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Environmental safety of CO_2 storage in geological formations: national research project

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GEO-TEAM Conference, Lillafüred
19-20. October 2015

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Climate change

Climate change is one of the greatest challenges for the 21th century!

Relation between climate change and increasing atmospheric CO_2 concentration
- •Possibilities of reducing CO_2 emissions
- •CO_2 **C**apture and geological **S**torage: **CCS**

(blog.sciencescore.org)

CCS is able to:
- Drammatic cuts in CO_2 emission
- Opportunity to use the national resource
- Resources share the same subsurface space

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International-national situation

MOTIVATION & BACKGROUND

- European Council and Parliament articulated the Climate and Energy Package on the 23rd of January, 2008, which puts a strong emphasis on emission reduction actions.
- The Directives accepted by the Council and the Parliament in April 2009; should have been implemented in every Member State's legislation by June, 2011. (May 2012, in Hungary)
- First time report of The Hungarian Office for Mining and Geology and Geological and Geophysical Institute of Hungary about the carbon dioxide storage potential in February 2013; *nature*, *storage capacity* and *geographical location* to the European Commission (based on 145/2012 (VII. 3) Government Regulation § 37 paragraph (2)).

Revision every 5 years

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EU CCS Directive

The CCS Directive establishes a legal framework for the environmentally safe geological storage of carbon dioxide (CO_2) to contribute to mitigating the effects of climate change.

The CCS Directive aims to ensure that there is
- no significant *risk of leakage* of CO_2 or
- *damage* to health or the environment, or
- to prevent any *adverse effects* on the security of the transport network or storage sites.

The Directive lays down requirements covering the *entire lifetime* of a storage site. The Directive contains also provisions on the capture and transport components of CCS.

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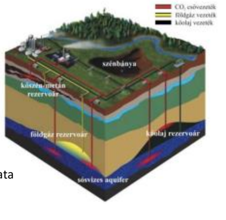
Minimization of risks

The essential steps in the various phases (based on the EU CCS Directive):

Before injection phase
- Detailed geological characterization of the selected site
- Long-term risk assessment
- "0-status" monitoring
- Creating remediation plan



Injection phase
- Short-term forecast
- Monitoring to verify the reliability of forecast

Abandonment phase
- Long-term forecasts based on accurate measurement data
- Determination of the period of site-specific monitoring

Post-abandonment phase
- Further clarification of forecast and the assignment of empowerment
- If necessary, continue the site-specific monitoring

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EU CCS Directive - details

CHAPTER 1	„This Directive establishes a legal framework for the environmentally safe geological storage of carbon dioxide (CO_2) to contribute to the fight against climate change."
CHAPTER 2	SELECTION OF STORAGE SITES AND EXPLORATION PERMITS
CHAPTER 3	STORAGE PERMITS
CHAPTER 4	OPERATION, CLOSURE AND POST-CLOSURE OBLIGATIONS
ANNEX I	CRITERIA FOR THE CHARACTERISATION AND ASSESSMENT OF THE POTENTIAL STORAGE COMPLEX AND SURROUNDING AREA REFERRED TO IN ARTICLE (Data collection, Building the three-dimensional static geological earth model, Characterisation of the storage dynamic behaviour, sensitivity characterisation, risk assessment
ANNEX II	CRITERIA FOR ESTABLISHING AND UPDATING THE MONITORING PLAN REFERRED TO IN ARTICLE 13(2) AND FOR POST-CLOSURE MONITORING (Establishing and updating the monitoring plan, Post-closure monitoring)

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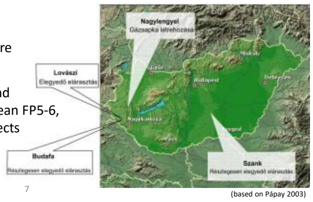
Hungarian research experience

- In Hungary, since 1972 CO_2 injection in oil production (tertiary phase) to increase the oil yield, in four oil fields, through more than 400 CO_2 injection wells.
- Several natural CO_2 fields.
- Over 100 well-logs, detailed investigation of drill cores, batch experiments, geochemical modeling
- More than 500 scientific reports and national and international articels were processed
- Experience and results of national and international projects: 6 years European FP5-6, 2 years MOL and 7 years MBFH projects



(based on Pápay 2003)

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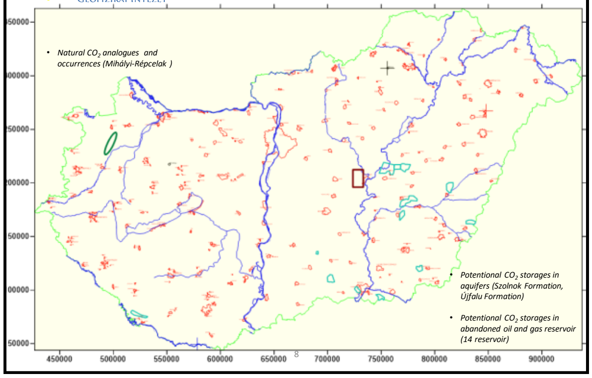
Investigated areas



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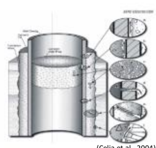
Scientific report of an area

1.Database building and information processing

2. Experimental and demo project tracking (EU, Global)

3. Results of pre-screening, distribution of potential storage sites, estimating their storage capacity

4. Investigation of potential areas after pre-sceening - Assesment of sensitivity and vulnerability
   - Location of the potential CO_2 emitters, accessibility of the transport network
   - The former function of the geological structure and the production history
   - The nearby protected natural resource areas, protected natural areas and the areas of Natura 2000 network
   - Activities relating to the geological subsurface areas, and the potential interactions of these activities
   - Seismic risk assessment
   - Regional distribution of the population
   - Investigation of the natural and human activity induced leakage pathways, fracture systems, well structures and assessment of associated risk.
   - Determination of possible monitoring methods



(Celia et al., 2004)

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Scientific report of an area

5. Detailed analysis of the selected area

- The structure of the geological storage complex
- Available, and effective pore volume and storage capacity estimation
- The geomechanical, geochemical, hydrological and other features of the storage and caprocks, as well as the surrounding formations
- Possible changes in the the fluid geochemical properties of the geological formations and the impact on mineralogy, geochemical reactions, geomechanical and the geochemical, hydrological and other properties
- Determination of the natural and human activity induced leakage pathways
- Estimation of the increased risks of seismicity and surface rise
- Determination of the short and long-term safety and integrity of the site, including the risk of leakage, and general analysis of the environmental and health impacts.

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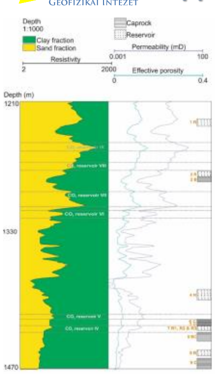
Applied research methods



- **Well-log geophysics**
  - Trend-effective porosity
  - Permeability
  - Clayeyness
  - Formation boundaries
  - Reservoir tracking

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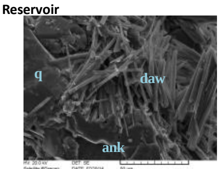
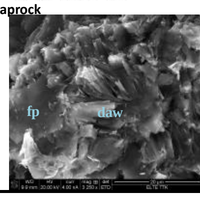
Applied research methods

Reservoir



Caprock



- **Analytical tools**
  - Polarization microscopy
  - **SEM**
  - **FTIR** (Infrared spectrometry)
  - **XRD** (X-ray powder diffraction)
  - Laser scattering grain size distribution analysis

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Future possibilities

- Cooperation with Universities (University of Miskolc),
- research institutes , public administration sector
- and potential indusry partners (large emitters, oil producers), to work together and to link the knowledge bases in Hungary.
- European and national project (CGS Europe, CO2STOP, OTKA)
- Horizon 2020

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Conclusions

- Climate change exists
- Obligations of Member States
- CCS research activity in Hungary (Revision every 5 year)
- Cooperation necessary
- Finding funding
- New fields of research
- Involvement of industry

To minimize the environmental risk of CO_2 storage!

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Acknowledgement

We would like to say thank you to the TÁMOP-4.2.D-15/KONV-2015-0030 project, Geological and Geophysical Institute of Hungary and our colleagues.

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Thank you for your kind attention!

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General requirements of potential CO_2 reservoirs

A potential carbon dioxide storage option may be taken into account if:
• Appropriate depth of reservoir, large enough and
• The porosity is high enough to store sufficient quantities of carbon dioxide,
• Sealed off from drinking water and geothermal reservoirs
• Integrity of cap rock ('0 'permeability, well-sealed cap, which prevents the leakage of carbon dioxide from the formation.)

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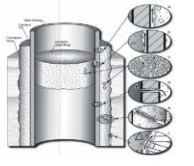
Environmental safety

Aquifers
- modeling of CO_2-saline aquifer-rock interaction
- Investigation of reservoirs and caprocks (mineralogy, transport properties, pore water properties, flow, tempreture and pressure conditions)

Oil and gas reservoirs
- technical conditions
- production status
- other (safety) aspects
- Investigation of reservoirs and caprocks



(Celia et al., 2004)

Assesment of sensitivity and vulnerability of area
- Mining, geothermal energy, water use (competitive use of subsurface), sustainable use of natural resources