic compounds.

14. COMPUTERIZED GAS CHROMATOGRAPHY/MASS SPECTOMETRY (GC/MS)

Gas chromatography/mass spectrometry employs a capillary column gas chromatograph linked in series with a mass spectrometer and data system (GC/MS/DS). As molecules are eluted from the capillary column they are bled into the analyser tube of.the mass spectrometer where they are bombarded with high energy electrons and consequently fragment to form several ions each with molecular weights less than that of the parent molecule. The fragmentation pattern is characteristic of the particular molecular type. The spectrum of these ions (referred to as a mass spectrum) is recorded approximately once every second and all of the mass spectra recorded during a GC/MS/DS analysis are memorised by the data system. Since any given class of molecules will breakdown in the analyser type to give one or more characteristic ion fragments of known molecular weight, after a GC/MS/DS analysis it is possible to examine the distribution of compounds within a given class by having the data system reproduce a mass fragmentogram (plot of ion concentration against gas chromatography retention time) representative of the particular class.

GC/MS/DS analyses can be carried out using one of the two following modes of operation:

(i)   Acquire mode - in which all ions in each mass spectrum are memorised by the data system;

(ii) Selective ion monitoring (SIM) mode - in which only selected ions of interest are memorised by the data system.

At present the sterane/triterpane/bicyclane fraction of petroleum is considered most useful for GC/MS/DS analysis and therefore we commonly use the second of the above mentioned modes of operation and run the following twenty-two ions which are pertinent to the sterane/triterpane/bicuclane fraction.

Ion	Molecular Type
177	Demethylated triterpanes
191	Normal triterpanes
205	Methyl triterpanes
163	Specific dethylated triterpanes
356	Parent ion - C26 triterpanes
370	Parent ion - C27 triterpanes
384	Parent ion - C28 triterpanes
398	Parent ion - C29 triterpanes

412	Parent ion - C30 triterpanes
426	Parent ion - C31 triterpanes
183	Isoprenoids
217	Normal steranes
218	Normal steranes
231	4-methylsteranes
259	Diasteranes
358	Parent ion - C26 steranes
372	Parent ion - C27 steranes
386	Parent ion - C28 steranes
400	Parent ion - C29 steranes
414	Parent ion - C30 steranes

GC/MS/DS analysis of the sterane/triterpane/bicyclane fraction can often provide information about the maturity and source type of petroleum and whether it has been affected by micro-organisms. This technique is also often useful for oil:oil and oil:source rock correlation. The following sections indicate which parameters are used to obtain this information and summarize the theory behind their use.

Maturity

(i)   Based on Steranes
      (a) The biologically produced $\alpha\alpha\alpha$ (20R) sterioisomer is converted in sediment
           to a mixture of the $\alpha\alpha\alpha$ (20R) and $\alpha\alpha\alpha$ (20S) compounds.   The ratio of

$$C29 \; \frac{\alpha\alpha\alpha \;(20S)}{\alpha\alpha\alpha \;(20R)+ \;\alpha\alpha\alpha \;(20S)}$$

           expressed as a percentage is about 25% at the
           onset of oil generation and increases almost linearily to a value of about
           50% at the peak of oil generation.

(ii) Based on Triterpanes
      (a) The C31, C32, C33, C34 and C35 hopanes have the biological   R
           configuration at C22. On mild thermal maturation equilibration occurs to
           produce a 60/40 mixture of S/R. This equilibration occurs before the
           onset of oil generation.

      (b) The conversion of the biological $17\beta,21\beta$ hopanes to the corresponding
           $17\alpha,21\beta$ and $17\beta,21\alpha$ compounds is also maturation dependant. For

           C30 triterpanes the ratio of $\frac{17\beta,21\alpha}{17\alpha,21\beta}$ decreases steadily from a

           value of about 0.4 at the onset of oil generation to a value of about 0.1
           at peak oil generation.

      (c) Two of the C27 triterpanes can also be used as maturity indicators. The
           ratio of 18 α(H) trisnorhopane to 17 α(H) trisnorhopane increases
           exponentially with increasing maturity from a value of approximately 0.2
           at the onset of oil generation to approximately 1.0 at peak oil
           generation.

      (d) It is our experience that the ratio of the C27 18α(H) + C27 17α(H)
           triterpanes to C30 17α,21β triterpane is maturity dependent. The ratio
           decreased from values around 1.0 at the onset of oil generation to a value
           of approximately 0.4 at peak oil generation. With increasing maturity at
           levels greater than that equivalent to peak oil generation the ratio

increases steadily to values greater than 3.0.

Source Type

(i) Based on Steranes
Algal organic matter contains steranes in which the C27 compounds are more abundant than the C29 compounds. General aquatic organic matter has approximately equivalent amounts of the C27 and C29 compounds while organic matter rich in land-plants usually has a lot more of the C29 steranes.

(ii) Based on Triterpanes
The triterpane components in petroleum can be derived from both bacteria and higher plants. The common bacterial products are the C27-C35 hopanes and moretanes whereas the higher plant triterpanes are compounds other than hopanes or moretanes and are commonly C30 compounds.

(iii) Based on Diasteranes
The diasteranes are not produced biologically but are formed during early diagenesis from sterane precursors. The diasterane ratios

$$\frac{C27(20R)}{C29(20R)} \quad \text{and} \quad \frac{C27(20R+20S)}{C29(20R+20S)}$$

should reflect the nature of the organic matter in the same manner as that outlined above for the steranes.

Biodegradation

It has been observed that in severely biodegraded petroleum the series of normal hopanes are converted to a series of A ring demethylated hopanes and the C29 (20R) sterane is selectively removed. For altered crudes which have not been degraded to this extent the severity of biodegradation can often be gauged by studying the isoprenoid and aromatic fractions. However, this type of investigation extends beyond a standard GC/MS/DS analysis.

Correlation

Our present approach to oil:oil or oil:source rock correlation problems is as follows:

(i) Compare the distribution of compounds in the 123, 177, 191, 205, 217, 218, 231 and 259 mass fragmentograms for an oil or sediment extract to the distribution of compounds in the respective fragmentograms for the other oil(s) or sediment extract(s). It is necessary in this type of comparison to make allowance for small variations due to possible maturity differences.

(ii) Examine the fragmentograms for peaks or sets of peaks which may represent compounds that are specific to the geological system under investigation. Normal steranes, diasteranes and bacterial hopanes cannot be used for this purpose because they are present in virtually all crude oils and sediment extracts. However, compounds like higher plant triterpanes, bisnorhopane and botryococcane can often prove very useful for this purpose.

15. CARBON ISOTOPE ANALYSIS

The measurement is carried out on one or more of the following mixtures; topped oil; saturate fraction; aromatic fraction; NSO fraction. The organic matter is combusted at 860 Deg. C in oxygen and the carbon dioxide formed is purified and transferred to an isotope mass spectrometer. The carbon isotope ratio is measured relative to a standard gas of known isotopic composition. In our case the standard gas is prepared from the NBS No. 22 oil. However, since the isotopic relationship between NBS No. 22 oil and the international reference PDB limestone are known, the values are adjusted to be relative to PDB limestone.

Although carbon isotope data has been commonly used for oil:oil and oil:source rock correlation its most significant application is the identification of the source of gas according to the following criteria (Fuex, 1977):

$\delta 13C$ (PDB)	Gas Type
-85 to -58	Biogenic methane
-58 to -40	Wet gas/associated with oil
-40 to -25	Thermal methane

16. VITRINITE REFLECTANCE MEASUREMENT

Vitrinite is a coal maceral which responds to increasing levels of thermal maturity. This response can be measured by the percent of light reflected off a polished surface of a vitrinite particle immersed in oil. Reflectance measurements are made on a number (40 if possible) of vitrinite particles in each sample, in order to establish a range and mean for reflectance values. Immature rocks have low reflectance values (0.2% Ro to 0.6% Ro), with mature values ranging from 0.6% Ro to 1.2% Ro. Very mature values are between 1.2 % Ro and 1.8% Ro, while severely altered rocks have reflectances above 1.8% Ro.

Vitrinite reflectance results are best obtained from coals or rocks deposited in environments receiving large influxes of terrestrially-derived organic matter. Unfortunately, these environments are not conducive to the accumulation of large quantities of oil-prone organic mater. Also vitrinite reflectance cannot be performed on rocks older than Devonian Age, due to the absence of land plants in the older geological time periods.

17. VISUAL KEROGEN

Visual kerogen assessment is carried out by the coal petrologist and/or the palynologist. In the case of the petrologist the assessment is made in reflected light using the plug prepared for vitrinite reflectance measurement, and reports the relative amounts of alginite, exinite, vitrinite and inertinite particles.

Visual study of kerogen by the palynologist is carried out in transmitted light and can indicate the relative abundance, size and state of preservation of the various recognizable kerogen types and hence indicates the source character of a sedimentary rock. In addition, the colour of the kerogen is related to the thermal maturity of the sediments and is often used as a maturation indicator.

The preparation of slides for visual kerogen assessment by the palynologist firstly involves concentration of the organic matter by removal of the rock matrix using hydrochloric and hydrofluoric acid treatment and heavy liquid separation. The organic concentrate is then mounted on a glass slide using Petropoxy.

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APPENDIX 1

SIGNIFICANCE OF
SELECTED PARAMETERS FROM GC/MS ANALYSIS

	Parameter	Ion(s)
1.	$18\alpha(H)$-hopane/$17\alpha(H)$-hopane (Ts/Tm)	191
2.	C30 hopane/C30 moretane	191
3.	C31 22S hopane/C31 22R hopane	191
4.	C32 22S hopane/C32 22R hopane	191
5.	C29 20S $\alpha\alpha\alpha$ sterane/C29 20R $\alpha\alpha\alpha$ steranes	217
6.	C29 20S $\alpha\alpha\alpha$ /C29 20R $\alpha\alpha\alpha$ + C29 20S $\alpha\alpha\alpha$	217
7.	$\dfrac{\text{C29 } \alpha\alpha\alpha \text{ steranes}}{\text{C29 } \alpha\alpha\alpha \text{ steranes} + \text{C29 } \alpha\beta\beta \text{ steranes}}$	217
8.	C27/C29 diasteranes	259
9.	C27/C29 steranes	217
10.	$18\alpha(H)$-oleanane/C30 hopane	191
11.	$\dfrac{\text{C29 diasteranes}}{\text{C29 } \alpha\alpha\alpha \text{ steranes} + \text{C29 } \alpha\beta\beta \text{ steranes}}$	217
12.	$\dfrac{\text{C30 (hopanes + moretanes)}}{\text{C29 (steranes + diasteranes)}}$	191/217
13.	C15 drimane/C16 homodrimane	123
14.	Rearranged drimanes/normal drimanes	123
15.	C15 alkylcyclohexane/C16 homodrimane	83/123

nd = not detectable

Significance of selected parameters from GC-MS analysis

1. 18α (H)-hopane/17α (H)-hopane   (Ts/Tm)

    Maturity indicator. The ratio of 18α (H) trisnorhopane to 17α (H) trisnorhopane increases exponentially with increasing maturity from approximately 0.2 at the onset to approximately 1.0 at the peak of oil generation, i.e. Tm decreases with maturity. This parameter is not reliable in very immature samples.

2. C30 hopane/C30 moretane

    Maturity indicator. The conversion of C30 17β, 21β hopane to 17β, 21α moretane is maturity dependent. Values increase from approx. 2.5 at the onset of oil generation to approx. 10. Once the hopane/moretane ratio has reached 10, no further changes occur. A value of 10 is believed to represent a maturity stage just after the onset of oil generation, hopane/moretane ratios are therefore mainly useful as indicators of immaturity in a qualitative sense.

3.&4.C31 and C32 22S/22R hopanes

    Maturity indicator. An equilibrium between the biological R- and the geological S- configuration occurs on mild termal maturation. A ratio of S:R = 60:40, i.e. a value of 1.5 characterise this equilibrium which occurs before the onset of oil generation.

5. C29 2OS $\alpha\alpha\alpha$ /C29 2OR $\alpha\alpha\alpha$ steranes

    Maturity indicator. Upon maturation, the biologically produced 2OR stereoisomer is converted into a mixture of 2OR and 2OS compounds. An equilibrium between the two forms is reached at approximately 55% 2OR and 45% 2OS compounds. VR equivalents are approximately 0.45% for a 2OS/2OR value of 0.2 and 0.8% for a 2OS/2OR value of 0.75. This parameter is most useful between maturity ranges equivalent to 0.4% to 1.0% VR.

6. $C29\ 2OS\alpha\alpha\alpha\ /C29\ 2OR\ \alpha\alpha\alpha\ +\ C29\ 2OS\alpha\alpha\alpha$

   <u>Maturity</u> indicator. Different way of expressing the conversion from the biological 2OR to the geological 2OS configuration (see parameter 5). Expressed as a percentage, a value of about 25% indicates the onset of oil generation and of about 50% the peak of oil generation.

7. $C29\ \alpha\beta\beta/C29\ \alpha\alpha\alpha\ +\ C29\ \alpha\beta\beta$ steranes

   <u>Maturity</u> indicator. The form is produced biologically, it converts gradually into a mixture of $\alpha\alpha$ (normal steranes) and $\beta\beta$ (isosteranes) compounds upon maturation. Equilibrium is reached at about 65% $\beta\beta$ compounds, which is equivalent to approximately 0.9% VR.

8.&9. C27/C29 diasteranes and steranes

   <u>Source</u> indicator. It has been suggested that marine phytoplankton is characterised by a dominance of C27 steranes and diasteranes whereas a preponderance of C29 compounds indicates strong terrestrial contributions. (C28 compounds are nearly always the lowest of the three sterane groups. High proportions of C28 compounds could indicate a contribution from of lacustrine algae). Values smaller than 0.85 for C27/C29 diasterane and sterane ratios are believed to be indicative for terrestrial organic matter, values between 0.85 to 1.43 for mixed organic material, and values greater than 1.43 for an input of predominantly marine organic matter.

   As it has shown recently that apparently also pelagic marine sediments can contain a predominance of C29 steranes, the above rules have to be applied with caution. Any simplistic interpretation of C27/C29 steranes and diasteranes can be dangerous and the interpretation of these data should be consistent with other geological evidence.

10. $18\ \alpha\ (H)$ - oleanane/C30 hopane

   <u>Source</u> indicator. Oleanane is a triterpenoid compound which has often been reported from deltaic sediments of late Cretaceous to Tertiary age. It is thought to be derived from certain angiosperms which developed in the late Cretaceous. If the 18 (H)-oleanane/C30 hopane ratio is below 10%, no significant proportions of oleanane are present. At higher values, it can be used as indicator for a reducing environment during deposition of land plant-derived organic matter.

11. C29 diasteranes/C29 $\alpha\alpha\alpha$ steranes + C29 $\alpha\beta\beta$ steranes

Source indicator. Parameter used to characterise the oxidity of depositional environments. High values (up to 10) indicate oxic conditions, low values (down to 0.1) indicate reducing environments.

12. C30 (hopanes + moretanes)/C29 (steranes + diasteranes)

Source indicator. Triterpanes are believed to be of prokariotic (bacterial) origin, whereas steranes are derived from eukariotic organisms. This ratio reflects the preservation of primary organic matter derived from eukariots relative to growth and preservation of bacteria in the sediment after deposition (prokariots).

13. C15 drimane/C16 homodrimane

Drimanes and homodrimanes are ubiquitous compounds most likely derived from microbial activity in sediments. The C15 drimane/C16 homodrimane ratio is a useful parameter for correlation purposes in the low molecular weight region, e.g. for condensates which lack most conventional biomarkers. Drimanes are also useful for an assessment of the level of biodegradation as the removal of C14 to C16 bicyclics characterises an extensive level of biodegration.
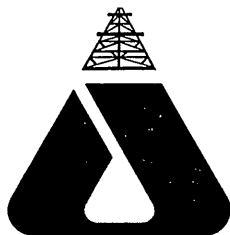

14. Rearranged/normal drimanes

Like parameter 13, for correlation purposes in samples without conventional biomarkers, and to assess level of biodegradation.

15. C15 alkylcyclohexane/C16 homodrimane

Like parameters 13 and 14, useful for correlation purposes. Mainly used for condensates and light oils.

ANALABS
A Division of Macdonald Hamilton & Co. Pty. Ltd.

OIL AND GAS DIVISION

PERTH, WESTERN AUSTRALIA

52 Murray Road,
Welshpool, W.A. 6106

Telephone: (09) 458 7999
Telex: ANALAB AA92560

Samples can be forwarded to Perth from any of the following Analabs Centres:

BRANCH ADDRESSES

WESTERN AUSTRALIA

PERTH — HEAD OFFICE

52 Murray Road,
Welshpool, Western Australia, 6106
Telephone (09) 458 7999, 458 7154
(P.O. Box 210, Bentley, W.A. 6102)
Telex ANALAB AA 92560

KALGOORLIE

Gt. Eastern Highway,
Kalgoorlie, Western Australia, 6430
Telephone (090) 21 1416
(P.O. Box 174, Kalgoorlie, W.A., 6430)
Telex KALAB AA 91784

NORTHERN TERRITORY

DARWIN

Cnr. Coonawarra & Mataram Roads,
Winnellie, N.T., 5789
Telephone (089) 84 3849
(P.O. Box 39344, Winnellie, N.T., 5789)
Telex NTLAB AA 85765

QUEENSLAND

BRISBANE

53 Suscatand Street,
Rocklea, Queensland, 4106
Telephone (07) 277 1668
Telex SEISEX AA 40988

CAIRNS

1 Ogden Street,
Cairns, Queensland, 4870
Telephone (070) 51 5518, 51 7829
Telex TETLAB AA 48423

MT. ISA

15 Traders Way,
Mt. Isa, Queensland, 4825
Telephone (077) 43 6837
(P.O. Box 2401, Mt. Isa, Qld., 4825)
Telex ISALAB AA 46850

SOUTH AUSTRALIA

ADELAIDE

15 Myuna Street,
Regency Park, S.A. 5010
Telephone (08) 268 8833
Telex SEISPLY AA88747

TASMANIA

BURNIE

14 Thirkell Street,
Cooee, Tasmania, 7320
Telephone (004) 31 6837
(P.O. Box 929, Burnie, Tas., 7320)
Telex TASLAB AA 59224

FIJI

SUVA

C/- Marine Pacific Ltd.
Stinson Building
Tofua Street, Walu Bay
Telephone 31 2488
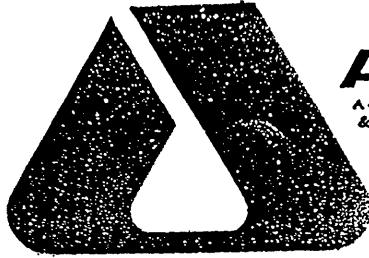(P.O. Box 1342, Suva, Fiji)
Telex TUGBOAT 2202

Appendix 6
Water Analysis

APPENDIX 6

WATER ANALYSIS

ANALABS

A division of Inchcape Inspection
& Testing Services Pty. Ltd.

Melbourne:
231 Burwood Road, Hawthorn, Victoria 3122.
Tel: (03) 819 4326.
Fax: (03) 819 6068.

The Shell Company of Australia Ltd
1 Spring Street
Melbourne
VICTORIA 3000

Date : 12/06/90
Your Ref : ITC 022752
Our Ref : 1312

ATTENTION : Mr M Hamonic
            Level 19

Dear Sir

You submitted two water samples on the 07/06/90 for analysis and the results obtained are as follows :

	Gummy - 1	
	3201.5m	3421.5m
pH	8.60	8.60
TDS mg/l	31500	36500
Electrical conductivity S/cm	63500	76000
Na mg/l	6000	7300
K mg/l	8600	10400
Ca mg/l	90	84
Mg mg/l	225	280
Soluble iron mg/l	16.9	2.5
Cl mg/l	15200	18200
NO3 mg/l*	44.5	55
SO4 mg/l	1800	2150
Total alkalinity as CaCO3 mg/l	840	830

Yours faithfully
ANALABS - a division of
I.I.T.S. (Australia) Pty Ltd

T.R. Staker
B.Sc M.R.A.C.I.
CHIEF CHEMIST

* N.B. MUD FILTRATE CHEMISTRY
~ 50 mg/l. NO₃ at
time of RFT run
EEPH   6/90