



**HAL**  
open science

**New insight on the 3D geometry of the  
Nord-Pas-de-Calais coal basin (N France) and its  
Devono-Carboniferous substratum by seismic imaging –  
contribution to a better definition of the low-energy  
geothermal resources**

Aurore Laurent, Olivier Averbuch, Laurent Beccaletto, Laure Capar, Fabien Graveleau, Frédéric Lacquement, Stéphane Marc

► **To cite this version:**

Aurore Laurent, Olivier Averbuch, Laurent Beccaletto, Laure Capar, Fabien Graveleau, et al.. New insight on the 3D geometry of the Nord-Pas-de-Calais coal basin (N France) and its Devono-Carboniferous substratum by seismic imaging – contribution to a better definition of the low-energy geothermal resources. 19th International Congress on the Carboniferous and Permian, German Stratigraphic Commission, Jul 2019, Cologne, Germany. hal-04387869

**HAL Id: hal-04387869**

**<https://hal.science/hal-04387869>**

Submitted on 11 Jan 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Contribution to the session E3-Carboniferous and Permian geothermal resources: oral presentation.

## **New insight on the 3D geometry of the Nord-Pas-de-Calais coal basin (N France) and its Devonian-Carboniferous substratum by seismic imaging - contribution to a better definition of the low-energy geothermal resources.**

Aurore LAURENT<sup>1</sup>, Olivier AVERBUCH<sup>1</sup>, Laurent BECCALETTO<sup>2</sup>, Laure CAPAR<sup>2</sup>,  
Fabien GRAVELEAU<sup>1</sup>, Frédéric LACQUEMENT<sup>2</sup>, Stéphane MARC<sup>2</sup>

<sup>1</sup> Université de Lille - Université du Littoral Côte d'Opale - CNRS - Laboratoire d'Océanologie et de Géosciences, UMR8187, 59000 Lille, France

Corresponding author: [aurore.laurent@univ-lille.fr](mailto:aurore.laurent@univ-lille.fr)

<sup>2</sup> BRGM - DGR, 3 av. Claude-Guillemin, 45060 Orléans Cedex 2 - France

Within the Act of 17.08.2015 on energy transition for green growth voted by the French government, the Hauts-de-France region (Northern France) is committed to invest and develop massively renewable energies in the coming decades. This objective requires here and now the development of regional alternative solutions to carbon-based fossil fuels, including low-temperature geothermal energy. The present research project aims at better characterizing the regional deep geothermal resources in the area of the Nord-Pas-de-Calais (NPC) coal basin. This area is densely populated (about 1.5 million inhabitants) and requires important present and future warming and cooling needs.

The NPC coal basin (that extends 85 km E-W from the Belgian border to St Omer and 15 km N-S from the Brabant foreland to the Midi Fault) is a Late Mississippian - Lower Pennsylvanian (formerly Namurian-Westphalian, ca 320-305 Ma) molassic synorogenic basin that forms part of the large-scale foredeep developed along the Northern Variscan Thrust Front of NW Europe. Lying onto the Brabant Caledonian basement, the basin and its Devonian-Lower Carboniferous substratum constitute the slightly-deformed part of the Avalonian continental margin classically referred-to as the Brabant Parautochthonous Unit. To the south, the basin is overthrust by the Ardennes Allochthonous Unit (also called the Dinant Thrust sheet) that formed by Devonian-Lower Carboniferous times the more distal southern margin of Avalonia. During the Variscan shortening stage (mid-Pennsylvanian in age in the most frontal part of the belt), this allochthonous unit was displaced over 70 km northward along a major crustal-scale thrust fault zone. One of the major emerging thrust fault is called the "Midi Fault" due to its recurrent position at the southern border of the NPC basin. The out-of-sequence dislocation of the frontal thrust zone is pointed out by the presence of some overturned thrust sheets at the footwall of this major fault.

Within the Devonian-Carboniferous substratum of the coal basin, two deep aquifers could represent a potential target for low-temperature geothermal energy: 1) the Dinantian karstic and brecciated limestone (360-330 Ma) and 2) the Givetian-Frasnian limestones (390-370 Ma). The occurrence of a regional geothermal resource has already been proven in Belgium in the Hainaut coal basin where the temperature in the Carboniferous carbonated reservoir of the St Ghislain, Ghlin and Douvrain boreholes reaches about 70°C. However, very little information is known on the structure of these deep reservoirs and their geothermal potential westward, in the NPC region. The geology of the NPC coal basin and its substratum needs therefore to be further investigated to determine and characterize in 3D the reservoirs depth and geometry, their extension and their facies and thickness variations.

As a back-ground of this large project, the first-order 3D geometry of the potential NPC basin geothermal system has been investigated through reprocessing of approximately 500 km of industrial reflection seismic lines acquired in the 1980s (*fig.1*). The seismic reprocessing of the Hauts de France lines used modern signal processing algorithms to improve the image obtained in the 1980s. Efforts were focused on 3 key steps, repeated several times throughout the processing sequence: computation of primary and residual static corrections, detailed velocity analyses and various methods of organized and random noise attenuation. Pre-stack time migration (PSTM), moving dipping events to their correct positions before adding

traces, completed this reprocessing sequence. The few available deep borehole data in the vicinity of the seismic lines (*fig.1*) have been used to set the major reflectors along the profiles and calibrate their depth conversion. Seismic interpretations highlight the major 3D structural framework of the Northern Variscan Foreland allowing the characterization of the different units; namely, the Brabant basement, the Brabant parautochthonous unit, the overturned thrust sheets and the Ardennes allochthonous unit. The internal deformations within each unit is also better constrained. The interpretation of obvious seismic markers emphasizes major thrust faults such as the Midi Fault and related features. The carbonate reservoirs have been identified and their depth and substantial southern extension has been pointed out. Correlations between the different seismic lines reveal lateral and vertical stratigraphic and structural heterogeneities and variabilities in the investigated area.

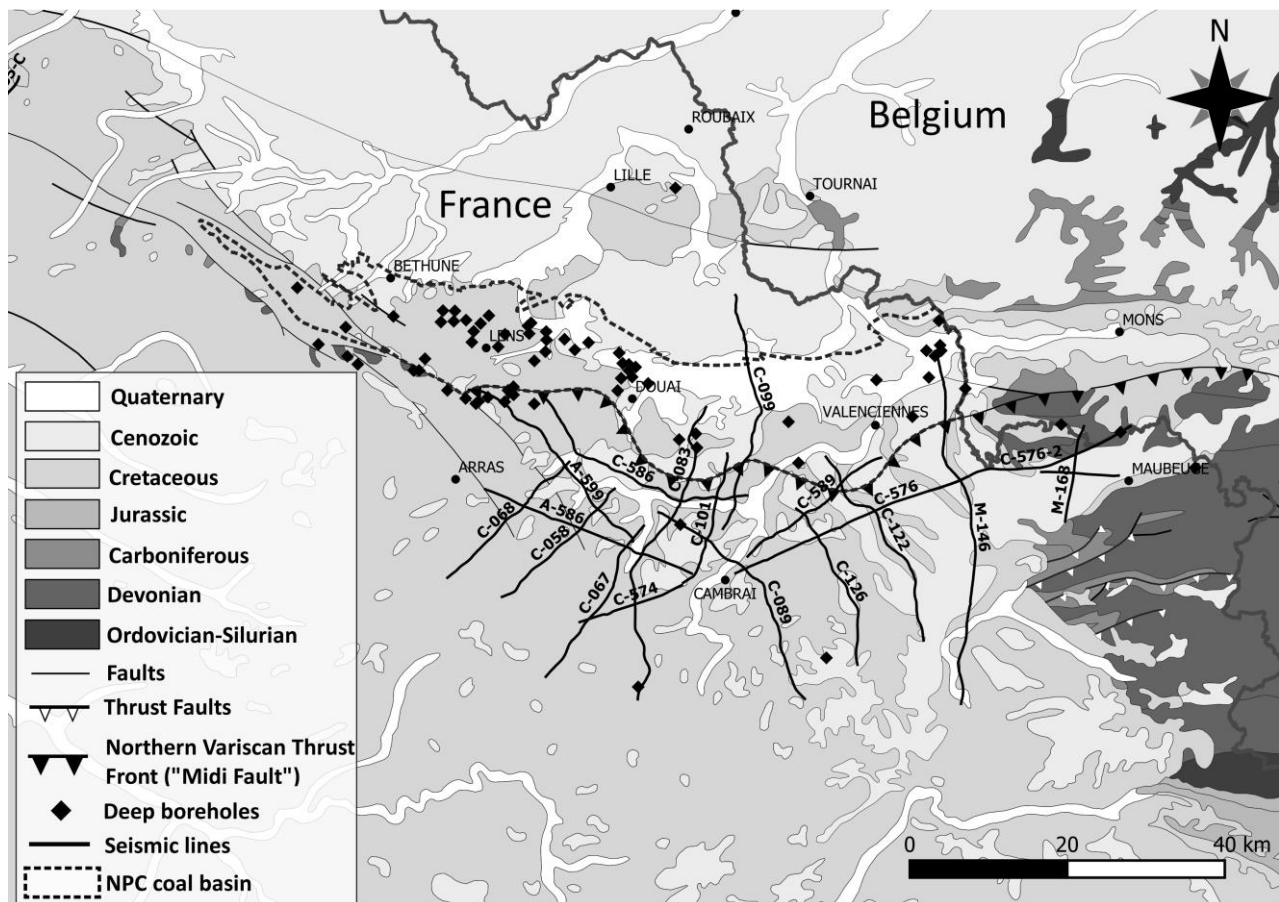


Figure 1 : Sketch geological map of Northern France reporting the location of reprocessed seismic profiles and available deep boreholes. The dashed line refers to the limit at depth of the NPC coal basin.