ET-EMR – borehole campaign (Phase 2): regional geological setting

Introduction

This document outlines the anticipated geological compositions and structures expected during the second phase of borehole investigations. These drilling sites campaign will be selected to investigate different tunnel location and configurations.

The geological information presented here is based on current regional subsurface data (geological maps, field observations, boreholes, geophysical survey, coal mining plans), although variations may occur due to the complex geological history, which includes multiple deformation and fracturing phases.

Geological Context

The investigated sites lie within the frontal zone of the Rhenohercynian fold-and-thrust belt, which developed during the Variscan orogeny (330–300 million years ago). The regional basement consists of Lower Palaeozoic and Devonian-Carboniferous (meta-) sedimentary rocks (Figure 1). This document focuses primarily on the Devono-Carboniferous formations. In the northern part of the study area, these formations are overlain by soft sediments, which cover the upper parts of the hills, shown in light yellow in Figure 1. This sedimentary cover is composed by clay, sand and chalk mainly of Cretaceous age. The thickness of this sedimentary cover is generally less than 100 m, but it can reach several tens of meters depending on local elevation.

This fold-and-thrust belt is characterized by a complex structural framework including an association of folds and southeast-dipping thrust faults. However, in certain areas, some of these faults display a low-angle northward dip due to their footwall deformation. The interplay between these deformed thrust faults and the erosion surface has led to the formation of tectonic windows and klippes.

The regional structural grain follows a NE-SW orientation, which represents the primary longitudinal direction of deformation, although local variations exist. Additionally, numerous transversal faults and fracture zones have been widely recognized, crosscutting the dominant structural trend. Some of these transversal faults show evidence of post-Variscan reactivation, as they are observed to offset the overlying Cretaceous cover.

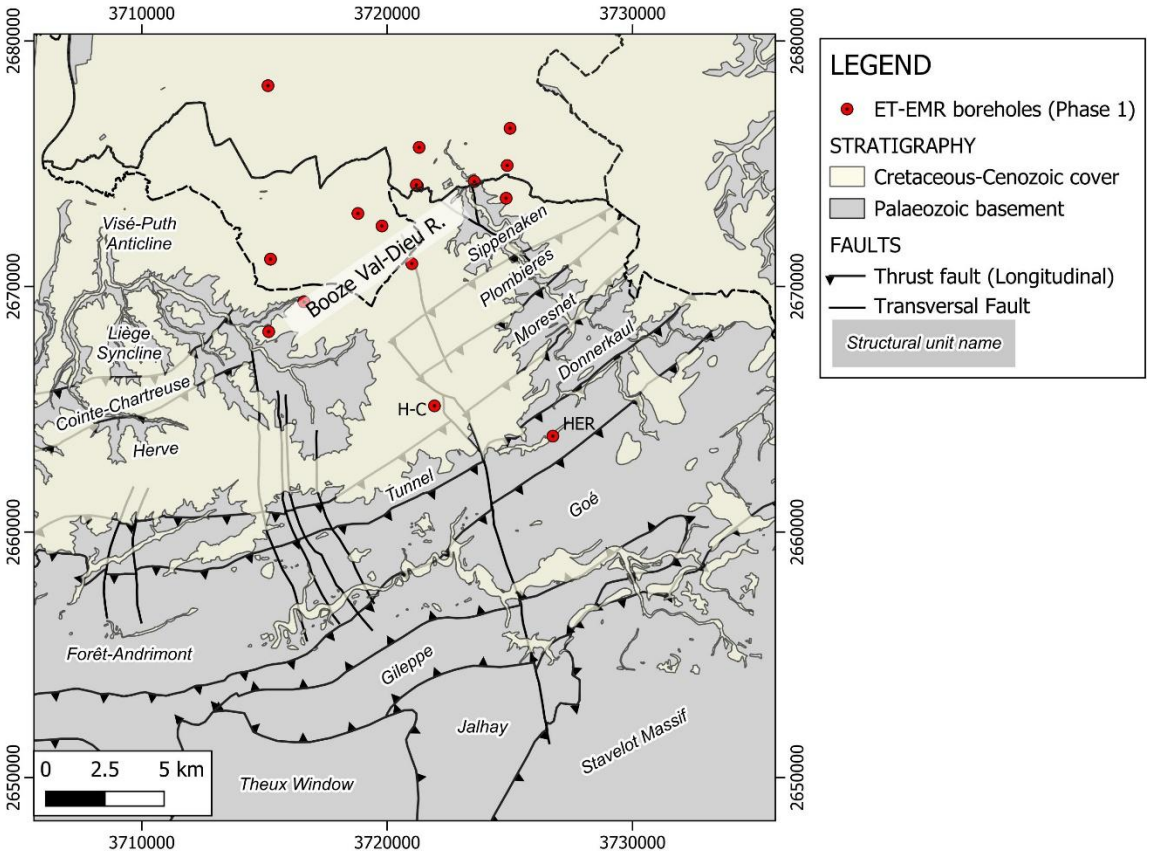

Figure 1 – Simplified geological map of the study area showing the main thrust faults separating the structural units. Location of boreholes drilled during phase 1 (red circles) and the Booze Val-Dieu ridge. H-C: Henri-Chapelle; HER: Herbesthal

The main lithologies of the Devonian-Carboniferous formations include a variety of sedimentary rocks, primarily sandstones, siltstones, shales/slates, along with carbonate units (limestones and dolomites). Local occurrences of conglomerates have also been identified. These rock formations are typically well-cemented and exhibit high degrees of hardness, making them resistant to weathering and erosion. Borehole data obtained during recent drilling phases have also consistently revealed the presence of fracture zones, often resulting in fragmented rock recovery, indicating widespread brittle deformation features. Figure 2 presents a summary of the lithostratigraphic columns representative of the study area. During the first drilling campaign, special attention was given to three main lithological units: the Namurian detrital layers, the Dinantian limestone and dolomites (Viséan and Tournaisian), and the Upper Famennian sandstones and siltstones.

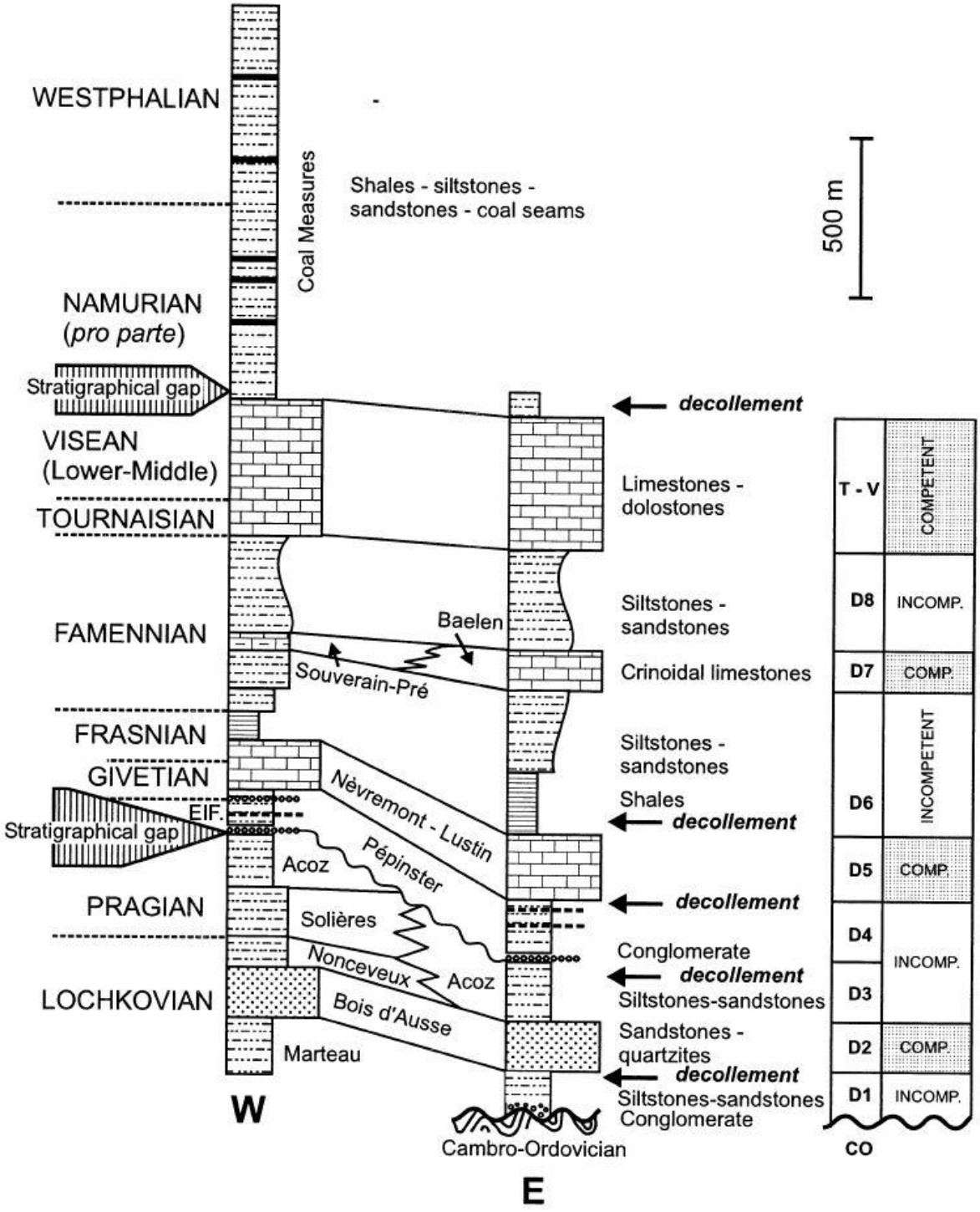

Figure 2 – Lithostratigraphic columns of study area (from Hance et al., 1999[1]).

In an economic geology perspective, fault zones—both longitudinal and transversal—played a crucial role in controlling ore deposition. Historically, Pb-Zn and Fe mineralization were extensively exploited along these faulted structures.

[1] Hance, L., Dejonghe, L., Ghysel, P., Laloux, M., Mansy, J.-L. (1999). Influence of heterogeneous lithostructural layering on orogenic deformation in the Variscan Front Zone (eastern Belgium). Tectonophysics 309, pp. 11-177.

In the western part of the study area, intensive coal mining activities provided valuable insights regarding the local structure. In central part of the coal basin, the operations reached depths of nearly 1 km.

Exploration Areas

1. The Booze-Val-Dieu Ridge

This NE-SW trending structural feature (see Figure 1) was partially investigated during the first phase of borehole drilling. Further investigations aim to refine understanding of its subsurface structure and composition.

Originally identified between Booze and the abbey of Val-Dieu, this ridge was incorporated into geological models of the region by Poty and Delculée (2011). Geothermal studies have suggested that it extends north-eastward toward Aachen, parallel to major Variscan structures.

Stratigraphically, this ridge is characterized by the absence of Lower Carboniferous Dinantian carbonates. Instead, Upper Devonian (Famennian) sandstones of the Montfort/Evieux formations directly underlie the Upper Carboniferous Namurian succession. These sandstone formations exhibit favourable rock-mechanical properties, making them potential host rocks for underground structures. However, engineering challenges remain, especially if the Dinantian carbonates—where present—are karstified.

Structurally, this ridge remains poorly understood. Near Val-Dieu, internal thrust faults have been inferred from outcrop observations. The ridge's northern and southern boundaries may be controlled by faults or folds, though lateral variations remain unclear. It is also possible that deep-seated faulting offsets the ridge internally.

2. Henri-Chapelle – Herbesthal Area

The second target area has been previously explored through boreholes, and further drilling is planned to refine knowledge of the local geological structure.

The Palaeozoic stratigraphy includes, from top to bottom:

- Upper Carboniferous (Namurian) shales and sandstones
- Dinantian limestones
- Sandstone and siltstone Upper Famennian formations

The borehole in Herbesthal (see Figure 1) explored the eastern part of the Forêt-Andrimont structural unit, while the borehole in Henri-Chapelle probably investigated the lateral extension of the Moresnet unit.

3. Northern Rim of the Stavelot Massif

As an alternative location, considerations can be given to investigate structural units located north of the Stavelot Massif (Figure 1). This zone is primarily composed of Lower- and Middle-Devonian formations, dominated by detrital lithologies, including shale/slate, siltstone, sandstone, and conglomerate. Devonian limestone is also present in certain areas.

Structurally, the thrust faults defining the geological units in this region exhibit noticeable bending, which may influence deformation patterns and structural compartmentalization. Exploring this area could provide additional insights while keeping options open for further investigations.

Conclusion

The geological complexity of the region necessitates an additional borehole campaign. While existing data provide a solid foundation for understanding subsurface conditions, actual findings may differ due to structural discontinuities, faulting, and lithological variability. The results of this second phase will contribute to refining geological models and evaluating the engineering suitability of these formations for underground infrastructure.