D-12

RESEARCH CENTRE

SUNBURY-ON-THAMES

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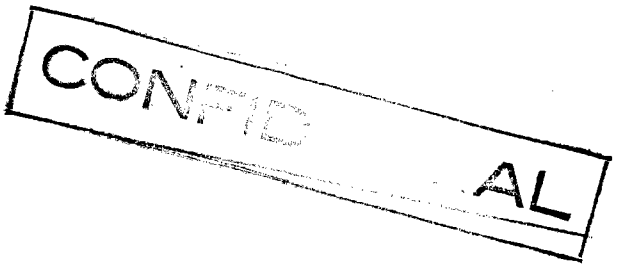

EXPLORATION AND PRODUCTION DIVISION

TECHNICAL NOTE

EPR/TN 7040

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COMPARISON OF CONSULTANTS GEOCHEMICAL DATA FROM NOCS WELLS 7/12-2 and 7/12-3

by

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7/12-2

D-12

SUMMARY

Reinterpretation of geochemical data produced by Geochem Laboratories UK Ltd., and Robertson Research International on material from NOCS Wells 7/12-2 and 7/12-3 showed that no great discrepancy existed between the maturation levels in these wells. Differences between the oil generation thresholds quoted in the original reports were attributed to incorrect interpretation of unrealiable data produced by the two geochemical consultants.

Examination of consultant's data in conjunction with that obtained from sample checks run by BP Sunbury, showed that maturation trends in the Lower Cretaceous to Upper Jurassic were very difficult to evaluate. However, an oil generation threshold of 3200 - 3600m would be consistent with all the geochemical data available on both wells.

(A) INTRODUCTION

Geochemical data available on wells drilled in Block 7/12 of the Norwegian Continental Shelf has been derived from three different sources. Robertson Research International (RRI) produced a detailed geochemical report for Conoco on the discovery Well 7/12-2. The geochemistry of 7/12-3 samples was reported on by Geochem Laboratories UK Ltd., (GCL) and later, a small number of samples from this well were checked by BP Sunbury.

The data from these various sources indicated widely differing results in the maturity trends across a small distance (2 - 3 Kms) so a re-examination of the available data was undertaken by Geochemistry Branch, Sunbury.

(B) ROBERTSON RESEARCH REPORT ON 7/12-2

A report on the sedimentary organic geochemistry of NOCS Well 7/12-2 was produced for Conoco, Norway, by RRI. This study included analysis of sidewall core material from 1633m to TD (3617m), supplemented by cuttings analysis over the interval 3190 - 3617m. Vitrinite reflectance and spore colouration variations were used to give indications of the Degree of Organic Diagenesis (DOD). In addition, parameters derived from soluble extract analysis and light hydrocarbon analysis have also been used to determine DOD trends.

Kerogen type was determined by visual examination of specially prepared concentrates.

(C) RESULTS

(i) Maturity Trends

These results are summarised in Table 2.

Unlike GCL and BP Sunbury analysis of 7/12-3, samples from above the Lower Cretaceous were examined by RRI. Hence, a maturity trend could possibly be established for the upper part of the succession. Similar problems to those found in the Lower Cretaceous and Upper Jurassic of 7/12-3 were, however, also observed in 7/12-2. Reworked material was found to be abundant and autochthonous material sparse. Maturity trends established over the top half of the well in rocks of Eocene to Recent age suggested an oil generation threshold of 2600 - 3200m. However, this value was obtained by extrapolation, and could be inaccurate. A large variation in the generation threshold was obtained when values from the Cretaceous and Jurassic were included in the least squares regression analysis used to calculate the generation threshold. The "fit" of the data was very poor, being only 35% at best.

Spore colours suggested a generation threshold of about 3300m. However, the increase of spore colour with depth is not a linear process and cannot be accurately extrapolated.

(ii) Light Hydrocarbon Analysis (LHA)

These results are summarised in Table 1.

Maturity trends based on LHA are of doubtful validity as many factors may affect the concentrations of light hydrocarbons. Coupled with these factors are the inherent difficulties in obtaining good quality samples for this type of analysis.

Several zones could be recognised on the basis of light hydrocarbon analyses.

Very large quantities of total gas were recorded at shallow depths, which suggested that some leakage from the reservoir may have occurred. RRI suggest that this may have been effected by a system of minor faults and fractures. Alternatively, some of the methane present could be of biogenic origin, contaminated by higher alkane homologues which are produced by normal maturation of oil prone kerogen.

A gradual change in the "wetness" of the gas was observed with increase in depth. This could either be interpreted as differential diffusion of C_1 to C_4 gases upwards from the reservoir or, more probably a genuine maturation trend. Samples from below $\simeq$3300m were from within the reservoir and results were of little value.

Five zones were recognised from these analyses :-

(a) 1500 - 2500m. High total gas, 92 - 95% Methane; high iC_4/nC_4 ratio 3 - 4.

(b) 2500 - 3040m. Lower gas content; 40 - 60% methane; iC_4/nC_4 ratio 1.2 - 1.9.

(c) 3040 - 3100m. Slightly higher total gas; 87% methane; iC_4/nC_4 ratio as (b).

(d) 3100 - 3250m. Total gas as (c) 30 - 40% methane; low iC_4/nC_4 ratio 0.6 - 0.7.

(e) 3250 - TD. Butane $\gg$ ethane $\gg$ propane $>$ methane; methane 5 - 33%, iC_4/nC_4 ratio 0.13 - 0.54.

These changes may be interpreted as

(I) (a) migrated/biogenic methane - not purely biogenic as $C_2 - C_4$ content too high.

(II) (b) (c) (d) increasing maturity trend, but changes in kerogen type giving rise to small amounts of gas of variable composition.

(III) (e) mature hydrocarbons - either indigenous or migrated from reservoir.

(iii) Soluble Extract Indications

These results are summarised in Table 3. The values used by RRI have been converted to the TSE/TOC, SAC/TOC and SAC/TSE parameters employed by GCL and BP Sunbury, so that results may be more easily compared.

Five zones were recognised from these parameters

(a) 1633 - 1980m. High TOC (3.1 - 7% wt.); High TSE contents, but low TSE/TOC ratios; low SAC/TOC. All parameters indicated immature rich sediments.

(b) 1980 - 2575m. Moderate to good TOC contents (0.9 - 2.02% wt.); moderate TSE contents, but low TSE/TOC ratios; low SAC/TOC. All parameters indicated immature sediments of moderate to good organic richness.

(c) 2575 - 3220m. Variable TOC (0.29 - 7.5% wt.); low TSE/TOC ratio; low SAC/TOC. These parameters indicated immature sediments, or gas prone kerogen.

(d) 3220 - 3319m. Variable but generally good TOC contents (0.36 - 7.0% wt.). High TSE/TOC ratios. Parameters indicated mature, oil prone kerogens or, possibly, small amounts of migration of hydrocarbons into the sediments from an imperfectly sealed reservoir.

(e) 3319 - 3617m. Low TOC contents (0.08 - 0.67% wt.). High TSE/TOC ratios. Parameters indicated lean source rocks but reservoired hydrocarbons.

Normal alkane distributions obtained by gas chromatography of the alkane fraction of the TSE showed obvious odd-even carbon number preferences (CPI) down to 2528m. No distributions were obtained between 2528 - 3243m. Below 3243m, no CPI exists, but this may be due to either a change in kerogen type or to an increase in maturity, or a combination of both.

(iv) Kerogen Type

Good oil prone source rocks were recognised over the interval 1633 to 2575m. The kerogen was described as mainly sapropelic and abundant. These rocks are good source rocks for oil but immature at this depth in 7/12-2.

Below 2575m the kerogen became more gas prone, but still retained some liquid hydrocarbon potential. These rocks are generally of poorer source quality, except over the interval 3243 - 3301m, where the kerogen is mainly oil prone. These rocks are marginally mature.

Below 3301m, the rocks have little or no hydrocarbon potential.

D. GEOCHEM LABORATORIES REPORT ON WELL 7/12-3

These results are summarised in Tables 4 to 7. A detailed comparison of GCL and BP Sunbury data on 7/12-3 has been made in EPR/TN 7039 (1). It became apparent from this study that whilst GCL data appeared reasonably accurate, their interpretation of the data was suspect. The largest discrepancies between GCL and BP Sunbury data were in the Total Organic Carbon (TOC) contents and in estimates of the Degree of Organic Diagenesis (DOD). The problems with TOCs were probably due to sample inhomogeneity, but DOD differences were considered to be due to incorrect interpretation of poor quality data.

Subsequent work on 7/12-2, 3, 3A and 4 has shown that conventional maturity indicators in these wells were of very poor quality, but that the oil generation threshold does not vary to the extent implied by the individual geochemical reports.

GCL concluded that the oil generation threshold in 7/12-3 is at about 4500m $\pm$, this was thought to be incorrect extrapolation of the data, and a more realistic estimate would have been 3200 - 3600m (1). No reliable DOD trends were observed over the intervals examined. Vitrinite reflectance determinations were complicated by large amounts of reworking and spore colours by anomalous colours which are observed in rocks of this age from the North Sea. It has been noted previously that sporomorphs from the so called "hot shale" of the Kimmeridge Clay Formation show lighter colours than would be expected from adjacent formations. Additionally, sediments of Lower Cretaceous age which are deposited on top of this formation, whether they be Hauterivian, Berriasian or Valanginian, contain sporomorphs which are darker than would be expected.

A popular explanation for this observation is that the over-pressuring of these shales causes preferential heatflow due to circulating fluids in rocks above and below the shales.

These factors, combined with large amounts of reworked material indicate that maturity trends are unreliable over this section of the stratigraphic succession.

Light hydrocarbon analyses suggest that the oil generation threshold could be about 3400m, as the iC_4/nC_4 ratio drops significantly around this depth to 0.88, and then to 0.64 from values greater than 1.0. However, changes in kerogen type complicate the interpretation of this type of data.

E. CONCLUSIONS

(1) Maturity indicators in the NOCS Wells 7/12-2 and 7/12-3 were of poor specificity, but the oil generation thresholds do not appear to differ greatly. An approximate value of 3200 - 3600m was considered appropriate for both wells.

(2) Soluble extract parameters supported these maturity observations, but may be of little value owing to the presence of migrated hydrocarbons in the lower sections of both wells.

(3) Light hydrocarbon analyses from both wells suggested an oil generation threshold of about 3400m for 7/12-3 and 3200m for 7/12-2.

(4) Both sets of results indicated that the top of the Jurassic contained moderate to good source rocks for liquid hydrocarbons, particularly the interval 3243 - 3301m in 7/12-2 and 3498 - 3525m in 7/12-3.

F. REFERENCES

(1) EPR/TN 7039 Comparison of Geochem Laboratories Limited and BP Sunbury Geochemical Data for NOCS Well 7/12-3. by J.A. Miles.

TABLE 1

HEADSPACE GAS ANALYSIS DATA

CLIENT: CONOCO NORWAY WELL: 7/12-2 LOCATION: NORWEGIAN N. SEA

SAMPLE DEPTH METRES	TOTAL C_1-C_4 GAS PPM	PERCENT C_1	PERCENT C_2	PERCENT C_3	PERCENT iC_4	PERCENT nC_4
1500-600	30100	93.7	2.0	2.7	1.2	0.4
1600-700	49100	95.7	1.4	1.8	0.9	0.2
1700-800	21600	92.8	2.2	3.2	1.4	0.4
1800-900	35000	93.2	2.5	3.0	1.0	0.3
2000-100	29400	91.7	2.9	3.7	1.3	0.4
2100-200	30100	91.8	2.8	3.5	1.5	0.4
2200-300	26400	92.8	3.1	2.6	1.2	0.3
2300-400	11400	93.2	2.5	2.8	1.2	0.3
2400-500	42000	94.8	3.5	0.9	0.6	0.2
2500-600	7000	66.4	3.5	14.9	7.6	7.6
2600-700	37000	95.5	0.5	2.0	1.2	0.8
2700-800	3000	62.0	3.6	17.0	10.3	7.1
2800-130	2100	59.0	4.1	16.6	12.2	8.1
2830- 60	1700	57.1	3.5	15.1	15.9	8.4
2860- 90	2200	57.2	6.5	19.9	10.4	6.0
2890-920	1800	57.6	5.4	19.0	10.8	7.2
2920- 50	1300	45.8	5.2	23.2	14.1	11.7
2950- 80	700	54.9	4.7	19.8	12.4	8.2
3010- 40	500	53.2	4.5	20.0	14.0	8.3
3040- 70	3000	86.9	3.5	5.8	2.3	1.5
3070-100	800	87.8	4.2	5.3	1.8	0.9
3160- 90	500	45.5	24.5	22.3	3.1	4.6
3190-220	400	31.5	33.0	25.6	3.1	4.8
3220- 50	1200	29.4	36.2	27.4	2.6	4.4
L.B.P.						
3250- 80	2800	14.4	21.7	32.7	7.6	23.6
3310- 40	2900	14.4	21.7	34.1	7.5	22.3
3340- 70	2600	19.0	27.5	32.5	5.8	15.2
3370-400	200	33.1	13.0	33.7	2.3	17.9
3460- 90	6900	4.5	4.2	6.0	23.4	61.9
3490-520	9000	5.0	8.4	34.7	17.0	34.9
3520- 50	20000	1.3	10.5	39.0	13.7	35.5
3510- 40	12000	13.3	11.0	36.6	12.9	26.2
K Robres						
3640- 70	6700	8.7	11.1	40.2	17.5	33.5
3640- 70	5800	6.2	8.2	34.8	17.8	33.0
3670- 76	2800	5.1	7.3	34.3	18.0	35.5

TABLE 2

GENERALISED KEROGEN DESCRIPTION AND SPORE COLOUR INDEX

DEPTH METRE	DOMINANT KEROGENS	SPORE COLOUR INDEX
1633	Vitrinite >> Inertinite > Sapropel	2
1651	Ditto	2
1685	Vitrinite > Inertinite > Sapropel	2
1717	Ditto	2
1750	Sapropel > Inertinite > Vitrinite	2-2.5
1784	Ditto	2-2.5
1868	Ditto	2-2.5
1904	Vitrinite > Sapropel	2-2.5
1930	Ditto	2-2.5
1980	Vitrinite and Sapropel	2.5
2104	Ditto	2.5-3
2148	Sapropel and Vitrinite	2.5-3
2233	Sapropel	3 - (3.5)
2272	Sapropel	3 - (3.5)
2358	Sapropel and Inertinite	3 - (3.5)
2427	Ditto	3 - (3.5)
2445	Sapropel, Inertinite and Vitrinite	3 - 3.5
2528	Sapropel and Exinite > Vitrinite > Inertinite	3?
2723	Inertinite > Sapropel	3.5 - 4
3075	Exinite > Inertinite ≥ Sapropel	4 - 4.5
3201	Inertinite >> Sapropel	4.5
3243	Inertinite ≥ Sapropel	4.5 - 5
3267	Sapropel >> Inertinite	4.5 - 5
3301	Sapropel > Inertinite	4.5 - 5
3319	Vitrinite, Inertinite and Sapropel	4.5-5 and pale ±
3489	Ditto	± 5
3517	Inertinite	± 5
3552	Inertinite	5 - 5.5
3561.5	Inertinite > Sapropel	5 - 5.5
3601	Inertinite, no measurable phytoclasts	*
3608.5	Inertinite, no measurable phytoclasts	*

SOURCE ROCK EVALUATION DATA

COMPANY : CONOCO NORWAY WELL : 7/12-2 LOCATION : NORWEGIAN N. SEA

SAMPLE DEPTH (METRES) OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT PPM	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO CARBONS
1. 1633	SWC	Brn-gy sl calc sh	3.1	2175	7.0	130	6	55
2. 1651	"	Ditto	4.0	2710	6.8	180	7	46
3. 1685	"	Ditto	4.9	3460	7.1	40	1	32
4. 1717	"	Brn-gy/ol-gy calc sh	3.2	2495	7.8	145	6	44
5. 1750	"	Ol-gy sh	3.3	3075	9.3	315	10	54
6. 1784	"	Brn gy calc sh	4.8	3800	7.9	250	7	41
7. 1868	"	Brn-blk sl calc sh	7.0	4850	6.9	445	9	40
8. 1904	"	Brn-blk sh mic sh	5.4	4210	7.8	280	11	41
9. 1930	"	Brn-gy/ol-gy sl mic sl calc sh	5.8	4880	8.4	395	7	41
10. 1980	"	Ol-blk calc sh	5.6	7170	12.8	650	8	32
11. 2104	"	Lt ol-gy calc sh	1.78	855	4.8	140	16	69
12. 2148	"	Ditto	1.57	685	4.4	125	18	48
13. 2180	"	Ditto	2.0?	1265	6.3	140	11	48
14. 2233	"	Ditto	1.50	790	5.3	95	12	49
15. 2272	"	Ditto	1.10	595	5.4	115	19	39
16. 2358	"	Lt ol-gy sh	1.24	600	4.8	85	14	35
17. 2427	"	Lt ol-gy sl calc sh	0.29	165	5.7	30	18	*
18. 2445	"	Lt ol-gy sh	0.35	205	5.9	40	20	66
19. 2528	"	Lt gy sh	1.70	1345	7.9	260	19	52
20. 2575	"	Lt gy sl slty sh	0.90	1250	13.9	145	12	59
21. 2723	"	Med gy calc sh	0.29	170	5.9	20	12	72
22. 3035	"	Lt gy calc sltst	0.31	95	3.1	<20	-	-
23. 3075	"	Dk gy sh	7.5	175	0.2	20	11	*
24. 3190-220	Ctgs	Dk ol-gy sh+mnr snd	0.42	340	8.1	70	21	55
25. 3243	SWC	Ditto						
3255	"	Lt ol gy calc sh	1.37	1665	12.2	590	35	62
26. 3267	"	Ol-blk sh						
3277	"	Ditto	7.0	15485	22.1	6060	39	41
27. 3289	"	Ditto	2.70	5335	19.8	1425	27	43
28. 3301	"	Dk gy mic calc sh	4.1	6450	15.7	2495	39	46
29 3319	"	Ol-blk calc sh	1.21	1060	8.8	435	46	66
30. 3370-400	Ctgs	Dk gy sh+mnr snd	0.56	300	5.4	30	10	29

SOURCE ROCK EVALUATION DATA

COMPANY : CONOCO NORWAY WELL : 7/12-2 LOCATION : NORWEGIAN N. SEA

SAMPLE DEPTH METRES OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT P.P.M.	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT
3537.5	S.W.C.	V lt gy sltst	0.19				
3550-80	Ctgs	Dk gy calc sh+tr lt gy sltst+tr red mdst	0.67				
3561.5	S.W.C.	Gn/gy calc sltst	0.16				
3569.5	"	Prn/red sl calc mdst	0.25				
3580-610	Ctgs	Dk gy calc sh+pnk calc sltst/sst	0.46				
3597.5	S.W.C.	Pale red calc mdst	0.14				
3601	"	Mtl pnk/gy calc sltst	0.09				
3608.5	"	Pale red sl calc sltst	0.08				
3610-40	Ctgs	Dk gy calc sh+tr pnk calc sltst/sst	0.44				
3640-70 K Robres	"	Ditto+ditto+tr blk sh	0.46				
3640-70 L.B.P.	"	Ditto+ditto	0.37				
3670-76	"	Ditto+50% pnk calc sltst	0.32				

TABLE 3 (Continued)

DEPTH (m)	SAC/TOC RATIO ‰	SAC/TSE RATIO %
1633	2	3
1651	2	3
1685	2	3
1717	2	3
1750	4	5
1784	2	3
1868	2	4
1904	3	5
1930	2	3
1980	3	3
2104	6	11
2148	3	7
2180	3	5
2233	4	6
2272	4	7
2358	3	5
2427	-	-
2445	7	13
2528	9	12
2575	10	7
2723	5	9
3190 - 3220	9	12
3243 + 3244	26	22
3267 + 3277	25	16
3289	23	12
3301	28	17
3319	27	30
3370 - 400	-	3
3460 - 90	45	22
3515	88	19
3517 + 3518	214	45
3552	98	55
3573	138	23
3580.5	102	49
3605.2	51	21
3611.8	46	15
3617	73	30

TABLE 4

VISUAL KEROGEN DATA

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION				THERMAL MATURATION INDEX
		TYPES	REMARKS	PARTICLE SIZE	PRESERV-ATION	
161-001A	3200m	W;C;H	sparse organic matter. Contamination	F-M	P	2- (?)
161-004 swc	3268m	W-C;-;(H)	very sparse organic matter, unreliable.	M	P	
161-005C	3290m	C-W;H;S	very sparse organic matter. Some at 2 to 2+	F	P-F	2- (?)
161-006A	3320m	W-C;-;-	very sparse organic matter, unreliable.	F-M	P	
161-007A	3350m	C-W;-;-	very sparse organic matter, unreliable.	M	P	
161-008 swc	3357m	C-W;H;-	sparse organic matter.	F-M	F	1+ to 2-
161-010A	3410m	W-C;H;-	sparse organic matter. Reworked material (2 to 2+/2+).	F-M	F	2- (?)
161-013 swc	3490m	C-W;-;H	very sparse organic matter.	F	F	
161-015 swc	3525m	W;C-H;-	sparse organic matter	F-M	F	1+ to 2-
161-017 swc	3555m	W;C;H		M	F	1+ to 2-
161-019A	3590m	W;C;H	sparse organic matter.	M	F	1+ to 2-

reworked organic matter present throughout

TABLE 5

VITRINITE REFLECTANCE DATA

GEOCHEM SAMPLE NUMBER	DEPTH	SAMPLE TYPE	AVERAGE REFLECTIVITY Ro (%)			NUMBER OF PARTICLES			REMARKS
			1	2	3	1	2	3	
161-001A	3200m	CUTTINGS	0.43	0.67		3	4		low organic content, only trace of true vitrinite
161-004	3268m	S.W.C.	0.44			3			low organic content
161-006A	3320m	CUTTINGS	0.43			19			
161-008	3357m	S.W.C.	0.45			18			
161-010A	3410m	CUTTINGS	0.51	0.80*		2	3		low organic content. *reworked
161-013	3490m	S.W.C.	0.36	1.49*		5	15		* reworked
161-015	3525m	S.W.C.	0.45			9			low-moderate organic content
161-017	3555m	S.W.C.	1.69*			13			* reworked, no true vitrinite
161-019A	3590m	CUTTINGS	0.39	0.65		18	2		

TABLE 6A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
161-001	3200m	203	77	165	58	48	551	348	63.1%	40	1.19
161-002	3230m	104	34	66	24	20	248	144	58.2%	27	1.19
161-003	3260m	173	33	56	21	13.6	297	124	41.8%	42	1.58
161-005	3290m	308	115	132	35	20	612	304	49.5%	9.0	1.74
161-006	3320m	241	53	98	37	21	452	209	46.3%	11.3	1.80
161-007	3350m	94	14.2	20	7.8	4.1	140	46	32.9%	-	1.90
161-009	3380m	139	38	42	12.8	9.1	241	102	42.2%	-	1.41
161-010	3410m	93	35	13.3	3.1	3.0	148	55	37.1%	0.1	1.01
161-011	3450m	122	71	37	6.3	7.5	243	121	50.0%	0.3	0.84
161-012	3470m	70	75	35	3.7	8.1	193	122	63.3%	0.2	0.46
161-014	3500m	193	136	208	36	126	700	507	72.4%	206	0.29
161-016	3530m	348	231	328	47	212	1165	817	70.1%	241	0.27
161-018	3570m	24	139	226	30	114	534	510	95.4%	40	0.27
161-019	3590m	20	370	694	71	293	1447	1427	98.6%	415	0.24

TABLE 6B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
161-001	3200m	36	22	90	71	68	288	252	87.6%	477	1.04
161-002	3230m	27	11.2	64	54	50	207	180	86.9%	118	1.09
161-003	3260m	163	52	168	121	77	582	418	71.9%	248	1.56
161-005	3290m	47	39	160	126	74	447	400	89.5%	219	1.69
161-006	3320m	19.9	66	66	31	18.4	201	181	90.1%	28	1.68
161-007	3350m	17.6	5.4	15.7	12.5	10.3	61	44	71.4%	25	1.21
161-009	3380m	21	12.6	29	19.7	12.9	96	75	77.7%	80	1.53
161-010	3410m	34	29	32	15.0	17.6	128	94	73.4%	65	0.85
161-011	3450m	35	27	31	8.2	15.3	116	81	69.9%	38	0.54
161-012	3470m	24	43	46	8.8	21	143	119	83.0%	36	0.42
161-014	3500m	36	39	126	41	174	417	381	91.3%	2478	0.24
161-016	3530m	126	189	548	198	838	1900	1773	93.3%	4648	0.24
161-018	3570m	71	90	193	67	210	631	560	88.7%	2082	0.32
161-019	3590m	62	238	871	257	1023	2453	2391	97.5%	1005	0.25

TABLE 6C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
161-001	3200m	239	99	255	129	116	838	599	71.5%	517	1.11
161-002	3230m	131	45	130	78	70	454	323	71.2%	145	1.11
161-003	3260m	336	85	224	142	91	878	541	61.7%	290	1.57
161-005	3290m	355	154	292	161	94	1056	701	66.4%	228	1.71
161-006	3320m	261	119	164	68	39	651	390	60.0%	39	1.73
161-007	3350m	112	19.6	36	20	14.4	202	90	44.6%	25	1.41
161-009	3380m	160	51	71	32	22	336	176	52.4%	80	1.48
161-010	3410m	127	64	45	18.1	21	275	148	53.8%	65	0.88
161-011	3450m	157	98	68	14.5	23	360	203	56.4%	38	0.64
161-012	3470m	94	118	81	12.5	29	335	241	71.9%	36	0.43
161-014	3500m	229	175	334	77	300	1115	886	79.5%	2684	0.26
161-016	3530m	474	420	876	245	1050	3065	2591	84.5%	4889	0.23
161-018	3570m	95	229	419	97	324	1164	1069	91.8%	2122	0.30
161-019	3590m	82	608	1565	328	1316	3899	3817	97.9%	1420	0.25

TABLE 7

SIGNIFICANT RATIOS (%) OF C_{15+} FRACTIONS AND ORGANIC CARBON

GEOCHEM SAMPLE NUMBER		DEPTH	ORGANIC CARBON	HYDROCARBONS / TOTAL EXTRACT	HYDROCARBONS / ORGANIC CARBON	TOTAL EXTRACT / ORGANIC CARBON
161-001		3200m	0.47	20.61	2.45	11.87
161-002		3230m	0.44	23.63	3.23	13.66
161-003		3260m	0.54	28.68	3.57	12.46
161-004	swc	3268m	0.26,0.26	15.44	15.23	98.65
161-005B		3290m	0.53	23.66	15.11	63.89
161-006D		3320m	0.37	18.60	42.16	226.68
161-007		3350m	0.41	16.52	2.37	14.32
161-008	swc	3357m	1.02	23.81	44.70	187.73
161-011		3450m	0.33	27.26	4.67	17.12
161-012		3470m	0.32,0.32	24.27	3.88	15.97
161-013	swc	3490m	0.57	25.36	100.44	395.98
161-014		3500m	0.32	32.34	4.06	12.56
161-015	swc	3525m	0.66	27.28	20.47	75.03
161-016		3530m	0.40	40.75	7.33	17.98
161-017	swc	3555m	0.70,0.70	33.86	20.51	60.59
161-018		3570m	0.38	37.28	3.82	10.24
161-019		3590m	0.40	45.28	7.68	16.95