



# **Petrophysical Report of the Dinantian Carbonates in the Dutch Subsurface**

Report by SCAN

April 2019

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## Report by Torbjörn Carlson

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

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## WELL DATA CAL-GT-02

Company Name : Californie Wijnen Geothermie BV

Well Name : CAL-GT-02

Field Name : Californie

Country : The Netherlands

Field Location : Grubbenvorst

Longitude : 06\*05'00.6" E

Latitude : 51\*29'20.257" N

Maximum Hole Deviation : 36 (deg)

Elevation of Kelly Bushing : 8.4m

Elevation of Ground Level : 0.0m

Elevation of Derrick Floor : 8.4m

Permanent Datum : Ground level

Elevation of Permanent Datum : 0.0m

Log Measured from : Surface to 16

Maximum recorded temperature : 50 degC

TD: 1694m by driller not reached with log

## Dinantian evaluation in CAL-GT-02 (1341-1463 m)

### Log quality, edits and depth shifts

The Dinantian has been drilled in two hole sizes; 12 ¼" and 8 ½".

The GR has been spliced from the environmentally corrected GR logged in the 12 ¼" hole and the standard GR in the 8 ½" hole. In the shallow section, surface to 903.3 m, the only GR that has been run is the GR run through casing with the USIT for cement evaluation. The chosen GR in this interval is the environmentally corrected GR because the standard GR is suppressed by the casing and cement, as well as the larger hole sizes. In the short interval 903.3-906.3 m the GR is suppressed by the casing and this has not been corrected. In the remaining hole, only a short section of GR is suppressed by the casing and that is in the interval 1389.9-1403 m where the GR on the HRLA in the 8 ½" hole has been pulled into the 9 5/8" casing. In the final spliced GR this section has been corrected for the casing and larger hole and spliced in to avoid errors in the interpretation.

The HRLA laterolog logs and caliper logs have also been spliced and here gaps have been allowed.

### Depth and TVD (TVDSS)

The well is deviated with a maximum deviation of 37 degrees at 1106 m. The result of the deviation is that there is a relatively large difference in measured and true vertical depth (TVD) in this well, 1400 m measured depth correspond to a TVD of 1235.2 m.

### Log corrections

The GR through casing down to 903.3 m and in the interval 1389.9-1403 m has been environmentally corrected, see above.

### Evaluation of Dinantian (1341-1463 m) (1186.8-1286.7 m TVD)

There are no density-neutron or sonic logs in this well and therefore the lithology and porosity cannot be determined from standard porosity tools.

The only log that can provide an estimate of the porosity is the deep laterolog resistivity and this can be done based on estimated  $R_w$  in the nearby well CAL-GT-01(S1). The estimated salinity in this well was 12000 ppm salinity. A porosity was calculated based on the deep laterolog (RLA5) and the  $R_w$  from CAL-GT-01(S1) corrected to the formation temperature (see below).

In this well, as in CAL-GT-01 (S1), a cut off for clay is required and therefore a clay indicator has been derived from the GR. It is likely that some intervals will be cut out due to high GR caused by Uranium, that have no or little clay, but it is necessary to cut out real clay intervals. The clay indicator curve is based on a clean GR of 18 and a 100 % clay GR value of 250 and the resulting equation is:

$$\text{Clay Indicator} = -0.07759 + 0.004310 * \text{GR}$$

The clay indicator cut off applied to the porosity is 0.1.

### Result

The result of the evaluation can be seen in the log evaluation plot.

The sums and averages for this well are provided in the table and graph below. The clay indicator cut off is 0.1.

Column 7 is a normalized product of average porosity and net ( $\text{Average porosity} \times \text{net} / \text{Average porosity} \times \text{net at no porosity cut off}$ ) to enable plotting in the same graph, see figure 1 below.

Gross	Net	Net/Gross	Average Porosity	Average Clay Indicator	Average Porosity * Net	Normalized Average Porosity * Net	Porosity cut off
TVD	TVD	TVD					
m	m	fract	fract	fract	m	fract	fract
99,85	10,98	0,110	0,091	0,029	0,99	1,000	0,00
99,85	10,98	0,110	0,091	0,029	0,99	1,000	0,01
99,85	10,98	0,110	0,091	0,029	0,99	1,000	0,02
99,85	10,61	0,106	0,093	0,030	0,99	1,000	0,03
99,85	10,11	0,101	0,096	0,031	0,97	0,980	0,04
99,85	9,49	0,095	0,099	0,032	0,94	0,949	0,05
99,85	8,99	0,090	0,102	0,032	0,91	0,919	0,06
99,85	7,49	0,075	0,109	0,035	0,81	0,818	0,07
99,85	5,37	0,054	0,122	0,032	0,65	0,657	0,08
99,85	4,25	0,043	0,132	0,030	0,56	0,566	0,09
99,85	3,50	0,035	0,139	0,028	0,49	0,495	0,10
99,85	2,87	0,029	0,147	0,024	0,42	0,424	0,11
99,85	2,75	0,028	0,148	0,021	0,41	0,414	0,12
99,85	1,88	0,019	0,160	0,022	0,30	0,303	0,13
99,85	1,13	0,011	0,177	0,006	0,20	0,202	0,14
99,85	0,88	0,009	0,185	0,001	0,16	0,162	0,15
99,85	0,75	0,008	0,189	0,001	0,14	0,141	0,16
99,85	0,63	0,006	0,194	0,001	0,12	0,121	0,17
99,85	0,38	0,004	0,208	0,001	0,08	0,081	0,18
99,85	0,25	0,003	0,217	0,001	0,05	0,051	0,19
99,85	0,25	0,003	0,217	0,001	0,05	0,051	0,20
99,85	0,13	0,001	0,226	0,002	0,03	0,030	0,21
99,85	0,13	0,001	0,226	0,002	0,03	0,030	0,22
99,85	0,00	0,000			0,00	0,000	0,23

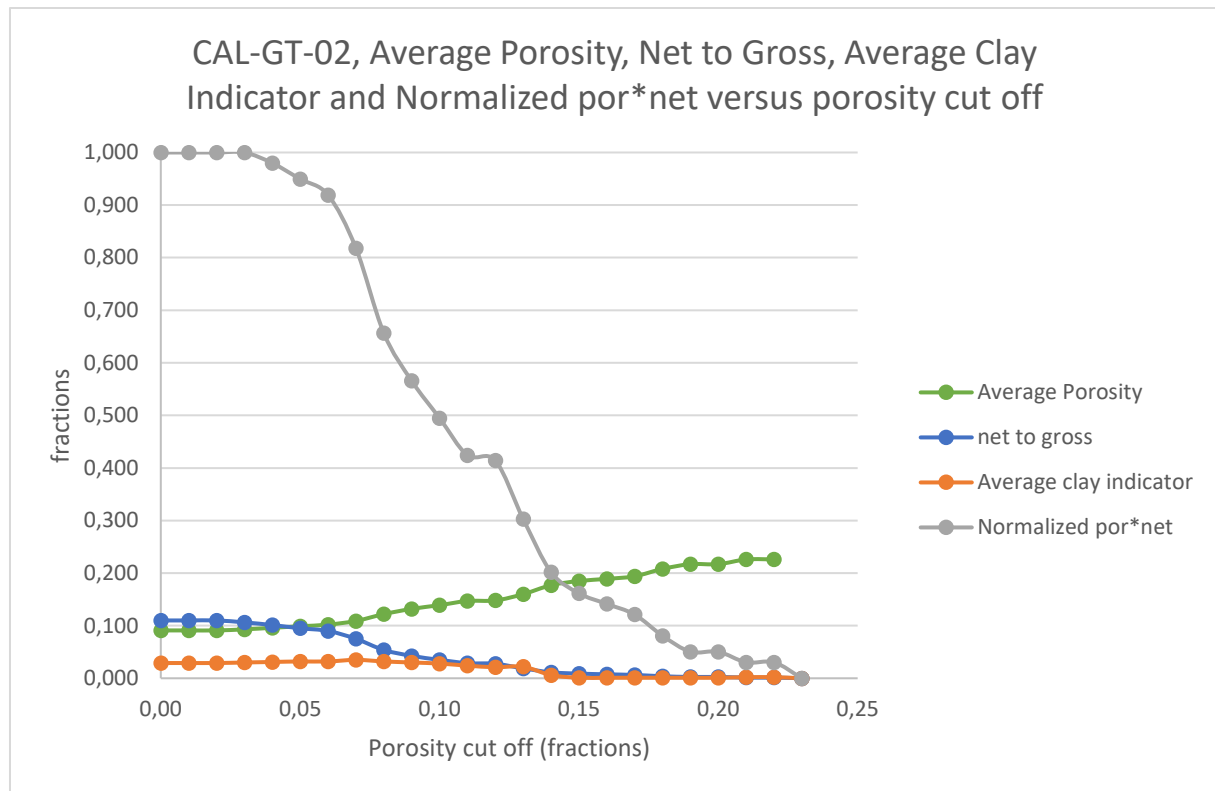


Figure 1. Average Porosity, net to gross, average clay indicator and normalized average porosity\*net versus porosity cut off.

In this well the net to gross decreases gradually with higher porosity cut offs and the normalized product of porosity and net decreases only marginally for the lower porosity cut offs and reaches a maximum decrease at a porosity cut off between 7 and 8 %. Above this cut off the decrease slows down until a porosity cut off of 12 % and then rapidly increases followed by a slowing decrease up to the final cut off at 23 %. The average porosity with no porosity cut-off is high at 9.9 % and increases slowly initially and then accelerating with higher porosity cut off. There is no porosity exceeding 23 % in this well. The average of the clay indicator starts at a value of 2.9 and is relatively stable until a porosity cut off of 10 % and then rapidly drops off to almost 0 at 15 % after which it remains close to 0. The conclusion from this is that the interval 1411-1439 m where the cleanest matrix exist is a clean carbonate and that the porosity is high. With this high porosity the permeability should normally be good. However, the different depth of investigating resistivity curves does not indicate a separation, something that would be expected when having invasion. A good permeability can therefore not be concluded.

## Discussion

The lithology column on the depth plot is based on a LAS file from the cuttings interpretation (from Petrel). It is quite likely that the proportions of the different minerals are exaggerated for some and suppressed for others. Although the clay content is high in the upper part of the Dinantian the cuttings interpretation of the clay content is almost certainly too high. The Dolomite may also be too high.

The logs show a large influence of clay in most of the Dinantian. Only a short section in the interval 1411-1439 m has cleaner matrix and has a good net based on a clay cut-off of 0.1. The reason for the very high clay content indicated in the upper part of the Dinantian is not known. It is possible that the hole is skirting along the interface between the shale and the Dinantian carbonate and that this could explain the high clay content in the cuttings and the log response, but this cannot be corroborated.

## Flow potential

CAL-GT-02 has an injection test, which is a multi-rate step test. The End of Well Report (EOWR) provides a brief overview of the measured flow rate and pressure values see table below.

55 min Test	mit 1500 l/min	Druck : 18 - 19,5 bar	Annular: 18 bar	Vol.: 77,6 m <sup>3</sup>
55 min Test	mit 2000 l/min	Druck: 33 - 30 bar	Annular: 20 bar	Vol.: 130 m <sup>3</sup>
60 min Test	mit 2500 l/min	Druck: 42 - 43 bar	Annular: 28 bar	Vol.: 174 m <sup>3</sup>
60 min Test	mit 3000 l/min	Druck: 53 - 51 bar	Annular: 32 bar	Vol.: 277 m <sup>3</sup>
50 min Test	mit 3500 l/min	Druck: 64 - 65 bar	Annular: 40,6 bar	Vol.: 228 m <sup>3</sup>
67 min Test	mit 4000 l/min	Druck: 74 - 71,5 bar	Annular: 41 bar	Vol.: 287 m <sup>3</sup>

Table: Flow rate (l/min) and pressure (“druck” in bar) for the injection test in CAL-GT-02

In the figure below the rates and pressures are converted to an approximate production index (PI) by dividing the rate with the mid-point pressure for each pressure step in the table above.

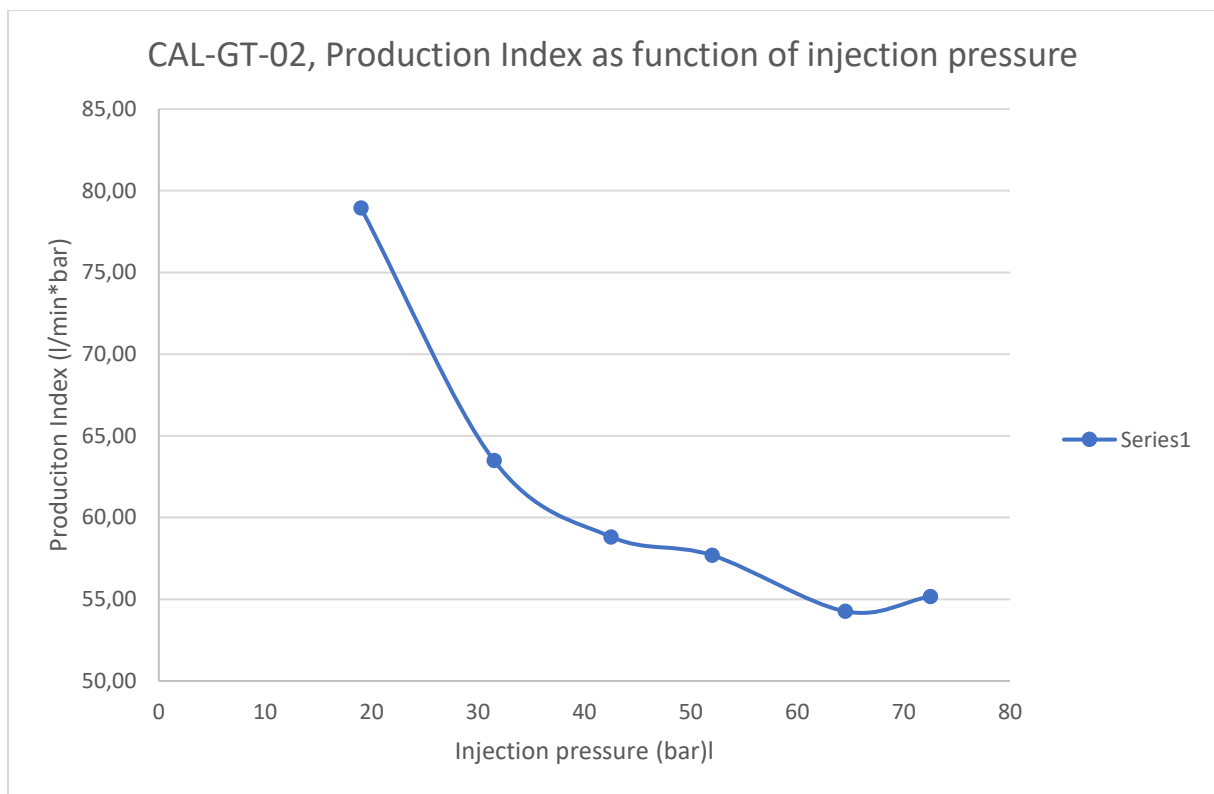


Figure 2. Production Index (PI) as function of injection pressure.

Figure 2 demonstrates that the PI decreases rapidly for the initial pressure steps and have a stabilizing trend towards the highest injection pressures. The reason for this is probably that it takes a higher and higher pressure to open up fractures further away from the wellbore. However, there may be other explanations.

The flow rate increases almost linearly with increasing pressure

There are no wireline formation tests in this well.

Losses occurred at the base of the 12 ¼” hole in the Dinantian.

### Formation temperature

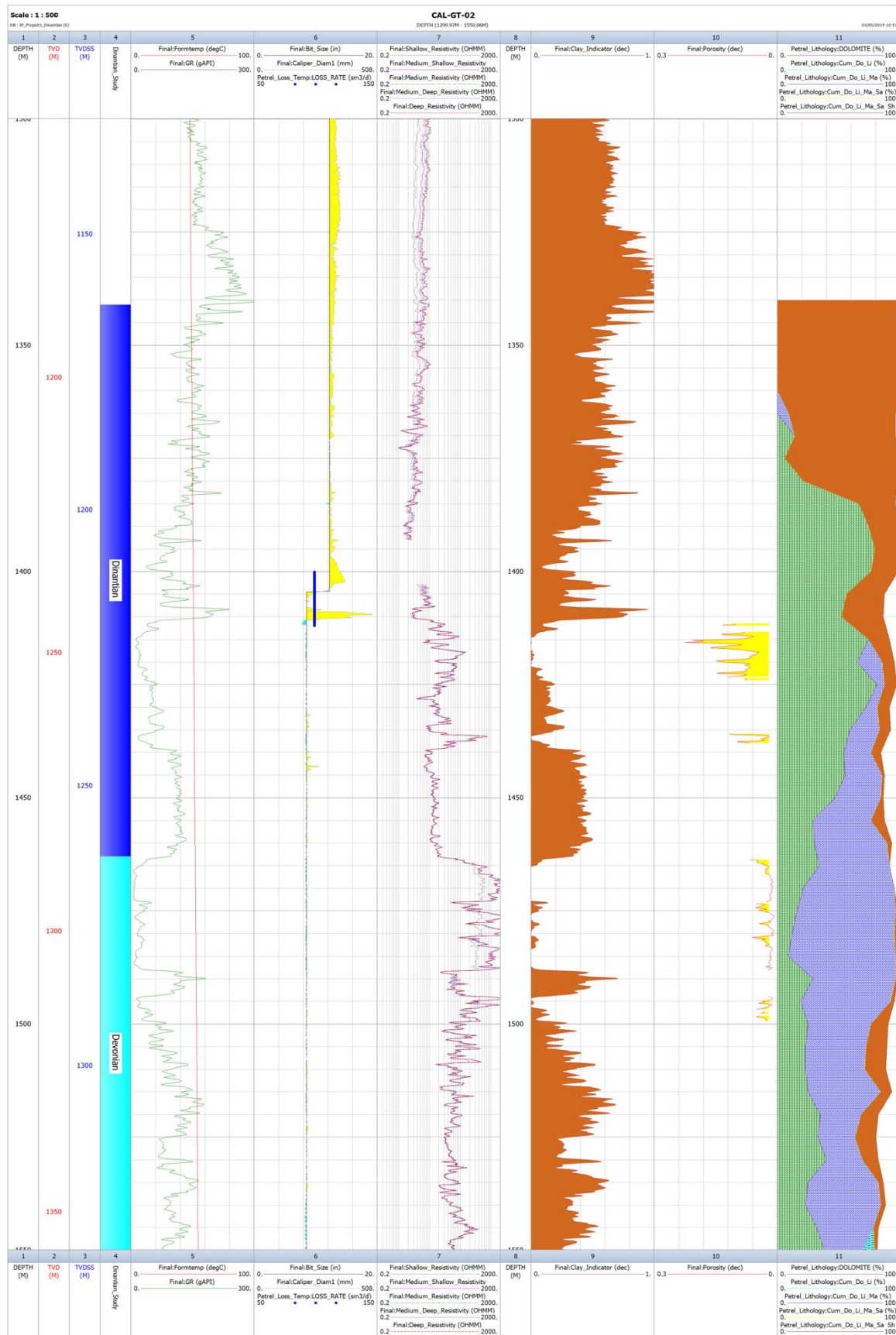
The two measured temperatures in CAL-GT-02 were both too low, 31 C at 1385 (1222.9 m TVD) and 50 C at 1665 m (1455.4 m TVD). Therefore, the temperature is based on the measured temperature in CAL-GT-01, see below.

Formation temperature is based on a surface temperature of 8 C and a formation temperature of 64 C (max temp measured is 64 C) at 1740 m (1575.2 m TVD) in CAL-GT-01 (S1) resulting in a function:

$$\text{Formtemp} = 10 + 0.03279 \cdot \text{TVD}$$



## Evaluation plot





## Well logging summary CAL-GT-02

<b>OPERATOR:</b>	CALIFORNIE WIJNEN Geothermie BV			<b>WELL LOGGING SUMMARY</b>							
<b>WELL:</b>	Californie Wijnen										
<b>WELL BORE:</b>	CAL-GT-02										
<b>FIELD:</b>	Californie										
<b>PLATFORM:</b>	onshore										
<b>COUNTRY:</b>	NETHERLANDS										
<b>DRILL PERMIT #:</b>											
<b>WELL STATUS:</b>											
Hole section:	Main Service:	Generic Logs	Service Company:	Mode:	Run #:	Sub file:	Run Type	Pass Direction (Up/Dow n)	Date:	Interval Top (m):	Interval Bot (m):
17 1/2"	GR-Cal_4-DIL-AL	GR-Caliper_4arm-Dual Induction-Acoustic (sonic) Log	BLM	EWL	1	1	Main	UP	26-AUG-2012	25	905
17 1/2"	GR-USIT-CCL	GR-Cement Evaluation	SCHLUMBERGER	EWL	2	2	Main	Up	7-SEPT-2012	25	906,5
12 1/4"	GR-HRLT-PPC	GR-High resolution laterolog-Caliper	SCHLUMBERGER	EWL	1	1	Main	UP	07-SEP-2012	906,5	1398,5
12 1/4"	GR-USIT	GR-Cement Evaluation	SCHLUMBERGER		2		Main	Up	17-sep-12	786	1401,4
8 1/2"	GR-HRLA-PPC-EMM	GR-High resolution laterolog-Caliper	SCHLUMBERGER	EWL	3	3	Main	Up	17-SEP-2012	1395	1680

# Onderzoek in de ondergrond voor aardwarmte