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Prepared for: AkzoNobel

Evaluation of the hydrocarbon risk and associated volumes in the Z1 and Z2 Carbonates over the Haaksbergen Salt Pillow

Report

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5.1.2.e

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SUMMARY

The chance of finding hydrocarbons in the Haaksbergen structure is considered small (<5%).

This is based on two observations:

- The sealing of the reservoir intervals is compromised
  - The anhydritic seal is fractured due to the extensional regime on top of the salt dome
  - Small faulting is observed on the seismic data, albeit of poor quality.
  - Shows are observed in the anhydrites of HKS1 suggesting seal failure (leakage into the seal).
  - Considerable uplift
- Charge is unlikely
  - Source rock is not mature within the catchment area of the structure
  - Across the reservoir intervals in the adjacent well only minor gas shows are observed.
  - Reservoir is shielded from charge from the underlying Carboniferous Coal Measures by the regionally well-developed Werra salt.
  - In addition the Carboniferous is barely mature for oil, and not mature for gas.
  - No seismic anomalies indicative of the presence of hydrocarbons (gas).

Pressures are expected to be around a gradient of maximum 1.25 gr/cm^3

Unrisked deterministic Oil Initially in Place volumes are estimated at some 13.48 MMbbls (2.12 MMm^3).
Unrisked deterministic Gas Initially in Place volumes are estimated at some 5.58 Bcf (0.1298 MMm^3)

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Enclosure 3 Correlation panel HGV-1, HKS-1 and HEN-1

Appendix 1: Project proposal

Appendix 2: Input/output Resource Calculations

1 INTRODUCTION

The study area is located in the eastern part of The Netherlands (Figure 1.1).

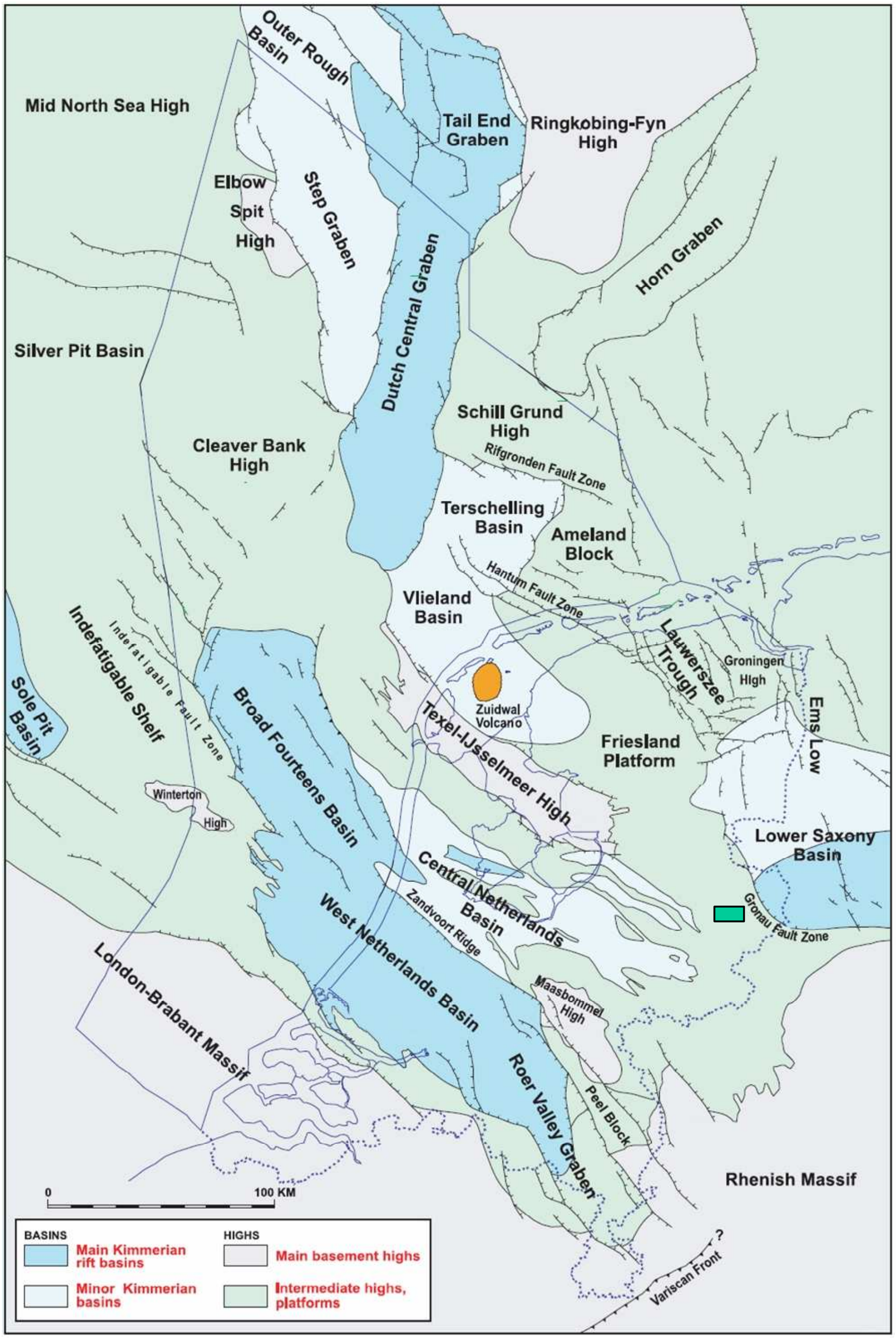


Figure 1.1 Overview of the structural elements of the subsurface of The Netherlands. The study area is highlighted by the green rectangle.

AkzoNobel plans to drill an exploratory well in the Haaksbergen area. This well is located on top of the Haaksbergen salt pillow within structural closure. AkzoNobel has requested

PanTerra Geoconsultants to assess the chance of hydrocarbons, in case of hydrocarbons to calculate the possible volumes and the expected pressures.

2 SEQUENCE OF EVENTS

On the 15th of January 2010 AkzoNobel requested a project proposal for the review of the chance of having hydrocarbons and related volumes in the Permian Platten- and Hauptdolomit in AkzoNobel planned salt exploration well.

Panterra submitted a project proposal on the 19th of January (Appendix 1) and the project was awarded on the 22nd of January 2010.

Panterra accepted the Terms and Conditions of AkzoNobel on the 20th of January 2010.

First batch of data was received on the 25th of January and the second (SEGY files) on the 26th of January.

Panterra proposed to have the logs of the wells HKS-1, HEN-1 and HGV-1 digitised on the 28th of January and approval was granted on the 4th of February.

Digitised logs were received on the 11th of February 2010.

3 AVAILABLE DATA

3.1 Coordinate System and Unit System

Rijksdriehoekstelsel (RD) with Netherlands datum (Figure 3.1.1).

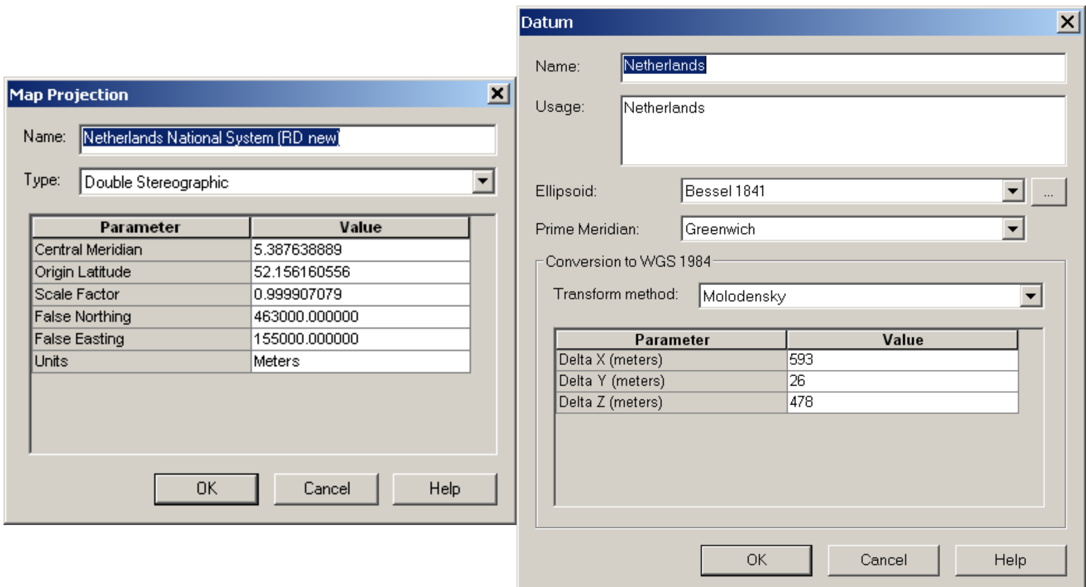


Figure 3.1.1 Project Coordinate System details

The coordinates of the German well EPE S96 have been transformed assuming that their projection system is the German Gauss-Kruger zone 2 with a Potsdam datum (Figure 3.1.2).

EPE S96:

Original coordinates:

X 2,565,575.0 m

Y 5,781,966.9 m

Coordinates RDnew, Netherlands datum:

X 262,439.2 m

Y 465,556.0 m

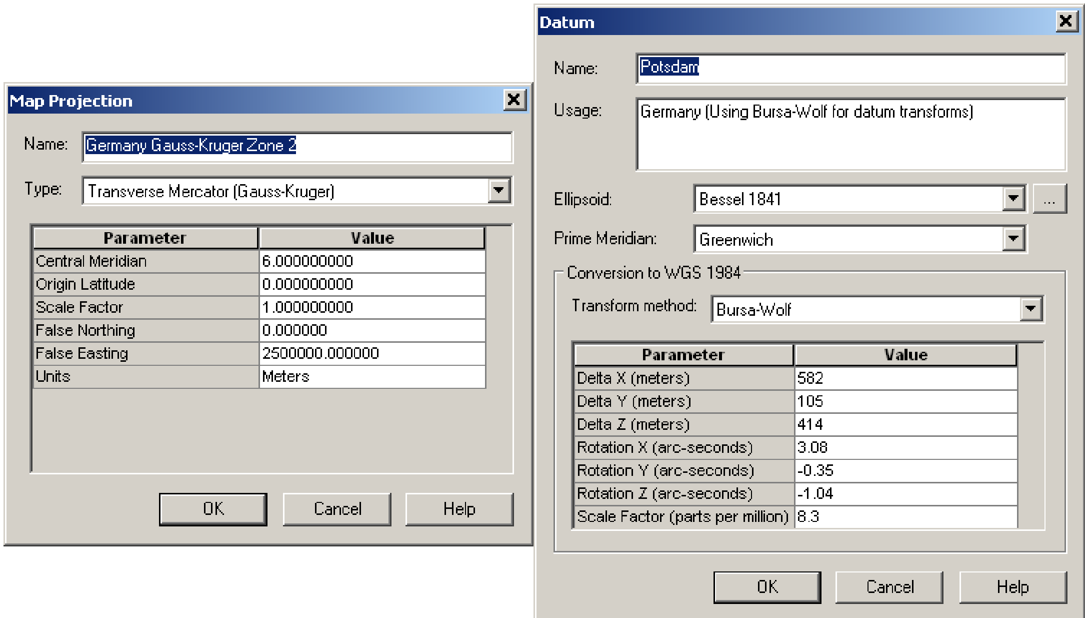


Figure 3.1.2 Assumed Project Coordinate System for the Western Germany well location data

Area of Interest of the Study:
North 475,000m, East 270,000m, South 450,000m and West 230,000m (Rijksdriehoekstelsel)

3.2 Existing reports

AkzoNobel supplied the “Study of the salt mining possibilities in the Haaksbergen area, The Netherlands” issued in 2008 by MWH B.V. Arnhem.

3.3 Seismic data

Seismic data has been received as SEGY data.
The following table summarises the data and the issues around data loading.

Line	Version	Type	SP range		SP Interval	CDP range		Remarks
716017	Migrated	Original	1024	1266	50	2025	2532	No SP's in trace header, CDP/SP relationship estimated, lead-in and lead-out had estimated
716019	Migrated	Original	1025	1308	50	2025	2640	No SP's in trace header, CDP/SP relationship estimated, lead-in and lead-out had estimated
6072	Stack?	Scanned	2543	2602	50			Created Sp file from navigation data
6073	Stack?	Scanned	2646	2710	50			Created Sp file from navigation data
6080 1	Stack?	Scanned	3256	3293	50			Created Sp file from navigation data
6080 2	Stack?	Scanned	3294	3324	50			Created Sp file from navigation data
706023	Stack?	Scanned	1073	1154	50			Created Sp file from navigation data
706036	Stack	Scanned	999	1538	50	1	1078	Created Sp file from navigation data
85EN(V) 03	Migrated	Scanned	2620	1	15	1	2620	Coordinate files according to CDP (inverted from SP order)
85EN(V) 08	Migrated	Scanned	1614	1	15	1	1614	Coordinate files according to CDP (inverted from SP order)
85EN(V) 10	Migrated	Scanned	1	2643	15	1	2643	
RGD8209	Stack	Scanned	2100	2594	10			Created Sp file from navigation data
RGD8306	Stack	Scanned	2250	2731	10			Created Sp file from navigation data

Some uncertainties remained regarding the exact location of the seismic data. The positioning is accurate to within two SP's for most of the data (+/- 20 m to +/- 100 m, depending on the survey). A comparison with the cadastral map (Figure 3.3.1) indicates that in particular the slalom lines, 85EN(V), closely follow the main roads, a further indication that the positioning is accurate to within the limits stated above.

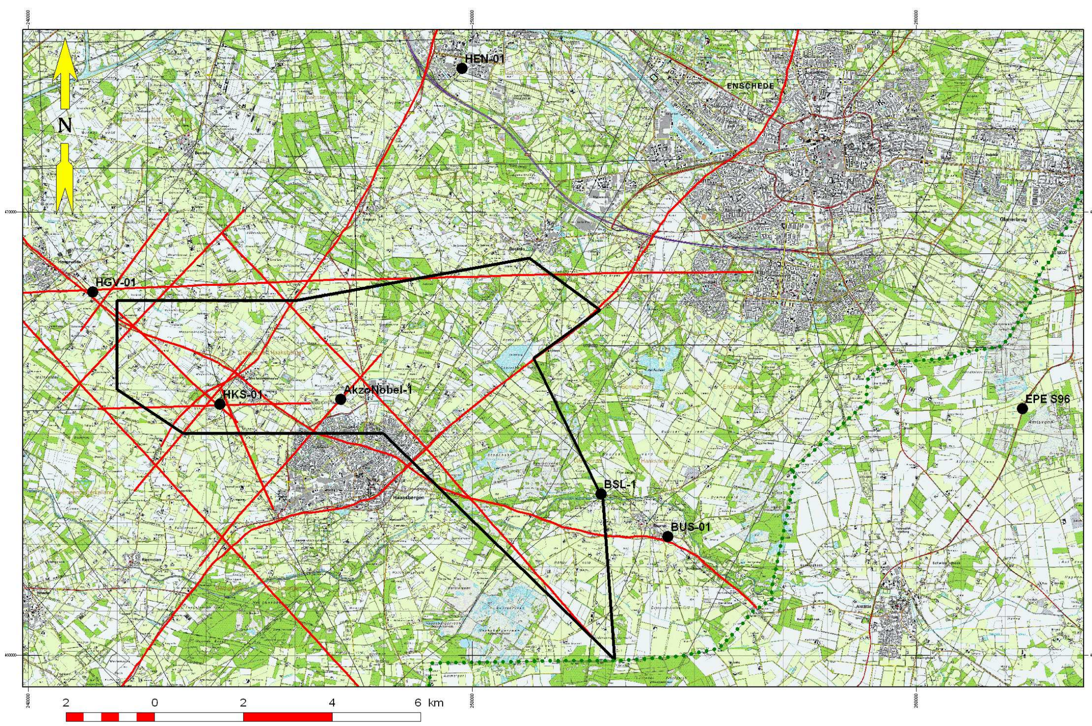


Figure 3.3.1 Overview of the data available for this study. The wells are marked by black dots and the available seismic is shown as red lines. The thin black lines represent the seismic location database of TNO. The exploration area applied for by AkzoNobel is highlighted. The planned AkzoNobel well is indicated.

The polarity is Reverse SEG. This implies that an increase in impedance is recorded as an upward movement of the geophone and as a negative number on tape. This polarity is kept during processing. An increase in impedance is mapped at the maximum of a negative loop on seismic (negative amplitude).

Seismic Reference Datum (SRD) is assumed to be at sea level (NAP).

Large quality differences between the various vintages of seismic occur. In particular the frequency content of the older surveys is less rich in higher frequencies than the more recent surveys (Figure 3.3.2).

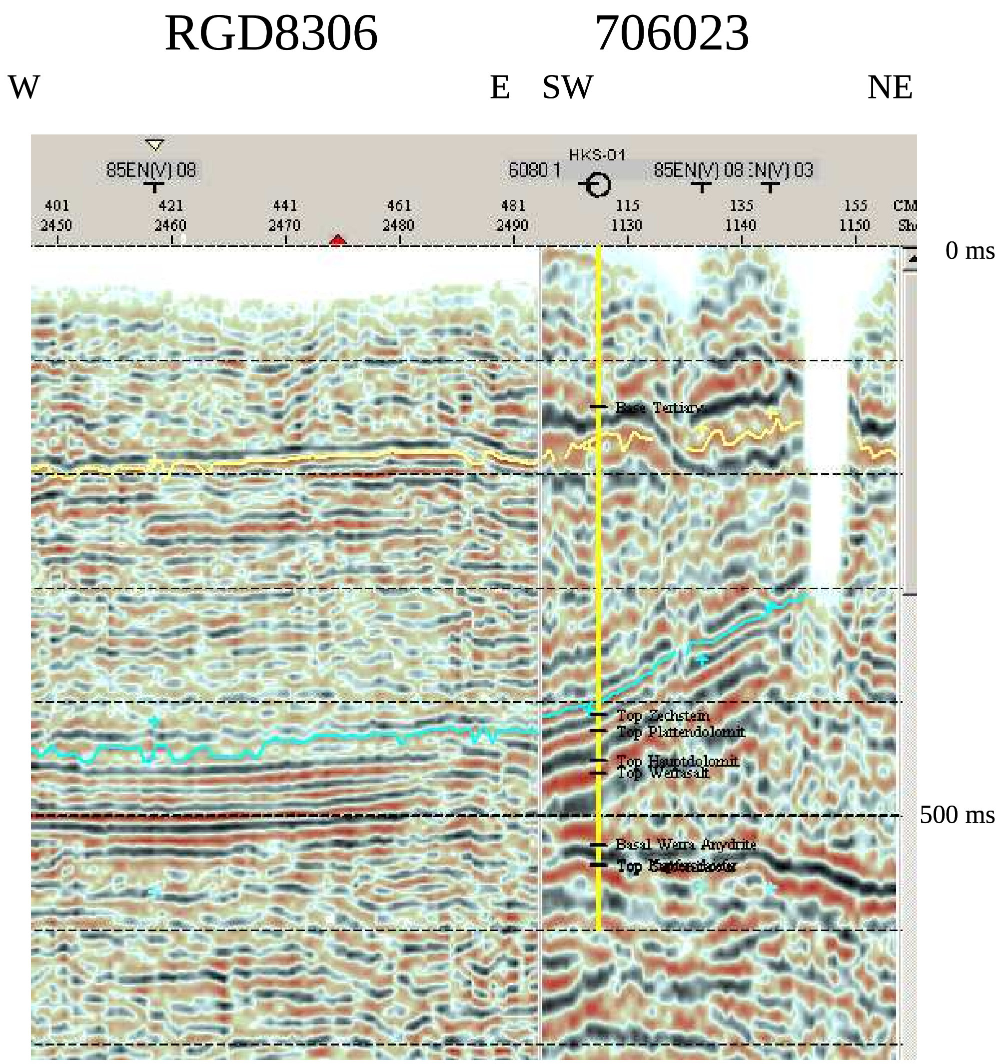


Figure 3.3.2 Example of an intersection between a seismic section from the early seventies and a more recent RGD line (1983). The RGD line is much richer in higher frequencies and allows a more confident picking of e.g. the Base Tertiary and the Basal Zechstein reflections.

Most of the data is relatively old and it is suspected to be of minimum phase.
Only for the 71 data (sections 716017 and 716019), which were reprocessed in 1989 a processing sequence was included in Extended Binary Coded Digital Interchange Character (EBCDIC) header. The detail is copied below:

C 1 CLIENT : N.A.M   ACQUISITION : PRAKLA SON V1   AREA : C.NETHERLANDS
C 2 LINE : 716017   STATION RANGE : 1024 1266` CDP RANGE 2025 2532`
C 3 6073   :   DATE RECORDED : JULY 1971
C 4 INSTRUMENT : DFS 3   MODEL : MDC 04   SERIAL NO :
C 5 SAMPLE INTERVAL : 2MS. RECORD LENGTH 5SECS   BYTES SAMP :
C 6 RECORDING FORMAT : TIAC SEGA   MEASUREMENT SYSTEM : METERS
C 7 SAMPLE CODE : FLOATING PT.   RECEIVER TYPE : HS J14
C 8 FILTERS ALIAS :   NOTCH :NONE BAND : 12HZ(18)   124HZ(72) DB OCT
C 9 SOURCE : DYNAMITE   SIZE HOLE : 2 8KG INTERVAL : 100 M DEPTH : 8 21 M
C10 NO OF GROUPS   : 48
C11 SPREAD OFFSET : 0M NOMINAL CABLE LENGTH: 2400 M   GROUP INTERVAL : 50 M
C12   PRE STACK PROCESSING BY DIGICON MAY 1989
C13   REFORMAT FROM SEGY TO DIGICON INTERNAL FORMAT
C14   RESAMPLE TO 4MS (WITH RESAMPLE FILTER)
C15   SPHERICAL DIVERGENCE   V*T 2
C16   AGC 1000 MSEC GATES
C17   F K FILTER : TXF (FULL TAPERED)` SLOPE : 6DB 12MS TRACE
C18   FIELD STATIC CORRECTIONS : DATUM N.A.P.
C19   TRACE EDIT
C20   COMMON DEPTH POINT GATHER : 12 FOLD
C21   DECONVOLUTION TYPE : SPIKE   OPERATOR LENGTH : 160MS
C22   DERIVE GATES AT NEAR TR. 1) 30M 500 2000MS` FAR TR. 2400M 2500 3000MS.
C23   2)   1500 3000MS`   3000 4500MS.
C24   VELOCITY ANALYSIS : FUNCTION INTERVAL 2KM
C25   AUTO. STATICS: SURFACE CONSISTENT STATICR` 3TR.PILOT` 20MS LIMIT
C26   VELOCITY ANALYSIS : FUNCTION INTERVAL 1.5KM
C27   NORMAL MOVEOUT CORRECTIONS
C28   NMO MUTE : (OFF`TIME) 150 0` 225 300` 750 800` 1500 1500` 3000M 2500MS.
C29   TRACE SCALING : NEAR TR. 30M 100 400` 300 600` 500 1000` 1000 1500
C30   1500 2000` 2000 3000` 3000 5000MS` FAR TR. 4000M 900 1200` 1100 1400
C31   1000 1500` 1500 2000` 2000 2500` 2500 3500` 3500 5000MS.
C32   CDP STACK   : 12 FOLD
C33   GAPPED DECON   : 120MS OP + 16MS GAP` 400 2000MS.
C34   PHASE COMPENSATION FILTER FIL907
C35   MIGRATION   : FINITE DIFFERENCE` STEEP DIP ALGO` 24MS LAYER THICK.
C36   FILTERING   : 0 1500MS 10 12 60 48 `3000MS 10 12 50 48`
C37   4800MS 10 18 40 36HZ
C38   TRACE SCALING : 0 250` 125 375` 300 800` 500 1500` 1000 2000`
C39   1500 2500` 2000 3000` 2500 3500` 3000 4000` 3500 4500` 4000 5000MS.
C40   OUTPUT ONTO THIS TAPE IN SEGY 6250BPI` 32BIT FLOATING POINT

The spike deconvolution, combined with the phase compensation suggests that the reprocessing was done to zerophase.

Shifts unto 50 ms were required to tie some of the scanned lines to the other data.

The vertical scale of all seismic examples shown in this report is in ms below SRD.

TNO carried out a regional interpretation of the subsurface of the Netherlands during the late nineties (TNO 1998), based on 2D seismic data (a selection of this 2D data set is included in this study). The map of the top of the Zechstein is included as Figure 3.3.3.

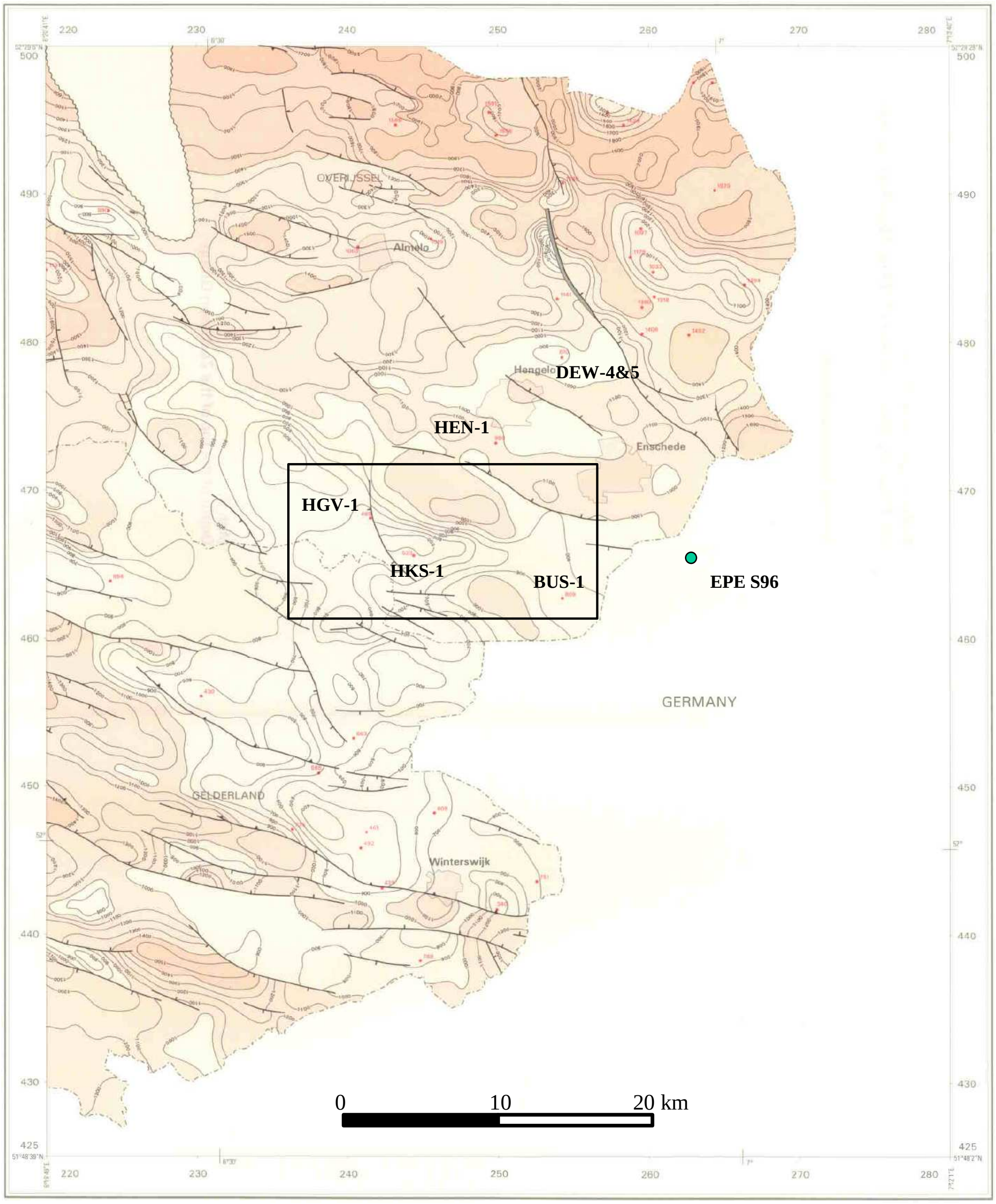


Figure 3.3.3 Depth map to Top Zechstein (TNO 1998). The objective of the AkzoNobel well is the salt pillow just north of the HKS-1 well. The Zechstein in the structure north of the Haaksbergen pillow has been conclusively tested as non-hydrocarbon bearing by the wells DEW 4&5.

3.4 Well data

An overview of well data received is given in the table below.

Well ID	Well name	Date	Litho-description	Logs run	Log prints	Digital logs	Cores across Zechstein	Remarks
HKS-1	Haaksbergen-1	1950	yes	yes	yes	no	no	Resistivity, SP, GR and caliper
HGV-1	Hengevelde-1	1985	yes	yes	yes	no	no	Investigation of Carboniferous
HEN-1	Hengelo-1	1966	yes	yes	yes	no	yes	Salt exploration well
EPE S96	EPE S96	2008	yes	yes	no	no	no	Salt exploration well
BUS-1	Buurse School-1	1910	yes	no				Geological survey
BSL-1	Buurse Sluis-1	1909	yes	no				Geological survey, didn't penetrate the Zechstein

Comments:

- Note that the earliest wells were drilled in the early part of the twentieth century and that only limited data is available (mainly a lithological description). The Haaksbergen well has a limited logging suite of resistivity, SP, GR and caliper only. The logging suites of the more recent wells do include sonic and density logs (some with a neutron log) allowing assessment of porosities and porefill.
- Neutron log of HEN-1 is measured in counts/sec and has to be recalculated to porosity values.
- Note that some of the log data has been acquired, but not available for this study (EPE S96). PanTerra has vectorised the log data of the HGV-1 , HKS-1 and HEN-1 wells (only available as tiff/pdf files).

A correlation panels of the HGV-1, HKS-1 and HEN-1 well is included as Enclosure 3.

In most of the wells hydrocarbon shows have been observed. Little gas but oil fluorescence has been commonly observed across the Platten- and Hauptdolomit intervals. Locally shows have been observed in the overlying anhydrites.

On the EPE S96 well Untergrundspeicher- und Geotechnologie-Systeme GmbH (UGS) reports:
Quote:
Dear Mr. den Hartogh,
during our drilling operations within the Werra Formation in the Epe area we encountered HC, mainly oil, several times. The HC did not cause severe problems during the drilling process, due to this an estimation about the quantity was never performed. There are no data about the influx of the HC on the later leaching procedure.
Hopefully this will help you a little bit, but do not hesitate to contact again for further discussion.

Best regards

Markus A. Stöwer
Head of Department Geology and Reservoirengineering
Unquote.

The next two figures summarise the core data over the Platten- and Hauptdolomite intervals in the Hengelo-1 well. No core measurements have been reported.

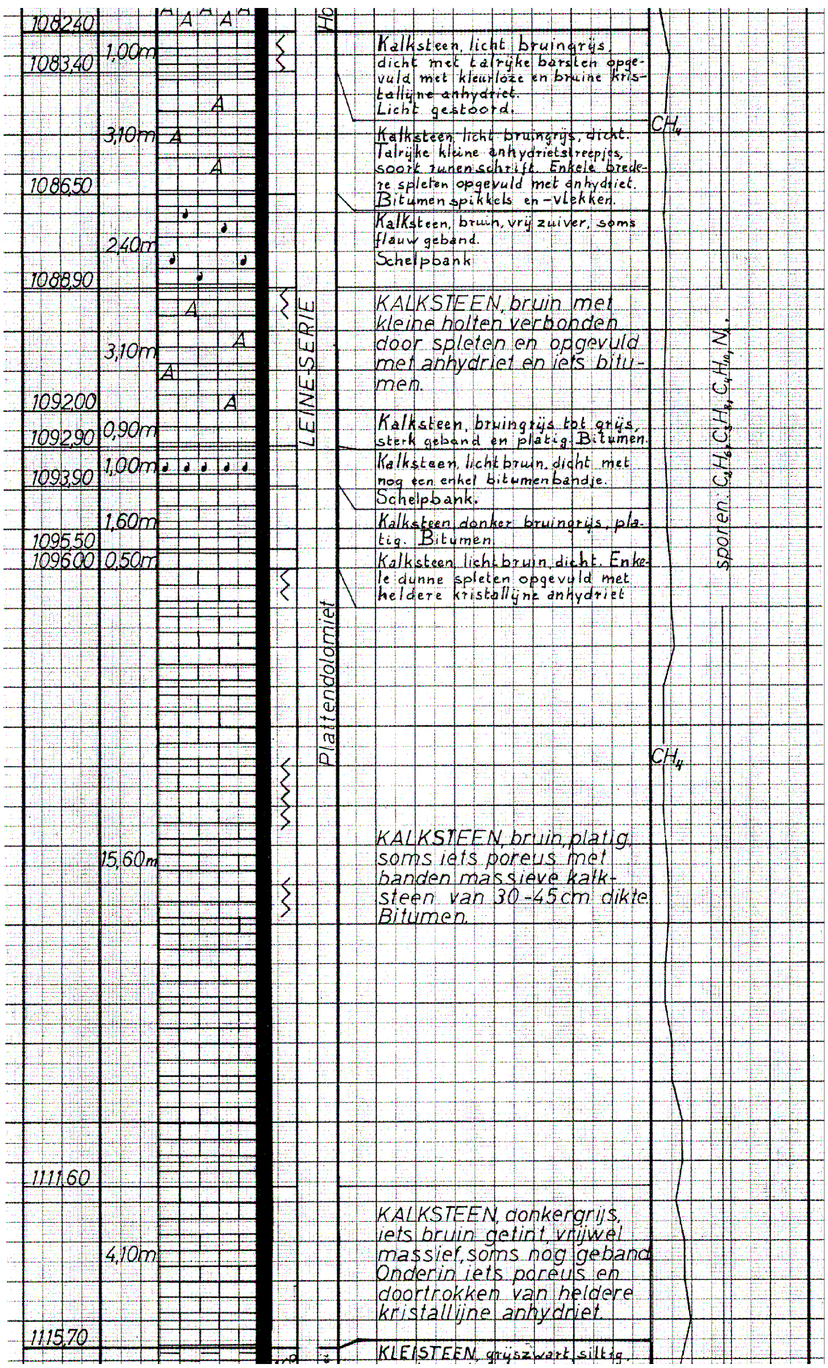


Figure 3.4.1 Core description of Plattendolomit in Well HEN-1. Note the very low gas readings and the in places bituminous character of the carbonates.

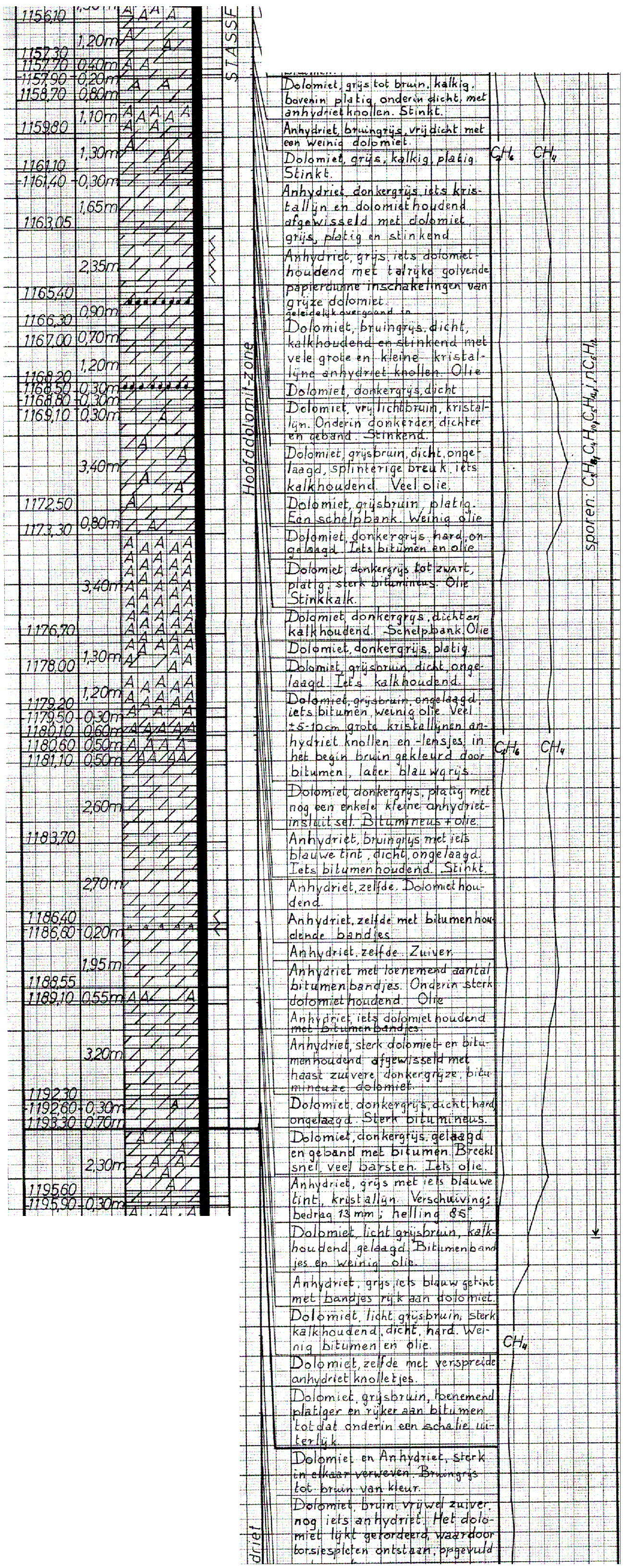


Figure 3.4.2 Core description of Hauptdolomit in Well HEN-1. Note the slightly higher gas readings and

the in places bituminous character of the carbonates.

3.5 Time depth data

Well velocity surveys are available for the HEN-1 and HKS-1 wells. The print of the latter is barely readable and only the average velocity curve could be read.

3.6 Stratigraphic frame work

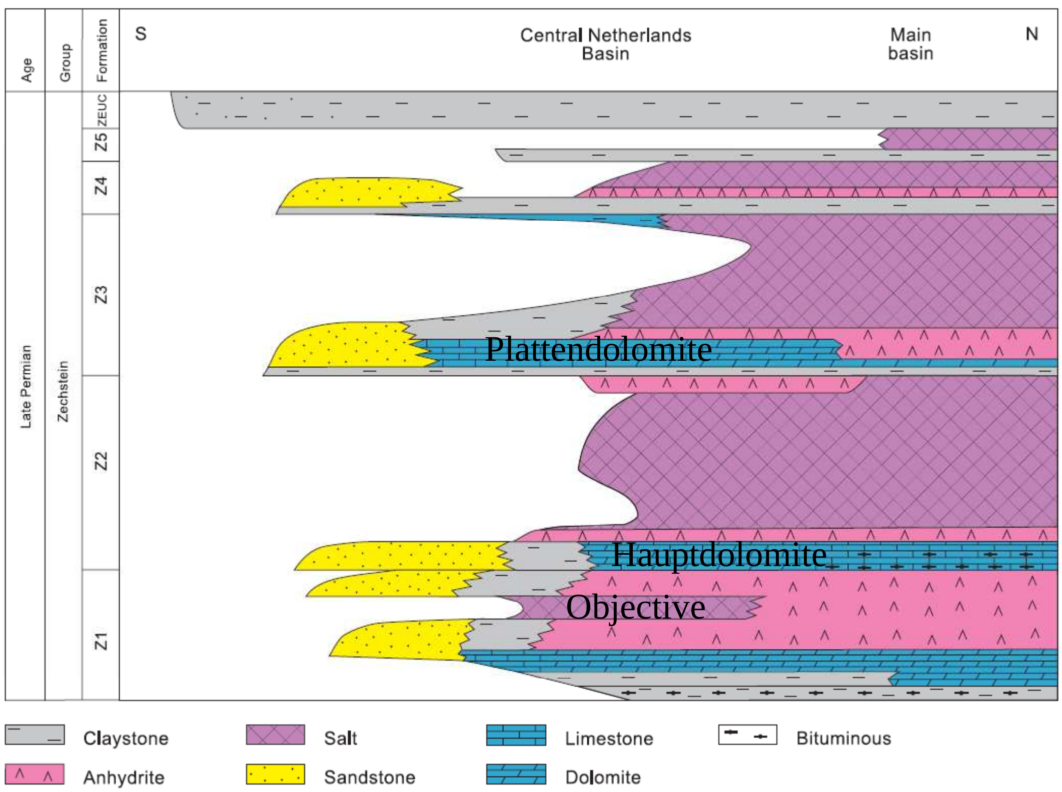


Figure 3.6.1 Stratigraphic framework of the Zechstein Group (After Geluk 2007).

Global Period	Epoch	Stage	Group	Subgroup	Formation	Basin Area Member
Jurassic	Lias	Sinemurian	Altena (AT)		Aalburg Fm (ATAL)	
		Hettangian				
Triassic	Late Triassic	Rhaetian			Sleen Fm (ATRT)	
		Norian	Upper Germanic Trias (RN)		Keuper Fm (RNKP)	Upper Keuper Claystone (RNKPU)
						Dolomitic Keuper (RNKPD)
						Red Keuper Claystone (RNKPR)
		Carnian				Red Keuper Evaporite (RNKPE)
						Middle Keuper Claystone (RNKPM)
	Middle Triassic	Ladinian				Main Keuper Evaporite (RNKPS)
						Lower Keuper Claystone (RNKPL)
					Muschelkalk Fm (RNMU)	Upper Muschelkalk (RNMUU)
						Middle Muschelkalk Marl (RNMUA)
		Anisian				Muschelkalk Evaporite (RNMUE)
						Lower Muschelkalk (RNMUL)
					Röt Fm (RNRO)	Upper Röt Claystone (RNROU)
						Upper Röt Evaporite (RNRO2)
						Intermediate Röt Claystone (RNROM)
						Röt Claystone (RNROC)
						Main Röt Evaporite (RNRO1)
	Early Triassic	Scythian			Solling Fm (RNSO)	Solling Claystone member (RNSOC)
						Basal Solling Sandstone member (RNSOB)
			Lower-Germanic Trias (RB)	Main Buntsandstein (RBM)	Hardegsen Fm (RBMH)	
					Detfurth Fm (RBMD)	Detfurth Claystone (RBMDC)
						Lower Detfurth Sandstone (RBMDL)
					Volpriehausen Fm (RBMV)	Volpriehausen Clay-Siltstone (RBMVC)
						Lower Volpriehausen Sandstone (RBMVL)
					Lower-Buntsandstein Fm (RBSH)	
						Rogenstein (RBSHR)
Perm	Late Perm	Lopingian				Main Claystone (RBSHM)
		Guadelupian				
	Early Perm	Kungurian				
		Artinskian				
		Sakmarian				
		Asselian				

Figure 3.6.2 Stratigraphic Framework of the Germanic Trias.

3.7 Bore hole image data

Hengelo-1 has been cored continuously. No image data are available for the other wells.

3.8 Database

A database, including all the seismic and well data has been created on Geographix. If need be this will allow effective monitoring of planned wells and quick updates of the subsurface model when additional or new data becomes available.

3.9 Core data

The well Hengelo-1 has been cored continuously, no other core data is available.

3.10 Pressure data

Pressure data have been derived from the drilling mud density, losses, DST's
The losses may indicate the presence of fractures.

3.11 Cultural data

Detailed topographical maps have been loaded. This aided in the quality checking of the well locations (summary maps are included in most of the Completion Well Logs) and the seismic data.

4 INTERPRETATION

4.1 Seismic interpretation

The available seismic data has been loaded on a Geographix Workstation. The following horizons have been correlated:

- Base Tertiary.
  - An angular unconformity. Over most of the study area strongly dipping Triassic strata subscrop this unconformity. It is picked at a strong negative loop, which over most of the area is of poor quality (close to surface, strongly affected by the mute)
- Top Muschelkalk
  - Strong reflector, occurring in the deep synclines surrounding the Haaksbergen Werra salt pillow. A strong positive loop has been correlated, possibly representing the change from the anhydritic Keuper to the more marine marls of the Muschelkalk.
- Top Röt salt.
  - Strong reflector, occurring over in the deep synclines surrounding the Haaksbergen salt pillow. Locally disturbed because of halokinesis. Picked at a positive reflector (decrease in impedance).
- Top Zechstein.
  - Relatively weak reflector, because the upper part of the Zechstein sequence is saline clay, without too much contrast with the overlying Lower Bunter shales.
- Top Basal Zechstein anhydrite.
  - Strong reflection at the base of the Werra salt. The transition from salt to anhydrite, an increase in impedance, causes a strong negative loop.
- Base Zechstein
  - Strong positive reflection caused by the decrease of impedance from the Anhydrite/Dolomites at the base of the Zechstein and the underlying Carboniferous clastics. Locally an angular unconformity can be observed.

4.1.1 Well to seismic ties

No formal well to seismic ties have been carried out.

4.1.2 Mapping in time

A time map at the top of the Zechstein has been produced (Figure 4.1.2.1 and Enclosure).

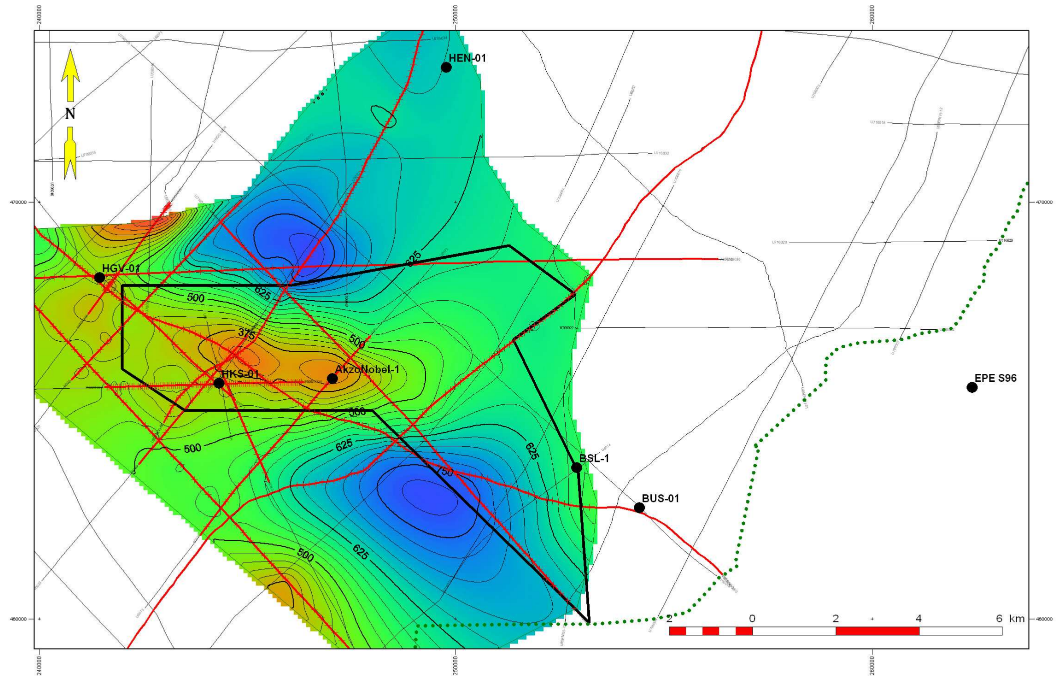


Figure 4.1.2.1 Time contour map of the top Zechstein. Contour values in ms below SRD, contour interval 25 ms. The red crosses represent data points. Contouring based on minimum curvature with a grid cell size of 100 m and a search radius of 10 km. Note that the interpretation has been extended beyond the study area of MWH in order to be able to assess the drainage area for any possible source rocks within the Platten- and Hauptdolomite carbonate sections. Map is included as Enclosure 1

A seismic section and its location are shown in respectively Figures 4.1.2.2 and 4.1.2.3

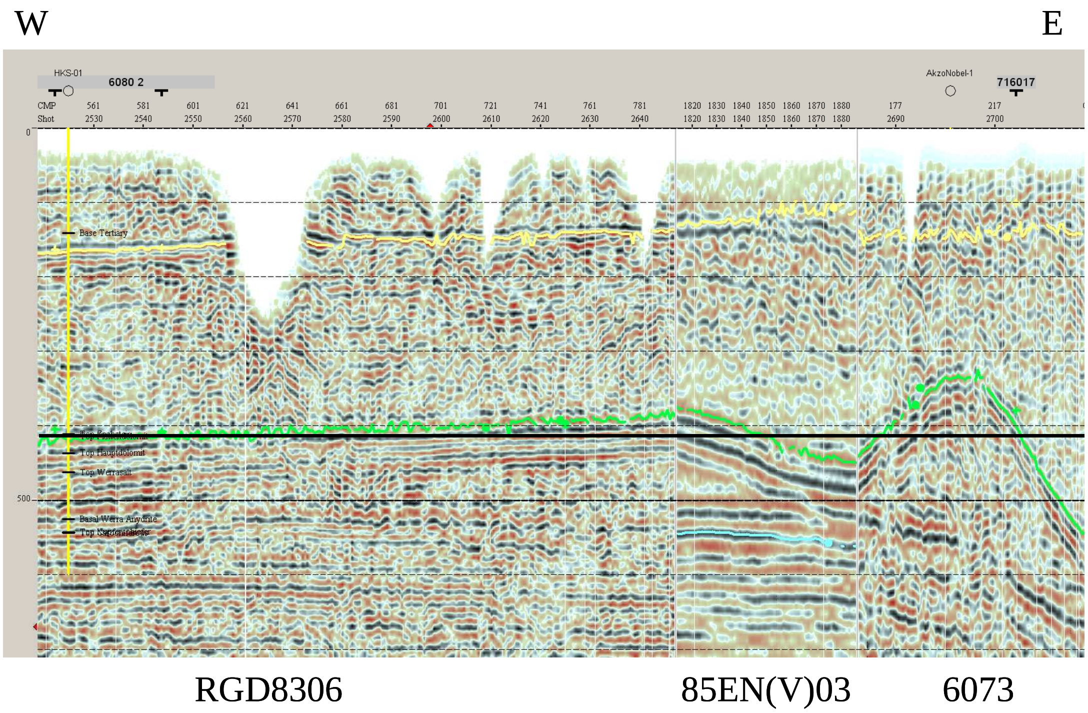


Figure 4.1.2.2 Regional W-E seismic section across the study area, linking the HKS-1 well with the proposed AkzoNobel well. The black line highlights the level at which HKS-1 penetrated the top Zechstein. The location of the line is shown in Figure 4.1.2.3.

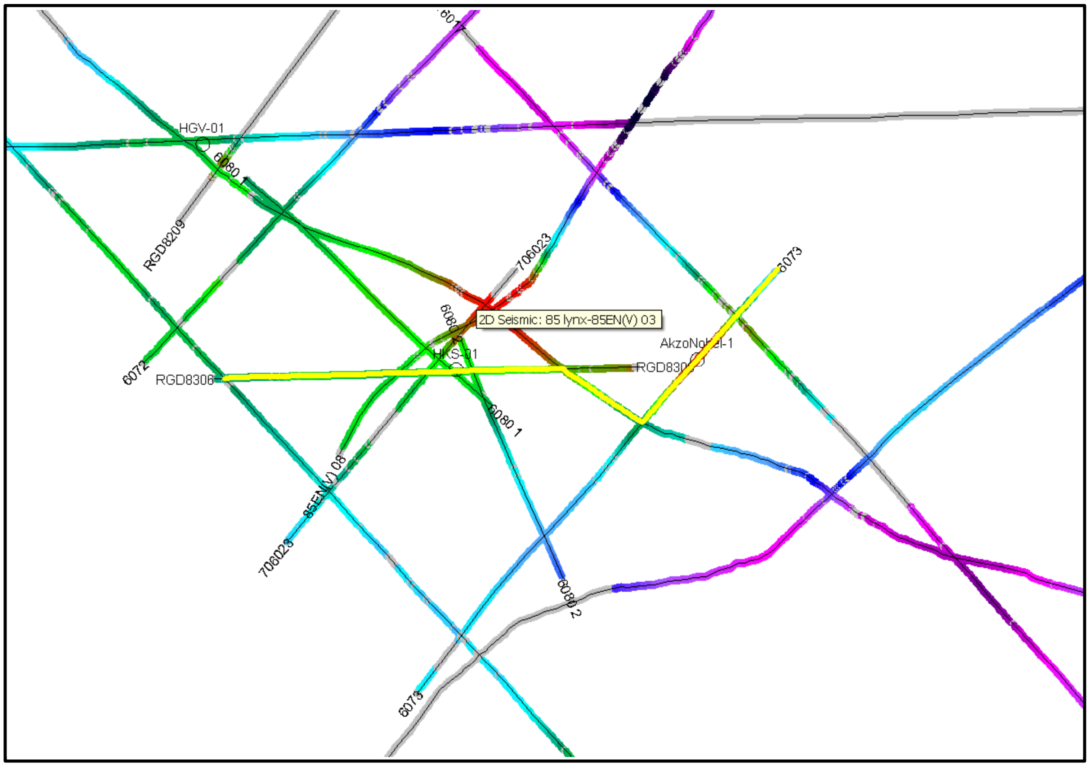


Figure 4.1.2.3 Seismic location map showing the location of the regional seismic section of Figure 4.1.2.2.

4.1.3 Mapping in depth

A time map of the top Zechstein has been depth converted (Figure 4.1.3.1) using the time/depth data for the HKS-1 well (time from seismic and depth from well) and is very comparable to the map included in the MWH report (Figure 4.1.3.2). A single velocity from Seismic Reference Datum to top Zechstein of 2666 m/sec was used. This model is only valid near the HKS-1 well and as can be noted from the differences between the depth map and the values encountered in the HEN-1 well and the BUS-1 well. As this study is meant to assess the hydrocarbon risk for the planned AkzoNobel well on top of the Haaksbergen salt pillow no further attempts have been carried out to refine the velocity model beyond the salt pillow. For more detailed depth maps reference is made to the MWH report (2008), which are based on the VELMOD study by TNO.

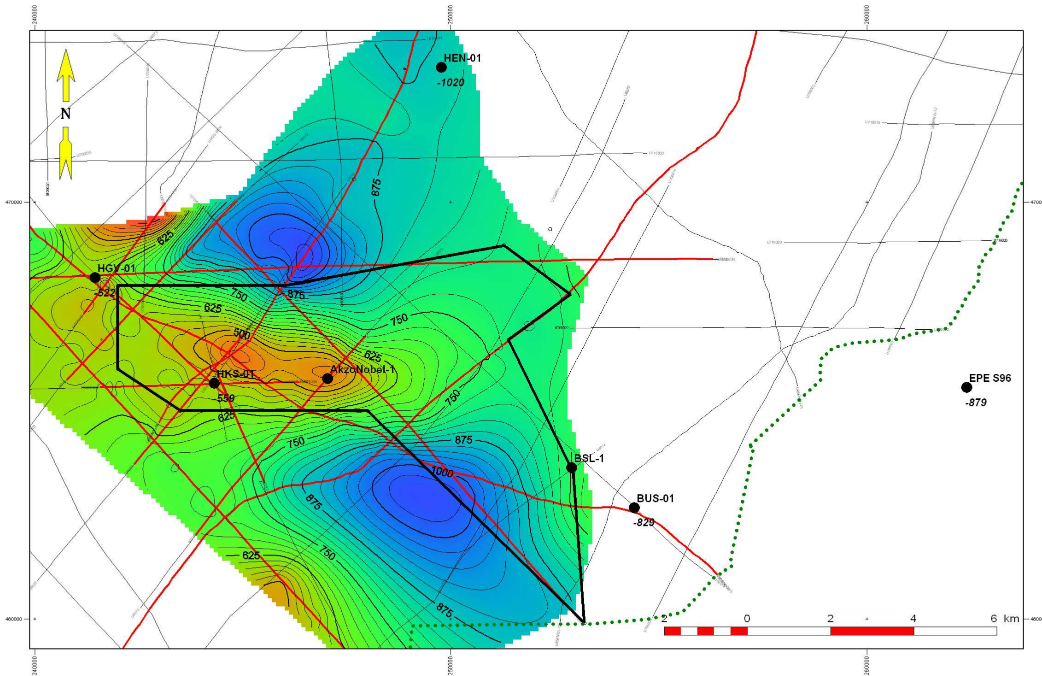


Figure 4.1.3.1 Depth contour map of the top Zechstein. Contour values in m below SRD, contour interval 25 m. The depth conversion is only based on the HKS-1 well and is not appropriate for the area around HEN-1 and BUS-1 (note the differences with the well values, which are plotted next to the well symbols). Note that the HKS-1 well is located slightly above the spill point towards the west. Map is included as Enclosure 2.

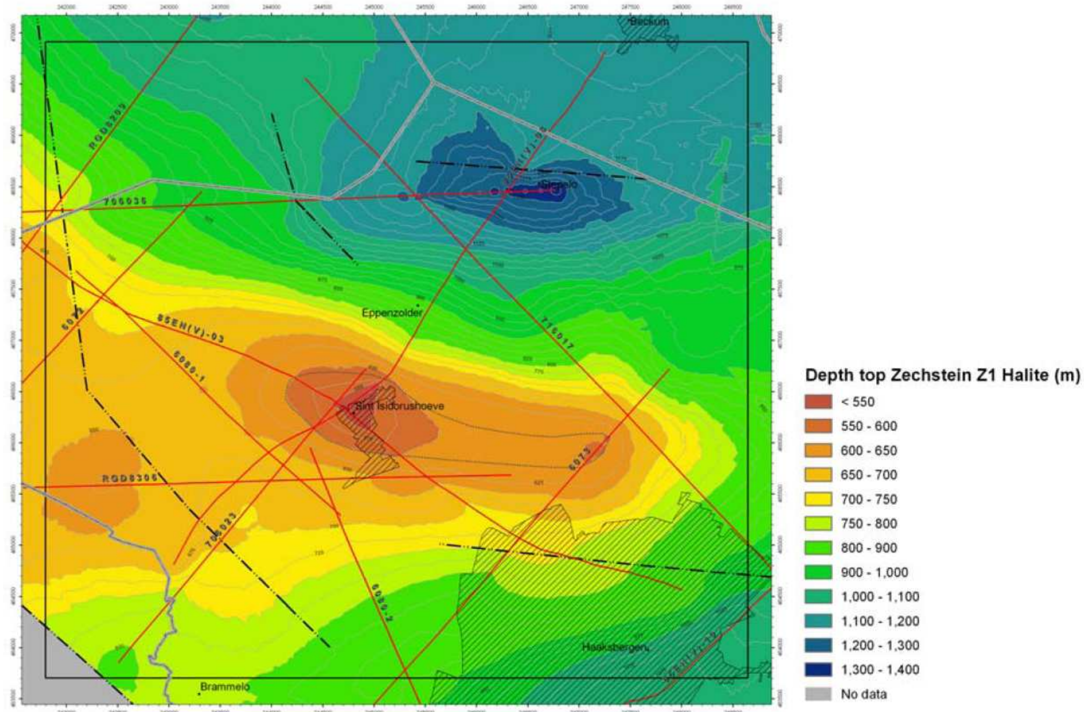


Figure 4.1.3.2 Top Z1 Halite depth contour map MWH report (report figure 15). This event occurs approximately 115 m below the Top Zechstein. The modelled contour represents the 600 m depth contour, approximately equivalent to the 485 m contour of Figure 4.1.3.1.

4.2 Reservoir

Palaeography of the Haupt- (Figure 4.2.1) and Plattendolomit (Figure 4.2.2) has been extensively studied by the Nederlandse Aardolie Maatschappij (NAM) en TNO and the details have been published in the recently issued Geology of the Netherlands (Edited by Wong et al, 2007).

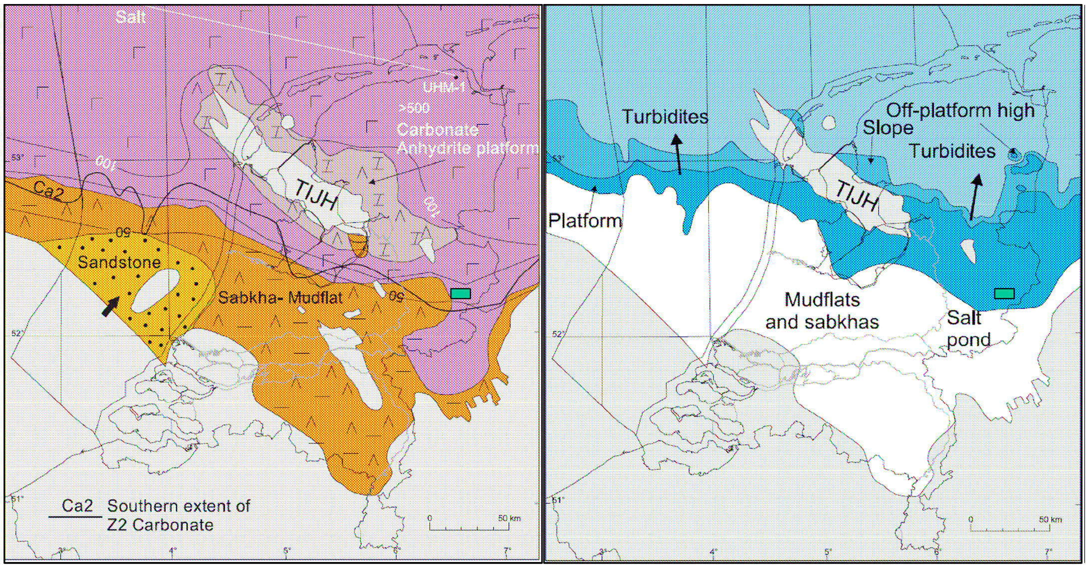


Figure 4.2.1. Facies and isopach (m) of the Z2 Stassfort Formation (right) and the Z2 Carbonate Member or Hauptdolomite (left, after Geluk 2007). The study area is located towards the southern edge of the platform area. The best source rocks occur in the off-platform, deeper part of the basin.

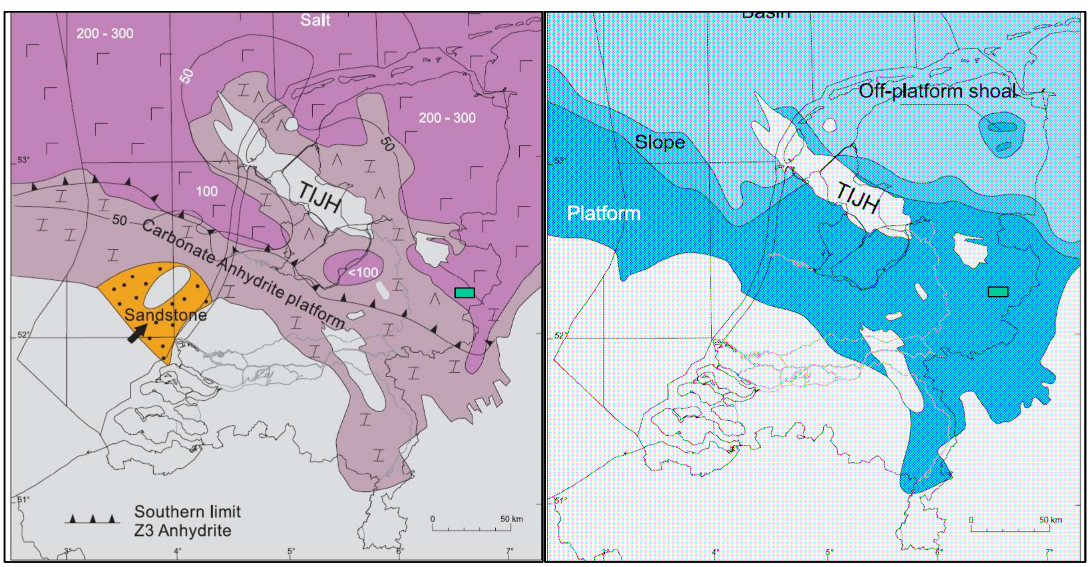


Figure 4.2.2. Facies and isopach (m) of the Z3 Leine Formation (right) and the Z3 Carbonate Member or Plattendolomit (left, after Geluk 2007). The study area is located in the central part of the platform area.

The depositional model is summarised in Figure 4.2.3.

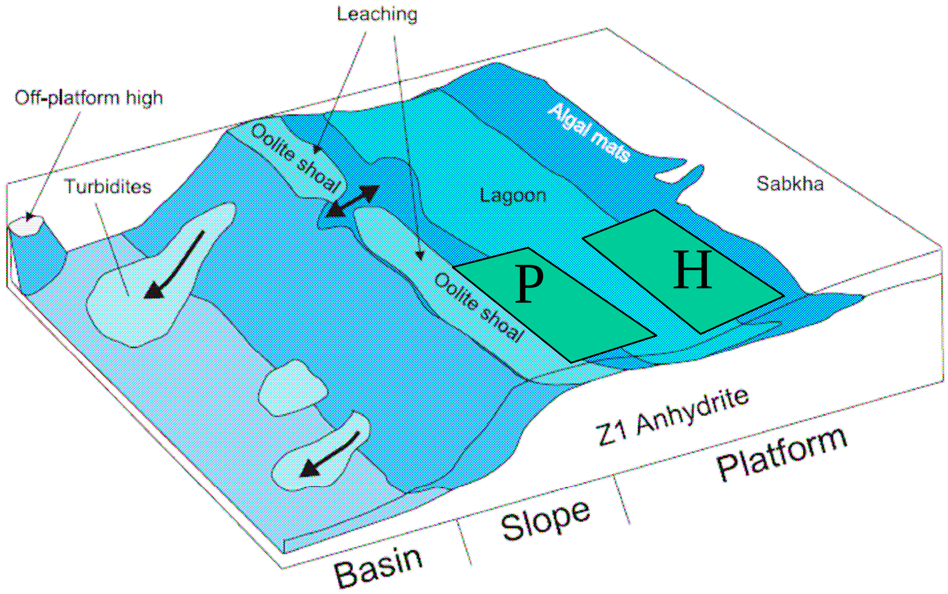


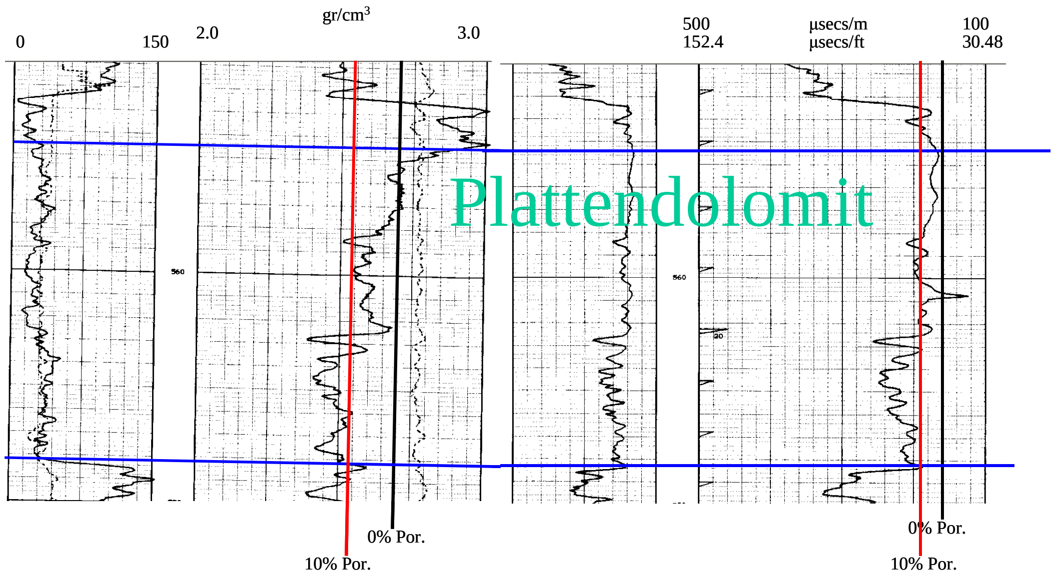
Figure 4.2.3 Depositional model for the Z2 Carbonate or Hauptdolomit (Geluk 2007). The approximate location of the study area in the model is marked with an H. The interaction with the hyper saline waters from the sabkha area and the basin caused wide spread dolomitisation in the lagoonal area, in particular close to the coast. A similar model can be used for the Plattendolomit (approximate location of the study area marked by P). The palaeogeographic reconstruction suggests that the Plattendolomit in the study area was located more towards the shelf edge.

The logs run in the HKS-1 well don't allow an estimate of the porosity and permeability. No sonic, neutron porosity or density logs have been run.

A more extensive set of logs was run in the HGV-1 well, just west of the Haaksbergen salt pillow. These logs allowed an estimate of the thickness and porosity of the Platten- and Hauptdolomite reservoir intervals (Figures 4.2.4 and 4.2.5).

A log correlation panel including the HGV-1, HKS-1 and HEN-1 well is included as Enclosure 3.

Hengevelde-1



Porosity cut-off's based on Limestone

0% = 2.71 gr/cm³, 10% = 2.54 gr/cm³

0% = 49 µsecs/ft, 160 µsecs/m 10% = 58 µsecs/ft, 190 µsecs/m

Figure 4.2.4 Log panel across the Plattendolomit in the well Hengevelde-1. The 0% and 10% porosity values are given based on the assumption that the Plattendolomit is mainly limestone ($CaCO_3$). The interval is overlain by anhydrite (high density values). Note that in particular the lower part of the interval shows porosities in excess of 10%. No correction for shaliness has been made, consequently the porosity values derived from the density log are slightly too high.

Hengevelde-1

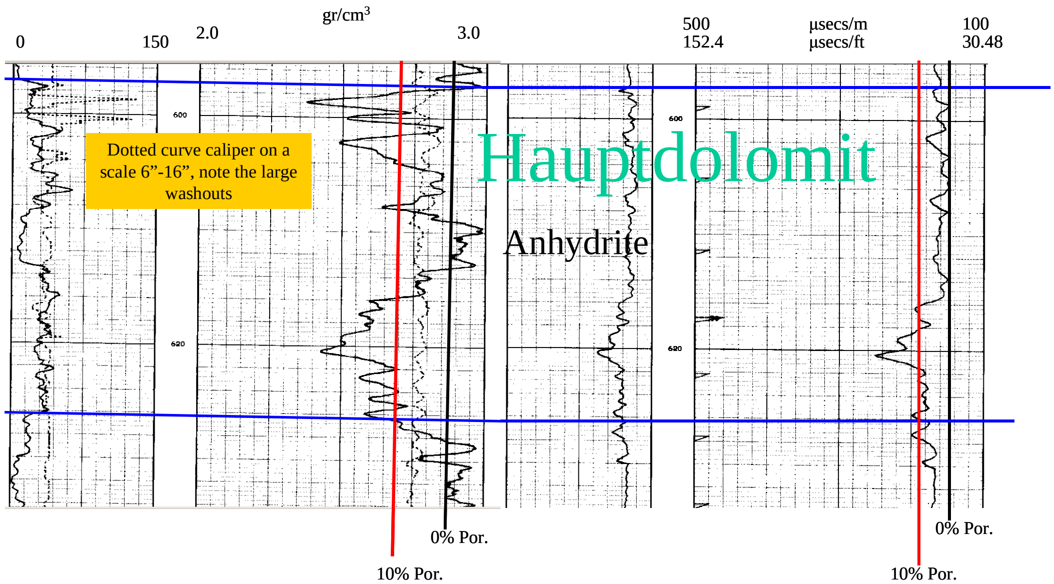


Figure 4.2.5 Log panel across the Hauptdolomit in the well Hengevelde-1. The 0% and 10% porosity values are given based on the assumption that the Hauptdolomit is mainly dolomite ($CaCO_3$ $MgCO_3$). The interval is overlain and underlain by anhydrite (high density values). Commonly an anhydrite layer occurs in the middle of the interval. Note that in particular the lower part of the interval shows porosities in excess of 10%. No correction for shaliness has been made, consequently the porosity values are slightly too high. The higher porosities in the upper part occur across badly washed out intervals and consequently are suspect. The washouts may, however, be indicative of fractured zones. The washouts may also be indicative of the presence of salt (dissolves in the mud), but the density doesn't support salt (too high).

A density, sonic and neutron log were run in the Hengelo-1 well. The density log (Figure 4.2.6) shows only poor quality reservoir, in line with the core observations (Figures 3.4.1 and 3.4.2).
The neutron has been acquired with the traditional count/sec (cps or API units) and has been recalculated to porosity units (Figure 4.2.7) using the following formula:

Log Φ = C – K * (API Neutron units) (ref. Log Review 1; Dresser Atlas 1974)

This formula is an approximation and valid only for lower porosity values (<40%).
The formula incorporates two unknowns. Typically a solution is obtained through the selection of a clay value (high GR and a porosity of approximately 30%) and a 1% porosity (low GR/pure salt or tight limestone).

Within the Bunter a high GR gamma section has been chosen for the 35% clay porosity:
Log 35% = C – K * 700
Within the salt section a 0% porosity has been selected:
Log .00001% = C – K * 1880

Solving these two equations for C and K results in:

K = 0.00555 and C = 5.4261.

Hengelo-1

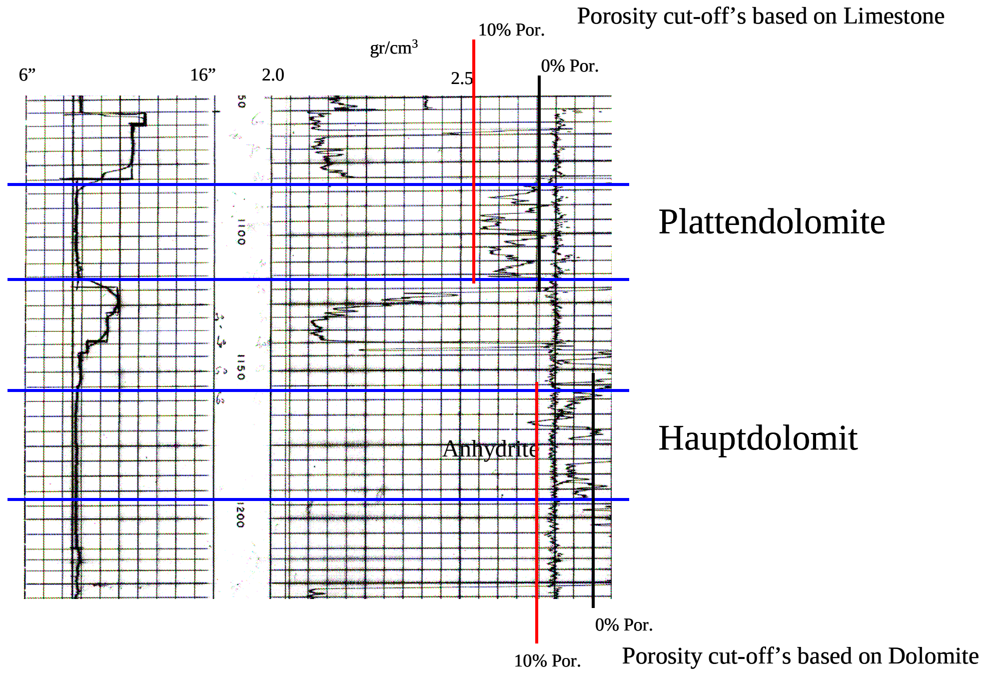


Figure 4.2.6 Caliper and density log over the Platten- and Hauptdolomite interval in Hengelo-1 well. The log derived porosities are very low, well below 10%, in line with the core description, which eludes to only thin shell-rich intervals with some porosity. Note that the right-hand value of the density plot is at 2.9 gr/cm^3.

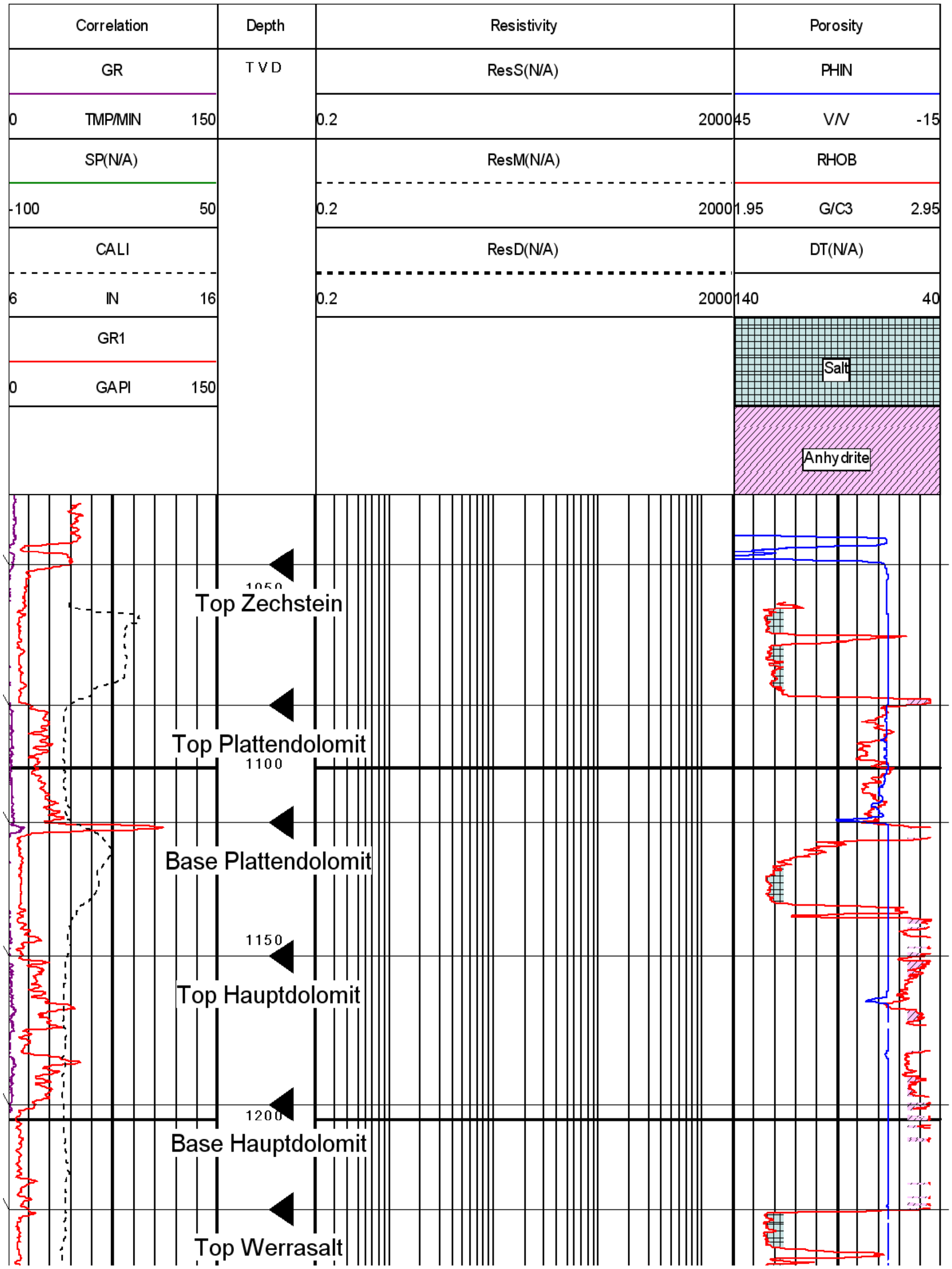


Figure 4.2.6 Log panel showing the digitised log data and the Neutron derived porosity for Hengelo-1. No resistivity logs have been run in this well. Note the, in general, low porosities across the Platten- and Hauptdolomit.

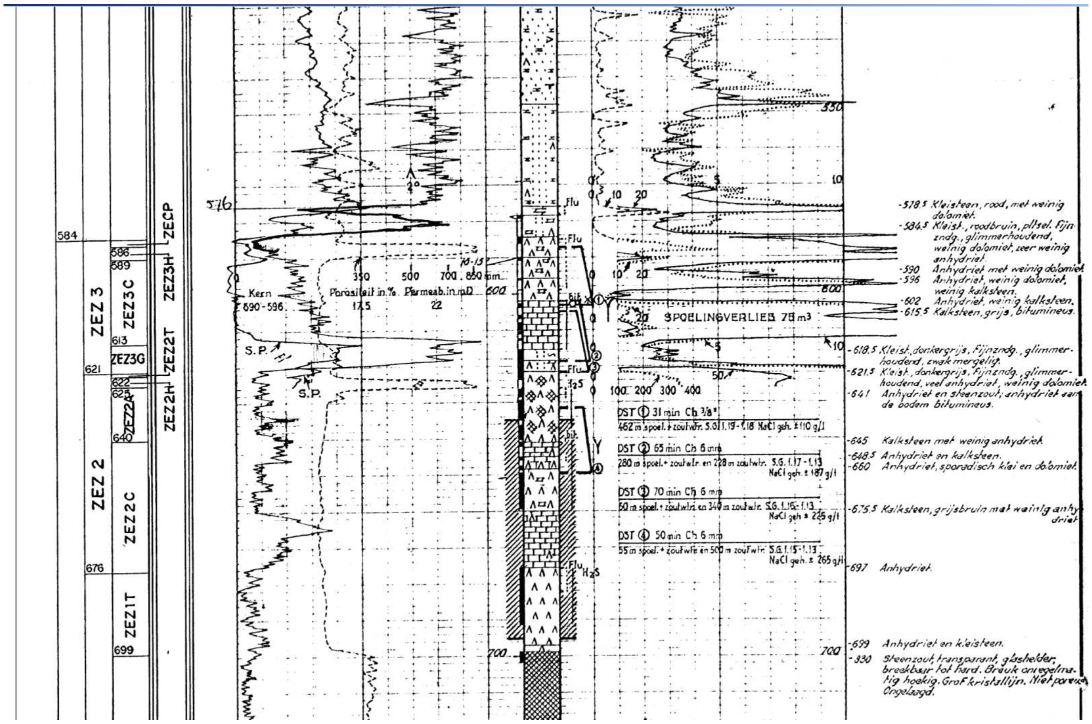


Figure 4.2.8 Summary log across the objective interval in the HKS-1 well. Note the very high resistivities across the carbonates of the Plattendolomit. The Plattendolomit has been extensively open-hole tested during drilling and the upper part of the Hauptdolomit once. It is interesting to note that the lower p[art of the Hauptdolomit, usually of reservoir quality (HGV-1), hasn't been tested.

The following table summarises the details of the Platten- and Hauptdolomite in the nearby wells.

Thickness Platten- and Hauptdolomit

Depth reference Rotary table
All depth and thickness in m.

HKS-1
Ref. Haaksbergen-1 cwl updated March 1978

		Depth	Thickness	Description	Remarks
Plattendolomit	Top	589	**23**	Grey, bituminous limestone, lower 10 m developed as carbonate	Losses 77 m^3 in carbonates
	Base	612			
Hauptdolomit	Top	640	**8**	Limestone, minor anhydrite	
	Base	648			
	Top	660	**16**	Greybrown limestone, minor anhydrite	
	Base	676			
			36		

HEN-1
Ref. Core description Zechstein section KNZ

		Depth	Thickness	Description
Plattendolomit	Top	1082.4	**33.3**	Brown, bituminous Limestone, lower 11 m porosities around 10%
	Base	1115.7		
Hauptdolomit	Top	1156.1	**17.2**	Grey-Brown dolomite, bituminous
	Base	1173.3		
	Top	1181.1	**14.8**	Grey-Brown dolomite, bituminous, some 11m with porosities of >10%
	Base	1195.9		
	Total		39.8	

HGV-1
Ref. Sonic and density logs and lithological summary

		Depth	Thickness	Description	Remarks
Plattendolomit	Top	549	**27.8**	Light grey dolomite	
	Base	576.8			Partial losses total 5.5 m^3, ref. daily drilling reports
Hauptdolomit	Top	597.6	**10.9**	Dolomite	
	Base	608.5			
	Top	615.2	**10.8**	Dolomite	
	Base	626			
			28.4		

BUS-1
Ref. Rapport Betreffende Boring Buurse-Sluis 1909

		Depth	Thickness	Description
Plattendolomit	Top	898.3	**19.5**	Grey/Brown dolomite, bituminous veins
	Base	917.8		

EPE S96
Ref. Bohrlochbild Epe S96 dated December 2008

		Depth	Thickness	Description
Plattendolomit	Top	982.8	**38**	Brown, bituminous Limestone
	Base	1020.8		
Hauptdolomit	Top	1052	**13**	Dolomite
	Base	1065		

Average thickness Plattendolomit	**28.3**
Average thickness Hauptdolomit	**29.3**
Average thickness Hauptdolomit without EPE S96	**34.7**

Summary of observations:

- Only the lower part of the Plattendolomit (about 10 m) is developed as a porous carbonate. In the HGV-1 well porosities of about 10% occur over a large part of the carbonate interval. The reservoir properties in the HEN-1 well are considerably poorer. Losses have been observed in the HKS-1 well, pointing to either fractures or a vuggy development of the reservoir. Losses have been observed in the HGV-1 well but it is unclear in which of the two intervals this occurred. Note that the low resistivities across the lower part of the Platten- and Hauptdolomit in HGV-1 (Enclosure 3), point to a saline water pore fill.

- The Hauptdolomit, true to its name, is indeed developed in most of the wells as a dolomite. An interesting exception is the HKS-1 well, where carbonates are reported. Only a GR and Caliper have been run over the interval in HKS-1, consequently it is impossible to derive the lithology from the logs. Porosities are only observed in the lower part of the interval, i.e. below the intervening anhydrite.
- Thickness is fairly constant over the area. The total Hauptdolomit in the EPE S96 well is considerably thinner because the intervening anhydrite is missing.

4.3 Seal

The sealing of the Platten- and Hauptdolomit carbonate intervals are ensured by respectively the Z2 and Z3 anhydrites and locally salts. The lower part of the overlying Bunter section is also shaly (Main Claystone). Anhydrites can be sealing (ref. Arab D Anhydrite, Ghawar field Saudi Arabia) as well as long as they are not too tectonically disturbed. The fact that hydrocarbon shows occur in the anhydrites suggests that at least locally the seal isn’t perfect. This is also observed in fields in the Middle East.

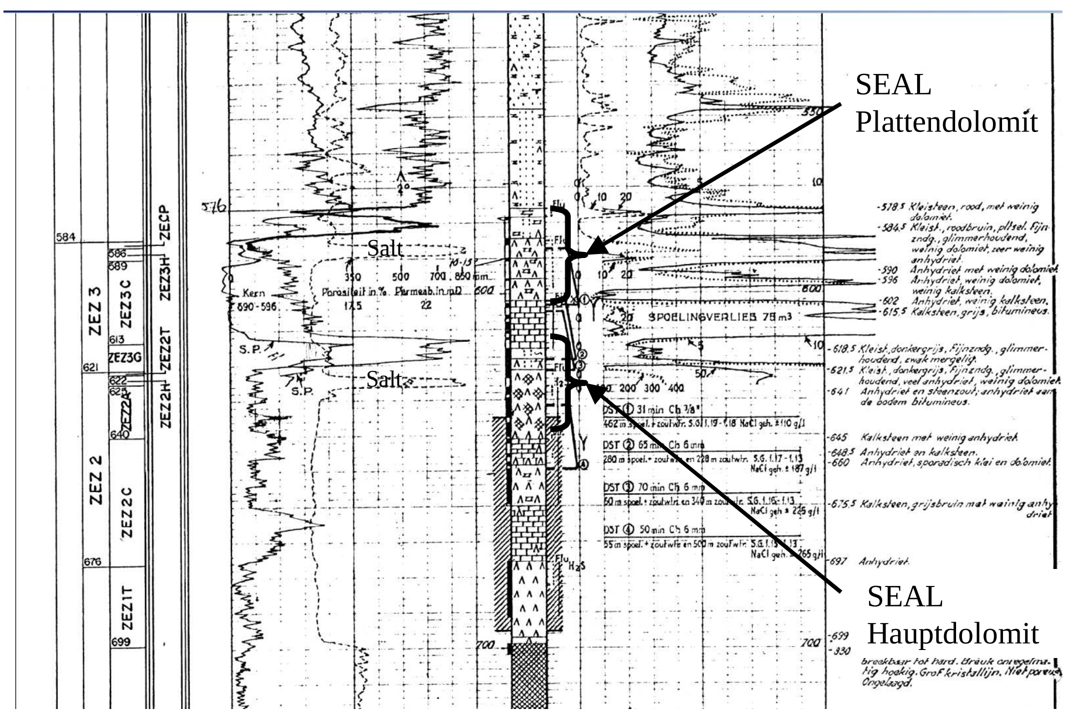


Figure 4.3.1 Summary log of the HKS-1 well with the sealing intervals to the Platten- and Hauptdolomit highlighted. The seal to the Plattendolomit is some 26 m (from 576 m to 602m) . Note the presence of fluorescence in the anhydritic section above the Plattendolomit (ZEZ3C) and Hauptdolomit (ZEZ2A, H and T). The seal to the Hauptdolomit is described as an alternation of anhydrite and rock salt. Included in the seal to the Hauptdolomit are the shales underneath the Plattendolomit (high GR, ZEZ3G). A total thickness of 28 m is observed (612m to 640m). The salt intervals are easily recognised by the large washouts.

The following table summarises the thickness of the seal to the Platten- and Hauptdolomit.

Thickness Seal to Platten- and Hauptdolomit

Depth reference Rotary table
All depth and thickness in m.

HKS-1

Ref. Haaksbergen-1 cwl updated March 1978

			Thickness	
Seal Plattendolomit carbonate	Top	576	**26**	Anhydrites, salts and clays fluorescense
	Base	602		
Seal Hauptdolomit	Top	612	**8**	Clay
	Base	620		
	Top	620	**20**	Clay, Anhydrites and dolomite
	Base	640		
			28	

HEN-1

Ref. Core description Zechstein section KNZ

			Thickness	
Seal Plattendolomit carbonate	Top	1000	**82.4**	Anhydritic clay, Anhydrites, salt
	Base	1082.4		
Seal Hauptdolomit	Top	1115.7	**0.3**	Clay
	Base	1116		
	Top	1116	**40.1**	Salt with anhydrite intervals
	Base	1156.1		
			40.4	

HGV-1

Ref. Sonic and density logs and lithological summary

			Thickness	
Seal Plattendolomit carbonate	Top	492	**57**	Clay, salt and anhydrite
	Base	549		
Seal Hauptdolomit	Top	576.8	**3.6**	Red Clay
	Base	580.4		
	Top	580.4	**47.2**	Anhydrite, salt
	Base	627.6		
			50.8	

BUS-1

Ref. Rapport Betreffende Boring Buurse-Sluis 1909

			Thickness	
Seal Plattendolomit carbonate	Top	861.8	**36.5**	Clay, Brecciated anhydrite, shale and some saltveins
	Base	898.3		

EPE S96

Ref. Bohrlochbild Epe S96 dated December 2008

			Thickness	
Seal Plattendolomit carbonate	Top	922	**60.8**	Anhydrite, salt and shale
	Base	982.8		
Seal Hauptdolomit	Top	1020.8	**0.7**	Claystone
	Base	1021.5		
	Top	1021.5	**30.5**	Anhydrite
	Base	1052		
			31.2	

Average thickness seal Plattendolomit	**52.5**
Average thickness seal Hauptdolomit	**37.6**
Average thickness seal Hauptdolomit without EPE S96	**45.6**

4.4 Source rocks, maturity and charge

The Platten- and Hauptdolomit are reported to be bituminous (Ref. HKS-1 and HEN-1) . This is a common feature with carbonates, which are usually a self-sourcing system, source rocks (derived from soft body parts of the carbonate builders) and reservoir occur in the same interval. Most of the fields further north are rich in H_2S, caused by the interaction of hydrocarbons and anhydrite, which occurs above, within and below the reservoir intervals. An H_2S smell is reported in the HKS-1 well.
Detailed maturity studies have been carried out on the coals and carbonaceous shales of the Carboniferous (Geotrack 1998, BP Research Division 1986). Some shallower samples were analysed as well.

For the HGV-1 well BP Research Division (1986) concludes:

2.3 Conclusions

- The Kupferschiefer sample (850.1m) is immature and has excellent source potential for oil. The sediment accumulated in a restricted marine environment with some terrestrial organic input.

- The Carboniferous sediments have generally moderate to good (occasionally excellent) source potential, predominantly for gas. Maturities were mainly within the early part of the oil generation zone (ca. 0.55 - 0.65% R_o equivalent) prior to uplift and samples have yet to realise their potentials. The kerogens are characteristic of non-marine/freshwater environments and are mainly terrestrially-derived. The presence of gammacerane in several of the extracts may indicate evaporitic conditions.

The Apatite Fission Track Analysis (AFTA) results for the HEN-1 (called HEZ-1, Hengelo Zout–1, in this report,)and HKS-1 wells are summarised below. A green bar highlights the Carboniferous samples and an orange bar marks the one post Zechstein sample in HEZ-1.

Table i: Paleotemperature analysis summary from AFTA, ZFTA and VR samples from four wells from The Netherlands (Geotrack Report #687)

Sample number GC-	Mean depth (mKB)	Strati-graphic age (Ma)	Present temp.*1 (°C)	Thermal history solution: First Episode: Maximum paleotemperature (°C)	First Episode: Onset of cooling (Ma)	Second Episode: Maximum paleotemperature (°C)	Second Episode: Onset of cooling (Ma)	Third Episode: Maximum paleotemperature (°C)	Third Episode: Onset of cooling (Ma)	*Measured VR value (Ro%)*	*Equivalent-VR value*2 derived from AFTA (Ro%)*
HEZ-1											
687-1	630	247-243	32			(80-110	247 to 80)	70-90	80 to 0		*(0.50-0.66%)*
687-2	1498	306-305	62			>110	306 to 150	<110	150 to 0		*>0.66%*
687-3	1513	306-305	62			100-120	306 to 50	<105	150 to 0		*0.61-0.73%*
687-3V	1513	306-305	62	154						*0.98?*	
HKS-1											
687-10	891	306-305	41			100-120	140 to 90	70-90	100 to 50		*0.61-0.73%*
	917	306-305	42			120				*0.73*	
	943	306-305	42			121				*0.74*	
687-11	1007	306-305	45			100-120	110 to 75	50-90	80 to 0		*0.61-0.73%*
687-11V	1007	306-305	45			120				*0.73*	

Summary of observations:

- In none of the studied wells, HGV-1, HEN-1 and HKS-1, the maturities within the Zechstein are sufficient to have generated liquid hydrocarbons.
    - The underlying Carboniferous is just about mature for the generation of liquid hydrocarbons, but not sufficient to have caused active migration of hydrocarbons.
- The AFTA study points to two cooling events (uplifts), one at about 140 to 75 MMyears (Lower Cretaceous) and a second period roughly between 100 and 50 MMyears (Late Cretaceous to Early Tertiary). Of note is, however, that these values are derived from the Carboniferous and consequently relate to an uplift of the basement. The one post Zechstein sample shows a similar temperature history.

The Intra Zechstein source rocks are not mature of hydrocarbon generation in the study area. In general, maturities should be at least some 0.8% Vr in order for the hydrocarbons to start moving. Some cracking of the formation (due to the increase in volume from kerogen to hydrocarbons) is required. This cracking then causes the migration paths out of the source rock into the carrier beds and finally into the trap.

The catchment area of the Haaksbergen structure is some 54 km^2 (Figure 4.4.1).

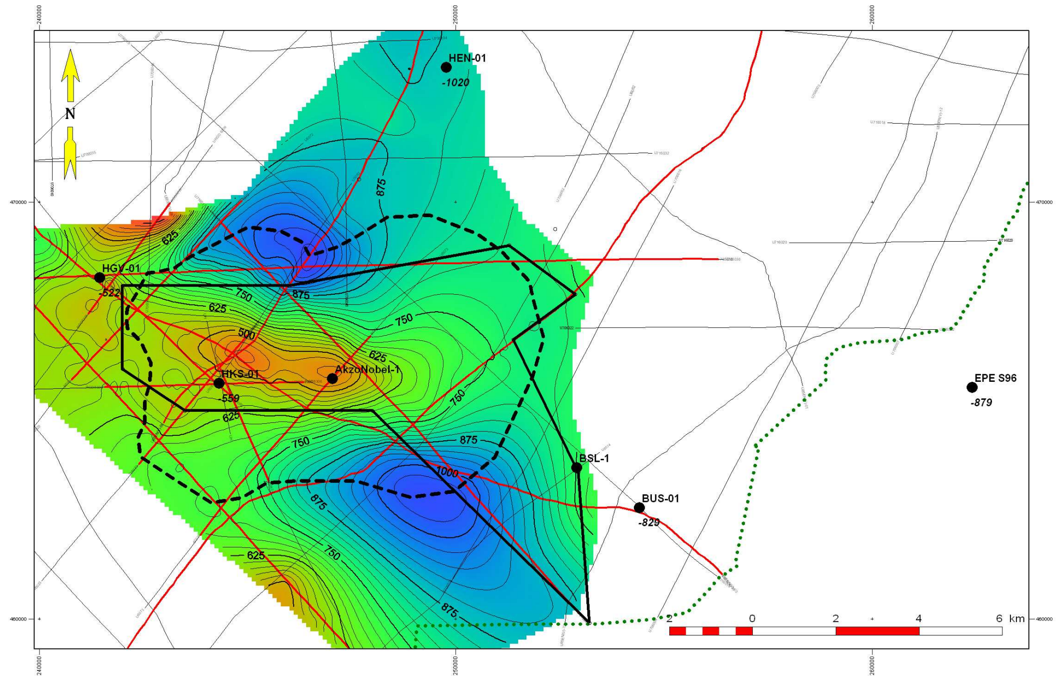


Figure Depth map top Zechstein with drainage area. Within the drainage area the source rock of the Platten- and Hauptdolomit is not mature. Consequently no estimate of expelled hydrocarbons has been derived.

4.5 Reservoir modelling

The following reservoir model has been used for the calculation of resources in case of charge:

Model used for resource calculations

Reservoir model

	Thickness	Porosity	N/G	Sw	Bo	
Interval Top Zechstein to Plattendolomite	5					Layer 1
Plattendolomit anhydritic upper part	13					
Plattendolomit carbonate	10	10%	80%	80%	1.01	Layer 2
Evaporite Interval	28					Layer 3
Hauptdolomit	8					
Hauptdolomite Anhydrite interval	12					
Hauptdolomit	16	10%	50%	80%	1.01	Layer 4

Bo derived assuming heavy oil 15 degrees API (.966 gr/cm^3), depth 500 m, temperature 25.5 degrees C
Density at reservoir conditions .961 gr/cm^3

Gas expansion factor 60, based on 60 bar, 25.5 degrees C, 79% methane, 5% ethane, 1% propane, 5% H2S and 10% nitrogen
Density at reservoir conditions .053 gr/cm^3

Area Depth Graph

All depth msubsea

Top Zechstein		Layer 2		Layer 4	
Contour	Area	Contour	Area	Contour	Area
410	top	428	top	486	top
450	0.62	468	0.62	526	0.62
500	3.16	518	3.16	576	3.16
550	6.22	568	6.22	626	6.22
560	7.03	578	7.03	636	7.03
		577.5	WUT	635.5	WUT

WUT Water Up To

Recovery factor

20% Oil
60% Gas

5 RISK ASSESSMENT

The Probability of Success in finding hydrocarbons or the risk of encountering hydrocarbons is derived through the following formula:

Probability of Success = (Chance of finding reservoir) x (chance of having a trap (structure and seal)) x (chance of having an active hydrocarbon system)

Two Petroleum Systems are considered:
The Zechstein Petroleum System, i.e. Zechstein source rock and the Carboniferous Petroleum System, i.e. the Westphalian and Namurian Coal measures and carbonaceous shales (Figure 5.1).

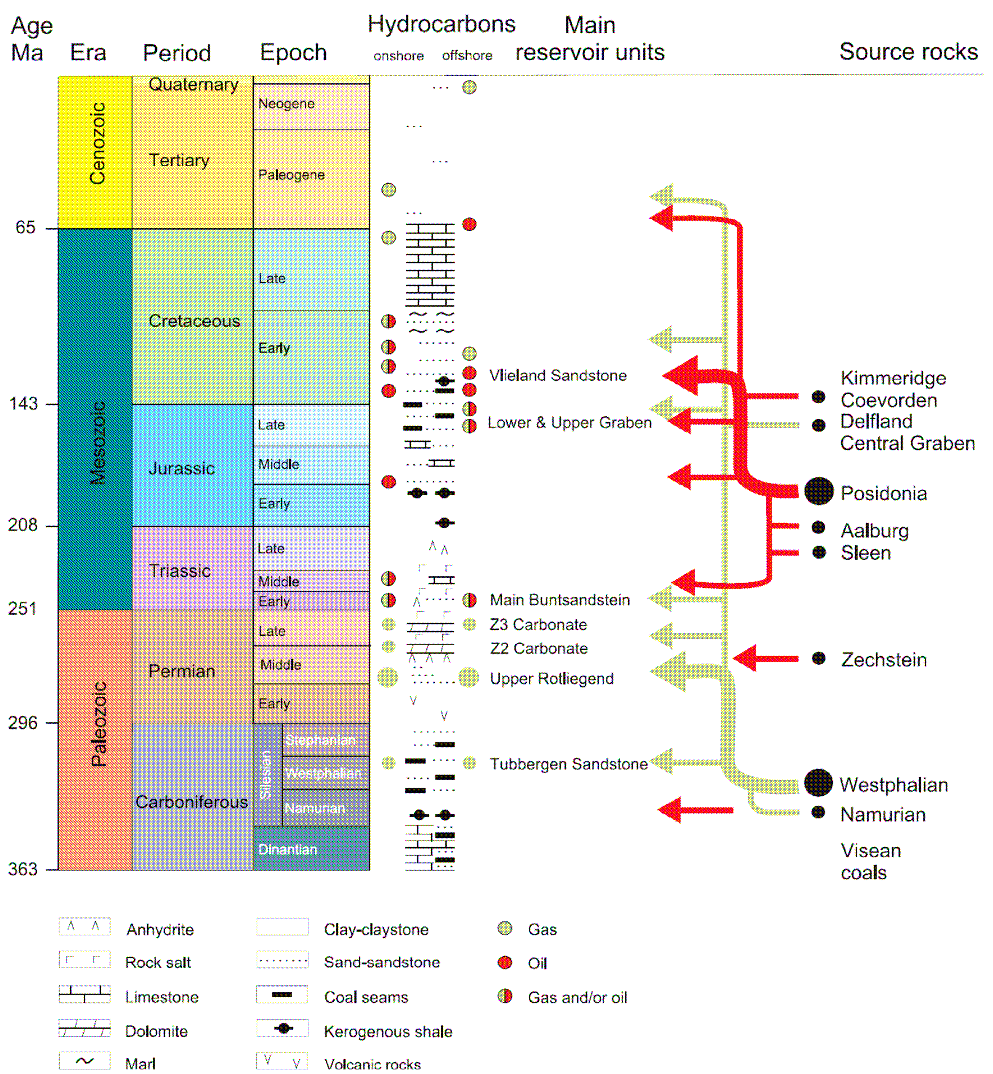


Figure 5.1 Overview of the Petroleum Systems of the Netherlands. The Zechstein and Westphalian/Namurian (Carboniferous) Petroleum Systems are of relevance to the study area.

5.1 Zechstein Petroleum System

- Chance of finding reservoir is relatively large. In many wells matrix porosities unto 10% have been calculated. In addition the occurrence of losses in particular the HKS-1 and HGV-1 well points to the presence of fractures and or large interconnected vugs. These are too large for a proper mudcake to form.
  - The chance of reservoir is close to 1 and is estimated at 90%
- Chance of having a trap. This chance depends on two factors, structure and seal.
  - The structure itself is well defined. It is basically a drape over a salt pillow.
  - The seal for the Plattendolomit, the shallowest of the two reservoir prone intervals, is mostly anhydrite and some salt. This in turn is overlain by the Bunter clastics, in this area mainly composed of carbonate-cemented sands. In the very lower part some shales occur. The total sealing interval varies between 26 m and 60 m for the Plattendolomit and between 28 m and 50 m for the Hauptdolomit . Two factors have adversely affected the seal:
    - The salt pillowing has caused an extensional stress regime within the reservoir and seal section in particular towards the culmination of the salt pillow. Extensive fracturing is therefore expected, compromising the sealing capacity.
    - The salt pillowing caused an uplift of at least 500 ms = 666 m (Figure 5.1.1). Uplift usually results in weaker seals.
    - Some faulting may be observed over the culmination of the structure. Seismic quality is poor, but some offsets can be noted. Given this nature of the seal this may juxtapose the shallowest reservoir against Bunter sands.
  - The chance of having a good seal estimated at 25%

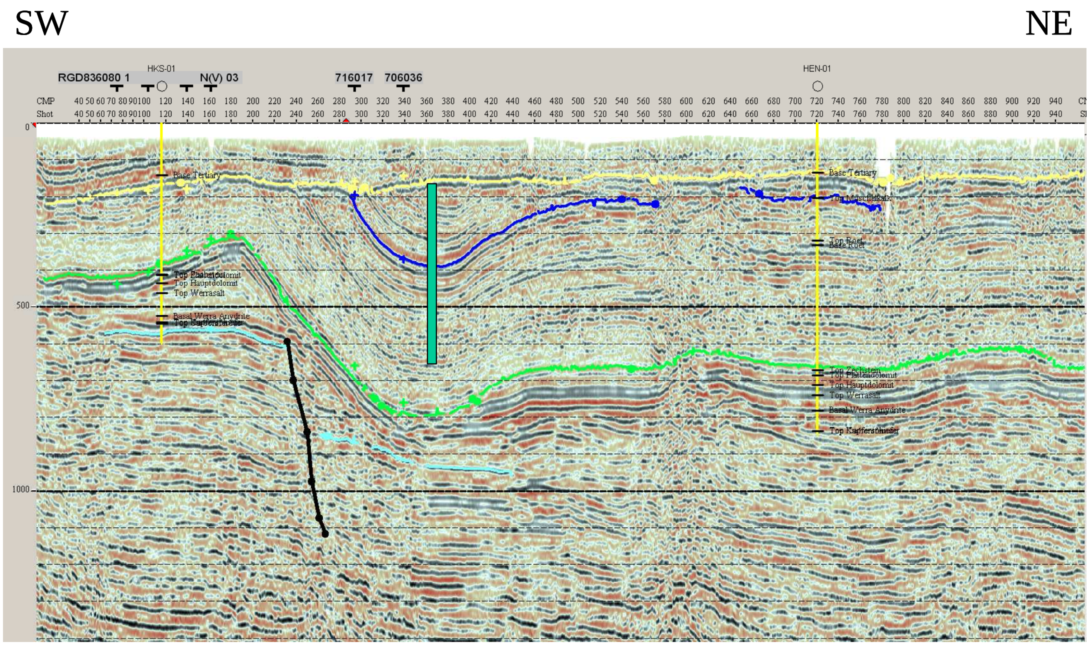


Figure 5.1.1 Regional seismic section through HKS-1 and HEN-1 (both wells are projected onto the line). The green bar shows the minimum amount of removed overburden (uplift) at the culmination of the Haaksbergen salt pillow.

- Chance of having an active Zechstein hydrocarbon system. This chance depends on a number of factors:
    - Chance of having source rock within the drainage area. This chance is considered high. Bituminous carbonates have been observed in all wells.
    - Chance of this source being mature within the drainage area. This chance is close to zero, the source rock doesn't reach maturity within the drainage area.
    - Timing of structuration with respect to hydrocarbon generation. The AFTA study pointed to a regional uplift during the Cretaceous. The salt pillowing can be dated as between the latest Triassic and Early Tertiary, a time window encompassing the Jurassic and the Cretaceous. But again the measured maturities are well below the onset of hydrocarbon generation and the uplift brought the source rock in an even lower maturity range. The modest Tertiary to recent burial is much less than the calculated uplift.
    - Chance of the generated hydrocarbons having migrated into the trap. As the source rock isn't mature this chance is also close to zero.
  - The chance of having an active hydrocarbon system related to Zechstein source rocks is considered close to zero, i.e. 5%.

The overall chance of having liquid hydrocarbons in the Haaksbergen structure is:

Probability of Success = (Chance of finding reservoir=90%) x (chance of having a trap (structure and seal)= 25%) x (chance of having an active hydrocarbon system = 5%) = 3.25%

5.2 Carboniferous Petroleum System

Reservoir and Trap chance are the same as for the Zechstein petroleum System. The chance of having a seal might be lower as gas as gas is lighter than oil and requires the seal to hold larger pressure differences

- Chance of having an active Carboniferous hydrocarbon system. This chance depends on a number of factors:
    - Chance of having source rock within the drainage area. This chance is considered high. Coals and carbonaceous shales have been observed in all wells.
    - Chance of this source being mature for gas within the drainage area. This chance is low, the source rock doesn't reach maturity for gas within the drainage area. Further to the northeast gas is produced from the De Lutte group of gas fields. This is derived from the Lower Saxony basin (see Figure 1.1).
    - Timing of structuration with respect to hydrocarbon generation. The AFTA study pointed to a regional uplift during the Cretaceous. But again the measured maturities are well below the onset of gas generation and the uplift brought the source rock in an even lower maturity range. The modest Tertiary to recent burial is much less than the calculated uplift.
    - Chance of the generated hydrocarbons having migrated into the trap is low as thick salt layers occur between the Zechstein reservoirs and the source rocks.
    - The presence of gas usually gives rise to seismic amplitude anomalies, e.g. the Gas Water interface a horizontal event. No such event is observed. The thin nature, the in general low porosities and the poor quality of the seismic may preclude such an observation.
  - The chance of having an active hydrocarbon system related to Carboniferous source rocks is considered close to zero, i.e. <5%.

6 VOLUMES IN PLACE/RECOVERABLE VOLUME CALCULATIONS

Resources have been calculated deterministically and probabilistically.
The reservoir model is summarised in paragraph and the input details and results can be found in Appendix 2.
The HKS-1 well is clearly water bearing and a possible hydrocarbon column has been risked between the culmination and the Water up To's defined by the HKS-1 well.
The maturity is at best very low and the reservoir temperature is some 25°C and only heavy biodegraded oil is expected (15° API).
The recovery factor is set at 20% for oil, in line with the assumption of heavy oil, but fractures may have enhanced the permeability. In addition reservoir temperature is rather low adversely affecting the viscosity. A recovery of 60% has been assumed for the gas case (shallow low pressure gas).

The probabilistic values have been derived by varying the various input parameters by +/- 30%.

Resource summary

	Deterministic unrisked		Probabilistic recoverable					
	OIIP	Recoverable	P90	P50	P10	MSV	POS	Expectation
Oil								
in MMbbls								
Plattendolomit	7.7	1.54	0.074	1.32	4.48	1.83	3.25%	0.059
Hauptdolomit	5.72	1.14	0.037	0.972	3.47	1.39	3.25%	0.045
Total unrisked	**13.42**	**2.68**		Total unrisked		**3.22**		
						Total risked		**0.105**
Oil								
in MMm^3								
Plattendolomit	1.22	0.245	0.011	0.209	0.712	0.29	3.25%	0.009
Hauptdolomit	0.9	0.18	0.006	0.154	0.552	0.221	3.25%	0.007
Total unrisked	**2.12**	**0.425**		Total unrisked		**0.511**		
						Total risked		**0.017**
Gas								
in Bcf								
Plattendolomit	2.64	1.58	0.0758	1.33	4.45	1.83	3.25%	0.059
Hauptdolomit	1.94	1.17	0.0382	0.98	3.47	1.4	3.25%	0.046
Total unrisked	**4.58**	**2.75**		Total unrisked		**3.23**		
						Total risked		**0.105**
Gas								
in MMm^3								
Plattendolomit	0.0747	0.0448	0.00219	0.0376	0.126	0.0519	3.25%	0.002
Hauptdolomit	0.0551	0.033	0.00108	0.0277	0.0984	0.0396	3.25%	0.001
Total unrisked	**0.1298**	**0.0778**		Total unrisked		**0.0915**		
						Total risked		**0.003**

P90 means a probability of 90 % of finding larger volumes
P50 means a probability of 50 % of finding larger volumes

P10 means a probability of 10 % of finding larger volumes

POS = Probability of Success
MSV= Mean Success Volume (Average of the 10,000 Monte Carlo runs)
Expectation= product of POS and MSV.

Note that the probabilistic volumes cannot be arithmetically added. Only the MSV's and the Expectation can be added arithmetically.

7 EXPECTED PRESSURES

No Closed-in Bottom hole pressures have been acquired. In HKS-1 a number of Drill Stem tests have been carried out when drilling through the Plattendolomit and the upper part of the Hauptdolomit. Flowing Top hole pressures are reported to be around several cm water, basically very close to zero. The detail is shown on the table below:

HKS-1

		Interval		water	salinity gr Nacl/ltr	Density gr/cm^3	Mudfiltrate	Density gr/cm^3	gas	olie	Pressure in bar		
		Top	Bottom								BHP	MaxFTHP	Choke
DST-1	Plattendolomit	587.2	603	yes	112		yes	1.18	no	no		0.003924	1/2"
DST-2	Plattendolomit	602	618.5	yes	187	1.17	yes	1.17	no	no		0.015304	1/4"
DST-3	Plattendolomit	605	621.5	yes	225	1.16	yes	1.16	no	no		0.011183	1/4"
DST-4	Hauptdolomit	631.5	649.5	yes	265	1.15	yes	1.15	no	no		0.005788	1/2"

Another source of the formation pressures is the mud data. The mud parameters could be read from the log headers. Losses have been observed in the HKS-1 and the HGV- well. In fact the mud gradient sets a maximum to the formation pressures. The losses indicate that the formation pressure is less than the mud weight used. The details of the mud are shown on the table below:

HKS-1

Mud Properties Interval						
Top	Bottom	Density gr/cm^3	Source	Casing	Casing shoe	
51.5	309.5	1.21	log header Electricite 1	133/8	41.5	
310	624.5	1.18	log header Electricite 2	95/8	306.75	
41	1001	1.25	Log Header GR 1 and Caliper 1	95/8	306.75	Losses 77 m^3 in carbonates

HEN-1

Mud Properties Interval						
Top	Bottom	Density gr/cm^3	Source	Casing	Casing shoe	
1025	1521.3	1.4	Log Header GR Neutron	95/8	1054.5	Salt saturated mud Partial losses total 5.5 m^3, ref. daily drilling reports

HGV-1

Mud Properties Interval						
Top	Bottom	Density gr/cm^3	Source	Casing	Casing shoe	
491	819	1.25	Log Header GR Density caliper	75/8	491.5	Salt saturated mud

The mud weights in the HKS-1 and the HGV-1 well are both around 1.25 gr/cm^3, in both cases losses have been observed. Consequently it is assumed that the formation pressure gradient doesn't exceed 1.25 gr/cm^3. As the reservoir intervals are most likely fractured, resulting in an interconnected system of fractures this pressure regime is assumed for the entire Haaksbergen structure.

A worst-case pressure scenario can be developed (Figure 7.1), assuming that gas and or oil occur just above the shallowest water-bearing interval in the HKS-1 well (602 mbKB, note this is different from the WUT used in the resource calculations, which has been referenced to sea level).

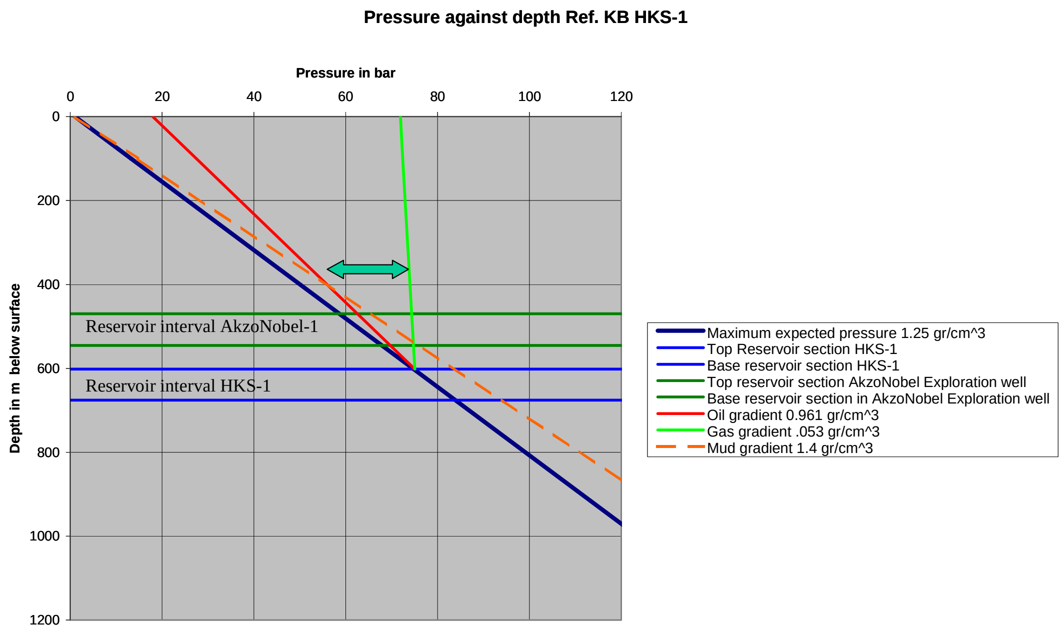


Figure 7.1 Pressure plot Haaksbergen structure with HKS-1 and expected AkzoNobel-1 reservoir interval highlighted. All pressures are absolute, i.e. surface pressure is 1 bar and gauges are all set at a minimum pressure of 1 bar. The gas (green) and oil (red) gradients are taken from the shallowest WUT in HKS-1. The green arrow highlight the possible formation pressure range in the to be drilled AkzoNobel well, i.e. between 58 and 67 bar. Note that this pressure range is referenced to the maximum possible pressure gradient shown in blue, which is based on a mud density of 1.25 gr/cm^3.

8 CONCLUSIONS

The chance of finding hydrocarbons in the Haaksbergen structure is considered small (<5%).

This is based on two observations:

- The sealing of the reservoir intervals is compromised
  - The anhydritic seal is fractured due to the extensional regime on top of the salt dome
  - Small faulting is observed on the seismic data, albeit of poor quality.
  - Shows are observed in the anhydrites of HKS1 suggesting seal failure (leakage into the seal).
  - Considerable uplift
- Charge is unlikely
  - Source rock is not mature within the catchment area of the structure
  - Across the reservoir intervals in the adjacent well only minor gas shows are observed.
  - Reservoir is shielded from charge from the underlying Carboniferous Coal Measures by the regionally well-developed Werra salt.
  - In addition the Carboniferous is barely mature for oil, and not mature for gas.
  - No seismic anomalies indicative of the presence of hydrocarbons (gas).

Pressures are expected to be around a gradient of maximum 1.25 gr/cm^3

Unrisked deterministic Oil Initially in Place volumes are estimated at some 13.48 MMbbls (2.12 MMm^3).
Unrisked deterministic Gas Initially in Place volumes are estimated at some 5.58 Bcf (0.1298 MMm^3)

9 RECOMMENDATIONS

Digitise logs from HKS-1, HGV-1 and HEN-1 (estimated cost Euro 600-1000).
Digitising of the neutron log of HEN-1 allows calculation of the neutron porosity values from the count/sec values.
Acquire the electrical logs of the EPE S96 well. On the well the summary sheet it is mentioned that logs have been run.

10 REFERENCES

Study of the salt mining possibilities in the Haaksbergen area, The Netherlands by MWH B.V., December 2008

Seismic Interpretation of salt deposits in the subsurface of the region Haaksbergen in the Netherlands by T&A survey B.V. September 2008, authors R. Giesen and V. Talsma

Permian by M. Geluk in Geology of the Netherlands edited by Th. E. Wong, D.A.J. Batjes and J. de Jager, Royal Netherlands Academy of Arts and Sciences, 2007.

Thermal History Reconstruction for four Wells from the Netherlands –HEZ-1, WSK-1, HKS-1 and DRN-1 using Zircon & Apatite Fission Track Analysis and Vitrinite Reflectance, Geotrack report #687, 1998

Geochemical data for the wells Hengevelde-1, Joppe-1 and Buurlo-1, Onshore Netherlands, BP Research Centre, Exploration and Production division, 1986

Geological Atlas of the Subsurface of the Netherlands, Explanation to map sheet X Almelo-Winterswijk, Netherlands Institute of Applied Geoscience TNO, 1998