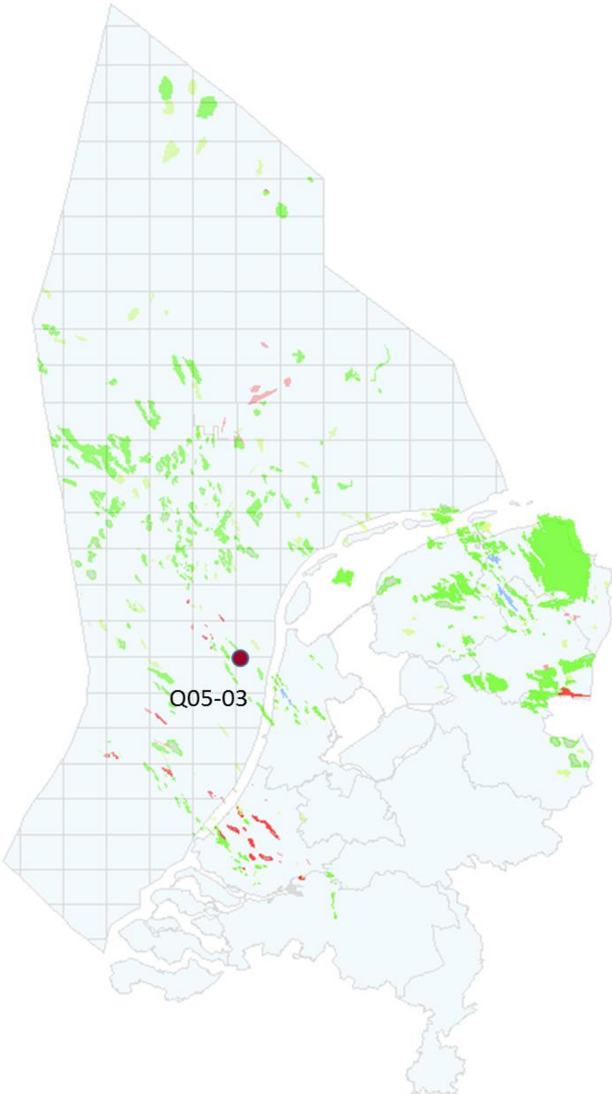

Missed pay analysis well Q05-03

(P045)

March 2016

Missed pay analysis well Q05-03

(P045)

Authors
Kirsten Brautigam

Reviewed by
Coen Leo

Prepared by
PanTerra Geoconsultants B.V.
Weversbaan 1-3
2352 BZ Leiderdorp
The Netherlands
T +31 (0)71 581 35 05
F +31 (0)71 301 08 02
info@panterra.nl

Contents

Summary

A DST proved the presence of gas in the Rotliegend. Petrophysical evaluation of the reservoir confirms the presence of a 60 m gas column in the Rotliegend. Core measurements and logs are indicative of moderate to good porosity. FMT pressure measurements and sedimentological study of the reservoir indicate that the reservoir is very tight due to illite plugging. Maximum gas flow rate was 378 m^3/day. Based on gas shows, electrical logs and FMT pressure data, the gas column extends to the Zechstein Z1 and Z2 carbonates, resulting in a total length of the gas column of 200 m.

Ranking: 1 (Gas in Rotliegend proven by DST)

1 Introduction

The Q05-03 is an exploration well drilled in 1989. Its main targets were the Rotliegend and Zechstein Platten Dolomite in a SW-tilted NW-SE trending horst block within the Texel platform. As a third objective the well would test the presence of sands in the Cretaceous Vlieland Formation. Well Q05-03 was plugged and abandoned "with gas shows" (NLOG) and is located in open acreage.

Table 1 Well data of Q05-03 (source: www.NLOG.nl)

Basisgegevens boorgat	
Naam :	Q05-03
Code :	Q05-03
Coördinaten (x, y in UTM31, ED50 formaat)	593806 , 5852395
Lat/Long (°)	52.8120583 , 4.3917222
Aangeleverde coordinaten	4.3917222 , 52.8120583 (ED50-GEOGR)
Diepte in meter t.o.v. :	Rotary Table
Einddiepte (m) :	3005
Verticale positie van Rotary Table :	35 meter t.o.v. MSL
Vorm boortraject :	Gedevieerd
Deviatie in de x-richting :	-4.02
Deviatie in de y-richting :	26.11
Werkelijke diepte (TVD) in m :	2995.076
Opdrachtgever :	Conoco
Begindatum	10-jun-1989
Einddatum	9-aug-1989
Type boring :	Exploratie koolwaterstof
Resultaat van de boring :	Gas shows
Status :	Plugged and abandoned

2 Available data

All used data is publicly available on www.NLOG and comprises of:

- Composite log
- Core analyses
- Digital logs (no openhole logs over Triassic interval)
- Documents (printouts of logs, well reports etc.)

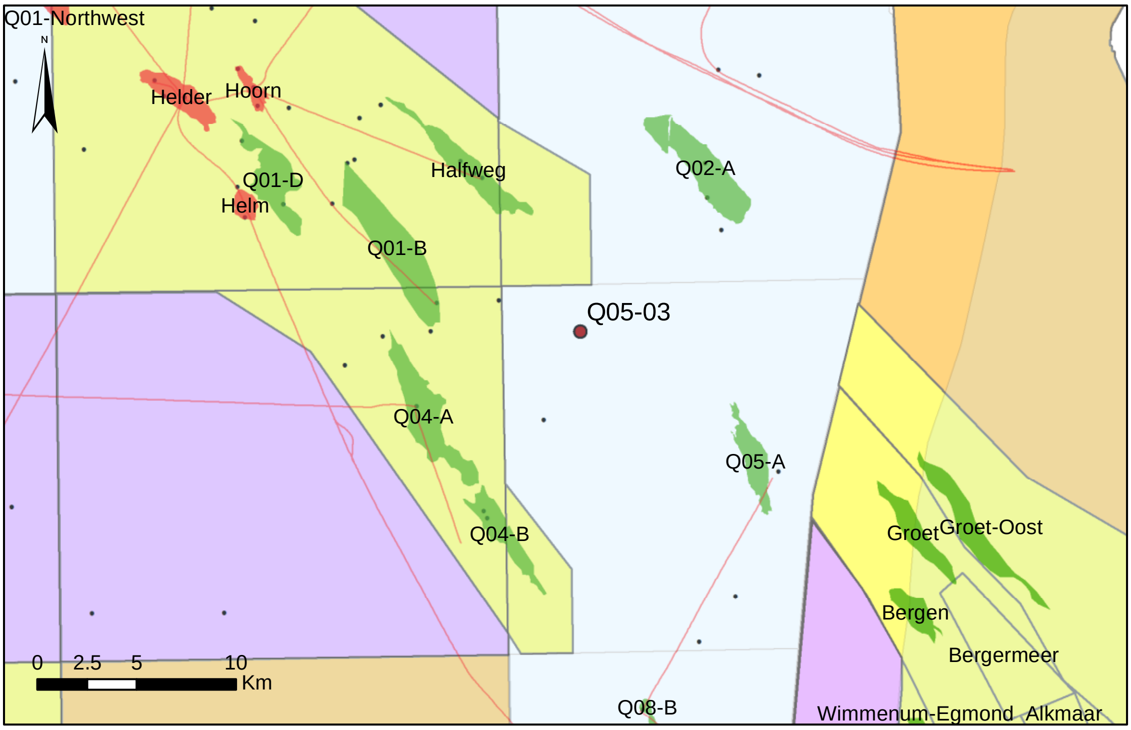

Figure 1 Culture map of well Q05-03. Existing production licences are in yellow, exploration licences in orange and fallow acreage in pink. Nearby onshore and offshore gasfields are in green and oilfields in red. The black dots represent exploration and evaluation wells. Red lines are pipelines

3 Nearby hydrocarbon fields

There are several oil and gas fields nearby well Q05-03. Nearby oil fields in the Q01 block produce from the Vlieland Sandstone Formation. Gas fields Q01-B and –D produce from the Main Buntsandstein, Halfweg from the Rotliegend.

The Q04-A and –B gas fields, southwest of Q05-03, produce from the Main Buntsandstein. The undeveloped Q02-A and abandoned Q05-A field contain gas in the Zechstein.

4 Drilling/logging problems

- No open hole logs were run over the interval 1719 – 2555 m MD due to a hold-up at 1719 m MD.
- There were major mud losses in the Volpriehausen, indicating a very porous formation. Losses were unstoppable and drilling was continued with seawater. A cement plug was set below the base of the Volpriehausen which successfully stopped the losses.

5 Missed pay analysis

5.1 Quick-look analysis

The stratigraphy of the well is listed in Table 1 (www.NLOG.nl).

Table 2 Stratigraphy of Q05-03 (source: www.NLOG.nl) Cretaceous

Stratigraphic unit	Top (MD)	Base (MD)
North Sea Supergroup	0	845
Ommelanden Formation	845	968
Texel Formation	968	1150
Upper Holland Marl Member	1150	1396
Middle Holland Claystone Member	1396	1552
Lower Holland Marl Member	1552	1575
Vlieland Claystone Formation	1575	1711
Lower Keuper Claystone Member	1711	1776
Upper Muschelkalk Member	1776	1858
Muschelkalk Evaporite Member	1858	1897
Lower Muschelkalk Member	1897	1981
Upper Röt Claystone Member	1981	2077
Main Röt Evaporite Member	2077	2109
Solling Claystone Member	2109	2135
Basal Solling Sandstone Member	2135	2141
Hardegsen Formation	2141	2151
Detfurth Claystone Member	2151	2173
Lower Detfurth Sandstone Member	2173	2190
Volpriehausen Clay-Siltstone Member	2190	2252
Lower Volpriehausen Sandstone Member	2252	2317
Rogenstein Member	2317	2476
Main Claystone Member	2476	2624
Zechstein Upper Claystone Formation	2624	2632
Z4 Salt Member	2632	2644
Z4 Pegmatite Anhydrite Member	2644	2647
Red Salt Clay Member	2647	2660
Z3 Claystone Member	2660	2672
Z3 Main Anhydrite Member	2672	2675
Z3 Carbonate Member	2675	2694
Grey Salt Clay Member	2694	2696
Z2 Basal Anhydrite Member	2696	2698
Z2 Roof Anhydrite Member	2698	2720
Z2 Middle Claystone Member	2720	2769
Z1 Fringe Carbonate Member	2769	2856
Z1 Lower Claystone Member	2856	2863
Coppershale Member	2863	2863
Slochteren Formation	2863	3005

5.1.1 Quaternary, Tertiary and Cretaceous

No zones of interest are observed in the Quarternary/Tertiary, and Cretaceous. The Cretaceous Vlieland Formation is developed as a sequence of thick shales with occasional thin limestone intercalations. No shows have been observed. The base of the Vlieland Formation is a major erosional surface separating the Cretaceous from the Triassic Muschelkalk.

5.1.2 Triassic

Apart from the lower 100 m, no open hole logs were run over the Triassic, limiting the missed-pay analysis of this section.

Three potential reservoirs can be identified within the Triassic sequence; the Hardegsen (15 m thick), Detfurth (25 m thick) and Volpriehausen (65 m) sandstones. No (visible) porosity estimates are available, but major losses of drilling fluid in the Volpriehausen indicates good porosity of the reservoir. No shows were observed and no cores or plugs taken.

5.1.3 Permian - Zechstein

Correlation and subdivision of the Zechstein sequence proved to be difficult (Final geological well report, July 1990, available at www.NLOG.nl). The stratigraphy that was adopted in the composite log, the geological well report and this report includes Z1 to Z4 sections, of which Z2, Z3 and Z4 are thinner than elsewhere in the region. Alternatively, the Z3 and Z4 might be absent due to a fault cut-out. However, according to the geological well report, evidence on seismic is tenuous.

Gas shows are observed in the Z3 Platten dolomite, Z2 carbonates and Z1 carbonates. The Z3 Platten dolomite is 25 m thick and very tight, there is no net thickness. The upper 10 m of the Z2 carbonates are porous, resistivity logs indicate the presence of gas. According to the geological well report, the total net gas interval is 5 m (2713-2715m, and 2717-2720 m MD), mean porosity is 11% and Sw is 9%. However, based on the logs, there might be a net gas interval of 10 m.

The net gas interval in the Z1 Carbonate Member is 4 m, mean porosity is 14% and Sw 23%. Resistivity logs confirm the likely presence of gas in the Z1 and Z2 Carbonates.

15 FMT pressure measurements were performed, of which the majority was aborted due to lack of seal. The three pressure measurements that were not aborted prematurely are indicative of a gas-bearing reservoir (Figure 3). The gas column likely extends to the Slochteren Formation.

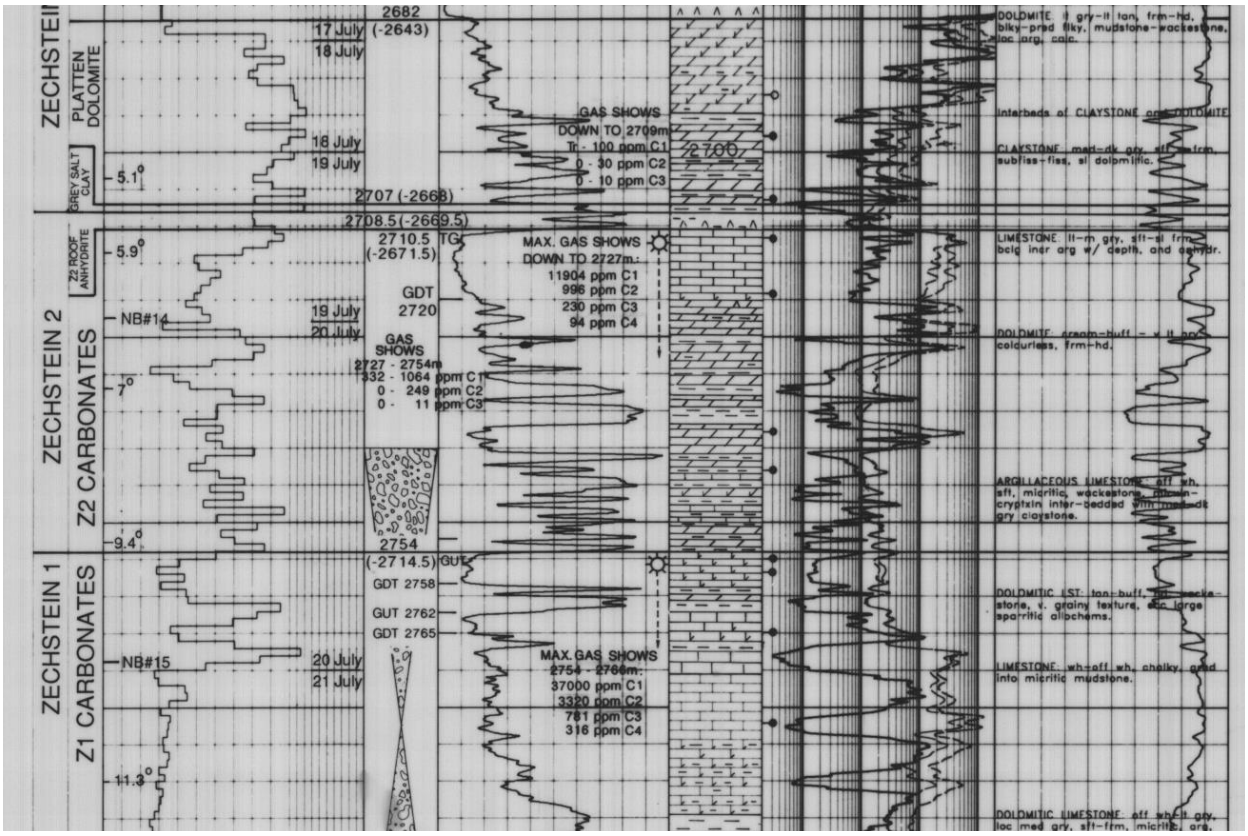

Figure 2 Composite well log of part of the Zechstein sequence. Gas shows are observed in the Z1, Z2 and Z3 formations. Resistivity logs (second panel from the right) indicate the presence of gas in the upper part of the Z1 and Z2 Carbonates.

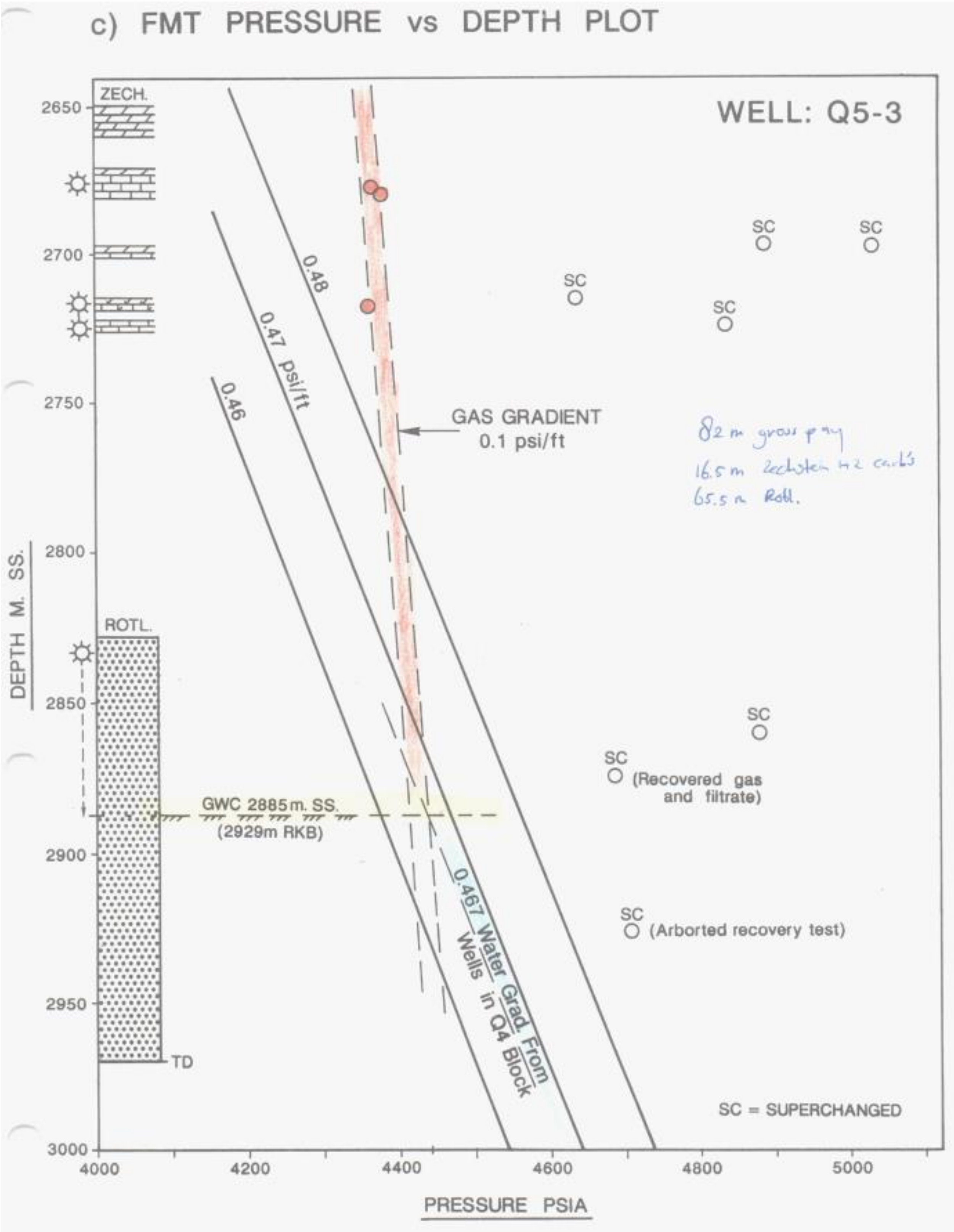

Figure 3 Pressure data are indicative of a 200 m gas column that extends from the Z1 and Z2 carbonates into the Rotliegend.

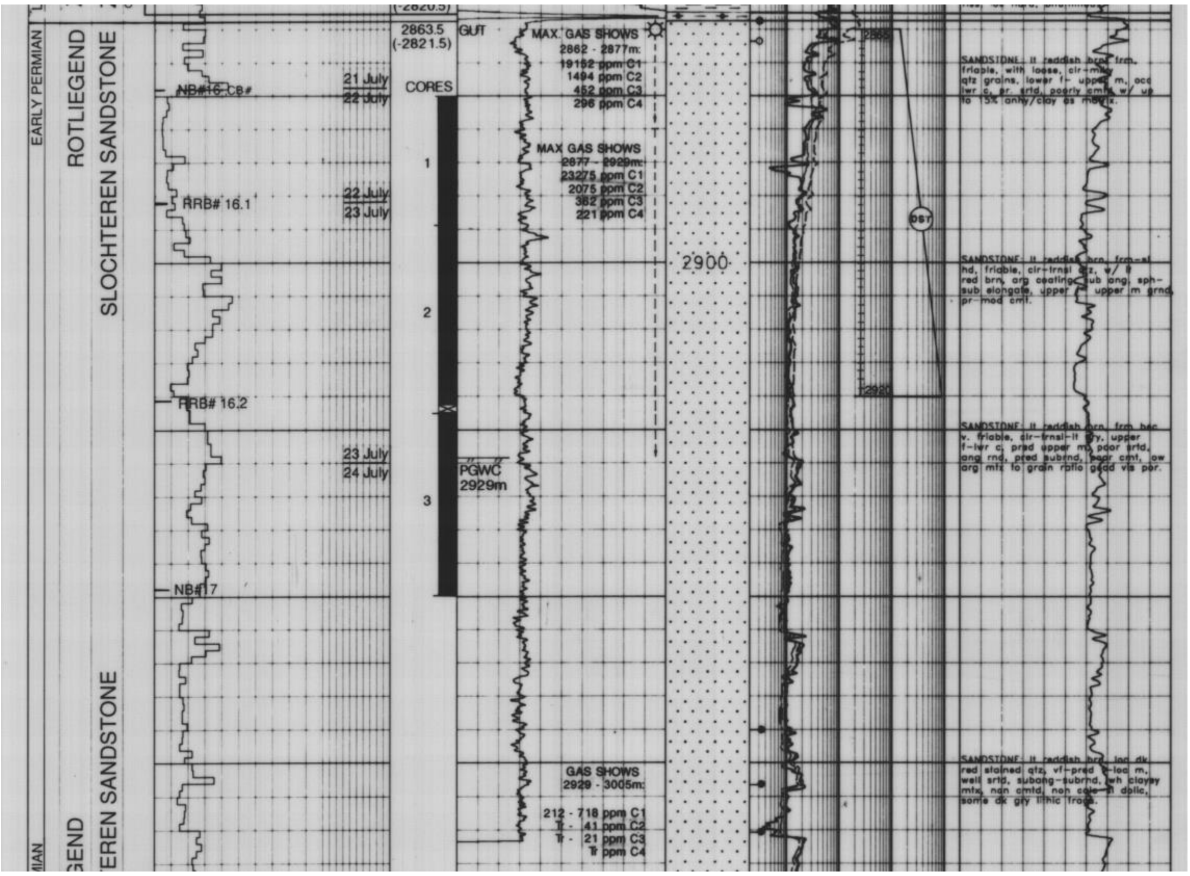

Figure 4 Composite well log of the Rotliegend. Resistivity logs (second panel from the right) are indicative of a (very tight) hydrocarbon-bearing top interval, which is supported by gas shows.

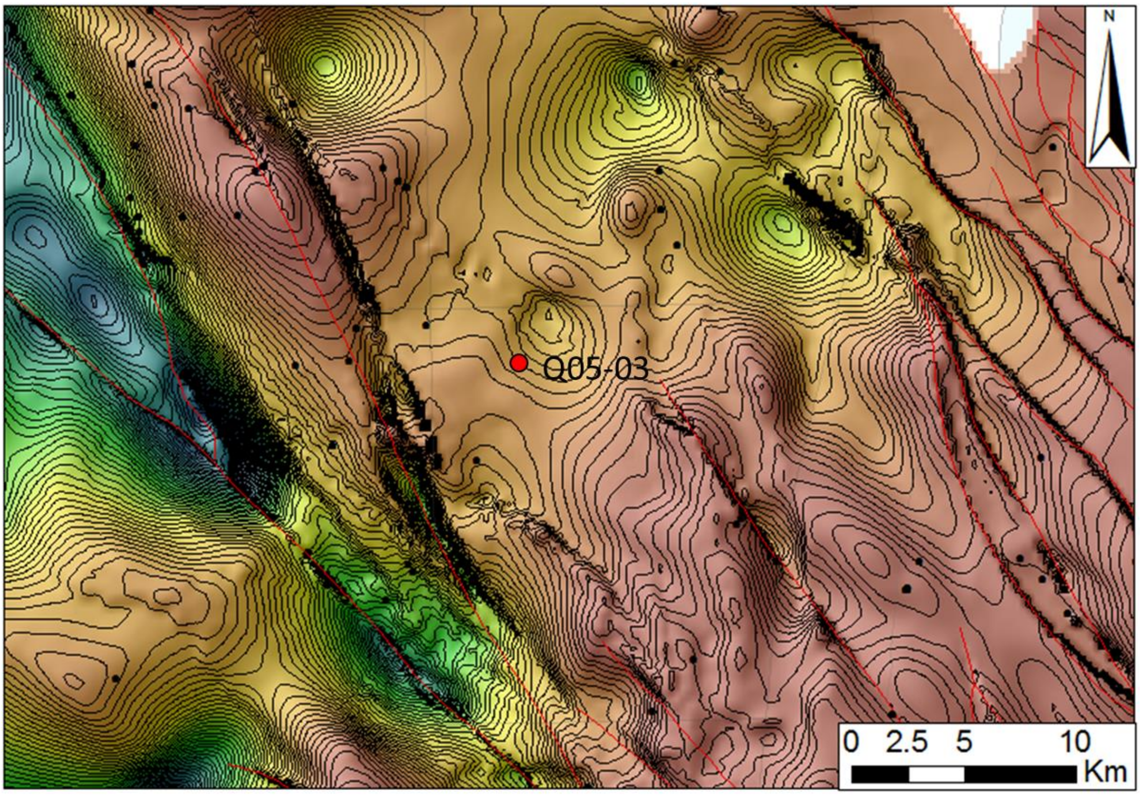

Figure 5 Well Q05-03 projected on a depth map of the base Zechstein (TNO, 2006, available at NLOG). Color distribution red to blue represents shallow to deep. Red lines are faults. Surrounding wells are indicated by black dots.

5.1.4 Permian – Rotliegend

Gas shows are observed in the upper 60 m of the Rotliegend sandstones. Resistivity logs indicate the possible presence of hydrocarbons. However the absence of large separation between the resistivity curves indicates a very tight rock. According to the geological well report the net gas-bearing thickness is 62 m, log porosity (in gas interval) is 10%, and mean Sw 67%.

Three cores were taken. Mean core porosity is 17.8%, average core permeability 0.23 mD. FMT measurements confirm that the reservoir is very tight. A DST was performed, resulting in low gas flow rates of max. 378 m3/day. Sedimentological study of the cores show that high core porosities are due to microporosities in altered feldspars and low permeabilities due to illite plugging of the small pore throats.

5.2 Petrophysical evaluation

A petrophysical evaluation was performed of the Zechstein carbonates and the Rotliegend. All log and core data were derived from NLOG. No corrections were applied to logs, apart from necessary depth shifts. 5% was deducted from core porosities to represent in situ values. No core shift was necessary.

5.2.1 Zechstein

Available logs include GR, density, neutron, PEF and deep resistivity logs. Shale volumes are calculated using the minimum of the GR, and neutron-density method. In the intervals in which anhydrite is present, a multi-mineral approach was used to calculate porosity. The PEF and sonic logs were used to determine the mineral volumes of limestone, dolomite and anhydrite (using default, textbook log values of calcite, dolomite and anhydrite). Porosity is subsequently calculated from the resulting apparent matrix density. In the other intervals the porosity is calculated based on the neutron and density log (grain density set to variable).

Because there are no SCAL data available, the Indonesian water saturation equation is applied. Cementation and saturation exponent (*m* and *n*) are assumed to be 2 and tortuosity factor (*a*) 1. An Rw of 0.055 at 25^{o}C was estimated from the Pickett plot of the waterleg of the Rotliegend, which corresponds to a salinity of 141,000 ppm. Calculated logs are displayed in Figure 6. A cut-off of 50% Vclay and 6% porosity is used to calculate reservoir properties (Table 3). In addition an Sw cut-off of 60% is used to calculate pay properties (Table 4).

5.2.2 Rotliegend

Core measurements are available for a substantial part of the Rotliegend and consist of porosity, permeability and grain density measurements. Available logs include GR, density, neutron and deep resistivity logs. Shale volumes are calculated using the minimum of the GR, and neutron-density method. Porosity is calculated based on the neutron and density log (grain density set to variable), based on core data, an input matrix grain density of 2.67 gm/cc is used. Calculated log porosities fit well with core porosities (fit between density log porosities and core porosities is less). Log grain densities are substantially lower than core porosities. This could be an indication that calculated water saturation is too high. Because there are no SCAL data available, the Indonesian water saturation equation is applied. Cementation and saturation exponent (*m* and *n*) are assumed to be 2 and tortuosity factor (*a*) 1. An Rw of 0.055 at 25^{o}C was estimated from the Pickett plot of the waterleg of the Rotliegend, which corresponds to a salinity of 141,000 ppm. Calculated logs are displayed in Figure 6. A cut-off of 50% Vclay and 6% porosity is used to calculate reservoir properties (Table 3). In addition an Sw cut-off of 60% is used to calculate pay properties (Table 4).

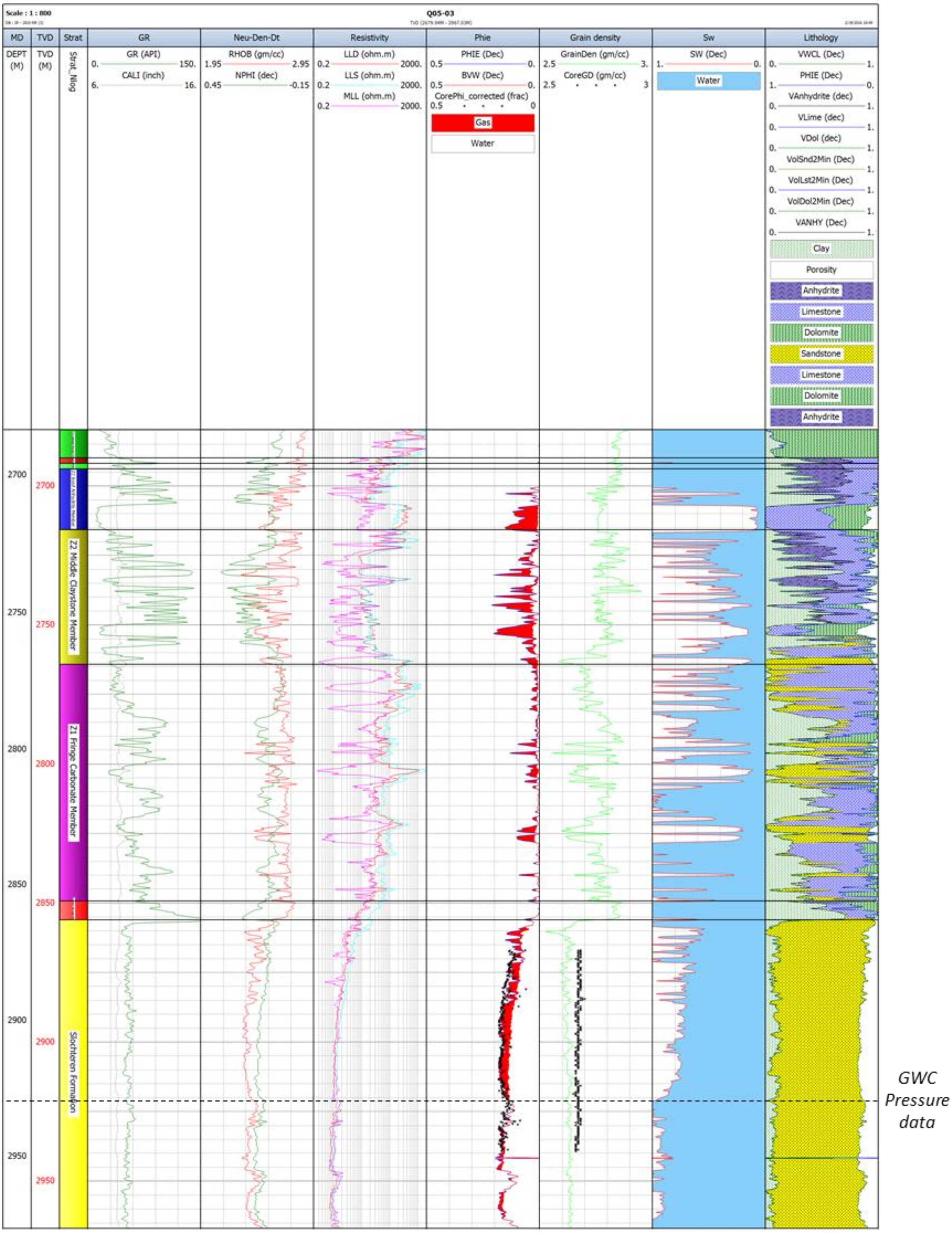

Figure 6 Log panel of the Zechstein and Rotliegend

Table 3 Petrophysical averages - Reservoir

Cut-offs	Reservoir	Interval (m, MD)	Net Thickness (m)	N/G	PHIE (frac)	Sw (frac)
50% Vclay	Z2 Basal Anhydrite Member	2696 – 2698	0	0	-	-
6% Phie	Z2 Roof Anhydrite Member	2698 – 2720	9.2	0.42	0.105	0.10
	Z2 Middle Claystone Member	2720 – 2769	14.6	0.30	0.121	0.27
	Z1 Fringe Carbonate Member	2769 – 2856	6.4	0.07	0.087	0.22
	Z1 Lower Claystone Member	2856 – 2863	0.1	0.01	0.066	0.61
	Slochteren Formation	2863 - 2996	127.3	0.98	0.150	0.84

Table 4 Petrophysical averages - Pay

Cut-offs	Reservoir	Interval (m, MD)	Net Thickness (m)	N/G	PHIE (frac)	Sw (frac)
50% Vclay	Z2 Basal Anhydrite Member	2696 – 2698	0	0	-	-
6% Phie	Z2 Roof Anhydrite Member	2698 – 2720	9.2	0.42	0.105	0.10
60% Sw	Z2 Middle Claystone Member	2720 – 2769	14.5	0.30	0.122	0.27
	Z1 Fringe Carbonate Member	2769 – 2856	6.4	0.07	0.087	0.22
	Z1 Lower Claystone Member	2856 – 2863	0	0	-	-
	Slochteren Formation	2863 - 2996	2.7	0.02	0.166	0.57

6 Conclusion

A DST proved the presence of gas in the Rotliegend. Petrophysical evaluation of the reservoir confirms the presence of a 60 m gas column in the Rotliegend. Core measurements and logs are indicative of moderate to good porosity. FMT pressure measurements and sedimentological study of the reservoir indicate that the reservoir is very tight due to illite plugging. Maximum gas flow rate was 378 m^3/day. Based on gas shows, electrical logs and FMT pressure data, the gas column extends to the Zechstein Z1 and Z2 carbonates, resulting in a total length of the gas column of 200 m.

7 References

Adrichem Boogaert, H.A. and W.F.P. Kouwe, 1993. Stratigraphic Nomenclature of the Netherlands, revision and update by the RGD and NOGEPA, Mededelingen Rijks Geologische Dienst, No. 50.

Website TNO, www.NLOG.nl.