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Preliminary physical and geochemical study on a sedimentary rock series of the Pannonian Basin for CCS (Hungary)

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Abstract

One of the largest storage potential for CCS is in the deep saline aquifers because their pore water cannot be used for drinking and for agricultural activities. In the Pannonian Basin (Hungary) there are sedimentary sub-basins filled up by sedimentary rock sequences containing such aquifers, which have the main potential for CCS in Hungary. Our chosen study area in the Pannonian Basin was the Jászság Subbasin, well known by numerous seismics and hydrocarbon exploration wells. As Hungary is situated in the middle of the Pannonian Basin, its emissions could be significantly reduced by CCS. That is the main reason to find a suitable place for CCS.

The process filling up the basin resulted in a sedimentary system from deep-water to deltaic sediments, including thick facies units of reservoir quality as well as thick facies units acting as seals above it. During the evolution of the basin, large rivers brought huge amounts of sediments from the NE and NW towards the deeper parts of Lake Pannon, forming huge deltas on the river mouths.

The potential reservoir formations now form a hidrogeologically coherent regional system, indicating a large potential for storage capacity. Furthermore, the saline aquifer system is large enough to ensure its long-term industrial usage for CCS, because the injection does not cause critical increase in the pressure. However, the system is not homogenous: there are siltstone interbeddings both in the Algyő (clayey cover formation), and the Szolnok Formations (dominantly sandstone), as we could see on well-logs of HC exploration wells. The siltstone in these formations does not have porosity high enough to be the storage rock, whereas the permeability is not low enough to be a good cap rock. That is why we try to avoid sampling siltstone-rich regions in the whole Jászság Basin. On the other places, and depth intervals we have used drilling cores to get a realistic quality and representative quantity of the tested formations.

Our detailed studies deal with the sandy Szolnok Formation, and the clayey Algyő Formation. The Szolnok Fm. is mainly formed by sandstone, its bottom is nearly 1000 to 3500 m deep under the surface, thus it would be used as a storage rock. Its cap rock (seal) is the Algyő Fm. with more than 1000 m thickness, and a clayey composition.

These potential rock associations are examined in detail in our ongoing research. We will do ex situ tests observing the behavior of the rocks when injecting supercritical CO_2 in the saline pore water on pressure and temperature representing the depth of planned injection conditions.

Keywords: Pannonian Basin, saline aquifer, sequestration, turbiditic sandstone

Introduction

Europe's efforts to cut Green House Gas (GHG) emissions, as well as the EU directives are major policy drivers in all the countries of the EU. In Hungary Carbon Capture and Sequestration (CCS) is considered to be one of the main possibilities to reduce CO_2 emissions, mostly in the energy sector. That is why preliminary studies have been carried out by Eötvös Loránd Geophysical Institute (ELGI) in the frame of the EUGeoCapacity Consortium to assess the available storage potential. The results show that the main storage potential of Hungary is in deep saline aquifers (2000 Mt), and hydrocarbon reservoirs (400 Mt), therefore a potential site for CO_2 storage can be a regional saline aquifer in the northeastern part of the Great Hungarian Plain (Figure 1) [1]. This poster presents. 1) The results of our preliminary

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research summarizing the information collected from literature, well-log databases, and hydrocarbon exploration about the potential storage and sealing formations (Figure 2). We also applied thin sections to describe them better; and 2) Our recently started lab experiments with samples from the provisional storage and sealing formations from a selected core sample.

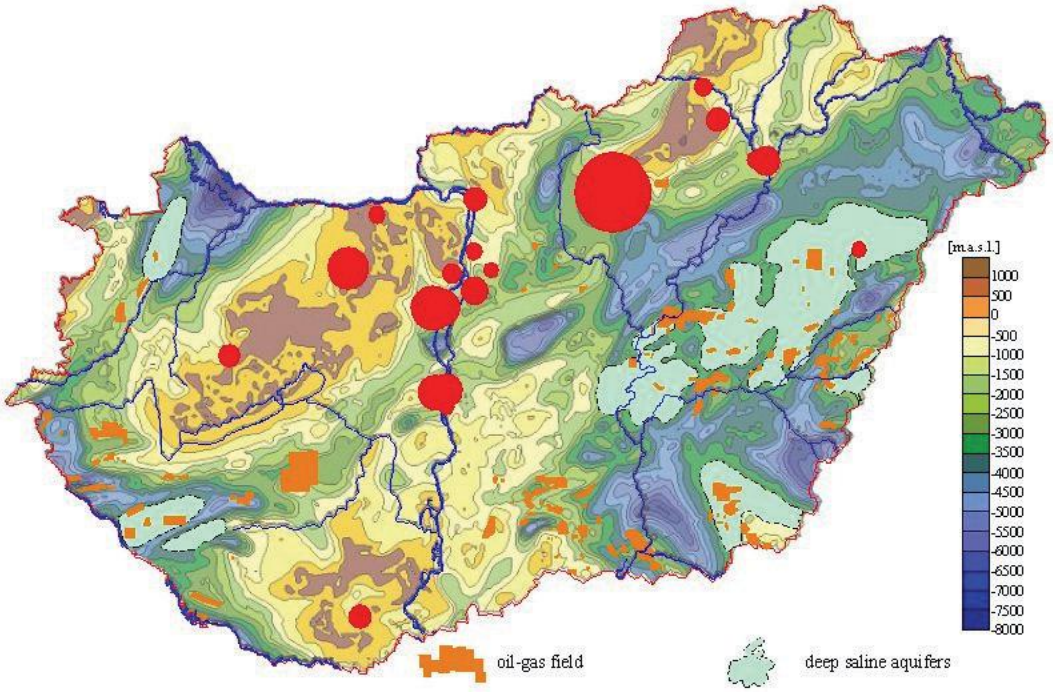

Figure 1 Map of the potential storage sites with the major carbon emitting points of Hungary

Geological background

The Pannonian Basin is our study area we have two pairs of potential reservoir-cap rock couples: Szolnok + Algyő Formations (Lower Pannonian), and Újfalu + Zagyva Formations (Upper Pannonian) (Figure 2). Previous studies suggest that the Lower Pannonian system is more suitable for storage because of generally better reservoir geological parameters. Moreover, the depth of the Lower Pannonian sedimentary sequences correspond to pressures high enough to maintain the supercritical state of CO_2. The filling was started from Middle Miocene, and resulted in these formations:

The thickness of the Algyő Formation at some points of the Pannonian Basin can reach 900 m, and it provides a regional cover for the Szolnok Formation. It is an association of sublitoral and slope facieses of the delta, containing mainly siltstone and clay marl, but there are some blocks of sandstone. From the aspect of the storage process it is considered to be the sealing formation (Figure 3/a).

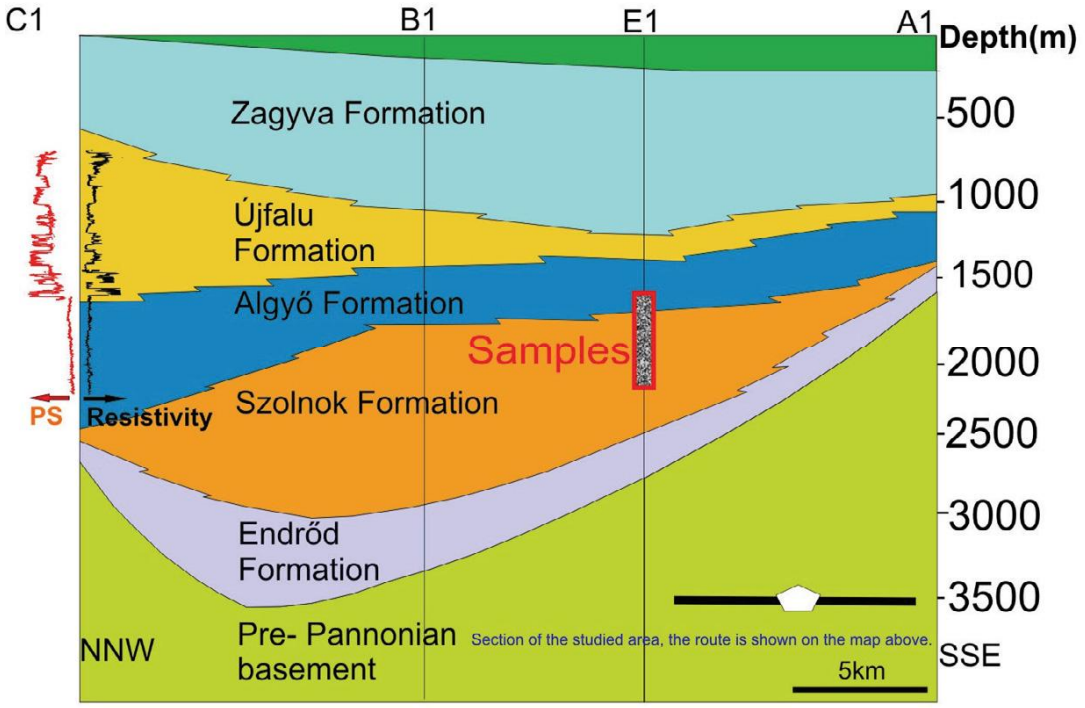

Figure 2 Theoretical section of the studied area

The thickness of the Szolnok Formation in the study area can reach 1000 m, it is composed mainly of sandstone, and siltstone. This formation is a thin-layered, turbiditic series, the layers are sharply separated from each other and sometimes contain charred plant pieces. For sequestration purposes it is considered to be used for storage [2] (Figure 3/ b).

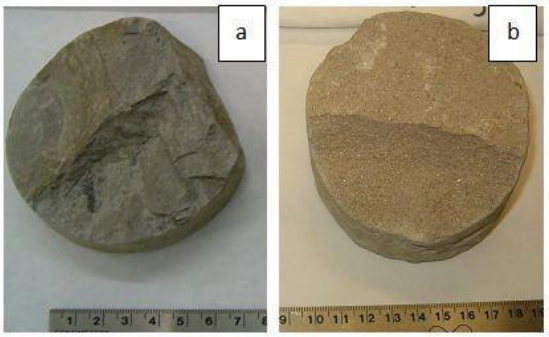

Figure 3 core samples from a) Algyő Formation, b) Szolnok Formation

Experimental work

Thin sections show the texture of potential storage system: in the sealing formation (Figure 4) quartz grains are surrounded by clay minerals not identified with microscope. Its lower porosity suggests smaller permeability, which is necessary for a future cap layer.

The potential storage formation is mainly composed sandstone (Figure 5 and 6). The mica flakes are nearly parallel to the orientation of described sedimentary processes. The carbonate is present in aggregated form.

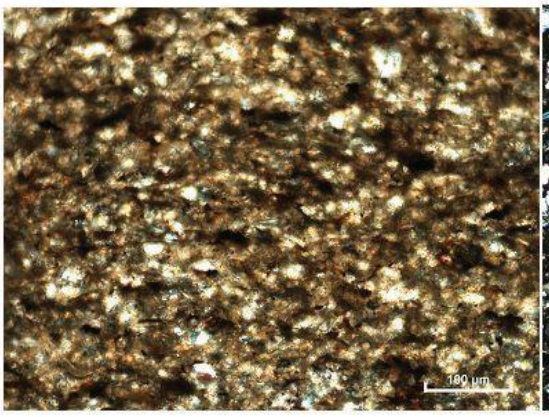

Figure 4 Thin section image with one nicol, taken from the clayey Algyő Fm.

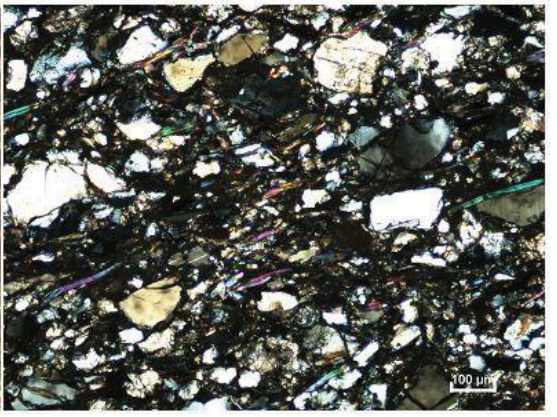

Figure 5 Thin section image with crossed polars, on a sample from the Szolnok Fm.

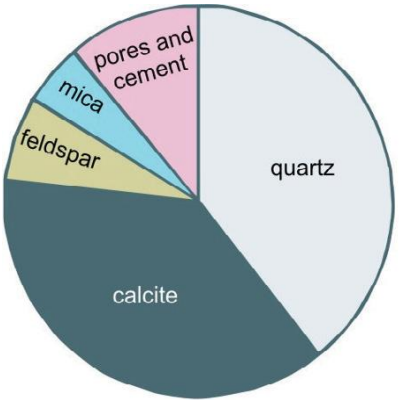

Figure 6 Diagram showing the modes of main mineral components and the porosity of the sandstone.

After we sampled the selected drilling cores, we have started preliminary tests with samples presenting the geological formations described above. We used SEM to observe the pores and the original morphology of minerals of the storage rocks (Figure 7), as well as thin sections to determine minerals and their modes (Figure 5). The most important for CCS is feldspar (Figure 7) because of its calcium content.

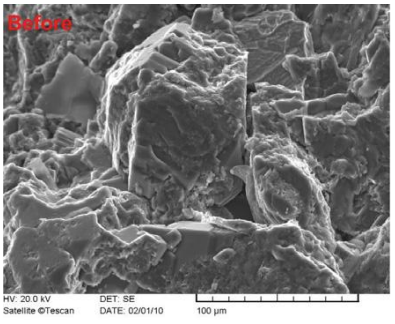

Figure 7 SEM picture: a sample taken from Szolnok Formation. (ab: albite, py:pyrite, q: quartz, cc: calcite)

Figure 8 Experimental apparatus at
150-175 bar and 55 ˚C.

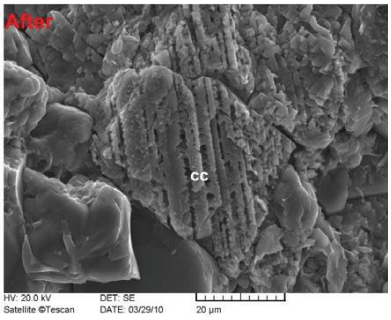

Figure 9 Signs of calcite (cc) solvatation and crystallizati0on can be seen. Other results (eg. pore water analyses) suggest that these might be mainly recrystallized minerals instead of alteration of feldspar by capturing

We have run a test with selected rock samples collected from the core shown on Figure 3.b First the rocks were saturated under vacuum with brine (similar in composition to that observed on the field (5% NaCl eq.) then we enclosed the samples in an INOX, pressure and temperature resistant tube and flooded the system with supercritical carbon dioxide (Figure 8). After the test was finished, we applied SEM to observe the results (Figure 9).

Acknowledgements

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