Comparison of two candidate hydrocarbon fields for a CO_2 storage pilot in the Czech Republic

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Introduction

To be able to demonstrate the technical viability, safety and minimum environmental impact of the technology, a realisation of a **CO2 storage pilot** as a first step towards industrial deployment of CCS technology has been deemed optimal.

For this purpose, the depleted or nearly-depleted **hydrocarbon fields** located in the south-eastern part of Czechia have been chosen as the primary target, mainly due to the overall good level of geological knowledge gained during the exploration and production phases of the fields.

A closer primary screening of possible suitable structures has resulted in selection of two candidate structures – LBr-1 and Zar-3.

This presentation provides an overview of the initial activities performed in this direction in the Czech Republic, focusing on the issue of site selection.

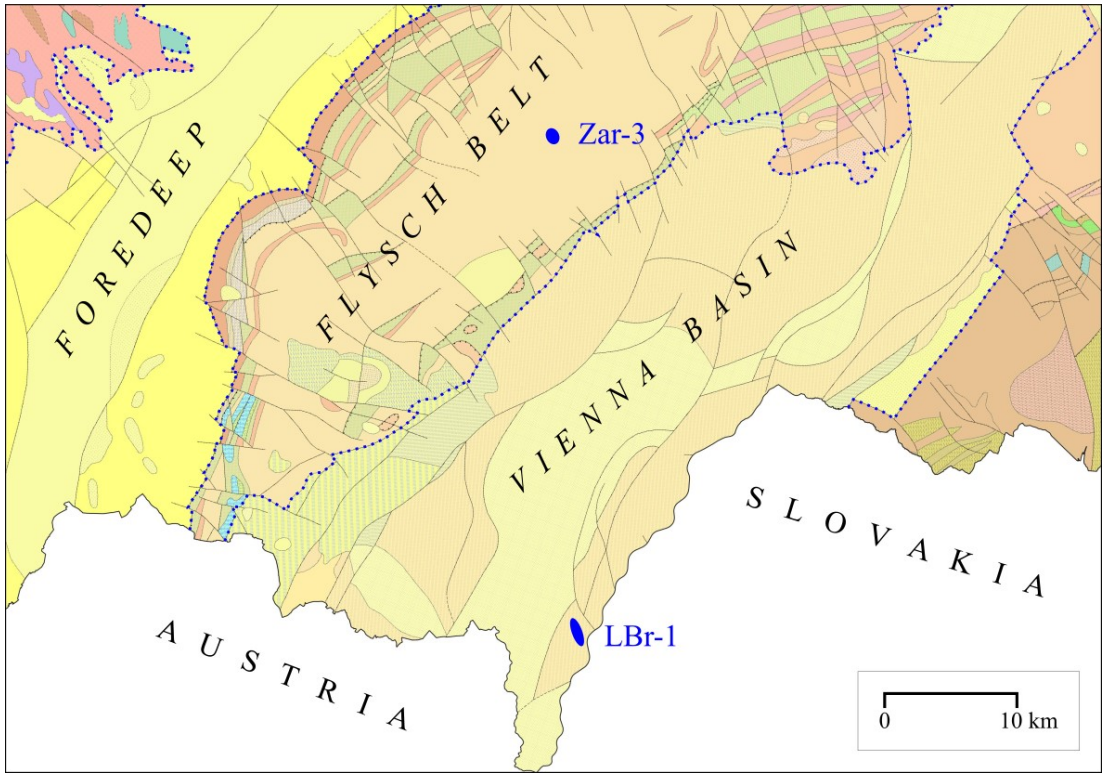
Two candidate sites assessed so far for this purpose are compared – the **LBr-1** abandoned oil and gas field in the Vienna Basin and a nearly depleted but still producing **Zar-3** field on the south–eastern slopes of the Bohemian Massif.

Geological settings

The area of interest with the two pre-selected structures is located in South Moravia (SE Czech Republic) at the **contact zone between the Bohemian Massif and the Western Carpathian thrust belt**.

Due to the complex tectono-sedimentary evolution of the area the local geological settings provides a varied range of lithological reservoir types in **different types of hydrocarbon-bearing structures** potentially suitable for CO2 storage.

From the regional geology point of view, one object of interest (LBr-1) is located in the northern part of the **Vienna Basin** while the other one (Zar-3) lies on **the SE slopes of the Bohemian Massif**.



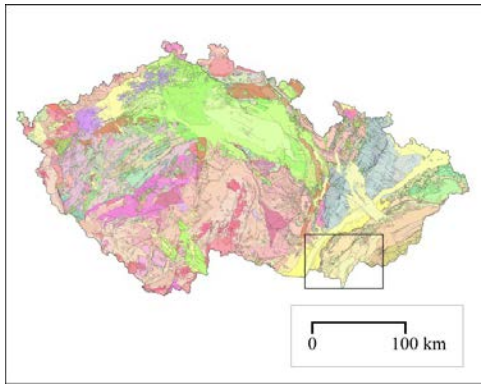


Figure 1
Location of the LBr-1 and Zar-3 sites on geological map of the SE part of Czech Republic and position of the area of interest within the Czech Republic.

Source: Czech Geological Survey ArcGIS server map services (http://www.geology.cz/extranet/mapy/mapy-online/esri).

LBr-1 site

An **abandoned oil and gas field** LBr-1 was the first target of the effort to prepare a CO2 storage pilot project in the Czech Republic.

The field at a depth of about 1000 m is mainly a **lithological trap** formed by reservoir pinch out, but with some reservoir layers bounded partly by the Brodske fault system.

The reservoir is a complex of the **Middle Badenian** Lab **sands** with an overall thickness of 80 m, porosity up to 30 % and up to 500 mD permeability.

The caprock is formed by a 35 - 55 m layer of the **Middle Badenian clays**.

The main production from LBr-1 field was recorded in the **1960s** but occasional production continued until 2001.

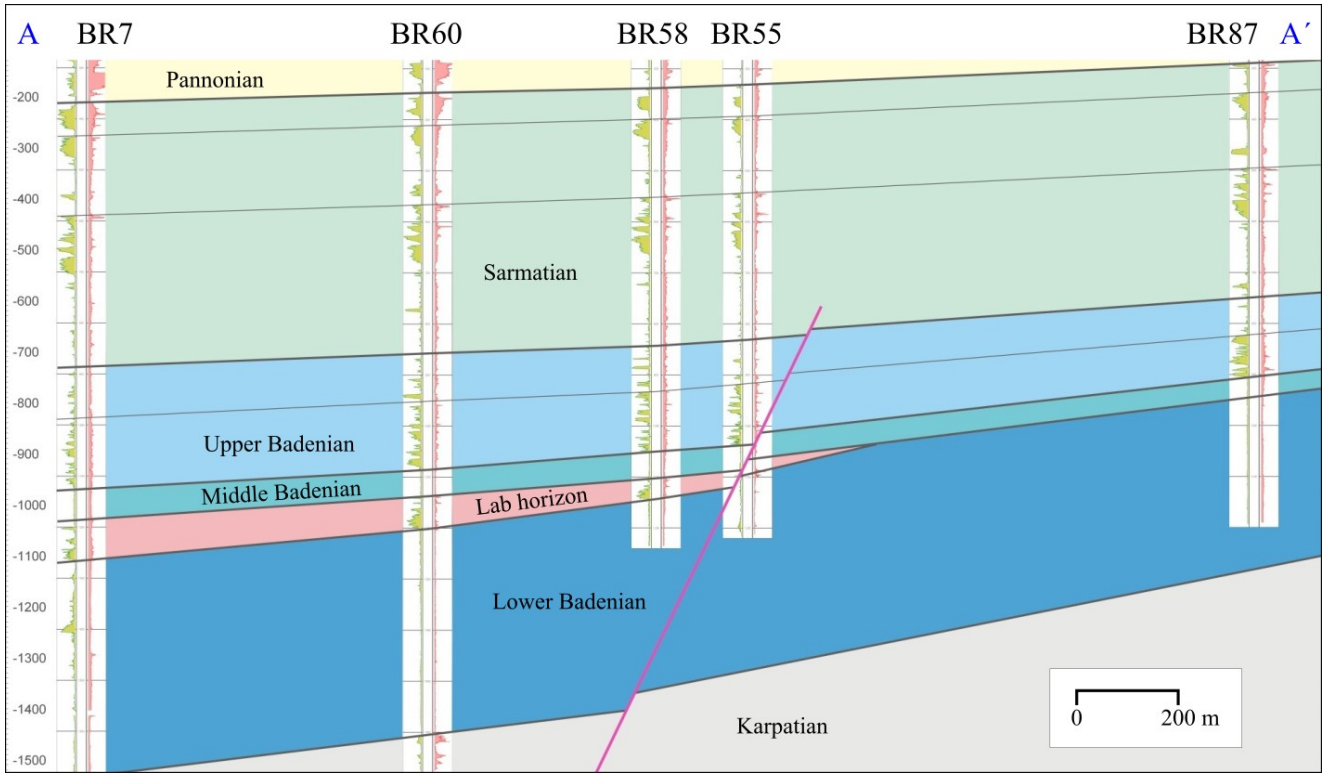


Figure 2 SW – NE geological section through the LBr-1 structure.

LBr-1 site

The LBr-1site was assessed in detail within the Czech–Norwegian **REPP-CO2** project, followed by some additional work in the EU-H2020 **ENOS** project.

The work included collecting the necessary data, laboratory investigations, construction of a 3D geological model of the storage complex, dynamic simulation models of the CO2 injection and post-injection phase, risk analysis and a monitoring plan.

In general, the LBr-1 structure has proved suitable for storing CO2, however, the main limiting factors include:

- **Absence of direct access to the reservoir** due to abandoned status of all wells;
- **Well interventions** required due to problematic status of some of the abandoned legacy wells;
- Need of drilling of **new wells** for the acquisition of reservoir and caprock cores;
- Necessity of **new exploration permit** to continue the work on the site, issues associated with conflicts of interests;
- Possible **trans-boundary issues** related to theoretical CO2 leakage pathways crossing the nearby state border.

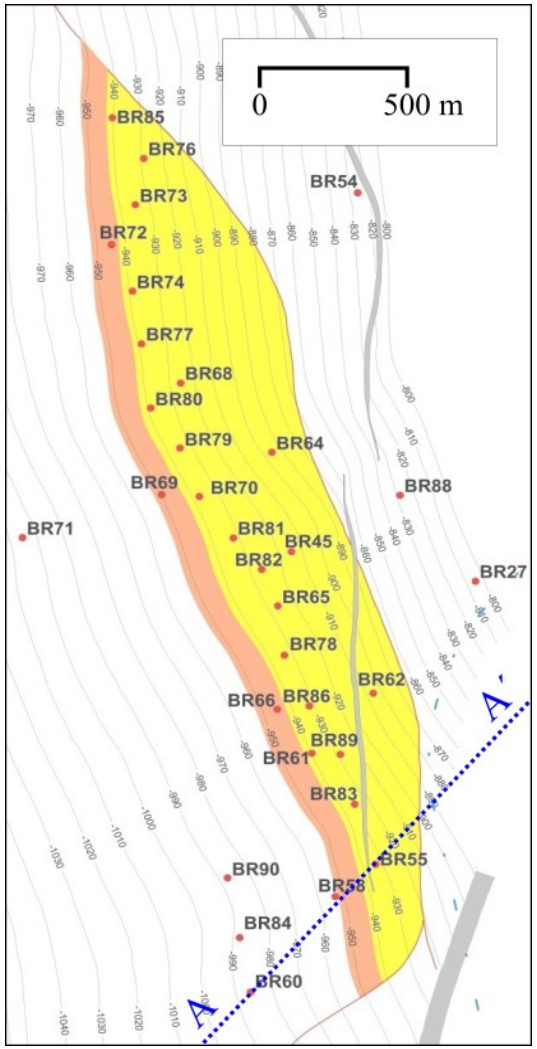


Figure 3
LBr-1 structure – depth contour map of the reservoir top.

Zar-3 site

The Zar-3 site is situated on the NE slope of the **Nesvacilka depression**, a deep paleocanyon incised in depositional successions within the SE slopes of the Bohemian Massif.

The structure comprises an oil field with a gas cap and an active aquifer in an erosional relict of **fractured Jurassic carbonates** (so called Vranovice carbonates).

The reservoir lies in the depth interval of about 1560 – 1820 m and is formed by dolomites with some limestones and sandstones.

Depending on the dolomitisation degree and clastic and carbonate components content within the reservoir, its porosity ranges from 2 to 20 % and permeability from 190 to 630 mD.

The Zar-3 field was **discovered in 2001** and is currently in its final stages of production.

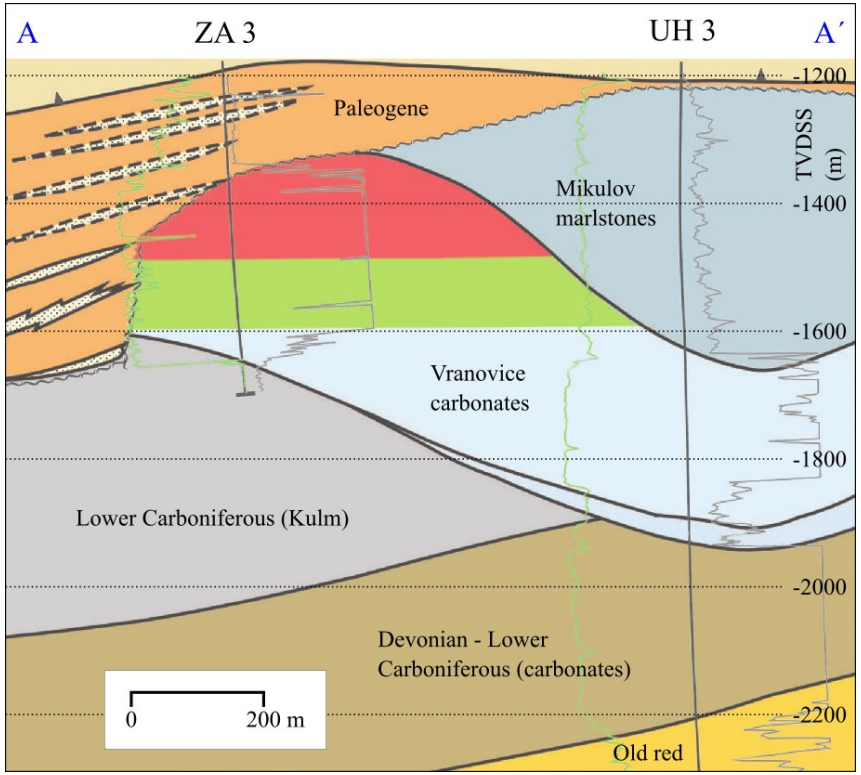


Figure 4 W – E geological section through the Zar-3 structure (Kostelnicek et al. 2006).

Zar-3 site

The Zar-3 site is target of a currently running Czech–Norwegian project titled **CO2-SPICER** that builds upon the experience and knowledge gathered in previous work, including the LBr-1 site assessment.

Advantages of Zar-3 site:

- **Access to the reservoir** using active production and monitoring wells;
- Better **condition of the wells** due to later discovery of the field;
- Availability of well-preserved archive **cores**;
- Significantly **more information on the reservoir** available, including advanced well monitoring during production history;
- **Minimum** probability of **conflicts of interest**, no trans-boundary issues;
- Possibility **to develop the pilot project** much more quickly (direct involvement of the field operator MND in the project consortium).

Challenges:

- More **complicated reservoir modelling**;
- Reactivity of carbonates – thorough **geochemical characterisation** and modelling needed
- **Transition** from production to CO_2 storage

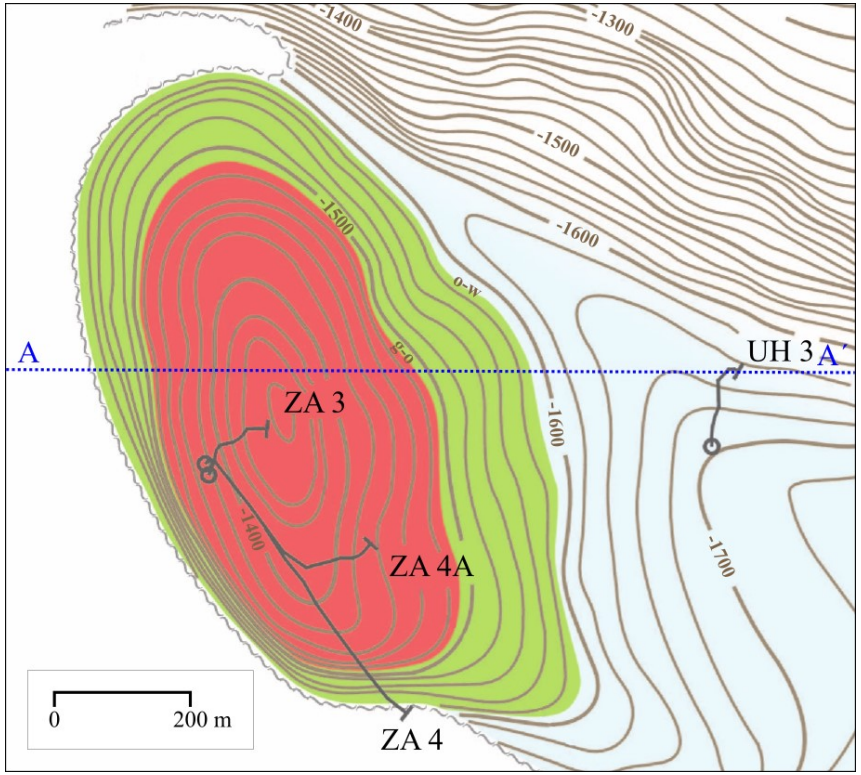
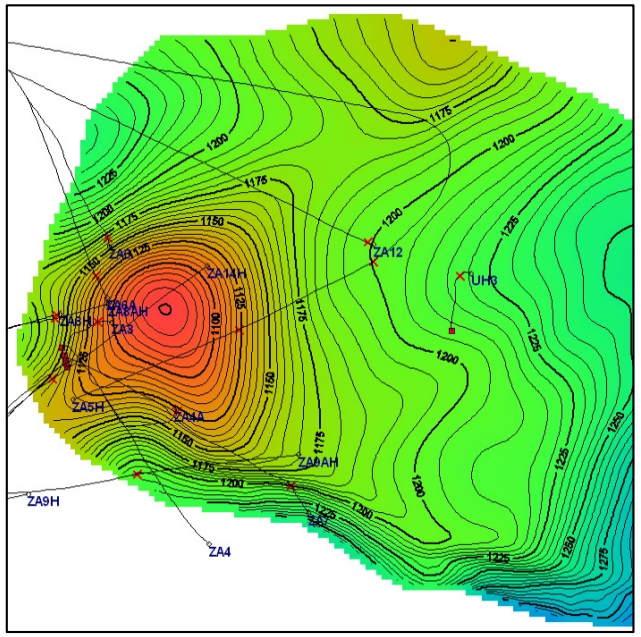
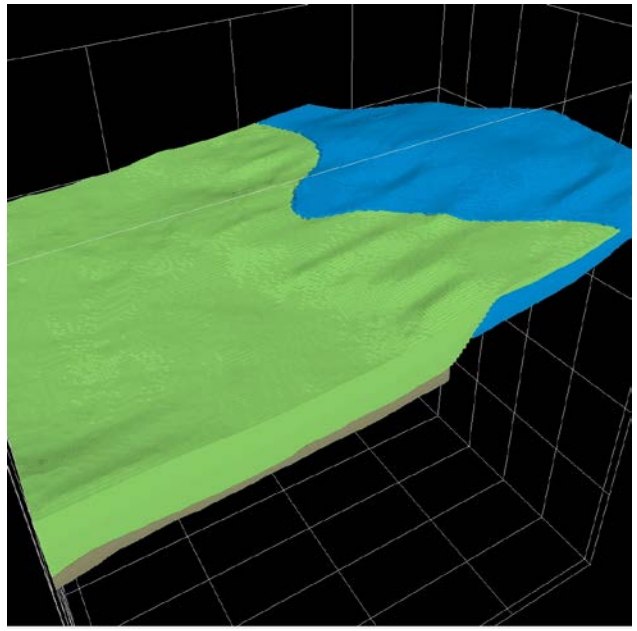


Figure 5 Zar-3 structure – depth contour map of the reservoir top (Kostelnicek et al. 2006).

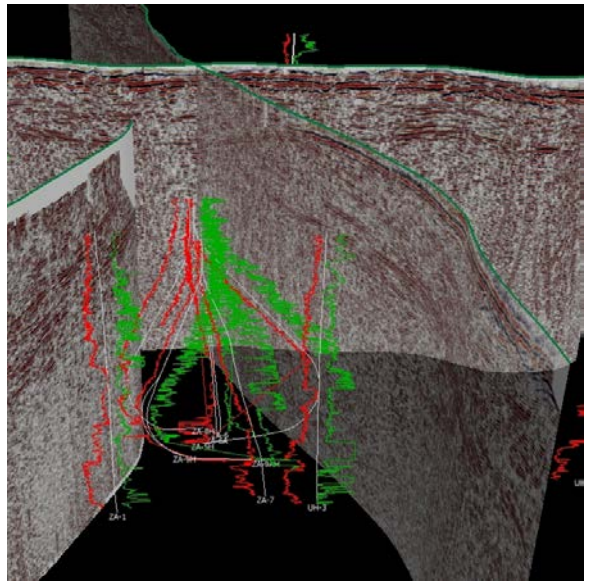
Zar-3 site – Work to date

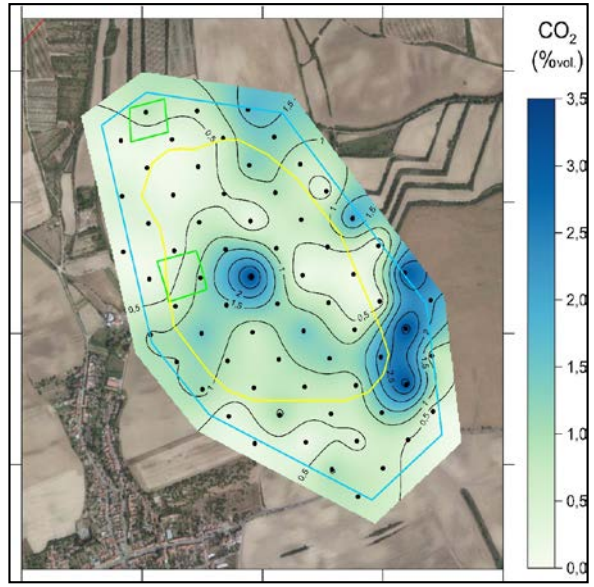
Collection of data (2D and 3D seismic data, well logs, well core samples, production data, pressure, temperature, reservoir fluid properties...) and their preparation for **geological interpretation** and **3D modelling**.





3D Seismic interpretation, construction of (preliminary) contour maps, regional 3D geological model





Spring and summer baseline monitoring of soil gases and ground waters

Conclusions

The comparison of the two candidate CO2 storage pilot sites in the Czech Republic has pointed out the importance of a careful and **holistic approach to site selection**.

In addition to the geological settings that play the most important role also proved to be important for the site selection:

- technical conditions, in particular **the state of the operating and legacy wells** related to both the exploration and production time periods
- the **site location** relative to protected areas and possible trans-border issues

The provisional comparison results of a depleted and **completely abandoned hydrocarbon field** with a **depleting but still producing reservoir** show benefits of the latter option that will also be reflected in lower associated costs. Surprisingly, however, the **regulatory framework** seems to be much clearer and more favourable for the completely abandoned field.

Regarding the comparison of a typical **clastic reservoir relative to fractured carbonates** the work is still ongoing for the latter case and especially the results of geochemical and petrophysical characterisation of the storage complex will provide the necessary insight into possible vulnerability of the carbonate reservoir at Zar-3 to **increased geochemical reactivity** and related changes in the properties of the storage complex, compared to sandy reservoir of the LBr-1 site.

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