Geological evaluation for the seismic acquisition programme for SCAN areas A (Noord-Gelderland and Zuidoost Flevoland) and B (Achterhoek and Zuid-Twente)

Report by SCAN

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Partners:

Ministerie van Economische Zaken en Klimaat

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

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Inleiding en duiding

Voor u ligt één van de geologische evaluaties van het SCAN programma, zoals deze in maart 2019 is vastgelegd. Deze inleiding en duiding is later toegevoegd om de actualiteit te kunnen toevoegen en duiding te geven aan het rapport.

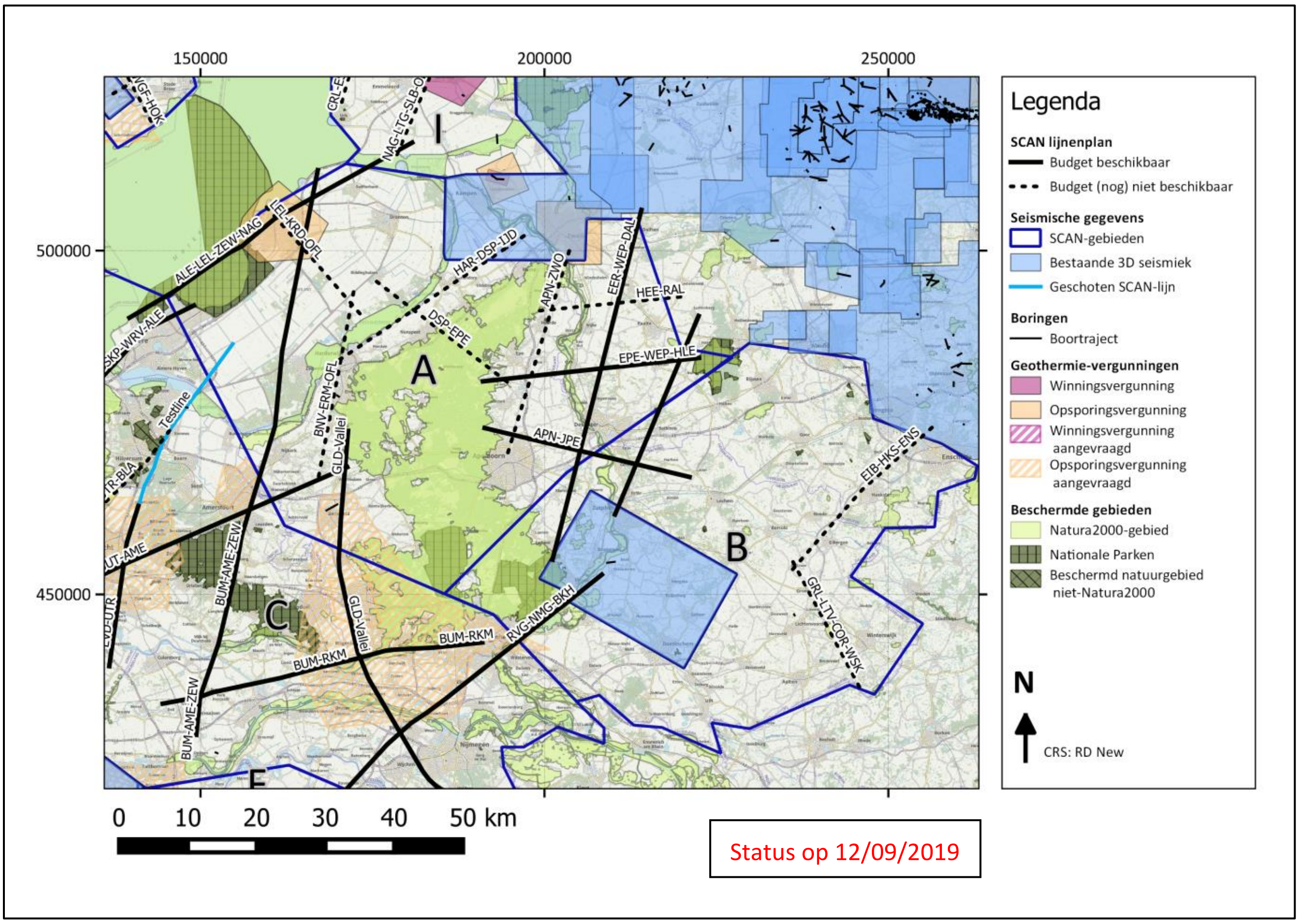
Om het acquisitieplan voor de SCAN 2D seismische lijnen te kunnen bepalen zijn door geologen en geofysici ondergrondevaluaties gemaakt van de verschillende SCAN-gebieden. Hierbij is gelet op welke delen van de ondergrond de beste kansen bieden voor geothermische projecten en welke informatie nog ontbreekt voor een goede evaluatie. Per (mogelijk) geothermische play is aangegeven welke gegevens en werkprogramma's nodig zijn om vast te stellen of de betreffende play al dan niet een interessant doel kan zijn voor geothermische boringen. Bij het opstellen van deze plannen en voorgestelde werkprogramma's is in eerste instantie vooral gekeken naar de technische bruikbaarheid en noodzakelijkheid, en minder naar een kosten-baten analyse van deze plannen. Voor elk SCAN-gebied (of combinatie van SCAN-gebieden) is op deze wijze een 2D seismisch lijnenplan gemaakt dat het beste de lacunes in de huidige 2D seismisch dataset, zowel in kwaliteit als kwantiteit, zou kunnen opvullen. Het rapport hierover en het voorgestelde acquisitieplan is vervolgens voorgelegd aan geologen en geofysici van EBN en TNO, die niet direct bij de evaluatie van het SCAN-gebied betrokken waren geweest. Op basis van de opmerkingen en aanvullingen van deze peer-reviewers zijn de plannen en rapporten waar nodig aangepast en afgerond. Het onderliggend rapport voor gebied A&B is het resultaat zoals dat op 20-03-2019 was afgerond. Om de informatie voor zoveel mogelijk geïnteresseerden toegankelijk te maken zijn de rapporten in het Engels geschreven, wat de meest gangbare taal is voor het geologische/geofysische vakgebied.

Nu alle rapporten en plannen afgerond zijn kan het totaal van de aanbevelingen hierin als "Best Technical Programme" worden gezien. Het Best Technical Programme is het acquisitieplan dat het meeste kans heeft om alle openstaande geologische vragen te beantwoorden. Echter, voor de 2D seismische acquisitie van het SCAN-project is er een beperkt budget beschikbaar bij het Ministerie van Economische Zaken en Klimaat. Op basis van de (veronderstelde) kosten van de seismische acquisitie is de verwachting dat voor het beschikbare budget niet het gehele "Best Technical Programme" kan worden uitgevoerd.

Om te bepalen welke seismische lijnen prioriteit hebben is een ranking van alle lijnen verricht. Deze ranking is onder andere gebaseerd op de volgende parameters: aantal mogelijk aanwezige primaire en secundaire plays, de dichtheid en kwaliteit van de seismische data in het gebied, de aanwezigheid van warmtevragers en de inpassing van lokale seismische initiatieven. Op basis van deze ranking wordt bepaald welke seismische lijnen met het beschikbare budget kunnen worden geacquireerd, terwijl de andere lijnen alleen zullen worden geacquireerd bij meevallende kosten of als aanvullend budget beschikbaar komt.

Na de acquisitie in het voorjaar van 2019 van een testlijn tussen Utrecht en Almere (deel van lijn EVD-UTR-BLA) om de acquisitieparameters in detail te bepalen, is besloten het programma verder te vervolgen in het oostelijk deel van SCAN gebied C. Op basis van de daar uitgevoerde terreinonderzoeken zijn enkele voorgestelde lijnen deels aangepast. Ook in sommige andere gebieden zijn er enkele kleinere aanpassingen gemaakt ten opzicht van het voorgestelde lijnenplan en ook in de toekomst zullen andere aanpassingen volgen nadat lokaal terreinonderzoek is verricht.

Op de kaart op de volgende bladzijde is de status van het lijnenplan van SCAN gebied A&B van heden weergegeven met inbegrip van de ranking van de lijnen. Op de website van SCAN (www.scanaardwarmte.nl) kan de status van de opname van de lijnen worden gevolgd.



Kaart met de status van het lijnenplan in de SCAN-gebieden A&B op 12/09/2019. Voor de lijnen die in doorgetrokken streep zijn weergegeven is met de huidige kostenverwachting budget voor acquisitie beschikbaar, voor lijnen die gestreept zijn weergegeven is met de huidige kostenverwachting geen budget beschikbaar.

Contents

1. Introduction to the SCAN project

In order to achieve the goals of the Paris Treaty and limit global warming a shift from fossil towards renewable energy resources is required. Geothermal energy is a proven and promising renewable energy resource. To successfully and safely plan, fund and execute geothermal projects subsurface data is essential. Presently producing geothermal projects in the Netherlands are generally located in areas where abundant subsurface data is available (Figure 1).

Although subsurface data availability in the Netherlands is excellent, the data is not well distributed over the country; data coverage is poor in roughly half of the country, including major residential and industrial areas with high heat demand (Figure 1). As a result, effective and economically feasible development of geothermal projects is not possible under the current circumstances in these areas. A framework study was carried out to identify what data acquisition is required to overcome this limitation (EBN–TNO-AGE, 2017). Subsequently, EBN and TNO-AGE have been asked by the Ministry of Economic Affairs and Climate to embark on a geothermal exploration program (SCAN: *'Seismische Campagne Aardwarmte Nederland'*) to decrease the subsurface uncertainty and hence shape the conditions needed for the successful development of geothermal projects in these areas.

The most important subsurface parameters that need to be known for the successful development of a geothermal project are permeability, thickness and depth of the aquifer. These parameters can be derived from seismic and well data (Table 1) (EBN – TNO-AGE, 2017). The SCAN project will therefore comprise acquisition of new 2D seismic data, reprocessing of vintage seismic data and drilling of new wells in areas with relatively low data availability. Nine such areas have been identified (Figure 1). The areas were prioritized based on the expected future heat demand. Area A, which comprises the cities of Lelystad, Deventer and Apeldoorn, was identified as an area of normal priority. Area B, which is a relatively rural area located between the cities of Arnhem and Enschede, was also identified as an area of normal priority. This report discusses both areas A and B, which have been evaluated together since their geological history and make-up is quite comparable. The combined area will be called 'area A&B' in this report.

This document outlines the geological objectives and design criteria (position and orientation) for the 2D seismic acquisition ("Acquisitieplan" in the tentative planning, EBN, TNO-AGE, 2017, appendix 6). More potential future work other than the seismic acquisition is presented in this report. This includes geological and geophysical studies, seismic reprocessing and the drilling of exploration wells to test the stratigraphy and/or sedimentology. It should be noted that this work will be subject to further detailed review but is presented here only to give the proper setting for the 2D seismic acquisition plan.

Information	2D-Seismic data	3D-Seismic data	Well
Economical evaluation: presence and quality of aquifer, temperature			
Presence, continuity, depth and thickness aquifer	+	++	+++
Porosity	–	+/–	+++
Permeability (transmissivity)	– –	– –	+++
Temperature	+	+	+++
Safety, well planning and regional geological knowledge			
Regional geological model	++	+++	++
Presence of faults	+	+++	+/–
Character of overburden on well trajectory	+	++	+
Risk-assessment of presence of hydrocarbons	+	++	+/–
Water composition	– –	– –	++

Table 1 – data-acquisition methods and information resulting from these methods. Legend: – – –: produces no or inaccurate information, +++: results in much, accurate information.

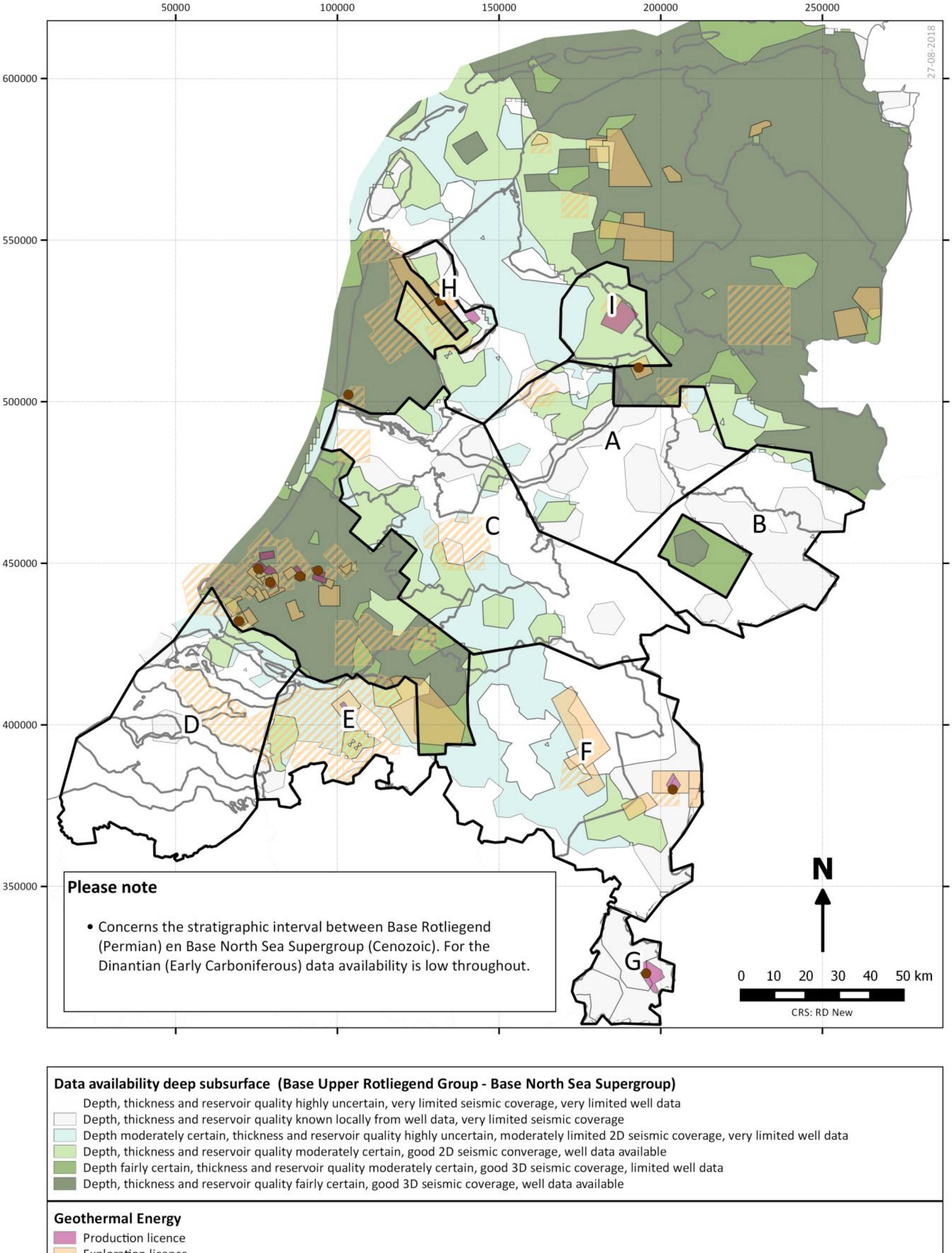


Figure 1 – SCAN areas, geothermal licenses and producing geothermal installations (after EBN -TNO-AGE 2017).

2. Geological overview of SCAN area A&B

The stratigraphic interval of interest for geothermal purposes ranges from Devonian sandstones at a depth of approximately 4500–6000 m to Cenozoic sands as shallow as 300 m below ground level. The most important target for geothermal projects in this area is the Rotliegend sandstone. Other primary targets are provided by the Lower Carboniferous carbonates, Westphalian C sandstones and the Brussels Sands of the Lower North Sea Gp. (Figure 2). Secondary targets include the Lower Cretaceous and Upper Jurassic sandstones.

Within area A&B the following structural elements (Kombrink et al. 2012)) can be distinguished for the Jurassic–Cretaceous tectonostratigraphic evolution of the area (Figure 3):

- Most of the area A&B is located in the Central Netherlands Basin (CNB), an inverted basin where Triassic and Lower Jurassic has been deposited and preserved, whereas Chalk and Rijnland have been completely eroded or never deposited.
- The Texel-IJsselmeer High (TIJH) is present in the northernmost point of area A, where no Rotliegend to Jurassic is preserved below Base Cretaceous Unconformity.
- To the north-east of area A&B the CNB borders to the Groningen Platform (GP), where limited inversion has taken place, preserving Upper and Lower Cretaceous sediments, which overlie the Triassic or Permian layers.
- Two local grabens, the Gouwzee Trough and a graben north of Barneveld (here called the Barneveld Graben), are present in the west of area A where Upper Jurassic sediments have been preserved.

Another important structural element in the Cenozoic is the Zuiderzee Low (Figure 3). This structure is associated with a thick development of the North Sea Groups in the (former) Zuiderzee area in contrast to the eroded Middle and Lower North Sea Groups of the Kijkduin High onshore Noord and Zuid Holland and the erosion or thin development of these intervals in the Achterhoek/Twente area.

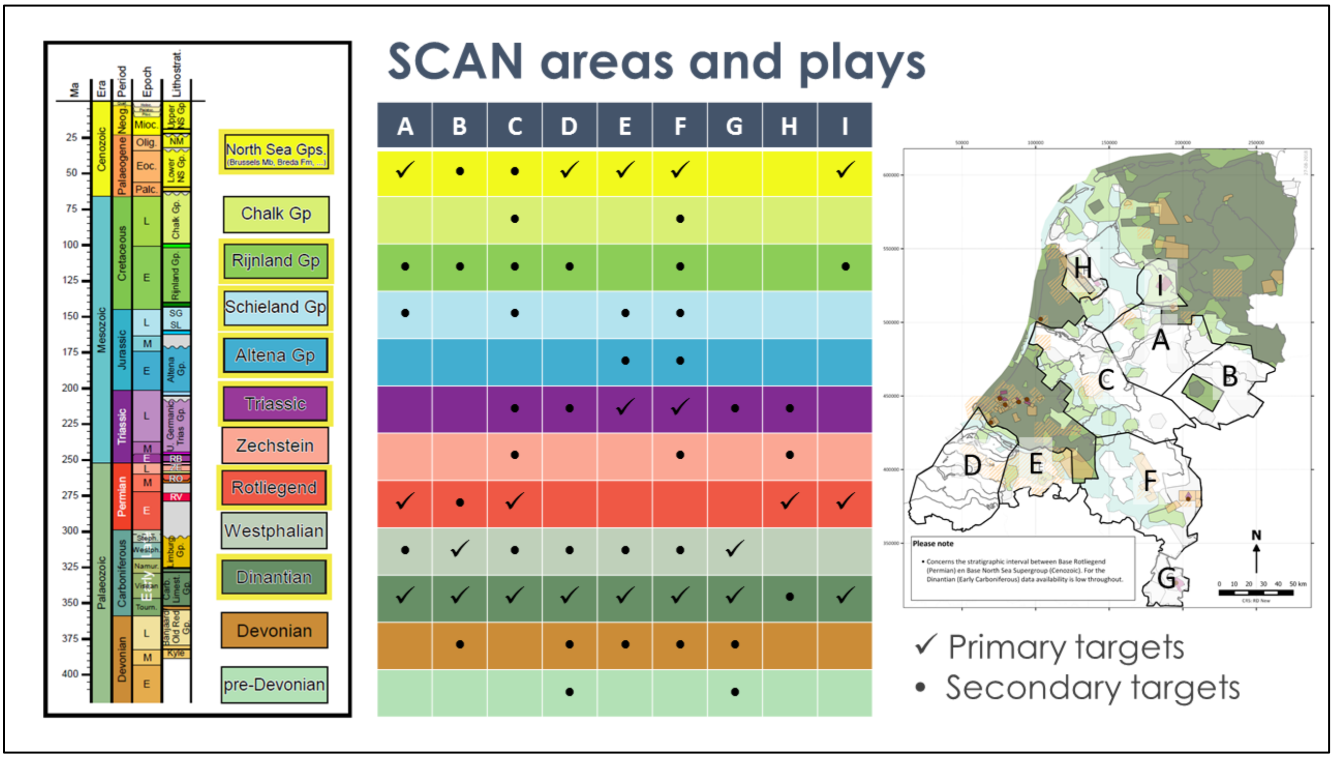


Figure 2 – Overview of the primary and secondary targets in the SCAN areas.

2.1 Stratigraphic Section

From old to young the stratigraphy (Van Adrichem Boogaert & Kouwe, 1993–1997) relevant to geothermal projects in area A&B is expected to consist of:

- A siliciclastic Devonian section. The oldest interval drilled in area A&B is a Devonian sandstone section in well WSK-01. TD of this well was called after drilling a 350m tight sandstone section. Above this sandstone section a nearly 200m thick claystone section was found, which is interbedded with thin tight sandstone intervals.
- Lower Carboniferous (Dinantian) carbonates. In well WSK-01 a 186m thick section of argillaceous limestone was drilled. The facies seen in the cores of this interval point to a deeper water depositional environment than the platform carbonates found in other cored Dinantian carbonates in The Netherlands
- An Upper Carboniferous siliciclastic sequence (sandstones, claystones and coal) (Figure 4 & Figure 5; Limburg Group). The top of the Upper Carboniferous sequence was eroded during the Variscan orogeny resulting in a significant time gap between the Carboniferous and overlying Permian sediments represented by the Base Permian Unconformity (BPU). The subcrop below the BPU varies significantly in area A&B. Generally, the sandstone-rich intervals of Westphalian C age are present in the center of area A&B, whereas claystone-rich Westphalian A and B is preserved below the BPU in the north and south of area A&B.

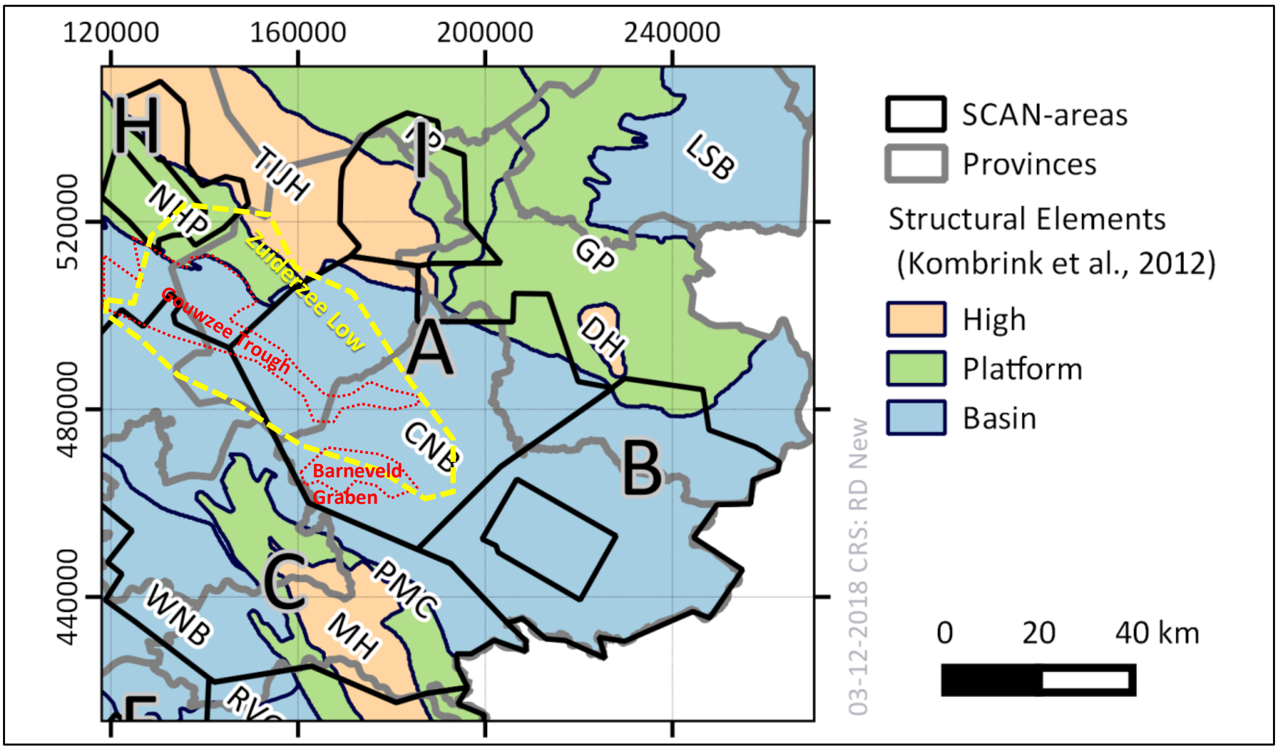


Figure 3 – Late Jurassic – Early Cretaceous structural elements in and around SCAN area A&B after Kombrink et al. (2012), CNB – Central Netherlands Basin, DH – Dalfsen High, FP – Friesland Platform, GP - Groningen Platform, LSB – Lower Soxony Basin, MH – Maasbommel High, NHP – Noord Holland Platform, PMC – Peel–Maasbommel Complex, TIJH – Texel-IJsselmeer High, WNB – West Netherlands Basin. Indicated in yellow dashed line is the Cenozoic Zuiderzee Low.

- The Permian Rotliegend Slochteren Sandstone interval (Figure 4 & Figure 5; Upper Rotliegend) overlies the BPU. In area A&B the Rotliegend sandstone is ranging in thickness between several meters to nearly absent in the east of area B to 150m in the north-west of area A. In wells APN-01/2, KRD-01 and near JPE-01 the Rotliegend has been eroded below the Base North Sea Unconformity.
- The Permian Zechstein interval (Figure 4 & Figure 5, Zechstein Group) is quite variable in facies and thickness in area A&B. It is characterized by anhydrite, dolomites and limestones, but locally also salt intervals can be present in one or more of the Zechstein cycles.
- The Lower Germanic Trias Group (Figure 4 & Figure 5) comprises the Lower Buntsandstein Formation and the Main Buntsandstein Subgroup. The Lower Buntsandstein consists of a regional uniform lacustrine claystone with thin

interbeds of oolitic limestone. The Main Buntsandstein in area A&B contains a thin sandstone interval, generally with poor reservoir properties, at its base whereas the remaining section is composed of claystones.

- The Upper Germanic Trias Group (Figure 4 & Figure 5) has a variable lithology on claystones, argillaceous limestone and dolomite, anhydrite and salt layers. The thicker and more complete sections are found in the north of area A and the east of area B.
- The Lower Jurassic claystones of the Altena Gp. (Figure 4 & Figure 5) are preserved below the Base North Sea Unconformity in down-faulted blocks, such as the Gouwzee Trough and Barneveld Graben.
- Upper Jurassic (Figure 4, Schieland and Niedersachsen Group) sediments have mostly been eroded or were never deposited. In the Barneveld Graben wells BNV-01 and VHZ-01 found interbedded sandstones and claystones. No wells have been drilled in the Gouwzee Trough in area A&B, however, further north in well IJM-01 the Schieland Group is sandstone-bearing. The Upper Jurassic interval in the east of area A&B (e.g. in wells LEL-01 and DRO-01) has the claystone-rich facies of the Niedersachen Group.
- The Lower Cretaceous Rijnland Group is mostly absent in area A&B (Figure 4 & Figure 5). Only where the Groningen Platform extends into area A&B Holland marl and Vlieland claystones can be found. In the north of area B Vlieland sandstones have been found at the base of the Lower Cretaceous. Vlieland sandstones can also be expected in the Barneveld Graben and Gouwzee Trough.
- The Upper Cretaceous Chalk Group (Figure 4). The Chalk Group is absent over most of area A&B, only in the very east of area A&B, on the Groningen Platform, Chalk has been preserved below the Base North Sea Unconformity. Note can be taken of the presence of thin (~20 m) Danian Chalk above the Base North Sea Unconformity in wells OFL-01, DSP-01, ERM-01 and EPE-01. This indicates that the major inversion of the Central Netherlands Basin pre-dates the Danian, so most likely happened during the Sub-Hercynian phase.
- The Lower and Middle North Sea Groups (Figure 4 & Figure 5). This interval consists primarily of unconsolidated sands, sandstones and claystones. The interval is thinner towards the east of area B due to erosion below the unconformity at the base of the Upper North Sea Gp.
- The youngest sediments, the Upper North Sea Group (Figure 4 & Figure 5). These consist mainly of sands and claystones. The interval is thickest in the west of area A in the Zuiderzee Low, while it is thin to nearly absent in the south and east of area B.

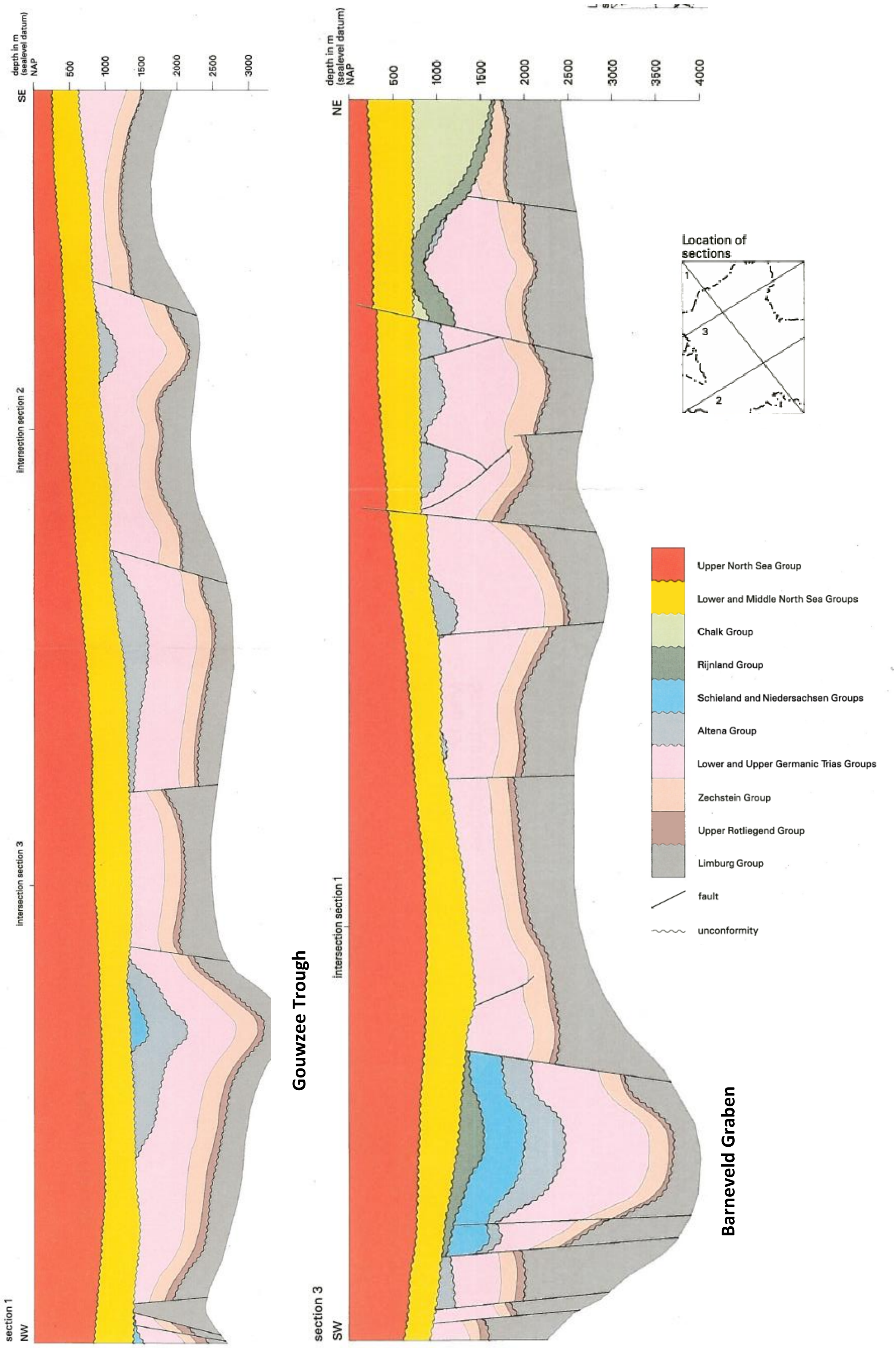


Figure 4 - Cross sections (section 1 and 3) through area A&B (NITG-TNO, 2004).

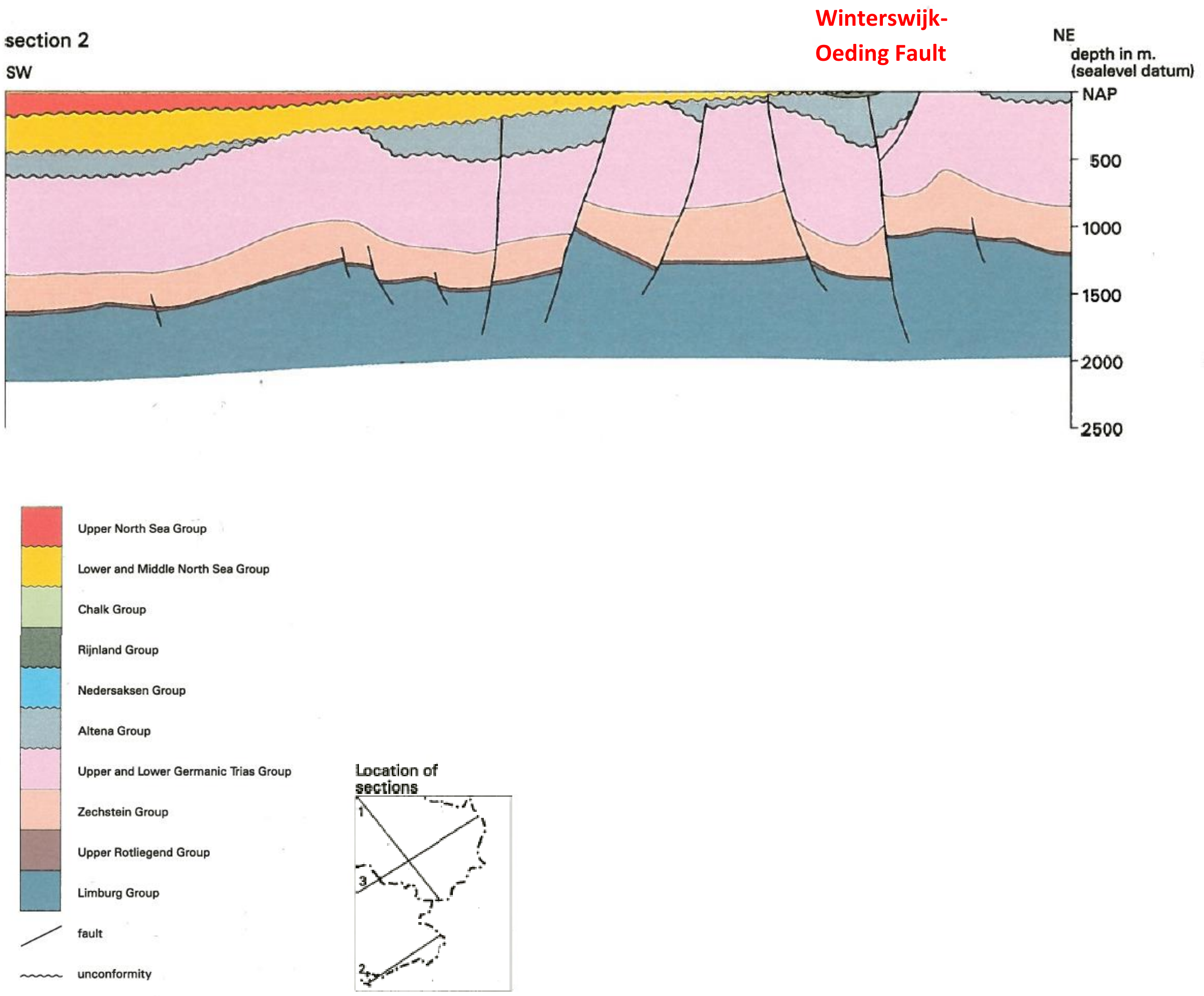


Figure 5 - Cross section (section 2) through area B (NITG-TNO, 1998). Note the significant Winterswijk-Oeding reverse fault.

2.2 Structure

The sequence of tectonic events, also applicable to area A&B, from Devonian times onwards is well summarised in De Jager (2007). The main NW-SE structural trend is interpreted to originate from the Caledonian tectonic event of mid-Palaeozoic times. The structural style at that time is considered to be a horst and graben configuration in an overall NE-SW extensional setting. The horsts and grabens were separated by major NW-SE trending normal fault systems with significant throw, which are expected to root in the basement.

These Caledonian fault systems were reactivated during Variscan and Alpine orogenic events, and in intermediate rifting events; each event under different stress-regimes: in orientation, strength and nature (compressive or extensional). For example, in the period from Mid/Late Jurassic until Late Cretaceous times, in the last phase of Pangean breakup, an extensional to transtensional regime resulted in the formation of the Mesozoic Basins (Broad Fourteens Basin, West Netherlands Basin, Roer Valley Graben) and intermediate platforms and/or highs. The subsequent Alpine tectonic events in which the Alpine stress regime forced oblique-slip movement along the old Caledonian faults resulted in, amongst others, thrust faults and flower structures in the Late Palaeozoic to Cenozoic sedimentary overburden.

For the development of geothermal systems and hazard assessment it is of utmost importance to have a good understanding of the structural evolution and architecture of the subsurface of area A&B, in an adequate detail. This requires a detailed interpretation of the structural and stratigraphic framework, for which control from seismic and well data is essential. These constraints are needed at least down to the top of the Dinantian, which is expected to be present at a depth of 4 to 6 km in area A&B.

From regional maps it appears that the structural architecture of area A&B below the Base North Sea Unconformity is dominated by NW-SE trending horst and graben faults. However, the current fault mapping is simplified by the fact that correlating faults using only 2D data is difficult and is prone to aliasing.

From the 2D seismic data that is available in area A&B it can be inferred (Figure 4 & Figure 5) that in this area:

1) The Cenozoic is mostly unfaulted and is deepening to the northwest into the Zuiderzee Low. The Lower and Middle North Sea Groups, however, are progressively eroded towards the Kijkduin High to the southwest and to the east to the high of the Achterhoek/Twente. Larger faults are locally present, e.g. around well DRO-01.
2) Inversion tectonics at the end of the Cretaceous resulted in uplift and erosion and local folding and reversal of fault movements in the Central Netherlands Basin (see e.g. the Winterswijk-Oeding Fault in Figure 5). The erosion event has cut into the underlying Lower Jurassic and Triassic section in most of area A&B, however, locally erosion cuts as deep as the Zechstein, Rotliegend and Westphalian section.
3) In the Upper Jurassic to Carboniferous interval a NW-SE trending fault system is present and locally horsts and grabens can be observed suggesting more faults with oblique orientations to the main trend. Some prominent larger grabens are present, such as the Gouwzee Trough and the grabens near Barneveld and Dronten.
4) The depth map of the Base Limburg Gp (TNO, 2014b) shows a prominent high or platform in the Twente and Achterhoek area (eastern part of area B) and near the NAG-01 well location in the northeast of area A.

2.3 Primary targets

2.3.1 Rotliegend sandstones

In area A&B the Upper Permian Rotliegend reservoir (Slochteren Fm.) is the most important geothermal reservoir. A significant number of wells has penetrated this interval, which resulted in good information on the depth, thickness, porosity and permeability of the Rotliegend reservoir of area A&B. The depth of the top of the formation ranges between 650m TVDss in the Achterhoek to around 4000m in the Gouwzee Trough west of ERM-01. The thickness of the formation ranges from several meters in the Achterhoek to around 150m near Lelystad. On the Texel-IJsselmeer High, in the northern part of area A near well NAG-01 the Rotliegend has been completely eroded. In wells KRD-01 and APN-01/2 no Rotliegend was found below the Base North Sea Unconformity. In the eastern part of the Achterhoek and Twente no Rotliegend is present, probable due to no deposition of this reservoir is that area.

From well logs and core porosity data it can be deduced that the Rotliegend reservoir has a significant variation in reservoir quality in area A&B. The best core permeabilities are found in wells HLE-01, LNH-01, WEP-01, WYH-01 and ZEW-01 all located in the north and east of area A, or just across its eastern boundary. Here the porosity is often higher than 20% with an associated core permeability higher than 100mD, which in most cases is expected to be high enough to warrant good flow rates in geothermal wells. Much poorer reservoir quality is found in the central part of the Central Netherlands Basin e.g. in wells ERM-01 and DSP-01. In other areas there is evidence that leaching below unconformities can improve the reservoir quality. In area A&B this has not been observed, however, there are some local areas where the Rotliegend is close to the Base North Sea Unconformity, e.g. near KRD-01, APN-01/2, JPE-01 and south of BNV-01.

The log data of well WYH-01 show that in this well the Z1 Carbonate and Kupferschiefer are not present. Most likely these have been cut-out by a fault of unknown offset. The (remaining) thickness of the Rotliegend in this well is 54 m, whereas in well WEP-01, which is located 4.3 km to the southeast, has a Rotliegend isopach of 102 m. Since well WEP-01 is located more towards the basin edge a rapid stratigraphic thinning to well WYH-01 is unlikely, so it is considered more likely that the thinning is caused by a fault cut-out. Consequently, the well should not be used to map the isopach of the Rotliegend.

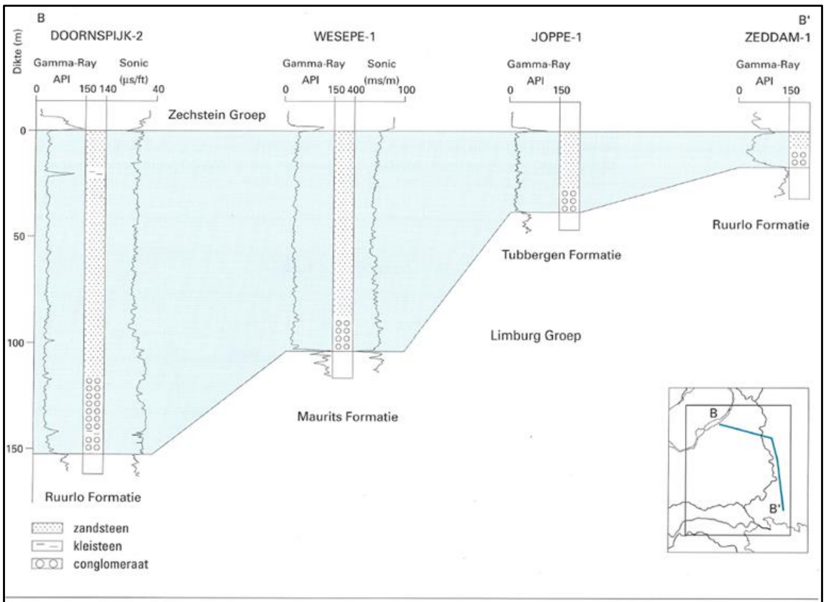


Figure 6 – Stratigraphic section of the Rotliegend in Area A&B (from NITG-TNO 2004). Note that the conglomeratic interval at the base of the formation is mainly interpreted from log response.

The Rotliegend in area A&B consists mainly of sandstone, however, at the base of the interval in some wells a package of up to 30m of conglomerates or conglomeratic sandstone is interpreted to be present (Figure 6). These wells, e.g. DSP-02 and WEP-01 are located in the east of area A and in the centre of area B. This could indicate that, at least locally, fluvial deposition took place. Since the area is positioned near the edge of the Rotliegend basin incised channels can be expected here determining the paleo-topography on the Base Permian Unconformity. During the Rotliegend these topographic lows were the focus of ephemeric fluvial channels and eventually deposition of fluvial sediments.

Based on the removal of well WYH-01 as valid isopach datapoint and the notion that incised fluvial channels may have existed at the base of the Rotliegend in area A&B, for the TNO 2014a isopach map of the Rotliegend alternative mapping is possible (Figure 7). Especially in the area between Zwolle and Wesepe in the IJsselvallei the Rotliegend may be thicker than expected from the TNO map. In area B, the thicker Rotliegend in wells GEL-03 (38m) and LVD-01 (36m) was interpreted by NITG-TNO 1998 as to be deposited in fault induced grabens. However, an alternative interpretation could be that the in-creased thickness is related to the presence of incised valleys connecting eroding uplands to the southeast with the fluvial channel between wells WEP-01 and DSP-02.

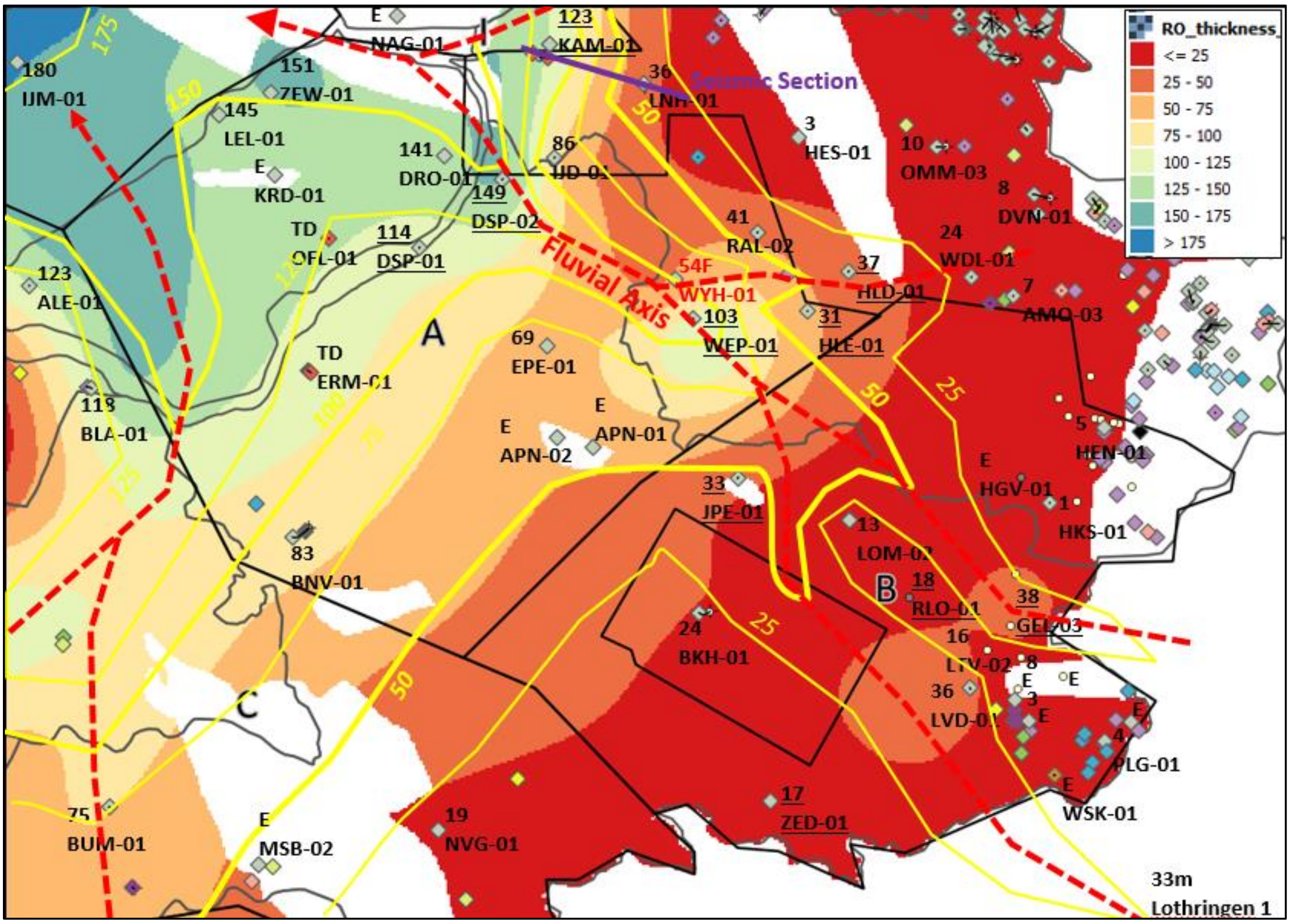


Figure 7 – Rotliegend isopach map (in m): in color the TNO 2014a map, in yellow lines adjustments were made to remove well WYH-01 with unrepresentative thickness due to faulting. Potential fluvial channels are indicated in red and used to guide the hand-contouring. The isopach in meters is indicated at the well locations. Underscored depth values indicate conglomerate at the base of the Rotliegend. Absence of the Rotliegend is indicated by 'E', incomplete penetration of the formation by 'TD'

To reduce the risk of geothermal projects in the Rotliegend of area A&B the following activities are proposed:

- Perform a test to asses if a seismic inversion project may help to seismically predict areas of good reservoir quality
- Acquisition of new 2D seismic data across the IJsselvallei where nearly no digital seismic data is available, but where geological considerations point to a thicker Rotliegend than expected from the TNO mapping
- Acquisition of new 2D seismic data near Lelystad where seismic data is poor, but the Rotliegend is thick and of good quality
- Acquisition of new 2D seismic data north of the Veluwe where seismic data is sparse. Rotliegend reservoir quality is typically poorer in this area. This area may serve as a poor-quality reference for the seismic inversion project

2.3.2 Cenozoic sands

The sands in the Cenozoic section are a relatively new target for geothermal exploration and production. Since the Cenozoic is in general not buried deeper than 1.5 km the temperature in these sands is relatively low (30-45 ˚C). The application of this heat is called in Dutch: Lage Temperatuur Aardwarmte (LTA). An LTA doublet has recently been drilled in SCAN area E near Zevenbergen. The reservoir here consists of the Brussels Sand Mbr. of the Dongen Fm. in the Lower North Sea Gp. located at a depth of around -600m. In area A&B the Brussels Sands are thought to have the best potential for geothermal exploration as well.

Since the Cenozoic was of nearly no interest to oil and gas exploration onshore The Netherlands very limited reservoir information is available. Additionally, the formation was usually not covered by an extensive logging suite in hydrocarbon exploration wells. The wells of the Zevenbergen doublet have not been released yet, however, some information is available on the website of the operator and in media coverage.

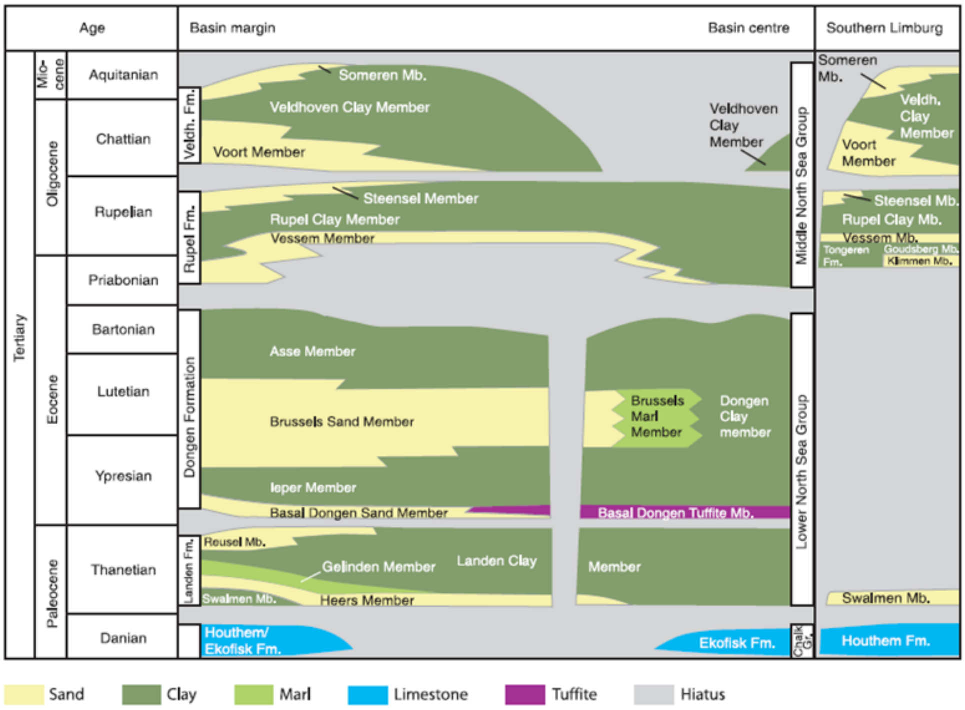


Figure 8 – Stratigraphic scheme of the Lower and Middle North Sea Groups in the Netherlands (Wong et al 2007).

The Middle and Lower North Sea Groups (Figure 8) consist mainly of marine claystones with interbedded sandstones. In general, the thickest sand interval is the Middle Eocene Brussels Sand Mbr. of the Dongen Fm. Locally in area A&B also the Vessem Mbr. (Figure 8) of the Rupel Fm. is present above the unconformity at the base of the Middle North Sea Gp. This last potential reservoir interval is considered less promising than the Brussel Sands and not further discussed here.

According to Van Adrichem Boogaert & Kouwe (1993-1997) the Brussels Sand Mbr. can be characterized as a succession of green-grey, glauconitic, very fine-grained sands with, mainly in the upper part, several hard, calcareous sandstone layers of some decimetres thickness (leading to high-resistivity peaks). Towards the base of the unit the clay content increases, and the calcium carbonate content and amount of glauconite decreases. A minor amount of mica occurs. The upper part with the cemented, calcareous sandstone layers is very rich in fossil fragments, abundant Nummulites, shells (including Pecten) and Echinodermata, indicating a near-shore environment. The member is deposited in an inner-neritic to near-shore environment. In general, the water depth appears to be shallowing upwards, with a possible exception for the uppermost part of the unit.

The Eocene formations are found in outcrop to the south in Belgium. It should be noted that the Dutch Brussels Sand Mbr. is not time-equivalent to the Belgian Brussels Fm. The upper half of the Dutch Brussels Sand Mbr. is more or less equivalent to the Belgian Lede Fm., whereas the base can be correlated to the Belgian Brussels Fm. In the Gobertange area (east of Brussels) the sandy limestones of the Brussels Fm. are mined for building use (Gullentops & Wouters, 1996). The tight layers form up to 20cm thick hard banks consisting of 73-87% carbonate. Some of these layers are seen to be continuous in the quarry, whereas there are also smaller discontinuous concretions. These hard carbonate banks are expected to be analogous to the calcareous sandstone layers described in the Dutch lithostratigaphy and seen in well logs (Figure 11) in the top part of the formation. In well WYK-12, 20km north of area A the Brussels Sands have been completely cored (297-375m MD). The core analysis data shows that the upper 25m of the formation is mostly tight, however the basal 50m section has porosities between 35-45% and permeabilities between 150-1000 mD, except in occasional tight streaks.

A quick-look seismic interpretation (Figure 9 and Figure 10) of area A&B of the Top and Base Brussels Sands shows these markers can be interpreted on the existing 2D seismic data. The depth of the Top Brussels increases from less than 100m in the east of area B on the Achterhoek/Twente High to around 1250m in the west of area A in the centre of the Zuiderzee Low. The thickness of the Brussels Sands varies from around 20m in the south of area B to typically around 40m in the centre of area A. To the north of area A, near Lelystad, and into area I the thickness increases to more than 80m. The absence of the Brussels Sand in Twente is due to erosion below the unconformity at the base of the Upper North Sea Gp, whereas in the Achterhoek the Brussel Sands are eroded below the Base Middle North Sea unconformity. Also, locally the Brussels Sand is seen to be eroded below the unconformity at the base of the Middle North Sea Gp; in and around well DRO-01 the Brussels Sands are absent, while the quick look interpretation shows it the be absent at locations west and east of ERM-01 as well.

In the western part of area A, in the Zuiderzee Low, the Upper North Sea Gp. consists of a sand-rich section, which has its base at a depth of 750m. These sands may provide additional geothermal potential. The aquifers may also be used to seasonally store excess heat. In the Veluwe area the Upper North sands may contain fresh water to a depth of 400m. These fresh water aquifers are to be avoided for geothermal applications.

For a more comprehensive evaluation of the Cenozoic geothermal plays the following activities are recommended:

- Drill a well to obtain good core and log coverage and well testing of the potential North Sea Gps. to evaluate the reservoir properties and sedimentological environments

In preparation of this well the following work could be done:

- Perform a petrophysical analysis of the Brussels reservoirs
- Seismic reprocessing of relevant seismic data (if field data available)
- Perform a detailed seismic interpretation
- Use new seismic data to be acquired for deeper targets to further refine the interpretation
- Test seismic inversion on North Sea reservoirs

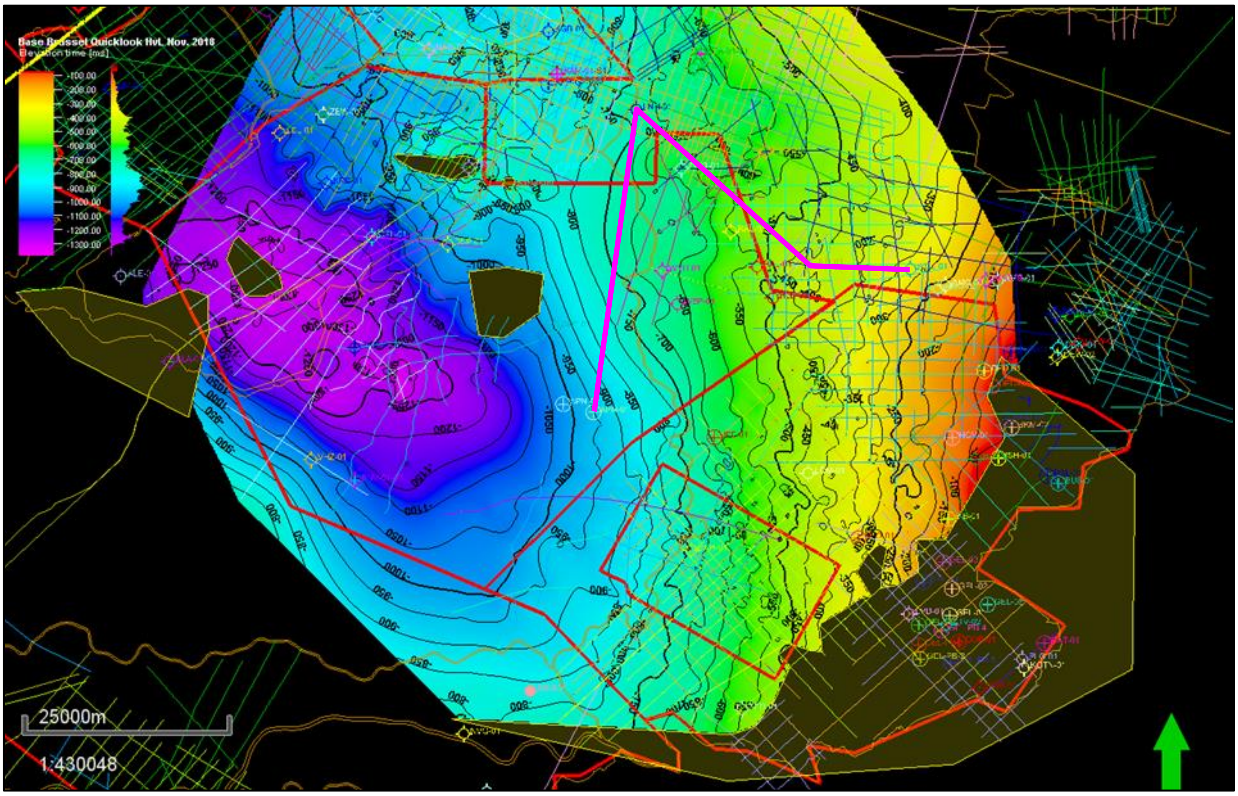


Figure 9 – Quick-look TWT map of Top Brussels Sands in area A&B. Note: a TWT map is very comparable to a depth map in the North Sea Gp. The location of correlation panel of Figure 11 is indicated by the pink line.

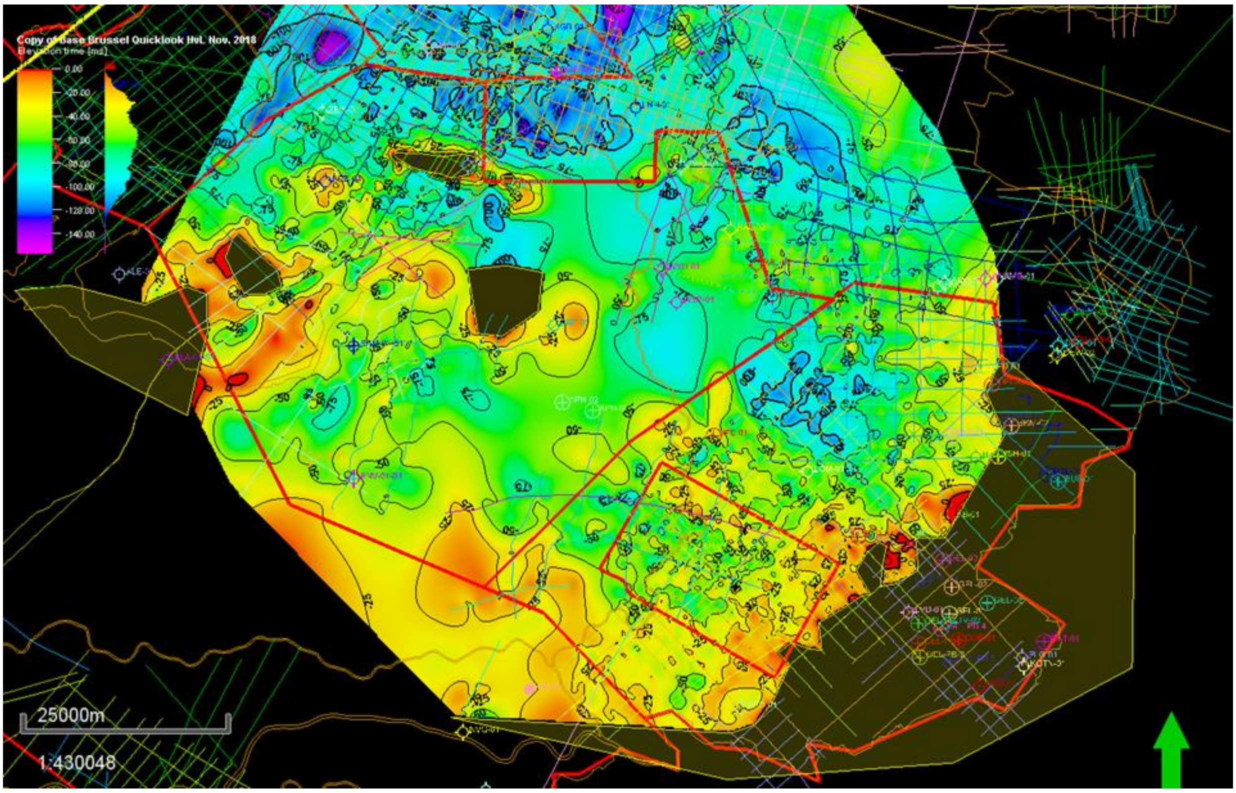


Figure 10 – Quick-look isochron map of Top Brussels Sands in area A&B. Note: an isochron map is very comparable to an isopach map in the North Sea Gp.

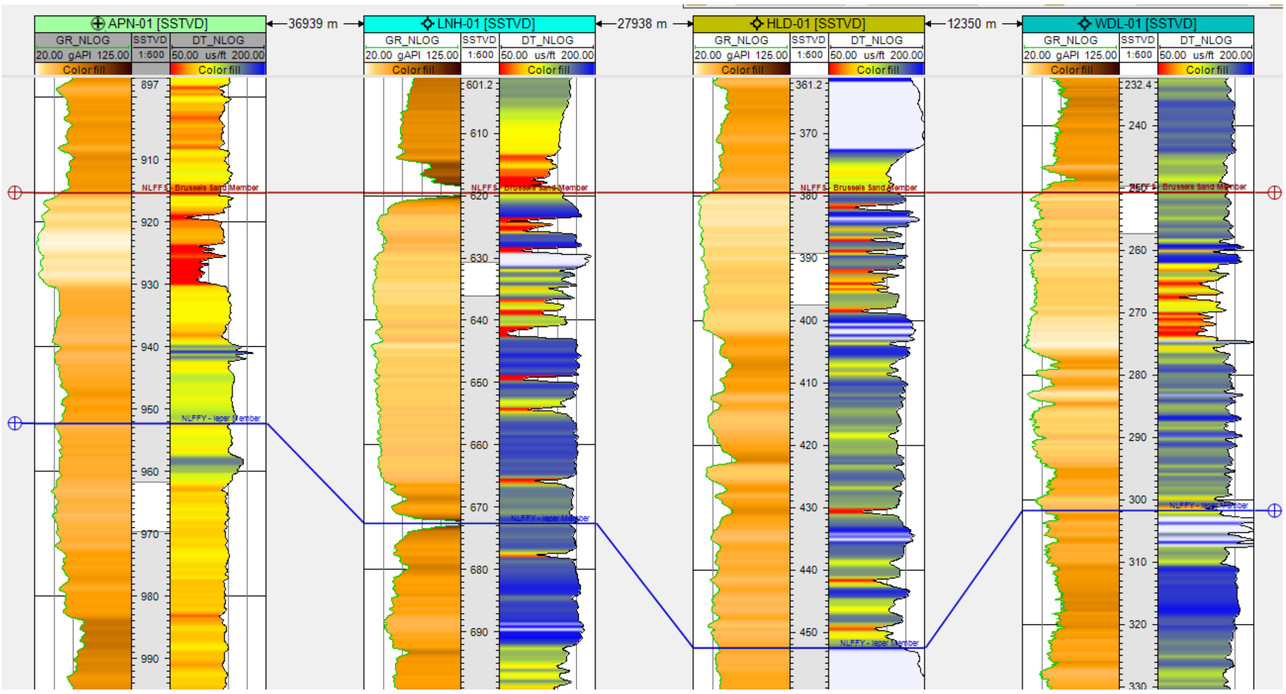


Figure 11 – Log Correlation (GR-DT) Brussels Sand Mbr. wells APN-01, LNH-01, HLD-01 & WDL-01. Note the low DT tight streaks in all wells. Location of panel see Figure 9.

2.3.3 Westphalian C sandstones

In the Carboniferous Limburg Group only the Tubbergen Formation with an Early Westphalian C to Early Westphalian D age is considered to be a potential geothermal reservoir. This interval is a gas reservoir in the Twente area and in the Dutch quads D, E and K, where the reservoir is known as the Hospital Grounds Fm. The Tubbergen Fm is mainly preserved in the northern part of area B and the central part of area A. In the rest of the area the formation has been eroded below the Base Permian Unconformity. In most area the Tubbergen Fm. is overlain by the Rotliegend, however if this formation is absent, in the east of area B, the Zechstein Gp will overlie the Carboniferous. Locally, e.g. near APN-01 and JPE-01, the Tubbergen Fm. lies unconformably below the Lower North Sea Gp.

The sandstone intervals in the Tubbergen Fm. are typically 10-30m thick and are separated by 5-40m claystone intervals. The sandstone beds can contain 50-80% of the formation, which could point to a good 3D connection between the reservoir layers deposited in a braidplain setting. The reservoir intervals vary in quality but sometimes display fair to good porosity (15-20%) and permeability (10-300 mD), especially in the Twente area. The reservoir quality in the central part of area A is less well known. The core measurements in well JPE-01 show anomalously low permeabilities (0.1-0.01mD) at a porosity of 10-15%

The distribution of the Tubbergen Fm. was assessed using the Top Pre-Permian subcrop map (Figure 12) of Mijnlieff (2002). Since in this area no 3D seismic is available the outline of the Tubbergen subcrop is quite uncertain and mainly based on clustering well penetrations. Especially the area between APN and JPE, where nearly no digital seismic data is available, the potential of the Tubbergen reservoir cannot be assessed with any certainty. In the north of area B, the presence of the Tubbergen reservoir is more certain as more digital 2D data of fair quality is present. This area is also adjacent to the Twente area where 3D seismic data is available to test the Tubbergen play in a data-denser location.

To reduce the risk of geothermal projects in the Westphalian C of area A&B the following activities are proposed:

- Acquisition of 2D seismic data near wells APN and JPE and between wells BNV and ERM where the Tubbergen reservoir may be present. Seismic data could help to constrain the mapping of the subcrop of the Tubbergen Fm.

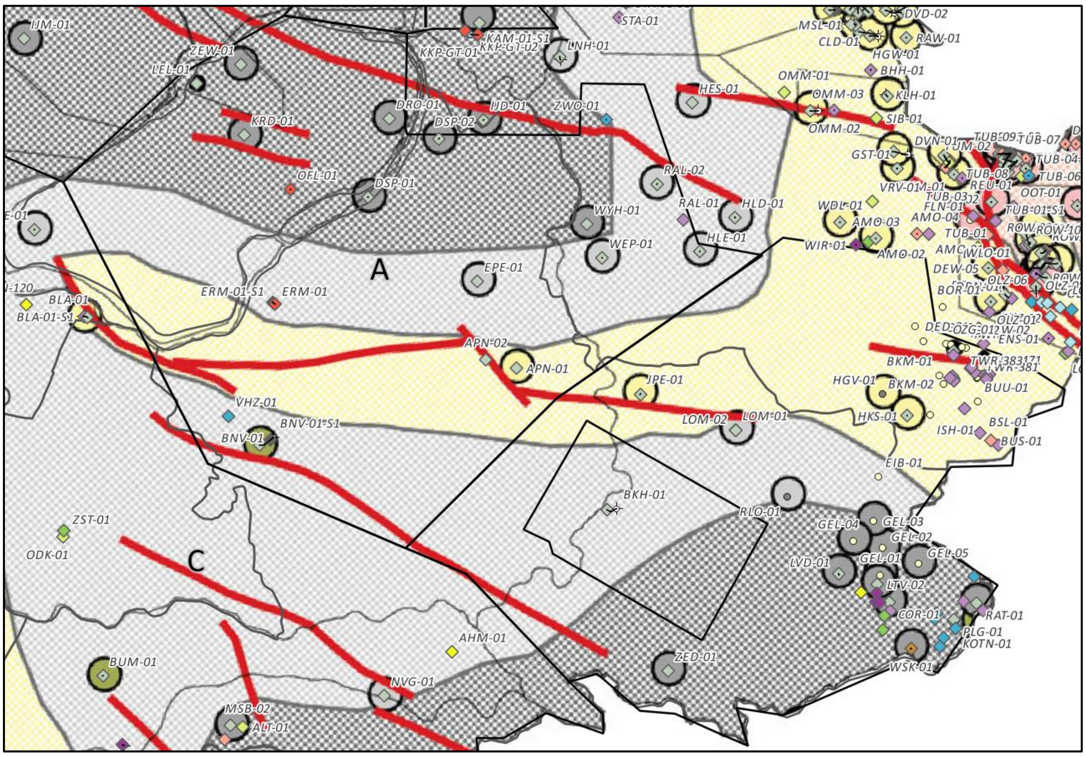


Figure 12 – Pre-Permian Subcrop map from Mijnlieff 2002. The Tubbergen Fm. is indicated in yellow and is present in the north of area B and in an east-west belt through area A

2.3.4 Lower Carboniferous (Dinantian) carbonates

In area A&B one well (WSK-01) has been drilled into the Dinantian carbonates (Figure 13). The well was drilled by NAM in 1977 for hydrocarbon exploration in this reservoir. The well was drilled to a TD of 5000m penetrating below the Lower Carboniferous carbonates a nearly 200m thick claystone section interbedded with thin tight sandstone intervals and below this a 350m tight sandstone section. This clastic interval is thought to be of Devonian age and possibly correlatable to a similar sandstone interval in well KTG-01 in Zeeland.

On the 2D seismic sections near the WSK-01 well location a very bright sub-horizontal reflector can be mapped in the deeper part of the Carboniferous. It proved that this reflector is caused by an approximately 70m thick intrusion of gabbro/dolerite material located in the basal part of the Epen Fm. in Namurian claystones, just above the top of the Dinantian carbonates. This bright reflector in fact obscures the Top Dinantian reflector. Since no seismic section crosses the well location, the well tie is ambiguous.

The Dinantian carbonates of well WSK-01 may be more argillaceous than found in other Dutch wells with this reservoir. This has been used as evidence that these sediments where deposited a deeper water setting or even as transitional facies to the more mixed lithology Kulm facies found in German wells and outcrops (NITG-TNO, 1998). It should be noted, however, that the cored interval is not very representative for the rest of the formation, as it has cored a clay-rich interval potentially equivalent to the Pont d'Arcole Fm. in Belgium and Germany.

It has been suggested by Boxem et al. (2016) that a platform structure (Figure 13) can be present in the area north of WSK-01, on the north-eastern border of area A&B. TNO 2014b (Figure 14) mapping shows that the top of the Dinantian is relatively shallow in the area north of WSK-01 on the north-eastern border of area A&B, e.g. in the Enschede/Twente area. Also, next to the LTG structure (Figure 13), more platforms could possibly be present on the Texel-IJsselmeer High, if this high were a long-lived structural feature, which was already present during Devonian/Dinantian times. TNO 2014b mapping (Figure 14) shows the presence of a Dinantian high below the location of well NAG-01. This well was drilled to a TD of 4300m in Lower Namurian claystones of the Geul Subgroup.

Since the normal matrix permeability of Dinantian carbonates is very low, geothermal plays in this reservoir will depend on secondary permeability. Three subplays on enhanced permeability can be identified: related to faulting and fracturing (e.g. the Californië project), karstification of the reservoir during the Dinantian/Namurian (e.g. Loenhout UGS in Belgium) and karstification below the Base Permian or Base Cretaceous Unconformity (e.g. KTG-01 well). This last subplay is not present in the A&B area.

In the context of the SCAN Dinantian studies the WSK-01 well is subject to more detailed evaluations. Since there is a large database of legacy 2D seismic data in area B, seismic reprocessing of this data may help to define fault zones in the Dinantian of this area, which could present a target for geothermal exploration. Acquisition of a new 2D seismic line over well WSK-01 (Figure 14) may help the interpretation of the reprocessed data. This line can be extended to cross a fault zone near the COR-01 well. The seismic interpretation for the SCAN Dinantian project has identified a top Dinantian high and potential build-up near Eibergen. Near Enschede, where there is interest of a deep geothermal project, the seismic data also indicates the possibility of finding faulted Dinantian. A new seismic section between WSK-01 and the Enschede 3D may provide a better tie and context to for the seismic interpretation of the Dinantian in the Achterhoek/Twente area.

Near Eerbeek a potential customer for UDG is currently investigating the Dinantian target. Seismic acquisition in this area may help to image this potential reservoir. Around well HLE-01 the Dinantian is expected to be relatively shallow and may be imaged on the seismic lines proposed for a Rotliegend target in this area, under the proviso the acquisition parameters allow for this deep penetration. A seismic line from LEL-01 connecting at NAG-01 to a SCAN seismic line across the LTG-01 structure may give some further insights in the Dinantian high mapped below well NAG-01.

To reduce the risk of geothermal projects in the Dinantian of area A&B the following activities are proposed:

- Detailed seismic interpretation and depth mapping of the Dinantian (in progress, part of SCAN Dinantian)
- Reservoir study of the Dinantian (in progress, part of SCAN Dinantian)
- Reprocessing of legacy 2D data in area B for a Dinantian target
- Acquisition of a deep-penetration 2D seismic line in the Enschede/Twente area and over the WSK-01 well location
- Acquisition of a deep-penetration 2D seismic line connecting to the NAG structure (and from there to the LTG structure)
- Acquisition of deep-penetration 2D seismic near well HLE-01 and over Eerbeek, in conjunction with the Rotliegend acquisition program

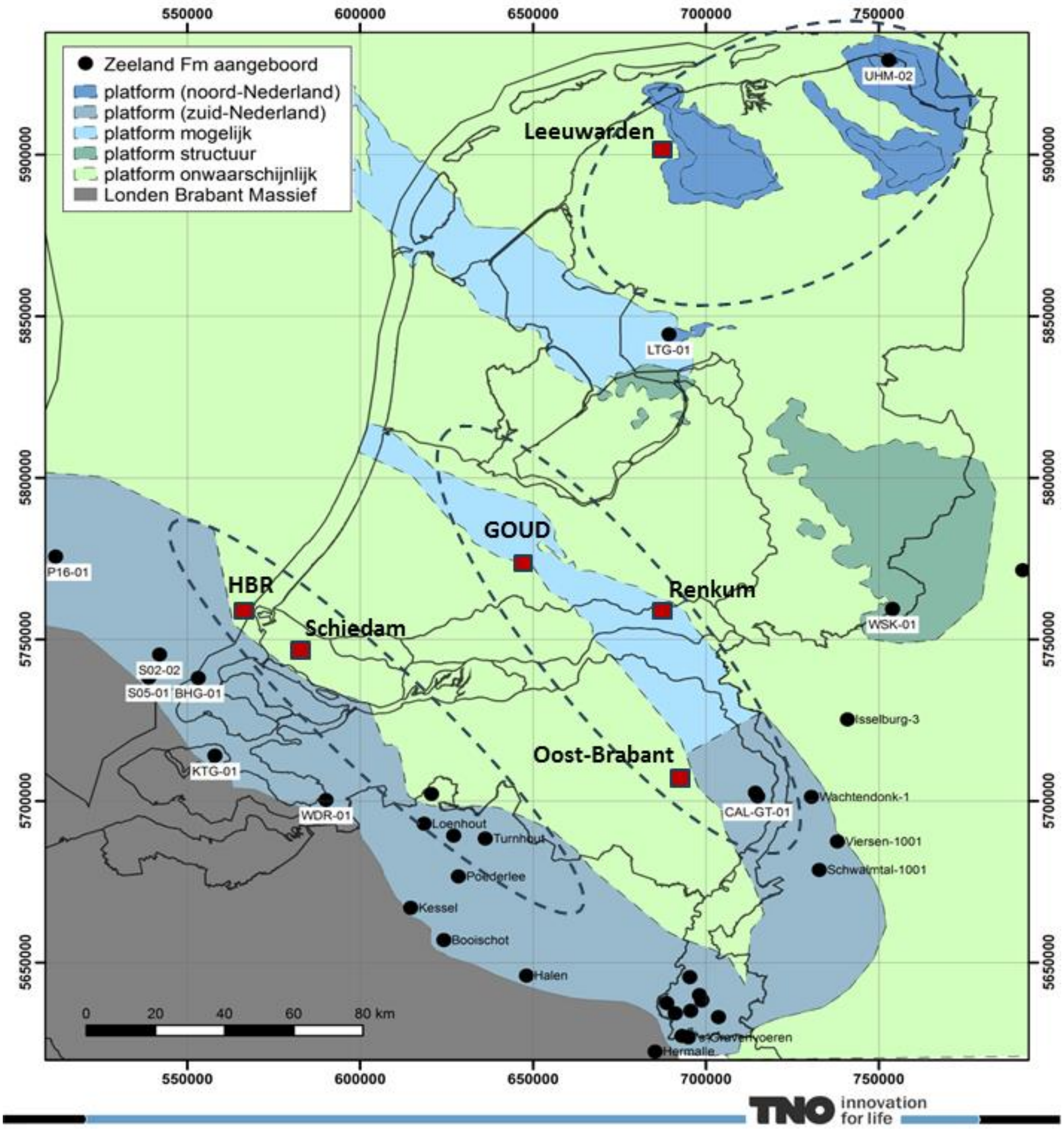


Figure 13 – Facies map of the Dinantian (Early Carboniferous) from Boxem et al. (2016). "Platform mogelijk": platform possible, "Platform structuur": platform structure, "Platform onwaarschijnlijk": platform unlikely, "Zeeland Formatie aangeboord": Zeeland Fm encountered in well. NB: This map may be outdated as it does not reflect the ongoing SCAN Dinantian work.

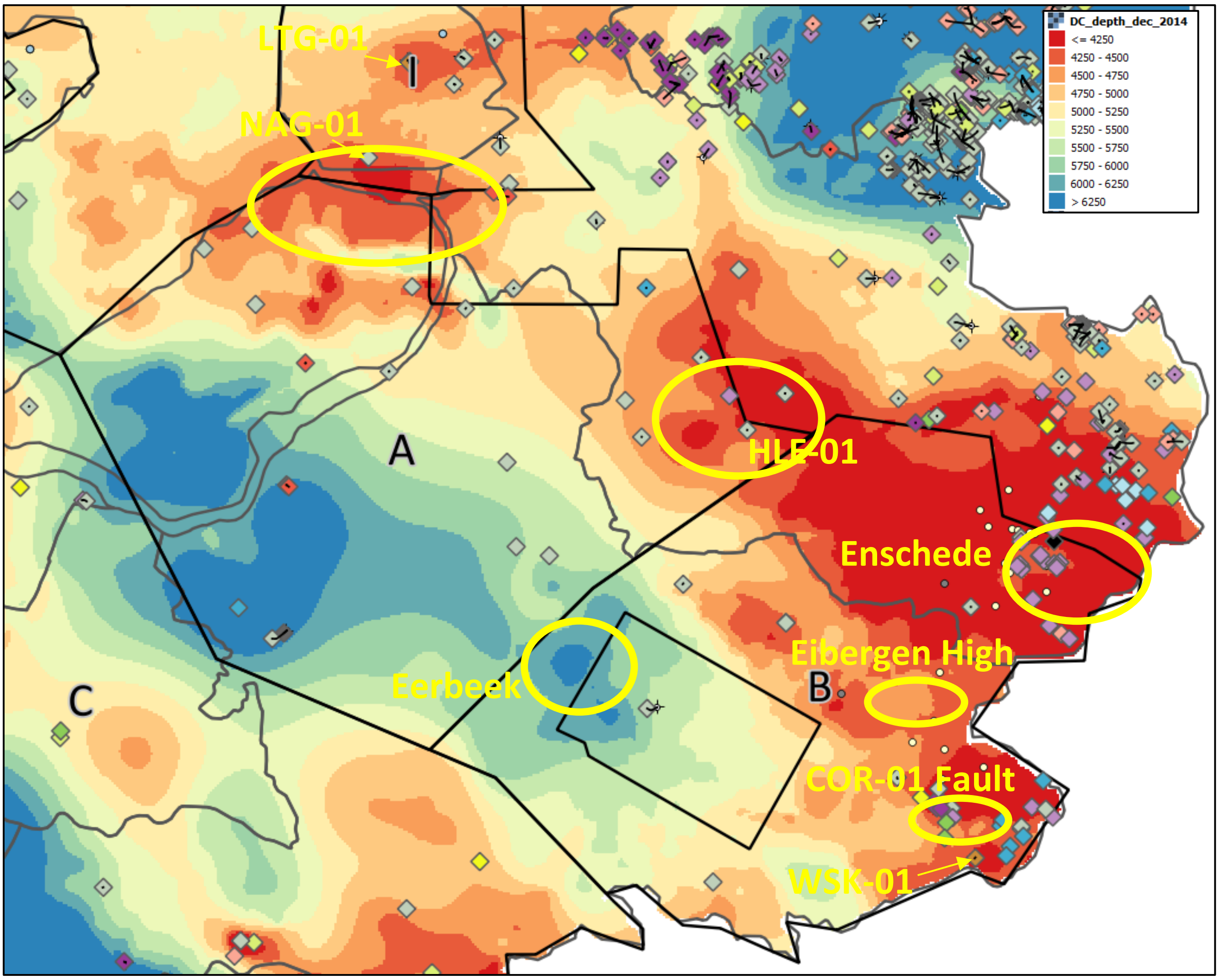


Figure 14 – Depth map of Top Dinantian horizon, as provided in Dinoloket (TNO 2014b) Potential target areas are highlighted by the yellow ovals. Note that the high near Eibergen was only recently identified in the SCAN Dinantian interpretation, so it is not represented on this depth map.

2.4 Secondary targets

2.4.1 Lower Cretaceous and Upper Jurassic sandstones

Two grabens are present in the west of area A which (potentially) contain Rijnland and/or Schieland sandstones. One graben is located north of Barneveld, which was penetrated on the southern flank by wells VHZ-01 and BNV-01, which found Upper Jurassic to Lower Cretaceous sandstones.

Further north the Gouwzee Trough runs through Flevoland into the Markermeer, where well IJM-01 found a sandy Lower Cretaceous/Upper Jurassic section and then further north-west under the Gouwzee to Waterland where several wells (e.g. well ZWK-01) proved sandstones in this interval as well.

The reservoir quality and thickness of the Lower Cretaceous/Upper Jurassic can be quite variable and is hard to predict from seismic for the undrilled parts of these two grabens. Eventually a well is needed to test this play.

Proposed work for the Lower Cretaceous/Upper Jurassic play in area A&B:

- Acquire 2D seismic lines over the Barneveld Graben and Gouwzee Trough to map the depth and thickness of the formation for the positioning and planning of an exploration well
- Reprocessing of existing seismic data (if field-data available)

3. Seismic survey design

In the previous chapter proposals were made for the further geological and geophysical evaluation of area A&B. These proposals have been reviewed and ranked on their respective potential impact of the play (w.r.t. expected areal extent and reservoir quality) and their estimated chance of success in delivering on the objectives of these projects. Figure 15 graphically summarizes the most important proposed work items and their ranking. These considerations are the starting point for defining the location and goals for the planned seismic acquisition. Additionally, next to the geological objectives (3.1) the new seismic survey design should meet a number of essential technical criteria (3.2).

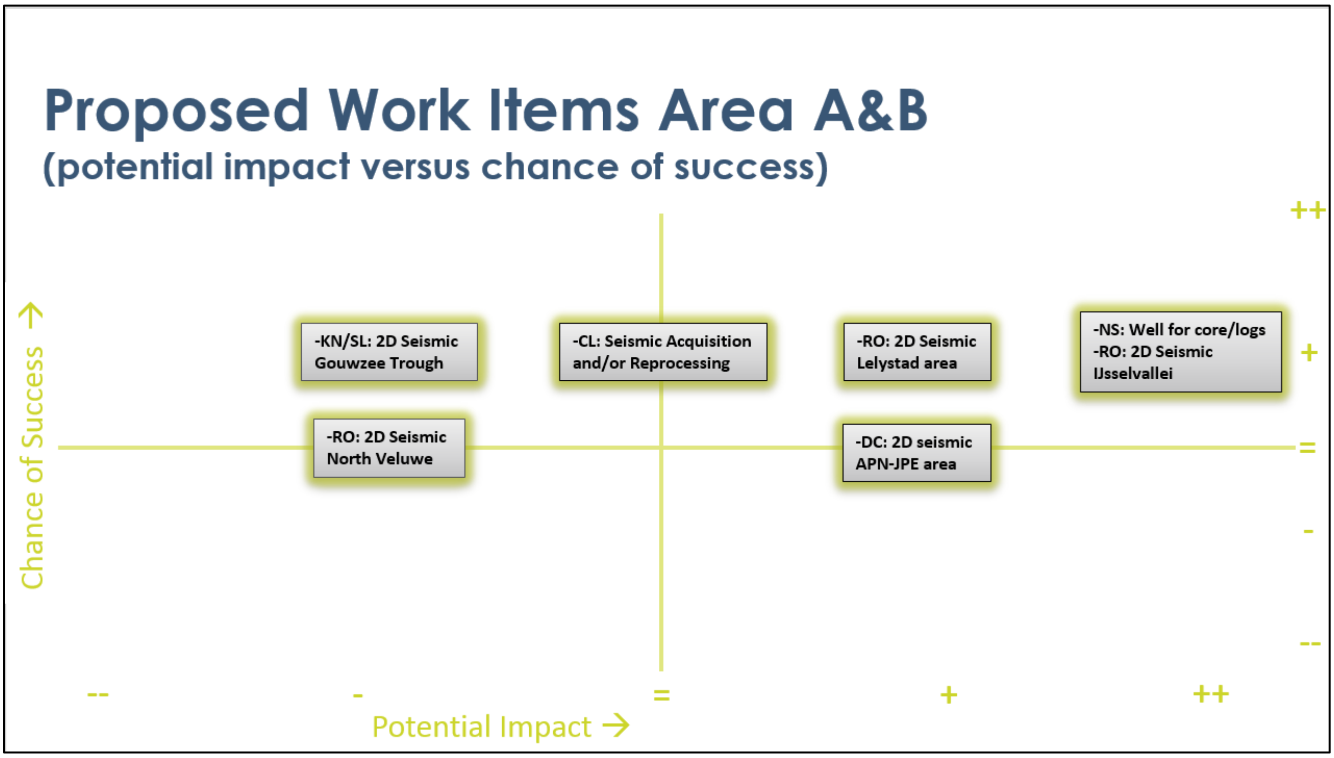


Figure 15 – Cartoon showing the main proposed work items for further evaluation of area A&B ranked according to potential impact of the play and estimated chance of success

3.1 Geological objectives of the seismic survey

The geological objectives of the seismic acquisition are summarized from high to low impact:

- Provide core and log data from area A&B where a thick and potentially good quality Brussels Sand and/or Upper North Sea Gp. sands are present. This could open a significant new play over an extensive area.
- Acquire new high-quality 2D seismic data in the IJsselvallei where there is a potential for good quality Rotliegend reservoir thicker than expected on the TNO maps. In the IJsselvallei there is a lack of digital 2D seismic data. Several wells with can be tied with the proposed seismic lines. The new seismic will be used for a seismic inversion project to test if reservoir quality can be predicted laterally using the seismic data.
- Acquire new high-quality 2D seismic data in the Lelystad area where there is a potential for good quality Rotliegend reservoir. Leaching of Rotliegend below the Base North Sea Unconformity near KRD-01 could extend the target area. Here seismic inversion may as well indicate the extent of the good reservoir area.
- Acquire new high-quality 2D seismic data in the Apeldoorn area where there is a potential for Westphalian C sandstones to be present below the Base North Sea Unconformity. Since the reservoir quality of the Westphalian sandstones is not well known, eventually a well will be needed to further upgrade this potential play.
- A large 2D seismic dataset is available in area B, where by reprocessing (if field data available) the imaging of the Dinantian horizon and faults may be improved. Depending on vintage acquisition parameters, the scope for reprocessing will be tested in areas with a focus to improve the Dinantian horizon and faults imaging. Acquisition of a new deep penetration 2D seismic line connecting well WSK-01 to the Enschede 3D. The SCAN Dinantian

interpretation has identified a potential build-up near Eibergen on this line. Some seismic lines with a Rotliegend target could also image the deep Dinantian. This opportunity especially exists in the NAG, HLE and Eerbeek areas.

- Acquire new high-quality 2D seismic data over the Upper Jurassic and Lower Cretaceous Gouwzee Trough and Barneveld Graben for a future exploration well. Since these grabens are quite narrow the expected impact may be small and will have mainly local impact.
- Acquire new high-quality 2D seismic data north of the Veluwe, where there is a lack of good 2D seismic data, whereas there are several wells to be tied with Rotliegend exceeding 100m in thickness. Since the reservoir quality is not optimal the potential impact of this seismic data is expected to be lower, however the seismic well ties may be used as poor-end reference for the seismic inversion project.

3.2 Criteria for design of the seismic survey

The positions and orientations of the lines were designed to meet as many of the criteria listed below as possible.

- De-risk of the geological issues and uncertainties described in sections 2 and 3.1.
- Take into account heat demand and active geothermal projects.
- Perpendicular to the regional NW-SE structural trend, where possible.
- Straight, long (>20 km) lines.
- Well ties for wells penetrating stratigraphic levels deeper than the Lower North Sea Group, preferably by choosing the line trajectory over / nearby an existing well location.
- Tie to 2D line to 3D seismic data.
- Minimalize complications from near-surface geology: push moraines, swamps, lakes, etc.
- Individual lines of survey cross each other.
- Avoid Natura2000 and other protected areas.
- Avoid mixing of land and water seismic.
- Synchronized with data acquisition plans (local seismic surveys, project locations) of active projects.
- Budget and time planning.

The acquisition parameters of the survey should take into account the following geological objectives:

- Have sufficient recording time and penetration energy to properly image Dinantian limestones at 5 sec TWT if the Dinantian is seen as a target for the line. If the Dinantian is not a target, it should be considered if Vibroseis acquisition is a cost-effective option.
- Be acquired with parameters that results in good imaging of subtle details as unconformities and karst-zones and permits quantitative interpretation reservoir properties. This would mean prestack data with dense source and receiver sampling in time and space and with long offsets. With this data special seismic processing/analyses should be possible such as: AVO, seismic inversion, Full Waveform Inversion, diffraction imaging and broadband processing.

3.3 Survey design

Figure 16 shows the proposed line locations covering area A&B which conform to the above listed geological objectives and design criteria. The geological goals for each of the lines are given in Table 2 and further highlighted per line in geological cross-sections in Appendix 5.1. A buffer of 2 km is drawn around the ideal trajectory to accommodate alternative routing; field scouting may lead to significant changes to the design.

In EBN& TNO-AGE (2017) the length of the lines required for area A was estimated at 287 km of which 100 km was marked contingent, whereas 100 km was foreseen in area B. The current design amounts to 432,8 km (Table 3). It is therefore plausible that it may not be possible to acquire all proposed lines and it is therefore necessary to decide which lines have the highest priority. To facilitate this, a scoring system has been developed to assess how well they meet the design criteria. To indicate how the 2D seismic acquisition fits within the overall planning of the SCAN project an indicative planning of the main activities in SCAN area A&B is given in Appendix 5.2. It is possible that if good results are obtained with seismic reprocessing, acquisition of some new lines may not be necessary.

Line	Goals
APN-ZWO	Image Rotliegend and Westphalian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Westphalian subcrop, facies and depth. Tie to well APN-02. Provide tie Zwolle 3D.
EER-WEL-DAL	Image Rotliegend, Westphalian and Dinantian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Westphalian subcrop, facies and depth. Map Dinantian presence, facies and depth. Tie to well WEP-01. Tie to Zwolle and Bronkhorst 3D surveys
JPE-HLE	Image Rotliegend, Westphalian & Dinantian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Westphalian subcrop, facies and depth. Map Dinantian presence, facies and depth. Tie to wells JPE-01 and HLE-01. Connect to 2D line RAL-01 to HLD-01
HEE-RAL	Image Rotliegend. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Tie to well RAL-02. Connect to 2D lines APN-ZWO and EER-WEL-DAL
EPE-WEP-HLE	Image Rotliegend & Dinantian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Dinantian presence, facies and depth. Tie to well EPE-01. Connect to 2D lines APN-ZWO, EER-WEL-DAL and JPE-HLE
APN-JPE	Image Rotliegend and Westphalian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Westphalian subcrop, facies and depth. Connect to 2D lines APN-ZWO, EER-WEL-DAL and JPE-HLE
DSP-EPE	Image Rotliegend. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Tie to wells DSP-01 & EPE-01. Connect IJsselvallei 2D line to Noord Veluwe/Flevoland 2D lines and to NAM-DEEP line
HAR-DSP-IJD	Image Rotliegend. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Tie to wells DSP-01, DSP-02 & IJD-01. Provide tie Zwolle 3D.
BNV-ERM-OFL	Image Rijnland/Schieland, Rotliegend & Westphalian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Westphalian subcrop, facies and depth. Map depth and thickness of Rijnland/Schieland in Barneveld and Gouwzee Grabens. Tie to wells ERM-01 and OFL-01. Connect to 2D lines HAR-DSP-IJD, LEL-KRD-OFL and NAM-DEEP
ALE-LEL-ZEW-NAG	Image Rijnland/Schieland, Rotliegend & Dinantian. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map Dinantian presence, facies and depth near NAG-01. Map depth and thickness of Rijnland/Schieland in Gouwzee Trough. Tie to wells LEL-01, ZEW-01 & NAG-01. Connect to 2D line NAG-MKN-BRL
Zeewolde-ZEW	Image Rijnland/Schieland and Rotliegend. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Map depth and thickness of Rijnland/Schieland in Gouwzee Trough. Tie to well ZEW-01. Continuation to 2D Lines BUM-AME-FLV. Connect to NAM-DEEP line
LEL-KRD-OFL	Image Rotliegend. De-risk Rotliegend reservoir quality, depth and thickness. Provide data for seismic inversion project in Rotliegend. Tie to wells LEL-01, KRD-01 & OFL-01. Connect 2D lines ALE-LEL-ZEW-NAG, Zeewolde-ZEW, BNV-ERM-OFL and NAM-DEEP
EIB-HKS-ENS	Image Dinantian and faults in Dinantian. Map Dinantian presence, facies and depth. Tie to Twente 3D, Tie to overburden wells EIB-01 & ISH-01
GRL-LTV-COR-WSK	Image Dinantian and faults in Dinantian. Map Dinantian presence, facies and depth. Tie Dinantian and Devonian to WSK-01 well. Tie overburden to LTV-02, GEL-04 and COR-01

Table 2 – Geological goals for the proposed lines

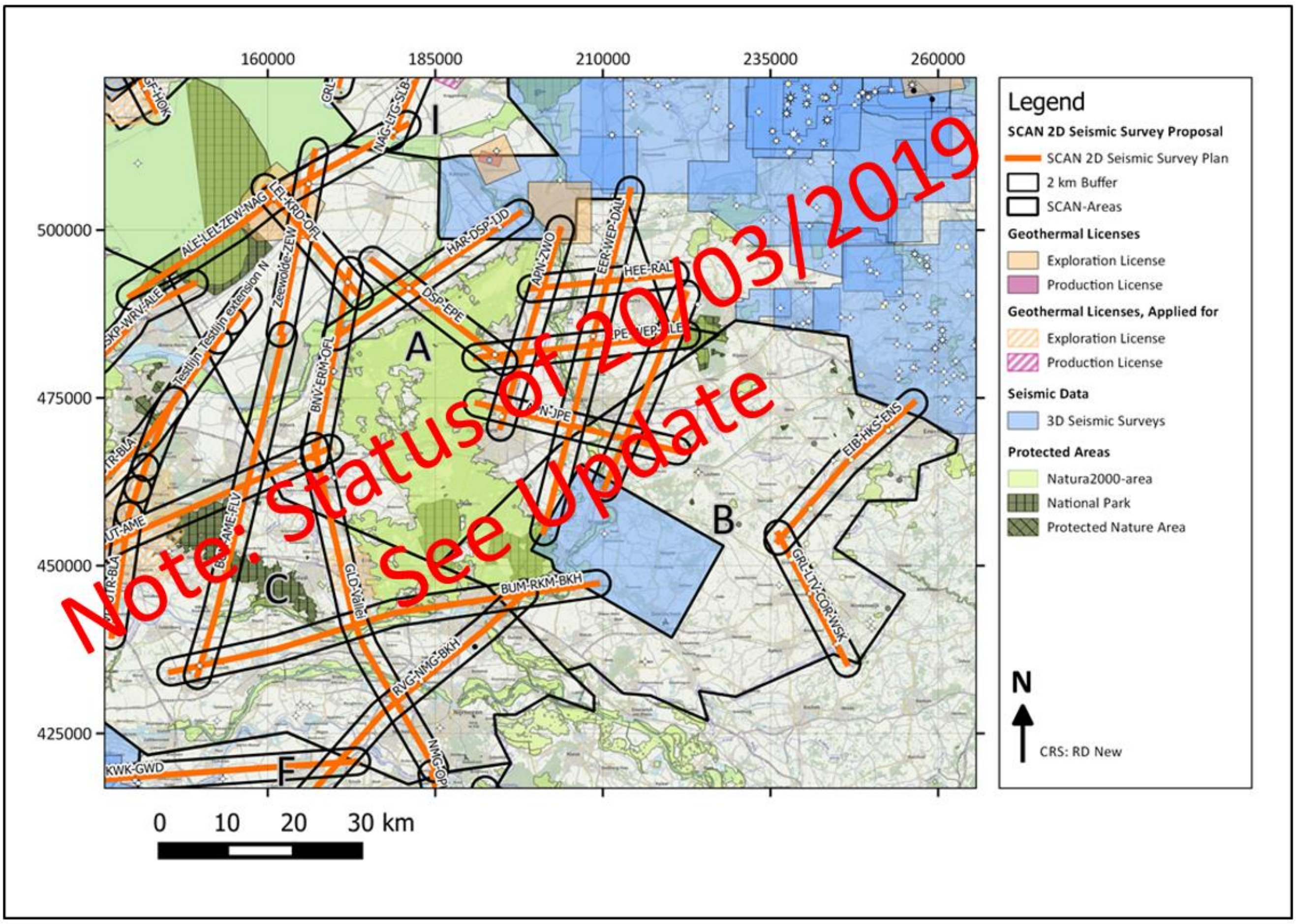


Figure 16 – Seismic survey design for SCAN area A&B. The outlines show the area where full-fold coverage is required. Note: the actual acquisition of these lines is subject to ranking and budget appropriation. ***Please note that this figure displays the status of 20/03/2019, an updated map can be found on page 6 of this report***

Line	Total Length (km)	Comment
APN-ZWO	30.8	
EER-WEL-DAL	52.5	
JPE-HLE	31.3	
HEE-RAL	21.5	
EPE-WEP-HLE	31.6	
APN-JPE	30.6	
DSP-EPE	24.7	
HAR-DSP-IJD	33.0	
BNV-ERM-OFL	28.5	
ALE-LEL-ZEW-NAG	48.6	
Zeewolde-ZEW	27.5	Continuation of line BUM-AME-FLV
LEL-KRD-OFL	21.4	
EIB-HKS-ENS	29.0	
GRL-LTV-COR-WSK	21.8	
Total length	432.8	

Status of 20/03/2019

Table 3 – Length of the proposed lines. ***Please note that line lengths may change if lines are updated***

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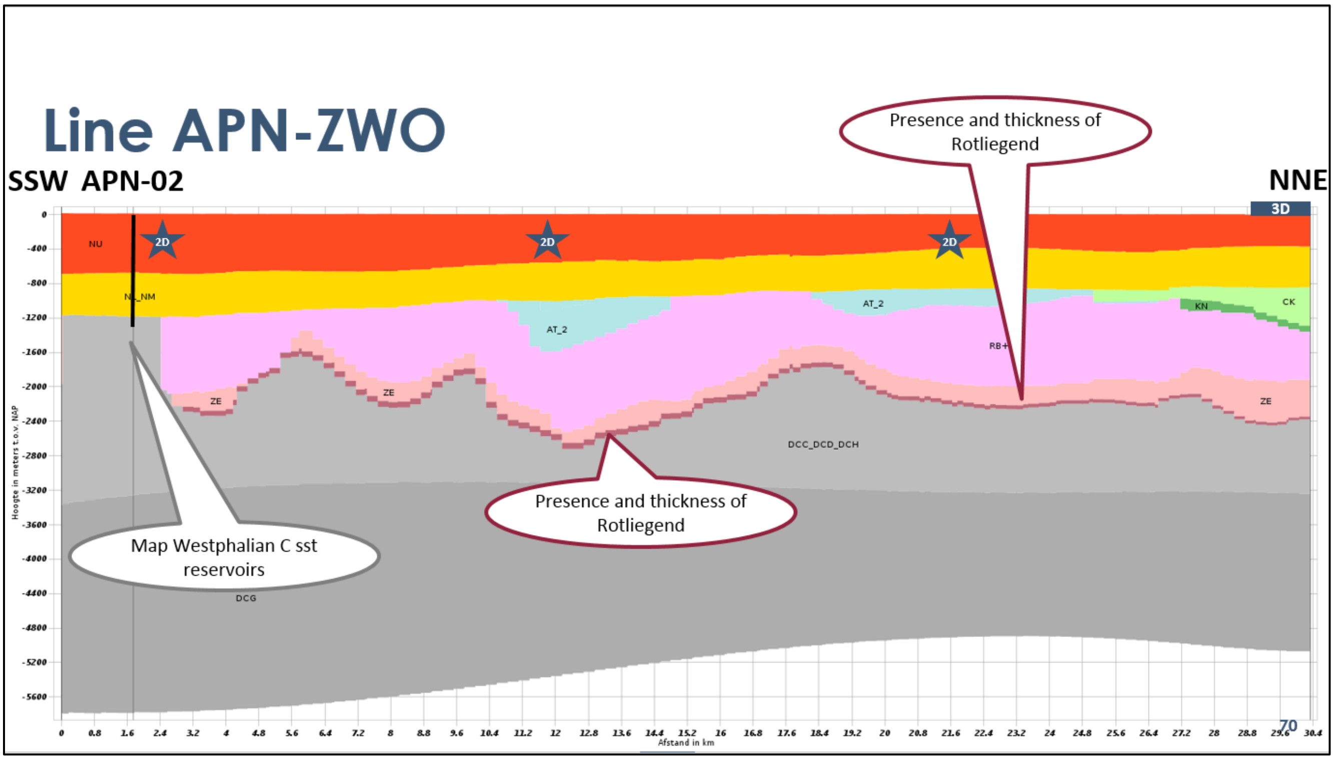
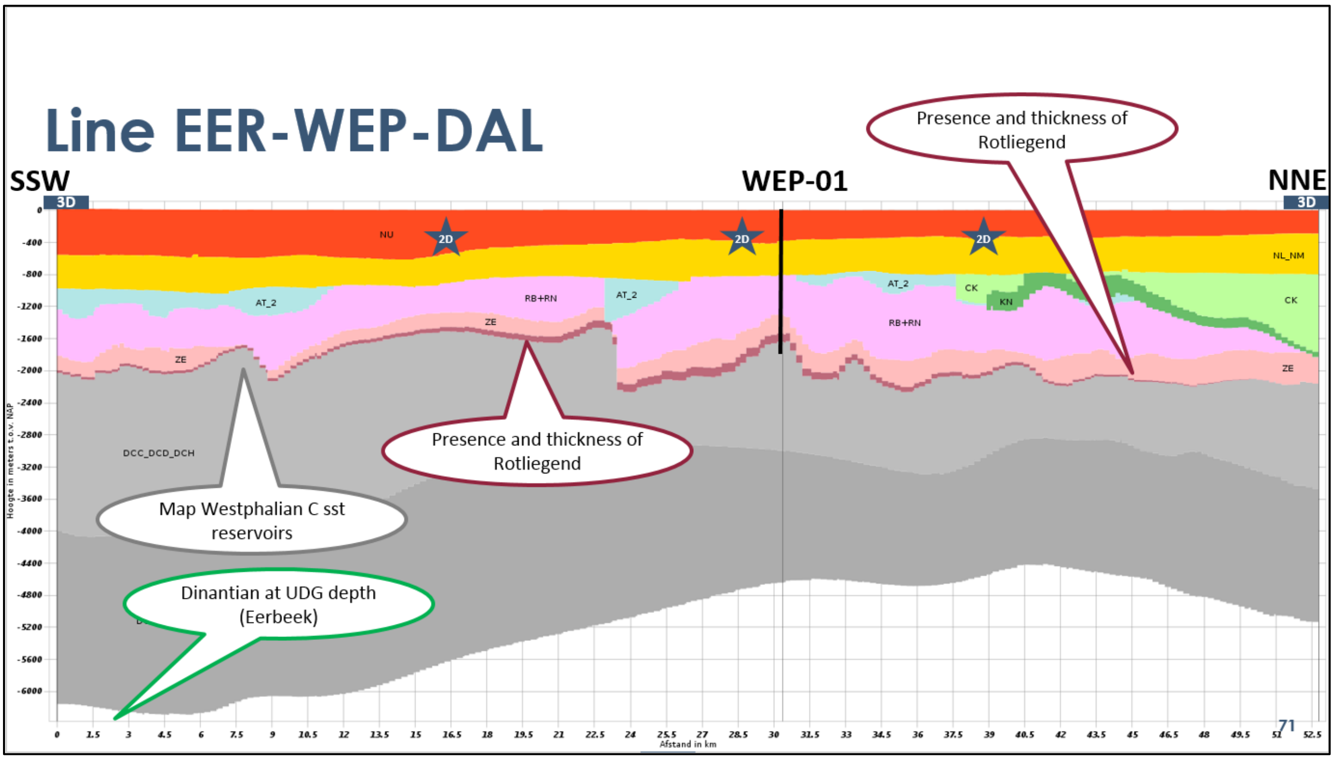
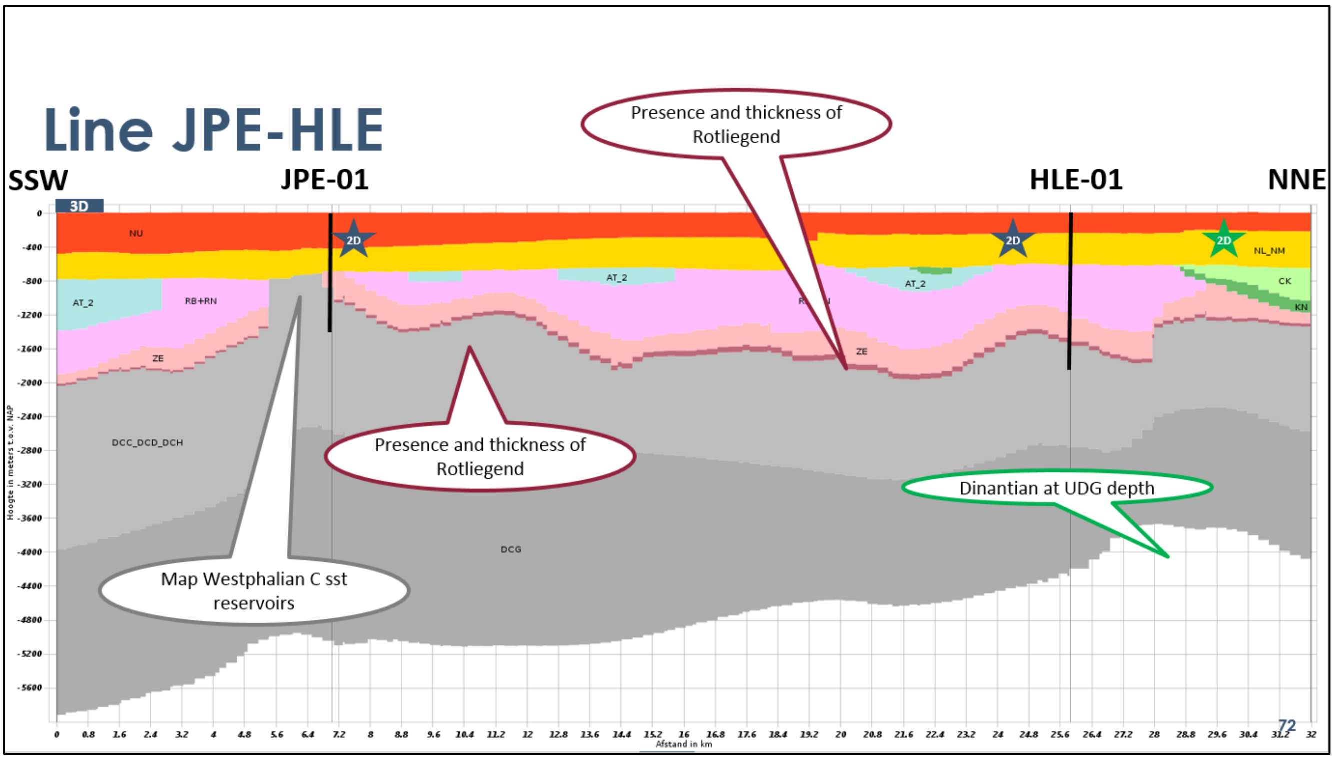
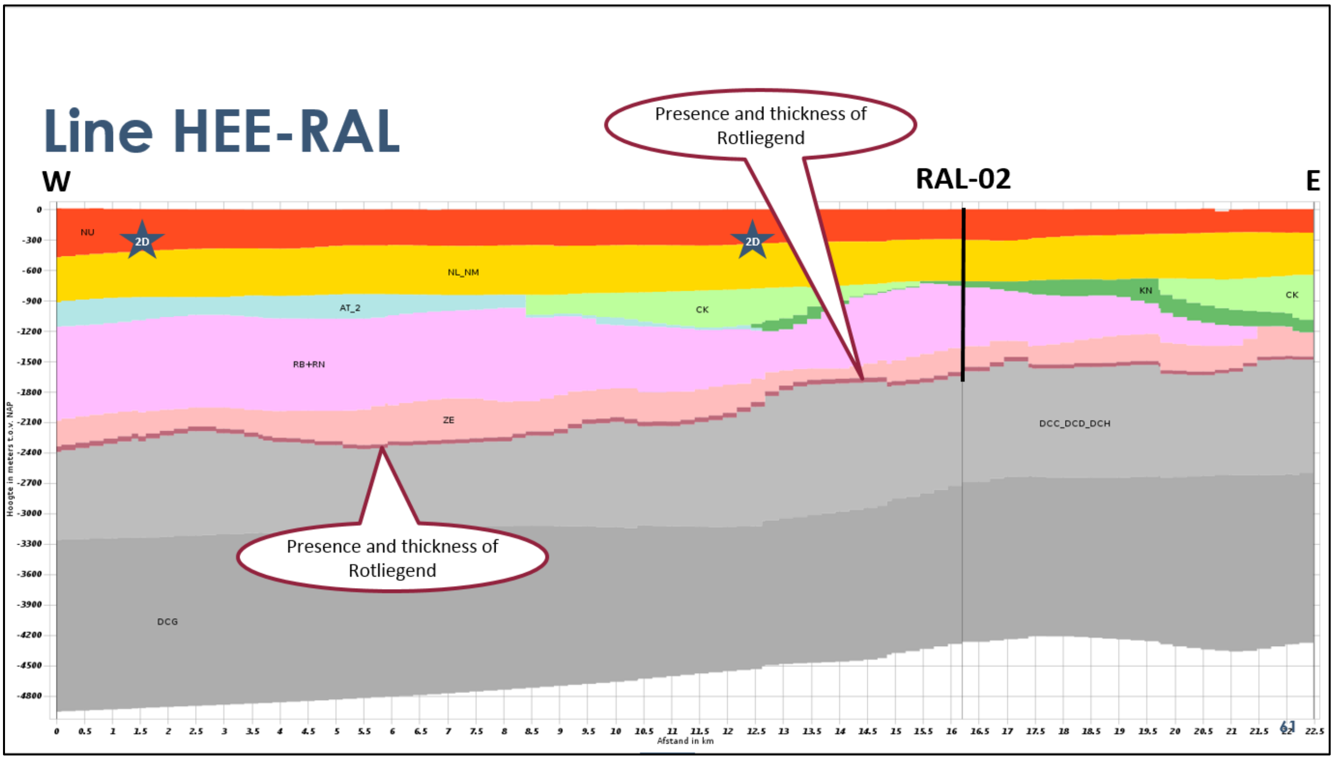
5. Appendices

5.1 Depth sections from DGMdiep v4.0 in Dinoloket over proposed seismic sections SCAN area A&B

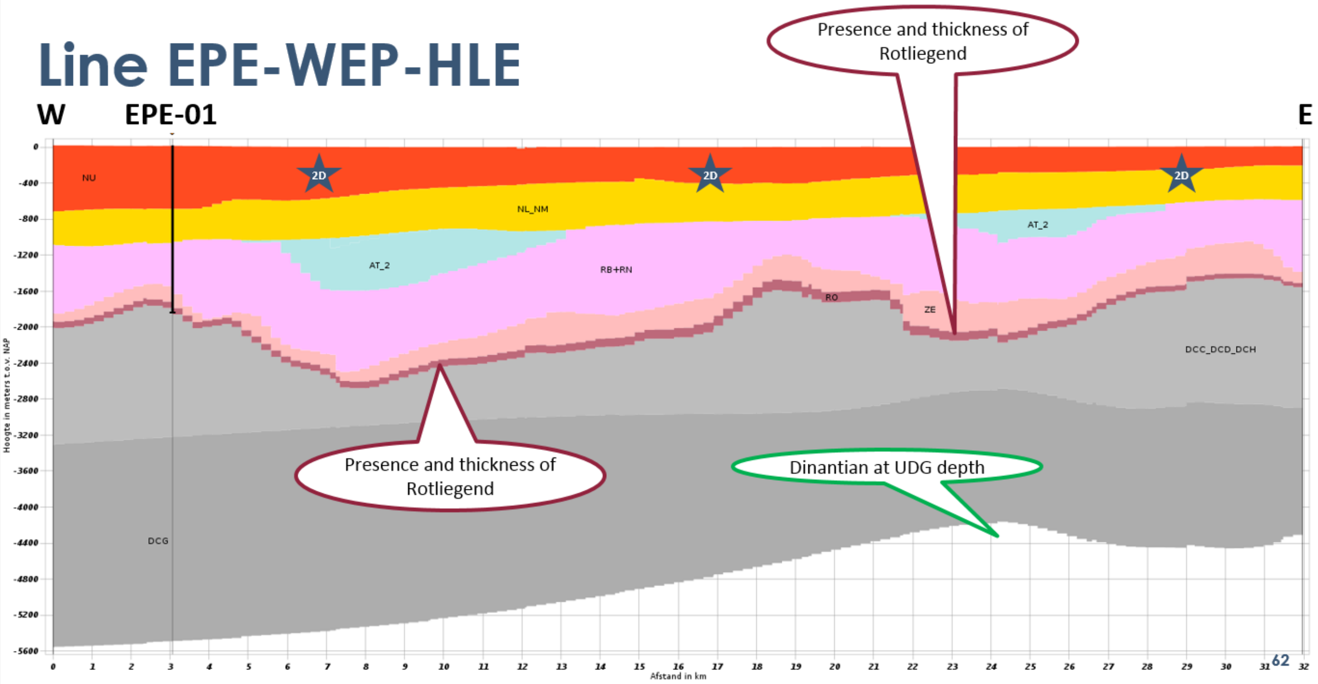




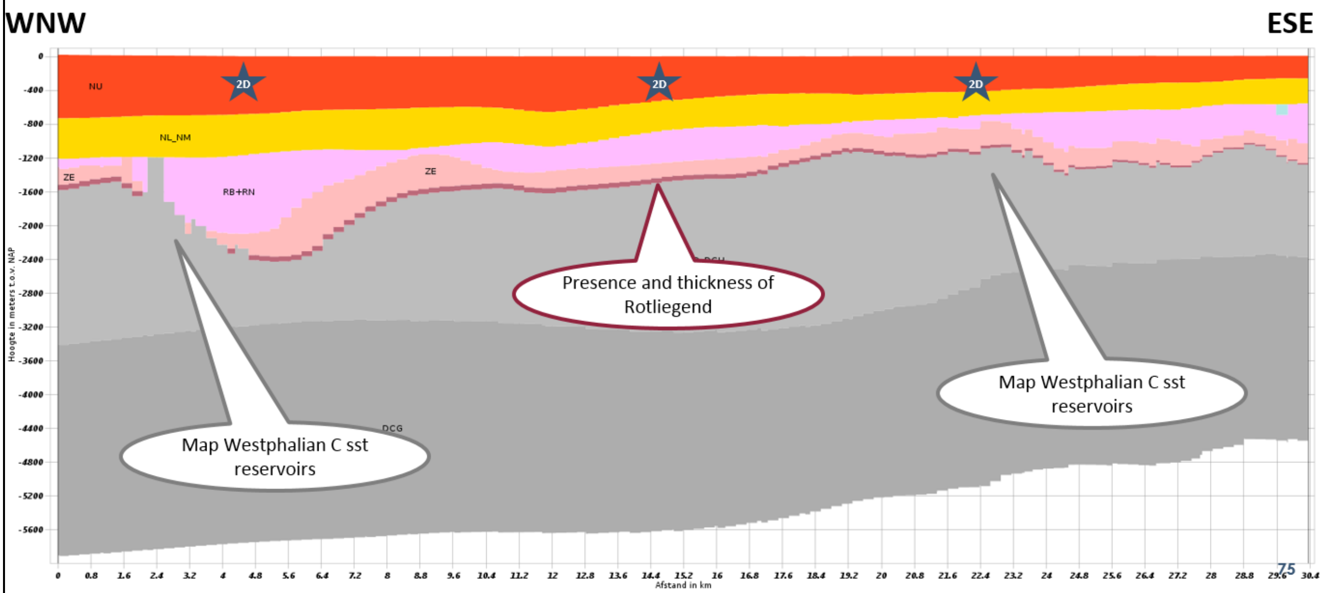

Line JPE-HLE
SSW
JPE-01
HLE-01
NNE
3D
2D
Presence and thickness of Rotliegend
Presence and thickness of Rotliegend
Map Westphalian C sst reservoirs
Dinantian at UDG depth
NU
NL_NM
AT_2
RB+RN
ZE
CK
KN
DCC_DCD_DCH
DCG
Hoogte in meters t.o.v. NAP
Afstand in km
72

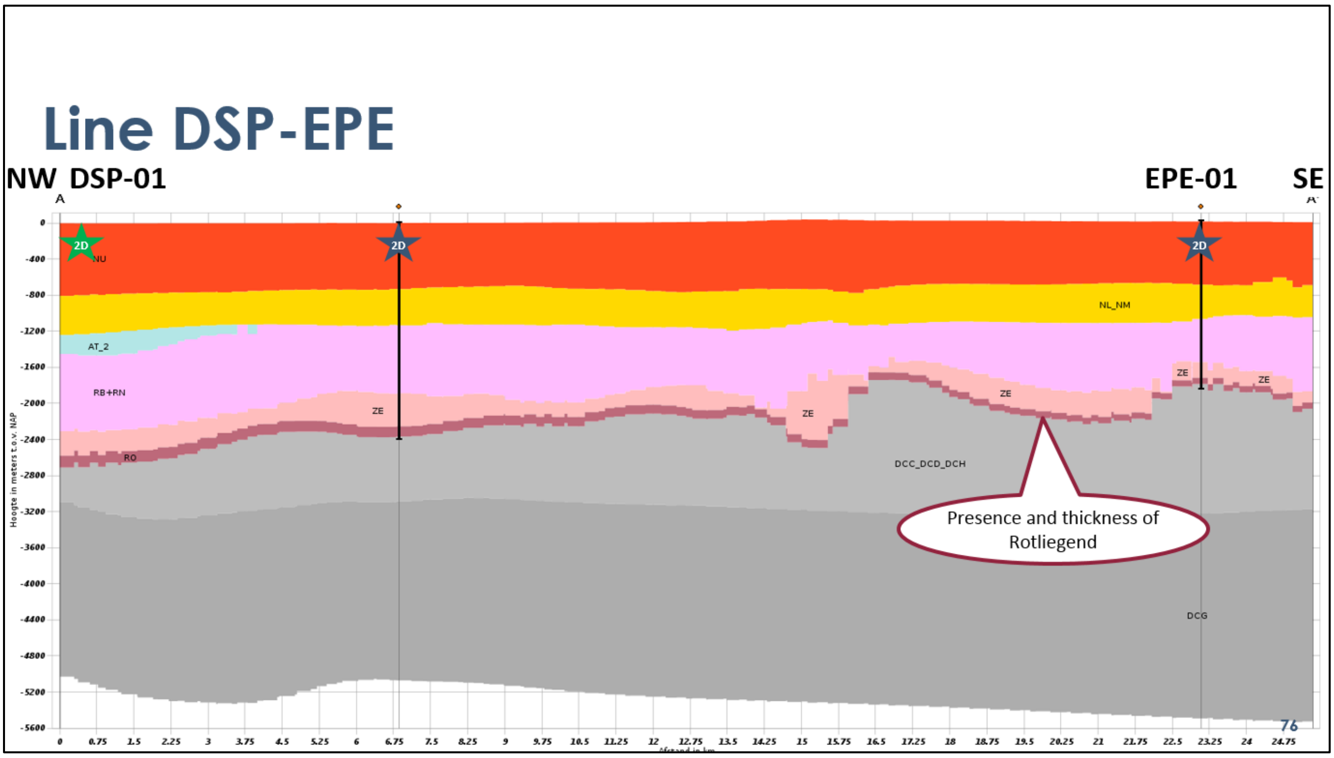

Line HEE-RAL
W
RAL-02
E
2D
Presence and thickness of Rotliegend
Presence and thickness of Rotliegend
NU
NL_NM
AT_2
CK
KN
RB+RN
ZE
DCC_DCD_DCH
DCG
Hoogte in meters t.o.v. NAP
Afstand in km
61

Line EPE-WEP-HLE

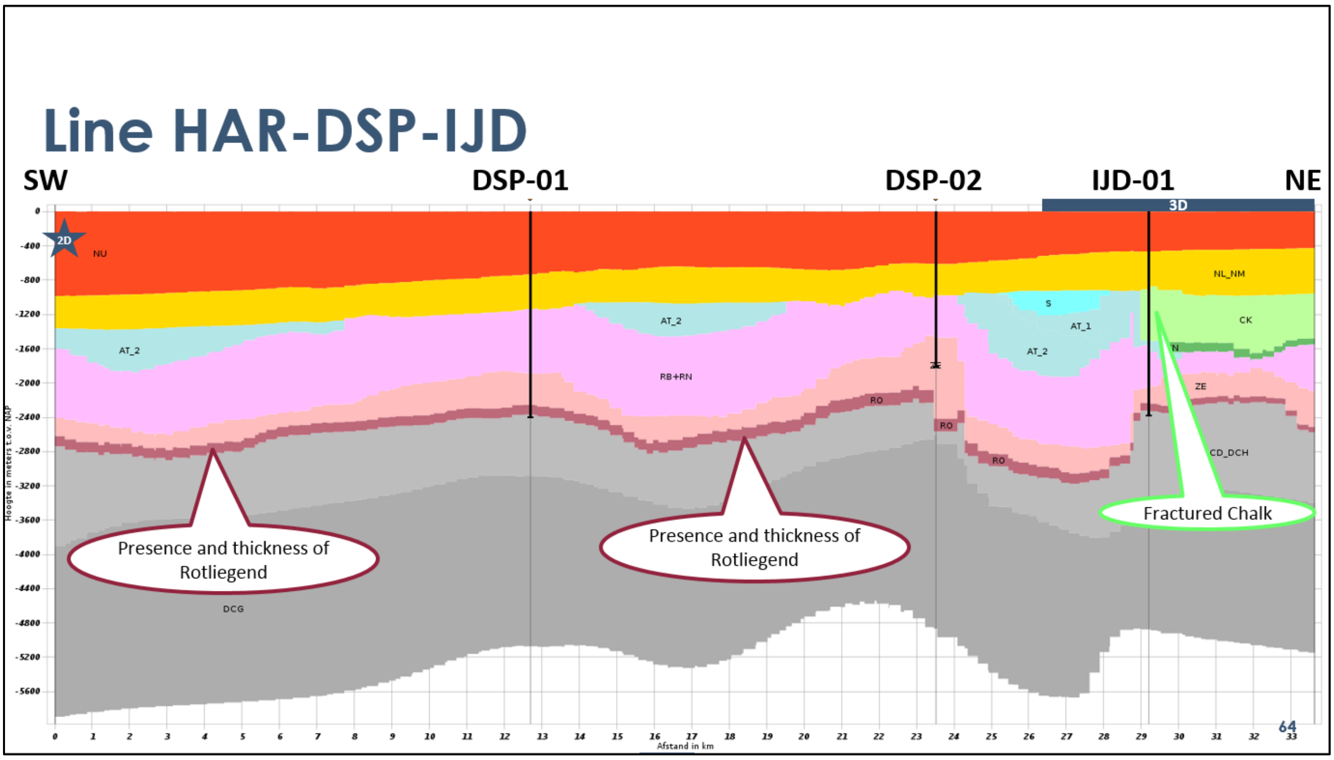


Line APN-JPE



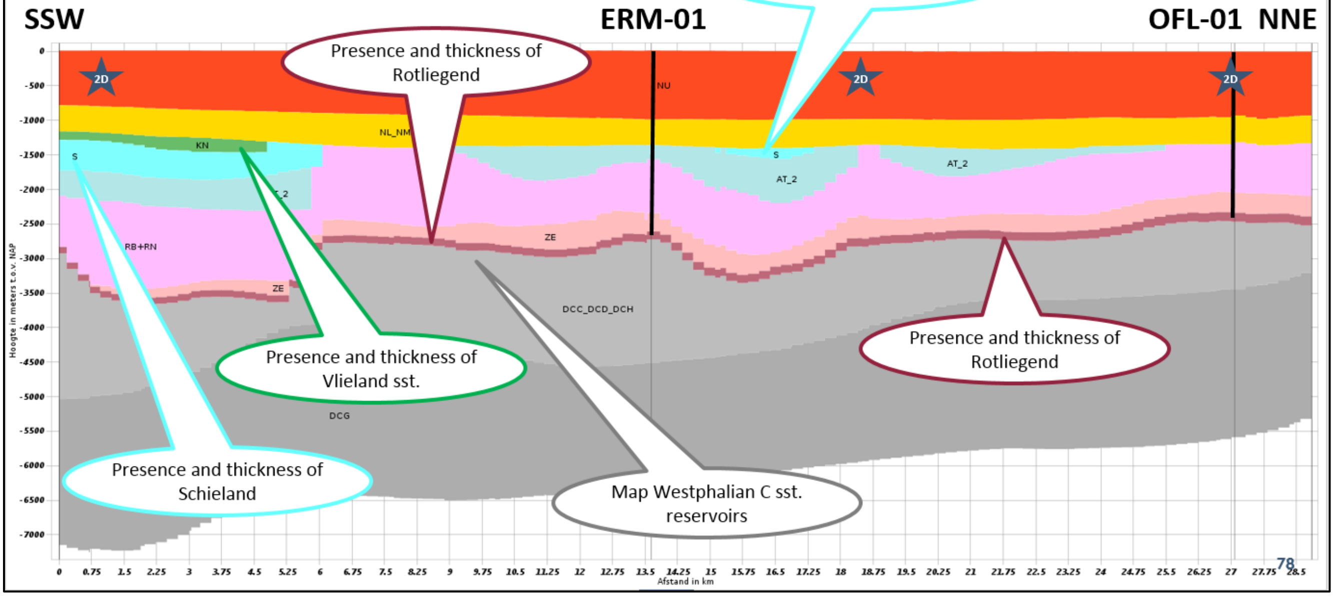


Line DSP-EPE
NW DSP-01
EPE-01
SE
NU
NL_NM
AT_2
RB+RN
ZE
RO
DCC_DCD_DCH
Presence and thickness of Rotliegend
DCG
2D

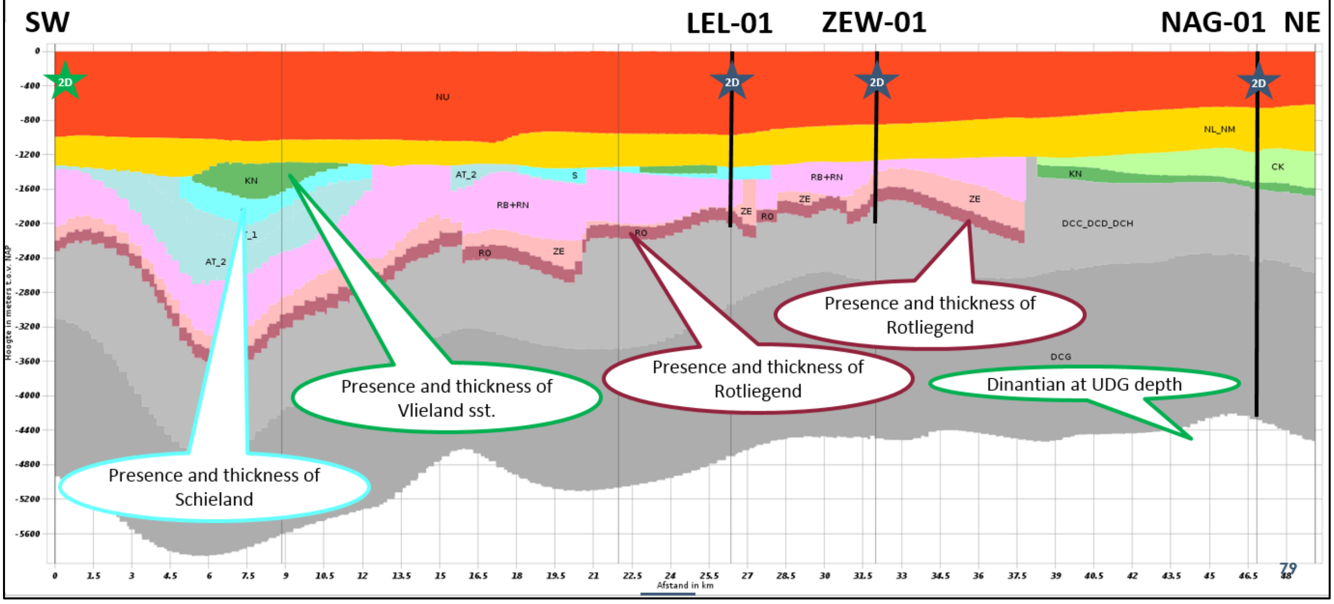


Line HAR-DSP-IJD
SW
DSP-01
DSP-02
IJD-01
NE
3D
NU
NL_NM
AT_2
AT_1
S
CK
RB+RN
RO
ZE
CD_DCH
DCG
Presence and thickness of Rotliegend
Presence and thickness of Rotliegend
Fractured Chalk
2D

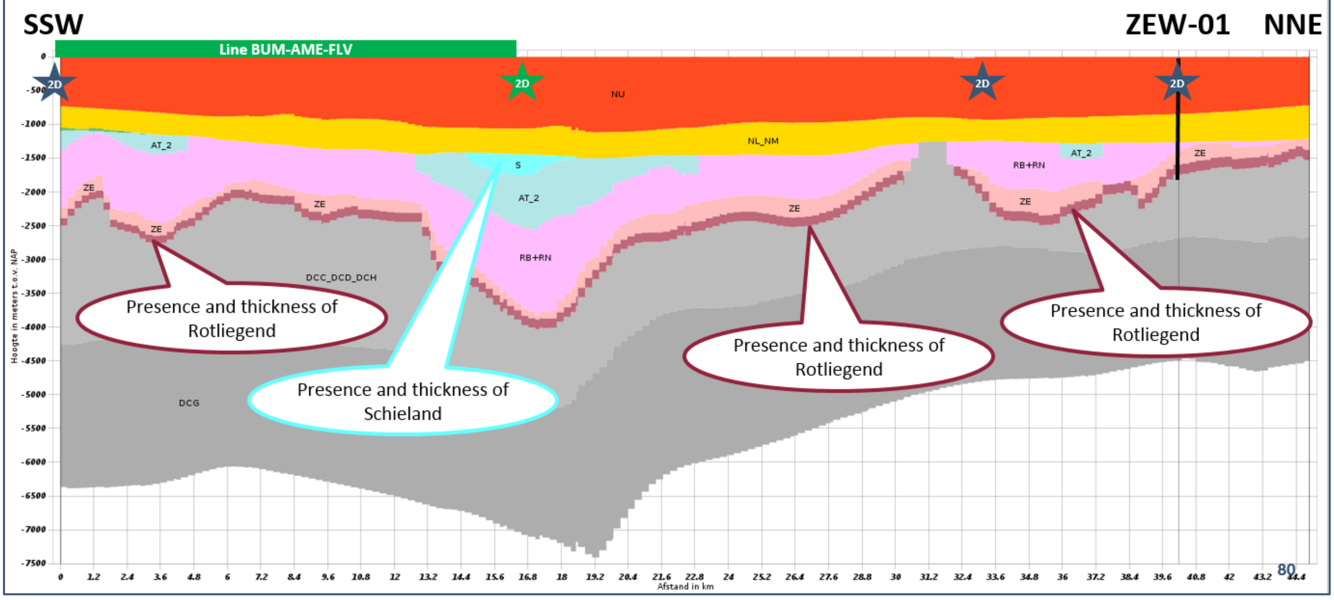
Line BNV-ERM-OFL



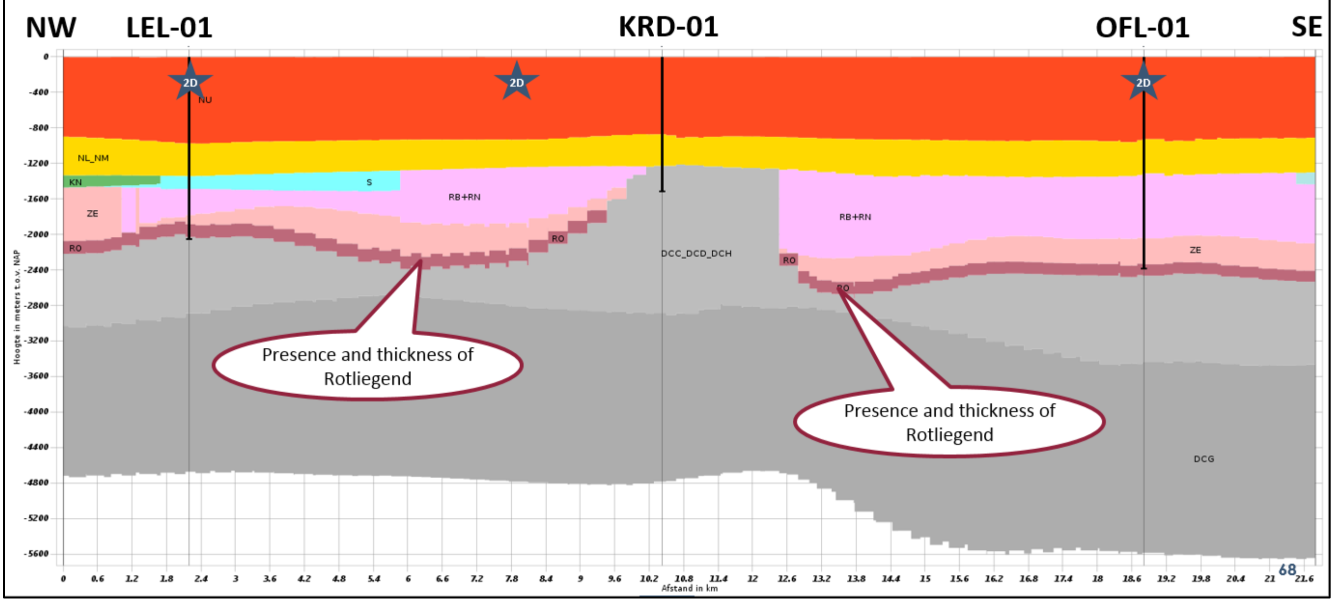
Line ALE-LEL-ZEW-NAG



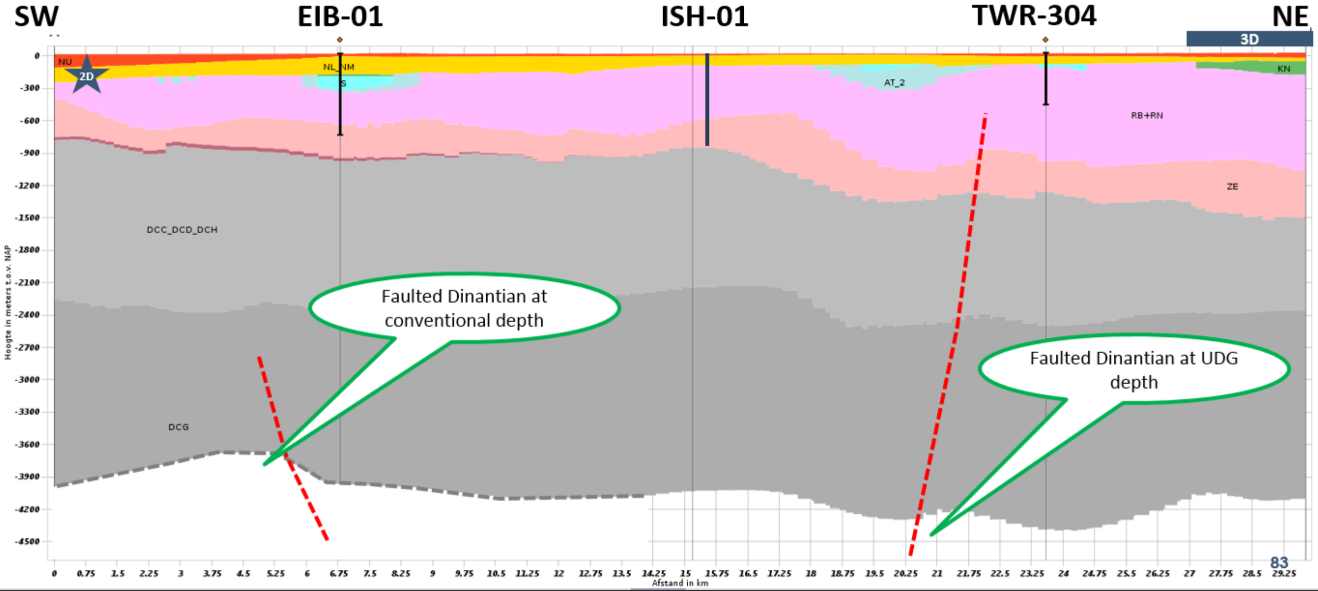
Line Zeewolde-ZEW



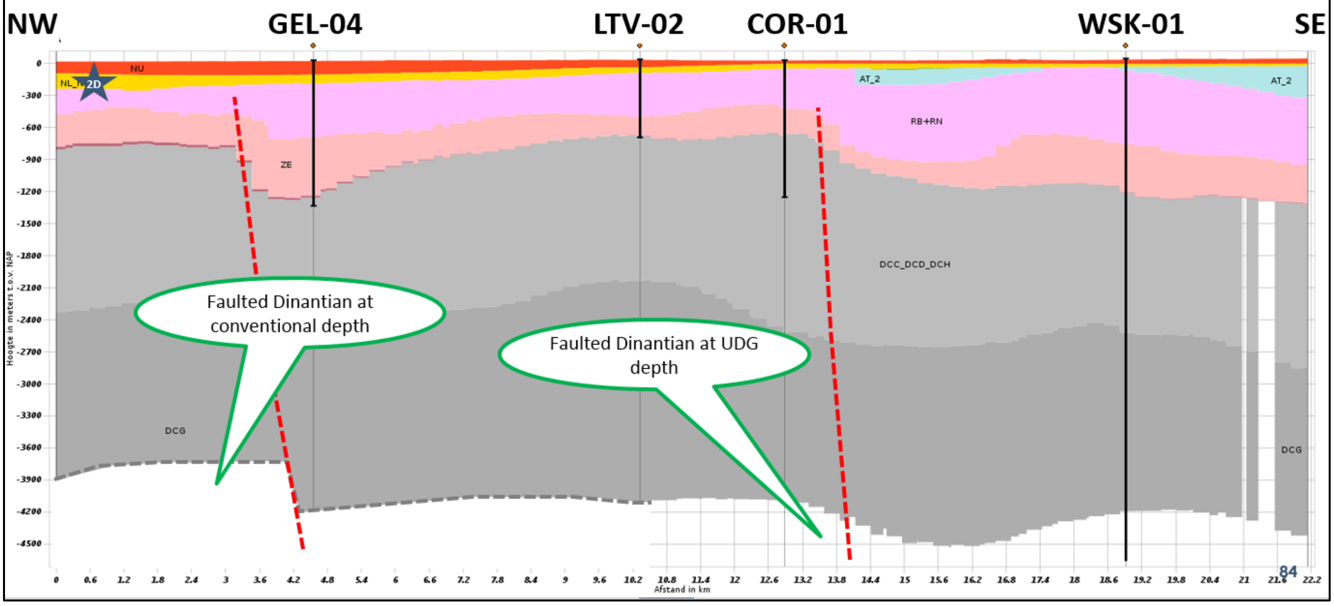
Line LEL-KRD-OFL



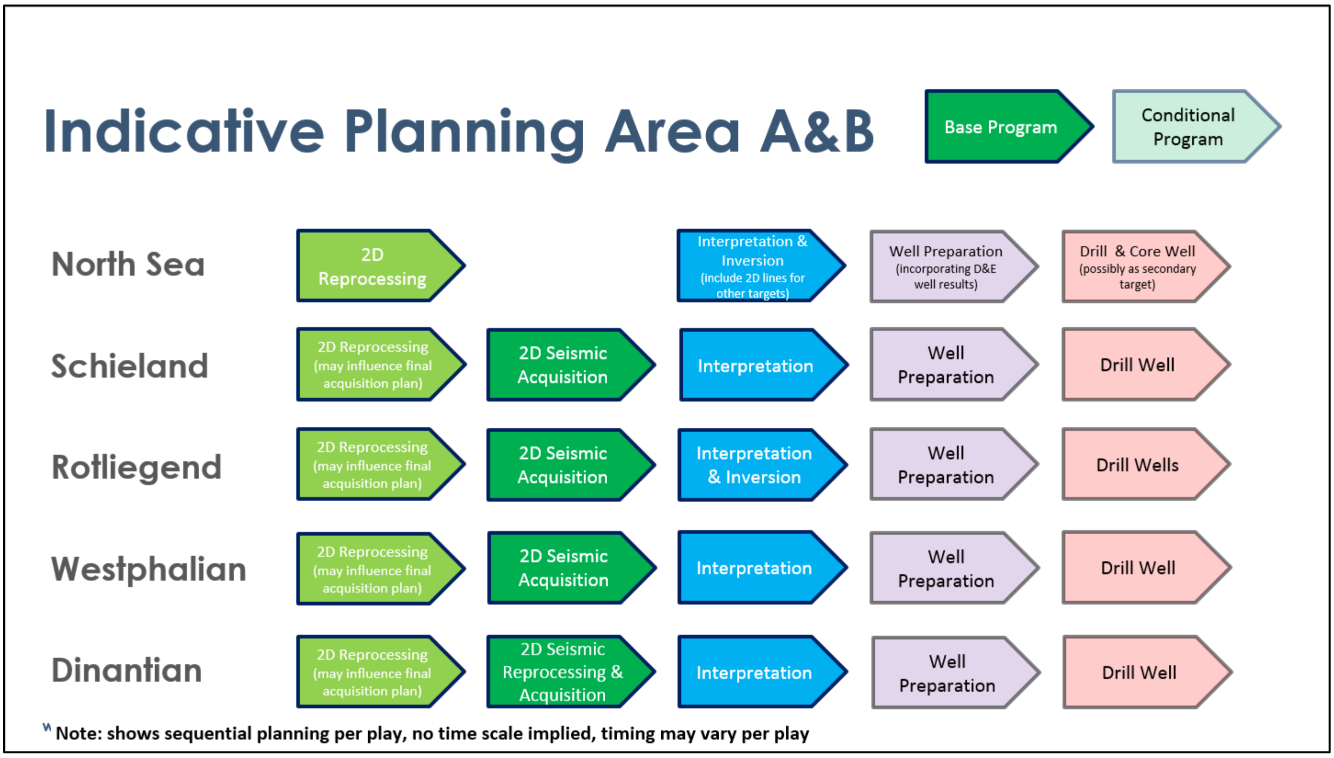
Line EIB-HKS-ENS



Line GRL-LTV-COR-WSK



5.2 Indicative planning SCAN area A&B



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