Petrophysical Report of the Dinantian Carbonates in the Dutch Subsurface

Report by SCAN

April 2019

Ministerie van Economische Zaken en Klimaat
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TNO
Interreg North-West Europe DGE-ROLLOUT

Contents

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Dit rapport is een product van het SCAN-programma en wordt mogelijk gemaakt door het Ministerie van Economische Zaken en Klimaat

WELL DATA LTG-01

Company Name : Total Nederland

Well Name : LTG-01

Field Name : Luttelgeest

Geological target : Lower Carboniferous Carbonates

Country : The Netherlands

Field Location :

Longitude : 05*48'07.5921"E

Latitude :   52*42'54.980"N

Maximum Hole Deviation : 21.42(deg)@TD

Elevation of Kelly Bushing : 5.85m NAP

Elevation of Ground Level : -3.5m

Elevation of Derrick Floor : 5.85m NAP

Permanent Datum : NAP

Elevation of Permanent Datum : 0m

Log Measured from : GR to surface other1130m MD

Maximum recorded temperature : 199 degC

TD : 5171m

Dinantian evaluation in LTG-01 (4355-5123 m MD)

Log quality, edits and depth shifts

The 8 ½” hole has had two logging suites, the upper one down to 4608 m and the second one to TD at 5171 m and the logs were spliced. The logs on the files from the contractor are not entirely on depth with the master logs from Petrel, probably due to later processing by either the contractor or the operator. To enable a good evaluation with the complete set of logs, the log runs were depth matched to the master logs. This has been done by shifting the density of the upper and lower runs to the density of the master log. For the upper section there is no doubt which file to depth match as there is only one. However, for the lower section it was the file number 066 that was used and shifted to the master log.

The upper sonic-induction in the 8 ½” was also depth matched to the master logs and then spliced.

There are some issues with the induction and it appears that the four-foot curves are the better ones. This is based both on a remark on the log header and by observation. The drawback of this is that the induction resistivity curves have poor resolution and there is no laterolog available.

Due to the use of a high density mud with Barite, the PEF is very high and very erratic and cannot be used in a qualitative sense only as an indication of invaded/loss zones.

Log corrections

The APLC is slightly too low, negative, in many intervals and although there may be a few places where a 0 APLC porosity is present, most of the values should however not be negative. A value of 0.008 has therefore been added to the APLC to normalize it.

The other logs have not been corrected.

Evaluation of Dinantian (4355-5123 m MD)

Porosity was calculated from the normalized APLC, the density and the sonic applying both Limestone and Dolomite properties. Cross plot porosity was calculated from density-normalized APLC and sonic-normalized APLC. The two x-plot porosities are overall in very good agreement. The exceptions are in the more severely washed out intervals.

In this well the invasion/losses are severe, and the resistivity is affected severely by this. Therefore, and because the induction resistivity is inappropriate for the very high resistivities seen, porosity has not been calculated from the resistivity.

The poor hole conditions in some intervals, particularly 4775-4798 m, result in an extremely poor density, which had to be edited, and the neutron is affected. The sonic is much less affected. The final porosity is therefore a combination of the x-plot porosity from the sonic-neutron and the Dolomite porosity calculated from the sonic (dtma=145 µs/m, dtfl=620 µs/m), taking the lower of the two.

A clay indicator was calculated from the K (Potassium) with clean formation having 0 % Potassium and 100 % clay having 5 % Potassium content, resulting in the following equation:

Clay Indicator = 20*K (K in fractions)

The proportions of Limestone and Dolomite is based on the calculated matrix slowness (DTMapp) from the sonic-neutron x-plot limited to the interval 145-160 µs/m. The Limestone proportion is calculated based on the following equation with a Limestone slowness of 160 µs/m and a Dolomite slowness of 145 µs/m corrected for clay:

Limestone proportion = (-9.667+0.06667*Calculated Matrix Slowness (DTMapp)) *(1-Clay Indicator)

Dolomite proportion = 1 – (Limestone + Clay indicator)

Result

The result of the evaluation can be seen in the log evaluation plot. In the middle depth track are the cored intervals and the core recovery indicated in brown. In the evaluation track 11 is the Clay Indicator, in track 12 the porosity and the core porosity on a 10 to 0 % scale with the test interval indicated in black. In track 13 is the core permeability and in track 14 is the calculated lithology displayed. The sums and averages for this well is provided in the table below with a Clay Indicator cut off of 0.1.

Gross	Net	Net/Gross	Average Porosity	Average Clay Indicator	Average Porosity times net	Normalized Porosity*net	Porosity cut-off
MD	MD	MD					
m	m	fract	fract	fract	m	fract	fract
768,0	747,88	0,974	0,011	0,010	8,32	1,00	0,00
768,0	237,95	0,310	0,025	0,011	6,02	0,72	0,01
768,0	115,82	0,151	0,037	0,011	4,33	0,52	0,02
768,0	82,45	0,107	0,043	0,011	3,52	0,42	0,03
768,0	42,06	0,055	0,050	0,012	2,09	0,25	0,04
768,0	16,31	0,021	0,059	0,014	0,97	0,12	0,05
768,0	6,10	0,008	0,067	0,015	0,41	0,05	0,06
768,0	1,52	0,002	0,079	0,016	0,12	0,01	0,07
768,0	0,61	0,001	0,086	0,018	0,05	0,01	0,08
768,0	0,15	0,000	0,093	0,016	0,01	0,00	0,09
768,0	0,00	0,000			0,00	0,00	0,10

The second column from the right is a normalized product of average porosity and net (Average porosity*net/Average Porosity*net at no porosity cut off) to enable plotting in the same graph as the other parameters, see figure 1 below.

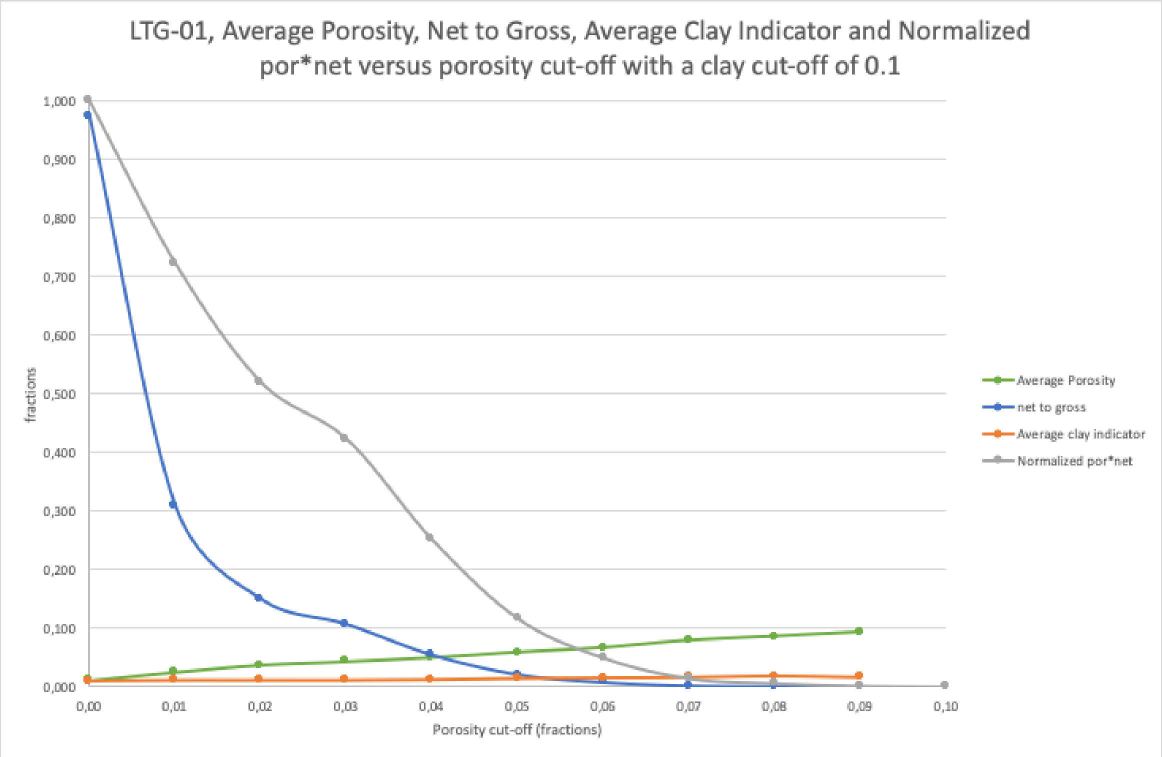


Figure 1. Average porosity, net-to-gross, clay indicator and normalized porosity*net thickness for increasing porosity cut-off

The graph illustrates a very rapid decrease in net to gross followed by a slowing trend in the decrease up to a porosity cut off of 7 % and then a short tail with almost no net up to 10 % where the net is 0. The product of average porosity and net (Normalized por*net) has a fast decrease. However, due to the rapid increase in average porosity with increasing porosity cut-off, the decrease is not very rapid. The average of the clay indicator is low and almost flat with increasing porosity cut-off showing that there is no relationship between porosity and clay content.

The average porosity at no porosity cut-off is 1.1 %, a low value consistent with most other Dinantian wells.

Discussion

This well have almost no clay at all in the Dinantian carbonate based on the Potassium and the Thorium concentration.

The porosity development is poor, and most intervals have a porosity below 2 % and in many intervals the porosity is close to 0. There are four thicker intervals with porosity above 2 % and they are 4474-4500 m, 4572-4597 m, 4760-4795 m and 5046-5092 m. In addition to these, there are a few short intervals with porosity above 2 % but these are only a few meters thick or less.

In the three upper thicker more porous intervals, the porosity is very erratic pointing to karstic nature of the porosity development.

In the lower interval, 5046-5092 m the blocky nature of the porosity development is most likely caused by dolomitization and the same is probably the case for the short intervals 15-30 m above this interval.

One very anomalous interval is between 4765-4769 m where the neither the sonic nor the density indicate a very high porosity, while the neutron indicate a high porosity. One explanation may be that the neutron sees deeper into the rock compared to the other two and detects a relatively large void, something the other two porosity tools cannot see due to the smaller depth of investigation of these tools. Another explanation could be that the higher porosity is on one side of the borehole and not on the other and the neutron detects this because it is a circumferential measurement, while the density only detects a small sector and the sonic detects the fastest path (lowest porosity). The resistivity does not contradict any of these possibilities.

Between 4830 and 4980 m there are a significant number of lower resistivity spikes and a check on the descriptions do not indicate anything obvious that could cause this. Fractures could be one explanation, however, if these would be open they would have barite mud in them and this would cause high to very high PE, but this is not the case. If fractures are cemented there could be some conductive minerals like Pyrite, but none has been reported from this interval. This is most likely the cause but cannot be confirmed. A similar set of anomalies do exist in UHM-02 but not in the other wells.

There are several places where the apparent matrix density is very high, while the apparent matrix slowness is close to that of Limestone. These might be Baryte or Sphalerite as they do not appear to affect the resistivity. The high density spike at 4535 m is most probably Baryte because it has also a very marked high PEF value. The other high density anomalies at 4551-4556 m and at 4617 m are probably more likely to be Sphalerite due to less pronounced PE, although there could also be Baryte or other non-conductive high density minerals. Part of the problem, to distinguish what mineral that may cause the high densities, is the high density mud with Baryte and the losses that cause high PE effects.

Core data

The Dinantian was cored in the following intervals: 4376-4379.5 m (2.4 m recovered, 69 %), 4470-4480 m (3 m recovered, 30 %).

Flow potential

Well Test

One well test was performed in the interval 4580-4620 m. No flow was recorded. Pressure recorded during test at 4475 m was 407 bar. Most likely this is an indication that something did flow into the wellbore during the test, but this would have to be confirmed by pressure records and the test report. It is likely that the large losses have damaged the productive zones in the Dinantian such that the productivity is significantly lower than it would have been without the losses. There is no record of any acid stimulation, something that would normally enhance the productivity.

It is recommended that the test report(s) for this well is requested from the present or previous operator.

Losses in Dinantian

Minor losses were recorded from 4450 m, heavy losses at 4606 m. From 4847 to 4925 m, minor gains were detected. Minor to major losses at 5023 m (top Devonian): <148 l/min to >15 m3/hr. Mud density in section was 1460 to 1470 kg/m3. The gains may be an indication of so called ballooning where the mud is first lost into the formation in fractures or porous sections and then, when the hydrostatic head is slightly lower, due to small variations in mud density, the fluids initially lost to the formation flows back into the wellbore. This is not an uncommon feature in carbonate rocks.

The lost circulation zones are easily identified by the PE due to the very high PE effect of Baryte, used as weighting agent in the mud. From the PE curve on the pressure and lost circulation plot, see below, the zones with the best porosity are generally the ones with the highest PE, identifying them as the zones where the losses occurred. It should be noted that the loss reports shown in the last track does not necessarily line up with where the largest losses occurred, this is due both to reporting and to that the worst losses may not occur immediately but a bit later than the zone taking the losses had been penetrated.

During drilling signs of H2S were recorded in the gasline.

Wireline formation tester

A large set of wireline formation pressures were attempted in the Dinantian, see Appendix.

Most pressure tests targeted the zones with better porosity and large losses. Most of these failed due to seal failure, something that is normal in such zones particularly when the hole is poor. Many pressure tests were tight.

Only 10 of all the pressure test points provided acceptable pressures that could be judged to be reasonable stable and had more than approximately 5 cubic centimeter (cc) draw down (dd). Seven of these targeted the very short interval 4604-4605 m and on several of these pressure tests there were pump outs and samples taken. Outside this interval, only 3 pressure recordings can be considered acceptable. These pressures were taken on three different runs and the hydrostatic pressure does therefore differ a bit from run to run. Another issue is that the temperature is very high, and the quartz gauges run did work but were close to the maximum temperature and this will affect the accuracy of the gauges. The runs on 29 September and 3 October, which both had pressure points in the interval 4604-4605 m had different quartz pressure gauges and a clear difference can be seen in the formation pressure between these two runs in this short interval. Under normal temperatures the difference should not be as large as seen here but with these extreme temperatures above 175 °C, it is not surprising that there is a difference of 2-3 bar.

In the tables below are the pressures with the best quality listed by run:

MDT on 11 September, 2004

Test No	File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilized Pressure during test	Remark
		m	bar	bar	bar	
39	42	4529.6	630.34	630.22	629.49	4th dd 0,6 cc dd. Stable. Mobility 0,5 mD/cP (previous dd's were 9.9, 10.5, 0.5 and 0.6 cc).
44	44	4445.6	618.64	618.6	611.44	2,4 cc dd. Almost stable. Mobility=0.7 mD/cP (previous dd was 2.3 cc)

MDT on 29 September, 2004

Test No	File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilized Pressure during test	Remark
		m	bar	bar	bar	
-1	25	5073.2	693.6	N/A	690.79	7.6 cc. Stable. Mobility=2 mD/cP (previous dd 2.2 cc)
29	210, 58	4604.7	629.88	629.89	605.20	Reset, 20 cc dd, Stable. Mobility=6.3 mD/cP
45	45	4604.5	629.05	629.01	604.53	Almost stable. 14.3 cc dd. Mobility 11.3 mD/cP (previous dd 6.3 cc)

MDT on 3 October, 2004

Test No	File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilized Pressure during test	Remark
		m	bar	bar	bar	
8	86	4604.5	632.3	632.2	602.39	Building slowly. 3.8 cc dd. Mobility=1.4 mD/cP (did several pressure tests and pumped out prior to this pressure test and sampled two MPSR's)
4	90	4604.3	632.1	686.91	602.38	Pressure slowly building. 1.1 cc dd. Mobility=1.1 mD/cP (previous dd's 2.2 cc and 19.1 cc)
9	92	4604.1	632.06	631.83	602.25	Stable. 1.4 cc dd. Mobility=2.2 mD/cP (previous dd's 3.4 cc, 1.6 cc and 10.1 cc)
18	98	4605	631.92	631.89	602.14	Slowly building. 3.3 cc dd. Mobility=1.1 mD/cP (previous dd 10.1 cc)
35	185	4604.4	631.66	631.62	601.83	Almost stable but bu too short for full stabilization. 5.4 cc dd. Mobility=5.3 mD/cP (previous dd's 5.2 cc, 9.9 cc and tiny pump out but larger than previous dd's)

The best pressures are plotted on the pressure plot below with black dots. From the plot and the tables above, it can be concluded that the 3 pressure points recorded outside the short interval 4604-4605 m have stabilized pressures close to the hydrostatic pressure (smaller brown squares), something that is a clear warning flag. The stabilized pressures in the interval 4604-4605 m have a significantly lower pressure than the hydrostatic pressure and are close together with the lower cluster around 602 bar (0.132 bar/m) on the run on 3 October, while the pressures recorded at this depth on 29 September are a bit higher, around 605 bar. Considering the high temperature and that two different quartz gauges where used on the two different runs, this is acceptable.

Most likely the pressures measured in the interval 4604-4605 m are close to formation pressure. On two of these pressure points, there were pump outs and samples taken. On one of these, there were pressure tests after the pumping and sampling, test 8 on 3 October, where the pressure before and after sampling was very similar with only a minor fall in pressure. This points to that these pressures are reflecting the actual reservoir pressures. The only caveat may be that this zone appears to have had the highest losses (see loss and pressure plot with extremely high PE in this interval) and it is not absolutely certain that this zone is not supercharged.

The formation pressure gradient is not known because there are no samples or valid indications of the salinity of the formation waters due to losses with high resistivity mud. Therefore, a sea water gradient has been used to calculate the formation pressure, see plot. Based on a normal pressure gradient with 1 atmosphere at surface and a sea water gradient down to the interval 4604-4605 m (approx. 4553 m TVDss), the overpressure at this depth is approximately 140 bar. With a salt saturated water with a density of 1190 kg/m^3 the overpressure is reduced to 69 bar.

The 3 pressure stations outside the interval 4604-4605 m, have pressures much higher than the pressure expected based on the pressures in the interval 4604-4605 m and the explanation of this is that these pressures were taken in zones that are poorly connected to the rest of the reservoir and that they therefore have been overpressured by the invading mud or mud filtrate, so called supercharging.

The conclusions that can be drawn from the pressures recorded in LTG-01 are:

- The Dinantian is overpressured and that the overpressure is in the region of 140 bar. Minimum overpressure with salt saturated to surface is 69 bar.
- The different porous intervals are very poorly connected such that in 3 of them, severely supercharge pressures are measured.
- The only interval that appear to be reasonably connected to a larger system is the porous interval in and around 4604.5 m, but this is not absolutely certain and, if not, the actual reservoir pressure could be lower, how much is not possible to say, probably not by much.

Formation temperature

The operator did tabulate the maximum measured bottom hole temperature from all logging runs and the temperature data is taken from this table. All these measurements are from maximum thermometers run in the cable head of the logging tools.

Table showing the maximum temperatures from the different logging runs in LTG-1. All logging runs were made in 2004 and the year is therefore not tabled. End of drilling is left out and only the timing of the last circulation is recorded.

Run	End of circulation	Log at TD	Time since circ.	Circ. Time	Max. Temp	Depth (MD)
			min	min	Deg C	m
1.1.1	21/06 13:30	22/06 10:45	1275	90	106	2806
1.1.2	21/06 13:30	22/06 18.37	1747	90	106	2806
2.1.1	18/07 12:30	19/07 15:20	1610	30	134	3845
2.1.3	18/07 12:30	21/07 00:18	3588	30	145	3821
2.1.5	18/07 12:30	22/07 01:45	5115	30	153	3838
3.1.1	08/08 08:00	09/08 07:10	1390	210	153	4261
3.1.2	08/08 08:00	09/08 20:30	2190	210	165	4283
3.1.3	08/08 08:00	10/08 06:10	2770	210	169	4279
4.1.1	03/09 18:00	04/09 11:20	1040	90	171	4592
4.2.1	05/09 07:30	05/09 21:55	865	240	174	4595
4.3.1	06/09 21:00	07/09 15:30	1110	240	161	4580
4.3.2	06/09 21:00	08/09 07:40	1850	240	174	4600
4.3.3	06/09 21:00	08/09 16:00	2610	240	177	4587
4.3.4	06/09 21:00	08/09 23:00	2930	240	179	4577
4.4.1	10/09 00:00	10/09 12:20	740	270	168	4595
4.4.2	10/09 00:00	11/09 01:50	1550	270	174	4555
4.4.3	10/09 00:00	11/09 15:00	2340	270	181	4550
5.1.1	22/09 16:30	23/09 19:40	1630	180	197	5168
5.1.2	22/09 16:30	24/09 04:40	2170	180	199	5154
5.1.3	22/09 16:30	24/09 11:50	2600	180	199	5163
5.2.2	26/09 03:00	27/09 07:20	1700	570	168	4416
5.3.2	28/09 10:30	29/09 13:20	1610	180	199	4647
5.4.1	02/10 16:00	03/10 04:30	750	270	176	5073

From the electronic temperatures it can be concluded that the maximum temperatures in this well were not at the bottom of the hole but approximately 100 m above bottom. Therefore, the depths where the temperatures will be recorded for temperature gradient will be approximately 50 m above the point recorded in the table above, which is not the actual TD but the top of the tool combinations deepest point.

For log suite 1 no Horner extrapolation can be done as the same temperature was recorded on both runs. The temperature recorded can only be used as a minimum at this depth.

For log suite 2, a Horner extrapolation result in a formation temperature of 159 deg C at 3780 m (deepest point reached with thermometers: 3821-3845 m).

For log suite 3, the Horner extrapolation result in a formation temperature of 186 deg C at 4220 m (deepest points reached with thermometers: 4261-4283 m)

For log suite 4 there are two sets of data that allow a Horner extrapolation. The first result in a formation temperature of 191 deg C at 4530 m (deepest points reached with thermometers: 4577-4600 m). The second set result in a temperature of 186 deg C at 4510 m (deepest points reached with thermometers: 4550-4595 m). The data is more scattered on the second set and it is overall a bit shallower and if only two points of the data would be used the temperature would be higher in both cases. Also, the first set have 4 points that all fall close to the interpolated line. A temperature of 190 deg C is therefore chosen at 4530 m.

For log suite 5, the three points from the first 3 runs result in a Horner extrapolated formation temperature of 203 deg C at 5100 m (deepest points reached with thermometers: 5154-5168 m).

Table of temperature gradients based on the Horner derived formation temperatures using a surface temperature of 10 deg C.

Depth	Depth TVDss	Temperature	Temperature gradient	Temperature gradient back to surface
m	m	Deg C	Deg C/m	Deg C/m
6	0	10		
3780	3729	159	0.040	0.040
4220	4169	186	0.061	0.042
4530	4479	190	0.013	0.040
5100	5048	203	0.023	0.038

From the temperature data the temperature gradient is very high in this well down to 4220 m (4169 m TVDss) and below this depth it is much lower. It is therefore best to divide the temperature calculated in the well with one equation down to 4220 m and a different below this depth. The formation temperature equations are as follows:

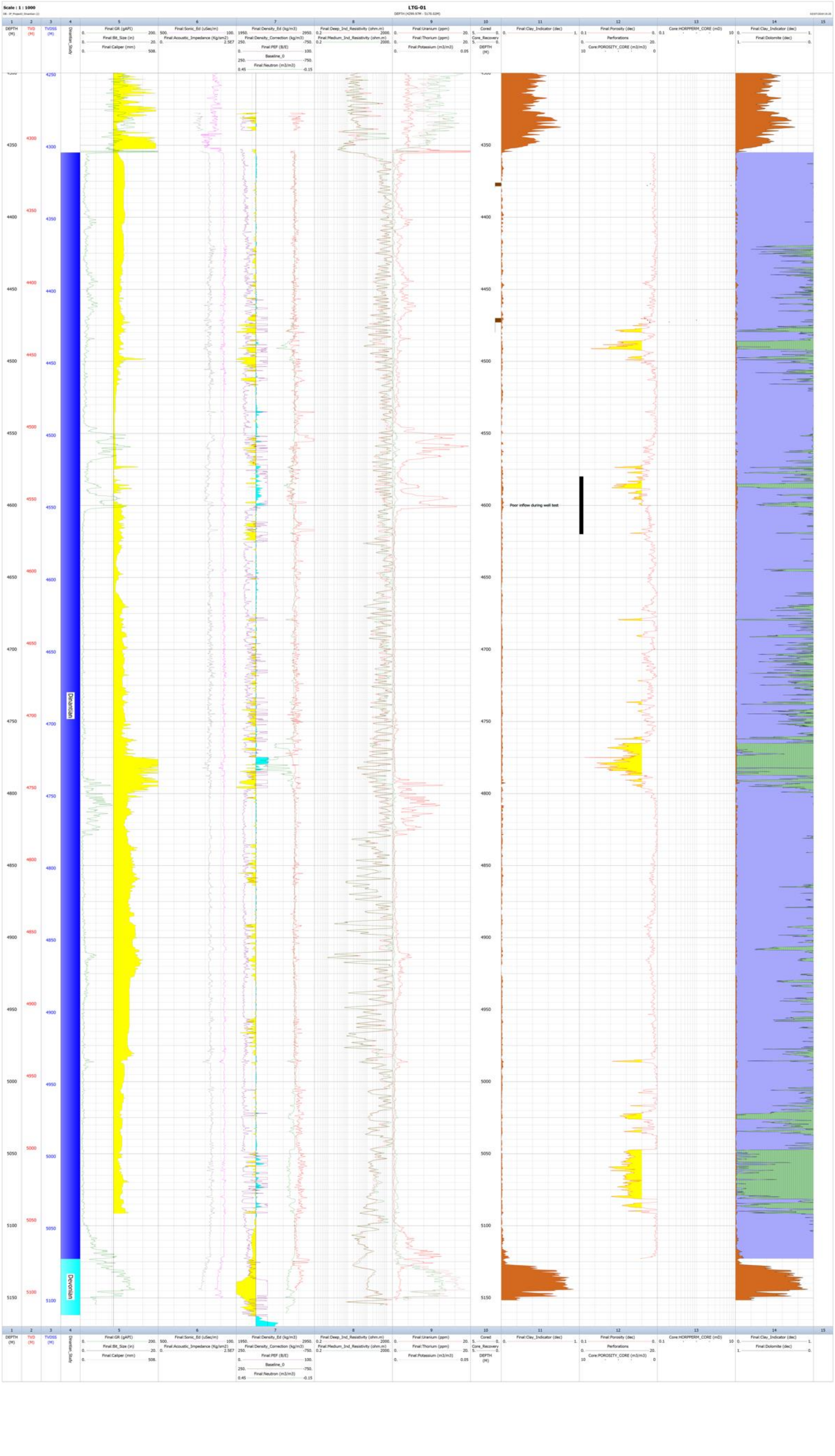
6-4220 m (0-4169 m TVDss)

Formation Temperature = 10 + 0.042216* TVDss

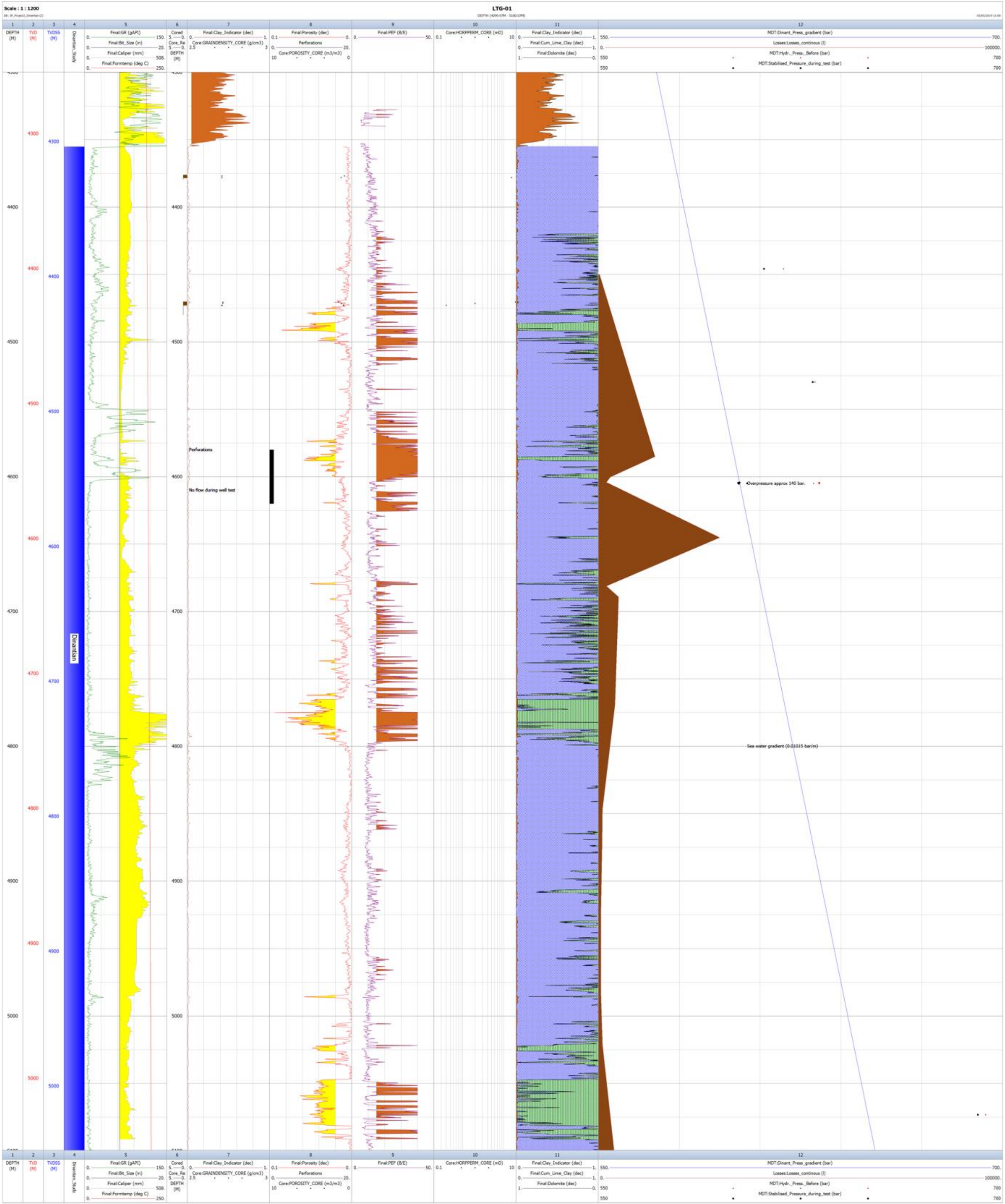
Below 4220 m (4169 m TVDss)

Formation Temperature = 105.4 + 0.01934 * TVDss

Evaluation plot



Pressure plot LTG-01



Well logging summary LTG-01

		WELL LOGGING SUMMARY
OPERATOR:	Total Nederland	
WELL:	Luttelgeest	
WELL BORE:	LTG-01	
FIELD:	Luttelgeest	
PLATFORM:	onshore	
COUNTRY:	NETHERLANDS	
DRILL PERMIT #:		
WELL STATUS:	p and a	

Hole section:	File name:	Main Service:	Generic Logs	Service Company:	Mode:	Run #:	Sub file:	Run Type	Pass Direction (Up/Down)	Date:	Interval Top (m):	Interval Bot (m):	Remarks:
17 1/2"		GR-AIT-DSI-EMS-ACTS	GR-IND-Sonic-CAL-SUB	SCHLUMBERGER	EWL	1	1	Main	UP	22-JUN-2004	1131	2782	**OBM**
17 1/2"		HNGS-LDS-APS-ACTS	SpecGR-DEN-NEU-SUB	SCHLUMBERGER	EWL	1	2	Main	UP	22-JUN-2004	1130	2782	**OBM**
12 1/4"		GR-AIT-DSI-EMS-ACTS	GR-IND-Sonic-CAL-SUB	SCHLUMBERGER	EWL	2	3	Main	UP	20-21-JUL-2004	2685	3838	**WBM**
12 1/4"		HNGS-LDS-APS-ACTS	SpecGR-DEN-NEU-SUB	SCHLUMBERGER	EWL	2	4	Main	UP	21-22-JUL-2004	3750	4300	**WBM**
12 1/4"		GR-AIT-DSI-EMS-ACTS	GR-IND-Sonic-CAL-SUB	SCHLUMBERGER	EWL	3	5	Main	UP	09-AUG-2004	3750	4300	**Thermadrill**
12 1/4"		ACTS-IPLT-EMS	SpecGR-DEN-NEU-CAL	SCHLUMBERGER	EWL	3	6	Main	UP	10-AUG-2004	3800	4300,0	**Thermadrill**
8 1/2"		GR-FMI-EMS	GR-Borehole Image-CAL	SCHLUMBERGER	EWL	3	7	Main	UP	03-SEP-2004	4310	4609,0	**Thermadrill poor data**
8 1/2"		HNGS-IPLT-ACTS	SpecGR-DEN-NEU-SUB	SCHLUMBERGER	EWL	3	8	Main	UP	08-SEP-2004	4285	4613,0	**Thermadrill**
8 1/2"		GR-AIT-DSI-EMS-ACTS	GR-IND-Sonic-CAL-SUB	SCHLUMBERGER	EWL	3	9	Main	UP	03-SEP-2004	4285	4613,0	**Thermadrill**
8 1/2"		GR-FMI-EMS	GR-Borehole Image-6 arm caliper mud resistivity	SCHLUMBERGER	EWL	3	10	Main	UP	03-SEP-2004	4310	4609,0	**poor data-CALIPER closed**
8 1/2"		MDT-Dual Packer 7"	Wireline formation testing	SCHLUMBERGER	EWL		11	Main	UP	05-06-SEP-2004	4534.9	4534.9	**Packer failure**
8 1/2"		MDT-Dual Packer 7"	Wireline formation testing	SCHLUMBERGER	EWL		12	Main	UP	03-SEP-2004	4591.6	4602.4	**Packer failure**
8 1/2"		MDT-Dual Packer 5"	Wireline formation testing	SCHLUMBERGER	EWL		13	Main	UP	03-SEP-2004	4285	4613,0	**Packer failure**
8 1/2"		HNGS-IPLT	SpecGR-DEN-NEU-SUB	SCHLUMBERGER	EWL		14	Main	UP	08-SEP-2004	4285	4613,0	
8 1/2"		GR-AIT-Array Sonic-CBL	GR-IND-Array Sonic-Cement Bond	SCHLUMBERGER	EWL		15	Main	UP	08-09-SEP-2004	2800 CBL 4285	4613,0	**poor results borehole conditions**
8 1/2"		MDT-Dual Packer 5"	Wireline formation testing	SCHLUMBERGER	EWL		16	Main	UP	10-SEP-2004	4588.8	4591.6	**Packer failure lost seal**
8 1/2"		MDT Single Probe	Wireline formation testing	SCHLUMBERGER	EWL		17	Main	UP	11-SEP-2004	4588.8	4591.6	**Failure on hydraulic module**
8 1/2"		MDT Single Probe	Wireline formation testing	SCHLUMBERGER	EWL		18	Main	UP	12-SEP-2004	4588.8	4591.6	**30 pretests 29 lost seal 1 good 2 PVTsamples**
8 1/2"		GR-FMI	GR-Borehole Image	SCHLUMBERGER	EWL		19	Main	UP	23-SEP-2004	4545	5167,0	**tool failure got stuck @ 4776m**
8 1/2"		HIPLT-HNGS	High temp press SpecGR-DEN-NEU-	SCHLUMBERGER	EWL		20	Main	UP	24-SEP-2004	4551	5170,0	DEN-Cal not open below 5061m
8 1/2"		GR-QAIT-QSLT-EMS	GR-VSP-CAL	SCHLUMBERGER	EWL		21	Main	UP	24-SEP-2004	4608	5163,0	
8 1/2"		GR-EMS	GR-6 arm caliper	SCHLUMBERGER	EWL		22	Main	UP	24-SEP-2004	4240	4608,0	caliper check for MDT tests
8 1/2"		GR-MDT-Dual Packer	Wireline formation testing	SCHLUMBERGER	EWL		23	Main	UP	26-SEP-2004	4250	4250,0	tool stuck and freed
8 1/2"		GR-MDT single probe	Wireline formation testing	SCHLUMBERGER	EWL		24	Main	UP	27-SEP-2004	4399	4379,0	9 pretests 5 no seal 4 supercharged
8 1/2"		GR-MDT-Dual Packer	Wireline formation testing	SCHLUMBERGER	EWL		25	Main	UP	28-29-SEP-2004	4283	4283,0	tool stuck @ 4283m and freed
8 1/2"		GR-MDT dual probe	Wireline formation testing	SCHLUMBERGER	EWL		26	Main	UP	29-30-SEP-2004	4590	5075,0	55 pretests 34 no seal 21 good seal no sampling
8 1/2"		GR-MDT single probe	Wireline formation testing	SCHLUMBERGER	EWL		27	Main	UP	03-OCT-2004	4547	4646.8	35 pretests 9 tight 15 lost seal 1 questionable @4646.8m 1 supercharged 9 fair pressure points 4604.1 to 4605m 3 PVT samples and 1 chamber taken

Appendix: Complete evaluation of MDT pressure tests in Dinantian.

Run :4.4.3. MDT Single probe, 11 Sept. 2004.

Test No	File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilised Pressure during test	Remark
		m	bar	bar	bar	
	27	4489,0	624,8	624,8	-	Seal Failure
	28	4488,8	624,8	624,9	-	Seal Failure
	29	4489,2	624,9	624,9	-	Seal Failure
	30	4493,0	625,5	625,5	-	Seal Failure
	31	4496,0	625,9	625,9	-	Seal Failure
	32	4478,0	623,4	623,4	-	Seal Failure
	33	4478,5	623,5	623,5	-	Seal Failure
	34	4477,5	623,4	623,4	-	Seal Failure
	35	4477,0	623,3	623,3	-	Seal Failure
	36	4534,8	631,24	631,24	-	Seal Failure
	37	4535	631,28	631,28		Seal Failure
27	38	4534,6	631,2	631,09		1) 20cc dd. Very Tight, Retracted too soon. 2) Retracted @ reset. 3.8 cc dd. Tight. Building at 629,67 bar.
	39	4537,2	631,47	631,46		Seal Failure
	40	4537,5	631,49	631,49		Seal Failure
34	41	4537	631,41	631,39		1) 10,1 cc dd. Very tight, then seal failure. 2) 1.1 cc dd. Building, tight. 3) 1.5 cc dd. Building rapidly. Very tight.
39	42	4529,6	630,34		629,48	1) 9,9 cc @ 60. Almost stable, low permeability.
cont.	same	same			629,31	2) 10,5 cc dd. Not fully built, waited too short
cont.	same	same			629,41	3) 0,5 cc dd. Slowly building
cont.	same	same			629,44	4) 0,6 cc dd. Not fully built, waited too short.
cont.	same	same			629,49	5) 0,6 cc dd. Stable Mobility 0,5 mD/cP
cont.	same	same				6) Pumped out (very small) building at 629,12 bar
cont.	same	same				7) Pumped out sampled bottle 1.
cont.	same	same		630,22		8) Pumped out, sampled bottle 2. 330-350 bar while pumping.
44	44	4445,6	618,64			1) 2,3 cc dd. Unstalbe at 611.66 bar
cont.	same	same			611,44	2) 2,4 cc dd. Almost stable
cont.	same	same				3) 4,9 cc dd. Building at 611,30 bar
cont.	same	same				4) Short pumpout
cont.	same	same				5) 4,9 cc dd. Rapidly building, very unstable.
cont.	same	same				6) 4,9 cc dd. Building at 610.89 bar
cont.	same	same		618,6		7) Pump out. Mobility 0.7 mD/cP
	45	4416,8	614,67	614,66		Seal Failure

	46	4417	614,69	614,68		Seal Failure
	48	4418	614,83	614,83		Seal Failure
	49	4416,6	614,63	614,62		Seal Failure
49	50	4403	612,77	612,77		9,9 cc dd. Dry test. Absolutely no flow.
50	51	4403,2	612,8	612,79		5,0 cc dd. Dry test. Absolutely no flow.
	52	4427	616,03	616,04		Seal Failure
	53	4426,8	615,99	615,97		Seal Failure
	54	4491	624,67			Seal Failure (no record of end test)
	55	4491,5	624,73	624,72		Seal Failure
	56	4495	625,22	625,19		Seal Failure
	57	4489,5	624,45	624,43		Seal Failure
	58	4488,2	624,27	624,27		Seal Failure

Run No: 5.2.2, MDT Single probe, 27 Sep. 2004

File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilised Pressure during test	Remark
	m	bar	bar	bar	
137	4398,0	598,4	598,4	-	Seal Failure
138	4398,2	598,4	598,4	-	Seal Failure
139	4398,5	598,4	598,4	-	Pressure builds back to same as hydrostatic, pressure cannot be validated. Two dd 2.1 cc and 3.0 cc, mobility 0,5 mD/cP
140	4398,3	598,4	598,4	-	Seal Failure
141	4398,2	598,4	598,4	-	Tight, builds back to hydrostatic, dd 1.2 cc + 0.5 cc, too small.
142	4380,0	595,9	595,9	-	Draw down too small, 3.5 cc. Very low permeability and builds back to hydrostatic.
143	4379,5	595,9	595,9	-	Seal Failure
144	4379,0	595,8	595,8	-	Seal Failure
145	4379,2	595,8	595,8	-	Invalid test, insufficient size of draw down. Indicating tight.

Run No: 5.3.2, MDT single probe, 29 Sep. 2004.

Test No	File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilised Pressure during test	Remark
		m	bar	bar	bar	
1	181	5061,8	692,3	692,3	-	Tight, 2 cc dd

3	182	5062,0	692,3		-	1st dd 2,5 cc. Building rapidly (631.25 bar). Very low mobility
same	same	same	-	692,3	-	2nd dd 1.5 cc. Building rapidly (631,58 bar). Very low mobility
4	183	5062,0	692,2	692,2	-	1.3 cc. Building rapidly (637.14 bar) Very low mobility.
-1	25	5073,2	693,6	-	690,8	2.2 cc dd. Almost stable
same	same	same	-	-	690,8	7.6 cc. Stable. Mobility=2 mD/cP
same	same	same	-	N/A	-	Pump out but not allowed to stabilize.
4	190	5073,2	693,5	-	-	1.9 cc. Building, too short build up (690,47 bar)
same	same	same	-	693,5		18,7 cc. Building, too short build up (690,17 bar) Header and summary plots are not same as recorded file 190. File 9 is not file 190! File 47 at 5073.2 m has correct header file. Mobility 1.9 mD/cP.
2	47	5073,4	693,64	693,61		Tight. 2.2 cc dd. Building at 663,82 bar.
5	54	5025,2	686,95	686,91		Tight, 1.4 cc dd.
7	55	5025	686,86	686,86		Tight. 1.5 cc + 1.6 cc dd.
9	56	5024,8	686,81	686,73		Tight. 1.7 cc+ 1.2 cc dd. Pressure dropping on first dd.
11	57	5059,4	691,4	691,42		Tight. 1.4 cc + 0.7 cc dd.
13	58	5049,5	690,05	690,08		Tight. 1.1 cc + 1.0 cc dd
	59	5049,2	690,01	690,01		Tight. 1.2 cc dd
16	60	4986	681,52	681,56		Tight and second bu is dry. 1.1 cc + 20 cc dd
	(14, 50)	4985,8	681,42	681,43		Seal failure
	(15, 16)	4985,6	681,39	681,38		Seal failure
	(16, 17)	4935	674,64	674,61		Seal failure
	(20, 21)	4890,2	668,54	668,52		Seal failure
	(21, 22)	4591,6	628,22	628,24		Seal failure
29	(210, 58)	4604,7	629,88			Too small dd. 2.8 cc dd
same	same	same			605,34	Stabilizing. .5 cc dd
same	same	same			605,09	Stable, 15.2 cc dd
same	same	same		629,89	605,2	Reset, 20 cc dd, Stable. Mobility=6.3 mD/cP
	(22, 23)	4625,2	632,8	N/A		No test
	3	4625,2	632,74	632,72		Seal failure
	4	4626	632,83	632,81		Seal failure
	(63, 5)	4626,2	632,83	632,8		Seal failure
7	6	4670	638,73		618,89	Building. 8.1 cc dd
Same	same	same			617,31	Building. 2.2 cc dd
Same	same	same			616,85	Building rapidly. 1.9 cc dd
Same	same	same		638,68	617,79	Building. 2.2 cc dd. Supercharged not valid test
	7	4668	638,41	638,4		Seal failure
	8	4691,8	641,61	641,61		Seal failure
	9	4717,5	645,12	645,1		Seal failure
12	10	4715,7	644,87	644,86		Tight, rapidly building. 4.4 cc + 1.9 cc dd
	13	4762,4	651,04	651,03		Seal failure

	14	4761,8	650,98	650,96		Seal failure
	15	4861,7	664,32	664,32		Seal failure
	(11, 12)	4861,5	664,3	664,34		Seal failure
	17	4856,9	663,73	663,73		Seal failure
19	18	4864,3	664,73	664,7		Tight, very rapidly building. 8.7 cc + 3.2 cc dd
23	(65, 21)	4889,1	667,9	667,9		Seal failure
	22	4892,3	668,34	668,32		Seal failure
25	23	5055,3	690,14	690,31		Tight, rapidly building. 4.7 cc dd
	24	4984,5	680,74	680,73		Seal failure
	27	4984,5	680,6	680,59		Seal failure
	28	4976	679,43	679,43		Seal failure
	29	4976,2	679,45	679,44		Seal failure
	31	4913,7	671,09	671,09		Seal failure
	32	4913,5	671,01	670,98		Seal failure
	(12, 33)	4895	668,53	668,52		Seal failure
	35	4717,4	644,67	644,61		Seal failure
34	36	4717	644,54	644,47		Tight, very rapidly building. 7.5 cc dd
	37	4691,4	640,97	640,96		Seal failure
	38	4653	635,74	635,71		Seal failure
	39	4653,5	635,78	635,76		Seal failure
40	40	4650	635,29		618,78	Tight, building. 5.6 cc dd
same	same	same				Unstable. 2,7 cc dd
same	same	same		635,24	612,5	Building. 1.4 cc dd. Too tight for valid test, supercharged.
	41	4649	635,1	635,09		Seal failure
	42	4647	634,81	634,8		Seal failure
	(13, 44)	4604,7	629,09	629,08		Seal failure
45	45	4604,5	629,05			Insufficient dd, 6.3 cc dd
same	same	same		629,01	604,53	Almost stable. 14.3 cc dd. Mobility 11.3 mD/cP

Run: 5.4.1, MDT single probe, 3 October 2004

Test No	File No	Depth	Hydr. Press. Before	Hydr. Press. After	Stabilised Pressure during test	Remark
		m	bar	bar	bar	
8	86	4604,5	632,3		-	Unstable, approx. 604.5 bar. 2.3 cc dd
same	same	same			602,65	slowly building. 1.2 cc dd.
same	same	same	-	-	-	Pumped out and sampled two MPSR bottles.
same	same	same		632,3	602,23	Building. 2.4 cc dd. Reset tool.
same	same	same	632,3	-	-	Building rapidly. 5.1 cc dd, possible leak.
same	same	same	-	632,2	602,39	Building slowly. 3.8 cc dd. Mobility=1.4 mD/cP
1	89	4604,7	632,2	632,2		Tight. Building rapidly. 1.9 cc dd.
4	90	4604,3	632,1	-	-	Pressure unstalbe, building. 2.2 cc dd.

same	same	same	-		602,42	Pressure stable. 19.1 cc dd.
same	same	same			602,38	Pressure slowly building. 1.1 cc dd. Mobility=1.1 mD/cP
same	same	same		686,91		Attempted pump out. Pressure after pump out 601.95 bar and building
	91	4604	632,05	632,05		Seal failure
9	92	4604,1	632,06			Building at 604 bar. 3.4 cc dd
same	same	same			602,30	Stable. 1.6 cc dd
same	same	same				Unstable pressure. 10.1 cc dd
same	same	same			602,25	stable. 1.4 cc dd. Mobility=2.2 mD/cP
same	same	same				Pumped out and sampled two PSR bottles followed by one MRSC. End pressure 601.39 bar prior sealing.
same	same	same		631,83	601,68	Pressure building slowly with indication of slowing down.
11	95	4604,4	631,83	631,84		Tight, rapidly building. 2 dd's, 4.3 + 0.8 cc
13	96	4604,6	631,87	631,87		Tight, rapidly building. 2 dd's, 8.6 + 1.8 cc
	97	4604,8	631,9	631,89		Seal failure
18	98	4605	631,92			Rapidly building @ 603.4 bar. 10.1 cc dd
same	same	same			602,14	slowly building. 3.3 cc dd
same	same	same				Unstable b.u, building @ 603.7 bar. 2.5 cc dd
same	same	same				Increasing build rate @ 602.34 bar after initial slower rate, possible leak. 2.5 cc dd. Mobility=1.1 mD/cP
same	same	same				Pump out 1170 cc.
same	same	same		631.89		Short bu after pump out, building rapidly at 600.98 bar.
20	99	4605,2	631,9	631,9		Tight, rapidly building. 2 dd's 3.4 + 0.8 cc
22	101	4604,2	631,78	631,76		Tight, rapidly building. 2 dd's 4 + 1.7 cc
24	102	4603,9	631,73			Unstable and rapid bu. 4.5 cc dd.
same	same	same		631,71	601,91	Initially stabilizing at 601.91 bar, then starting to build. Uncertain quality of press. 2.1 cc dd. Mobility=0,4 mD/cP
26	103	4603,8	631,71	631,69		Tight, rapidly building. 2 dd's 5.6 cc + 3.4 cc
27	106	4604,7	631,72	631,72		Tight, rapidly building. 3.7 cc dd
29	107	4604,5	631,69			Tight/Leak, rapidly building at 604.13 bar. 5.1 cc dd
same	same	same		631,68		Building at 602.13 bar. Mobility=0.4 mD/cP
30	108	4604,3	631,66	631,64		Tght. 4.1 cc dd
32	109	4604,1	631,62	631,61		Tight. 2 dd's, 3.8 cc + 1.4 cc
35	185	4604,4	631,66			Almost stable at 601.92 bar, then accelerating. 5.2 cc dd.
same	same	same				Almost stable at 601.87 bar, then accelerating. 9.9 cc dd.
same	same	same				Almost stable at 601.59 bar, then acceleratiing after very small pump out.

same	same	same			601,83	Almost stable but bu too short for full stabilizaton. 5.4 cc dd. Mobility=5.3 mD/cP
same	same	same		631,62		Pumped out 1170 cc but did not allow bu.
36	111	4604,5	631,65	631,64		Tight. 4.6 cc dd
39	113	4547	623,8	623,8		Tight. 2 dd's, 7.9 cc + 1.2 cc
	114	4551,4	624,41	624,41		Seal failure
43	115	4551	624,36	624,35		Tight. 2 dd's, 4.8 cc+ 1.9 cc
	116	4553,4	624,69	624,68		Seal failure
47	117	4553	624,63	624,61		Tight, buidling steadily at 607.64 bar. 5.9 cc dd
	122	4558	625,28	625,27		Seal failure
	123	4557,8	625,23	625,23		Seal failure
	124	4557,6	625,22	625,21		Seal failure
	125	4562,6	625,89	625,89		Seal failure
	126	4562,6	625,89	625,88		Seal failure
	127	4563,6	626	626		Seal failure
	128	4563,4	625,97	625,96		Seal failure
	129	4568,2	626,61	626,61		Seal failure
	131	4632	635,11	635,17		Seal failure
	132	4639,4	636,18	636,18		Seal failure
	133	4639,1	636,13	636,12		Seal failure
21	168	4646,8	637,09			Insufficient dd, 5,5 cc dd
same	same	same				Unstable and rapid bu. 6.2 cc dd
same	same	same			610,25	Almost stable after unstable and long bu (800 sec). Supercharged. Mobility=0.2 mD/cP
same	same	same			609,84	Seal failureSmall pump out. Unstable and overall bu indicated supercharging.

Appendix: Horner plots

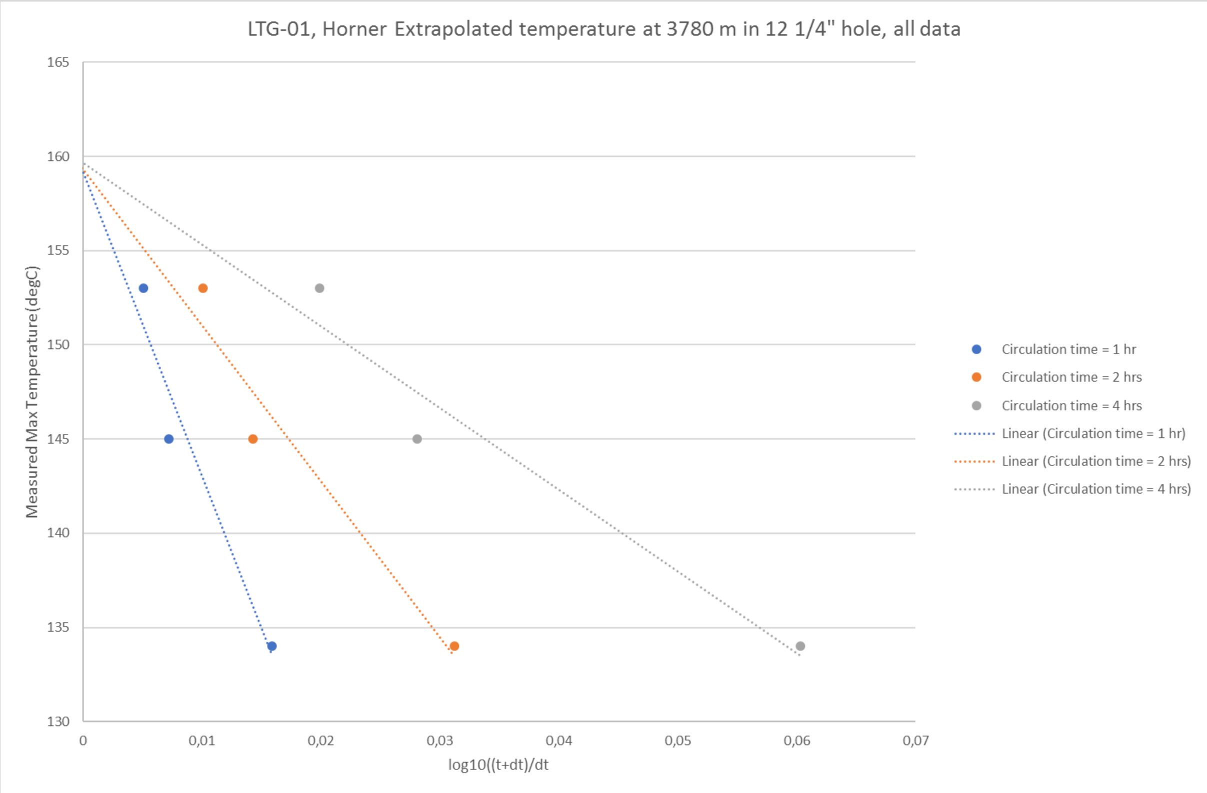


Figure 1. Horner plot at 3780m

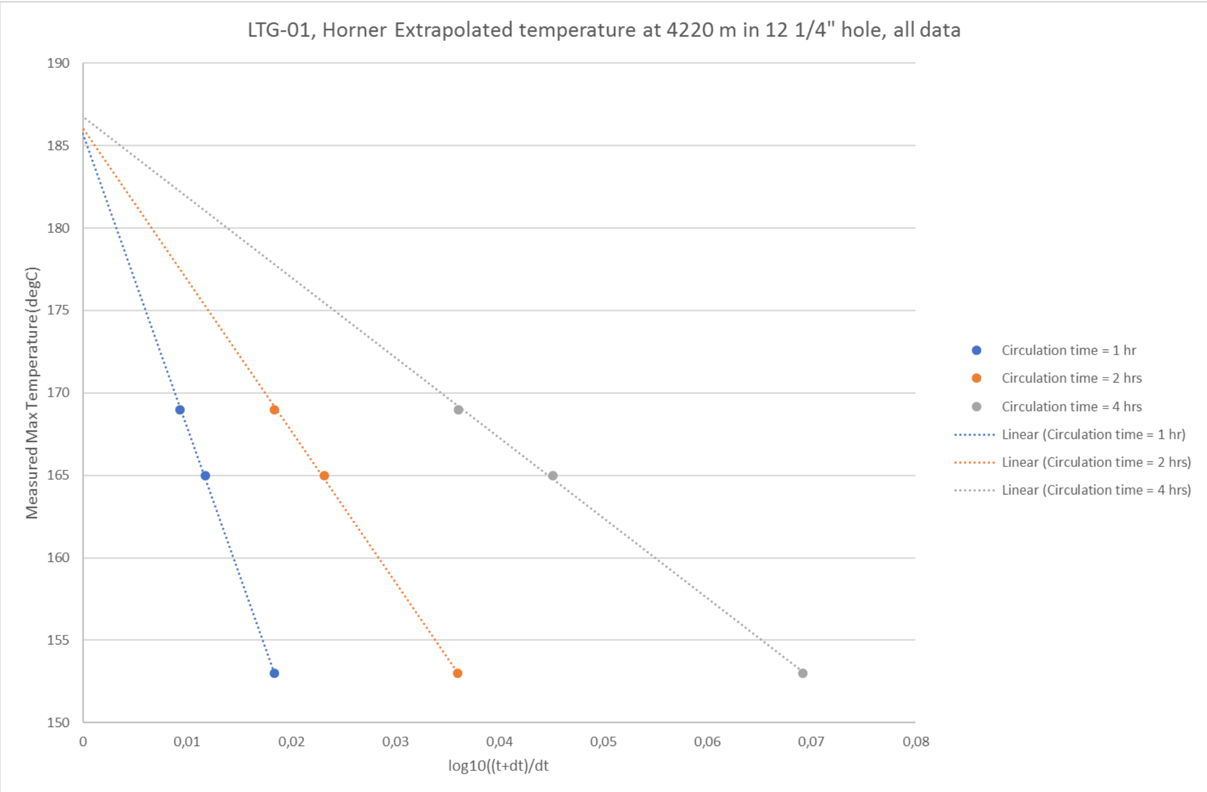


Figure 2. Horner plot at 4220m

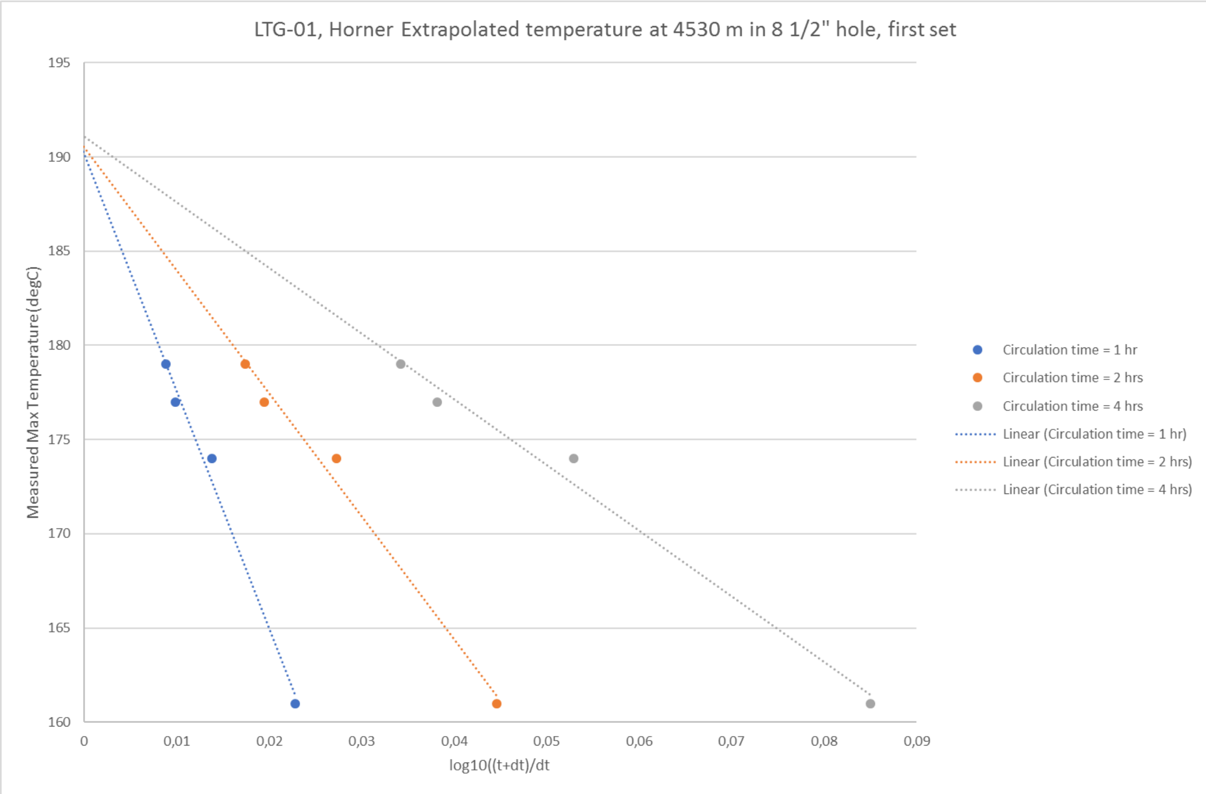


Figure 3. Horner plot at 4530m

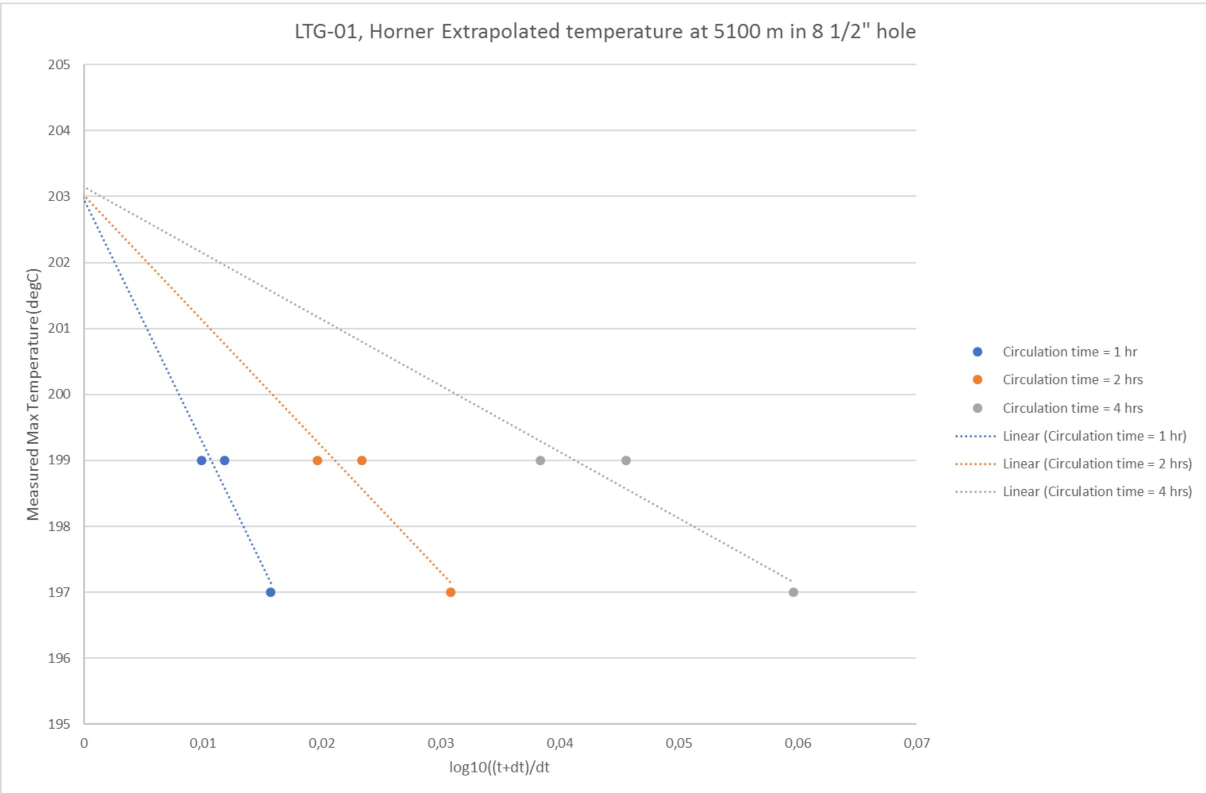


Figure 4. Horner plot at 5100m

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