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Insights Into a Complex Geothermal Reservoir in the Lower Carboniferous Carbonates in Northern Belgium

Matsen Broothaers [1], Stijn Bos [1 2], David Lagrou [1], Helga Ferket [3], Virginie Harcouët-Menou [1] and Ben Laenen [1]

[1] VITO – Vlaamse Instelling voor Technologisch Onderzoek, Boeretang 200, 2400 Mol, Belgium

[2] HITA NV, Kleinhoefstraat 5 bus 62, 2440 Geel, Belgium

[3] Departement Omgeving, Afdeling Vlaams Planbureau voor Omgeving, Koning Albert II-laan 20 bus 8, 1000 Brussel, Belgium

matsen.broothaers@vito.be

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ABSTRACT

In January 2016, the Flemish Institute of Technological Research (VITO) completed the geothermal exploration well MOL-GT-01 in Mol-Donk, northern Belgium. The well targeted a Lower Carboniferous fractured carbonate reservoir at a depth between 3000 and 3600 m. A well test proved the geothermal potential of the limestones, with a bottom hole temperature of 138-142°C. This led to the drilling of a second well to close the geothermal loop. Well MOL-GT-02 was completed and tested in summer 2016. Both wells form a doublet delivering heat to VITO and neighboring companies. With regard to the addition of extra low temperature heating networks, VITO drilled a third well in 2018, MOL-GT-03. The latter well targeted the same faulted and fractured zone as MOL-GT-01, although now at 1,6 km towards the Southeast, and furthermore explored the potential of the underlying Devonian strata. For the Carboniferous limestone sequence, comparable reservoir characteristics were expected as for the first well. However, the results of the well test indicated a lower transmissivity than expected. In order to have a better understanding of the reservoir, a detailed analysis was performed on all three wells. The analysis covers both structural, geological, petrographical and hydrogeological aspects. It should lead to a decision on which steps need to be taken to make MOL-GT-03 a successful geothermal well too. The first results indicate a complex structural setting where the identification and positioning of faults in the reservoir is challenging. Petrographical analysis on core samples points to deposition in a restricted environment. It also reveals the presence of anhydrite. Its role in the formation or preservation of secondary porosity (and hence permeability) is not clear yet and will be further investigated in the near future.

1. INTRODUCTION

Berckmans and Vandenberghe (1998) examined the geothermal potential of various reservoirs in the Campine Basin in northern Belgium. Their evaluation pointed to the Lower Carboniferous carbonate sequence as the reservoir with the highest amount of recoverable heat. The first indications of the favourable properties of this stratigraphic interval were derived from the Turnhout well (17E225), drilled in 1953-1955, where the Lower Carboniferous Limestone Group (or Kolenkalk Group) was encountered between 2174 and 2705 m depth. Data on the reservoir characteristics were published by Gulinck (1956), whereas Grosjean (1954) reported on the temperature data. Both the karstified top of the limestone and an anomalously high temperature of 103°C of the water proved the geothermal potential.

Renewed interest in the exploitation of geothermal resources in the 1980s led to several projects targeting the Lower Carboniferous Limestone Group in northern Belgium. The Beerse-Merksplas well (17W265) in 1983, and the wells drilled for the gas storage facility in the region of Loenhout, both confirmed the presence of karstified limestones (Dreesen et al 1987, Vandenberghe et al 2000, Dusar and Lagrou 2007). Vandenberghe et al (2000) published the results of the Merksplas exploration well and geothermal production test. A 70°C hot brine (140 g/l TDS) was found with a productivity index of 5,4 m^3/h per bar. However, the project was suspended due to changing economic conditions and the lack of heat demand in the vicinity of the well.

No further exploration for geothermal energy was carried out in the region until 2009 when VITO became interested in providing heat and electricity from a geothermal plant in Mol targeting the Lower Carboniferous Limestone Group. A prospect was defined, and a drilling location found on the Balmatt brownfield site, near VITO's offices. The idea was to demonstrate the technical and economic feasibility of developing a geothermal plant in the Campine Basin.

In contrast to earlier geothermal wells into the Lower Carboniferous carbonates in the Campine Basin, the project in Mol, which is situated in the deeper part of the basin, did not aim for enhanced permeability in karst zones, but was rather targeting fault and fracture zones. The differences in productivity between the first wells reveal that the reservoir indeed is controlled by fracture permeability, but the reservoir characteristics and the connectivity between wells are not well understood yet. The aim of this paper is to present the first results on two fields of research: the structural setting and the sedimentary succession encountered in the wells.

2. GEOLOGICAL SETTING

The Belgian part of the Campine Basin covers the major part of the Flemish provinces Antwerpen and Limburg (Fig. 1). It is part of the extensive Carboniferous basin of north-western Europe. The northern border of the Campine Basin is formed by the Krefeld high and IJmuiden ridge. Eastward the basin extends into Dutch Limburg, where the NE-SW striking Variscan Anticlinal fault/Oranje fault system forms the boundary with the German Carboniferous Wurm Basin. To the West and South, the basin is bounded by the subcropping early Palaeozoic rocks of the Caledonian London-Brabant Massif.

Predominantly clastic Devonian sediments are present above an angular unconformity at the top of the Caledonian basement. The Devonian strata are covered by Lower Carboniferous dolostones and limestones. In a large part of the basin, these carbonates are intensely karstified. The transition from the Lower to the Upper Carboniferous is marked by a shift from a carbonate to a siliciclastic setting that is characteristic for the Upper Carboniferous paralic coal basin of northwestern Europe. The Silesian sequence starts with marine sediments, gradually becomes more proximal and finally ends with the deposition of fluvial sandstones in the latest Westphalian. In the north-eastern part of the Campine Basin, the Westphalian rocks are disconformably covered by sediments of late Palaeozoic and early Mesozoic age (Permian, Triassic and Jurassic strata). The Palaeozoic and Mesozoic successions are disconformably covered by a 300 to 1.000 m thick sequence of gently dipping Upper Cretaceous chalk and predominantly clastic Tertiary deposits.

The area is transected by a predominant set of (N)NW - (S)SE striking normal faults. Most of these faults already existed during the Carboniferous. The most striking ones have been reactivated during the Jurassic, and some are still active today. A tectonic inversion of these reactivated faults during the Late Cretaceous and Early Tertiary was followed by the subsidence of the Roer Valley Graben in the mid-Tertiary (Van Wijhe 1987; Langenaeker 2000). The resulting pattern is a series of elongated, NW-SE striking fault blocks that are generally tilted towards the North-Northeast. The tilting was caused by the uplift of the London-Brabant Massif during the Kimmerian orogenic phases (Langenaeker, 2000). It causes the Carboniferous subcrop to deepen quickly towards the North and Northeast.

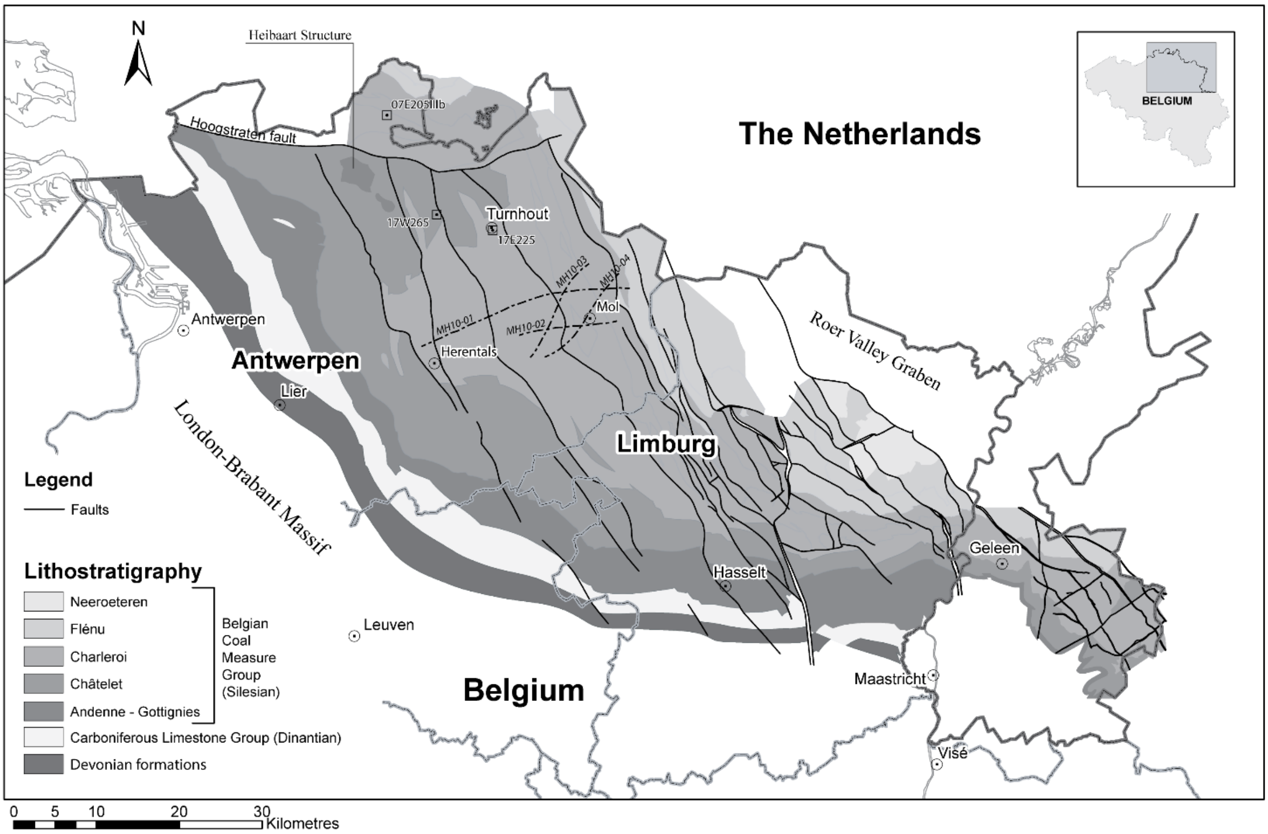

Figure 1: Pre-Permian subcrop map of the Campine Basin in northern Belgium (compiled after Langenaeker 2000 and Patijn and Kimpe 1961). The location of a number of previously drilled wells is indicated (Turnhout – 17E225 and Merksplas – 17W265). The wells drilled for the gas storage facility near Loenhout are positioned on the Heibaart structure. The map also shows the location of the 2D seismic survey carried out by VITO in 2010 (near Mol).

3. EXPLORATION LEADING TO THE PROJECT

3.1 Past exploration (pre-2010)

In the past, several exploration surveys have been carried out in the Campine Basin. In the north-western part of the basin, exploration was initially aimed at finding pockets of natural gas, but later exploration was continued in the framework of subsurface gas storage in the Lower Carboniferous limestone. This eventually led to the development of the subsurface gas storage of Loenhout in the mid-1980s. Seismic surveys in the south-eastern part of the basin were executed in the framework of coal exploration and focused on the extent of coal-bearing formations North of the mining area in Limburg. As Mol is located in between both regions, the amount of seismic data available for interpretation of deep strata was very limited. This prompted VITO to carry out a 2D seismic survey in 2010 (Fig. 1).

3.2 Seismic survey of 2010

The seismic survey carried out in 2010 (2D Mol-Herentals 2010, Fig. 1) covers the area between the towns of Herentals, Mol and Turnhout. The survey comprises four lines with a combined length of 67,5 km. The proposed location of the geothermal plant in

Mol (Balmatt site) is located in between the four lines and is positioned roughly 350 m to the nearest line. To the West, the seismic survey can be correlated with existing surveys.

The results of the survey confirmed and refined the geological model. The data revealed that strata dip towards the Northeast. The depth of the base of the Chalk Group increases to more than 850 m. Below the base Cretaceous angular unconformity, the Carboniferous strata of the Coal Measures Group and Carboniferous Limestone Group dip more steeply. As a result, the Cretaceous subcrop shows progressively younger strata in a north-easterly direction.

The total thickness of the Coal Measures Group also increases in this direction and accordingly, the top of the Carboniferous Limestone Group deepens towards the Northeast. In the West of the survey area the top is situated at a depth about 1730 m, whereas the depth amounts to more than 3400 m in the north-eastern part of the survey area. For the project location, the depth is estimated around 2800 m below surface. This estimate is a refinement of previous assumptions and models, putting the top of the Carboniferous Limestone Group between 2500 and 3500 m depth.. However, uncertainties about the top reservoir interpretation remained significant after the seismic survey, in the order of several hundreds of metres. This is mainly due to the correlation of the top-limestone seismic reflector over the faults downthrowing the limestones to the East (Bos and Laenen 2017).

The Carboniferous strata are affected by a series of faults, dominantly oriented Northwest-Southeast (Fig. 1, Fig. 2). Most faults show a normal displacement and dip steeply to the Northeast. However, some faults dip in the opposite direction.

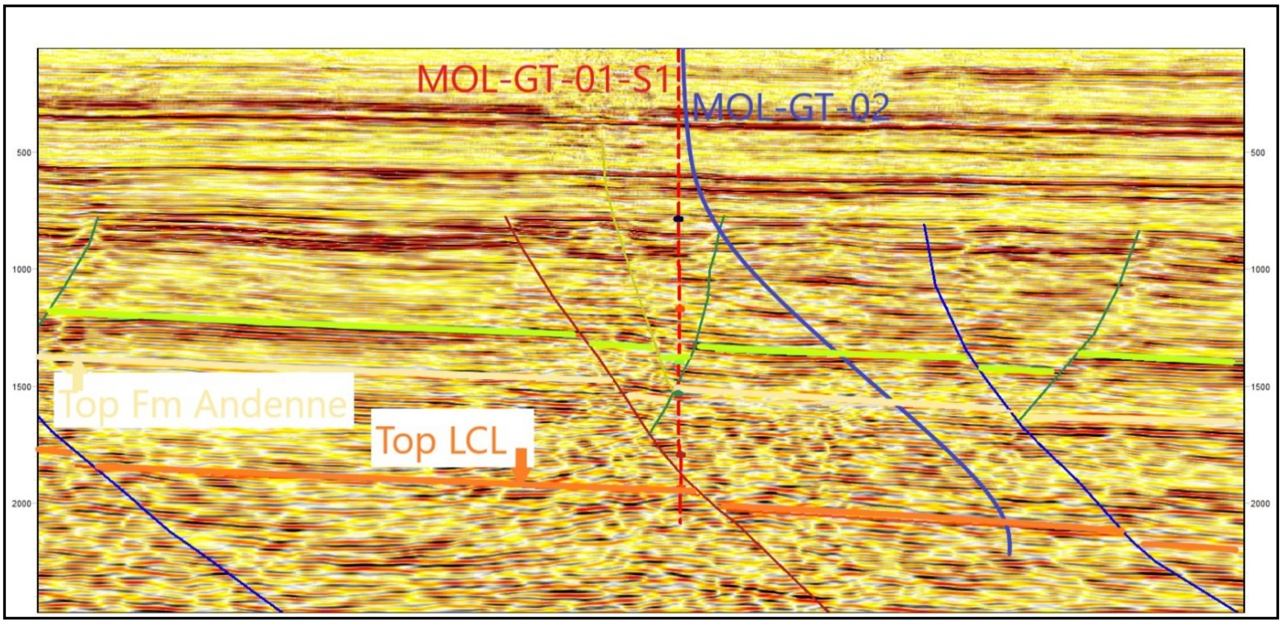

Figure 2: Seismic section (line MH 10-04) showing the interpretation after drilling the wells MOL-GT-01 and MOL-GT-02. The top of the Lower Carboniferous Limestone Group (LCL) is drawn in orange. The length of the cross-section from left (Southwest) to right (Northeast) is approximately 6km. Vertical scale is roughly 2.500 ms TWT.

4. DRILLING OF WELLS

4.1 Results

The first well (MOL-GT-01) was spudded in September 2015 and drilled vertically. It was aimed at a fault zone located directly below the well site. The well design was made considering an anticipated top of the Lower Carboniferous Limestone Group at 2800 m vertical depth. As the top of the reservoir was encountered roughly 370 m deeper, drilling technical issues required the abandoning of the deepest well section and the drilling of a side-track MOL-GT-01-S1[1] (Bos and Laenen 2017). The side-track reached the top of the Lower Carboniferous Limestone Group at a depth of 3175 m. Well TD was called at 3610 m depth. Total mud losses were encountered while drilling in the reservoir section, indicating the presence of transmissivity at least in the immediate vicinity of the well. This was later confirmed by well tests. Testing also revealed a gas content of 2,5 Nm^3 per m^3, consisting mainly of CO_2 (75-80 $\%_{vol}$).

A second well (MOL-GT-02) was spudded in March 2016 and deviated towards the Northeast (Fig. 3), away from the faults visible on the seismic lines. This trajectory was also parallel to the seismic line MH 10-04. The target was an area where the reservoir was not affected by faults to minimize the risk of fault reactivation when injecting water under pressure. This would also provide the opportunity to test the reservoir characteristics of the limestone sequence away from faults. The top of the Lower Carboniferous Limestone Group was encountered at 3300 m TVD (True Vertical Depth), some 200 m deeper than expected. This indicated a larger throw of the normal fault positioned West of the entry point (Bos and Laenen 2017). TD was reached in July 2016 at 4341 m MD (Measured Depth) or 3830 m TVD.

[1] Apart from the technical and drilling aspects, all data, observations and measurements described are from the same borehole which from now on will be referred to as MOL-GT-01. The same holds for MOL-GT-03.

Following the completion of both wells, work started on the construction of the surface installations of the geothermal plant and on the connection to the already existing heating network of VITO (and adjacent companies). The pre-existing high temperature grid would impose a return temperature of 80°C, therefore limiting the thermal power output of the geothermal plant to 8-9 MW. Connecting low temperature heating networks, that could go as low as 30°C, would double the thermal output. Regarding this addition of extra low temperature heating networks, VITO drilled a third well in 2018, MOL-GT-03.

MOL-GT-03 targeted the same faulted and fractured zone as MOL-GT-01, some 1,6 km further to the Southeast (distance at the top of the reservoir). The well also aimed at exploring the underlying Devonian strata. MOL-GT-03 was spudded in December 2017. The top of the Lower Carboniferous Limestone Group was reached at a depth of 3643 m MD (3142 m TVD below surface). For the first time the entire Lower Carboniferous sequence was drilled. The base was found at 4654 m MD or 3992 m TVD (base Vesdre Formation). Due to failure of equipment, a side-track had to be drilled, reaching TD within the Devonian at 4905 m MD (4236 m TVD) in July 2018. Initial well tests pointed to productivity far lower than anticipated.

4.2 Differences between observations and expectations

Observations in the wells show that the Lower Carboniferous Limestone Group is present at considerably greater depth than anticipated. Where a depth around 2800 m was expected in MOL-GT-01, the limestone sequence was only encountered at 3170 m. The larger depth can be explained by both errors or uncertainty in the interpretation of the seismic data and the time-to-depth conversion of the data, and by the larger throw of normal faults (for MOL-GT-02).

Another striking observation was that MOL-GT-03 did not provide the anticipated productivity although the same fault zone as cut by MOL-GT-01 was targeted (Fig. 3). As no mud losses were encountered during drilling, and since well tests did not reveal significant permeability, the exact position of the fault zone in MOL-GT-03 is questionable. The low productivity of the well compelled to a thorough analysis of all data (still ongoing) to attain a better understanding of the reservoir and to clarify why well MOL-GT-01 is successful and well MOL-GT-03 is not.

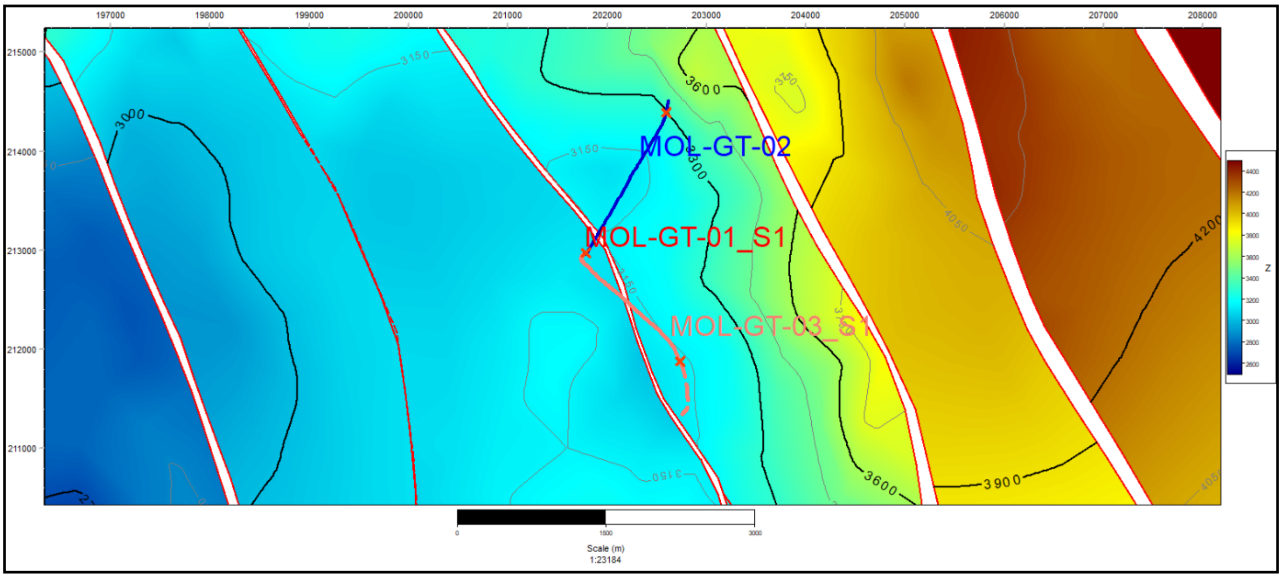

Figure 3: Depth map of the top of the Lower Carboniferous Limestone Group (corrected after drilling all three wells). Well trajectories are shown with entry-points into the formation marked in red.

5. COMPLEXITY OF THE RESERVOIR

In contrast to earlier geothermal wells in the Lower Carboniferous carbonates in the Campine Basin, the project in Mol did not aim for enhanced permeability in karst zones, but was rather targeting fault and fracture zones. As the first well (MOL-GT-01) was targeted at a fault zone directly below the well site, the permeability that was encountered is seen as enhanced due to fracturing in the fault zone. The third well aimed at the same fault zone, and a comparable productivity was anticipated. However, contrary to expectations, well tests and the lack of mud losses during drilling indicate a low permeability in well MOL-GT-03. This reveals significant differences in permeability even within the same fault zone.

The observations suggest the origin and preservation of permeability along the fault zone (and in the reservoir in general) is a complex interplay between different processes. Several factors can be envisaged to have played a role, including (1) the structural setting and the presence of faults, (2) the presence of fractures and their relation to the mechanical properties of the strata, (3) the stratigraphic succession and depositional environment, (4) the diagenetic processes that impacted the reservoir rocks, and (5) the presence of gas (although in solution). The contribution of the various factors and their interplay is not well understood yet.

The first results concerning the structural setting and the sedimentary succession encountered in the wells are highlighted below. For a detailed study of fractures in the reservoir we refer to the ongoing study of van der Voet et al (2019) and van der Voet and Laenen (in preparation). The diagenesis of the carbonate rocks in the Mol wells as well as the origin and role of gas have not been studied yet. Also the analysis of the well tests will not be discussed in this paper.

6. STRUCTURAL ASPECTS

Seismic lines MH 10-01, MH 10-02 and MH 10-04 run closest to the project location on the Balmatt site. Additional processing was carried out in 2011 on line MH 10-04, with both CRS processing and pre-stack time migration (PSTM). A similar reprocessing was done on the remaining lines in 2018. The reprocessed data confirm the main structures already identified. However, several additional faults can also be distinguished in the Upper Carboniferous section (800-1500 ms TWT). The continuation of faults at larger depth remains uncertain, and different interpretations seem possible.

The data quality and the limitations inherent to 2D seismic data sets lead to higher uncertainty in the interpretation of both horizons and faults at reservoir depth (below 2500 m). For faults in particular, there are questions whether their extent is correct both in a vertical (depth) direction as in a horizontal direction (correlation between seismic lines). Different interpretations remain possible on which faults dominate, which faults continue in depth, and how faults interact. As there is no unique solution, additional data are required to constrain the structural interpretation. Observations from wells can be used for this purpose.

Broothaers et al. (2019) looked at observations made during drilling, FMI data, differences in interval thickness between the three wells, and changes in the apparent bedding orientation with depth. All four approaches can provide indications for the presence of faults, however, they may not be conclusive on their own. Combining these methods may give a stronger indication that a fault was actually cut by the well.

Observations during drilling include sudden changes in drilling parameters such as rate of penetration (ROP), but also the occurrence of mud losses or presence of accessory minerals in the cuttings. In this respect the presence of anhydrite in the Upper Carboniferous claystones of the Andenne Formation (2875 m depth) in well MOL-GT-01 is remarkable. Its occurrence coincides with an increase of ROP. It is also present within the Lower Carboniferous limestone sequence (upper part of the Loenhout Formation). Closely below the levels containing anhydrite, (total) mud losses occurred while drilling (from 3280 m).

A Formation Micro-Imaging log (FMI) was run in the lowermost well section of both MOL-GT-01 and MOL-GT-03 (Lower Carboniferous reservoir section). The FMI indicates strong changes in bedding orientation with depth. In both wells there is an interval where dip changes are characteristic of a drag zone. In MOL-GT-01 this drag zone occurs between roughly 3200 and 3325 m depth (Fig. 4). It appears almost centred around the top of the mud loss zone. Higher up, the bedding is inclined towards the East-Northeast. Below the zone, strata dip predominantly towards the Southeast (5-10°).

The most obvious drag zones in MOL-GT-03 are positioned deeper, around 4100 m MD (van der Voet et al., this volume) and between 4300 and 4450 m MD (Fig. 5). Neither of these zones coincides with the occurrence of mud losses nor with the presence of anhydrite. Strata in the uppermost part of the section have a variable dip direction (until almost 3850 m MD). Between 3850 and 4080 m MD, bedding dips to the Southeast to East, similar to well Mol-GT-01. Further down, there is a zone where bedding dips towards the West, on top of the drag zone between 4300 and 4450 m MD.

Finally, stratigraphic markers were analysed in order to identify changes in interval thickness between the wells. As one of the wells cuts a normal fault, part of the stratigraphic section should be missing (faulted out). Therefore, the thickness of the interval between two marker beds should decrease in this well. This is combined with an evaluation of the apparent bedding orientation between the three wells based on XYZ data of the marker beds. The apparent bedding orientation is expected to vary gradually, but sudden significant changes may point to the presence of a fault in one of the wells.

An evaluation of the stratigraphic marker interpretations, has given several possible locations for faulting in the Upper Carboniferous intervals. The fault expected in the Andenne Formation in well MOL-GT-01 is confirmed by the analysis of stratigraphic markers (thickness and orientation) and coincides with observations made during drilling. No FMI data are present for this well section.

The extension of these faults into the Lower Carboniferous Limestone Group remains more difficult. From the FMI data, it was found that a fault might be present in MOL-GT-03 at depths between 4300 m and 4450 m, as previously expected. However, as the other wells did not reach the same depth and stratigraphic interval, changes in thickness and bedding orientation cannot be used to confirm the FMI data. Similarly, a drag zone identified by the FMI log in well MOL-GT-01 does not seem to be confirmed by a change in the apparent bedding orientation or by a missing stratigraphic section. Its position does however coincide with the loss of mud returns during drilling. Even if both wells have cut a fault within the Lower Carboniferous section, it remains unclear if the same fault zone was encountered twice (as anticipated prior to drilling).

7. LITHOLOGY, MINERALOGY AND SEDIMENTARY SETTING

Four well sections were cored when drilling well MOL-GT-01. The first two are positioned in the Upper Carboniferous strata. Two attempts at coring the Lower Carboniferous limestone were made at 3340 m and 3349 m depth (MD). Coring was not successful and only 0,7 m was recovered at the first attempt (3340,0 – 3340,7 m). The result of the second attempt was comparable (3349,0 – 3350,2 m). Poor core recovery (8-10%) was due to the core getting stuck in the core barrel after breaking. Nevertheless, the core material allowed for visual examination and the study of thin sections.

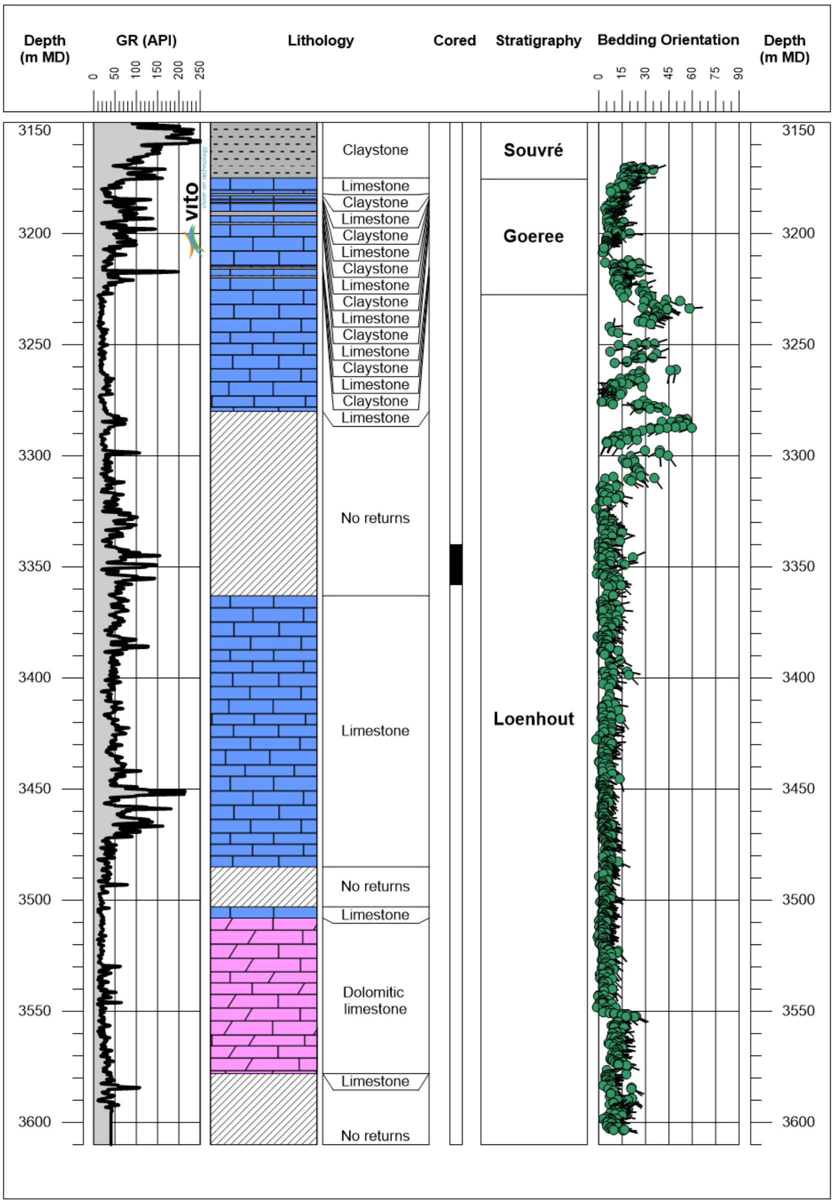

Figure 4: Overview of the Lower Carboniferous section in well MOL-GT-01. From left to right: Gamma ray log, lithology and lithology description, the position of the cored sections, lithostratigraphy (formations) and the bedding orientation derived from the FMI data. Depth is presented in meter MD.

7.1 Main lithology

Based on the macroscopic core description a representative set of the core material was selected for detailed petrographical research. The cored section consists predominantly of grey very fine limestone with silt texture. There are some rare intercalations of coarser bioclastic limestone with hummocky stratification. Eleven high quality fluorescence impregnated thin sections were made.

Macroscopically the rocks samples can be subdivided in 4 groups:

- Dark grey homogeneous limestone with silt texture
- Grey limestone with fine silt texture
- Grey limestone, very fine grained
- Coarse grained limestone

The dark grey homogeneous limestone with silt texture is petrographically classified as a biomicritic wackestone to packstone. The different shades of grey are caused by a varying amount of finely dispersed organic material: the more organic material the darker the color.

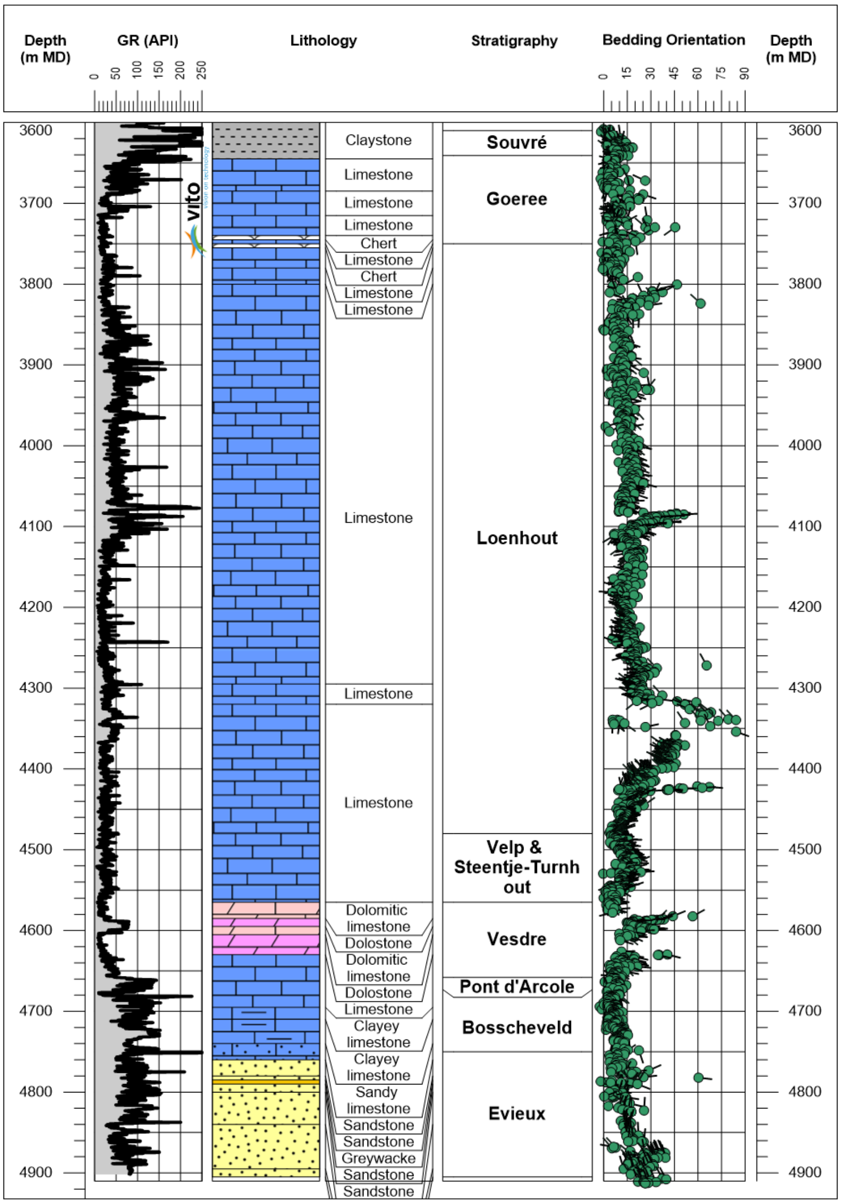

Figure 5: Overview of the Lower Carboniferous section in well MOL-GT-03. From left to right: Gamma ray log, lithology and lithology description, stratigraphy (formations) and the bedding orientation derived from the FMI data. Depth is presented in meter MD.

The coarser grained limestone tends to be slightly lighter grey in color. Typical is the stylolaminated texture (Fig. 6), which is indicative for an intensive pressure dissolution. The original texture of the limestone is heavily overprinted by this dissolution effect. Bioclasts are partly collapsed and compressed. Bioclasts consist of small (benthic?) foraminifera, crinoids, sponge spicula (quartz), pelecypoda (thin shelled), bryozoa, echinoderms, rarely some fish bones. Next to the stylolaminated textures real stylolites are present, made up of an accumulation of organic material (3340,51-3340,58 m).

The numerous presence of sponge needles (spicula) reveals the presence of a spiculitic wacke- to packstone (3340,63-3340,70 m), whereas elsewhere the wacke- to packestone contains lenses of grainstone. The grainstones consist of the same bioclasts assemblage as the wacke- and packstones, but are coarser grained and with a less fine grained matrix. This is an indication of more current or wave activity during deposition. Some of the bioclast encrusted by micritic/iron oxide rim, which means they are transported/reworked sediment (3349,57-3349,66 m, Fig. 5).

Another observation, in line with observations made during drilling, is the presence of completely black chert layers.

In summary, three different lithofacies were recognized:

- Bioclastic Wackestone-Packstone, often with stylolaminated texture, sometimes spiculitic
- Peloidal grainstone (Pelsparite)
- Grainstone

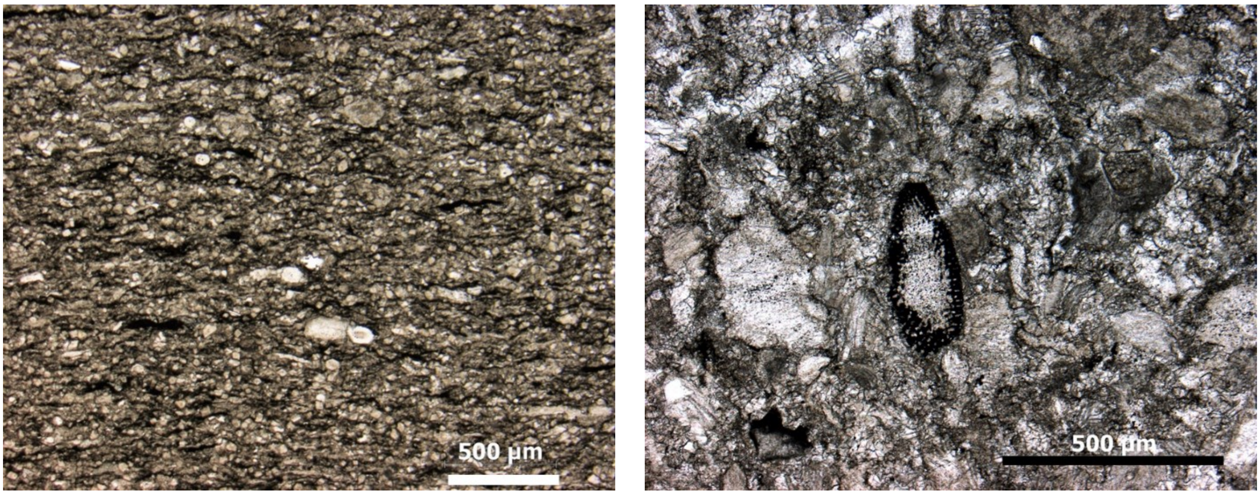

Figure 6: Thin section from 3340,06 m (left) showing a very compacted bioclastic wackestone-packstone with a stylolaminated fabric and recrystallized idiomorphic carbonates. Bioclastic grainstone (right) at 3349,57-3349,66 m with encrusted echinoderm fragment in the center of view, indicating the presence of reworked fossil debris.

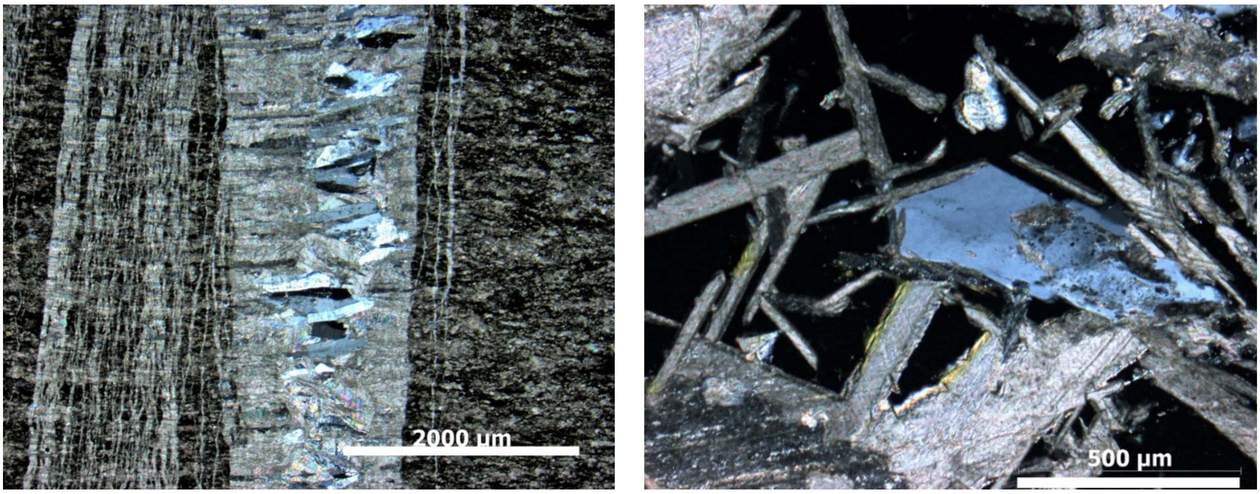

Figure 7: Thin section with crossed-polar view (left) of a calcite vein (swarm) at 3349,97-3350,07 m; in the center of the image there are grey and black gypsum and anhydrite crystals. Detail of a vein infill (crossed-polar view) at 3349,22-3349,32 m (right) showing pseudomorphic calcite after gypsum (selenite) and anhydrite, fluorite and quartz.

7.2 Mineralogy

Veins are abundant in the thin sections. Most of them are thin, closed calcite veins, dipping in different directions (subvertical to subhorizontal). The thin section at 3349,3 m shows a vein of 0,5 mm thick (Fig. 7), clearly consisting of different generations. In the center of the vein relatively large idiomorphic crystals are recognized consisting of pseudomorphic calcite with inclusions of gypsum and anhydrite. Also fluorite and quartz are present. The identification of gypsum or anhydrite is an important observation, as this points to the presence of soluble, evaporitic minerals in the limestone. The presence of these highly soluble minerals might be related to the permeability and porosity in the productive zones of MOL-GT-01.

The presence of gypsum, anhydrite, fluorite, pyrite and bitumen was also observed in the cuttings examined from wells MOL-GT-01 and Mol-GT-03. The schizohaline minerals are clearly related to porous zones in MOL-GT-01, while in MOL-GT-03 very few anhydrite crystals could be identified in the matrix. Sedimentologically, both wells seem to corelate quite well, but the diagenetic setting in and around the fault zone is very different. This seems to indicate that the fault cut in MOL-GT-03 is not the same as the one in MOL-GT-01.

7.3 Depositional setting

On their own, the present bioclasts are not specific enough to precisely define the sedimentological depositional environment. On the one hand there is a lack of typical shallow fauna, like corals, calcispheres or green algae. On the other hand there is a diverse fauna, like sponge spicula, foraminifera, crinoids, bryozoans, and echinoderms.

Altogether and considering the presence of anhydrite, the sedimentary environment during deposition was probably restricted. However, this relatively shallow marine depositional environment was sometimes connected to an open marine environment. The influence of waves is demonstrated by the presence of hummocky stratification.

7. CONCLUSIONS

Interpretation and correlation of faults on the seismic data is hampered by the lower data quality at depth and the lack of 3D data. Using well observations and FMI logs, in combination with the analysis of stratigraphic markers (interval thickness and changes in apparent bedding orientation), allows to better identify the position of faults. Within the Lower Carboniferous reservoir section, FMI data and observations during drilling point to faults in wells MOL-GT-01 and MOL-GT-03, but these are not confirmed by stratigraphic marker analysis. However, further work is needed on the correlation between faults identified in the wells and those interpreted in the seismic lines. Indeed, slight deviations from the overall (N)NW-(S)SE fault trend may result in significant differences in the position of faults with respect to the wells.

The first results from the petrographical analysis of core samples points to a shallow restricted depositional environment. The analysis also reveals the presence of anhydrite, which may play a role in the enhancement of secondary porosity and permeability in the strata. It should be noted, however, that the core samples only cover a short interval of the entire sequence. Further analysis of the cuttings is required for confirmation. Further research should also focus on correlations with offset wells, diagenetic processes that occurred, the origin and role of anhydrite in the strata, and the origin and role of gas in the creation or preservation of porosity (and hence permeability).

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