Facies analysis and diagenetic evolution of the Dinantian carbonates in the Dutch subsurface: data and analyses well WSK-01

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Facies analysis and diagenetic evolution of the Dinantian carbonates in the Dutch subsurface: data and analyses well WSK-01

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15. Winterswijk-1 (WSK-01)

15.1 Introduction

The Winterswijk-01 well is located in the Gelderland province of the Netherlands, to the east of the country (Figure 15-1 and Table 15-1). This well was drilled in 1977-1978 for hydrocarbon exploration by NAM. The well was dry and then abandoned.

Figure 15-1: Map showing all the wells penetrating the Dinantian carbonates. Location of the WSK-01 well is indicated by a dashed red circle.

Table 15-1: Table summarising the coordinates of the WSK-01 well (from www.nlog.nl).

Co-ordinates (x, y in utm31, ed50 format)	753966, 5759423
Lat/Long (°)	51.92642317, 6.69379123
Supplied co-ordinates	244787, 438270 (RD)
Depth in meters referred to:	Rotary Table
Total depth (m, along hole):	5009.5
Vertical position of Rotary Table :	44.61 meter relative to NAP
Trajectory shape :	Deviated
Deviation in X-direction :	64.58
Deviation in Y-direction :	49.56
True vertical depth (TVD) in m :	5002.977

15.2 Available dataset

Most of the available data and reports on the WSK-01 well are available on "www.nlog.nl" within the following link:

https://www.nlog.nl/nlog/requestData/nlogp/allBor/metaData.jsp?tableName=BorLocation&id=106511082

This well is rarely mentioned in the literature, probably because of the scarcity of data available and is described mostly in technical reports. The most relevant publications discussing and presenting the data obtained from WSK-01 well are as following:

Carlson, T. (2019). Petrophysical Report of the Dinantian Carbonates in the Dutch Subsurfaceacies analysis and diagenetic evolution of the Dinantian carbonates in the Dutch subsurface. SCAN Report, 26 p. Report downloadable from www.nlog.nl/scan.

Pickard, N. A. H., and Gutteridge, P. (1997). Dinantian depositional systems and exploration potential: offshore and onshore, The Netherlands. Sedimentological study.

Schroot, B. M., V.Bergen, F., Abbink, O. A., David, P., V.Eijs, R., and Veld, H. (2006). Hydrocarbon potential of the Pre-Westphalian in the Netherlands on- and offshore. TNO report.

Sissingh, W. (2004). Palaeozoic and Mesozoic igneous activity in the Netherlands: A tectonomagmatic review. Geologie En Mijnbouw/Netherlands Journal of Geosciences, 83(2), 113-134. https://doi.org/10.1017/S0016774600020084

15.2.1 Logs

A full suite of logs is available, but without the spectral gamma ray that would be useful for a proper formation evaluation (Figure 15-2). The petrophysics has been re-evaluated in the frame of the SCAN project (Carlson, 2019).

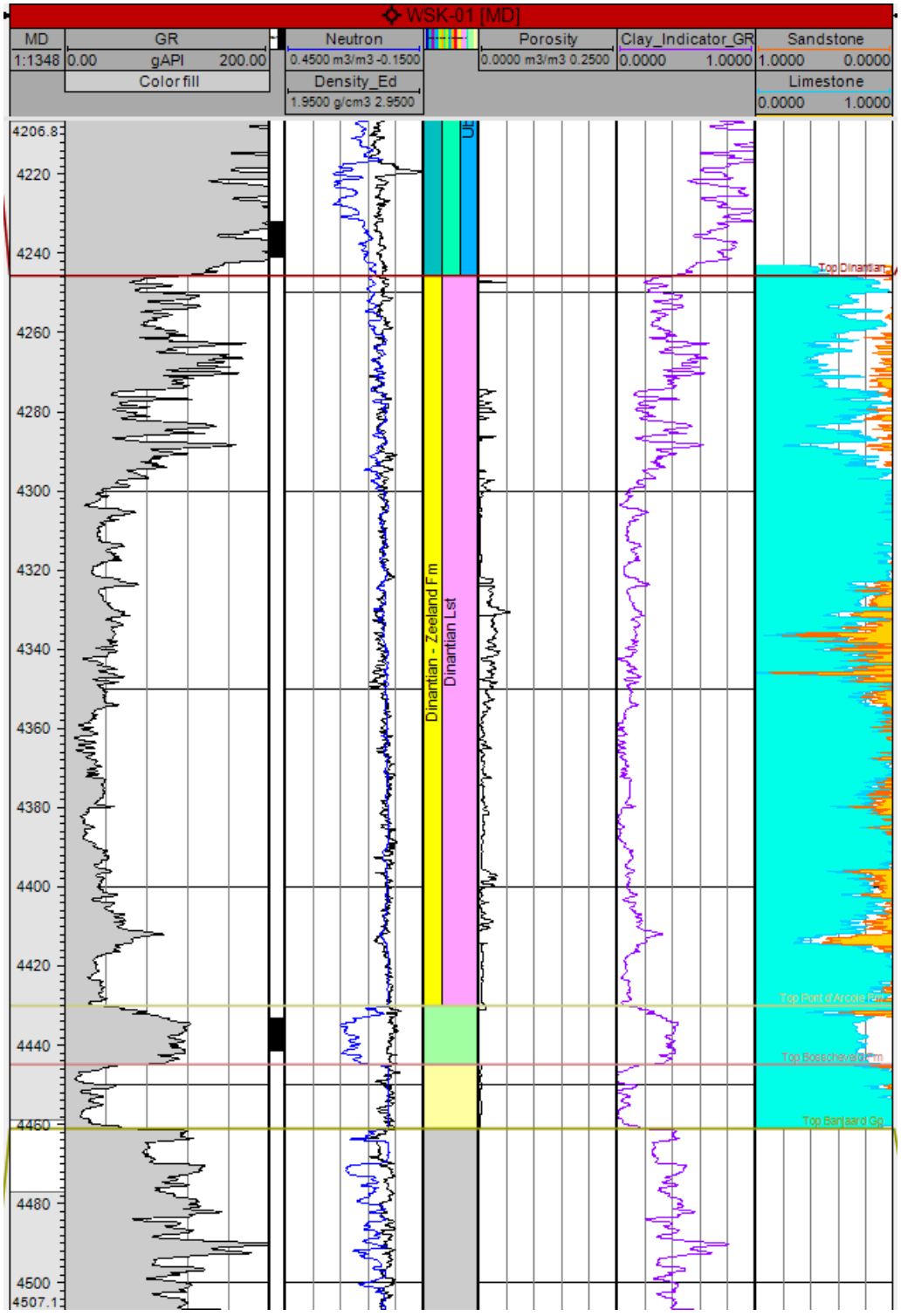

Figure 15-2: Main well logs and formation evaluation of the WSK-01 well.

15.2.2 Cores, sidewall cores and cuttings

This well was cored in the interval 4434-4442 m (Core 5) within the Pont d'Arcole Formation. This consists of very dark grey carbonate mudstone and shale with scattered reworked bioclast including crinoids stems, ossicles, reworked solitary corals and disarticulated and articulated brachiopods (Figures 15-3 and 15-4). This was deposited in a very deep water setting below storm wave base by setting of peri-platform carbonates and hemi-pelagic muds.

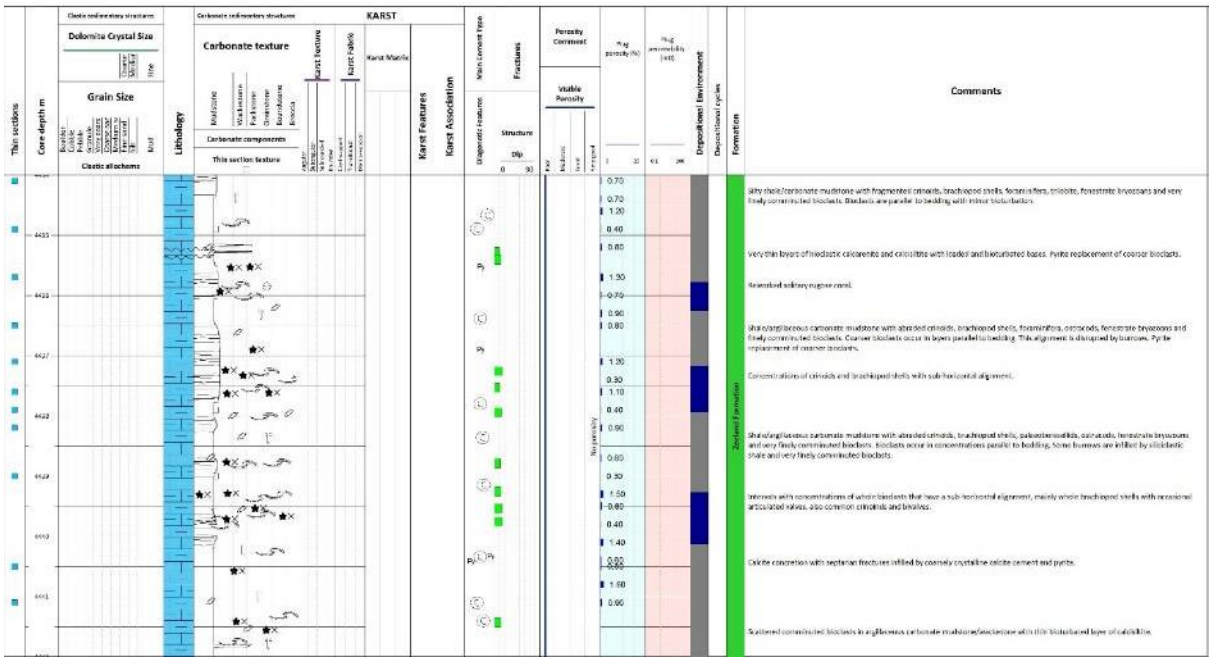

Figure 15-3: Overview of the sedimentological log constructed for Core 5, well WSK-01 (an image of higher resolution is available in Appendix B a supplementary document).

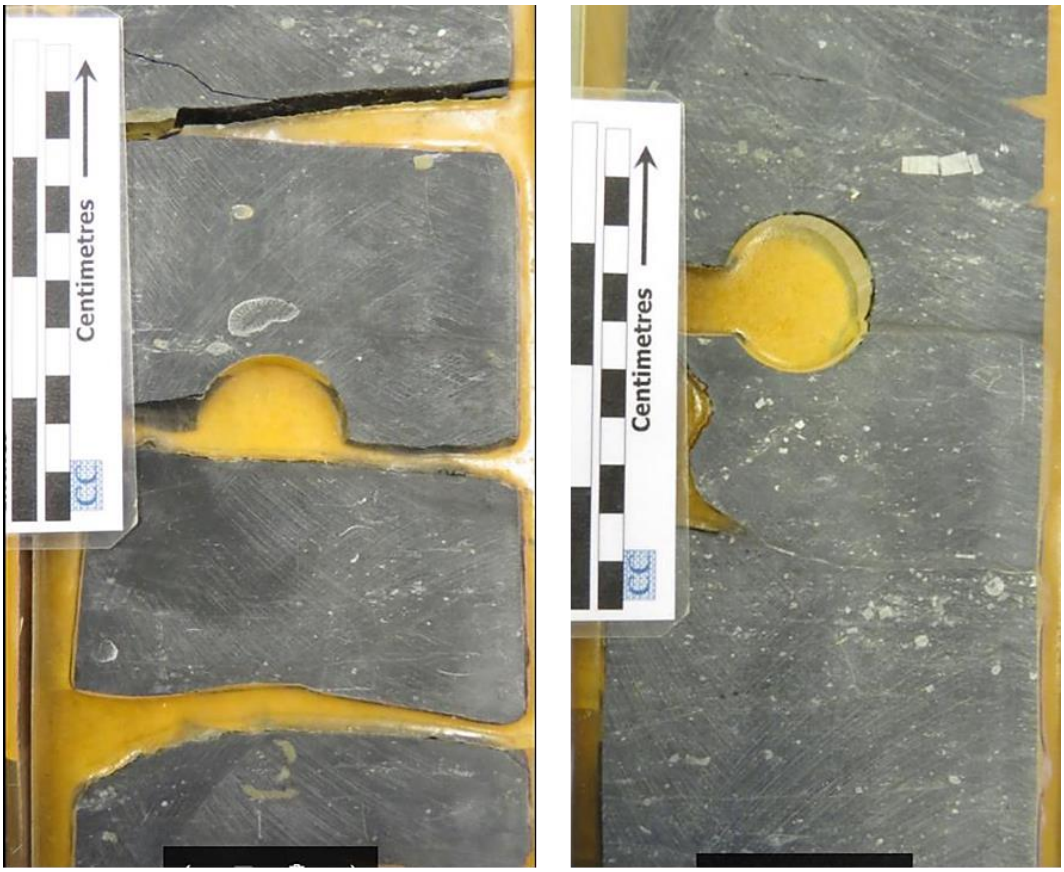

Figure 15-4: left) Argillaceous carbonate mudstone/wackestone with reworked crinoids and solitary rugose coral (4437.5 m). Right) Argillaceous carbonate mudstone/wackestone with reworked crinoids and brachiopod valves (4437.1 m).

15.2.3 Petrography and additional analyses

Only 11 thin sections are available from the cored interval, described by Pickard and Gutteridge (1997). Five vitrinite reflectance measurements are available from the NLOG dataset, with one value exceeding 5 %Ro (Figure 15-5).

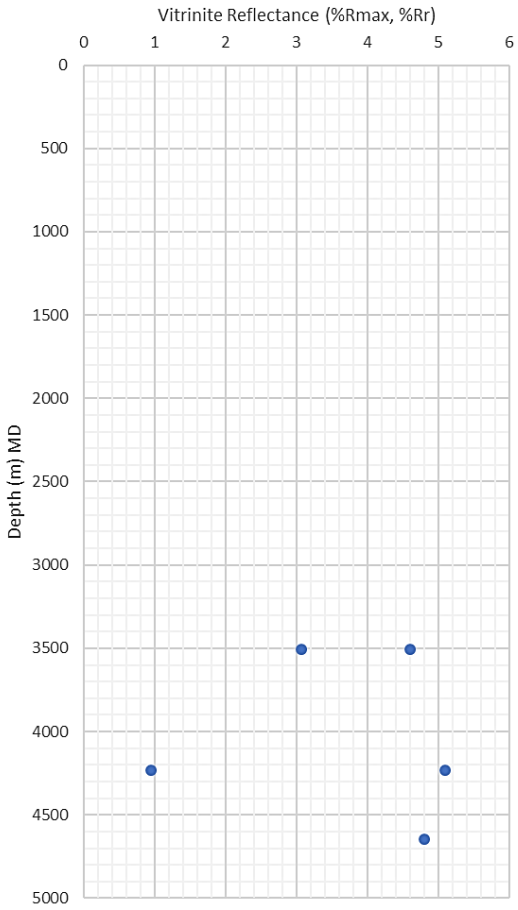

Figure 15-5: Vitrinite reflectance data obtained for the WSK-01 well (NLOG database).

15.3 Stratigraphy

The base of the WSK-01 well encounters the Givetian (Devonian) carbonates and presents a relatively thin Dinantian succession with an undistinguishable depositional environment. A peculiarity of this well is the presence of a volcanic sill dated as Upper Triassic (218±6 Ma; Sissingh, 2004). This sill affected the Epen Formation.

Table 15-2: Stratigraphic succession of the WSK-01 well, modified from NLOG. The formations indicated by * were revised during this project.

Stratigraphical unit	**Top interval**	**Base interval**
QUATER. UNDIFF.	0	12
Breda Fm.	12	49
Rupel Fm.	49	76
Aalburg Fm.	76	122
Sleen Fm.	122	129
Lower Muschelkalk Mb.	129	155
Upper Röt Claystone Mb.	155	301
Main Röt Evaporite Mb.	301	352
Solling Claystone Mb.	352	453
Basal Solling Sandstone Mb.	453	456
Volpriehausen Clay-Siltstone Mb.	456	497
Lower Volpriehausen Sandstone Mb.	497	512
Rogenstein Mb.	512	616
Main Claystone Mb.	616	815
Zechstein Upper Claystone Fm.	815	827
Z4 Pegmatite Anhydrite Mb.	827	828
Red Salt Clay Mb.	828	834
Z3 Main Anhydrite Mb.	834	840
Z3 Carbonate Mb.	840	856
Grey Salt Clay Mb.	856	859
Z2 Roof Anhydrite Mb.	859	866
Z2 Salt Mb.	866	895
Z2 Basal Anhydrite Mb.	895	913
Z1 Salt Mb.	913	1259
Z1 Lower Anhydrite Mb.	1259	1284
Coppershale Mb.	1284	1286
Slochteren Fm.	1286	1289
Ruurlo Fm.	1289	1864
Baarlo Fm.	1864	2538
upper Epen Mb.	2538	2722
Ubachsberg Mb.	2722	2740
main Epen Mb.	2740	4078
VOLCANIC Sill	4078	4149
main Epen Mb.	4149	4195
Geverik Mb.	4195	4275
Zeeland Fm.*	4246	4430
Pont D'Arcole Fm. (added in this report)*	4430	4445
Bosscheveld Fm.*	4445	4510
Bollen claystone Fm.	4510	4645
Banjaard Gp.	4645	5009

15.3.1 Dinantian interval

There are no direct evidences regarding the depositional settings in this well apart from the short, poorly-representative core drilled in the Pont d'Arcole interval.

15.4 Biostratigraphy

The cored interval (Core 5) is of late Tournaisian to early Moliniacian age based on several specimens of the microproblematicum Sphaerinvia pia. The age of the rest of the succession is not clear, as there is no description nor micropaleontological studies of the rest of the succession. Based on the correlation with the other wells, we could assign the succession overlying the core as generic Tournaisian-Visean. The overlying Geverik Member is showing a lowermost Namurian age, based on paleontological studies on the available core (no. 4). It appears that a complete, but thin Dinantian succession (late Tournaisian to early Namurian) is present in WSK-01.

15.5 Sequence stratigraphy

Ten depositional cycles have been recognised in the Dinantian succession of WSK-01; that are tentatively correlated with the ten depositional cycles recognised in the SW Netherlands. These have been grouped (Table 15-3 and Figure 15-6) according to the gamma ray character. The depositional cycles are interpreted in terms of the evolution of surrounding carbonate platforms.

Table 15-3: Sequence stratigraphic model for the Dinantian of the WSK-01 well.

Depositional cycles (this study)	Gamma ray character	Depositional setting	Age
3b	Gamma ray increases upwards to very high followed by low gamma ray HST	Condensed deposition in basin during LST and TST; high stand shedding of carbonates into basin	Late Warantian (Brigantian) age from deep purple sequence
3a			
2d	Moderate to high gamma ray, with progressive increase through interval.	Mid – to distal carbonate ramp or carbonate slope.	
2c			
2b			
2a			
1d	Moderate to low with moderate to high gamma ray peaks interpreted as max. flooding followed by low gamma ray HST	Distal carbonate ramp with increasing carbonate input as ramp progrades during in HST. Maximum flooding events marked by high gamma intervals.	
1c			
1b	Very high gamma ray	Deep water	Tournaisian
1a	Low to moderate gamma ray HST	Initial transgression of basin.	

Cycles 1a and 1b: these cycles are interpreted as the initial deposits of the basin following the late Tournaisian/early Visean transgression. The 1a cycle is interpreted as the shallow water carbonates deposited during the initial transgression of the basin. The 1b cycle (equivalent to the Pont d'Arcole Formation) represents the establishment of deep water conditions in the in the basin.

Cycles 1c and 1d: These cycles are interpreted as distal carbonate ramp cycles; the initial low gamma ray signature reflects the deposition of reworked carbonates sourced from shallow to mid-ramp settings during the TST. The higher gamma ray interval represents the drowning of the source of redeposited carbonates during the maximum flooding.

Cycles 2a to 2c: These cycles have a higher, more uniform gamma ray signature, they are interpreted as distal ramp or carbonate slope facies, possibly associated with a transition from carbonate ramp- to flat-topped carbonate shelves in surrounding carbonate platforms. The low gamma ray intervals are interpreted as influx of resedimented carbonates during high stands.
Cycles 2d to 3b: These cycles show an increasing-upward gamma ray signature, they are interpreted as distal carbonate slope or basinal facies. The high gamma ray intervals are interpreted LST to TST when there is no carbonate production on platforms on exposed carbonate platforms and the surrounding areas are starved of peri-platform carbonates. The low gamma ray intervals are interpreted as HSTs when carbonate production was taking place on flooded carbonate platforms with some high stand shedding of carbonates to the basin.

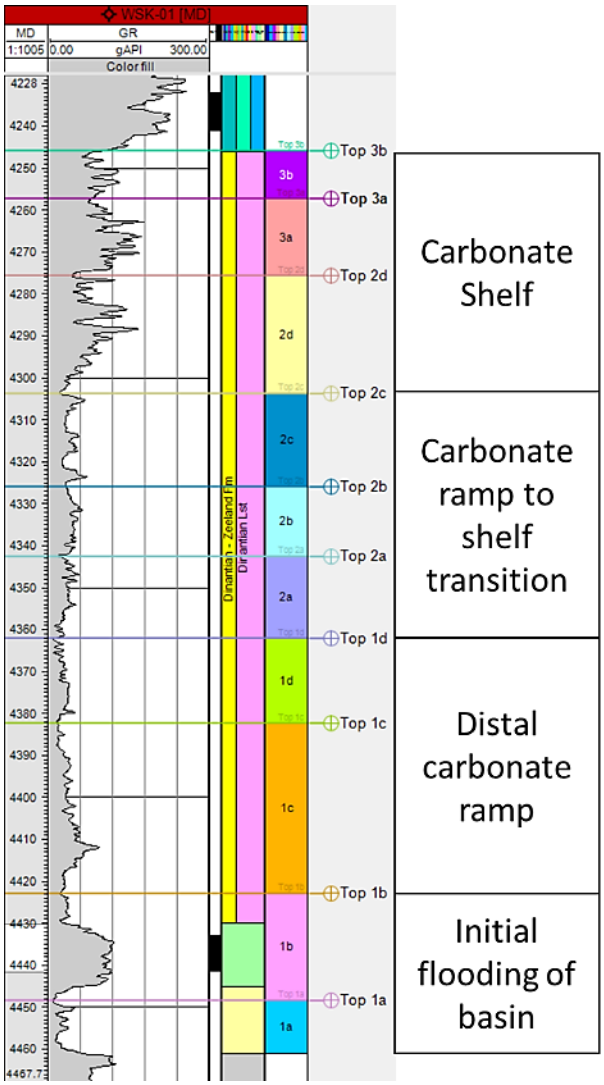

Figure 15-6: Speculative depositional and sequence stratigraphic interpretation of the WSK-01 well.

15.6 Diagenesis

No available data.

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