Petrophysical Report of the Dinantian Carbonates in the Dutch Subsurface

Report by SCAN

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Ministerie van Economische Zaken en Klimaat
ebn
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 GVK-01

Company Name : NEOM - RGD GBH

Well Name : GVK-01

Field Name : OPAC Project Zuid-Limburg

Country : The Netherlands

Field Location : onshore

Geological targets : Lower Carboniferous

Longitude : 182.530 X

Latitude : 326.340 Y

Maximum Hole Deviation : see deviation diagram

Elevation of Kelly Bushing : no data

Elevation of Ground level : 106m

Elevation of Derrick Floor : no data

Permanent Datum : see ground level

Elevation of Permanent Datum : see ground level

Log Measured from : Ground level first data from 31m

MRT Maximum recorded Temperature : 46 degC

TD : 1687.8m on 06.09.2018 final BPB Density Log

There was no drilling report available to verify important details.

Dinantian evaluation in GVK-01 (992-1492 m MD)

Log quality, edits and depth shifts

The Dinantian has been logged in two sections, 12 ¼" and 8 ½". The result is that many logs that are not included on the Petrel composite had to be spliced after being depth shifted.

There are some issues with overpulls that have resulted in lost data or lower quality data. The largest overpull is on the sonic-GR log at 1325 m.

The hole is of good quality and therefore no issues with poor data due to washouts.

The change from 12 ¼" hole to 8 ½" does also cause some loss of data and for seismic purposes the sonic has been straight line edited across this interval (1094.5-1100.9 m).

In most of the depth shifts, the GR's have been used as a guide. An exception is the laterolog where the laterolog resistivity has been shifted to the neutron (NPHI) of the Petrel composite data.

Spectral GR and GR curves have been spliced such that they are continuous. However, the section 1087-1100 m have been logged inside casing and the GR curves are therefore suppressed in this interval.

Log corrections

Both neutron and density need correction to have the lowest porosity centered close to the 0 porosity of Limestone, see fig 1. After correcting the neutron by deducting 0.01 and adding 20 kg/m3 to the density, the cross plot agrees with this basic consideration. It is possible that the density should have a larger correction.

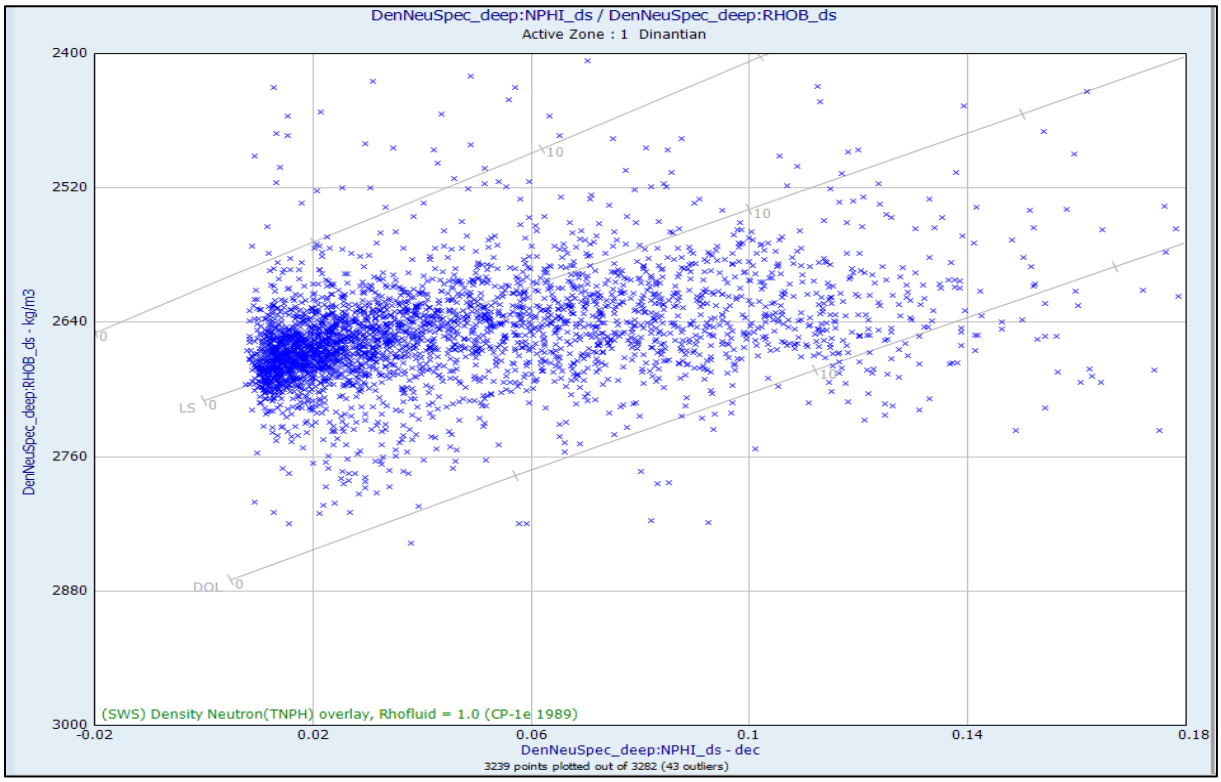


Figure 1. Density-Neutron cross plot, uncorrected data.

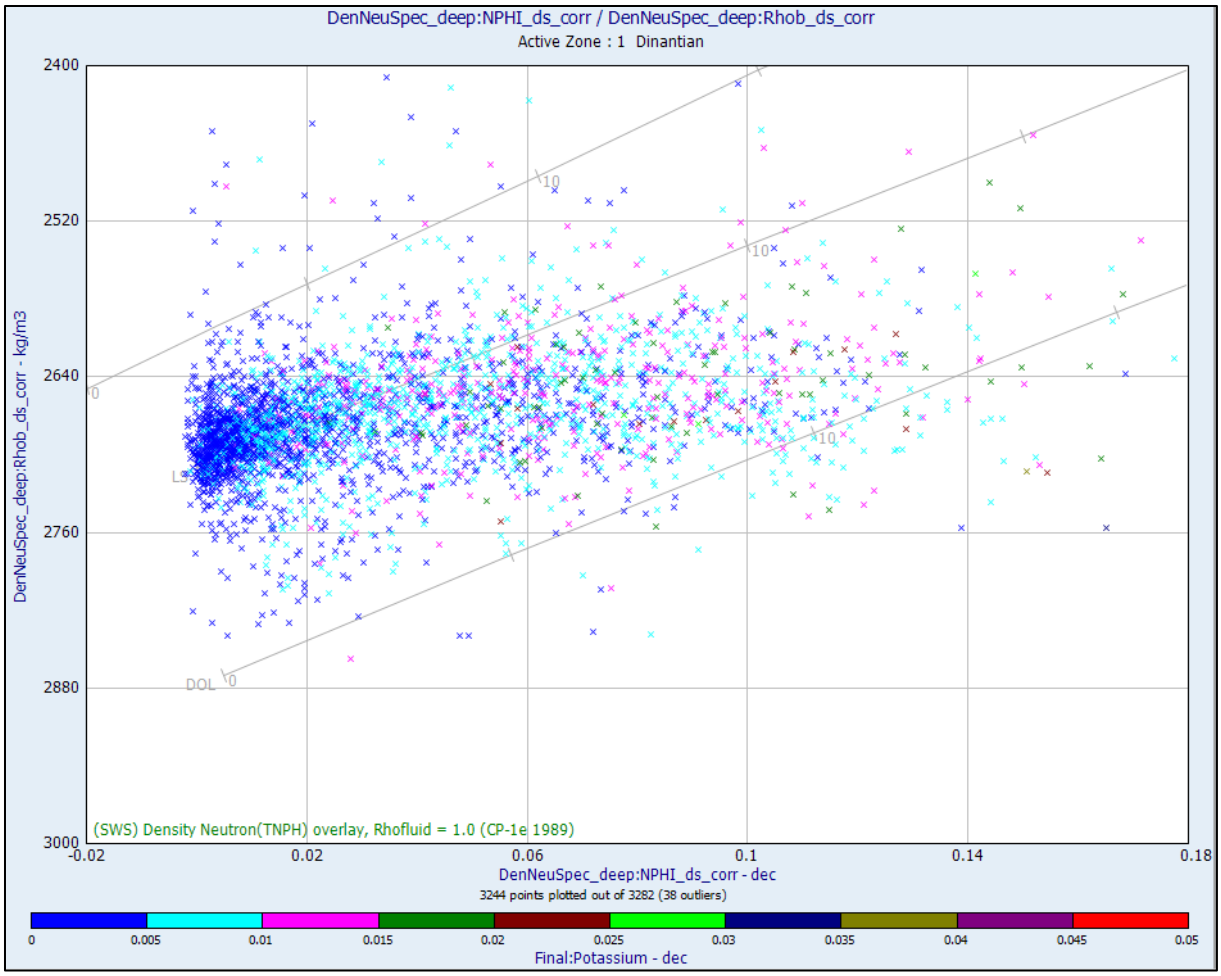


Figure 2. Density-Neutron cross plot after correcting neutron by subtracting 0.01 and adding 20 kg/m3 to the density. The Potassium scale indicate that the cleanest points are close to the 0 point on the Limestone line.

Evaluation of Dinantian (992-1492 m MD)

This well has an anomalous high clay content in the Dinantian based on the high Potassium concentration measured by the spectral GR (NGT) compared to the majority of the other wells evaluated in this study. A clay indicator has been calculated based on the Potassium curve. (There should be some caution on this because the tool used for the separation of Uranium, Potassium and Thorium used a 5 energy window calculation, where the energy windows included peaks from more than one element. The result can be that if one element is very high it may artificially increase the one or both the others) The equation derived for the Clay indicator is based on 0 % clay at a Potassium concentration of 0.002 and 100 % clay at a Potassium concentration of 0.05. The resulting equation is as follows:

Clay Indicator (fract.) = -0.04167 + 20.83 * Potassium content (fract.)

Another factor that also affects the logs to some degree is the organic content, although the shale effect is probably the dominant. The very high Uranium concentrations seen in this well, frequently in thicker intervals, is indicative of a high organic content and it is obvious from the core that the organic content is high, sometimes very high.

Porosity was calculated from the density-neutron x-plot in all of the Dinantian, except in the interval 1092.6-1099.7 where the porosity has been calculated from the density with the assumption of a Limestone matrix with a density of 2710 kg/m3. A clay indicator cut off of 0.2 has been applied.

The lithology has been calculated from the apparent matrix density from the density-neutron x-plot and corrected for the clay index and with a Limestone matrix density of 2710 kg/m3 and a Dolomite matrix density of 2850 kg/m3.

Result

The result of the evaluation can be seen in the log evaluation plot. In the evaluation track 11 is the Clay Indicator displayed. In track 12 is the calculated porosity on a 0 to 10 % scale. In track 13 is the calculated lithology described in this report 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
500,0	260,50	0,521	0,021	0,047	5,34	1,00	0,00
500,0	174,50	0,349	0,028	0,052	4,87	0,91	0,01
500,0	97,74	0,195	0,038	0,056	3,76	0,70	0,02
500,0	56,64	0,113	0,049	0,057	2,76	0,52	0,03
500,0	33,27	0,067	0,059	0,056	1,96	0,37	0,04
500,0	19,10	0,038	0,070	0,056	1,33	0,25	0,05
500,0	10,56	0,021	0,082	0,054	0,86	0,16	0,06
500,0	7,21	0,014	0,089	0,051	0,64	0,12	0,07
500,0	4,27	0,009	0,100	0,060	0,43	0,08	0,08
500,0	2,29	0,005	0,115	0,052	0,26	0,05	0,09
500,0	1,52	0,003	0,123	0,056	0,19	0,04	0,10
500,0	0,91	0,002	0,135	0,056	0,12	0,02	0,11
500,0	0,76	0,002	0,139	0,065	0,11	0,02	0,12
500,0	0,61	0,001	0,142	0,061	0,09	0,02	0,13
500,0	0,30	0,001	0,149	0,073	0,05	0,01	0,14
500,0	0,15	0,000	0,156	0,076	0,02	0,00	0,15
500,0	0,00	0,000			0,00	0,00	0,16

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 3 below.

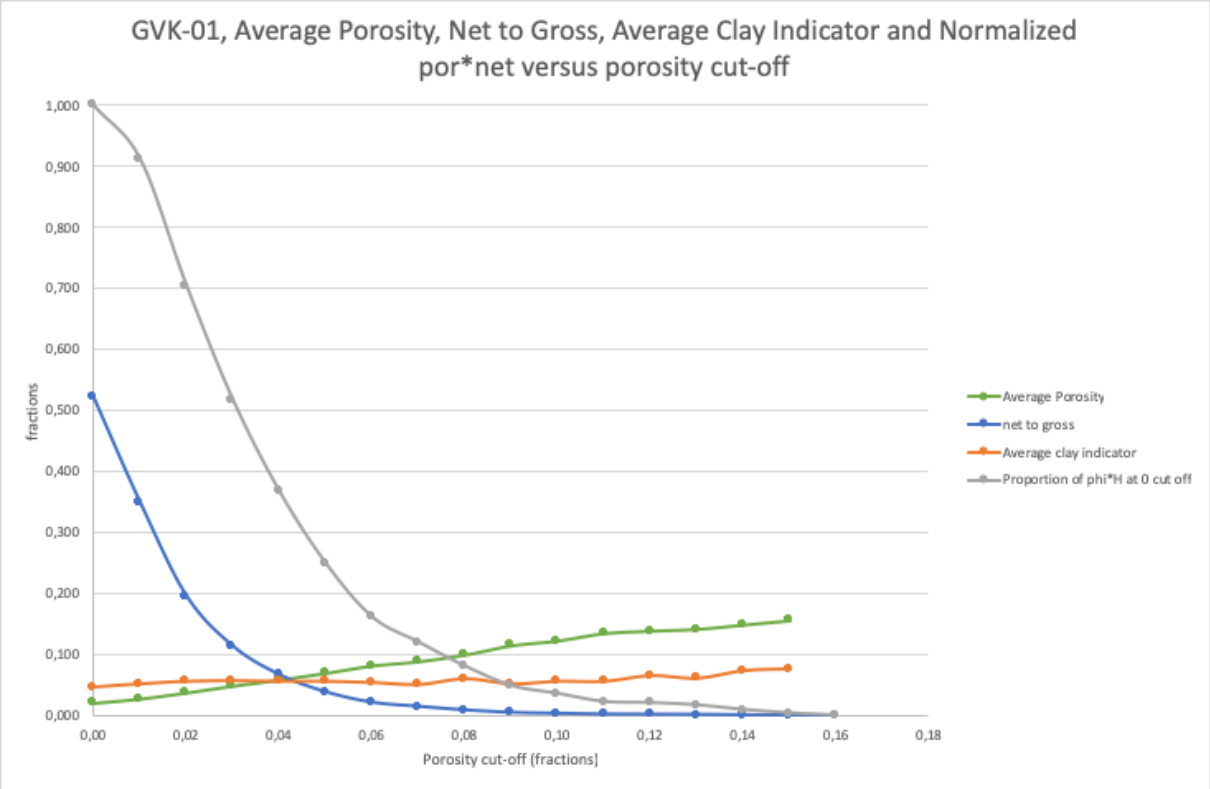


Figure 3. Average porosity, net-to-gross, clay indicator and normalized porosity*net thickness for increasing porosity cut-off

Due to the high clay content the net/gross is only 52.1 % with no porosity cut off. The net/gross declines rapidly up to 2 % porosity cut-off and gradually slower with increasing cut-off and becomes 0 at a cut-off of 16 %. The product of average porosity and net (Normalzed por*net) has a fast decrease up to 5 % and then a slowing decrease up to a porosity cut-off of 11 %. Above this cut-off, the Normalized por*net has a tail with only a gradual decrease up to a cut-off of 16 % where it becomes 0. The porosity has an almost linear increase with increasing porosity cut-off. The Average Clay Indicator has a value of 0.047 at no porosity cut-off and increases slowly with increasing porosity cut-off with a final value of 0.076 at 15 % porosity cut-off. This indicates that there is a relationship between porosity and Clay Indicator but it is not strong.

The porosity at no porosity cut-off is 2.1 %, which is significantly higher than for most of the other Dinantian wells.

Discussion

The Uranium content is high or very high and very spiky in the entire Dinantian section. Based on the core, the high Uranium content is almost certainly associated with a high organic content. The Potassium and Thorium and therefore the clay content is high in this Dinantian section compared to most of the other Dinantian penetrations.

The porosity is, like the other properties, very varied (spiky) in this Dinantian section with many short (a couple of meter, often less) porosity intervals above 4 % porosity and some exceeding 10 %.

The dominant lithology is Limestone in most of the Dinantian. There are only a few intervals with high Dolomite content and there is no trend to higher Dolomite content towards the base of the Dinantian, see evaluation plot.

Core data

GVK-01 has continuous core from 397 m to 1687 m (check if a break at 9 5/8" shoe) and there appear to be no missing core.

Only a limited set of core analyses was performed for rock mechanical purposes. The porosity measured in conjunction with this was in the range 0.3-4.2 %, with the majority in the 0.3-2 % range. No permeability was measured. The core measurements have no depth associated with them.

Flow potential

No test data is available and no wireline formation tester was run in this well. It is likely that this well would produce, both through matrix and through fractures.

Formation temperature

Temperature has only been recorded as a maximum temperature in the well at the three logging intervals and not as a maximum on each logging run (typical of Schlumberger). These temperatures are as follows with approximate depth of temperature measurements:

Shallow at 390 m: 19.6 deg C

Intermediate at 1090 m: 38 deg C

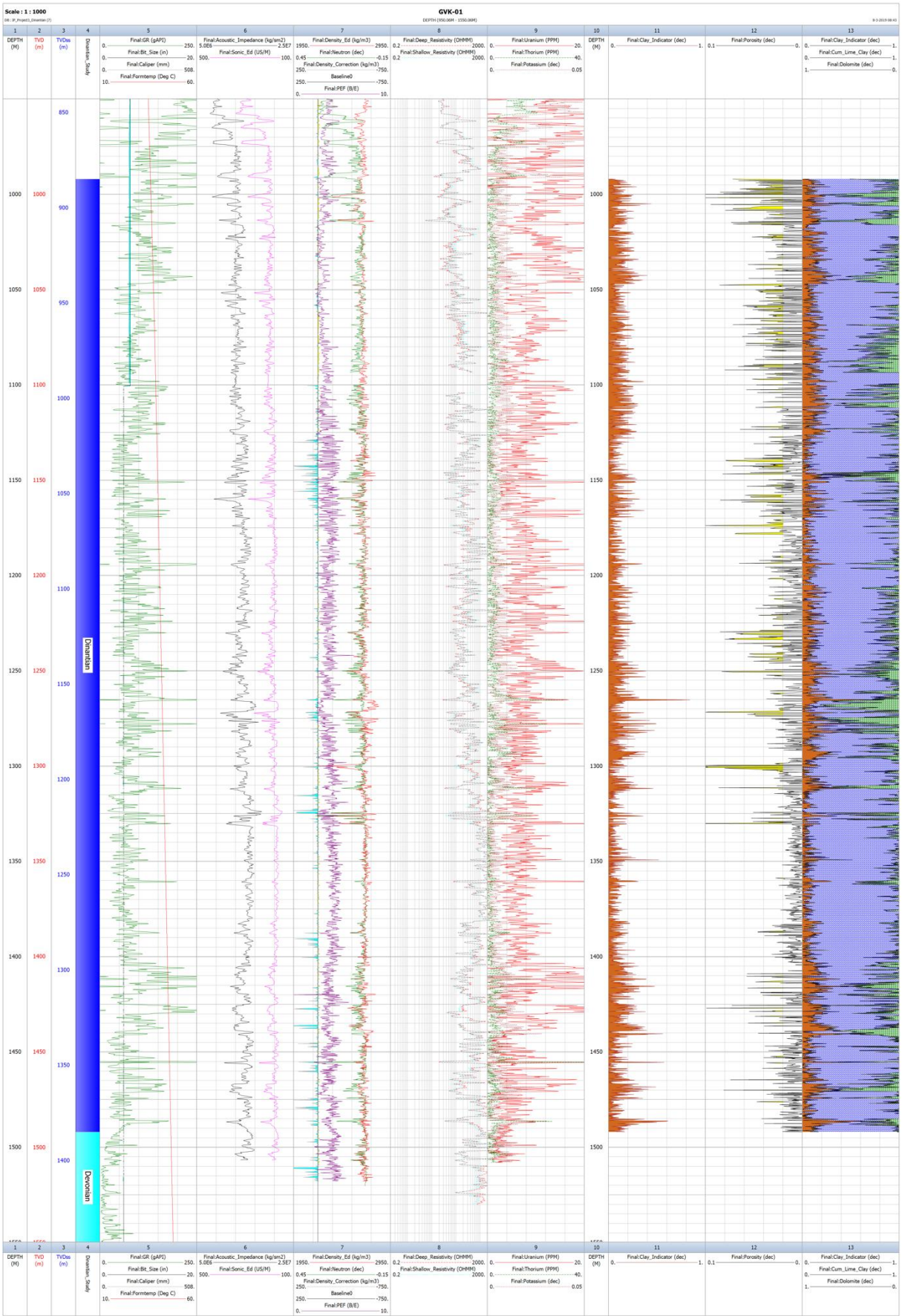
Deep at 1510 m: 47 deg C

Assuming a temperature of 11 C on surface and that the actual formation temperature gradient is 0.03 deg C/m, the resulting formation temperature equation is:

Formtemp = 11 + 0.03 * depth

This is a lower temperature gradient than in the other wells evaluated which have a temperature gradient of 0.031-0.038 deg C/m. However, it is not extremely low. The temperature from this well should not be used for any other purpose than calculating an approximate formation temperature.

Evaluation plot GVK-01



Well logging summary GVK-01

WELL LOGGING SUMMARY

OPERATOR:	NEOM-RGD GBH
WELL:	GEVERICK
WELL BORE:	WELL Nr.1
FIELD:	Geverick
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:
9 7/8"		SP-MTEM-DLL	SP-TEMP-DLL	SCHLUM BERGER	EWL	1	1	Main	**Up**	17-MAY-1986	36	396	
9 7/8"		NGL-CNL-LDL	Spectral GR-NEU-DEN	SCHLUM BERGER	EWL	1	2	Main	**Up**	17-MAY-1986	37	395	
9 7/8"		SHDT	Diplog 4-arm	SCHLUM BERGER	EWL	1	3	Main	**Up**	17-MAY-1986	37	395	
9 7/8"		GR-SDT-MTEM	GR-SON waveform transit times TEMP	SCHLUM BERGER	EWL	1	4	Main	**Up**	17-MAY-1986	37	395	**noise on DT**
6 1/4"		GR-DLL	GR- Dual Laterolog	SCHLUM BERGER	EWL	2	5	Main	**Up**	13-JUL-1986	394	1095	**No SP**
6 1/4"		NGL-CNL-LDL	Spectral GR-NEU-DEN	SCHLUM BERGER	EWL	2	6	Main	**Up**	14-JUL-1986	394	1099	
6 1/4"		GR-SDT	GR-SON waveform transit times	SCHLUM BERGER	EWL	2	7	Main	**Up**	13-JUL-1986	394	1095	
6 1/4"		SHDT	Diplog 4-arm	SCHLUM BERGER	EWL	2	8	Main	**Up**	14-JUL-1986	394	1100	
4 7/8"		NGL-CNL-LDL	GR-NEU-DEN-CAL	SCHLUM BERGER	EWL	3	9	Main	**Up**	23-AUG-1986	218	331	**TD 1632.6m not reached**
4 7/8"		GR-DLL	GR- Dual Laterolog	SCHLUM BERGER	EWL	3	10	Main	**Up**	23-AUG-1986	1099.4	1532	**TD 1632.6m not reached**
4 7/8"		GR-SDT	GR-SON waveform transit times	SCHLUM BERGER	EWL	3	11	Main	**Up**	23-AUG-1986	1099	1508	**TD 1632.6m not reached**
4 7/8"		HDT	Diplog 4-arm	SCHLUM BERGER	EWL	3	12	Main	**Up**	24-AUG-1986	1099	1438	**TD 1632.6m not reached**
4"		GR-BRD	GR-DEN	BPB	EWL	4	13	Main	**Up**	02-SEP-1986	1470	1670	**Logged through the rods**

There are several reports available like GLOBAL MECHPRO and Diplog advanced interpretations like DETFRA by SLB

Appendix: Horner plots

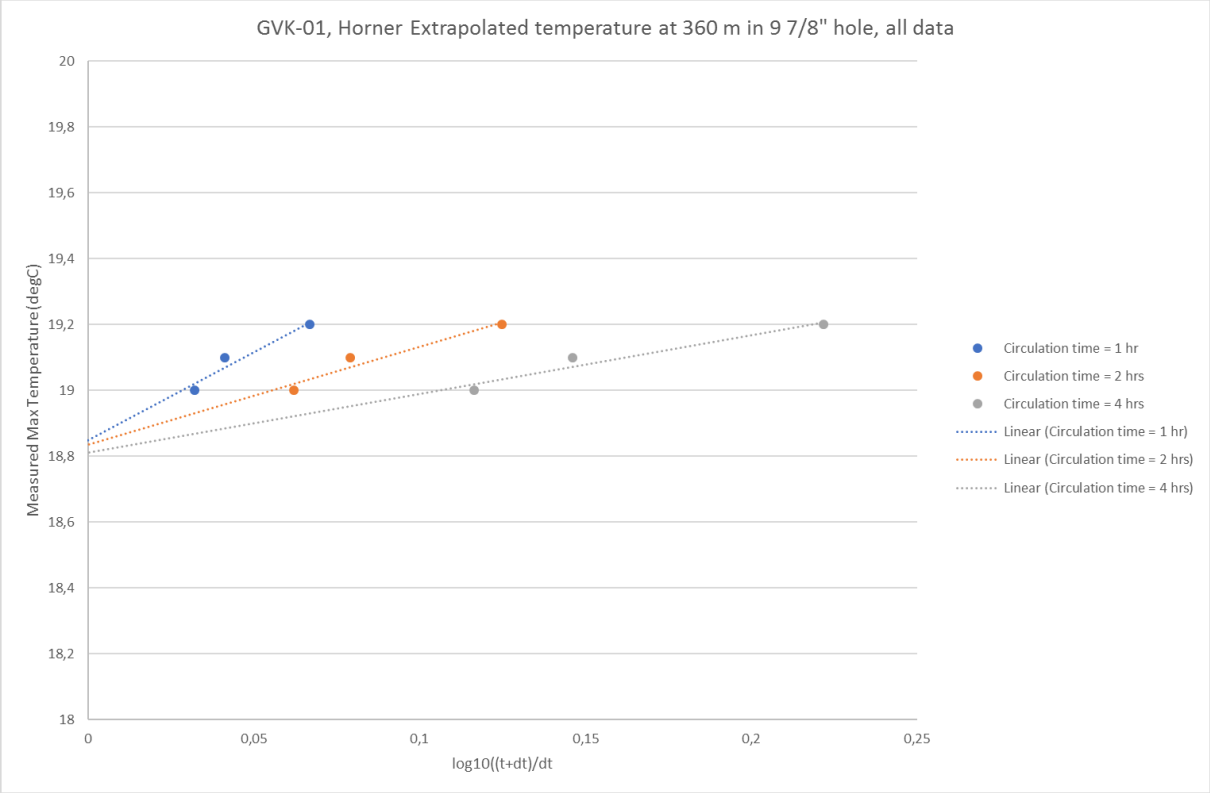


Figure 1. Horner plot at 360m

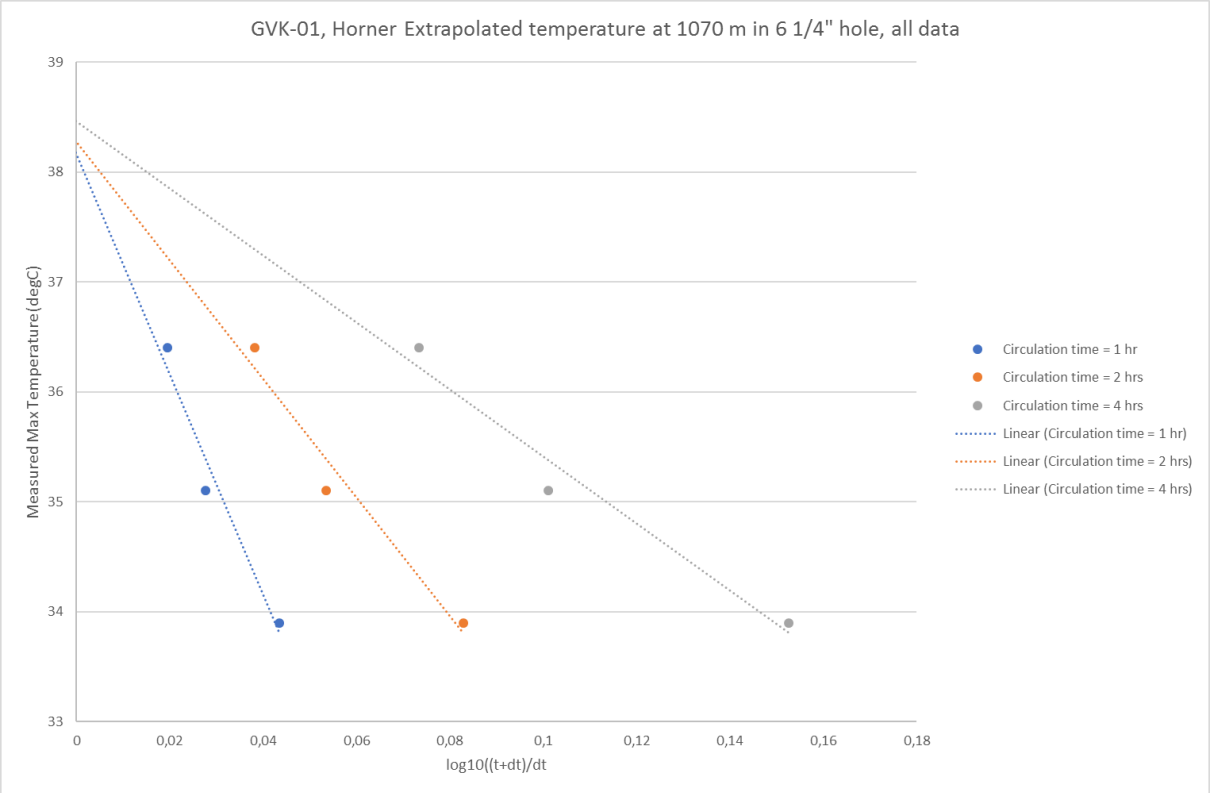


Figure 2. Horner plot at 1070m

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