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Exploring Dinantian Carbonates in the SNS - New Data Offering New Insights

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SUMMARY

Recent well data is throwing new light on the prospectivity of the Dinantian Carbonates, a play which is under-explored in the Southern North Sea area. The geothermal well CAL-GT-01, drilled onshore the Netherlands in 2012, encountered a thick interval of highly productive Dinantian limestone. This is in contrast with the tight carbonate reservoir encountered in two other wells that also drilled Dinantian carbonate build-ups located to the North of the London-Brabant Massif. Comparison of the geological evolution of the build-ups has led to insights with the potential to better predict the presence of karst and fractures. These learnings are relevant for petroleum exploration and for geothermal projects. The prospectivity screening, as conducted by EBN, has identified a cluster of leads in the Southern North Sea, close to existing infrastructure.

The presentation will explain the play, with examples from seismic and well data to illustrate the differences in the evolution and reservoir quality of the Dinantian carbonate build-ups in the Dutch subsurface. Also comparisons are made to relevant outcrops and fields producing from Dinantian carbonate reservoirs. In addition the results of the prospectivity screening will be presented.

Introduction

The Dinantian Carbonate play is under-explored in the Southern North Sea and surrounding onshore areas. Relatively few wells have been drilled into this stratigraphic level and several of these wells had a different objective than finding hydrocarbons. As the state participant in exploration and production in the Netherlands, EBN is undertaking a complete review of this play. The objective of the review is prospectivity screening in selected areas in the Dutch on- and offshore, with the goal to find resources that supplement the declining production from the "traditional" Westphalian and younger reservoirs.

A large regional seismic dataset and all relevant wells are being used in this evaluation. The well dataset includes the geothermal well CAL-GT-01, drilled in 2012. This well encountered a thick zone of strongly fractured, karstified and highly productive Dinantian limestone, very different from the tight Dinantian carbonate reservoir encountered in two other, recently released, wells. This find stresses the need for a good understanding of the diagenesis, faulting and fracturing processes which take place after deposition of the limestone.

The presentation will firstly review the Dinantian Carbonate play, with examples from seismic and well data to illustrate the differences in the evolution of the various carbonate build-ups present in the Dutch subsurface. The dissimilarities in evolution have led to large differences in present-day reservoir quality, as proven by the wells. Also comparisons to relevant outcrops and producing fields with Dinantian carbonate reservoir are made.

The second part of the presentation will discuss the prospectivity screening in the Winterton High area, straddling the UK-NL median line in the Southern North Sea. A cluster of interesting Dinantian Carbonate leads has been identified in currently unlicensed blocks, close to existing infrastructure. The methodology and the results of the evaluation will be presented.

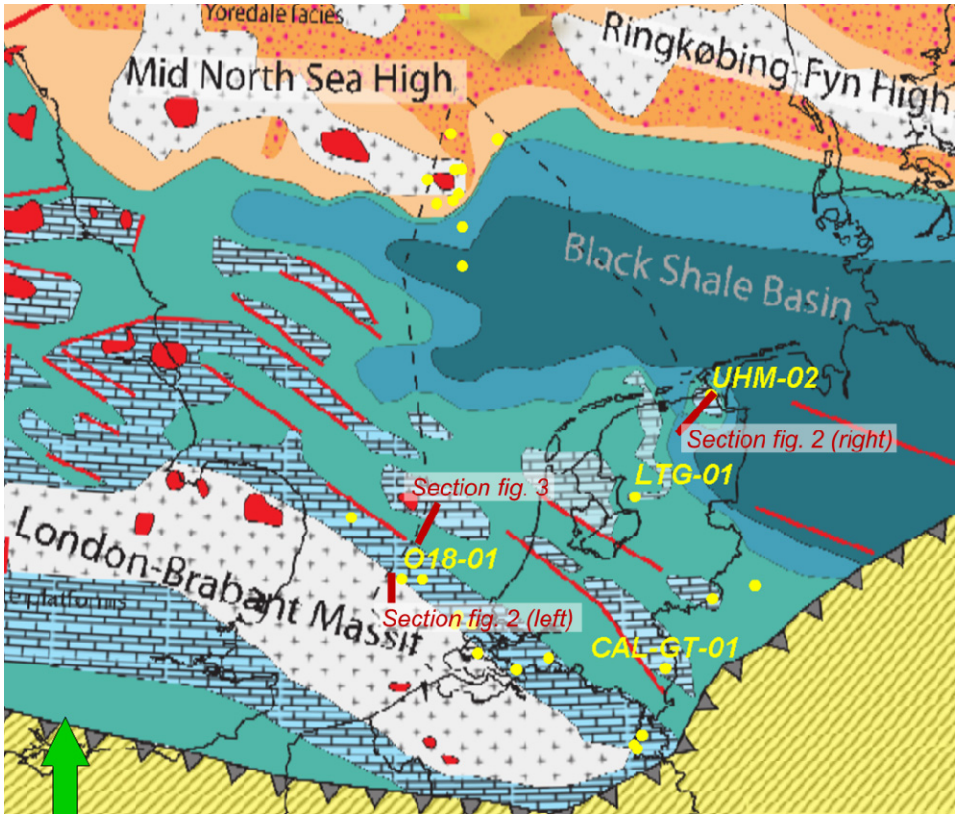

Figure 1 *Lower Carboniferous palaeogeography map (from Van Hulten (2012)). Light blue hashed areas indicate the carbonate build-ups across the Dinantian Basin. The added yellow dots and well names indicate wells penetrating Dinantian strata. Seismic sections in figures 2 and 3 are indicated.*

The Dinantian Carbonate system – setting the scene

The Dinantian basin in Northwestern Europe is delineated by the Mid North Sea-Ringkøbing-Fyn High to the North and the London-Brabant Massif to the South (Gerling et al., 1999), see figure 1. Deposition in the basin varied from predominantly calcareous deposits of the Zeeland Formation in the South to clastic deposits in the North (Farne Group). Onshore wells penetrating the Dinantian all encountered carbonate build-ups. These wells include the recently released wells LTG-01 (drilled 2004) and UHM-02 (2002) and the 2012 drilled well CAL-GT-01. Deeper parts of the basin have not been penetrated by wells, but are expected to contain (deep-) marine shales, similar to the Lower Bowland Fm deposits which outcrop onshore UK.

The Dinantian Carbonate Petroleum Play – assessment of reservoir quality

Relevant analogues for the studied Dinantian carbonate reservoirs are found in various parts of the world. Well-studied outcrops are present in Belgium (Ardennes) and Germany (near Aachen). In the Underground Gas Storage of Loenhout (Belgium), gas is stored in karstified and fractured Dinantian carbonates with porosities up to 20% and darcy permeabilities. In the UK East Midlands, oil used to be produced from Dinantian carbonate reservoirs, e.g. Nocton and Hardstoft. Well known, large fields producing hydrocarbons from this type of reservoir are the Tengiz and Kashagan oil fields in the Caspian Sea region.

As in many other carbonates, the primary porosity of Dinantian carbonates will generally be low, and the reservoir properties strongly depend on post-depositional diagenesis, faults and fractures. Understanding these processes is the key to prediction of reservoir quality and producibility of hydrocarbons or hydrothermal capacity. The Dinantian play has been tested by the drill bit in the Netherlands and immediate surroundings. Few of the ~35 wells drilled so far had HC shows, however, several of these wells were drilled for geothermal or mineral water projects. The wells show that the Dinantian carbonate successions in the Dutch subsurface are characterised by varying levels of fracturing and karstification. The two recent Northern onshore wells UHM-02 and LTG-01 drilled two separate Dinantian carbonate platforms (see Figure 1). Figure 2 illustrates the UHM-02 well and the platform it drilled. Both wells encountered tight limestones with relatively small amounts of fractures and karst features. The LTG-01 has a hiatus at the top, indicating removal of the possibly karstified top section during emergence of the platform. On the contrary, limestones on the edge of the London Brabant Massif were repeatedly karstified due to long-term emergence, as shown by some historical wells in the Southern onshore of the Netherlands (Bless et al., 1981) and as shown by the Loenhout UGS. Seismic data on the flank of the London-Brabant Massif shows anomalies which probably indicate doline features close to well O18-01 (see figure 2).

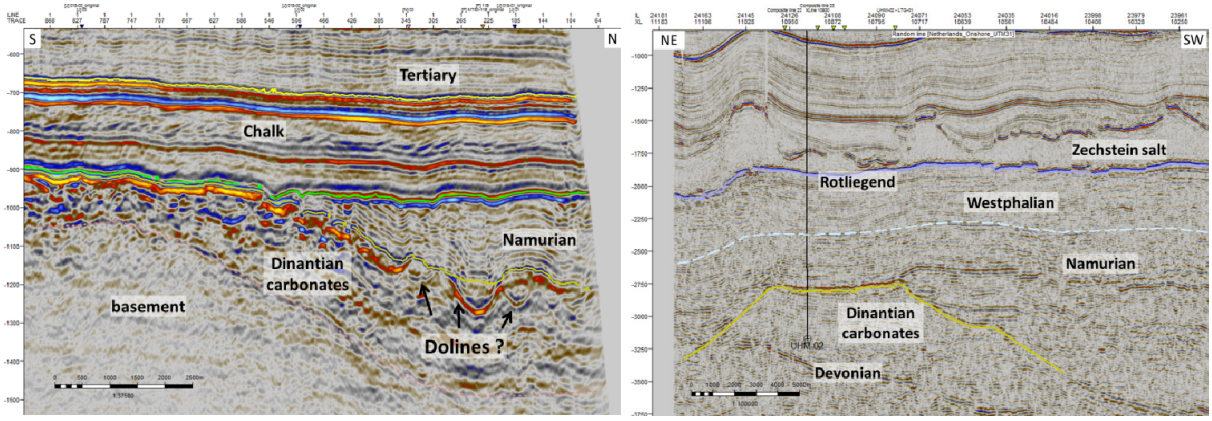

Figure 2 *Left: seismic 2D line running through the flank of the London-Brabant Massif showing possible large scale karst features (dolines).*
Right: seismic section from 3D survey showing the Groningen platform drilled by the UHM-02 well, which encountered few fractured or karstified zones. See figure 1 for the location of the seismic lines.

The California geothermal well – finding a cave

In 2012, the geothermal well CAL-GT-01 drilled a Dinantian carbonate build-up North of the London-Brabant Massif (see figure 1 for location). At a depth of c. 1600 m, this well encountered an extensive zone of karstified and fractured Dinantian limestone, causing total losses and off scale caliper readings. The fractures and karst features could be related to the Roer-Valley graben – Peel Block fault system. This major structural trend runs NW-SE and has been active through time. Part of the karstified zone is related to one of the large faults which extends from Dinantian up till the Tertiary section. The major unconformity and time hiatus at the top of the Namurian-Dinantian section indicates long period(s) of emergence of the structure, possibly giving rise to the karstification encountered in the well. Analysis of samples also indicate that the original deposition of the limestone was in a very shallow marine setting.

From comparing the different results of these three recent wells it is clear that understanding the burial history and fault development is the key to predicting the presence of karst and fractures in the Dinantian carbonates.

Prospectivity screening in the Winterton High area – source, seal and reservoir

Dinantian carbonates are present along the northern edge of the London-Brabant Massif, both in the British and the Dutch Southern North Sea sectors (see figure 1). A prospectivity review is taking place, focusing on currently unlicensed acreage close to existing gas and oil fields and infrastructure in the Dutch P Quads near the Winterton High. Applying the insights, a cluster of leads has been identified that straddles the UK-NL median border (see figure 3).

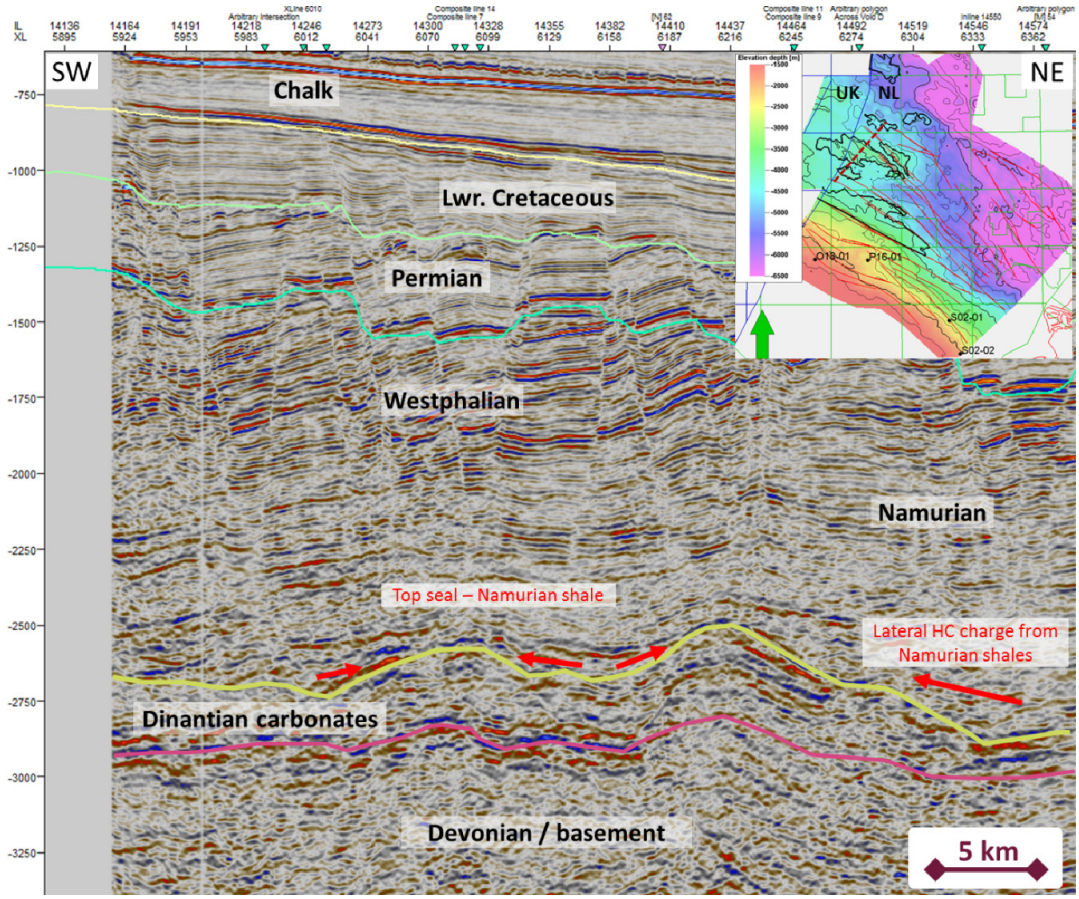

Figure 3 *Seismic section from 3D survey showing a prospective Dinantian carbonate build-up with lateral and overlying Namurian shales which could provide source and seal, respectively. The inset map shows the top Dinantian depth map in the Winterton High area, lead outlines in black.*

The evaluation of the leads includes mapping and time-depth conversion of the Dinantian carbonate ramp and the Namurian section, followed by analysis of the key play elements: source, seal and reservoir quality. Overlying and adjacent Namurian shales can act as seal and source and they are expected to be distributed widely in the area. Modeling indicates that these are mature enough for hydrocarbon generation in parts of the study area. Additional source rock could be found in the Dinantian shales. Closer to the London-Brabant Massif, more sandy clastic intervals might be present in the Namurian section, providing a thief zone that also could become a secondary target for exploration wells.

Probability maps are generated for the presence of fractures, and for the presence of different types of karstification: meteoric, hydrothermal and mix zone karstification. Volumetrics indicate combined GIIP of 10's BCM in five leads. Similar leads have been identified on trend in the adjacent UK blocks. The leads have an average depth of around 4000 m, which is very similar to the average depth of the Kashagan field. The play and prospects could be tested by drilling wells with a secondary target in the Namurian sands.

Conclusions

New data and insights have put a new, positive light on the under-explored Dinantian Carbonate Play in the Dutch sub-surface. A recent geothermal well has proven the possibility of finding productive Dinantian limestone North of the London-Brabant Massif. Analysing multiple wells has led to insights with potential to improve on reservoir quality prediction. Prospectivity screening in the Winterton High area has resulted in a cluster of interesting leads in this play. The study results and learnings regarding reservoir quality are also relevant for geothermal applications.

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