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THERMAL HISTORY ANALYSIS OF SEVEN SAMPLES FROM THE 35/3-2 WELL, NORWEGIAN NORTH SEA

GEOTRACK REPORT #401

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A report prepared for
Mobil Exploration Norway,
Stavanger, Norway

Report prepared by:	S.J. Marshallsea
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Track length measurements by:	S.J. Marshallsea

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APPENDIX D

Vitrinite Reflectance Measurements

D.1 New vitrinite reflectance determinations

Samples

Sixteen samples from **Norwegian North Sea well 35/3-2** were submitted for vitrinite reflectance determination to Keiraville Konsultants, Australia. Details of these samples are summarised in Table D.2, while results and supporting data are presented in the following pages.

Equipment

Leitz MPV1.1 photometer equipped with separate fluorescence illuminator, Swift point counter. Reflectance standards: spinel 0.42%, YAG 0.91%, GGG 1.72%, SiC standard for cokes and masked uranyl glass for measurement of intensity (I) in fluorescence mode. With the Keiraville Konsultants equipment, it is possible to alternate from reflectance to fluorescence mode to check for associated fluorescing liptinite, or importantly with some samples, to check for bitumen impregnation, or the presence, intensity, and source of oil-cut.

Sample preparation

Samples are normally mounted in cold setting polyester resin and polished using Cr_2O_3 and MgO polishing powders. Epoxy resins or araldite can be used if required. "Whole rock" samples are normally used but demineralisation can be undertaken. Large samples of coals and cokes can be mounted and examined.

Vitrinite Reflectance measurement

The procedure used generally follows Australian Standard (AS) 2486 but has been slightly modified for use with dispersed organic matter (DOM). For each sample, a minimum of 25 fields is measured (the number may be less if vitrinite is rare or if a limited number of particles of vitrinite is supplied, as may be the case with hand-picked samples). If wide dispersal of vitrinite reflectances is found, the number of readings (N) is increased until a stable mean is obtained.

Vitrinite identification is made primarily on textural grounds, and this allows an independent assessment to be made of cavings and re-worked vitrinite populations. Histograms are only used for population definition when a cavings population significantly overlaps the range of the indigenous population. Where such data provides additional information, the mean maximum reflectance of inertinite and/or the mean maximum reflectance of liptinite (exinite) is reported. For each field, the maximum reflectance position is located and the reading recorded. The stage is then rotated by 180° which should give the same reading. In practice, the readings are seldom identical because of stage run-out and slight surface irregularities. If the readings are within ±5% relative, they are accepted. If not, the cause of the difference is sought and the results rejected. The usual source of differences is surface relief. The measurement of both maxima results in a total of 50 measurements being taken for the 25 fields reported. Thus, the 50 readings consist of 25 pairs of closely spaced readings which provide a check on the levelling of the surface and hence additional precision.

As the vitrinite reflectance measurements are being made, the various features of the samples are noted on a check sheet to allow a sample description to be compiled. When the reflectance measurements are complete, a thorough check is made of liptinite fluorescence characteristics. At the same time, organic matter abundance is estimated using a global estimate, a grain count method or point count method as required.

Data presentation

Individual sample results are reported in the following format.

KK No.	Depth (ft)	$\overline{R}_V max$*1	Range*2	N*3
x10324	3106	0.79	0.64 - 0.91	25

*1 Mean of all the maximum reflectance readings obtained.

*2 Lowest Rmax and highest Rmax of the population considered to represent the first generation vitrinite population.

*3 Number of fields measured (Number of measurements = 2N because 2 maximum values are recorded for each field)

Table D.2: Vitrinite reflectance sample details and results - samples from well 35/3-2, Norwegian North Sea (Geotrack Report #401)

Sample number	Depth (m)	Sample type	VR %	N
GC401-8	550	cuttings	0.34	4
GC401-9	880	cuttings	1.34 *2	1
GC401-10	920	cuttings	0.38	2
GC401-11	1150	cuttings	-	-
GC401-12	1400	cuttings	0.45	5
GC401-13	1600	cuttings	0.45	5
GC401-14	1800	cuttings	0.38	1
GC401-15	2000	cuttings	0.47	4
GC401-16	2200	cuttings	0.46	9
GC401-17	2600	cuttings	0.48	5
GC401-18	2800	cuttings	1.02 *2	5
GC401-19	3000	cuttings	0.51	5
GC401-5	3605	core	0.55	31
GC401-20	3695	cuttings	1.64	8
GC401-21	3946	cuttings	0.59	26
GC401-6	4000	core	-	-

Note: Some samples may contain both vitrinite and inertinite. Only vitrinite data is shown for these samples.

*1 See Appendix A for discussion of present temperature data.

*2 Inertinite.

JOB GC 401, 35-32

KK/Ref. No.	Depth(m)/ Type	$\bar{R}_v$ max	Range	N	Description Including Liptinite (Exinite) Fluorescence
					PLIOCENE
v5807	550	0.34	0.19-0.44	4	Rare sporinite and liptodetrinite, yellow to orange.
GC401-8	Ctgs $\bar{R}_I$	1.47	1.00-1.93	5	(Sandstone>silty claystone>carbonate. Coal rare, V>>I>L. Vitrite>inertite. Dom sparse, I>L. Inertinite sparse, liptinite rare, vitrinite rare. Oil drops rare, greenish yellow. Mineral fluorescence pervasive, faint green. Glauconite rare. Mud additives sparse. Iron oxides sparse. Pyrite rare.)
					PLIOCENE-MIOCENE
v5808	880	-	-	-	Rare lamalginite and liptodetrinite, yellow. (Sandstone>
GC401-9	Ctgs $\bar{R}_I$	1.34	-	1	carbonate. Dom rare, L>I. Liptinite and inertinite rare, vitrinite absent. Oil drops rare, greenish yellow. Mineral fluorescence pervasive, faint green. Glauconite common. Iron oxides rare. Pyrite sparse.)
v5809	920	0.38	-	2	Sparse lamalginite, yellow, rare sporinite, yellow to orange,
GC401-10	Ctgs $\bar{R}_I$	1.59	1.00-2.00	10	rare liptodetrinite, yellow. Coal rare, V>>L>I. Vitrite = clarite. Dom sparse, I=L. Inertinite and liptinite sparse, vitrinite absent. Oil drops rare, greenish yellow. Mineral fluorescence pervasive, faint green to moderate orange. Glauconite sparse. Fossil fragments sparse. Mud additives common. Iron oxides sparse. Pyrite common.)
v5810	1150	-	-	-	Rare lamalginite and liptodetrinite, yellow. (Sandstone>
GC401-11	Ctgs $\bar{R}_I$	-	-	-	calcareous siltstone>carbonate. Dom rare, L only. Mineral fluorescence pervasive, faint green. Glauconite rare. Fossil fragments rare. ?Cavings rare (Rv 0.17-0.19). Iron oxides common. Pyrite abundant.)
v5811	1400	0.45	0.36-0.56	5	Sparse lamalginite, yellow to orange. (Carbonate>calcareous
GC401-12	Ctgs				siltstone>>coal. Coal rare, vitrinite only. Vitrite only. Dom sparse, L>I>V. Liptinite and inertinite sparse, vitrinite rare. Mineral fluorescence pervasive, dull green to orange. Iron oxides sparse. Pyrite common.).
v5812	1600	0.45	0.40-0.49	5	Sparse lamalginite, yellow to orange, liptodetrinite rare,
GC401-13	Ctgs				yellow . (Carbonate. Dom sparse, L>I>V. Liptinite and inertinite sparse, vitrinite rare. Shell fragments sparse. Mineral fluorescence pervasive, green to orange. Iron oxides sparse. Glauconite sparse. Pyrite abundant.).
v5813	1800	0.38	-	1	Sparse lamalginite and liptodetrnite, yellow to orange.
GC401-14	Ctgs $\bar{R}_I$	1.00	0.81-1.40	8	(Carbonate>calcareous siltstone. Dom common, L>I>>V. Liptinite and inertinite sparse, vitrinite rare. Shell fragments sparse. Iron oxides sparse. Pyrite abundant.)

JOB GC #401, WELL 35-32 (CONTINUED)

KK/Ref. No.	Depth(m)/ Type	$\bar{R}_v$ max	Range	N	Description Including Liptinite (Exinite) Fluorescence
v5814	2000	0.47	0.39-0.54	4	Sparse lamalginite, yellow to orange, rare liptodetrnite, yellow
GC401-15	Ctgs $\bar{R}_I$	1.08	0.78-1.41	11	to orange. (Calcareous, silty claystone>carbonate>sandstone. Dom common, I=L>>V. Inertinite and liptinite sparse, vitrinite rare. Mineral fluorescence pervasive, faint green to orange. Coal cavings rare, $\bar{R}_v$ of about 0.21%. Shell fragments sparse. Glauconite sparse. Iron oxides abundant. Pyrite abundant.)
v5815	2200	0.46	0.42-0.53	9	Common sporinite and ?lamalginite, yellow to orange, rare
GC401-16	Ctgs				liptodetrinite, yellow to orange. (Calcareous, silty claystone>carbonate. Dom common, L>I>V. Liptinite common, inertinite sparse, vitrinite rare. Mineral fluorescence pervasive, faint green to orange. Coal cavings rare, $\bar{R}_v$ of about 0.31%. Forams and shell fragments sparse. Glauconite sparse. Iron oxides common. Pyrite abundant.)
					SANTONIAN-TURONIAN
v5816	2600	0.48	0.43-0.53	5	Rare lamalginite and liptodetrnite, yellow to orange.
GC401-17	Ctgs				(Carbonate>calcareous, clayey siltstone>sandstone. Dom sparse, I>L>V. Inertinite sparse, liptinite and vitrinite rare. Mineral fluorescence pervasive, moderate yellow to dull orange. Mud additives rare. Coal and siltstone cavings rare, $\bar{R}_v$ ranges from 0.27 to 0.33%. Forams and shell fragments sparse. Glauconite sparse. Iron oxides abundant. Pyrite abundant.)
v5817	2800	-	-	-	Rare lamalginite and liptodetrnite, yellow to orange.
GC401-18	Ctgs $\bar{R}_I$	1.02	0.76-1.21	5	(Cuttings probably from a turbodrill. If this is correct, the reflectance cannot be determined. Carbonate>calcareous, silty claystone>sandstone. Dom rare, L>I. Liptinite and inertinite rare, vitrinite absent. Mineral fluorescence weak to absent from most grains, moderate orange from about 10% of grains. If the non-fluorescing grains are not from a turbodrill, it is possible that they are thermally altered and the moderately fluorescing grains represent a cavings population. If this is the case, the inertinite reported is probably from a cavings populations. Forams and shell fragments rare. Iron oxides abundant. Pyrite abundant.)
v5818	3000	0.51[1]	0.44-0.68	5	Rare lamalginite and liptodetrnite, yellow to orange.
GC401-19	Ctgs $\bar{R}_I$	1.27[1]	0.76-1.75	10	(Cuttings probably from a turbodrill. If this is correct, the reflectance cannot be determined. Carbonate>calcareous, silty claystone>siltstone. Dom sparse, I>L>V. Inertinite sparse, liptinite and vitrinite rare. Mineral fluorescence weak to absent from most grains, moderate orange from about 10% of grains. If the non-fluorescing grains are not from a turbodrill, it is possble that they are thermally altered and the moderately fluorescing grains represent a cavings population. Both the vitrinite and the inertinite reported is probably from a cavings populations. Mineral fluorescence pervasive, moderate yellow to dull orange. Coal cavings rare, $\bar{R}_v$ of about 0.25%. Forams and shell fragments sparse. Glauconite rare. Iron oxides abundant. Pyrite abundant.)

1 Probably cavings

JOB GC #401, WELL 35-32 (CONTINUED)

KK/Ref. No.	Depth(m)/ Type	$\bar{R}_v$ max	Range	N	Description Including Liptinite (Exinite) Fluorescence
					UPPER ALBIAN
v5819 GC401-5	3605.1 Core	0.55	0.40-0.68	31	Abundant lamalginite, yellow to orange, sparse liptodetrinite, yellow to orange. (Siltstone>sandstone. Dom major, V>I>L. All three maceral groups abundant. Mineral fluorescence pervasive, faint green to dull orange. Iron oxides rare. Pyrite abundant.)
					MIDDLE ALBIAN-UPPER APTIAN
v5820 GC401-20	3695 Core	?1.64	1.41-1.77	?8	Fluorescing liptinite absent. (Thermally altered calcareous siltstone. Dom common, I>?V. Inertinite common, ?vitrinite rare, liptinite absent. Mineral fluorescence very weak and the conclusion that the sample is thermally altered is based on the fluorescence characteristics of the mineral matter. Glauconite rare. Fossil fragments common. Vitrinite with a reflectance of 0.44 - 0.60% is present in mud cake in a crack. Iron oxides sparse. Pyrite rare.)
					LOWER BAJOCIAN-MIDDLE TORCIAN
v5821 GC401-21	3946 Core	0.59	0.46-0.73	26	Common lamalginite, yellow to orange, sparse liptodetrinite, yellow to orange. (Calcareous siltstone. Dom abundant, I>L>V. All three maceral groups common. Mineral fluorescence patchy ranging from weak green to moderate orange. Iron oxides sparse. Pyrite abundant.)

SAGLAB RESULTS MANAGEMENT : VITRINITE ANALYSIS RESULTS

Data for Well 35/3-2 Page 1

Type	St.Depth	En.Depth	VRo 1	Pop	VRo 2	Pop	VRo 3	Pop	Sample ID	Dup
CUT	0.00	2410.00	.47	7	.63	3			27811	1
SWC	2410.10	2410.10	.73	3					27813	1
SWC	3162.00	3162.00	.49	5					27379	1
SWC	3336.00	3336.00	.34	1	.45	5			27383	1
SWC	3391.00	3391.00	.54	4					27385	1
SWC	3468.50	3468.50	.50						27387	1
SWC	3477.00	3477.00	.39	1	.48	1			27389	1
SWC	3477.10	3477.10	.61	1					27815	1
SWC	3483.00	3483.00	.34	1	.62	4			27391	1
UNS	0.00	3593.10	.96	4					27817	1
CUT	3593.00	3620.00	.42	4	.63	12			27819	1
SWC	3653.00	3653.00	.61	1	.50	3			27399	1
SWC	3671.00	3671.00	.64	2					27401	1
SWC	3750.00	3750.00	.71	1	.54	1			27405	1
CUT	3746.00	3776.00	.58	15	.81	5			27821	1
SWC	3830.00	3830.00	.71	14	.57	5			27411	1
UNS	0.00	3830.10	.88	2					27823	1
SWC	3898.00	3898.00	1.18	3	.62	2			27415	1

SAGLAB RESULTS MANAGEMENT : VITRINITE ANALYSIS RESULTS

Data for Well 35/3-2 Page 2

Type	St.Depth	En.Depth	VRo 1	Pop	VRo 2	Pop	VRo 3	Pop	Sample ID	Dup
SWC	3922.00	3922.00	.69	18	.48	3			27417	1
CUT	0.00	3965.00	.35	1	.54	20			27419	1
SWC	3980.00	3980.00	.55	20					27421	1
SWC	4033.50	4033.50	.66	20					27423	1

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1 Introduction

This report gives the result of vitrinite reflectance analyses performed on 47 cuttings samples and 4 core samples from well 35/3-2 offshore Norway. The report is a revision of a previous report IFE/KR/F-92/066) in that the four core samples are included.

2 Material

The samples were provided from the client as washed cuttings and core chips respectively.

3 Analytical techniques

The samples were treated with hydrochloric or hydrofluoric acid prior to further preparation in order to concentrate the organic material and ensure good polishing quality. The core samples were not treated any acid prior to further prepration. They were embedded as bulk rock. Both sample types were polished using 0.25 micron diamond paste and magnesium oxide as the two final steps. The polishing quality obtained was quite satisfactory.

The analytical equipment being used was a Zeiss MPM 03 photometer microscope equipped with an Epiplan-Neofluoar 40/0.90 oil objective. The sensitive measuring spot was about 2.5 micron in diameter, and the measurements were made through a green band pass filter (546 nm) and in oil immersion. The readings were made without a polarizer and using a stationary stage. On each sample about 20 points were measured, if possible. A representative population was selected among the readings, and an arithmetic mean was calculated for this population.

4 Results

The vitrinite reflectance results are given in Table 1. Histograms for each sample are given in Appendix. Vitrinite reflectance versus depth plots on linear and log scales are given in Figure 1 and 2 respectively.

Table 1. Vitrinite reflectance data

Sample code IFE	Sample depth mrkb	type	Sample lithology	Vitrinite reflectance %Rm	±std	(N)	Sample quality	Preparation
SA 327	470	cut	clst	0.13	±0.04	(16)	oo---	HF
SA 328	570	cut	clst	0.24	±0.06	(20)	oo-oo	HF
SA 329	670	cut	clst				Barren	HF
SA 330	770	cut	clst				Barren	HF
SA 331	870	cut	clst	0.20	±0.03	(8)	-o---	HF
SA 332	970	cut	clst	0.26	±0.06	(20)	o-oo-	HF
SA 333	1070	cut	clst	0.27	±0.05	(20)	o-oo-	HF
SA 334	1170	cut	clst	0.24	±0.05	(20)	oo---	HF
SA 335	1270	cut	clst	0.26	±0.06	(20)	oo-o-	HF
SA 336	1370	cut	clst	0.27	±0.05	(20)	-o---	HF
SA 337	1470	cut	clst	0.33	±0.06	(20)	ooo--	HF
SA 338	1570	cut	clst				Barren	HF
SA 339	1670	cut	clst	0.36	±0.04	(20)	ooooo	HF
SA 340	1770	cut	clst	0.32	±0.05	(21)	-oo-o	HF
SA 341	1870	cut	clst	0.37	±0.04	(16)	ooooo	HF
SA 342	1970	cut	clst	0.40	±0.07	(21)	ooooo	HF
SA 343	2070	cut	clst	0.30	±0.07	(20)	LIGN.CONT.	HF
SA 344	2170	cut	clst	0.40	±0.04	(11)	o±ooo	HF
SA 345	2270	cut	clst	0.36	±0.05	(14)	o±ooo	HF
SA 346	2370	cut	clst	0.42	±0.07	(11)	-oooo	HF
SA 347	2470	cut	clst	0.43	±0.04	(9)	-oooo	HF
SA 348	2570	cut	clst	0.44	±0.04	(10)	-oooo	HF
SA 349	2670	cut	clst	0.58	±0.06	(13)	-+o-o	HF
SA 350	2770	cut	clst	0.58	±0.06	(13)	ooooo	HF
SA 351	2870	cut	clst				Barren	HF
SA 352	2970	cut	clst	0.59	±0.07	(16)	-±+o-	HF
SA 353	3070	cut	clst	0.61	±0.06	(13)	-oooo	HF
SA 354	3170	cut	clst	0.68	±0.06	(11)	-++o-	HF
SA 355	3270	cut	clst	0.58	±0.05	(10)	-±+o-	HF
SA 356	3370	cut	clst				Barren	HF
SA 357	3470	cut	clst	0.73	±0.07	(16)	-+o-o	HF
SA 358	3569	cut	clst	0.63	±0.08	(21)	o+o-o	HF
SA 596	3633.1	core	clst	0.63	±0.08	(2)	-±±oo	HF
SA 597	3635.4	core	clst				Barren	HF
SA 598	3640.3	core	clst	0.79	±0.06	(7)	-±ooo	HF
SA 359	3668	cut	clst	0.65	±0.07	(20)	ooo-o	HF
SA 599	3696.0	core	clst	0.90		(1)	-±±oo	HF
SA 360	3740	cut	clst	0.73	±0.05	(11)	oo+oo	HF
SA 361	3761	cut	clst	0.69	±0.07	(20)	oo+oo	HF
SA 362	3779	cut	clst	0.68	±0.07	(20)	oo+oo	HF
SA 363	3800	cut	clst	0.69	±0.06	(20)	oo+oo	HF
SA 364	3821	cut	clst	0.66	±0.08	(21)	oo+oo	HF
SA 365	3842	cut	clst	0.66	±0.09	(20)	oo+oo	HF
SA 366	3860	cut	clst	0.65	±0.05	(10)	-o+-o	HF
SA 367	3881	cut	clst	0.69	±0.05	(17)	-±±o-	HF
SA 368	3902	cut	clst				Barren	HF
SA 369	3920	cut	clst				Barren	HF
SA 370	4019	cut	clst	0.69	±0.05	(17)	-±±o-	HF
SA 371	4121	cut	clst	0.66	±0.06	(13)	-±±o-	HF
SA 372	4220	cut	clst				Barren	HF
SA 373	4319	cut	clst				Barren	HF

LEGEND

Rm : mean random reflectance in oil
Std: standard deviation **clst**: claystone
N : number of readings

CODE FOR DATA QUALITY

The sample quality is characterized by five items as follows:

ooooo
1 : abundance of vitrinite
2 : identification of vitrinite
3 : type of vitrinite
4 : particle size
5 : particle surface quality

+ : may give a too high vitrinite reflectance value
o : has no effect on the resulting vitrinite reflectance
- : may give a too low vitrinite reflectance value

An ideal sample is characterized as follows: ooooo