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Title
A Reservoir Geochemical Evaluation of the Upper Jurassic sandstones in well 34/4-3

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3 Dataset

A total of 14 sandstone samples was picked from the cored interval of the Upper Jurassic sandstones. Previous data suggested that the degree of staining in the sandstones is very low, and no obvious hydrocarbon staining or odour was present in the cores. However, several zones in the well appear to have thin (2-25 mm thick) oil stained zones. These zones are often present directly below thin shale lamina and during the sampling only sandstones with light brown staining were selected (Tab. 1).

To confirm whether the core extracts have a local origin or not, the bulk core extract and an extract from the shale fraction of two samples from 34/4-3 (3567.4 and 3580.25 mRKB) were analysed by GC and GC-MS.

The two samples from well 34/4-5 (3568.0 and 3600 mRKB) were analysed in the same batch as DST 1 from 34/4-6 to allow a calibration with the other data set.

Sample batch 1, 23/8-94:	34/4-3	3569.9, 3576.75 and 3581.5 mRKB core samples, sst.
	34/4-6	DST 1
Sample batch 2, 11/9-94:	34/4-3	3567.4, 3580.25 mRKB core samples, bulk
Sample batch 3, 12/9-94:	34/4-6	DST 1
	34/4-5	3568.0 and 3600.0 mRKB core samples, sst.
Sample batch 4, 23/9-94:	34/4-3	3567.4, 3580.25 mRKB core samples, shale

Table 1 Sample description.

Depth, mRKB	Sample description
3567.5	Thin zone with light brown staining in sand between thin shale laminae
3568.7	Thin zone with light brown staining in sand between thin shale laminae
3569.9	Thin zone with light brown staining in sand between thin shale laminae
3570.7	10 mm oil staining below 8 mm thick shale
3571.4	Light brown sandstone
3572.8	10 mm oil staining below 2 mm thick shale
3575.55	10 mm oil staining below 8 mm thick shale
3575.8	7 mm oil staining in sandstone interval
3575.9	8 mm oil staining
3576.5	15 mm oil staining below thin shale
3576.75	8 mm oil staining
3577.7	8 mm oil staining between two shale lamina
3579.9	10 mm oil staining below 20 mm shale lamina with sandstones
3581.5	25 mm thick oil stained zone below thin shale

All samples were analysed by Iatroscan TLC-FID and three samples were selected for GC-FID and GC-MS analyses (Tab. 2). These three samples were analysed in batch with a sample from the Snorre Field (34/4-6 DST 1) to allow an oil-oil correlation with the nearest oil discovery.

Table 2 Geochemical data.

Depth, mRKB	TLC-FID	GC-FID	GC-MS	Isotopes
3567.5	x			
3568.7	x			
3569.9	x	x	x	x
3570.7	x			
3571.4	x			
3572.8	x			
3575.55	x			
3575.8	x			
3575.9	x			
3576.5	x			
3576.75	x	x	x	x
3577.7	x			
3579.9	x			
3581.5	x	x	x	x
34/4-6 DST 1		x	x	x

4 Iatroscan (TLC-FID) screening

A total of 14 samples in the interval 3567.5 to 3581.5 mRKB were screened by Iatroscan (TLC-FID) to detect traces of extractable hydrocarbons. All samples, with the exception of the sample from 3575.55 mRKB, contain significant concentrations of extractable hydrocarbons (Tab. 3), and the generally high relative content of saturated hydrocarbons suggest that the extracts represent migrated hydrocarbons and are not indigenous.

Table 3 Iatroscan (TLC-FID) Screening

Depth mRKB	EOM mg/g	Sat mg/g	Aro mg/g	Polars mg/g	Sat %	Aro %	Polars %	Sat/Aro	S/(S+A)
3567.5	1.58	0.78	0.16	0.64	49.36	10.12	40.50	4.87	0.82
3568.7	1.45	0.69	0.17	0.59	47.58	11.72	40.68	4.05	0.80
3569.9	**3.63**	**1.51**	**0.36**	**1.75**	**41.59**	**9.91**	**48.20**	**4.19**	**0.80**
3570.7	2.07	0.94	0.18	0.95	45.41	8.69	45.89	5.22	0.83
3571.4	0.4	0.17	0.06	0.16	42.50	15.00	40	2.83	0.73
3572.8	4.02	1.55	0.31	2.17	38.55	7.71	53.98	5	0.83
3575.55	0.04	0	0	0.04	0	0	100.00	0	0
3575.8	2.88	1.41	0.24	1.23	48.95	8.33	42.70	5.87	0.85
3575.9	1.58	0.91	0.12	0.55	57.59	7.59	34.81	7.58	0.88
3576.5	3.62	1.92	0.54	1.16	53.03	14.91	32.04	3.55	0.78
3576.75	**4.32**	**2.14**	**0.67**	**1.5**	**49.53**	**15.50**	**34.72**	**3.19**	**0.76**
3577.7	5.18	2.71	0.68	1.78	52.31	13.12	34.36	3.98	0.79
3579.9	1.69	0.8	0.45	0.44	47.33	26.62	26.03	1.77	0.64
3581.5	**3.23**	**2.38**	**0.2**	**0.65**	**73.68**	**6.19**	**20.12**	**11.90**	**0.92**

Based on the compound class distribution alone, it is not possible to decide whether the petroleum has been generated from local shales or migrated into the sandstones from the adjacent basin.

5 GC-FID analysis

Three samples (3569.9, 3576.75 and 3581.5 mRKB core depth, highlighted in Tab. 3) were selected for detailed analysis by GC-FID, GC-MS and carbon isotope signature. These samples were analysed in the same batch as an oil sample from the Snorre Field (34/4-6 DST 1), to allow an oil-oil correlation to be performed.

All the selected samples have high saturated/aromatic hydrocarbon ratios and more than 40% saturated hydrocarbons, suggesting that they represent migrated hydrocarbons (Tab. 4).

Table 4 Iatroscan (TLC-FID) screening and selected GC parameters

Depth mRKB	EOM mg/g	Sat %	Aro %	Polars %	Sat/Aro	Pr/ nC_{17}	Ph/ nC_{18}	Pr/Ph
3569.9	3.63	41.59	9.91	48.20	4.19	1.01	0.82	1.37
3576.75	4.32	49.53	15.50	34.72	3.19	1.41	0.92	1.17
3581.5	3.23	73.68	6.19	20.12	11.90	1.02	0.73	1.11
34/4-6						0.76	0.53	1.69

Table 5 Stable carbon isotope signature (IFE, Kjeller)

Well	Depth, mRKB	EOM mg/g	Sat %	$\delta^{13}C$ Sat	$\delta^{13}C$ Aro	Pr/Ph	CPI
34/4-3	3569.9	3.63	41.59	-31.5	-30.5	1.37	0.97
34/4-3	3576.75	4.32	49.53	-31.9	-31.2	1.17	0.94
34/4-3	3581.5	3.23	73.68	-31.2	-29.9	1.11	1.03
34/4-5	DST 1			-30.0	-29.0		
34/4-5	DST 2			-29.9	-28.8		
34/4-5	3568			-30.0	-28.9		
34/4-5	3600			-29.9	-29.9		

Biological marker identification

Hopanes

Q/E	C_{23} Tri-cyclic terpane/30αβ
Ts/Tm	27Ts/27Tm
Z/C	28αβ/29αβ
C'/C'+C	29Ts/(29Ts+29αβ)
Z/(Z+E)	28αβ/(28αβ+30αβ)
B/E	27Tm/30αβ
Z/E	28αβ/30αβ
C/E	29αβ/30αβ
(J1+ J2)/E	(32αβS+32αβR)/ 30αβ
X/X+F	30D/(30D+30βα)
X/X+ba	30D/(30D+29βα)
X/X+E	30D/(30D+30αβ)
ab/ab+ba	30αβ/(30αβ+30βα)
%22S	32αβS/(32αβS+32αβR)
C27hop	(27Ts+27Tm)/(27Ts+27Tm+28αβ+29αβ+29Ts+29βα)
C28hop	28αβ/(27Ts+27Tm+28αβ+29αβ+29Ts+29βα)
C29hop	(29αβ+29Ts+29βα)/(27Ts+27Tm+28αβ+29αβ+29Ts+29βα)
C27hop/C29hop	(27Ts+27Tm)/(29αβ+29Ts+29βα)
M1+M2/L1+L2	(35αβS+35αβR)/(34αβS+34αβR)

Steranes

%20S	29ααS/(29ααS + 29ααR)
%bb	29ββS + 29ββR)/(29ααS + 29ααR + 29ββS + 29ββR)
a/a+j	27dβS/(27dβS+27ααR)
C27St	27ββ20S/(27ββ20S +28ββ20S+29ββ20S)
C28St	28ββ20S/(27ββ20S +28ββ20S+29ββ20S)
C29St	29ββ20S/(27ββ20S +28ββ20S+29ββ20S)
C27StC29St	27ββ20S/29ββ20S

Hopanes and steranes

SHI	C29 steranes/ΣC30 hopanes
DiaSt/DiaHo	27dβS/30D
Maturity	(27Ts/27Tm) + (30d/(30d+30βα)) + (29Ts/(29Ts + 29αβ)) + (29ααS/(29ααS + 29ααR)) + ((29ββS + 29ββR)/(29ααS + 29ααR + 29ββS + 29ββR)) + (27dβS/(27dβS + 27ααR)]/6

0 WELL NAME	1 BATCH	2 FIELD	3 CONS.	4 UPPER DEPTH	5 DEPTH	6 LITH	7 TYPE	8 Comment	9 Q/E	10 Ts/Tm	11 Z/C	12 C'/C'+C	13 Z/(Z+E)
1 34/4-3	Batch 1	34/4	SAG	3569.90	3569.90	SST	CCP	On column	0.06	0.70	0.24	0.26	0.10
2 34/4-3	Batch 1	34/4	SAG	3576.75	3576.75	SST	CCP	On column	0.04	0.63	0.31	0.27	0.12
3 34/4-3	Batch 1	34/4	SAG	3581.50	3581.50	SST	CCP	On column	0.07	1.93	0.24	0.37	0.08
4 34/4-6	Batch 1	SNORRE	SAG	2577.00	2585.00	DST 1	OIL	On column	0.07	1.76	0.64	0.33	0.21
5													
6 34/4-3	Batch 2	34/4	SAG	3567.40	3567.40	SLTYSST	CCP	On column	0.07	0.65	0.21	0.28	0.09
7 34/4-3	Batch 2	34/4	SAG	3580.25	3580.25	SLTYSST	CCP	On column	0.08	0.79	0.21	0.27	0.09
8													
9 34/4-5	Batch 3	ZETA	SAG	3568.00	3568.00	SST	CCP	On column	0.08	1.66	0.53	0.30	0.19
10 34/4-5	Batch 3	ZETA	SAG	3600.00	3600.00	SST	CCP	On column	0.07	1.65	0.54	0.30	0.19
11 34/4-6	Batch 3	SNORRE	SAG	2577.00	2585.00	DST 1	OIL	On column	0.08	1.87	0.61	0.33	0.21
12													
13 34/4-3	Batch 4	34/4	SAG	3567.40	3567.40	SHALE	CCP	On column	0.07	0.66	0.23	0.28	0.10
14 34/4-3	Batch 4	34/4	SAG	3585.25	3580.25	SHALE	CCP	On column	0.05	0.75	0.18	0.29	0.07

0 WELL NAME	14 B/E	15 Z/E	16 C/E	17 J1+J2 E	18 X X+F	19 X/X+ba	20 X/X+E	21 ab/ab+ba	22 %22S	23 SHI	24 C27hop	25 C28hop
1 34/4-3	0.16	0.11	0.47	0.68	0.26	0.49	0.06	0.85	0.58	0.48	25.41	10.42
2 34/4-3	0.15	0.14	0.45	0.71	0.25	0.46	0.06	0.85	0.57	0.59	23.26	12.96
3 34/4-3	0.10	0.08	0.34	0.67	0.58	0.78	0.13	0.90	0.59	0.41	30.86	8.59
4 34/4-6	0.11	0.27	0.42	0.52	0.55	0.62	0.11	0.91	0.59	0.51	24.24	20.91
5												
6 34/4-3	0.18	0.10	0.46	0.77	0.29	0.53	0.07	0.85	0.58	0.53	26.69	8.78
7 34/4-3	0.17	0.10	0.48	0.67	0.31	0.51	0.07	0.86	0.57	0.54	26.50	9.19
8												
9 34/4-5	0.12	0.24	0.44	0.50	0.55	0.63	0.10	0.91	0.58	0.43	25.45	18.86
10 34/4-5	0.12	0.23	0.43	0.51	0.55	0.67	0.11	0.91	0.59	0.44	25.39	18.89
11 34/4-6	0.11	0.26	0.43	0.52	0.56	0.62	0.11	0.91	0.59	0.50	24.93	20.29
12												
13 34/4-3	0.21	0.11	0.47	0.65	0.27	0.47	0.06	0.85	0.59	0.45	29.79	9.12
14 34/4-3	0.14	0.07	0.39	0.83	0.32	0.55	0.06	0.87	0.58	0.28	25.93	7.82

0 WELL NAME	26 C29hop	27 C27Hop C29Hop	28 M1+M2 L1+L2	29 %20S	30 %bb	31 a/a+j	32 C27st	33 C28st	34 C29st	35 C27St C29St	36 DisSt DiaHo	37 Maturity
1 34/4-3	64.17	0.40	1.33	0.45	0.42	0.54	33.33	34.62	32.89	1.04	4.38	0.44
2 34/4-3	63.79	0.36	1.12	0.44	0.39	0.51	31.36	33.12	34.69	0.88	4.10	0.42
3 34/4-3	60.55	0.51	1.03	0.49	0.59	0.73	33.96	33.28	32.93	1.04	2.10	0.78
4 34/4-6	54.85	0.44	0.83	0.51	0.58	0.64	31.83	32.64	34.53	0.90	1.93	0.73
5												
6 34/4-3	64.53	0.41	1.15	0.44	0.39	0.55	33.44	34.94	32.70	1.06	4.41	0.43
7 34/4-3	64.31	0.41	1.10	0.45	0.42	0.53	33.45	33.61	33.16	1.02	4.13	0.46
8												
9 34/4-5	55.69	0.46	0.87	0.52	0.62	0.74	31.44	31.91	34.99	0.86	2.13	0.73
10 34/4-5	55.73	0.46	0.89	0.52	0.62	0.72	30.65	32.23	35.39	0.83	1.96	0.73
11 34/4-6	54.78	0.46	0.81	0.50	0.59	0.64	32.64	31.99	34.21	0.92	2.02	0.75
12												
13 34/4-3	61.09	0.49	1.11	0.44	0.38	0.51	34.45	35.45	31.80	1.14	3.95	0.42
14 34/4-3	66.26	0.39	1.19	0.47	0.40	0.49	32.57	33.27	33.86	0.95	1.62	0.45

0 WELL NAME	39 LOADED
1 34/4-3	940907
2 34/4-3	940907
3 34/4-3	940907
4 34/4-6	940907
5	
6 34/4-3	940920
7 34/4-3	940920
8	
9 34/4-5	940920
10 34/4-5	940920
11 34/4-6	940920
12	
13 34/4-3	941003
14 34/4-3	941003