Macondo Technical Note

Title:	Depleted Pressure for Well Control Planning
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Question Addressed in this Technical Note:

The team planning the relief well has requested a revised estimate of the pressures which they may encounter at the reservoir interval.

This note differs from Version B in two aspects: 1) it addresses questions from the drilling team regarding pressures in the M57 sands, and 2) it incorporates simulation results to 22-July (the previous note included simulated results to 2-July).

Key Conclusions

The likely pressure in the M56E (main oil sand) is approximately 10,100 psia. This value is based on the pressure observed at the BOP, corrected for static head. This new estimate lies within the previously estimated range for this sand, 9,360 – 10,550 psia (ref. note: "Depleted Pressure for Relief Well Planning" vA, 2-July-2010, by Bob Merrill)

The pressures in the M57 interval are expected to be considerably higher than the pressure in the M56E, for the following reasons:

- The sands may or may not be producing, which raises the possibility that they could be at initial pressure. Communication between these sands and the wellbore is unknown, but we assume that the sands are open to flow.

- These sands were logged as low permeability sands (7.5 mD and 0.1 mD in the B and C, respectively). The flow potential of these sands is quite low. Both were encountered slightly overpressured, which suggests limited areal extent.

The M56A sand, on the other hand, is likely to be depleted relative to the M56E. The fluid in the sand is uncertain (either gas or oil). We have modeled it as a gas, and it has considerable flow potential (logged permeability: 400 mD).

These conclusions can be summarized in the following table:

Calculated Reservoir Pressures on 20-July

Zone	Mid-pt TVDss (ft)	Modeled Fluid	Mobility (KH/0)	Wellbore (psia)	Near Wellbore	Reservoir (psia)	Near Wellbore Minimum (60mbd/no Aq)	Maximum (35 mbd/+Aq)
M57B	17,382	Gas	200	9,893	10,790	11,353	10,111	11,324
M57C	17,619	Gas	13	9,951	11,827	12,877	11,402	12,162
M56A	17,719	Gas	13,240	9,976	8,620	8,008	7,104	9,814
M56B	17,897	Water	43	10,019	10,764	11,272	10,179	11,224
M56C	17,945	Water	23	10,031	11,147	11,991	10,663	11,528
M56D	17,992	Oil	8,458	10,043	10,555	11,206	9,703	11,225
M56E	18,070	Oil	79,058	10,062	10,100	10,363	8,897	11,047
M56F	18,142	Oil	3,191	10,079	10,503	11,090	9,579	11,230

- "Wellbore" pressure is based on a static head from the observed BOP pressure (6850 psia). In high mobility zones, this pressure will approximate the reservoir pressure. This is not the case for lower mobility zones.
- "Near well" and "reservoir" pressures are based on a weighted average of simulation cases.
  - "Near Well" represents the pressure within 20ft of the wellbore
  - "Reservoir" represents the average reservoir pressure
- "Extreme" cases are shown; these represent the calculated maximum and minimum "Near Well" pressures.

For completeness, the following table includes the static wellbore pressures calculated at each of the casing points:

Shoe or Formation	Depth MD	Depth TVD	SIP (Prosper thermal)	□P (from gauge)
Mudline	5,067	5,067	6,855	16
36"	5,321	5,321	6,920	81
28"	6,217	6,217	7,146	307
22"	7,937	7,937	7,572	733
18"	8,969	8,969	7,826	987
16'	11,585	11,585	8,469	1,630
13-5/8'	13,145	13,133	8,850	2,011
11-7/8"	15,103	15,092	9,331	2,492
9-7/8"	17,168	17,157	9,838	2,999
Top M57B	17,467	17,381	9,893	3,054
Top M57C	17,700	17,614	9,950	3,111
Top M56A	17,804	17,718	9,975	3,136
Top M56B	17,976	17,890	10,017	3,178
Top M56C	18,030	17,844	10,006	3,167
Top M56D	18,067	17,981	10,040	3,201
Top M56E	18,120	18,034	10,053	3,214
Top M56F	18,218	18,132	10,077	3,238
7"	18,304	18,293	10,116	3,277
TD	18,360	18,349	10,130	3,291

Assumed Pressure: 6850 psia at capping stack
Pressure of 6839 recorded at the BOP (5046 ft) at 23:56 on 20-July

Assumptions / Discussion

1. The wellbore pressures are based upon a static head. The others are based upon simulation.
2. Reservoir Parameters for simulation (unchanged from previous note):
   - Oil B_{oi}: 2.345 rb/stb
   - c_f: 6 x 10-6 $psia^{-1}$
   - c_w: 3 x 10-6 $psia^{-1}$
   - GOR: 2993 SCF/stb
   - OOIP: 109.9 mmstb
   - Reservoir Volumes: Oil: 257.8 mmrb, S_{wc}: 9.7% (in M56E, varies in other zones), Aquifer: 991.6 mmrb (excludes connate water, 3.8x oil volume)
3. Average depletion for each case (psi/day) from 20-April to 1-July were calculated. This factor was applied to the simulation results (through 1-July) to update them to 20-July.
4. The model is a stylized representation of the reservoir, with each layer homogeneous, and no dip.
5. Reservoir sands' properties and depths were modelled per spreadsheet "MC252 – 1 Sand Description v2.xls", (24-May, email Kelly McAughan, attached). The sands without permeability but calculated porosity were assigned a nominal permeability (see table).

Reservoir Properties

Top of Sand MD Depth	Bottom of Sand MD Depth	Top of Sand TVDSS Depth	Bottom of Sand TVDSS Depth	Fluid Content	Expected to flow (Used in Modeling)	Sand Name	Gross Sand	Net Sand	Pay Sand	Average Gross Porosity	Average Net Porosity	Average Pay Porosity	Average Net Sw	Average Pay Sw	Arithmetic Air Perm.	Geometric Air Perm	Geometric Perm Converted to Oil (85%)	Perm Used in Model	Temperature	Pressure	Pressure Depth Datum
Feet	Feet	Feet	Feet				Feet	Feet	Feet	%	%	%	%	%	MD	MD	MD	mD	Degrees F	psia	Feet TVDSS
12030.0	12246.0	11945.0	12161.0	Gas	Yes if Liner Leak	S023	2	2	2								1000	N/A	162	7061 psia (based on 11.3 ppg pore pressure)	12053
13227.2	13230.2	13141.6	13144.6	Gas	Yes if Liner Leak	S026	3	3	3								1000	N/A	178	8406 psia (based on 12.3 ppg pore pressure)	13143
17467.0	17469.0	17381.1	17383.1	Gas	Yes	M57B	2	2	2	17.95	17.95	17.95	51.58	51.58	15.08	7.5	7.50	7.5	234	12847 psia (based on post well 14.2 ppg pore pressure)	17382
17700.0	17708.5	17614.1	17622.6	Uncertain	No	M57C	8.5	0	0	8.95								0.1	237	13017 psia (Geo tap @ 17713' tvdss) (MDT 3 attempts no seal)	17713
17804.0	17806.5	17718.1	17720.6	Oil or Gas	Yes	M56A	2.5	2.5	2.5	22.48	22.48	22.48	24	24	1702.07	467.39	397.28	397.3	239	12038 psia (one MDT pressure at 17721' tvdss)	17721
17975.5	17989.5	17889.6	17903.6	Brine	No	M56B	5	3	0	14.19	16.99		57.65		7.43	3.12		3.0	241		
18030.0	18032.0	17944.1	17946.1	Brine	No	M56C	2	2	0	17.29	17.29		64.2		4.73	4.06		4.0	241		
18067.0	18089.0	17981.1	18003.1	Oil	Yes	M56D	22	22	22	20.67	20.67	20.67	17.17	17.17	257.67	101.8	86.53	86.5	242	11838 psia (MDT & Geotap)	17993
18120.0	18191.0	18034.1	18105.0	Oil	Yes	M56E	69.5	64.5	64.5	21.42	22.08	22.08	9.7	9.7	514.04	323.76	275.22	276.2	243	11856 psia (MDT)	18066
18217.5	18238.5	18131.5	18152.5	Oil	Yes	M56F	6.5	6.5	6.5	21.08	21.08	21.08	21.85	21.85	1440.59	129.87	110.39	110.4	244	11875 psia (based on fluid gradient 0.568 gm/cc)	18142
							Vsh<0.4	Poro>0.14	Sw<0.5	Vsh<0.4	Poro>0.14	Sw<0.5									

If Density log is not corrected to match core porosity

18067.0	18089.0	17981.1	18003.1	Oil	No Use Other	M56D	22	22	22	18.32	18.32	18.32	18.55	18.55	[illegible]	10.46	26.96

1. From core in M56D and M56E: K (klinkenberg air core at net confining stress = 2000 psi) is a function of core porosity at net confining stress
2. Log porosity is calibrated to core porosity at net confining stress in M56D & M56E
3. Log perm is calculated from core derived equation (from #1)

Gross has Vshale cut off Vsh<0.4
Net has a Porosity cut off Poro>0.14
Pay has a Sw cut off Sw<0.5

Water Depth = 4992 feet

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