COMMERCIAL-IN- CONFIDENCE

LGC Geochemistry

Geochemical Analysis of Shallow Core Samples from 83/20-sb01 and 83/20-sb02, Rockall, IRLCS

October, 2000

LGC/2000 LFX/228/203

LGC Geochemistry

Geochemical Analysis of Shallow Core Samples from 83/20-sb01 and 83/20-sb02, Rockall, IRLCS

October, 2000

Contact Point:
Petroleum Geochemistry Team, LGC
Tel: (UK)-0208-943-7527
(Direct Line and Voicemail)
FAX: (UK)-0208-943-2767

Email:geochem@lgc.co.uk

Report Prepared by:

N Goodwin

Checked by:

M Dee

_____

Date: October, 2000

LGC/2000 LFX/228/203

Contents

DISTRIBUTION

NO. OF COPIES	NAME	LOCATION
1	Martin Davies	PIPCo RSG
1	Steve Cawley	BP
1	N GOODWIN	LGC

1. Summary

Five samples from two cores taken in the Irish Rockall area have been analysed by organic geochemical methods. All samples examined have negligible potential for hydrocarbon generation (TOC<=2%, S2 <5Kg/Tonne). GC analysis of the two "richest" samples indicates both samples are very immature. No indications of migrated mature hydrocarbons (oil seepage) were found. The depositional environment of the samples is difficult to assess completely due to their low maturity. However strong bias of steranes to C29 (only C29's), suggests organic input dominated by landplant material, probably a deltaic environment. There are limited indications that of the two solvent-extracted samples (SB01 176.26 and 176.57), the deeper sample is slightly more marine in nature.

2. Introduction

This report contains geochemical data for shallow core samples from the Irish Rockall area (Table 1).

Five samples have been screened for organic richness by Total Organic Carbon content (TOC%wt) and for their hydrocarbon yield on pyrolysis. Hydrocarbon yield was determined by bulk flow pyrolysis as, i) free hydrocarbons - the "S1 component" and ii) their hydrocarbon potential - the "S2 component" (cf. "Rock Eval" type analysis in $Kg_{oil}/Tonne_{rock;}$ Espitalie, 1977). The two samples with the greatest hydrocarbon potential were solvent extracted and the extract obtained fractionated by HPLC into saturate-alkanes, aromatic and residue material. Samples were further characterised by gas chromatography of the saturate fractions and by GCMS analysis of the whole oil for biological markers. The latter techniques are used to characterise the thermal maturity and source organo-facies of hydrocarbon materials.

3. Results

The organic screening data are presented in Table 2 with their derived geochemical parameters. Appendix-A contains the GC chromatograms from the saturate alkanes, Appendix-B the GCMS mass chromatograms for the biological markers, Appendix-C the GCMS molecular parameter data and Appendix-D the peak identification codes in the GCMS chromatograms. Numerical data derived from HPLC fractionation, GC and GCMS analysis are summarised in Tables 3 to 4.

4. Discussion

4.1 Organic Richness

All the samples have negligible potential for hydrocarbon generation as they have TOC contents of 2%wt or less (cf. Kimmeridge N Sea 5 to 12%wt when immature). This conclusion is supported by the low yield on pyrolysis (S2 Kg/T, Table 2) where all samples are well below the 5Kg/T threshold for effective source rocks (Tissot & Welte, 1984). Where organic carbon is present the Hydrogen Indices (100*S2/TOC) are low indicating predominantly inert material. Two samples SB02 71.47m and SB01 177.13m show slightly higher HI typical of gas prone coals, however, their carbon content is negligible. Due to the low hydrocarbon potential of the samples none were selected for Pyrolysis GC analysis to characterise their products.

The two "richest" samples were selected for solvent extraction (SB01 176.26 and 176.57) and further analysis.

4.2 Saturate Fraction GC

Examination of the saturate GC chromatograms (Appendix-A) indicates that one sample 176.26 has an n-alkane distribution characteristic of a highly immature extract with a bimodal distribution maximising at n-C16 and C27. The shorter chain material originates from marine algal input, while the long chain n-alkanes with the strong odd/even predominance (CPI of 2) are typical of terrestrial land plant derived waxes. Land plant waxes give rise to odd carbon chain length alkanes, particularly in the C25 to C33 range; thus, the odd/even predominance (CPI) tends to be high in deltaic environments, but will diminish with maturity.

In the more organic "rich" siltstone 176.57m there is a more complete suite of n-alkanes, maximising at n-C16 and ranging to C40+. This suggests a sample with a larger marine algal content, but the strong odd/even predominance and amount of longer chain material still suggests a significant terrestrial land plant contribution.

In both these samples the saturate alkanes represent a minor part of the extractable material, typical of a very immature sample (Tissot and Welte, 1984).

4.3 Biological Markers (GCMS data)

4.3.1 Source Facies

Examination of the Sterane and Triterpane mass chromatograms (m/z 217 and 191 Appendix-B1.1 and 2.1), indicate both samples organic matter is mostly derived from terrestrial land plant material. This is shown by the singular dominance of C29 steranes over all other types (Peters and Moldowan, 1993). Much of the pentacyclic triterpane components are unsaturated hopenes, due to the sample immaturity, making a more comprehensive assessment difficult.

4.3.2 Maturity

Examination of molecular parameters, used to assess the maturity of hydrocarbon extracts and oils, indicate that both the samples contain very immature hydrocarbons. This is shown by the absence of the 20Sααα sterane isomers and the presence of 20R 5β steranes. Methylbiphenyl maturity parameters (Cumbers et al., 1987) of 8.2 and 9.9 (MBP, Appendix-C) are typical of immature extract (for terrestrial kerogens, as MBP is a facies dependent parameter). Methyldibenzothiophene data MDR 1.4 and 1.72 are again typical of immature values for landplant derived materials (Schou and Myhr, 1987). It was possible to measure the ratio of triaromatic to monoaromatic sterane hydrocarbons (parameters A1 and A2 ca 0.05, Appendix-C; after Mackenzie, 1980) in the 176.27 sample, which confirmed the immaturity of the sample

5. Conclusions

- All samples examined have negligible potential for hydrocarbon generation (TOC<=2%, P2 <5Kg/Tonne)
- GC analysis of 2 “richest” samples indicate both samples are very immature (high Odd/Even preference of n-alkanes and molecular parameters from biomarkers)
- There are no indications of migrated mature hydrocarbons (oil seepage)
- The depositional environment difficult to assess completely due to immaturity, however the strong bias of steranes to C29 (only C29’s) suggests organic input is dominated by landplant material, probably in a deltaic environment.
- There are limited indications that of the two samples extracted (SB01 176.26 and 176.57), the deeper sample is slightly more marine in nature.

6. References

Cumbers K.M., Alexander R and Kagi R.I. (1987). Methylbiphenyl, ethylbiphenyl and dimethyl biphenyl isomer distributions in some sediments and crude oils. Geochim et Cosmochim ACTA 51, 3105-3111

Espitalie J., Laporte J.L., Madec M., Marquis F., Leplat P., Paulet J. and Boutefeu A. (1977) Methode rapide de characterisation des roches meres , de le potentiel petrolier et de leur degre d'evolution. Rev Inst. Fr. Pet. 32, p23-42.

Mackenzie, A.S, Maxwell, J.R. (1980). Molecular parameters of maturation in the Toarcian shales Paris Basin iii - changes in aromatic steranes. Geochim Cosmochim Acta V45, p1345

Schou L. and Myhr M. (1987). Sulphur aromatic compounds as maturity parameters. Adv. Org. Geochem 1987 Pt1, 61-66. Pergamon Press, Oxford.

Tissot B.P. and Welte D.H. (1984) Petroleum formation and Occurrence. Springer-Verlag, Berlin. 697pp.

Peters K.E. and Moldowan (1993) The Biomarker Guide. Interpreting molecular fossils in petroleum and ancient sediments. Prentice Hall, NJ 07632. 363pp.

Table 1 - Samples

Sample code	Well name	Max sample depth	Sample type
0007SED010S004	83/20-sb01	177.13	COR
0007SED010S001	83/20-sb01	169.76	COR
0007SED010S002	83/20-sb01	176.26	COR
0007SED010S003	83/20-sb01	176.57	COR
0007SED011S001	83/20-sb02	71.47	COR

Table 2

SOURCE ROCK QUALITY INDICATORS

COUNTRY: UKCS
WELL: 83/20-sb01

DEPTH (M)	DEPTHRANGE (M)	FORMATION	PICKED LITHOLOGY	S1 (kg/t)	S1 (mg/gC)	S2 (kg/t)	TOC (%)	TMAX deg C	HI	GOGI	CARBT (%)	S (%)
169.76			Limestone	0.47	782.5	0.50	0.06	473	835		77.2	0.03
176.26			Mudstone	0.73	40.7	1.11	1.79	411	62		3.6	2.76
176.57			Siltstone	0.50	23.3	1.54	2.15	435	72		27.4	1.36
177.13			Limestone	0.56	69.7	1.14	0.81	405	140		61.1	0.61

SOURCE ROCK QUALITY INDICATORS

COUNTRY: UKCS
WELL: 83/20-sb02

DEPTH (M)	DEPTHRANGE (M)	FORMATION	PICKED LITHOLOGY	S1 (kg/t)	S1 (mg/gC)	S2 (kg/t)	TOC (%)	TMAX deg C	HI	GOGI	CARBT (%)	S (%)
71.47			Mudstone	0.65	154.7	0.68	0.42	556	162		6.0	0.19

Table 3

Sediment/Extract Analysis

Well name : 83/20-sb01
Suite name : Rockall
Country Of Origin : United Kingdom
Depth (m) : 176.26
Sample name :
Lab Number: 0007SED010S002

HPLC

Saturates %wt : 22.87
Aromatics %wt : 24.41
Residues %wt : 52.72
Asphaltenes (Micro Method) %wt :

Extraction

Sediment Weight (g) :
Total Soluble Extract Weight (g) :

TSE %wt : 0.017

Saturates GC

Pristane/Phytane : 0.47
Pristane/nC17 : 0.04
Phytane/nC18 : 0.90
CPI : 2.00
ALKIND : 68.58
R22 : 0.67

Biomarker Ratios

H1 :	S1 :	M2 :0.15
H2 :	S2 :	M3 :0.18
H3 :	S3 : ::	M4 :
H4 :	S4 : ::	M5 :
H5 : :::::	S5 :	A1 :0.05
H6 :		A2 :0.05
H7 :	S6 :	A3 :
	S7 :	
H8 :	S8 :	A4 :
H9 :		A5 :
H10 :	S9 :	A6 :
	S10 :	MDR : 1.40
H11 :		
H12 :		MBP :8.24
H13 :		
H14 :		
H15 :		
H16 :		
H17 :	N.B.	ALKIND –
		R22 -
H18 :		

MCH% - Methylcyclohexane as Percentage of nC7’s

Light Hydrocarbons

MCH % :
HER % :
HXR % :

Stable Carbon Isotopes

Saturates :
TSE :
Aromatics :
Residue :
Asphaltenes :

Kerogen :

STANDARD:

Table 4

Sediment/Extract Analysis

Well name : 83/20-sb01
Suite name : Rockall
Country Of Origin : United Kingdom
Depth (m) : 176.57
Sample name :
Lab Number: 0007SED010S003

HPLC

Saturates %wt : 4.26
Aromatics %wt : 61.34
Residues %wt : 34.40
Asphaltenes (Micro Method) %wt :

Extraction

Sediment Weight (g) :
Total Soluble Extract Weight (g) :

TSE %wt : 0.023

Saturates GC

Pristane/Phytane : 1.91
Pristane/nC17 : 1.09
Phytane/nC18 : 0.67
CPI : 1.35
ALKIND : 56.94
R22 : 1.08

Biomarker Ratios

H1 :	S1 :	M2 :0.31
H2 :	S2 :	M3 :0.35
H3 :	S3 : ::	M4 :
H4 :		
	S4 : ::	M5 :
H5 : :::::	S5 :	A1 :
H6 :		A2 :
H7 :	S6 :	A3 :
	S7 :	
H8 :	S8 :	A4 :
H9 :		A5 :
H10 :	S9 :	A6 :
	S10 :	MDR : 1.72
H11 :		
H12 :		MBP :9.96
H13 :		
H14 :		
H15 :		
H16 :		
H17 :		
H18 :		

Light Hydrocarbons

MCH % :
HER :
HXR :

Stable Carbon Isotopes

Saturates :
TSE :
Aromatics :
Residue :
Asphaltenes :

Kerogen :

STANDARD:

N.B. ALKIND -
R22 -

MCH% - Methylcyclohexane as Percentage of sum nC7’s

Appendix A
Saturate GC Chromatograms

Saturate GC's – Double click to view

Chromatograms.ppt

Software Version: 4.1<2F12>

Date:	29/08/2000	08:44			
Sample Name:	0007SED010S002 83/20-sb01 176.26m				
Data File:	C:_DATA\B0007010\SAC002.RAW	Date:	########	13:26	
Sequence File:	C:_DATA\B0007010\SAC_GC.SEQ	Cycle:	2	Channel:	A
Instrument:	SAC_GC	Rack/Vial:	0	0	Operator:
Sample Amount:	1	Dilution Fa	1		

Saturates Fraction GC Analysis

Component Name	Time [min]	Area [µV·s]	Amount [%]
N-C12	8.203	1356	0.04
N-C13	9.696	5605	0.15
N-C14	11.115	104088	2.84
N-C15	12.482	716671	19.52
N-C16	13.755	934211	25.45
N-C17	14.94	456440	12.43
PRISTANE	15.042	17031	0
N-C18	16.056	40559	1.1
PHYTANE	16.213	36563	0
N-C19	17.143	57440	1.56
N-C20	18.174	27471	0.75
N-C21	19.166	35715	0.97
N-C22	20.114	33294	0.91
N-C23	21.025	63278	1.72
N-C24	21.897	41257	1.12
N-C25	22.744	140622	3.83
N-C26	23.547	47106	1.28
N-C27	24.341	209143	5.7
N-C28	25.084	57389	1.56
N-C29	25.823	199207	5.43
N-C30	26.718	145263	3.96
N-C31	27.204	121433	3.31
N-C32	27.783	146221	3.98
N-C33	28.675	43634	1.19
N-C34	29.51	8417	0.23
N-C35	30.45	26451	0.72
N-C36	31.504	8610	0.23
		3724475	100

→	Batch Code	0007SED010S002
	Data File	C:_DATA\B0007010\SAC002.RAW
	CPI (24 to 32)	2.00
	Pr/Ph Ratio	0.47
	Pr/n-C17	0.04
	Ph/n-C18	0.90
	Alkane Index (C17/(C17+C27)%	68.58
	R22 Index 2*C22/(C21+C23)	0.67
	Note: -1 denotes not calculated	

Software Version: 4.1<2F12>

Date:	29/08/2000	08:44			
Sample Name:	0007SED010S003 83/20-sb01 176.57m				
Data File:	C:_DATA\B0007010\SAC003.RAW	Date:	#########	16:05	
Sequence File:	C:_DATA\B0007010\SAC_GC.SEQ	Cycle:	3	Channel:	A
Instrument:	SAC_GC	Rack/Vial:	0	0	Operator:
Sample Amount:	1	Dilution Fa	1		

Saturates Fraction GC Analysis

Component Name	Time [min]	Area [µV·s]	Amount [%]
N-C12	8.24	0	0
N-C13	9.698	35640	1.14
N-C14	11.123	175159	5.62
N-C15	12.466	242787	7.79
N-C16	13.734	241497	7.75
N-C17	14.932	181101	5.81
PRISTANE	15.054	197129	0
N-C18	16.07	154154	4.95
PHYTANE	16.222	103422	0
N-C19	17.154	152994	4.91
N-C20	18.19	146907	4.72
N-C21	19.179	157206	5.05
N-C22	20.128	166296	5.34
N-C23	21.036	149368	4.8
N-C24	21.909	124373	3.99
N-C25	22.748	148567	4.77
N-C26	23.557	118795	3.81
N-C27	24.339	136972	4.4
N-C28	25.09	101518	3.26
N-C29	25.822	136688	4.39
N-C30	26.52	83885	2.69
N-C31	27.208	119003	3.82
N-C32	27.914	70902	2.28
N-C33	28.682	87325	2.8
N-C34	29.52	54763	1.76
N-C35	30.467	76050	2.44
N-C36	31.525	52885	1.7
		3415387	100

→	Batch Code	0007SED010S003
	Data File	C:_DATA\B0007010\SAC003.RAW
	CPI (24 to 32)	1.35
	Pr/Ph Ratio	1.91
	Pr/n-C17	1.09
	Ph/n-C18	0.67
	Alkane Index (C17/(C17+C27)%	56.94
	R22 Index 2*C22/(C21+C23)	1.08
	Note: -1 denotes not calculated	

Appendix B
GCMS Chromatograms

GCMS Chromatograms – click to view

Chromatograms.ppt

Appendix C
Molecular Parameters

```
                              *************
                              * CONFIRMED *
                              *************
   BP METH - BIOMARKER PARAMETERS  29-AUG-00 09:58:44    (V 3.20)
   -- ----   --------- ----------
Sample#6 Text:83/20-sb01 176.26m $0007SED010S002$ File Text:6000RP GCMS
ANALYSIS: MPDMIO00926061.LIS          EQUATION FILE: sacaro.EQN
HSRUN = MPDMIO00926061

H1     C32 HOPANES 22S/(22S+22R)                              =
H2     C31 HOPANES 22S/(22S+22R) M/Z205                       =
H3     C30: HOPANE/(HOPANE+MORETANE)                          =
H4     C30: BB HOPANE / C30 HOPANE AS %                       =

H5_0   C29 HOPANE AS % OF C30                                 =
H5_1   HOPANE DISTRIBUTION RELATIVE TO C30                    =
H5_2   C31 HOPANES AS % OF C30 (M/Z205 CORRECTED)             =
H5_3   C32 HOPANES                                            =
H5_4   C33 HOPANES                                            =
H5_5   C34 HOPANES                                            =
H5_6   C35 HOPANES                                            =

H6     C27 HOPANES TS/(TS+TM)                                 =
H7     C33 HOPANES 22S/(22S+22R)                              =
H11    C23 TRICYCLIC/C30 HOPANE AS %                          =
H12    C24 TETRACYCLIC/C30 HOPANE AS %                        =
H13    28,30 BISNORHOPANE/HOPANE AS %                         =
H14    C30 DIAHOPANE PI/HOPANE AS %                           =
H15    OLEANANE/HOPANE AS %                                   =
H16    GAMMACERANE/HOPANE AS % (205 BACK CALCULATED)          =
H17    HOPANE INDEX C35/(C35+C34) %                           =
H18    25-NORHOPANE(Y)/HOPANE AS % G                          =
H19    C29 18A-NORHOPANE D2/C30 HOPANE AS %                   =

S1     C29 STERANES 20S/(20S+20R)                             =
S2     C29 STERANES m/z218 ABB/(ABB+AAA)                      =

S3_1   STERANE DISTRIBUTION AAA C27 %                         =
S3_2                            C28 %                         =
S3_3                            C29 %                         =

S4_1   STERANE DISTRIBUTION ABB C27 %                         =
S4_2                            C28 %                         =
S4_3                            C29 %                         =

S5     BA DIASTERANES/(BA DIASTERANES+AAA+ABB STERANES) %      =
S7     STERANE INDEX C27/(C27+C29) % FROM S3                  =
S8     C30 4-ME STERANE AS % OF C29 20R AAA                   =

M4     SUM C27 TO C35 HOPANES/(SAME+C27 TO C29 STERANES)      =

PR/PH  PRISTANE/PHYTANE RATIO ESTIMATE                        =
```

```
                              *************
                              * CONFIRMED *
                              *************
   BP METH - BIOMARKER PARAMETERS  29-AUG-00 09:58:44    (V 3.20)
   -- ----   --------- ----------
Sample#6 Text:83/20-sb01 176.26m $0007SED010S002$ File Text:6000RP GCMS
ANALYSIS: MPDMIO00926061.LIS          EQUATION FILE: sacaro.EQN
continued...

T19    C19 TRICYCLIC/C23 TRICYCLIC %                        =
T20    C20 TRICYCLIC/C23 TRICYCLIC %                        =
T21    C21 TRICYCLIC/C23 TRICYCLIC %                        =
T22    C22 TRICYCLIC/C23 TRICYCLIC %                        =
T23    C23 TRICYCLIC/C23 TRICYCLIC %                        =
T24    C24 TRICYCLIC/C23 TRICYCLIC %                        =
T25    C25 TRICYCLIC/C23 TRICYCLIC %                        =
T26    C26 TRICYCLICS/C23 TRICYCLIC %                       =
T28    C28 TRICYCLICS/C23 TRICYCLIC %                       =
T29    C29 TRICYCLICS/C23 TRICYCLIC %                       =
T30    C30 TRICYCLICS/C23 TRICYCLIC %                       =

19/23  C19 TRICYCLIC/C23 TRICYCLIC AS %                     =
20/21  C20 TRICYCLIC/C21 TRICYCLIC AS %                     =
22/21  C22 TRICYCLIC/C21 TRICYCLIC AS %                     =
24/23  C24 TRICYCLIC/C23 TRICYCLIC AS %                     =
26/25  C26 TRICYCLICS/C25 TRICYCLIC AS %                    =
244_24 C24 TETRACYCLIC/C24 TRICYCLIC AS %                   =
TET_23 C24 TETRACYCLIC/C23 TRICYCLIC AS %                   =
```

```
                              *************
                              * CONFIRMED *
                              *************
   BP METH - BIOMARKER PARAMETERS  29-AUG-00 09:58:44    (V 3.20)
   -- ----   --------- ----------
Sample#6 Text:83/20-sb01 176.26m $0007SED010S002$ File Text:6000RP GCMS
ANALYSIS: MPDMIO00926061.LIS          EQUATION FILE: sacaro.EQN
continued...

M2     PHENANTHRENES  (3ME+2ME) / (9ME+1ME)                  =      0.15
M3     MPI1 PHENANTHRENES (3ME+2ME) / (9ME+1ME+PHEN) * 1.5  =      0.18

A1     ARO STERANES: C28 20R TRI/(SAME+C29 20R 5A&B MONO 12 =      0.05
A2     ARO STERANES: SUM TRI/(SAME+SUM MONO)(F9&F12split)   =      0.05
A3     TRI ARO STERANES: C20/(C20+C28 20R)                  =
A4     TRI ARO STERANES: (C20+C21)/(SAME+SUM C26 TO C28)    =

A5     TRI ARO STERANES: C26 20S / C28 20S                  =
A6     TRI ARO STERANES: C27 20R / C28 20R                  =

MDR    4-ME DIBENZOTHIOPHENE / 1-ME DIBENZOTHIOPHENE        =      1.40

MBP    3-METHYLBIPHENYL / 2-METHYLBIPHENYL                  =      8.24

MNR    2-ME NAPTHALENE/1-ME NAPHTHALENE                     =      0.91

SMN    (2-ME NAPTH+1-ME NAPTH)/C23 TRICYCLIC                =

DBTP   DIBENZOTHOIOPHENE(MZ184)/PHENANTHRENE(MZ178)         =      0.11




SAC% 0    ARO% 0    OIL/TSE (MG) 0
SAC STD (UG) 0      ARO STD (UG) 0      ROCK (G) 0      TOC% 0
```

```
                              *************
                              * CONFIRMED *
                              *************
   BP METH - BIOMARKER PARAMETERS  29-AUG-00 09:54:43 _  (V 3.20)
   -- ----   --------- ----------
Sample#4 Text:83/20-sb01 176.57m $0007SED010S003$ File Text:6000RP GCMS
ANALYSIS: MPDMIO00926041.LIS          EQUATION FILE: sacaro.EQN
HSRUN = MPDMIO00926041

H1     C32 HOPANES 22S/(22S+22R)                              =
H2     C31 HOPANES 22S/(22S+22R) M/Z205                       =
H3     C30: HOPANE/(HOPANE+MORETANE)                          =
H4     C30: BB HOPANE / C30 HOPANE AS %                       =

H5_0   C29 HOPANE AS % OF C30                                 =
H5_1   HOPANE DISTRIBUTION RELATIVE TO C30                    =
H5_2   C31 HOPANES AS % OF C30 (M/Z205 CORRECTED)             =
H5_3   C32 HOPANES                                            =
H5_4   C33 HOPANES                                            =
H5_5   C34 HOPANES                                            =
H5_6   C35 HOPANES                                            =

H6     C27 HOPANES TS/(TS+TM)                                 =
H7     C33 HOPANES 22S/(22S+22R)                              =
H11    C23 TRICYCLIC/C30 HOPANE AS %                          =
H12    C24 TETRACYCLIC/C30 HOPANE AS %                        =
H13    28,30 BISNORHOPANE/HOPANE AS %                         =
H14    C30 DIAHOPANE PI/HOPANE AS %                           =
H15    OLEANANE/HOPANE AS %                                   =
H16    GAMMACERANE/HOPANE AS % (205 BACK CALCULATED)          =
H17    HOPANE INDEX C35/(C35+C34) %                           =
H18    25-NORHOPANE(Y)/HOPANE AS % G                          =
H19    C29 18A-NORHOPANE D2/C30 HOPANE AS %                   =

S1     C29 STERANES 20S/(20S+20R)                             =
S2     C29 STERANES m/z218 ABB/(ABB+AAA)                      =

S3_1   STERANE DISTRIBUTION AAA C27 %                         =
S3_2                            C28 %                         =
S3_3                            C29 %                         =

S4_1   STERANE DISTRIBUTION ABB C27 %                         =
S4_2                            C28 %                         =
S4_3                            C29 %                         =

S5     BA DIASTERANES/(BA DIASTERANES+AAA+ABB STERANES) %      =
S7     STERANE INDEX C27/(C27+C29) % FROM S3                  =
S8     C30 4-ME STERANE AS % OF C29 20R AAA                   =

M4     SUM C27 TO C35 HOPANES/(SAME+C27 TO C29 STERANES)      =

PR/PH  PRISTANE/PHYTANE RATIO ESTIMATE                        =      2.42
```

```
                                *************
                                * CONFIRMED *
                                *************
   BP METH - BIOMARKER PARAMETERS  29-AUG-00 09:54:43 _  (V 3.20)
   -- ----   --------- ----------
Sample#4 Text:83/20-sb01 176.57m $0007SED010S003$ File Text:6000RP GCMS
ANALYSIS: MPDMIO00926041.LIS          EQUATION FILE: sacaro.EQN
continued...

T19    C19 TRICYCLIC/C23 TRICYCLIC %                        =
T20    C20 TRICYCLIC/C23 TRICYCLIC %                        =
T21    C21 TRICYCLIC/C23 TRICYCLIC %                        =
T22    C22 TRICYCLIC/C23 TRICYCLIC %                        =
T23    C23 TRICYCLIC/C23 TRICYCLIC %                        =
T24    C24 TRICYCLIC/C23 TRICYCLIC %                        =
T25    C25 TRICYCLIC/C23 TRICYCLIC %                        =
T26    C26 TRICYCLICS/C23 TRICYCLIC %                       =
T28    C28 TRICYCLICS/C23 TRICYCLIC %                       =
T29    C29 TRICYCLICS/C23 TRICYCLIC %                       =
T30    C30 TRICYCLICS/C23 TRICYCLIC %                       =

19/23  C19 TRICYCLIC/C23 TRICYCLIC AS %                     =
20/21  C20 TRICYCLIC/C21 TRICYCLIC AS %                     =
22/21  C22 TRICYCLIC/C21 TRICYCLIC AS %                     =
24/23  C24 TRICYCLIC/C23 TRICYCLIC AS %                     =
26/25  C26 TRICYCLICS/C25 TRICYCLIC AS %                    =
244_24 C24 TETRACYCLIC/C24 TRICYCLIC AS %                   =
TET_23 C24 TETRACYCLIC/C23 TRICYCLIC AS %                   =
```

```
                              *************
                              * CONFIRMED *
                              *************
   BP METH - BIOMARKER PARAMETERS  29-AUG-00 09:54:43 _  (V 3.20)
   -- ----   --------- ----------
Sample#4 Text:83/20-sb01 176.57m $0007SED010S003$ File Text:6000RP GCMS
ANALYSIS: MPDMIO00926041.LIS          EQUATION FILE: sacaro.EQN
continued...

M2     PHENANTHRENES  (3ME+2ME) / (9ME+1ME)                  =      0.31
M3     MPI1 PHENANTHRENES (3ME+2ME) / (9ME+1ME+PHEN) * 1.5  =      0.35

A1     ARO STERANES: C28 20R TRI/(SAME+C29 20R 5A&B MONO 12 =
A2     ARO STERANES: SUM TRI/(SAME+SUM MONO)(F9&F12split)   =
A3     TRI ARO STERANES: C20/(C20+C28 20R)                  =
A4     TRI ARO STERANES: (C20+C21)/(SAME+SUM C26 TO C28)    =

A5     TRI ARO STERANES: C26 20S / C28 20S                  =
A6     TRI ARO STERANES: C27 20R / C28 20R                  =

MDR    4-ME DIBENZOTHIOPHENE / 1-ME DIBENZOTHIOPHENE        =      1.72

MBP    3-METHYLBIPHENYL / 2-METHYLBIPHENYL                  =      9.96

MNR    2-ME NAPTHALENE/1-ME NAPHTHALENE                     =      1.04

SMN    (2-ME NAPTH+1-ME NAPTH)/C23 TRICYCLIC                =     18.23

DBTP   DIBENZOTHOIOPHENE(MZ184)/PHENANTHRENE(MZ178)         =      0.04




SAC% 0    ARO% 0    OIL/TSE (MG) 0
SAC STD (UG) 0      ARO STD (UG) 0      ROCK (G) 0      TOC% 0
```

Appendix D
GCMS Peak Identification Codes

BIOMARKER IDENTIFICATION - PENTACYCLIC HYDROCARBONS

LGC CODE	ASSIGNMENT BASED ON MASS SPECTROMETRY (m/e 191)
I	9-DODECYLPERHYDROANTHRACENE [INTERNAL STANDARD]
Ts	18α(H)-22,29,30-TRISNORNEOHOPANE
Tm	17α(H)-22,29,30-TRISNORHOPANE
Q	17β(H)-22,29,30-TRISNORHOPANE
W	17α(H)-25,30-BISNORHOPANE
X	17α(H),18α(H),21β(H)-28,30-BISNORHOPANE
Y	17α(H)-25-NORHOPANE
D	17α(H),21β(H)-30-NORHOPANE
D2	18α(H)-30-NORNEOHOPANE
π	17α(H),15α(Me)-27-NORHOPANE ("DIAHOPANE")
A	17β(H),21α(H)-30-NORMORETANE
B	18α(H)-OLEANANE
G	17α(H),21β(H)-HOPANE
H	17β(H),21β(H)-30-NORHOPANE
K	17β(H),21α(H)-MORETANE
N	(22S)-17α(H),21β(H)-30-METHYLHOPANE
O	(22R)-17α(H),21β(H)-30-METHYLHOPANE
S	GAMMACERANE
P	17β(H),21β(H)-HOPANE
R	17β(H),21α(H)-30-METHYLMORETANE
U	(22S)-17α(H),21β(H)-30-ETHYLHOPANE
V	(22R)-17α(H),21β(H)-30-ETHYLHOPANE
J	17β(H),21β(H)-METHYLHOPANE
α	(22S)-17α(H),21β(H)-30-n-PROPYLHOPANE
β	(22R)-17α(H),21β(H)-30-n-PROPYLHOPANE
L	17β(H),21β(H)-ETHYLHOPANE
γ	(22S)-17α(H),21β(H)-30-n-BUTYLHOPANE
δ	(22R)-17α(H),21β(H)-30-n-BUTYLHOPANE
ε	(22S)-17α(H),21β(H)-30-n-PENTYLHOPANE
ζ	(22R)-17α(H),21β(H)-30-n-PENTYLHOPANE

BIOMARKER IDENTIFICATION - AROMATIC STEROIDAL HYDROCARBONS

(AROMATIC STERANES)

LGC CODE	TENTATIVE ASSIGNMENT BASED ON MASS SPECTROMETRY
	(m/e 253 mass fragmentogram)
F22	C_{21} DIMETHYL MONOAROMATIC STEROID
F23	C_{22} DIMETHYL MONOAROMATIC STEROID
F2	C_{27}(20S)5β(H)DIMETHYL MONOAROMATIC STEROID
F3	C_{27}(20R)5β(H)DIMETHYL MONOAROMATIC STEROID
F4	C_{27}(20S)5α(H)DIMETHYL MONOAROMATIC STEROID
F5	C_{28}(20S)5β(H)DIMETHYL MONOAROMATIC STEROID
F6	C_{27}(20R)5α(H)DIMETHYL MONOAROMATIC STEROID
F7	C_{28}(20S)5α(H)DIMETHYL MONOAROMATIC STEROID
F8	C_{28}(20R)5β(H)DIMETHYL MONOAROMATIC STEROID
F9	C_{29}(20S)5β(H)DIMETHYL MONOAROMATIC STEROID
F10	C_{29}(20S)5α(H)DIMETHYL MONOAROMATIC STEROID
F11	C_{28}(20R)5α(H)DIMETHYL MONOAROMATIC STEROID
F12	C_{29}(20R)5β(H)DIMETHYL MONOAROMATIC STEROID
F13	C_{29}(20R)5α(H)DIMETHYL MONOAROMATIC STEROID
	(m/e 231 mass fragmentogram)
F14	C_{20}METHYL TRIAROMATIC STEROID
F15	C_{21}METHYL TRIAROMATIC STEROID
F16	C_{26}(20S)METHYL TRIAROMATIC STEROID
F17	C_{26}(20R)METHYL TRIAROMATIC STEROID
F18	C_{27}(20S)METHYL TRIAROMATIC STEROID
F19	C_{28}(20S)METHYL TRIAROMATIC STEROID
F20	C_{27}(20R)METHYL TRIAROMATIC STEROID
F21	C_{28}(20R)METHYL TRIAROMATIC STEROID

BIOMARKER IDENTIFICATION - STERANES

LGC

CODE ASSIGNMENT BASED ON MASS SPECTROMETRY (m/e 217)

10	(20S)-13β(H),17α(H)-DIACHOLESTANE
11	(20R)-13β(H),17α(H)-DIACHOLESTANE
13	(20R)-13α(H),17β(H)-DIACHOLESTANE
14	(20S)-13α(H),17β(H)-DIACHOLESTANE
15	(24S/R)-(20S)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
16	(24S/R)-(20S)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
18	(24S/R)-(20R)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
19	(24R/S)-(20R)-13β(H),17α(H)-24-METHYLDIACHOLESTANE
20A	(24S/R)-(20S)-13α(H),17β(H)-24-METHYLDIACHOLESTANE
20B	(20S)-5α(H),14α(H),17α(H)-CHOLESTANE
21A	(24R+S)-(20S)-13β(H),17α(H)-24-ETHYLDIACHOLESTANE
21B	(20R)-5α(H),14β(H),17β(H)-ISOCHOLESTANE
22	(20S)-5α(H),14β(H),17β(H)-ISOCHOLESTANE
25	(20R)-5α(H),14α(H),17α(H)-CHOLESTANE
27	(24S+R)-(20R)-13β(H),17α(H)-24-ETHYLDIACHOLESTANE
29	(24S+R)-(20S)-13α(H),17β(H)-24-ETHYLDIACHOLESTANE
33A	(24S+R)-(20R)-5α(H),14β(H)17β(H)-24-METHYLISOCHOLESTANE
33B	(24S+R)-(20R)-13α(H),17β(H)-24-ETHYLDIACHOLESTANE
34	(24S+R)-(20S)-5α(H),14β(H),17β(H)-24-METHYLISOCHOLESTANE
36	(24S+R)-(20R)-5α(H),14α(H),17α(H)-24-METHYLCHOLESTANE
39	(24S+R)-(20S)-5α(H),14α(H),17α(H)-24-ETHYLCHOLESTANE
40	(24S+R)-(20R)-5α(H),14β(H),17β(H)-24-ETHYLISOCHOLESTANE
41	(24S+R)-(20S)-5α(H),14β(H),17β(H)-24-ETHYLISOCHOLESTANE
42	(24S+R)-(20R)-5α(H),14α(H),17α(H)-24-ETHYLCHOLESTANE
43	(24S+R)-(20S)-5α(H),14α(H),17α(H)-24-PROPYLCHOLESTANE
44	(24S+R)-(20R)-5α(H),14β(H),17β(H)-24-PROPYLCHOLESTANE
45	(24S+R)-(20S)-5α(H),14β(H),17β(H)-24-PROPYLCHOLESTANE
46	(24S+R)-(20R)-5α(H),14α(H),17α(H)-24-PROPYLCHOLESTANE
47	C30 4α-ME-24-ETHYLCHOLESTANE
48	C30 4β-ME-24-ETHYLCHOLESTANE
49	C30 4α,23,24-TRIMETHYLCHOLESTANE