Hungarian perspectives of CCS

Dóra Cseresznyés,

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17th CO_2GEONET Open Forum
21-22 May 2024
Venice

Team

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Collaboration with universities and research institutes

Main question:
What processes can take place in the CO_2-water-rock system?

What we do? - Regulations

European Union: Directive 2009/31/EC

The **amendment** of **Goverment Decree No. 145/2012** (VII. 3.) about the geological storage of CO_2 published **in 2022 by SARA** (**S**upervisory **A**uthority for **R**egulatory **A**ffairs)

Decree No. 29/2022 (I. 31.) for geological structures suitable for the storage of carbon-dioxide of energy and industrial origin are currently **in force**.

29/2022. (I. 31.) SZTFH rendelet

az energetikai és ipari eredetű szén-dioxid tárolására alkalmas földtani szerkezetekkel kapcsolatos részletes szabályokról

A bányászatról szóló 1993. évi XLVIII. törvény 50/A. § (1b) bekezdés 15. pontjában kapott felhatalmazás alapján, a Szabályozott Tevékenységek Felügyeleti Hatóságáról szóló 2021. évi XXXII. törvény 13. § *n)* és *o)* pontjában foglalt feladatkörömben eljárva a következőket rendelem el:

1. Értelmező rendelkezések

1. § E rendelet alkalmazásában
1. *elvándorlás:* a szén-dioxid mozgása a tároló-komplexumon belül;
2. *hidraulikai egység:* hidraulikailag összefüggő pórustér, amelyben a nyomásátadás műszaki módszerekkel mérhető, és amelyet záró rétegek, úgymint vetők, sódómok, litológiai határok, vagy a geológiai formáció kiékelődése vagy felszínre bukkanása határol;
3. *hulladék:* a hulladékról szóló törvényben meghatározott hulladék;
4. *szén-dioxid kibocsátó:* az, aki - a közbenső technológiai szén-dioxid kivételével - ipari vagy energetikai eredetű szén-dioxidot végső kezelés céljából leválaszt;
5. *kutatási blokk:* a kutatási területen belüli olyan kutatási területegység, amelynek térképi vetülete egyenes szakaszokkal határolt zárt sokszög, vagy az államhatár, illetve más mesterséges objektum vagy természeti képződmény határvonala;
6. *szén-dioxid csóva:* a geológiai formációban szétáramló szén-dioxid halmaz.

Requirements for the first step in a CCS project

To apply for a geological prospecting licence it is essential to submit the application which includes the:

- Exploration work program and budget
- Exploration plan map
- Proposal for the amount of the exploration assurance

→ final exploration report

In the *exploration work program*, it is required to plan in detail:

- the research tasks,
- technology description,
- a list of planned exploration facilities,

information for the:

- quantity,
- timing,
- planned duration,
- method,
- depth,
- technology,
- anticipated hazards during the exploration.

Additionally, a detailed budget for the exploration is also required.

First project

Company: biorefinery

Planning to inject CO_2 in deep saline aquifers

✓ First exploration permit

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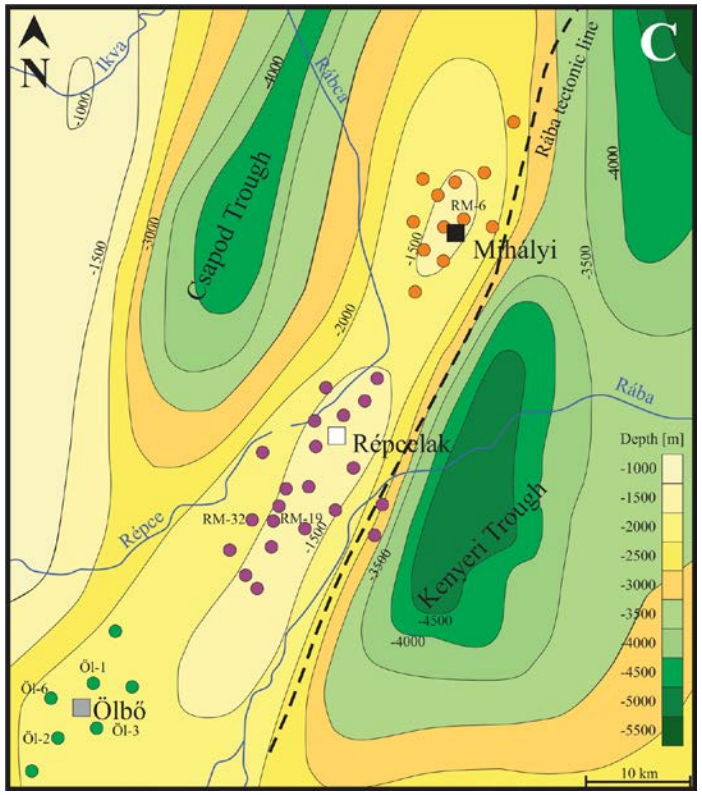
What we do? – Research and development

- Field surveys
- Collecting the core samples
- Geochemical analysis of the rock samples

Core sample at Répcelak

„Christmas tree” at Répcelak



Natural CO_2 occurrences

- Gas and water sampling in the field
- Stable isotope analysis of water and carbonates
- Geochemical modeling
- Laboratory experiments

Cooperation with:

Linde

MESSER Gases for Life

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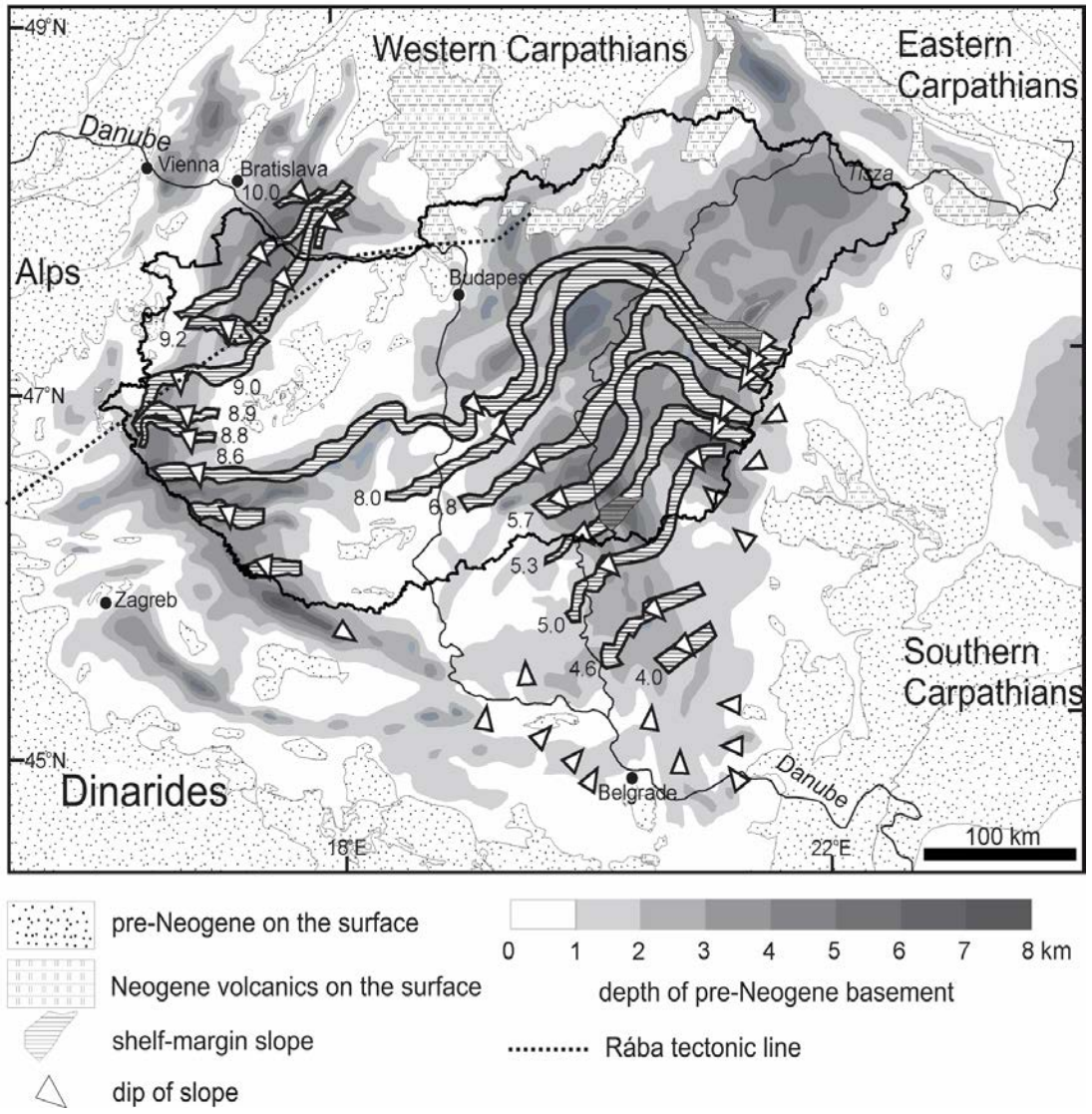
Geological background



Magyar et al. (2013)

- Pannonian Basin
- filled up by Neogene sediments
- Middle Miocene and Late Miocene formations (sandstone, limestone) are potential for CO_2 storage
- EOR started in 1970's (sandstones, karstified carbonate, fractured metamorphic reservoir)
- Natural CO_2 occurrences and emanation

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Assessment of storage potential

Two major groups of geological structures

Depleted hydrocarbon fields

- they had the capability of storing gaseous fluids for geological timescales
- screening methodology was used as recommended by Bruno *et al.* (2014) and Bachu (2010)

Deep saline aquifers

- more widespread in the Pannonian Basin
- they have a regional extent (>100 km^2)
- their top depth is deeper than approximately 900 meters
- regionally covered by thick, low permeability strata

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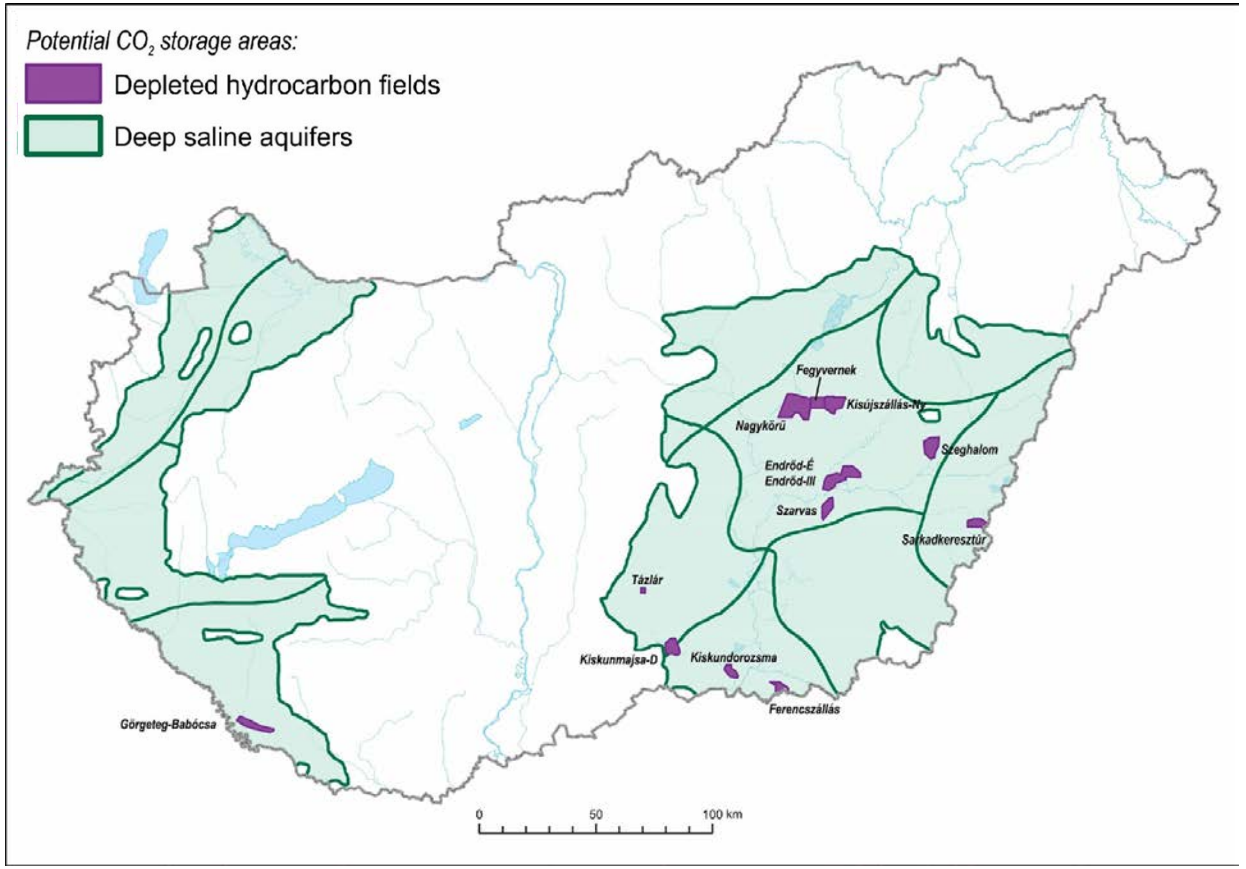
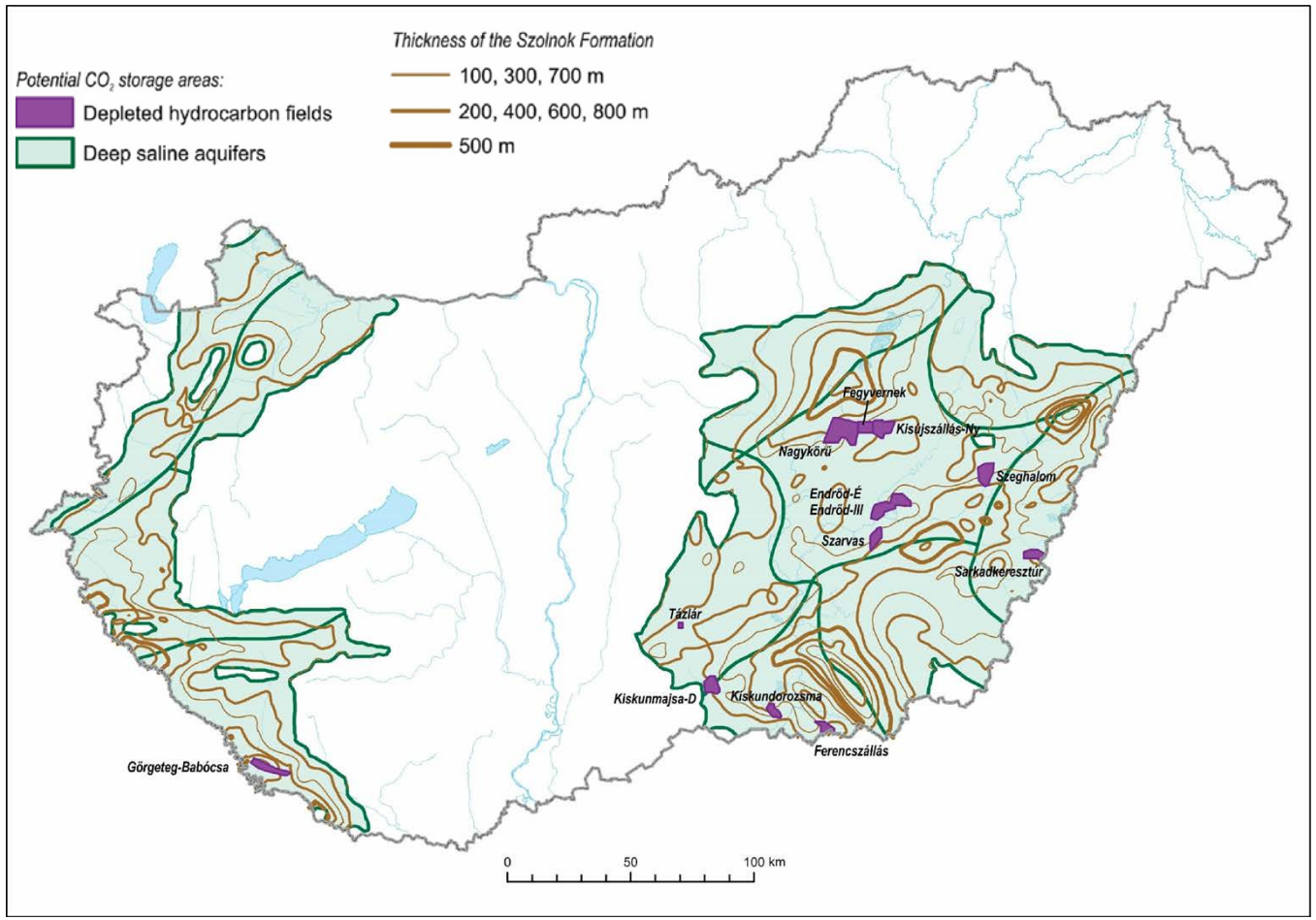
Screening method – depleted hydrocarbon sites

The main parameters for screening:

- the depth of the reservoir (>900 m),
- porosity and permeability of caprock (<4 %, <0.001 mD)
- reservoir (>10 %, >20 mD),
- thickness of the caprock (>10 m)
- etc.



Screening method – deep saline aquifers



The main parameters for screening:

- adequate reservoir depth (900 - 3000 m),
- integrity and low permeability (<0.001 mD) of the overlying caprock or closure,
- sufficient volume (2 Mt) for economically viable CO_2 storage,
- appropriate geological parameters for the reservoir,
- adequate separation from potable and thermal water systems.

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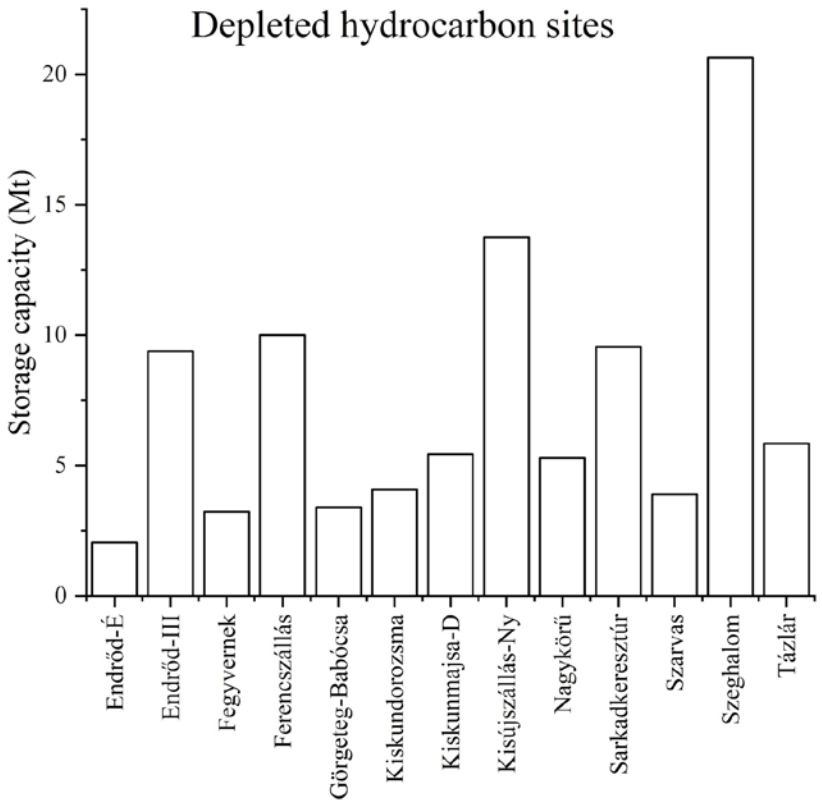
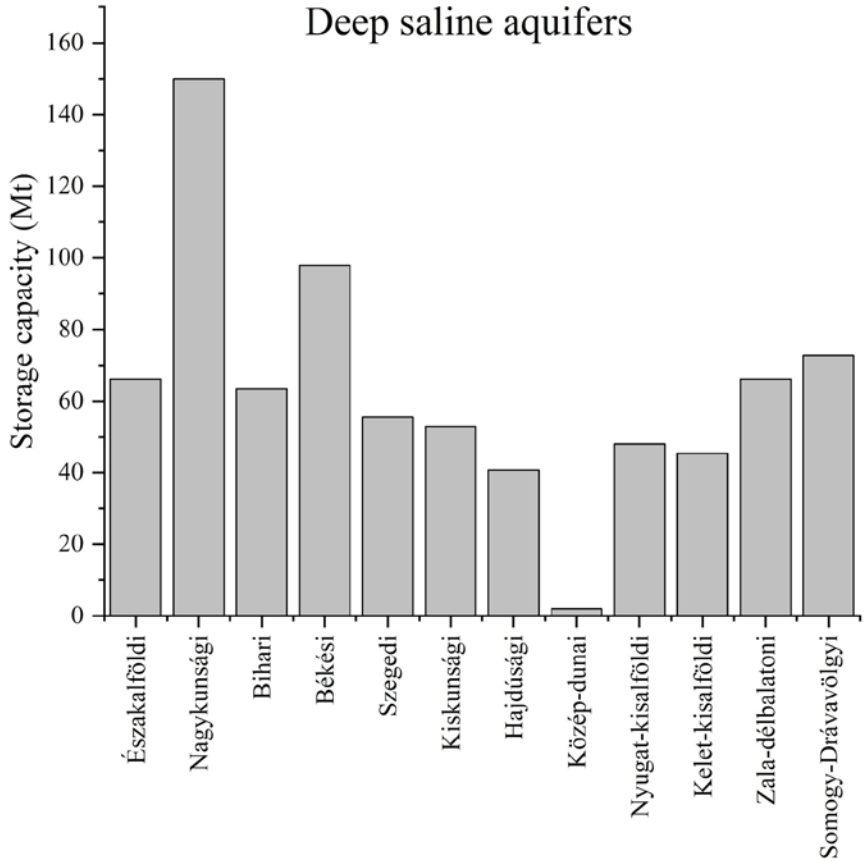
Storage capacity



← SUM: ~100 Mt

SUM: ~760 Mt →



The CO_2 storage capacity of the potential fields was estimated based on volumetric parameters. Monte Carlo simulation was also applied when the storage capacity was estimated.

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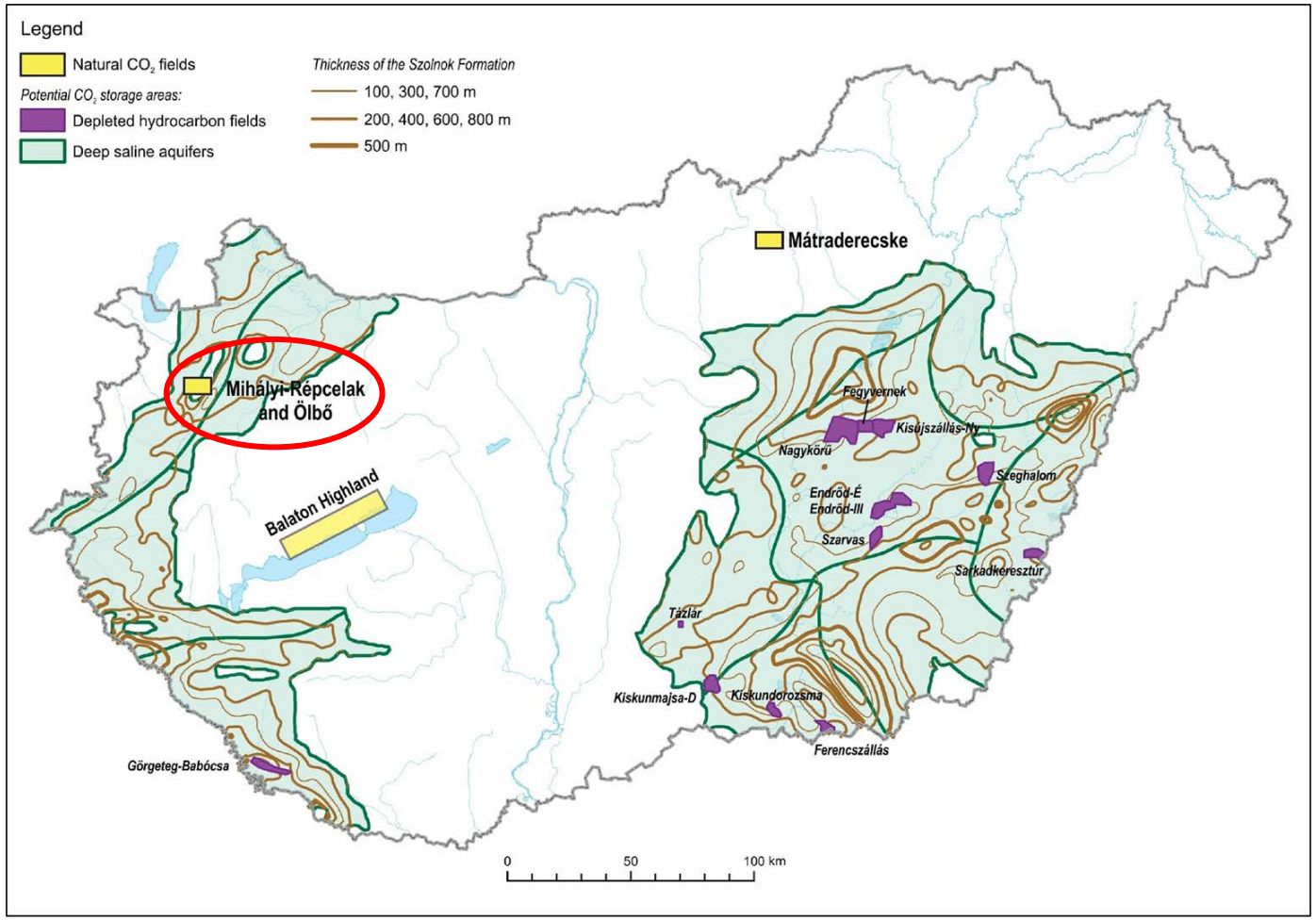
Natural CO_2 reservoirs



Falus et al., 2024. under review, Geol. Soc. of London

Mátraderecske: active dry CO_2 emanation (mofetta) is present

Balaton Highland: CO_2-rich springs

Little Hungarian Plain:

- CO_2 accumulated (4-7 Ma) in the Pannonian sediments
- Mihályi-Répcelak **sandstone formation** trapped ~25 million tons of CO_2
- In Ölbő ~8 million tons of CO_2 trapped in a **limestone formations**

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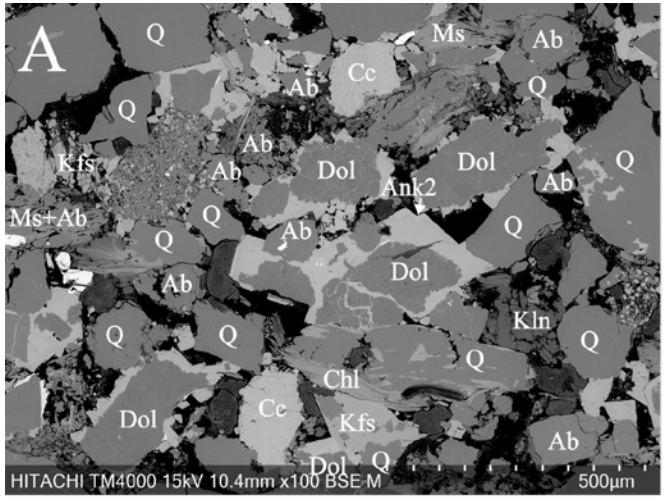
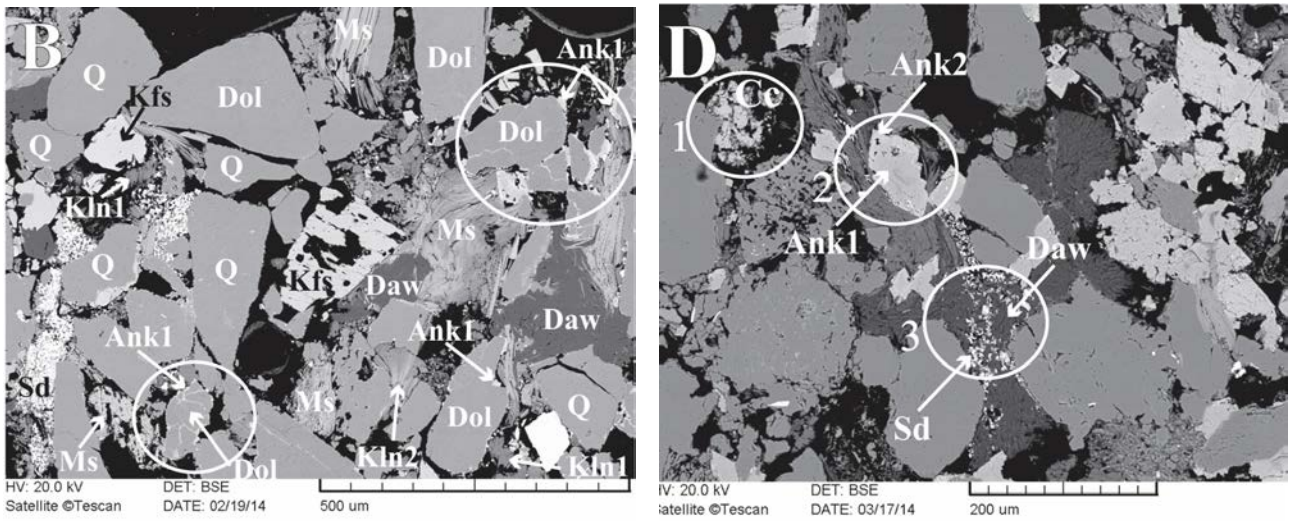
Natural CO_2 reservoirs - sandstone

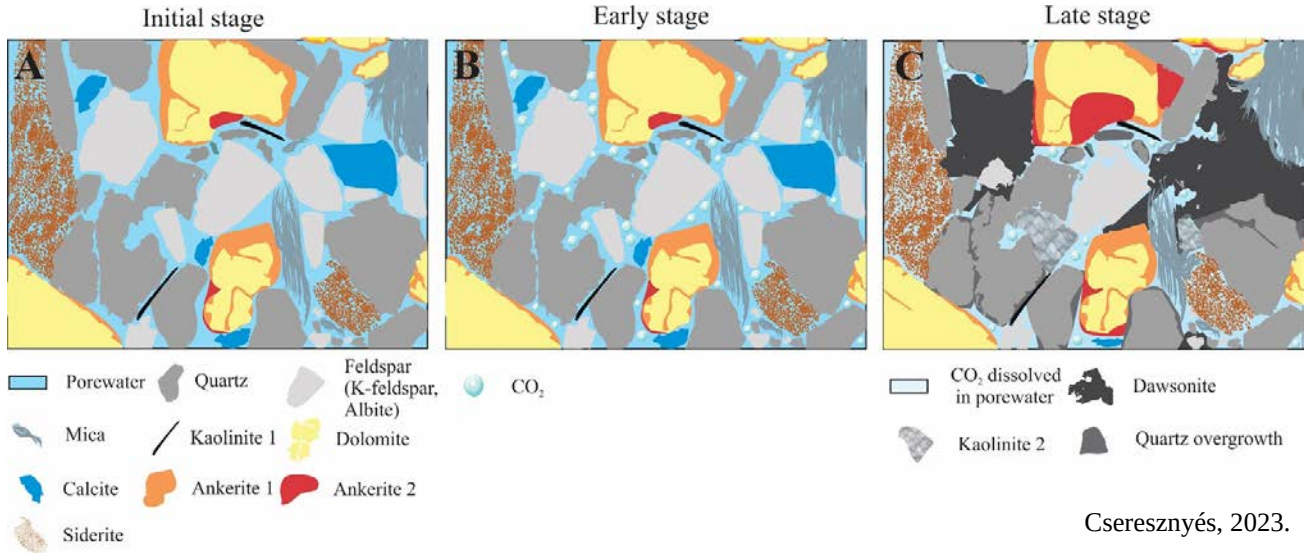
CO_2-free sandstone



CO_2-flooded sandstone



Interactions in the CO_2-water-sandstone system



Cseresznyés, 2023.

Ab: albite,

Ank1: ankerite (lower Fe content),

Ank2: ankerite (higher Fe content),

Cc: calcite,

Dol: dolomite,

Daw: dawsonite,

Kfs: K-feldspar,

Kln: kaolinite,

Ms: muscovite,

Sd: siderite,

Q: quartz

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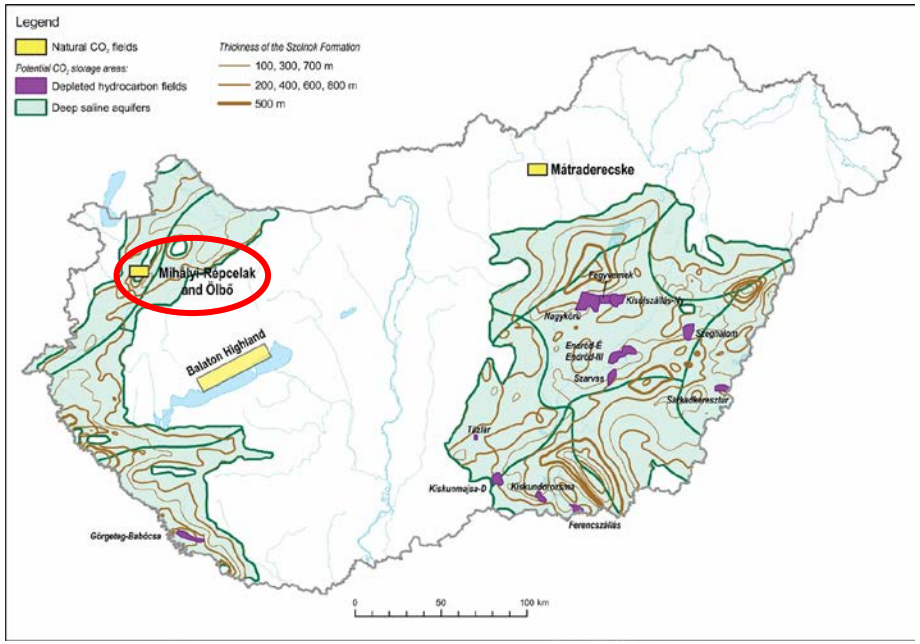
Natural CO_2 reservoirs - limestone

- Ölbő natural CO_2 occurrence
- CO_2 trapped in carbonates reservoir → in the Middle Miocene *Lithothamnium*-bearing limestone at 1700-1900 m depth
- Natural gas composition: 96.3 v/v% CO_2, 1.3 v/v% nitrogen, 2.4 v/v% hydrocarbons
- Sarmatian clay marl is acting as caprock

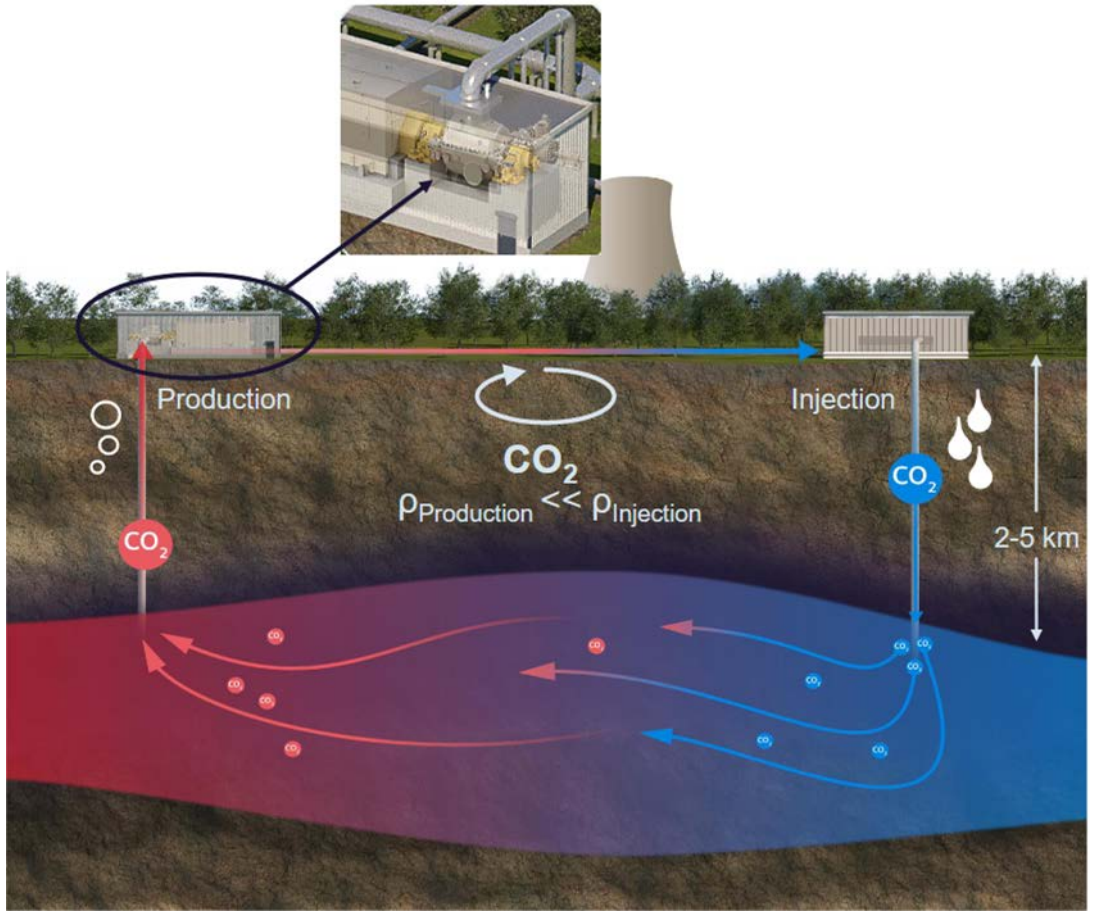


Questions:

- Is it true that CO_2 aggressively dissolves the limestone (matrix, grains, cement) and causes drastic changes in the reservoir on geological timescale?
- Mineral trapping of CO_2 is happened in the *Lithothamnium*-bearing limestone reservoir?

Geothermal energy with CCS – pilot project in Hungary

- NextGen Geothermal Power (NGP) is using emitted CO_2 as working media for geothermal power generation
- Cooperation between Siemens Energy and MOL Group
- Nagylengyel, Hungary
- The CO_2 was injected in a depleted oil and gas reservoir, and used as a working media for geothermal power generation.
- CO_2 is heated by geothermal energy, CO_2 flows to the surface and expands in a turbine to generate electricity and is reinjected (gravity driven) again



Source: Siemens Energy, presentation of Felix Boehmer (2023) and Sudhoff et al. (2019)

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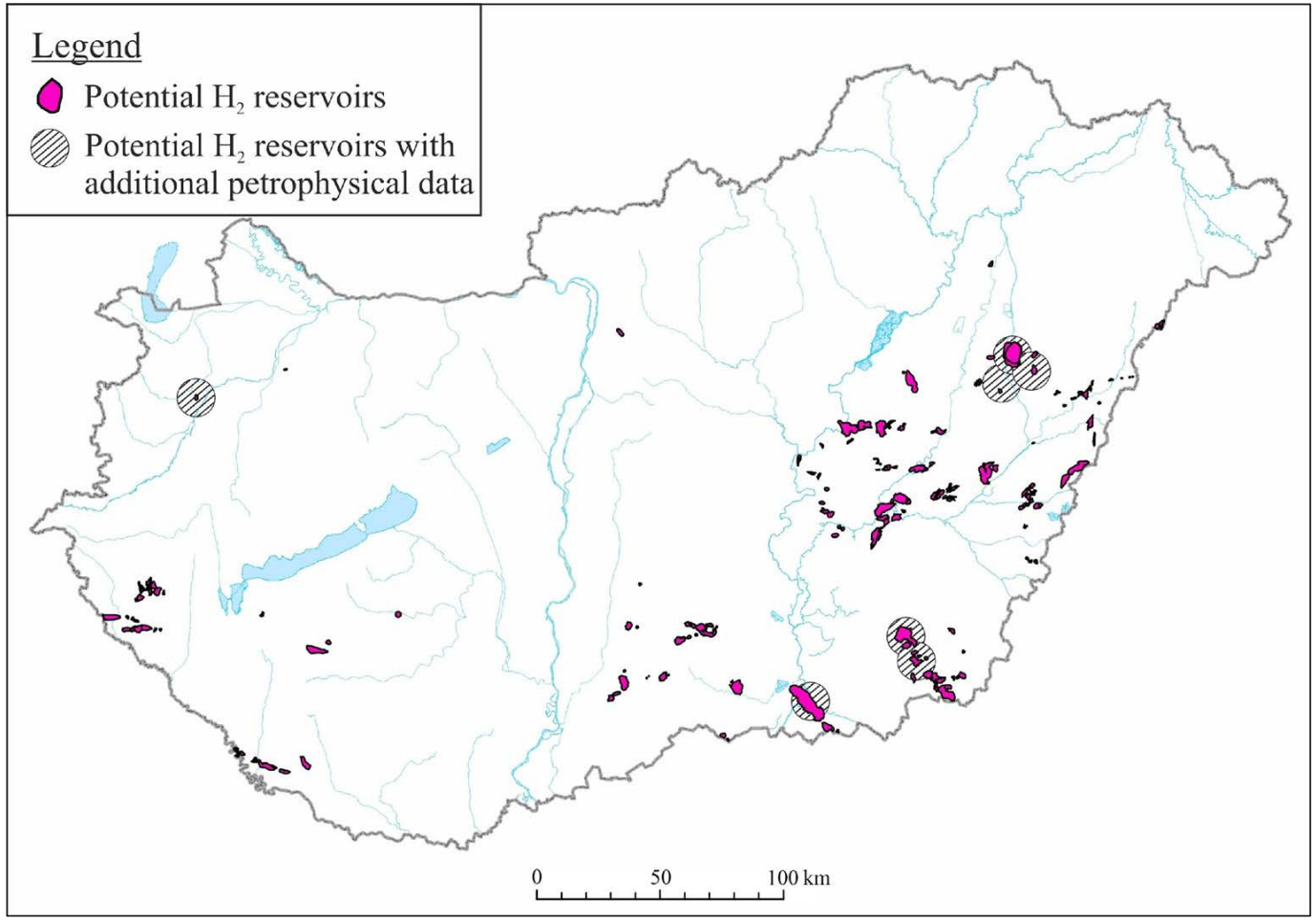
Perspectives of underground hydrogen storage

Depleted oil and gas fields



Gelencsér et al., 2024. under review, Geol. Soc. of London

Screening method:

1) natural CO_2 reservoirs;
2) the reservoirs where the H_2S content is higher than 0.5%,
3) the reservoirs where the OGIP is smaller than 10^6 m^3 **were excluded**.

Based on these results, the potential H_2 reservoirs are shown on the figure marked with pink fields.

The cumulative natural gas production volume of these reservoirs is more than 5 x 10^9 Nm^3 which seems a perspective number for future H_2 storage.

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Environ Earth Sci (2016) 75:635
DOI 10.1007/s12665-016-5399-6

ORIGINAL ARTICLE

Caprock analysis from the Mihályi-Répcelak natural CO_2 occurrence, Western Hungary

Csilla Király[1] · Ágnes Szamosfalvi[2] · László Zilahi-Sebess[2] · Péter Kónya[2] · István János Kovács[2] · Eszter Sendula[1] · Csaba Szabó[1] · György Falus[2]

Available online at www.sciencedirect.com
ScienceDirect
Energy Procedia 125 (2017) 527–534
Energy Procedia
www.elsevier.com/locate/procedia

European Geosciences Union General Assembly 2017, EGU
Division Energy, Resources & Environment, ERE

How much CO_2 is trapped in carbonate minerals of a natural CO_2 occurrence?

Csilla Király[a], Zsuzsanna Szabó[b], Ágnes Szamosfalvi[b], Péter Kónya[b], Csaba Szabó[a], György Falus[b,*]

Contents lists available at ScienceDirect
International Journal of Greenhouse Gas Control
journal homepage: www.elsevier.com/locate/ijggc

Experimental-modelling geochemical study of potential CCS caprocks in brine and CO_2-saturated brine

Zs. Szabó[a,*], H. Hellevang[b], Cs. Király[c], E. Sendula[c], P. Kónya[d], Gy. Falus[d], Sz. Török[a], Cs. Szabó[c]

Available online at www.sciencedirect.com
ScienceDirect
Energy Procedia 114 (2017) 4477 – 4485
Energy Procedia

13th International Conference on Greenhouse Gas Control Technologies, GHGT-13, 14-18 November 2016, Lausanne, Switzerland

New investigation of old well-logs and core samples in a natural CO_2 occurrence

Ágnes Szamosfalvi[a], László Zilahi-Sebess[a], Csilla Király[b], Anita Jobbik[c], Zoltán Szalai[d,e], György Falus[a,*]

The relevance of dawsonite precipitation in CO_2 sequestration in the Mihályi-Répcelak area, NW Hungary

Authors: Csilla Király, Eszter Sendula, Ágnes Szamosfalvi, Réka Káldos, Péter Kónya, István J. Kovács, Judit Füri, Zsolt Bendő, and György Falus | AUTHORS INFO & AFFILIATIONS

Publication: Geological Society, London, Special Publications • Volume 435 • Pages 405 - 418
https://doi.org/10.1144/SP435.15

Contents lists available at ScienceDirect
Chemical Geology
journal homepage: www.elsevier.com/locate/chemgeo

Origin of dawsonite-forming fluids in the Mihályi-Répcelak field (Pannonian Basin) using stable H, C and O isotope compositions: Implication for mineral storage of carbon-dioxide

Dóra Cseresznyés[a,b], György Czuppon[c,d,*], Csilla Király[e], Attila Demény[c], Domokos Györe[f], Viktória Forray[a], Ivett Kovács[c], Csaba Szabó[a], György Falus[a,b]

Environmental Earth Sciences (2021) 80:765
https://doi.org/10.1007/s12665-021-10050-9

ORIGINAL ARTICLE

Mineralogical and geochemical changes in conglomerate reservoir rocks induced by CO_2 influx at Mihályi-Répcelak natural analogue, NW-Hungary

Viktória Forray[1] · Csilla Király[2] · Attila Demény[3] · Dóra Cseresznyés[1,4] · Csaba Szabó[1] · György Falus[1,4]

Investigation of Natural CO_2 occurrences

- Caprocks
- Reservoirs: sandstone, conglomerates
- Geophysical data, well-logs

Experiments and Geochemical modelling

Hydrogen storage

Journal of Energy Storage 61 (2023) 106737
Contents lists available at ScienceDirect
Journal of Energy Storage
journal homepage: www.elsevier.com/locate/est

Short communication

Effect of hydrogen on calcite reactivity in sandstone reservoirs: Experimental results compared to geochemical modeling predictions

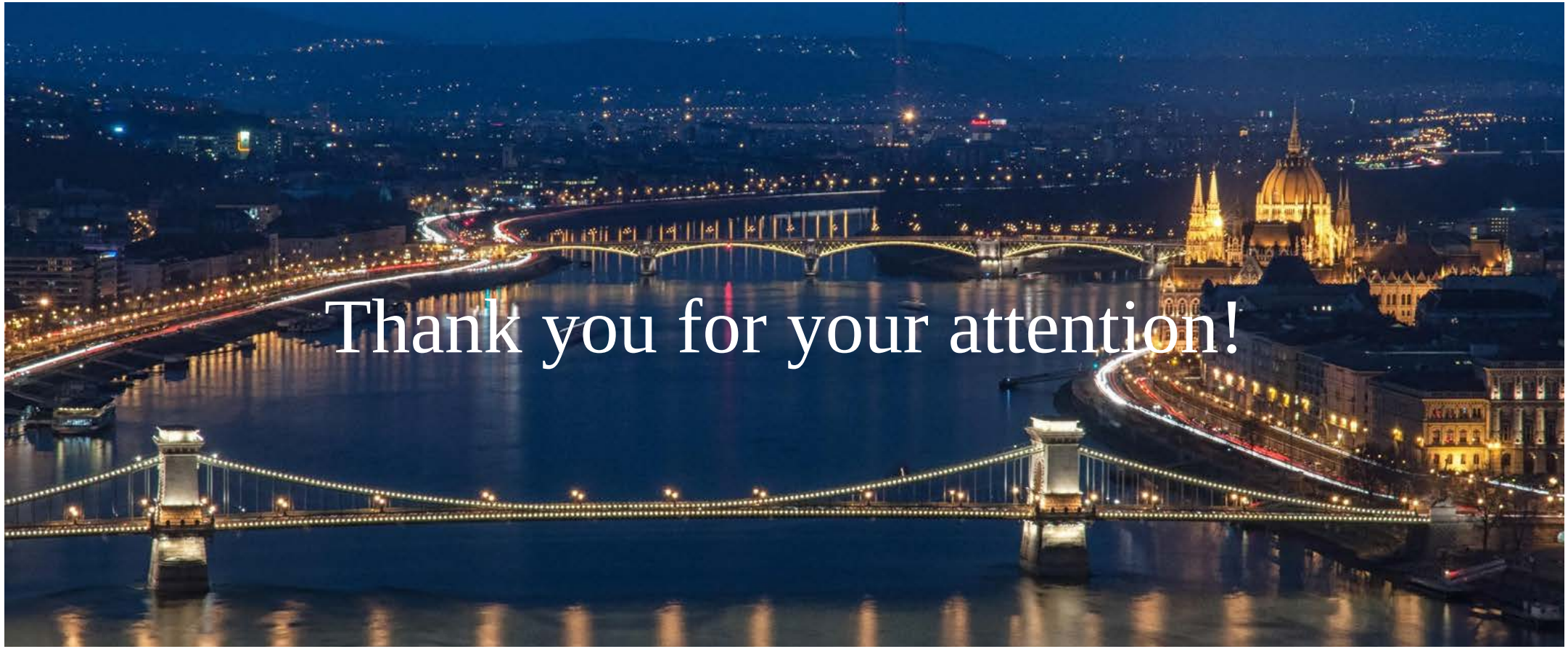
O. Gelencsér[a,b,c], Cs. Árvai[d], L.T. Mika[d], D. Breitner[e], D. LeClair[e], Cs. Szabó[a,f], Gy. Falus[g], Zs Szabó-Krausz[a,h,*]

Acta Geodaetica et Geophysica
https://doi.org/10.1007/s40328-024-00436-z

ORIGINAL STUDY

Microstructural study of the Praid Salt Diapir (Transylvanian basin, Romania) and its implication on deformation history and hydrogen storage potential

O. Gelencsér[1,2] · A. Szakács[3] · Á. Gál[4] · Á. Szabó[5] · Z. Dankházi[5] · T. Tóth[6,7] · D. Breitner[8] · Zs. Szabó-Krausz[2] · Cs. Szabó[2,9] · Gy. Falus[10]


Thank you for your attention!