4.9 Reservoir fluid sampling

Three phases of fluid were obtained during sampling. Oil and water were sampled from the Tor Formation. Gas, oil and water were sampled from the Basement. Due to high draw down during pumping with the wireline tools, most of the hydrocarbon samples are flashed and not representative for PVT analysis, but there is still good quality of gas and oil samples from the Basement. See table 4.9 for sample depths, volumes and sampling conditions.

Table 4.9: Onsite Sampling

Depth	Volume	Temp. deg C	Formation pressure, bar	Drawn down, bar	Run	Comments
1886.7m	2x450cc+ 1 gallon	87.8	190.5	1.5	2A	1 gallon empty back at surface. Basement
1727.5m	2x450cc	80.1	196.5	103	2A	Fluid flashed. Tor Fm
1896.1m	2x450cc	88.3	190.9	N/A	2A	Mudfiltrat. Backup sampling after pump failure
1710m	2x450cc+1gallon	79.3	191.4	100	2B	Water sampling. Tor Fm
1898m	3x450cc+2¾"gallon	88.4	191	50	2B	Fluid flashed. Basement
1939m	1x450cc+1gallon	90.4	194.1	116	2B	Water sample. Basement
1930	3x450cc	89.9	193.4	170	2D	Fluid flashed. Basement
1904	3x450cc+2¾"gallon	88.7	191.5	55	2D	Good quality. No flash observed during sampling for downhole sensors

4.10 MiniDST summary

With dual packer MDT configurations miniDST were performed in both the chalk and the Basement reservoir section. The configuration was changed from the normal 1m spacing between the dual packer elements, as used in the 16/2-3 well, to 2.5m spacing. Only one test was performed with 1m spacing, as indicated in the below summary table. For further interpretations and results, refer to the "Test analysis report well 16/2-4 Ragnarrock 2, PL265 miniDST tests".

Depth[1]	Test	Pres	kh	k	h[2]	Rinv	Fluid	Model
(m)	(No.)	(bar)	(md.m)	(md)	(m)	(m)		
1710.1	Chalk	189.09	0.32	0.128	2.5	6.8	Water	Radial flow
1718.6	Chalk	193.68	0.3	0.06	5	3.6	Oil	Limited flow entry
1725.1	Chalk	189.26	0.065	0.022	3	4.1	Oil	Radial flow
1733.6	Chalk	196.3	0.027	0.011	2.5	1.9	Oil	Radial flow[3]

5.7.4 Drilling fluids

Figure 5.4 Summary of drilling fluids program

DRILLING FLUIDS PROGRAMME

Well: 16/2-4
Field: Ragnarrock 2
Rig: West Epsilon

All depths refers to RKB.
RKB-MSL West Epsilon: 47 m

HOLE SIZE	HOLE TVD MD	CASING SIZE	CASING TVD MD	MUD TYPE	MW [SG]	LGS [kg/m3]	10 sec. [Pa]	10 min. [Pa]	Funnel Visc.	Fann 3 rpm	O / W ratio	PV [mPa]	API FL [ml]	HTHP FL [ml]	MBT [KG/m3]	pH	KCl [KG/m3]	Glyc. [%]	Ca++ [mg/l]	Sulphate [mg/l]	Usage Volume [m3]
36"	288 288	30"	281 281	#1 Spud Mud Sweeps #1 Spud Mud Displacements	1.03-1.08 1.35				103-105 103-105							9.6- 12 9.6- 12					486 174
	The section was drilled in 12 hours with an average rate of penetration of 10 m/hr, using seawater. A sweep of 10m3 of high viscosity seawater/bentonite fluid was pumped every 15m drilled to aid hole cleaning. The section was drilled to a depth of 288 m with 5,100 -5700 l/min at 124-136 bars and 80-83 rpm on the drill string with no hole problems. A 17 1/2" bit was used along with a 26"x36" hole opener and no boulders were encountered. At 287 m the hole was swept twice with 20 m3 high viscosity pills and the assembly pulled 2 stands for check. Ran back in hole to check for fill and no fill was experienced. The hole was then displaced with 1.35sg KCl/Polymer/Glycol fluid prior to pulling out to run the 30" conductor. The 20 x 30" conductor was run through seabed at 160m and set at 281 m from RKB. A cement stinger was run and the conductor was cemented and displaced with sea water as per Halliburton plan.																			
12 1/4" Pilot hole	630 630	N/A		Seawater CMC EHV Sweeps #1 Spud Mud Displacements	1.08 - 1.10 1.10				100+ Sec 100+ Sec				<9			>9 >9					247 204
	COMMENTS: Mix seawater/CMC EHV for the sweep pills. Drill with weighted seawater/CMC EHV mud from 400 meters of at least 1.08 SG at the highest possible rate. If required, flush the hole with 5 m3 of high viscosity sweep. Dump and dilute, with volume control as required on connection whilst MW is maintained between 1.08 - 1.10 sg trying to stay on the low side of the range to prevent losses. If permeable sand formation gives losses add pre hydrated bentonite and/or polymers to cure seepage losses. Have at least 200 m3 of 1.20 SG kill mud made up before drilling this section. At TD: Pump 2 x 20 m3 of weighted Hi vis sweep if required. Well to be left with 1.10 sg mud in hole to open it up to 17 1/2".																			
17 1/2"	648 648	13 3/8"	631 631	#1 Spud Mud Sweeps #1 Spud Mud Displacements	1.08 - 1.10 1.1				45 - 98 45 - 98				6.0 - 7.2			8.8 - 9.55 8.8 - 9.55					549 165
	The 17 ½" drilling assembly was run in and 3m new formation was drilled. A 10 m3 LCM Pill was spotted at 291m. Concentrations of pill: 31.3 kg/m3 STEELSEAL, 22.7 kg/m3 BAROFIBRE COARSE, 29.2 kg/m3 WALNUT COARSE and 41.7 kg/m3 MICA FINE. Total: 125 kg/m3 LCM materials. The FIT was performed to 1.15 EMW and the well displaced to 1.08sg Bentonite/Polymer mud prior to drilling the 17 ½" section. Drilling commenced to section TD at 640m with an average ROP of 18 m/hr. A 10m3 Hi-Vis pill was pumped to sweep the hole and the assembly was pulled out with only manor pressure restrictions. Some down hole losses were observed at 460m and 480m (1m3 in total) and additions of BAROFIBRE COARSE & STEELSEAL at 1sx/30 min of each directly to the active system were added from this stage to TD. DEXTRID E & PAC RE were constantly added at a rate of 100 kg/hr of each from the beginning to the end of the section. This controlled the filtrate between 5-7ml's and a tough thin filter cake as a result. Some of the clay particles drilled were dissolved into the mud system, but the MBT was kept below 25 kg/m3 throughout the section, mainly due to good shakers handling and high dilution rate.																			

Figure 5.5 Summary of drilling fluids program

DRILLING FLUIDS PROGRAMME

Well: 16/2-4
Field: Ragnarrock 2
Rig: West Epsilon

All depths refers to RKB.
RKB-MSL West Epsilon: 47 m

HOLE SIZE	HOLE TVD	HOLE MD	CASING SIZE	CASING TVD	CASING MD	MUD TYPE	MW [SG]	LGS [kg/m³]	10 sec. [Pa]	10 min. [Pa]	Funnel Visc.	Fann 3 rpm	O/W ratio	PV [mPa]	API FL [ml]	HTHP FL [ml]	MBT [KG/m³]	pH	KCl [KG/m³]	Glyc. [%]	Ca++ [mg/l]	Sulphate [mg/l]	Usage Volume [m³]
12 1/4"	1690	1690	9 5/8"	1689	1689	#8a KCl/GEM GP/Polymer	1.30 - 1.35	22 - 130	3 - 4	4 - 5		4 - 7			2.1 - 2.9		17 - 35	8.5 - 9.8	103 - 120	3.8 - 4.0	80 - 280		217
						New formation was drilled to 645 m before circulating the hole clean and an even mud weight in / out at 1.10 SG. A formation integrity test was performed to 1.45 SG. The hole was displaced to 1.30 SG KCl / polymer / glycol mud while drilling ahead. When 1.30 SG mud was confirmed on surface by the mud engineer, the pumps where stopped and all of the old mud dumped and pits cleaned prior to further drilling. An average of 30 m/hr was drilled down to top of Utsira Fm at 833 m where the ROP was reduced to 20 m/hr due to possibility of gas. The mud weight was increased from 1.30 SG to 1.35 SG while drilling at the bottom of Utsira Fm. Fresh mud was constantly bled into the active system to maintain volume and fluid properties. Only minor treatments of soda ash and PAC-RE were necessary while drilling. When reaching TD at 1690 m, 0,5 kg/m3 of BARAZAN was added to the active to raise viscosity before pulling out of hole. A wire line log was run to 1686.2 meter. The average open hole diameter from the caliper log was 13, 47 inches where the wash out was seen in Utsira and minor washouts in Balder. The 9 5/8" liner was run and cemented without any problems. No cement or spacer contamination observed in returns during cement job.																		
8 1/2"	2000	2000	OH			#8b KCl/GEM GP/Polymer Low Sulphate	1.20	39 - 76	4 - 5	5 - 6		5 - 6			2.4 - 2.8	6-7@75°C	Jan-35	Jan-35	120 - 150	4	40 - 180	20 - 80	172
						The 9 5/8" shoe track and float was drilled out using mud from the previous section to avoid cement contamination of the new mud. New formation was drilled to 1693 m before displacing the well to new 1.20 SG KCl / polymer / glycol low sulphate mud. An extended LOT was performed to 1.80 SG at 1693 m before drilling ahead to core point. 5 cores were taken. A new 8 ½" BHA was run in hole to drill from 1684 m to TD at 2000m. The hole was circulated clean by 3 times bottom up with 1800 lpm prior to pull out of hole. 5 wireline logging runs were performed. A BOP test was successfully performed before the last wireline run #6 was performed without any incidents or hole related problems after 17 days in static conditions.																		