

4.10.4 FMT-Pressure measurements

The formation pressure was measured from 2462 - 3315 mRKB with the Dresser FMT tool. In addition, pressure data from five downhole gauges were recorded during a drill stem test (2476 - 2484 mRKB). The pressure data are listed in table 4.12 and plotted versus depth in fig. 4.10.

From fig. 4.10, the gas water contact is determined to 2516.5 mRKB.

The pressure gradient in the gas zone is 0.29 psi/m, corresponding to a fluid density of 0.20 g/cm³. In the water zone the pressure gradient is increasing from 1.46 psi/m in the Middle Jurassic Sandstone to 1.55 psi/m in the Coal unit. The high water density in the deeper formation is caused by more saline formation water.

Based on the pressure measurements, the formations from the Middle Jurassic Sandstone to the Triassic Grey Beds are apparently in the same pressure regime.

Segregated samples were collected at the following depths:

2486.0 mRKB	(gas)
2512.5	" (gas)
2539.5	" (water)
2546.0	" (water)

Table 4.12 FMT and DST-Pressure Points, 6407/2-2

GAUGE NO.		DEPTH (mRKB)	P _{Tempc.} (Psig)
FMT	No. 66594	2468.0	3629.0
"	No. "	2477.0	3630.0
DST PRESSURE		2480.0	3631.0
"	No. "	2485.5	3633.0
"	No. "	2492.5	3634.0
"	No. "	2501.0	3637.0
"	No. "	2512.5	3642.0
FMT	No. 68648	2512.5	3637.0
"	No. "	2512.5	3638.0
FMT	No. 66594	2516.5	3651.0
"	No. "	2530.5	3663.0
"	No. "	2539.5	3676.0
"	No. "	2546.0	3685.0
"	No. "	2556.5	3703.0
"	No. "	2567.5	3717.0
"	No. "	2576.0	3729.0
"	No. "	2599.5	3764.0
"	No. "	2711.5	3926.0
"	No. "	2712.5	3927.0
"	No. "	2716.5	3934.0
"	No. "	2721.0	3940.0
FMT	No. 66595	2800.5	4073.0
"	No. "	2863.0	4159.0
"	No. "	2962.0	4305.0
"	No. "	3065.0	4467.0
"	No. "	3187.0	4653.0
"	No. "	3264.0	4780.0
"	No. "	3279.0	4801.0
"	No. "	3315.0	4859.0

4.10.5 Drill Stem Test

One drill stem test was carried out in the gas bearing interval of the Middle Jurassic Sandstone. The test interval was 2476 - 2484 mRKB. The depths refer to CDL-CNL-GR run 4C of 6th July 1983.

A high viscous pill was spotted across the test interval before perforating.

The drill string and a test assembly for surface read-out of the data was used. Four down-hole memorizing gauges were placed in the string below the perforated anchor.

The well was produced at 4 rates. Between the different rates, the well was shut in for some hours. The flow rates and bottom hole pressures and temperatures are shown in fig. 4.11. Additional data are listed in table 4.13 and 4.14.

The first flow lasted 9 hours. It was flowed on a 24/64" choke with a rate of 9.0 MMscf/d and a final wellhead pressure of 2788 psig. When the well was shut in at the PCT-valve, most of the pressure build up took place during the first seconds. The first build-up period lasted for 4 hours and 7 minutes.

The second flow period lasted for 6 hours and 30 minutes. The well flowed 18.6 MMscf/d through a 36/64" choke with a wellhead pressure of 2662 psig. The following shut-in period lasted for 2 hours and 3 minutes.

During the third flow period, 6 hours and 15 minutes, the well was flowing through a 48/64" choke with a rate of 28.7 MMscf/d and a wellhead pressure of 2361 psig. The following shut-in period lasted for 2 hours and 2 minutes.

The last flow period lasted for 5 hours and 7 minutes. After 26 minutes of flow through a 60/64" choke, the choke was increased to 64/64". Because of a large pressure loss in the surface equipment, the flow through the choke became subcritical. The well was therefore choked back to 60/64" after 55 minutes of total flow.

DST 6407/2-2

BOTTOM HOLE PRESSURE, TEMPERATURE

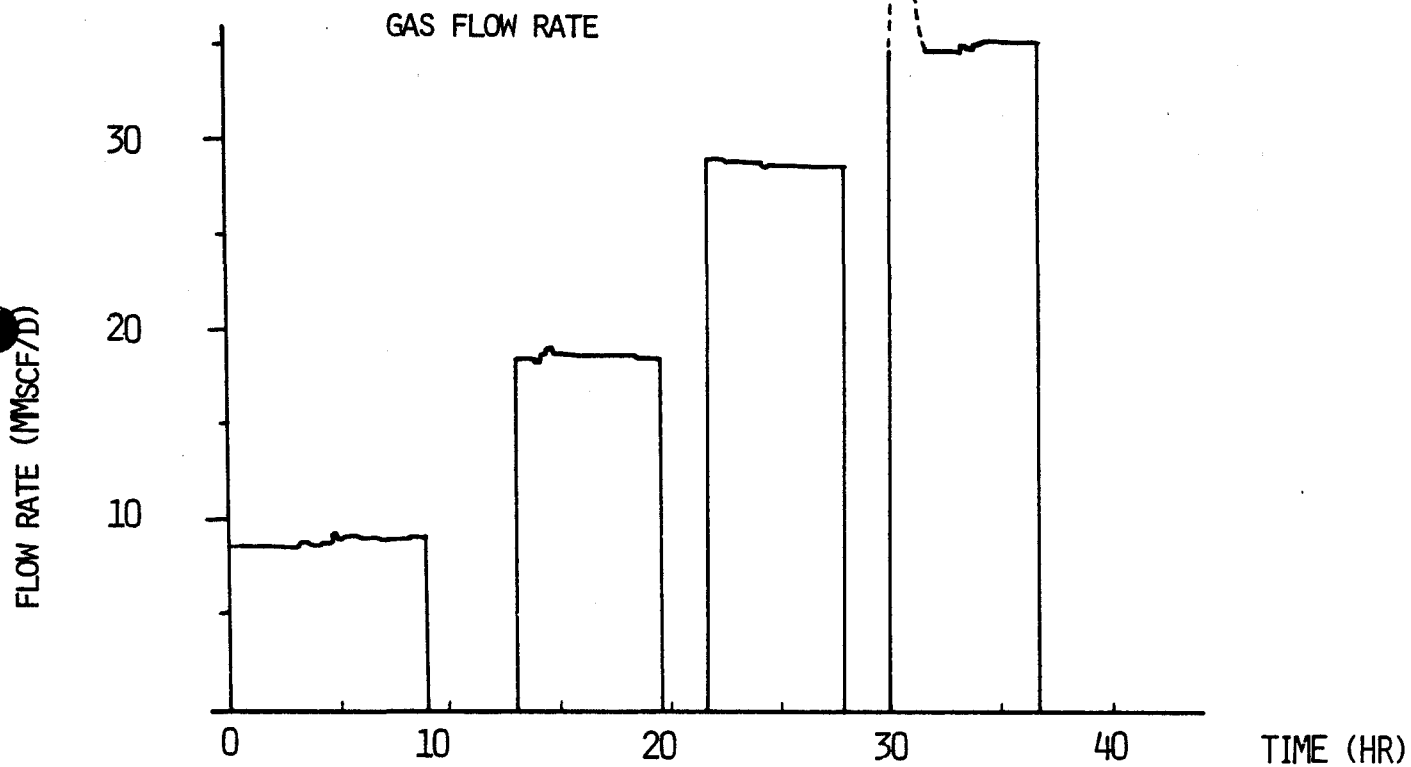
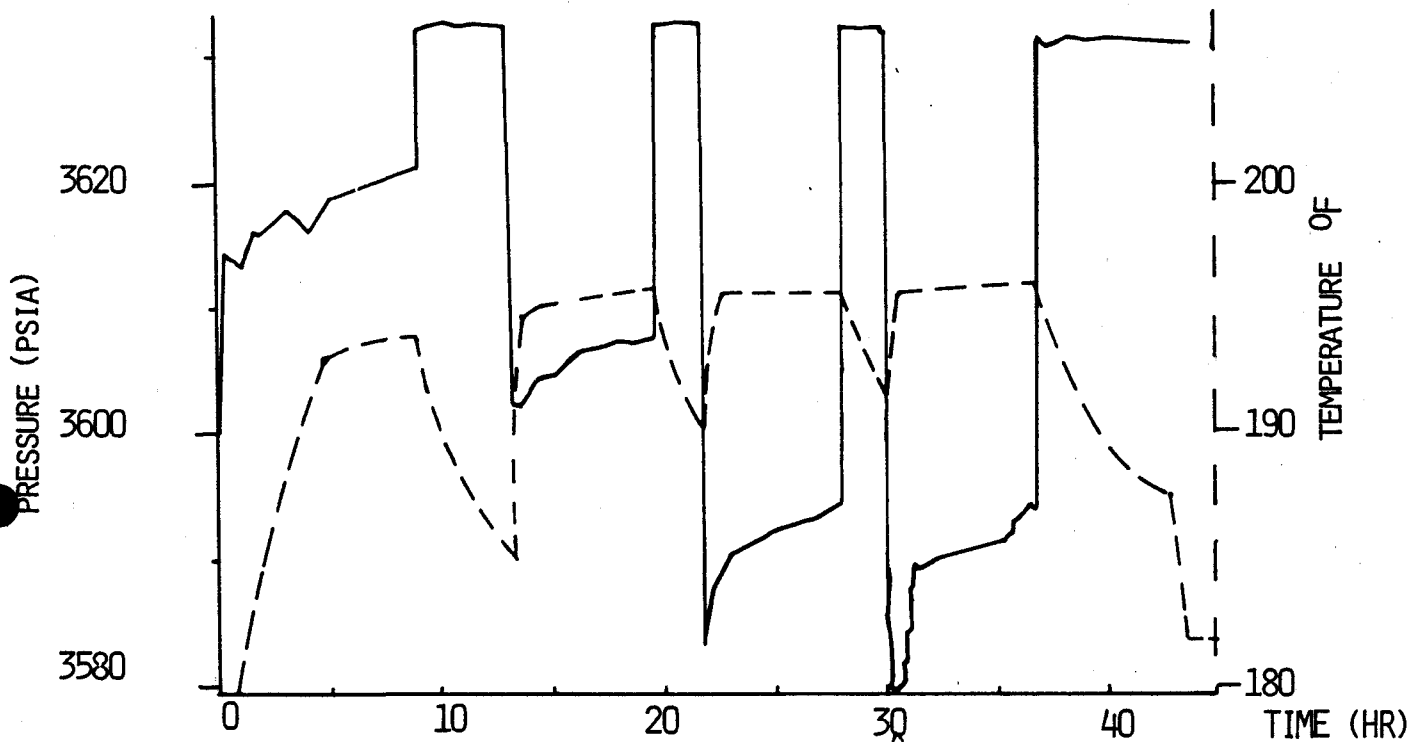


Fig. 4.11 Flowrate, bottom hole pressure and temperature DST 6407/2-2

Table 4.13 Flow data, DST, 6407/2-2

PARAMETERS	FLOW/BU #1	FLOW/BU #2	FLOW/BU #3	FLOW/BU #4
Qg (MMscf/d)	9.0	18.6	28.7	35.3
LGR (STB/MMscf/d)	24.4	20.4	21.5	30.3
Qo (STB/d)	220	380	517	1061
Choke (inch)	26/64	36/64	48/64	60/64
Pwh (Psig)	2788	2662	2361	2041
Psep (Psia)	470	425	510	530
Tsep (^o F)	100	120	120	72
Gas gravity (air=1)	0.688	0.685	0.688	0.670
Oil density (g/cc)	0.773	0.778	0.774	0.756
Oil density (^o API)	51.6	50.5	51.3	55.6
Res. fluid gravity(air=1)	0.753	0.740	0.747	0.747
Oil Mol.weight (lb Mol)	125	127	126	117
Mol stream gas(lb mol/d)	23707	48994	75599	92984
Mol stream oil(lb mol/d)	477	816	1328	2404
Tot.mol stream(lb mol/d)	24184	49810	76927	95388
Qg total (MMscf/d)	9.18	18.91	29.20	36.21
Pwfs (Psia)*	3629	3616.3	3603.3	3604.0
Pws (Psia)*	3641.6	3641.6	3641.2	3641.3
(P _i ² -P _{wf} ²)**/Qg tot (Psi ² /Mscf/d)	9.99	9.71	9.90	7.52
PI (Scf/Psi ²)	100	103	105	133

* Flopetrol Gauge 82014, corrected for temperature to 196^oF by -0.155 psi/^oF,

** P_i = 3641.6 psia

Table 4.14 Average reservoir and fluid data DST 6407/2-2

Pressure at SDP 82014	3641.6 psia
Temperature	656 °R
Height of reservoir open to flow	75 ft
Average flowing pressure	3625 psia
Res. fluid gravity (air=1)	0.747
Pseudo critical pressure	668 psia
Pseudo critical temperature	405 °R
Average pseudo reduced pressure	5.43
Average pseudo reduced temperature	1.62
Average z-factor	0.876
Average viscosity	0.0224 cp
Ct (PVT-analysis 6507/11-1)	0.008 psi ⁻¹
Re/rw	9000
S completion (Brons and Martin)	6

The well produced 35.3 MMscf/d with a wellhead pressure of 2041 psig through the 60/64" choke. The following shut-in period lasted for 4 hours and 7 minutes.

During the first three flow periods, the flow was directed through the heater. Glycol was injected in the teststring during the first minutes of all the flow periods.

During each flow, recombination samples were collected at the separator. Wellhead samples were collected during the second and third flow. Condensate and emulsion was also sampled from the separator during each flow.

No water or sand was produced during the test. The gas condensate ratio varied from 20.4 to 30.3 STB/MMscf/d. The maximum drawdown reached 38.3 psi. A reservoir pressure of 3646 psig and a temperature of 196^oF was estimated at 2480 mRKB or 2454 mSS. The main results of the test analysis are shown in table 4.15. Fig. 4.12 shows the Horner plot used to analyse the test.

Table 4.15 Main results, DST, 6407/2-2

Interval	2476 - 2484 mRKB
Reservoir pressure at 2480 mRKB	3646 psia
Reservoir temperature at 2480 mRKB	196 ^o F
Permeability 2475.5 - 2498.5 mRKB	1400 mD
Skin, first rate (Build up)	50
, second rate (Steady state)	48
, third rate (")	47
, last rate (")	36
Ideal Productivity (no skin)	3.6 (MMsdf/d/psi ²)

BUILD UP No I

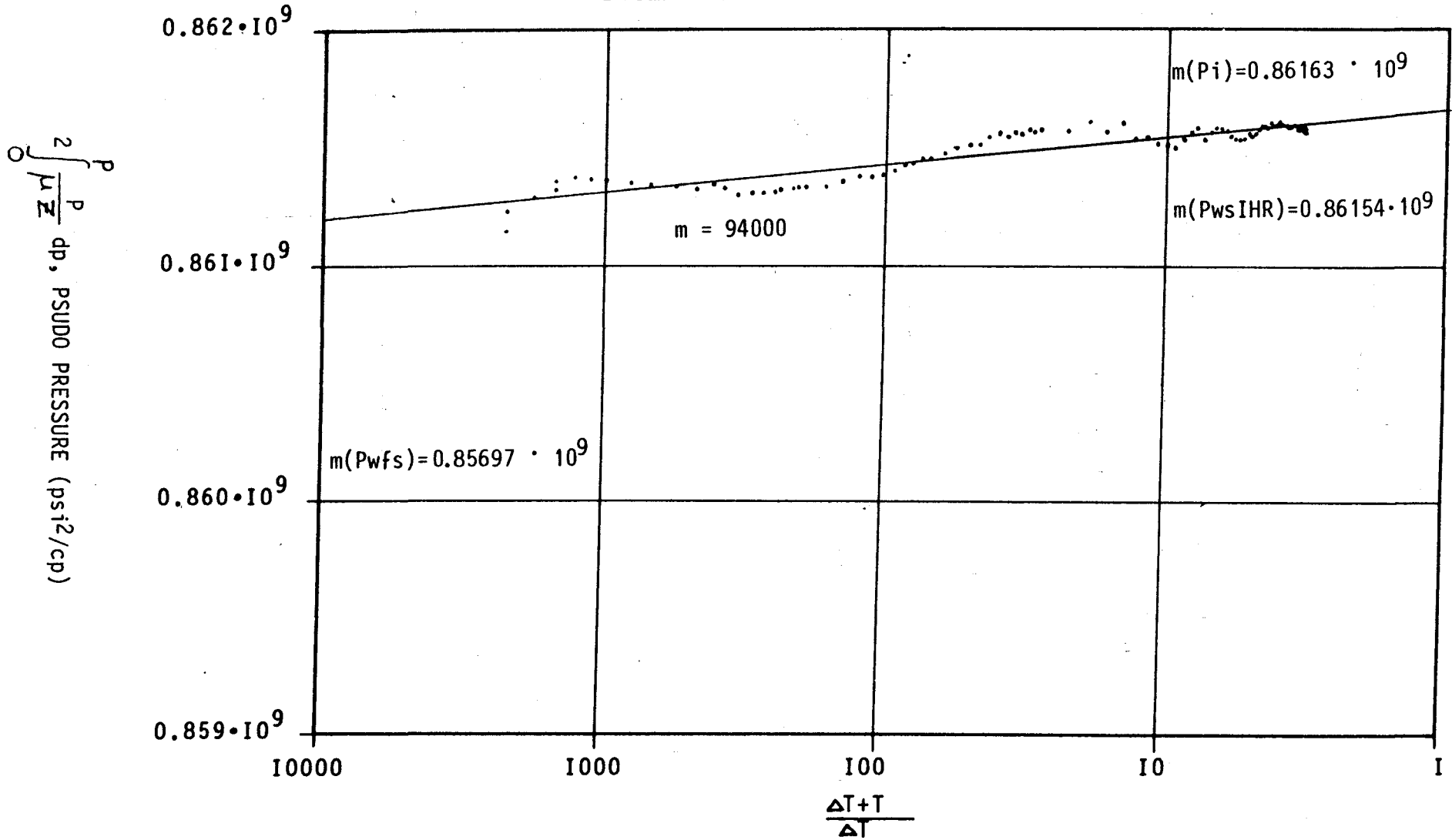


Fig. 4.12 Build up no. 1, TPT gauge

4.10.6 Fluid Analysis

Two FMT segregated samples of gas/condensate were collected at 2486 and 2512.5 mRKB. The content of the 1 gallon chambers were transferred to 670 cc evacuated bottles on the rig. The transfer was carried out at 200^oF and 4000 psig. The compositions of the samples are listed in table 4.16.

It can not be said which gas sample is the most representative. The difference in dewpoint may indicate that the sample with the lowest dewpoint (No 810827) have lost some liquid during the transfer.

Another two FMT segregated samples were collected at 2539.5 and 2546 mRKB in the water zone. Table 4.17 and 4.18 shows the results of the analysis of the 1 gallon chambers.

A conventional PVT-study has been ordered on recombination samples from the drill stem test.

Table 4.16 Mol composition of FMT gas-samples.

Bottle no.	810827	810820	
Depth (mRKB)	2486,0	2512,5	
Sampling pressure (psig)		3638	3674
Opening pressure (psig)	2800	2450	
Dewpoint at 180 ^o F (psig)		2685	3940

COMPONENT

MOL PERCENT

<u>COMPONENT</u>	<u>MOL PERCENT</u>	<u>MOL PERCENT</u>
H ₂ S	NIL	NIL
C02	0.65	0.67
N2	0.61	0.60
C1	84.43	83.26
C2	8.99	8.94
C3	3.26	3.56
1-C4	0.47	0.57
n-C4	0.71	0.97
1-C5	0.20	0.31
n-C5	0.20	0.31
C6	0.15	0.20
C7	0.11	0.18
C8	0.11	0.20
C9	0.07	0.18
C10 plus	<u>0.04</u>	<u>0.05</u>
	100.00	100.00

Table 4.17 Constituents of FMT water sample

Bottle No.	115097	116202	
Depth (mRKB)	2546.0	2539.5	
Total dissolved solids Mg/l		40680	29080
Specific gravity as 60/60 ^o F		1.030	1.021
Resistivity as 60 ^o F (m)		0.218	0.296
pH	7.19	7.71	
H ₂ S	NIL	NIL	
	Mg/l	Mg/l	
Na	13900	10030	
K	370	230	
Ca	1120	670	
Mg	165	93	
Ba	0.5	0.3	
Sr	105	56	
Fe total	20	150	
Fe dissolved	8.7	1.5	
Cl	22730	15300	
SO ₄	1680	1970	
HCO ₃	605	730	
CO ₃	NIL	NIL	
OH	NIL	NIL	

Table 4.18 Gas content of FMT water samples

Bottle No.	115097	116202
Depth mRKB	2546.0	2539.5
Gas-water ratio (SCF/STB)	1.0	3.0
Gas gravity (air = 1)	.644	.606
Volume factor water (BBL/STB)	1.023	1.026

MOL PERCENT

H ₂ S	NIL	NIL
CO ₂	4.34	1.23
N ₂	4.42	4.51
C ₁	86.28	90.82
C ₂	4.14	3.00
C ₃	0.60	0.23
i-C ₄	0.04	0.02
n-C ₄	0.08	0.05
i-C ₅	0.03	0.02
n-C ₅	0.03	0.02
C ₆	0.02	0.04
C ₇ plus	<u>0.02</u>	<u>0.06</u>
	100.00	100.00

5.2.1. Mud Properties, Daily Report

Well no: 6407/2-2

Saga
Petroleum a.s.



DATE	HOLE SIZE INCHES	DEPTH METERS	MUD WEIGHT ppG	P.V.	Y.P.	GEL STRENGTH	n	K	WATER LOSS	pH	ALKALINITY Pf/Mf	Ca+ ppm	CL- ppm	SAND %	SOLIDS %	COMMENTS
17.5.	36	361														
18.5.	36	398														
19.5.	36	398	9,2													
20.5.	14 3/4	490	9,1	12	37	22/26	.32	6,6	-	9,9	.4/.6	570	9000	TR	6	
21.5.	14 3/4	865	9,8	10	38	26/30	.27	8,9	-	9,5	.4/.5	1000	13000	TR	10	
22.5.	26	515	9,6	10	42	27/31	.25	10,9	-	9,0	.1/.3	840	13500	TR	9	
23.5.	26	755	9,7	7	55	35/36	.15	24,4	-	9,5	.15/.6	1080	16000	1/4	4	
24.5.	26	866	11,8	12	45	35/37	.27	10,6	-	9,0	.13/.4	1080	16000	1	14	
25.5.	26	865	11,0	10	35	20/30	.29	7,4	-	9,0	.13/.4	1200	18000	1	12	
26.6.	26	865	11,0	10	35	20/30	.29	7,4	-	9,0	.1/.4	1200	18000	1	12	
27.5.	20	865	11,0	11	36	20/30	.30	7,3	-	9,0	.1/.4	1120	18000	1	12	Land bop
28.5.	17 1/2	868	10,5	14	15	4/5	.57	.83	16,0	10,0	.1/.3	1300	18000	TR	9	GYP-POLYMER MUD
29.5.	17 1/2	1235	10,5	13	20	5/9	.48	1,65	20	10,0	.1/.4	1300	20000	1/2	9	DRL
30.5.	17 1/2	1386	10,5	13	17	6/15	.52	1,17	20	9,6	.1/.3	1400	20000	TR	12	DRL Pooh
31.5.	17 1/2	1676	10,6	14	20	10/18	.50	1,50	20	9,5	.1/.2	1200	20000	.25	14	DRL
1.6.	17 1/2	1894	11,0	17	30	10/30	.45	2,83	16	9,5	.1/.3	1400	20000	TR	14	DRL
2.6.	17 1/2	1990	11,0	18	30	11/30	.459	2,74	18	9,5	.1/.4	1920	20000	TR	14	LOG
3.6.	17 1/2	1990	11,7	20	29	10/30	.485	2,39	20	9,5	.1/.4	2000	20000	TR	15	Pooh
4.6.	17 1/2	1990	11,7	20	29	10/30	.485	2,39	20	9,5	.1/.4	2000	20000	TR	15	W.O.C.
5.6.	17 1/2	1990	11,7	21	31	8/24	.489	2,4	21	9,3	.1/.4	2000	20000	TR	15	Rih. Circ.
6.6.	12 1/4	1995	11,7	21	31	8/24	.485	2,4	21	9,3	.1/.4	1400	20000	TR	15	W.O.C
17.6.	12 1/4	1995	11,7	21	20	12/25	.596	.99	20	9,5	.1/.4	1600	20000	TR	15	Run. bop + riser
18.6.	12 1/4	356	11,7	14	35	15/35	.362	5,11	20	9,5	.1/.5	1440	20000	TR	16	Test bop Drl cmt
19.6	12 1/4	2219	11,7	11	46	15/45	.254	11,66	30	10,5	.15/.55	1680	18000	0,5	16	Drl to 2219
20.6.	12 1/4	2439	12,2	18	25	16/35	.504	1,85	20	9,5	.1/.5	1280	19000	.25	15	Weigh up to 12,2
21.6.	12 1/4	2476	12,2	20	17	16/33	.623	.759	12	9,5	.15/.55	1040	14000	TR	14	start cor.2461,3
22.6.	12 1/4	2480	12,2	20	18	18/31	.183	16,24	10	10,0	.13/.5	800	14000	TR	14	Core 2473 - 2480
23.6.	12 1/4	2502	12,3	23	16	7/15	.664	0,650	8,5	9,7	.1/.5	580	13900	TR	17,5	Rih co.2476-2502
24.6.	12 1/4	2504	12,4	24	14	7/13	.705	0,465	9,0	9,7	.1/.4	320	13500	TR	17,5	Core
25.6.	12 1/4	2518	12,4	22	14	6/12	.688	0,494	7,0	9,8	.1/.4	320	13100	TR	16,5	Core
26.6	12 1/4	2330	12,4	24	15	7/15	.691	0,523	7,1	9,8	.1/.4	320	13000	TR	16,5	Pooh, test bop, rih
27.6.	12.1/4	2335	12,4	28	20	10/23	12	19,064	8,5	9,7	.1/.4	320	13500	TR	17	Cut core no.8 pooh

5.2.2. Mud Materials used

Well no: 6407/2-2



MATERIAL	UNIT	36" HOLE	26" HOLE	17 1/2" HOLE	12 1/4" HOLE	8 1/2" HOLE	5 7/8" HOLE	TOTAL
BENTONITE CAUSTIC SODA ASH LIME	MT 25 kg 50 kg 20 kg	14,6 19 5 19						\$ 7.059,13
BARITE BENTONITE CAUSTIC SODA ASH KWICK SEAL FINE	MT MT 25 kg 50 kg 40 LBS		174 455 39 2 72					\$ 52.554,95
BARITE CAUSTIC SODA ASH GYPSUM MILPOLYMER 302 AL-STEARATE DRISPAC S/L DRISPAC REG PERMALOSE MILGEL	MT 25 kg 50 kg 40 kg 25 kg 25 kg 50 LB 50 LB 25 kg 50 kg			269 82 3 236 170 5 18 23 31 6				\$107.504,27
BARITE BENTONITE CAUSTIC SODA ASH BICARBONATE UNICAL DRISPAC REG DRISPAC S/L GYPSUM SAFF GEL MILGEL	MT MT 25 kg 50 kg 50 kg 25 kg 50 lb 50 lb 40 kg 25 kg 50 kg				449 8,5 90 2 21 321 1 72 20 33 13			\$ 106.798,67
BENTONITE BENTONITE CAUSTIC BARITE UNICAL BICARL DRISPAC REG DRISPAC S/L	50 kg MT 25 kg MT 25 kg 50 kg 50 lb 50 lb					276 18 24 27 48 13 1 1		\$ 20.692,78
				Total well cost		\$ 294.609.8		