

5.2 FMT and Test Summary

5,2.1 Reservoir pressure

Prior to setting 9 5/8" casing, the formation multi-tester was run in the hole to define the reservoir pressure and reservoir fluid gradient and to get bottom hole samples of the reservoir fluid. The results indicate a gas gradient of 1.210 KPa/m (SG = 0.123) with a pore pressure equivalent to 1.06 g/cc at top reservoir (1519 m RKB) decreasing to normal pressure at the hydrocarbon/ water contact at 1572.5 m RKB. Below the contact the reservoir is normally pressured with a water gradient of 10.3 KPa/M (SG = 1.05 g/cc).

The results are presented in Fig. 5.1.

No oil gradient could be established due to the thinness of the oil layer which is estimated to be between 2 to 3 meters.

From the production test a reservoir pressure of 15784 KPa was recorded at 1526 m RKB. This pressure confirms the FMT results.

5.2.2 Reservoir Temperature

Before opening for multirate flow during test 1A, the temperature/pressure gauges were run in the hole on wireline. A stable temperature of 62.2°C at 1526 m RKB was recorded during the time before opening the well.

5.2.3 Test Performance

A. Test no. 1

The test was unsuccessful due to the downhole gauges being stuck 8 meters above the planned setting depth

thus obstructing the well stream. The gauges acting as a downhole choke plus freezing problems in the SSTT and STT, resulted in unstable production conditions and the data obtained was therefore unrepresentative.

B. Test no. 1A

Test no. 1A was the retest of the same gravel packed interval. The test consisted of one acid treatment, one multirate test and three Nautilus flow periods. The use of 5" tubing, 4" coflexip hose from the STT to the choke manifold and a 5000 psi heat exchanger with low flow restriction gave high flowrates, but compared to earlier testing at the Troll field, the pressure drop across the gravelpack was very high (21541 KPa at a rate of $1266 \times 10^6 \text{ Sm}^3/\text{D}$). Damage to the gravel pack plus turbulent flow were major contributors to this pressure drop.

No operational problems were encountered under the gravel packing operation but the perforations and the gravelpack itself were undoubtedly damaged whilst killing the well after perforating and again when the first test was aborted. In both cases contaminated fluid from the annulus was pumped into the formation.

During the multirate test on 96/64" choke freezing occurred in the SSTT and in the surface lines. This freezing caused unstable surface pressures and decreasing gas rates.

With the Nautilus sampling manifold connected to the flowline hydrates formed in the choke manifold at both high and low flowrates. Three sampling periods were therefore needed before representative PVT samples and flow data were obtained.

Water lost to the formation during acid treatment and killing operations resulted in hydrate formation.

Efficient removal of this water was impossible due to the lifting capacity of the 5" tubing.

Glycol/methanol injection pumps were used on the SSTT and on the choke manifold had insufficient capacity to prevent the formation of hydrates.

A summary of the test results are presented in Tab. 5.2.

Table 5.2 Summary of test results, test no. 1A

Perf. interval:	1558 - 1568 m RKB			
Choke size (inch):	32/64	48/64	64/64	96/64
Gas rates ($10^3 \text{Sm}^3/\text{D}$):	467	788	1049	1266
Bottomhole flowing pressure (KPA):	15303	14850	14250	13630
Permeability thickness ($\mu\text{m}^2 \text{ m}$):	59.379			
Permeability (μm^2):	4.750	(4813 mD)		
Skinfactor:	88.89*			
IT-factor (SM^3/D) ⁻¹	2.995 E-4*			
Static res. pressure (KPA):	15784 (at 1526 m RKB)			
Static res. temp. (°C):	62.2 (at 1526 m RKB)			

* Based on Pseudopressure analysis

DRILLING MUD RECAP

WELL NAME: 31/6-5, TROLL.

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MUD PROPERTY RECAP

DATE	DEPTH feet XXX metres	DENSITY PPG/ Spcf/ SG	VISC- OSITY secs	FILTRATE ccs	HT/HP filt		pH	RHEOLOGY				FILTRATE ANALYSIS					RETORT ANALYSIS			C E C	OTHER			H ₂ S GGT					
					Cake 1"/hr	°500psi 32/hr		PV cp	YP lbs/100ft ² -gm/100	10" rpm	10' rpm	Cl mg/litre	Ca ppm	Pf	Mf	Mg ppm	Oil %	Water %	Solids %	PPB Bent. Eq.	HDS ppb	LDS ppb	KCl ppb						
17/3	392	1.08	130					26	68	16	22																		
18/3	394	1.05	65	34	3		9.0	12	46	10	16	12000	380				0	96	4										
19/3	431	1.05	40	36	3		9.2	7	24	14	16	10000	360				0	96	4										
20/3	552	1.07	39	46	3		9.0	6	25	15	17	11000	360				0	95	5			0			42				
21/3	653	1.05	35	38	3		8.9	5	18	11	14	10000	440				0	96	4			0			32				
22/3	653	1.06	40	42	3		8.8	6	19	14	16	9000	440				0	95	5			0			38				
23/3	653	1.05	56	NC	4		10.0	10	24	11	15	9000	440	.1	.2		0	95	5			0			38				
24/3	UR526	1.05	62	NC	4		10.0	11	27	11	18	9000					0	95	5			0			27				
25/3	UR630	1.05	50	NC	4		11.7	11	47	12	16	9000					0	95	5			0			27				
26/3																													
27/3				MIXING		KCl/POLYMER MUD																							
28/3	664	1.08	56	NC	1		7.8	14	22	6	7	62000	32			120	0	95	5	0		0			0		50		
29/3	649	1.09	54	NC	1		7.8	13	22	6	7	62000	120			32	0	95	5	0		0			0		50		
30/3	630	1.10	54	42	1		8.1	14	22	7	9	62000	125			75	0	94	6	0						50			
31/3	790	1.23	45	9.5	1		9.1	14	21	5	8	63000	250	.3	.8	150	0	90.5	9.5	4		57			4		49	0	
1/4	1076	1.23	48	8.6	1/2		8.6	17	21	5	12	65000	320	.1	.3	200	0	88	12	10		53			10		50	0	
2/4	1265	1.26	49	7.6	1/2		8.4	22	28	5	16	62000	180	.3	.8	120	0	88	12	12.5		59			16		48	0	
3/4	1389	1.26	54	5.7	1/2		8.6	22	28	7	25	67000	120	.2	.5	120	0	88	12	13		59			17		49	0	
3/4	1445	1.27	55	5.3	1/2		8.3	24	22	6	23	70000	120	.2	.85	460	0	88	12	15		40			30		48		

MUD PROPERTY RECAP

DATE	DEPTH feet metres	DENSITY XXX Spcf/ SG	VISC- OSITY secs	FILTRATE		HT/HP filt		pH	RHEOLOGY				FILTRATE ANALYSIS				RETORT ANALYSIS			CEC PPB Bent. Eq.	OTHER			H ₂ S GGT	
				Cake 1"/32"	°500psi 32/HR	PV cp	YP lbs/100ft ²		10" gms/100 cm ²	10' gms/100 cm ²	Cl mg/litre	Ca ppm	PI	MI	Mg ppm	Oil %	Water %	Solids %	HDS ppb		LDS ppb	KCl ppb			
																							ccs		ccs
4/4	1445	1.27	55	6.0	1/2			8.3	21	20	4	21	70000	120	.2	.7	460	0	88	12	14	40	30	50	
5/4	1445	1.27	52	5.5	1/2			8.5	20	17	4	20	69000	80	.2	.75	520	0	88.5	11.5	14	45	25	49	
5/4	1445	1.27	53	5.9	1/2	8.0	1	8.5	20	17	4	21	69000	180	.3	.65	500	0	88.5	11.5	13	45	25	49	
6/4	1380	1.24	46	5.9	1/2	8.3	1	8.3	15	14	3	13	69000	140	.3	1.0	480	0	89	11	11	30	23	48	
7/4	1449	1.22	50	5.6	1/2	12.0	1	12.0	16	17	4	14	63000	200	.3	1.0	60	0	90	10	10	27	20	47	
7/4	1461	1.22	50	4.6	1/2	9.0	1/2	11.8	15	17	5	14	67000	200	.45	.9	20	0	90	10	10	27	20	50	
8/4	1470	1.22	52	4.0	1/2	8.2	1/2	11.8	16	18	5	15	67000	300	.45	.9	40	0	90	10	10	27	20	50	
8/4	1479	1.22	48	4.0	1/2	8.2	1/2	11.6	17	18	5	15	67000	200	.2	.8	40	0	90	10	10	27	20	50	
9/4	1496	1.22	49	4.0	1/2	8.4	1/2	11.9	16	18	5	15	67000	200	.2	.8	40	0	90	10	10	27	20	50	
10/4	1523	1.22	50	4.0	1/2	8.0	1/2	11.3	16	20	5	16	64000	320	.1	.6	80	0	90	10	10	27	20	49	0
10/4	1545	1.22	48	4.0	1/2	8.0	1/2	11.2	16	18	4	14	66000	300	.1	.6	80	0	89	11	10	25	22	49	
11/4	1557	1.22	51	4.0	1/2	8.0	1/2	11.1	16	18	4	15	64000	300	.1	.55	40	0	90	10	10	27	20	49	
12/4	1584	1.22	52	4.0	1/2	7.2	1/2	11.1	16	19	5	15	65000	140	.1	.65	20	0	90	10	10	27	20	49	
13/4	1611	1.22	51	4.2	1/2	8.4	1/2	9.8	15	22	5	16	62000	120	.1	.6		0	89	11	10	41	33	48	
14/4	1611	1.22	52	4.2	1/2	8.4	1/2	9.8	15	21	5	17	62000	120	.1	.6		0	89	11	10	41	33	48	
15/4	1655	1.22	52	4.8	1/2	9.0	1/2	9.8	18	24	7	19	60000	80	.1	.6		0	88	12	10	32	48	48	
16/4	1693	1.22	54	4.6	1/2	8.8	1/2	9.7	17	20	6	20	62000	80	.1	.7		0	89	11	10	41	33	50	
17/4	1720	1.22	51	4.8	1/2	9.0	1/2	9.7	16	19	6	18	60000	80	.1	.7		0	91	9	10	43	31	48	
18/4	1720	1.22	51	5.0	1/2	9.2	1/2	9.7	15	18	5	16	61000	80	.1	.65		0	91	9	10	43	31	48	

MUD PROPERTY RECAP

DATE	DEPTH metres	DENSITY SG	VISCOSITY secs	FILTRATE		HY/HP filt		pH	RHEOLOGY				FILTRATE ANALYSIS					RETORT ANALYSIS			CEC PPB Bent. Eq.	OTHER																
				Cake ccs	1"/32" mm	°500psi ccs	1"/32" mm		PV cp	YP lbs/100ft ²	10" dynes/cm ²	10' dynes/cm ²	Cl mg/litre	Ca ppm	Pf	Mf	Pm	Oil %	Water %	Solids %		PPB	HDS ppb	LDS ppb	KCl ppb													
																										ccs	1"/32" mm	ccs	1"/32" mm									
19/4	MIXING		AQUAGEL/	SEA WATER/CMC	MUD																																	
20/4	1742	1.10	59	7.2	1/2	18.6	1/2	11.5	20	20	8	32	1000	200	.25	.4		0	97	3	18	30	10															
21/4	1934	1.10	52	6.2	1/2	17.0	1/2	11.7	15	16	7	30	1000	20	1.2	1.7		0	97	3	20	47	10															
22/4	2072	1.10	51	6.8	1/2	17.4	1/2	10.3	16	13	6	31	1000	80	.6	1.2		0	97	3	22 1/2	43	12															
23/4	2081.5	1.10	55	6.8	1/2	17.0	1/2	10.3	16	16	7	33	1000	60	.5	1.0		0	97	3	20	50	8															
24/4	2081.5	1.11	55	7.2	1/2			11.8	16	21	10	40	1000	240	1.4	2.3		0	96	4	20	40	10															
25/4	2081.5	1.11	57	8.6	1/2			12.0	16	22	10	45	1000	380	2.1	3.2		0	96	4	20	40	10															

NORSK PETROLEUM SERVICES A/S.

OPERATING AREA 31/6-5, TROLL.

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MATERIALS USED PER CASING INTERVAL

36" Hole with 30" casing set at 389m.

MATERIAL	ESTIMATED REQUIREMENTS		ACTUAL REQUIREMENTS	
	QUANTITY	COST \$	QUANTITY	COST \$
AQUAGEL	17 MT	4,250.00		
BARGAIN	12 MT	1,200.00		
CAUSTIC SODA			1	11.25
CaCl ₂			21	418.32
CMC EHV			18	724.32
LIME			2	16.32
Total Cost		5,450.00		1,170.21
Cost per m ³	198.8 m ³	27.41	297 m ³	3.88
Cost per m	65 m	83.85	65 m	17.75

:297 m³ mud salvaged from 31/6-4.

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MATERIALS USED PER CASING INTERVAL

26" Hole with 20" Casing set at 649m.

MATERIAL	ESTIMATED REQUIREMENTS		ACTUAL REQUIREMENTS	
	QUANTITY	COST \$	QUANTITY	COST \$
AQUAGEL	51 MT	12,750.00	101 MT	25,250.00
BARGAIN	120 MT	12,000.00	8 MT	800.00
CMC EHV	100	4,024.00	5	201.20
CAUSTIC SODA			23	258.75
SODA ASH			23	467.36
CaCl ₂			14	278.88
AQUAGEL sx			27	399.60
Q BROXIN			1	13.25
KWIK SEAL			120	4,068.00
MICA Coarse			210	3,696.00
MICA Fine			240	4,224.00
WALLNUT Fine			235	4,136.00
WALLNUT Coarse			190	3,344.00
Total Cost		28,774.00		47,137.04
Cost per m ³	874.5m ³	32.90	1262m ³	37.35
Cost per m	432 m	68.02	279m	169.95

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MATERIALS USED PER CASING INTERVAL

17½" Hole with 13³/8" Casing set at 1424m

MATERIAL	ESTIMATED RWQUIREMENTS		ACTUAL REQUIREMENTS	
	QUANTITY	COST \$	QUANTITY	COST \$
ALCOMER 110L	117	16,335.54	144	20,107.84
BARGAIN	161	16,100.00	109	10,900.00
DEXTRID			112	6,648.32
KCl sx	1182	22,316.16	1118	21,107.84
KCl brine	1500	30,000.00		28,630.88
XCD Polymer	117	42,073.20	143	51,422.80
SOD Bicarbonate			8	172.80
SODA ASH			26	528.32
AQUAGEL sx			36	532.80
Total Cost		126,824.90		140,049.04
Cost per m ³	679.7m ³	186.59	706m ³	198.37
Cost per m	630m	201.31	782m	179.09

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OPERATING AREA 31/6-5, TROLL.

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MATERIALS USED PER CASING INTERVAL

12 $\frac{1}{2}$ " Hole with 9 $\frac{5}{8}$ " Casing set at 1707m

MATERIAL	ESTIMATED REQUIREMENTS		ACTUAL REQUIREMENTS	
	QUANTITY	COST \$	QUANTITY	COST \$
BARGAIN	35 MT	3,500.00	25 MT	2,500.00
DEXTRID	229	13,593.44	181	10,774.16
KCl sx	487	9,194.56	526	9,930.88
Sod.Bicarb	20	432.00	27	583.20
XCD Polymer	23	8,270.80	55	19,778.00
Total Cost		34,990.80		43,749.12
Cost per m ³	135.1m ³	259.00	110m ³	397.72
Cost per m	285m	122.77	275m	159.09

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OPERATING AREA 31/6-5, TROLL.

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MATERIALS USED PER CASING INTERVAL

8½" Hole to 2081.5m TD

MATERIAL	ESTIMATED REQUIREMENTS		ACTUAL REQUIREMENTS	
	QUANTITY	COST \$	QUANTITY	COST \$
AQUAGEL	25 MT	6,250.00	38 MT	9,500.00
BARGAIN	15 MT	1,500.00	17 MT	1,700.00
Caustic Soda	41	461.25	46	517.50
Soda Ash	10	203.20	43	873.76
CMC LV	82	3,013.50	53	1,947.75
CMC HV			60	2,205.00
Q BROXIN			2	26.50
Total Cost		11,427.95		16,770.51
Cost per m ³	357.8m ³	31.94	345m ³	48.61
Cost per m	345m	33.12	361.5m	46.39

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OPERATING AREA 31/6-5

MATERIALS USED PER CASING INTERVAL

STOCK ADJUSTMENT

<u>Material</u>	<u>Quantity</u>	<u>Cost \$</u>
XCD Polymer	15 sx	5,394.00

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OPERATING AREA 31/6-5, TROLL

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TOTAL MATERIAL CONSUMPTION

MATERIAL	PACKAGING	QUANTITY
Aquagel	M/T	219
Aquagel	50 kg	63
BARGAIN	M/T	197
Caustic Soda	25 kg	88
Soda Ash	50 kg	113
Sodium Bicarbonate	50 kg	35
CaCl ₂	50 kg	61
Lime	50 kg	13
Q-Broxin	25 kg	5
CMC LV	25 kg	53
CMC HV	25 kg	60
CMC EHV	25 kg	23
DEXTRID	50 lb	293
KCl Brine	bb1	1500
KCl sx	50 kg	1644
XCD Polymer	50 lb	213
Alcomer 110 L	25 kg	144
Kwik Seal	40 lb	120
Mica Course	25 kg	210
Mica Fine	25 kg	240
Wallnut Course	25 kg	190
Wallnut Fine	25 kg	235