Volve

15/9-F-1 C

Petrophysical (static) well evaluation

Interpreter: Torill Vee

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1 Introduction

Objective of 15/9-F-1 C: oil producer in the Northwest segment. Due to uncertainties regarding pressure and fluid communication within the NW, the 15/9-F-1 C well path was planned with a high inclination through the Hugin Fm. with the main aims being connecting different fault blocks and maximizing reservoir section (hence providing greater perforation flexibility).

2 Summary

15/9-F-1 C was side-tracked from F-1 with KOP @ 1364 m MD RKB. TD @ 4094 m MD RKB (Heather Fm.)

Baker Hughes’ AziTrak and NearBit GR (ZoneTrak G) were used for geosteering.

The well penetrated Hugin Fm. through 3 major fault blocks named Upflank fault block, F-11 A fault block and F-1 B fault block.

Flooded intervals are given in table in chapter 4.8. A flag curve showing flooded intervals is named FLOODED_FLAG (in flooded intervals is FLOODED_FLAG = 1), and plotted as turquoise intervals in track no. 7 in the CPI plot.

Most of Hugin in the Upflank fault block was flooded.

In the F-11 A fault block the well penetrated all major reservoir units which seemed not flooded, hence revealed good perforation options.

Also the part of Lower Hugin Fm. that was penetrated in F-1 B fault block seemed to be un-flooded. The field boundary fault F5 came in later than prognosed, hence increases the volumes downflank.

Property averages of Hugin Fm. are given in table in chapter 6.

The formation pressure points in Hugin show 2 main different pressure levels with a pressure difference of ~ 2.9 bar, ref. plot in chapter 5.5. The pressure points seem to confirm an oil gradient. All pressures are interpreted to be in communication with Hugin main field. Change in pressure level seems to occur in connection to the shale in Hugin 3.2 and the “offshore shale” (the shale between Upper Hugin and Middle Hugin / Thief Zone).

LWD log data is in general of good quality. Exception is an interval of ~ 3 meters (3755 – 3758 m MD RKB) where there are gaps in the density log. Baker Hughes could not explain the reason for these gaps. Bad data is flagged in a BADDATA_FLAG curve (shaded black) in track 9 in the CPI.

13 intervals have been perforated. These are listed in table on next page and plotted as light green intervals in the rightmost track (no. 17) in the CPI (chapter 7).

15/9-F-1 C PERFORATIONS						
Run no.	**Depth [m MD RKB]**	**Date**	**Shot Density**	**Open / Closed**	**Zone**	**Fault block**
1	3973 - 3991	10.04.2014	4SPF	Open	Hugin 1.2	F1B
2	3936 - 3954	10.04.2014	4SPF	Open	Hugin 1.2	F1B
3	3918 - 3936	11.04.2014	4SPF	Open	Hugin 1.2	F1B
4	3888 - 3906	12.04.2014	4SPF	Open	Hugin 1.3	F1B
5	3870 - 3888	12.04.2014	4SPF	Open	Hugin 1.3	F1B
6	3852 - 3870	13.04.2014	4SPF	Open	Hugin 1.3	F1B
7	3817 - 3835	15.04.2014	4SPF	Open	Hugin 1.4, Hugin 1.3	F11A
8	3786 - 3804	15.04.2014	4SPF	Open	Hugin 1.5	F11A
9	3768 - 3786	17.04.2014	4SPF	Open	Hugin 1.6	F11A
10	3640 - 3658	17.04.2014	4SPF	Open	Hugin 2.2	F11A
11	3600 - 3609	18.04.2014	4SPF	Open	Hugin 3.1	F11A
12	3579 - 3588	19.04.2014	4SPF	Open	Hugin 3.2	F11A
13	3545 - 3554	20.04.2014	4SPF	Open	Hugin 3.3	F11A

3 Data Acquisition and QC

3.1 15/9-F-1 C Measurement While Drilling (MWD) / Logging While Drilling (LWD)

The MWD / LWD logging contractor for the entire wellbore was Baker Hughes.
Mud type in the 8 ½" reservoir section was OBM (Enviromul Yellow).
No cores were taken.

		15/9-F-1 C MWD / LWD Run Summary						
		Contractor: Baker Hughes						
LWD Run	**Hole Section [inch]**	**Logging service (tool combination)**	**Pass**	**Pass direction**	**Logging speed**	**Bit depth Interval [m MD RKB]**	**Logging interval [m MD RKB]**	**Remark**
1	17 1/2	OnTrak	Drill	Down	ROP	1364 – 2514	1276 – 2506	Good logging run.
2	12 1/4	CoPilot / OnTrak	Drill	Down	ROP	2514 – 3056	2449 – 3037	Good logging run.
3	8 1/2	AziTrak / CoPilot / LithoTrak / TesTrak / ZoneTrak G	Drill	Down	ROP	3056 - 3059	n.a. – n.a.	Lost connection with AutoTrak after drilling 3 m formation.
4	8 1/2	AziTrak / CoPilot / LithoTrak / TesTrak / ZoneTrak G	Drill	Down	ROP	3059 - 4094	3008 - 4091	Good logging run.

Memory data:

All data was in memory, except gaps in the density log in the interval ~ 3755 – 3758 m MD, which was not explained by Baker Hughes. These gaps were slightly larger in the RealTime data. The gaps have been flagged in a bad data curve; BADDATA_FLAG = 1, which is plotted in black in track. no. 8 in the CPI. The data quality of the memory data is in general good.

3.2 Electrical Wireline Logging

No electrical logging performed in open hole.

4 Petrophysical Evaluation

Petrophysical evaluation is performed according to the Volve petrophysical field model, described in report: “Sleipner Øst and Volve Model 2006, Hugin and Skagerrak Formation, Petrophysical Evaluation”. November 2006. Author: Elin Solfjell, Karl Audun Lehne.

The petrophysical evaluation software used is Geolog, and the Geolog project is SLEIPNER_OST (at Stavanger server: FROST_SVG).

4.1 Porosity

Total porosity, PHIF (ϕ_F), is derived from the density log which is calibrated to overburden corrected core porosity for wells drilled with either OBM or WBM.

The Neutron log, NPHI, has been used to correct for varying mud filtrate invasion.

$$\phi_F = \phi_D + A \times (NPHI - \phi_D) + B$$

where:

$$\phi_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}} \text{ [fraction]}$$

ρ_{ma} is the matrix density [g/cm^3]
ρ_b is the measured bulk density (RHOB), [g/cm^3]
ρ_{fl} is the pore fluid density [g/cm^3].

A and B are regression coefficients.

NPHI: Neutron log in limestone units [fraction]

4.2 Shale volume

To determine VSH, the standard model VSH_{GR} from linear GR relationship is applied:

$$VSH = VSH_{GR} = \frac{GR - GR_{\min}}{GR_{\max} - GR_{\min}}$$

where:

GR = gamma ray log reading [API]
$GR_{\min}$ = GR reading in clean sand [API]

GR_{max} = GR reading in shale [API]

VSH is used quantitatively in deriving permeability, and quantitatively indirectly in Netsand cutoff.

In order to pick GR_{min} and GR_{max} in a more objective way, and to avoid over-estimating of VSH, GR is "normalized" against VSHDN (VSH from density / neutron) by cross plotting GR versus VSHDN. VSHDN is considered to be the most reliable shale indicator (except in intervals dominated by mica and heavy minerals). This shale indicator compares porosity derived from the Density log with porosity from the Neutron log. If the Neutron log reads higher porosity than the density, is this believed to be due to the hydrogen content of present clay minerals.

VSHDN is derived from the response equation for the Neutron log:

$$VCLDN = \frac{NPHICS - (PHIT * HIFL)}{HICL}$$

$$VSHDN = \frac{VCLDN}{(1 - PHISH)}$$

where:

VCLDN = Dry shale volume from density / neutron logs [fraction]
NPHICS = Neutron log corrected to sandstone matrix [fraction]
PHIT = Total log porosity [fraction]
HIFL = Hydrogen Index to fluid
HICL = Hydrogen Index to clay
PHISH = Shale porosity [fraction]

In table below are the general parameters used in Hugin Fm. for deriving VSHDN, given the assumption that Kaolinite is the dominant clay mineral:

VSHDN Parameters		
HIFL (oil / water)	**HICL**	**PHISH**
0.95 / 1	0.5	0.07

4.3 Water saturation

Water saturation is calculated using Archie equation, giving a total water saturation:

$$Sw_t = \left(\frac{a \times R_w}{\phi_F^m \times R_t} \right)^{\frac{1}{n}}$$

where:

a = Archie (tortuosity) factor
R_w = resistivity of formation water [Ohmm]
ϕ_F = total porosity [fraction]
m = cementation exponent
R_t = true resistivity [Ohmm]
n = saturation exponent

4.4 Permeability

The horizontal log permeability, KLOGH, is derived from the following equation based on multivariable regression analysis between log porosity and shale volume ("normalized" against VSHDN) against overburden corrected core permeability:

Heather Fm.: $KLOGH = 10^{(2+8\times PHIF - 9\times VSH))}$

Hugin Fm.: $KLOGH = 10^{(2+8\times PHIF - 9\times VSH))}$

4.5 Composite curves

The following composite curves are used for the petrophysical evaluation:

GR	: GRCFM from OnTrak
RHOB	: BDCFM from LithoTrak
NPHI	: NPCKLFM from LithoTrak
PEF	: DPEFM from LithoTrak
RT	: RPCEHM from OnTrak
DRHO	: DRHFM from LithoTrak
CALI	: CALCM from UltraSonic Caliper, part of LithoTrak

Note that in the 8 ½" section a re-scaled NearBit GR (NBGRCFM) is spliced into GR for the ~ 9 last meters. NearBit GR has been re-scaled by -8 API in order to match GRCFM level.

Note also in general that the final «average» density curve - RHOB (BDCFM) - from Baker is weighted with respect to which of the 16 sectors / bins that provide the best density measurement (smallest standoff).

NPHI (NPCKLFM) is in limestone units, Caliper and salinity corrected and filtered.

The composite curves were created by Logtek from the memory data delivered by Baker Hughes.

Logtek's RDEP (Resistivity Deep) curve = RPCELM, named RD in the OW Volve project.
Logtek's RMED (Resistivity Medium) curve = RPCEHM, named RM in the OW Volve project.

4.6 Depth shift

Depth shifting has been applied, typically in limited overlap intervals around kick off depth and hole sections in Overburden. These depth shifts and the splicing of the individual runs are reported in Logtek's info file; WLC_COMPOSITE_1_INF_1.PDF which is stored in Petrobank.
All depths are referenced to Driller's depth.

Logtek's general "philosophy" with respect to depth shifting in the transition zone between a mother well and a kick off well is as follows: aim to keep the stop-coupled depths as shallow as possible, preferably at KOP. But sometimes it has to be sat deeper (a few meters deeper, preferably in a shale if possible) due to a) if overlapping curves are not on depth at KOP, or b) if the depth shifts have been so large, that the logs else will be too compressed. This "philosophy" also applies of course for depth shifting in overlap between hole sections.

4.7 Evaluation parameters

The following evaluation parameters are used for calculation of porosity, shale volume and water saturation:

15/9-F-1 C Evaluation parameters		
	Formation name	
Parameter	Heather Fm.	Hugin Fm.
ρ_{ma}	2.66	2.65
ρ_{fl}	1	0.9
A	0	0.4
B	0	0.01
$GR_{\min}$	7	7
$GR_{\max}$	120	120
a	1	1
m	2	*)
n	2	2.45
*) $m = 1.865 \times \left(KLOGH^{(-0.0083)}\right)$		
R_w = 0.07 ohmm @ 20 ^{o}C.		
Temperature gradient = 2.6 ^{o}C / 100 m. Reservoir temp.: 111 ^{o}C @ 2800 m TVD MSL.		

Note that the RT curve used for saturation calculation, has been edited in intervals where RPCEHM is affected by polarization horns or is saturated. This editing is kept on a specific curve in Geolog, named RT_EDIT.

4.8 Flag curves

Netsand flag:

Cutoffs on PHIF and VSH are used to determine Netsand; SAND_FLAG = 1.
Hugin Fm.: SAND_FLAG = 1 when PHIF > 0.10 and VSH < 0.50.

These cut offs correspond to an overburden corrected core permeability of 0.5 mD, and are also applied for the Heather Fm.

In addition some manual editing might have been performed on the SAND_FLAG curve.

Carbonate volume:

A varying carbonate volume curve, VCARB, has been made instead of a carbonate flag curve. This carbonate volume curve has been calculated from an empirical relationship:

$$VCARB = \left[\frac{0.2 - (PHIF + 0.3 \times VSH)}{0.2} \right] \times (1 - PHIF - VSH)$$

Note that the volume carbonate is just meant to be used visually / qualitatively, and not for any quantitative purposes.

Bad data flag:

BADDATA_FLAG = 1 whenever data (density log) is bad or missing. BADDATA_FLAG = 0 whenever data is OK. BADDATA_FLAG curve (shaded black whenever 1) is plotted in track 9 in the CPI.

Coal flag:

No coal layers were observed in the well.

Flooded interval flag:

A flag curve showing flooded intervals is named FLOODED_FLAG. When flooded intervals, FLOODED_FLAG = 1.

Flooded intervals are given in table below, and are also plotted as turquoise intervals in track no. 7 in the CPI plot.

15/9-F-1 C FLOODED INTERVALS			
DEPTH [m MD RKB]	**DEPTH [m TVD MSL]**	**ZONE**	**FAULT BLOCK**
3235.5 – 3278.7	2885.8 – 2894.1	Hugin 2.1 (7)	UPFLANK
3291.9 – 3294.5	2896.2 – 2896.6	Hugin 1.6 (6)	UPFLANK
3302.8 – 3303.8	2897.9 – 2898.0	Hugin 1.5 (5)	UPFLANK
3305.7 – 3306.1	2898.2 – 2898.3	Hugin 1.5 (5)	UPFLANK
3344.7 – 3368.6	2902.9 – 2905.5	Hugin 1.4 (4)	UPFLANK
3378.2 – 3379.5	2906.6 – 2906.7	Hugin 1.3 (3)	UPFLANK
3380.6 – 3381.8	2906.8 – 2906.9	Hugin 1.3 (3)	UPFLANK
3383.2 – 3384.3	2907.1 – 2907.2	Hugin 1.3 (3)	UPFLANK
3386.5 – 3460.8	2907.5 – 2918.7	Hugin 1.2 (2), Hugin 1.3 (3)	UPFLANK
3465.0 – 3482.0	2919.5 – 2923.0	Hugin 1.3 (3), Hugin 1.2 (2)	UPFLANK
3488.5 – 3490.0	2924.4 – 2924.7	Hugin 1.2 (2)	UPFLANK
3500.5 – 3503.3	2926.9 – 2927.5	Hugin 1.2 (2)	UPFLANK
3627.6 – 3630.3	2960.0 – 2961.0	Hugin 2.3 (9)	F11 A
3893.0 – 3897.6	3053.9 – 3055.5	Hugin 1.3 (3)	F1B

5 Evaluation of Formation Pressure Data

Baker's TesTrak Formation Pressure While Drilling tool was run in the 8 ½" section of 15/9-F-1 C.

The formation pressures were taken after reached TD while POOH.

5.1 General remarks about Baker's TesTrak test type

In general the test type chosen will have no influence on the acquired pressures – there might however be slight differences in mobility estimates from the second and third drawdown.

If "tight supercharged" test in a Darcy sand is chosen, one will still get the same pressure as a "high mobility" test. As seen from the table below all test types are volume controlled for the first drawdown (DD) anyway – it is only the second and third DD that are different. (The only difference between High and Low Mobility is the third drawdown).

Test Type	First DrawDown (DD)	Second DD	Third DD
High Mobility	Volume	DeltaP	Steady State
Low Mobility	Volume	DeltaP	DeltaP
Tight Supercharged	Volume	Volume	DeltaP
Unconsolidated Sand	Volume w/ initialization	Volume	Volume

The "Unconsolidated Sand" test includes an initialization sequence which might be beneficial to use for the first test. It is also the safest test to run if experiencing problems with the testing. The initialization sequence does however take about 1 min extra time, so if doing a large number of tests one would save some rig-time by doing one of the other types. Under normal conditions any of the tests could be chosen and would give good results.

Test time will be dictated by the formation mobility, independent of the test type (except the 1 extra minute of the "Unconsolidated Sand") – the "smart test" downhole logic will determine when it has 3 stable formation pressures and automatically finish the test. If 3 pressures are not obtained within the specified 10 minutes, the test will abort and the recorded pressures will be transmitted to surface.

To sum up:

Picking the most permeable zones for testing and having proper depth control is far more important than worrying about which test type to choose.

5.2 General remarks about temperature measured by Baker's TesTrak

The TesTrak temperature is the temperature on the quartzdyne pressure sensor, which will require exact temperature correction. This temperature measurement is therefore strongly affected by the temperature of the drilling fluid (and also by annulus temperature and steel temperature), but minor affected by the volume of formation liquid which is drawn in (30 cc).

The temperature of the drilling fluid will also change when circulating: downhole it warms up by the formation and cools down when coming up at the rig, hence will probably be somewhat lower than absolute formation temperature. If extensive pumping it will therefore also be difficult to see relative temperature trends from TesTrak measurements.

To sum up:

TesTrak temperature measurements cannot be used for absolute formation temperature, and most likely cannot be trusted for looking for relative temperature trends either.

5.3 Evaluation of Formation Pressure Data 15/9-F-1 C

13 of 13 tests were successful and of good technical quality. When judging the pressure quality by mobility range (flag curve in OpenWorks: PRES_QUAL), the tests can be summarized as 7 very good quality pressures, 5 good quality pressures and 1 poor quality pressure.

The results are shown in table below and in plots of all formation pressures in Hugin Fm. at Volve (F-1 C formation pressures are marked as brown balls) in chapter 5.4 and 5.5.

The formation pressure points in Hugin show 2 main different pressure levels with a pressure difference of ~ 2.9 bar, ref. plot in chapter 5.5. The pressure points seem to confirm an oil gradient. The 2 different pressure levels seem to be independent of fault block and of whether it is Lower Hugin, Middle Hugin (Thief Zone) or Upper Hugin, but change in pressure level seems to occur in connection to the shale in Hugin 3.2 and the “offshore shale” (the shale between Upper Hugin and Middle Hugin / Thief Zone).

When comparing to initial fm. pressure measured in 15/9-F-12 (February 2008), the formation pressure points in Hugin in F-1 C were respectively ~12.8 bar higher and ~ 15.6 bar higher. The upper level is interpreted to be in good communication with the main field (fits with approx. 12 bar increased pressure). The increased pressure level deeper is interpreted to be due to injection in F-1 B: the pressure was originally much higher and is gradually bleeding back to equilibrium with the main field, but had not quite reached equilibrium at the time of logging (therefore approx. 15 bar higher pressure).

The drawdown mobility is plotted in the permeability track in the CPI plot, and the formation pressure is plotted in the density / neutron track, both marked as red balls.

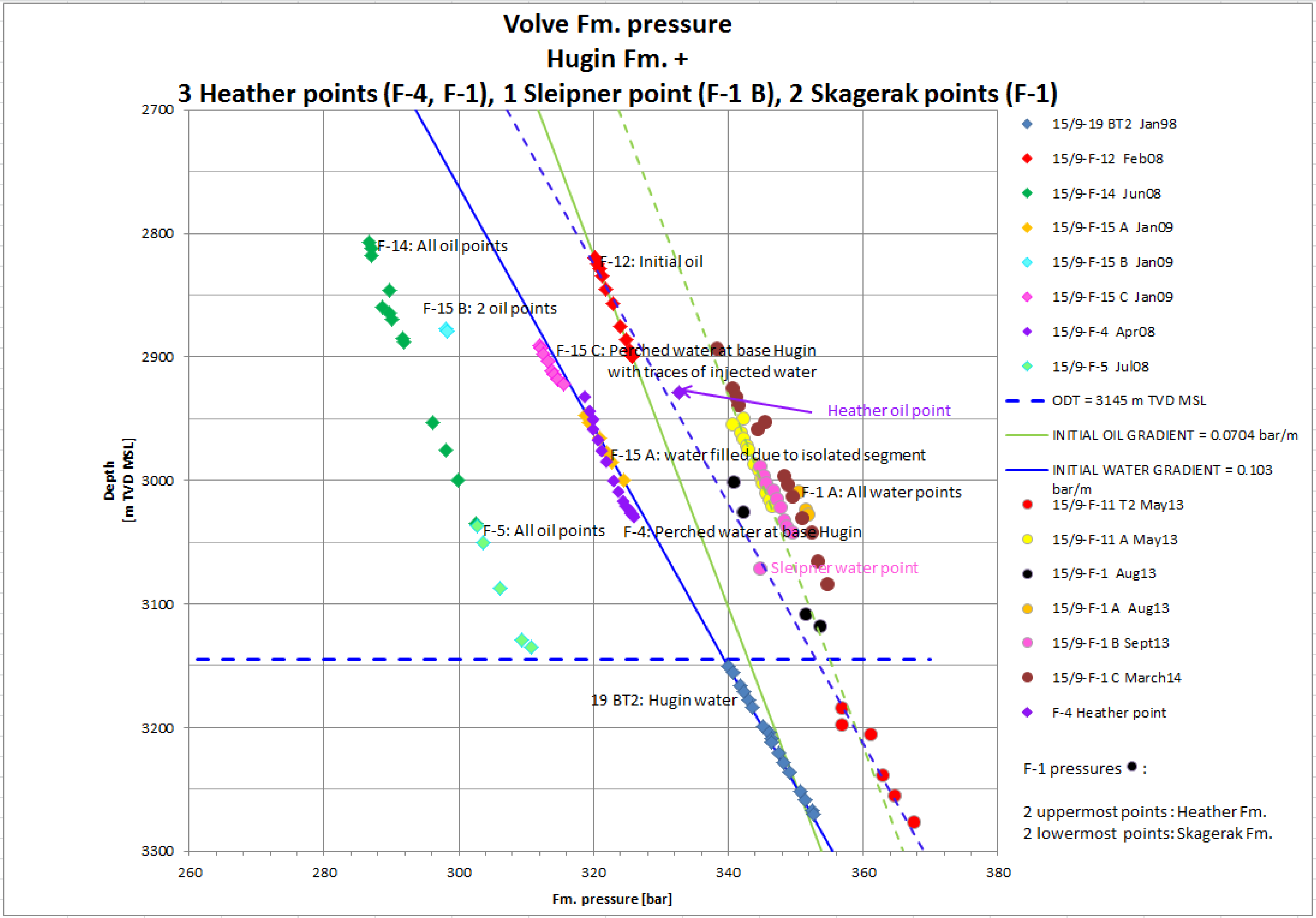
		Well: 15/9-F-1 C Date: 15. March 2014 Rig: Mærsk Inspirer RKB: 54.9 m Baker's TesTrak tool								PORE PRESSURE (s.g ref. RKB) = 10.195*FORM. PRESSURE / m TVD RKB		
FAULT BLOCK	**ZONE NAME**	**Log Run No.**	**Test No.**	**DEPTH [m MD RKB]**	**DEPTH [m TVD RKB]**	**FORM. PRESS. [bar]**	**TEMP. [°C]**	**GOOD SEAL (Y/N)**	**REMARKS**	**DrawDown MOBILITY [mD/cP]**	**PORE PRESS. s.g ref. RKB [g/cm3]**	**MUD+ECD PRESS. s.g ref. RKB [g/cm3]**
F1B	Hugin 1.2	4	1	3977	3138.8	354.577	92.5	Y	OK	148.6	1.152	1.452
F1B	Hugin 1.2	4	2	3925.1	3120.2	353.166	91.4	Y	OK	84.1	1.154	1.454
F1B	Hugin 1.3	4	3	3858	3096.6	352.211	90	Y	OK	35.4	1.160	1.453
F11A	Hugin 1.3	4	4	3823.1	3084.9	350.954	89.3	Y	OK	8	1.160	1.452
F11A	Hugin 1.6	4	5	3768.1	3066.9	349.49	88.6	Y	OK	270.3	1.162	1.451
F11A	Hugin 2.1	4	6	3739.9	3057.5	348.785	87.9	Y	OK	610.4	1.163	1.452
F11A	Hugin 2.1	4	7	3720.1	3050.4	348.273	87.3	Y	OK	322.8	1.164	1.451
F11A	Hugin 2.3	4	8	3620.2	3012.5	344.353	87.1	Y	OK	550.3	1.165	1.452
F11A	Hugin 3.1	4	9	3603	3007.1	345.382	86.1	Y	OK	77.6	1.171	1.447
F11A	Hugin 3.3	4	10	3551.1	2993.1	341.506	85.1	Y	OK	95.9	1.163	1.441
F11A	Hugin 3.3	4	11	3523.2	2986.8	340.985	84.5	Y	OK	53.7	1.164	1.440
UPFLANK	Hugin 1.2	4	12	3493	2980.2	340.45	83.7	Y	OK	458.6	1.165	1.444
UPFLANK	Hugin 2.1	4	13	3273.1	2948.1	338.172	85	Y	OK	1151.6	1.169	1.438
	Total number of tests: 13							No. of Successful tests: 13			No. of Fluid samples: none	
								Hydrostatic gradient in logged interval: -				
	Minimum measured pore pressure (ref. RKB): 1.152 g/cm^3							Maximum measured pore pressure (ref. RKB): 1.171 g/cm^3				
	Using LWD/GR for depth correlation.							All pressure tests were taken as Test Type Option = "High Mobility".				
	Formation pressure data is entered into OW. The curve is named PRES_FORM. Mobility is named PRES_MOBL and temperature PRES_TEMP. Formation pressure test quality in OW is called PRES_QUAL; 0: lost seal, 1: Tight, 2: Poor (<10mD/cP), 3: Good (10-100 mD/cP), 4: Very Good (>100 mD/cP).											

5.4 Plot of Formation Pressure Data

Ref. plot on next page:

Note that the initial water gradient of 0.103 bar/m has been forced through the F-11 T2 pressure points, drawn as a blue, dashed line.

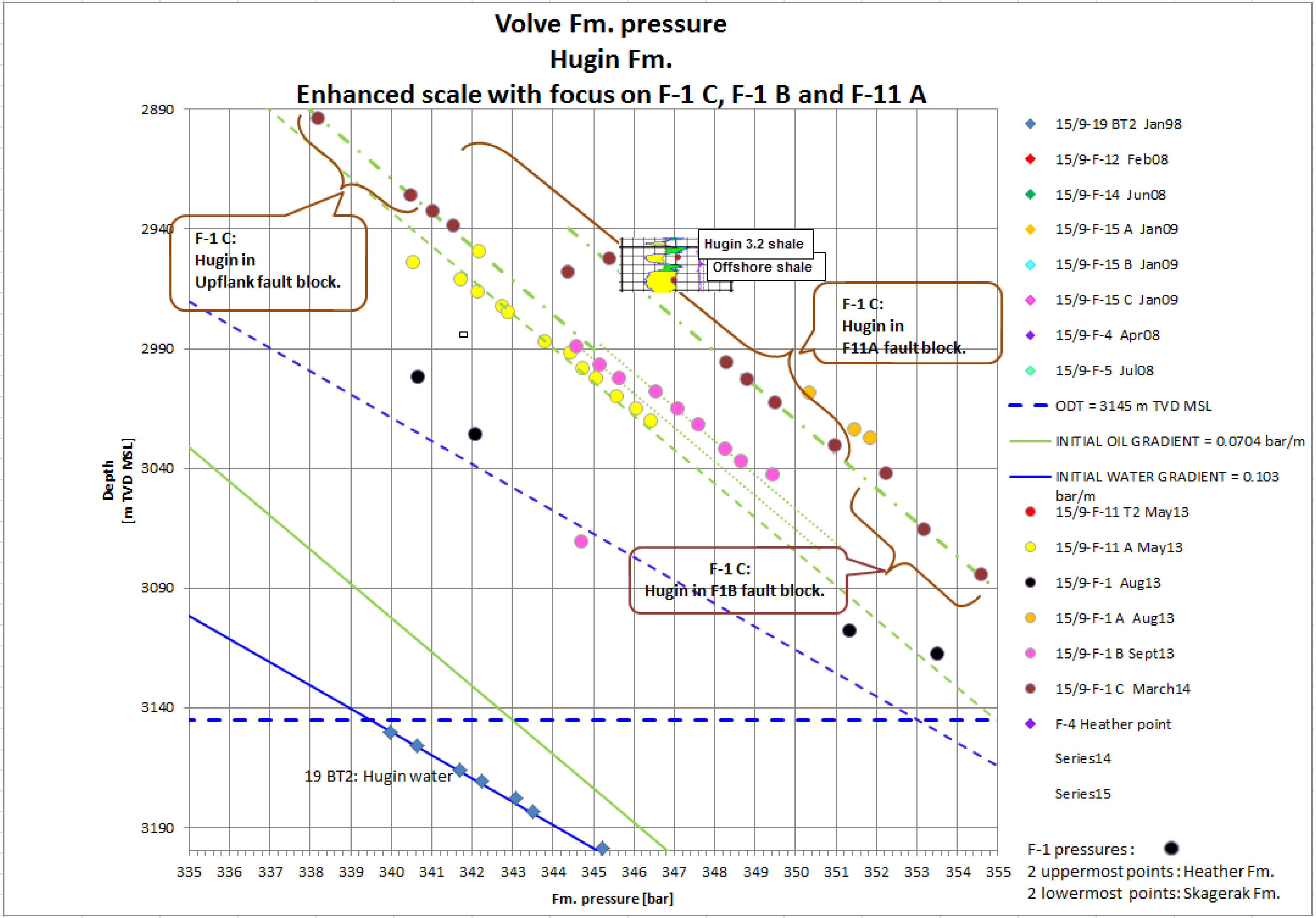
Note also that the initial oil gradient of 0.0704 bar/m has been forced through the F-11 A pressure points, drawn as a green, dashed line.


Volve Fm. pressure
Hugin Fm. +
3 Heather points (F-4, F-1), 1 Sleipner point (F-1 B), 2 Skagerak points (F-1)
Depth [m TVD MSL]
Fm. pressure [bar]
2700
2800
2900
3000
3100
3200
3300
260
280
300
320
340
360
380
F-14: All oil points
F-12: Initial oil
F-15 B: 2 oil points
F-15 C: Perched water at base Hugin with traces of injected water
Heather oil point
F-15 A: water filled due to isolated segment
F-1 A: All water points
F-5: All oil points
F-4: Perched water at base Hugin
Sleipner water point
19 BT2: Hugin water
15/9-19 BT2 Jan98
15/9-F-12 Feb08
15/9-F-14 Jun08
15/9-F-15 A Jan09
15/9-F-15 B Jan09
15/9-F-15 C Jan09
15/9-F-4 Apr08
15/9-F-5 Jul08
ODT = 3145 m TVD MSL
INITIAL OIL GRADIENT = 0.0704 bar/m
INITIAL WATER GRADIENT = 0.103 bar/m
15/9-F-11 T2 May13
15/9-F-11 A May13
15/9-F-1 Aug13
15/9-F-1 A Aug13
15/9-F-1 B Sept13
15/9-F-1 C March14
F-4 Heather point
F-1 pressures :
2 uppermost points: Heather Fm.
2 lowermost points: Skagerak Fm.

5.5 Plot of Fm. Pressure Data with enhanced scale with focus on F-1 C, F-1 B and F-11 A

Ref. plot on next page:

Note that the initial oil gradient of 0.0704 bar/m has been forced through the F-1 C pressure points, drawn as two green, dash dotted lines.



Volve Fm. pressure
Hugin Fm.
Enhanced scale with focus on F-1 C, F-1 B and F-11 A
Depth [m TVD MSL]
Fm. pressure [bar]
F-1 C: Hugin in Upflank fault block.
Hugin 3.2 shale
Offshore shale
F-1 C: Hugin in F11A fault block.
F-1 C: Hugin in F1B fault block.
19 BT2: Hugin water
15/9-19 BT2 Jan98
15/9-F-12 Feb08
15/9-F-14 Jun08
15/9-F-15 A Jan09
15/9-F-15 B Jan09
15/9-F-15 C Jan09
15/9-F-4 Apr08
15/9-F-5 Jul08
ODT = 3145 m TVD MSL
INITIAL OIL GRADIENT = 0.0704 bar/m
INITIAL WATER GRADIENT = 0.103 bar/m
15/9-F-11 T2 May13
15/9-F-11 A May13
15/9-F-1 Aug13
15/9-F-1 A Aug13
15/9-F-1 B Sept13
15/9-F-1 C March14
F-4 Heather point
Series14
Series15
F-1 pressures:
2 uppermost points: Heather Fm.
2 lowermost points: Skagerak Fm.

6 Petrophysical results

Table below in this chapter is showing average values of Net/Gross (N/G), total porosity (PHIF), total water saturation (SW) and horizontal permeability from logs (KLOGH) in Netsand.

Note that the reported water saturation averages are from case calculated with pure Hugin Formation water salinity, as if no flooding.

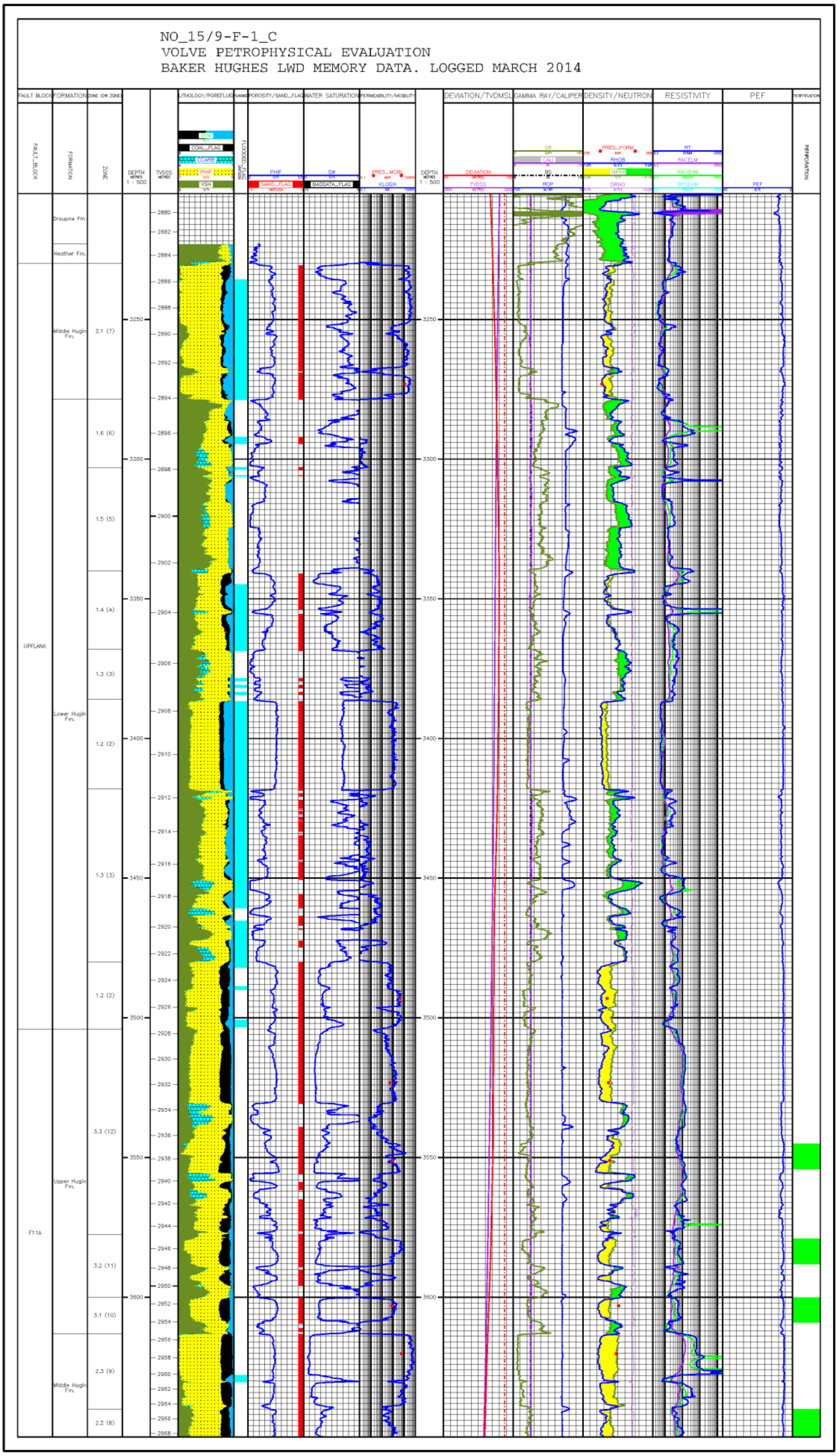
15/9-F-1 C Averages								
Formation / Zone	**Top [m MD RKB]**	**Base [m MD RKB]**	**N/G [fraction]**	**PHIF [fraction]**	**SW [fraction]**	**KLOGH arithmetic [mD]**	**KLOGH harmonic [mD]**	**KLOGH geometric [mD]**
Heather	3223 4004	3230 4094	0 0.039	- 0.123	- 0.896	- 0.3	- 0.2	- 0.3
	Weighted Heather averages:		0.036	0.123	0.896	0.3	0.2	0.3
Hugin	3230	4004	0.809	0.209	0.365	618	2	55
Upper Hugin	3504	3613	0.797	0.215	0.289	100	1	28
Middle Hugin (“Thief Zone”)	3230 3613	3278.5 3765	0.980 0.963	0.217 0.220	0.696 0.223	1890 1608	36 9	968 204
	Weighted Middle Hugin averages:		0.967	0.219	0.338	1677	11	299
Lower Hugin	3278.5 3765	3504 4004	0.574 0.902	0.199 0.204	0.613 0.278	61 209	0.4 10	7 56
	Weighted Lower Hugin averages:		0.743	0.202	0.402	153	1	25
Hugin 3.3 (12)	3504	3577.5	0.797	0.213	0.269	86	6	31
Hugin 3.2 (11)	3577.5	3600	0.776	0.220	0.305	160	0.9	27
Hugin 3.1 (10)	3600	3613	0.835	0.217	0.369	78	0.3	15
Hugin 2.3 (9)	3613	3640	1.000	0.220	0.183	2709	25	1526
Hugin 2.2 (8)	3640	3704	0.959	0.226	0.369	20	4	8
Hugin 2.1 (7)	3230 3704	3278.5 3765	0.980 0.949	0.217 0.213	0.696 0.078	1890 2777	36 251	968 2343
	Weighted Hugin 2.1 (7) averages:							
Hugin 1.6 (6)	3278.5 3765	3303 3786	0.127 1.000	0.170 0.221	0.703 0.217	0.3 117	0.2 62	0.2 87
	Weighted Hugin 1.6 (6) averages:		0.530	0.214	0.267	102	1	41
Hugin 1.5 (5)	3303 3786	3340 3803	0.031 1.000	0.122 0.214	0.970 0.258	0.1 41	0.1 22	0.1 32
	Weighted Hugin 1.5 (5) averages:		0.336	0.208	0.285	39	0.9	22
Hugin 1.4 (4)	3340 3803	3368 3820	0.923 0.947	0.195 0.197	0.500 0.321	4 8	2 5	3 6

	Weighted Hugin 1.4 (4) averages:		0.932	0.196	0.431	6	2	4
Hugin 1.3 (3)	3368 3418 3820	3386 3480 3916.5	0.231 0.640 0.803	0.113 0.152 0.204	0.687 0.783 0.341	0.8 2 71	0.4 0.2 5	0.5 0.5 13
	Weighted Hugin 1.3 (3) averages:		0.687	0.184	0.468	46	0.5	4
Hugin 1.2 (2)	3386 3480 3916.5	3418 3504 4004	0.986 1.000 0.960	0.253 0.233 0.199	0.700 0.383 0.233	114 172 430	65 47 230	104 100 333
	Weighted Hugin 1.2 (2) averages:		0.972	0.217	0.383	314	103	208

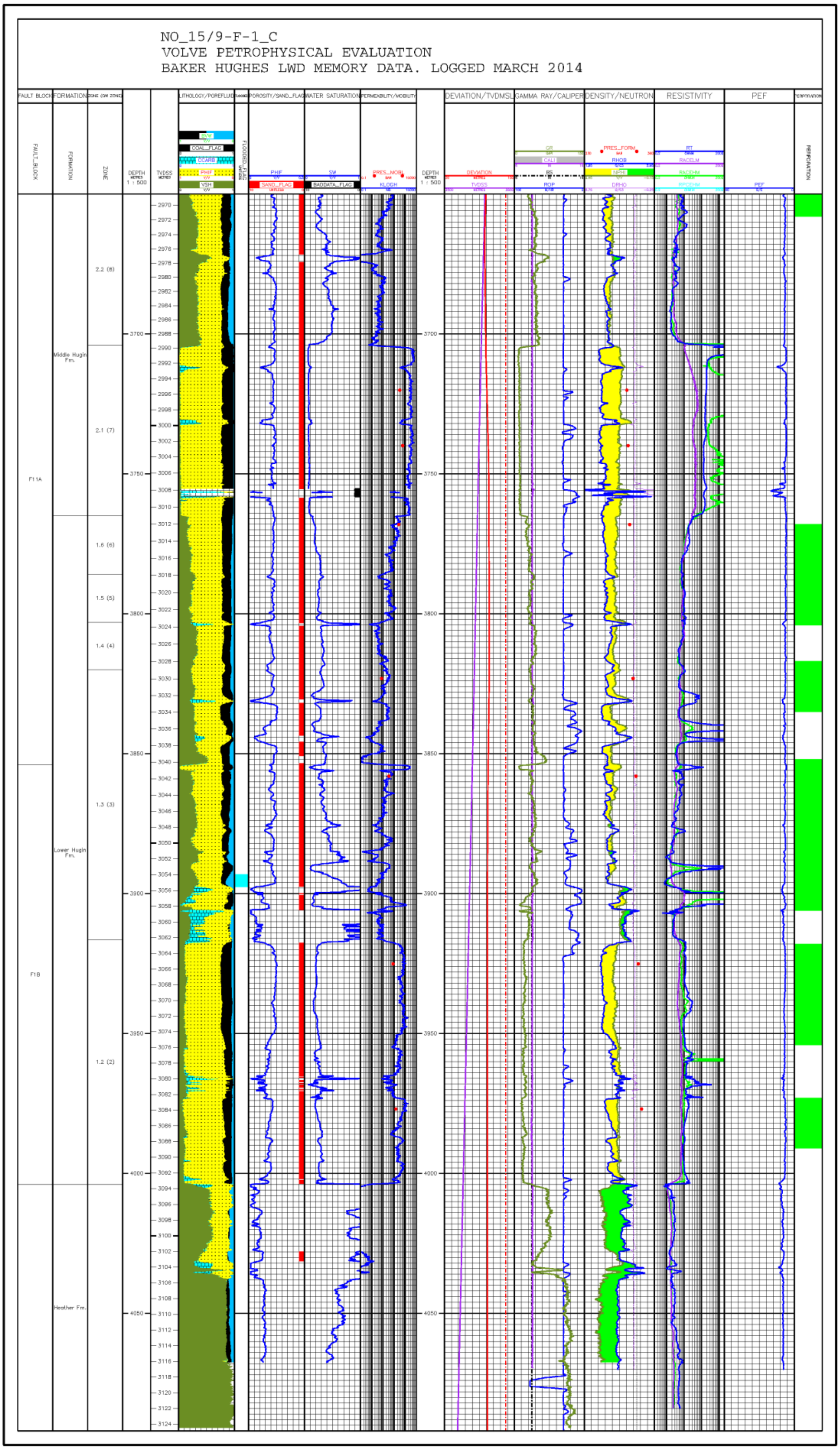
7 CPI plot of evaluated curves and raw data

Note that the CPI is separated in 2 parts for better visualization.

CPI plot 15/9-F-1 C, interval 3205 – 3650 m MD RKB



CPI plot 15/9-F-1 C, interval 3650 – 4092 m MD RKB



8 References

1. “Sleipner Øst and Volve Model 2006, Hugin and Skagerrak Formation, Petrophysical Evaluation”. November 2006. Author: Elin Solfjell, Karl Audun Lehne.
2. Logtek’s info file for well 15/9-F-1 C: WLC_COMPOSITE_1_INF_1.PDF