EGU 2011-2893

Petrophysical properties of sandstones exposed to supercritical carbon dioxide ($scCO_2$)

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Outline

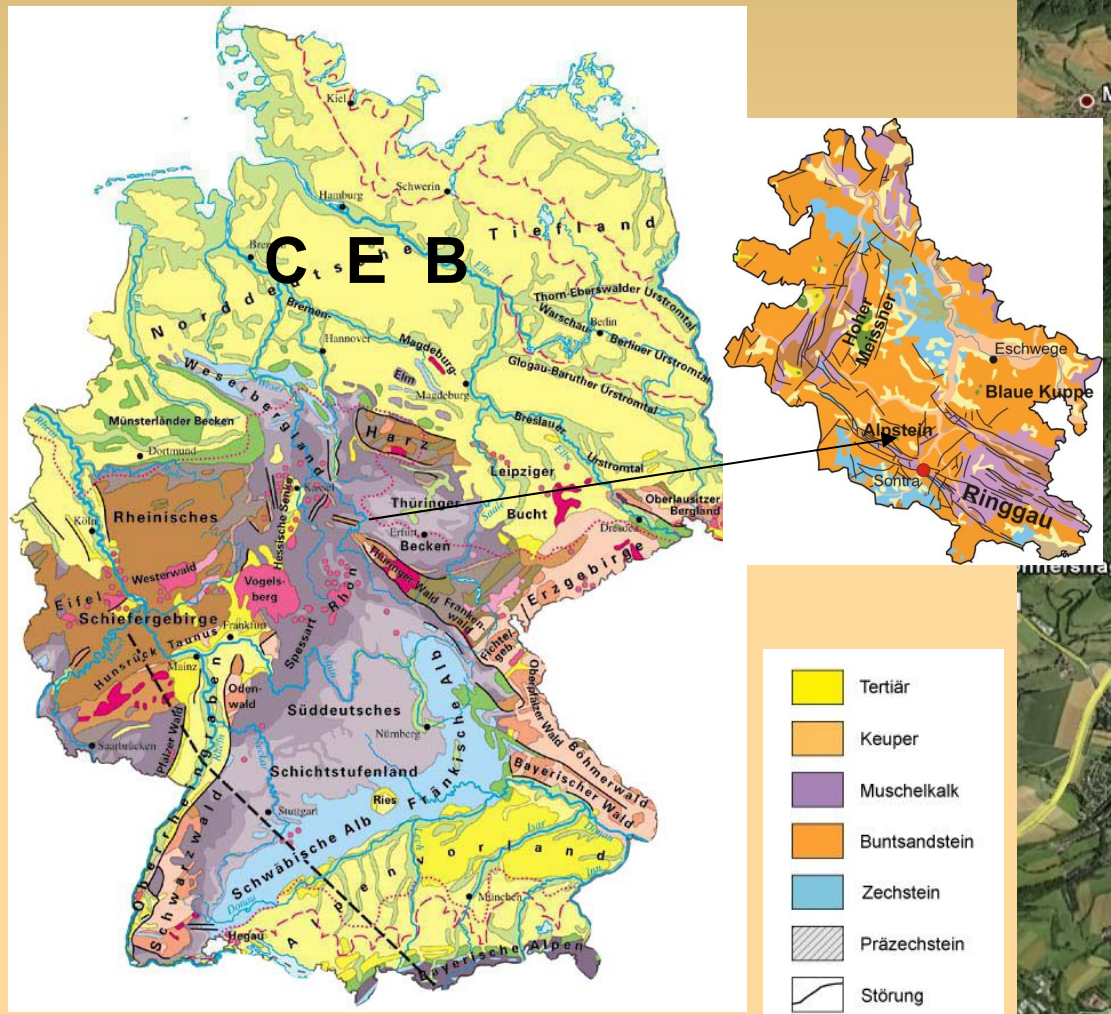
1. Sample characterisation prior to $scCO_2$-treatment
2. Autoclave experiments simulating the p,T-conditions of a deep seated aquifer
3. Sample characterisation after $scCO_2$-experiments
4. Summary – Future work

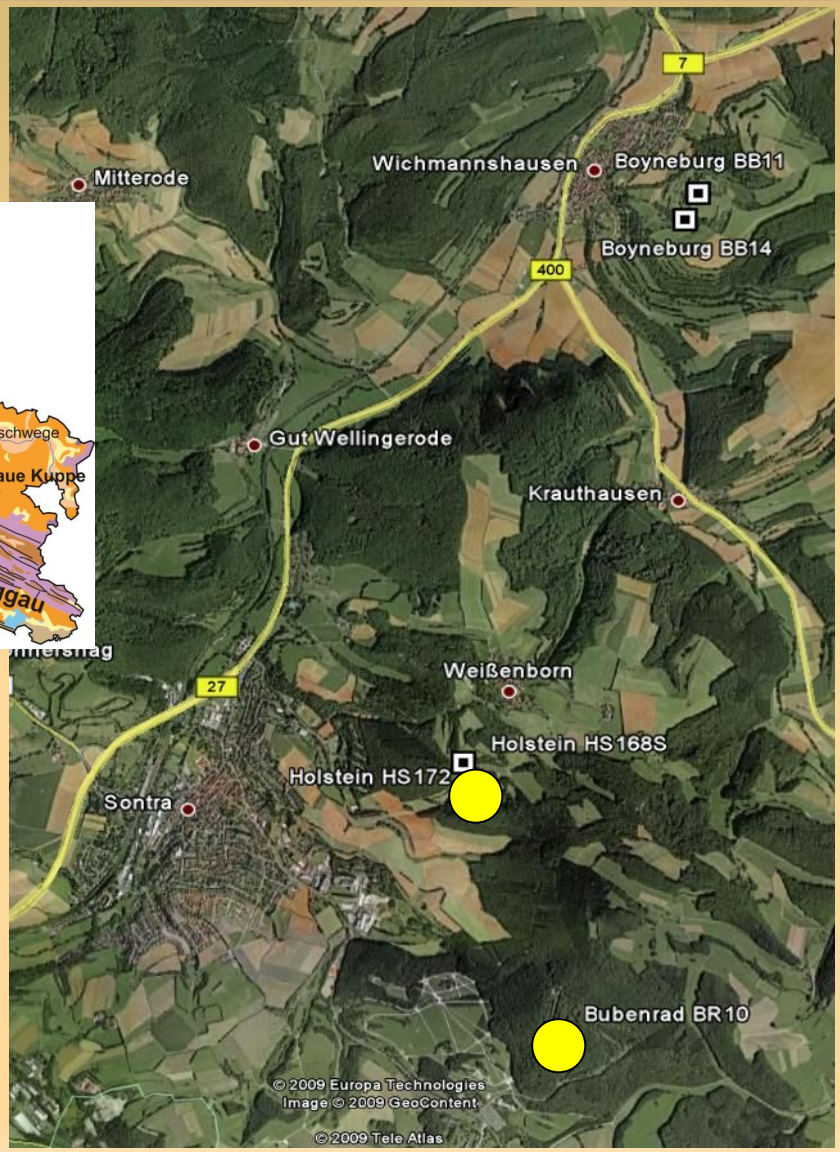
COMICOR: Fault(fracture) related CO_2-fluid migration and its impact on wall rock alteration and the integrity of CO_2 reservoir rocks

EGU_ERE2.1 Long-term storage of CO_2 in geological systems: Results from laboratory studies. Wien, 05.April 2011, 09:15

Sample Locations (Hessian Depression)

Southern part of the CEB (Central European Basin)





Sample characterization prior to $scCO_2$ treatment

Heterogeneity of the Sandstone drill cores:

- Variations in mineralogical composition (clay, feldspar, carbonate, etc.)
- Anisotropy of petrophysical properties (e.g. permeability, electrical conductivity)

Sample selection

- compositional & petrophysical parameters
- axial and radial oriented plugs
- bleached and unbleached samples:

  natural analog for CO_2 contamination

Sample characterization prior to $scCO_2$ treatment

Petrophysical properties

- **Density**
- ***Porosity***
- ***Permeability***
- ***Electrical conductivity (IS, SIP)***
- ***BET pore surface***

Mineralogical / chemical composition & reactions

- ***XRD***
- **XRF**
- **Thermal reactions (DTA/TG)**

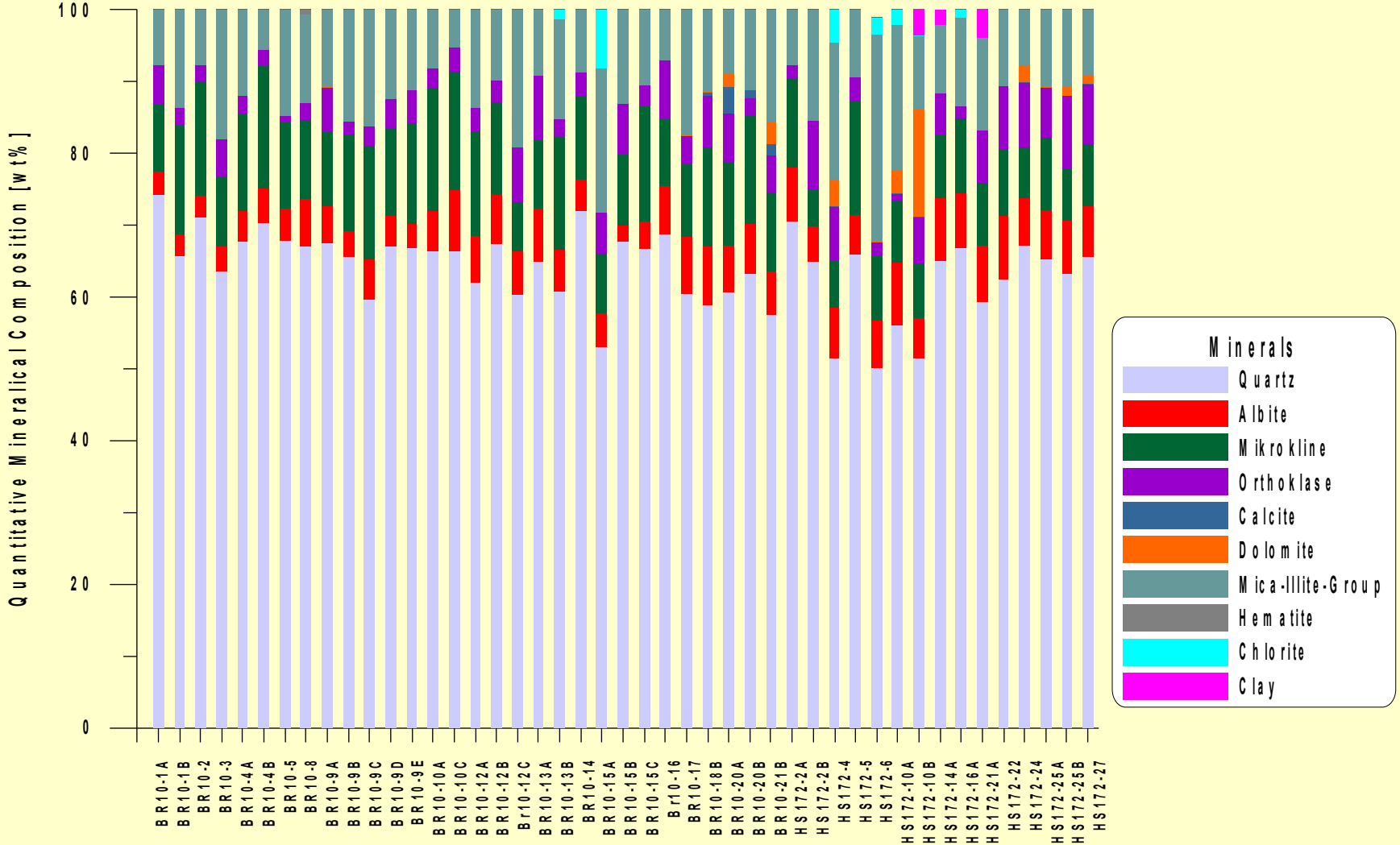
Fluid chemistry

Optical analysis

- **Thin sections**
- **Microprobe**

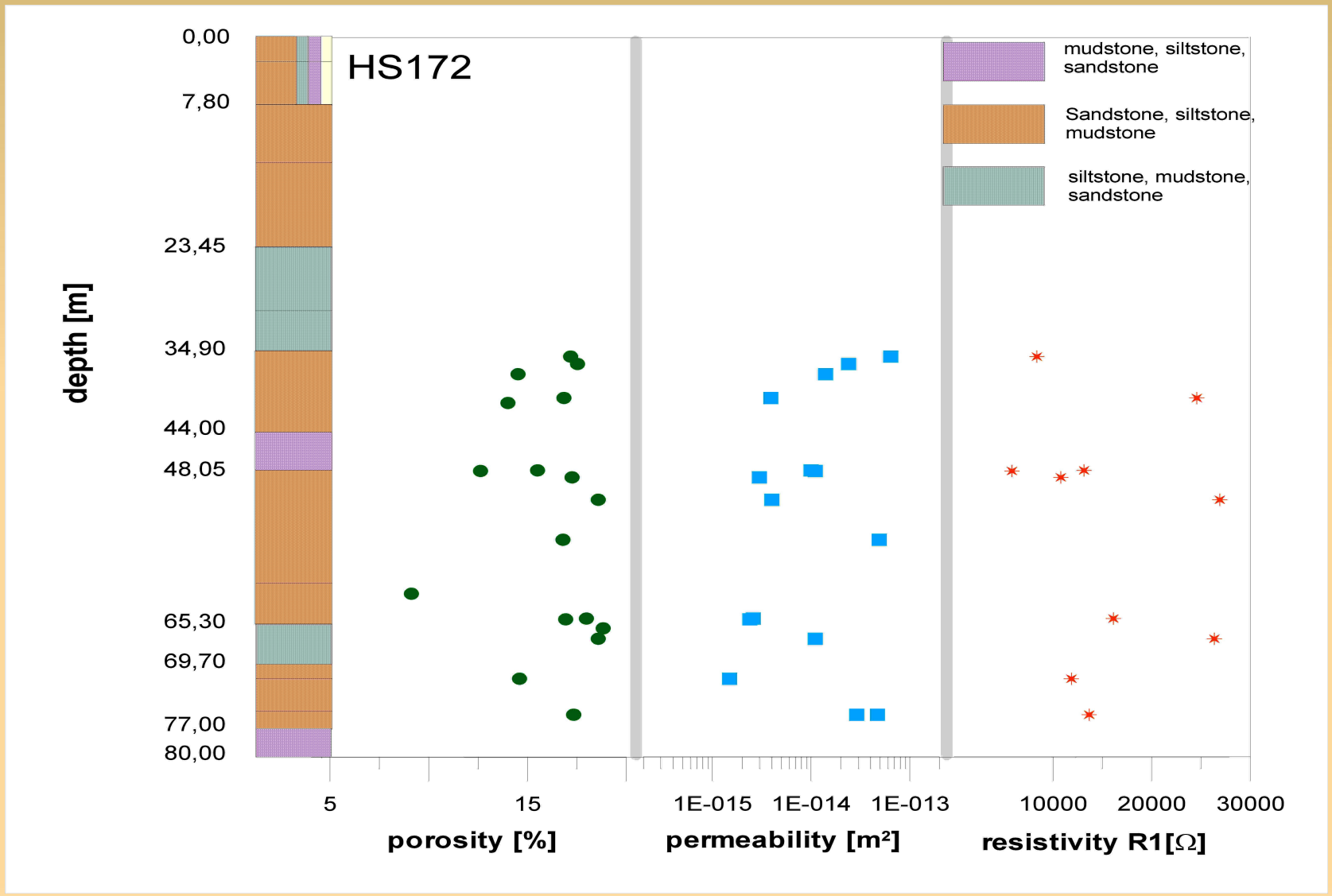
Results of pre-scCO$_2$ characterization:

Phase analysis (XRD) & Rietveld-refinement



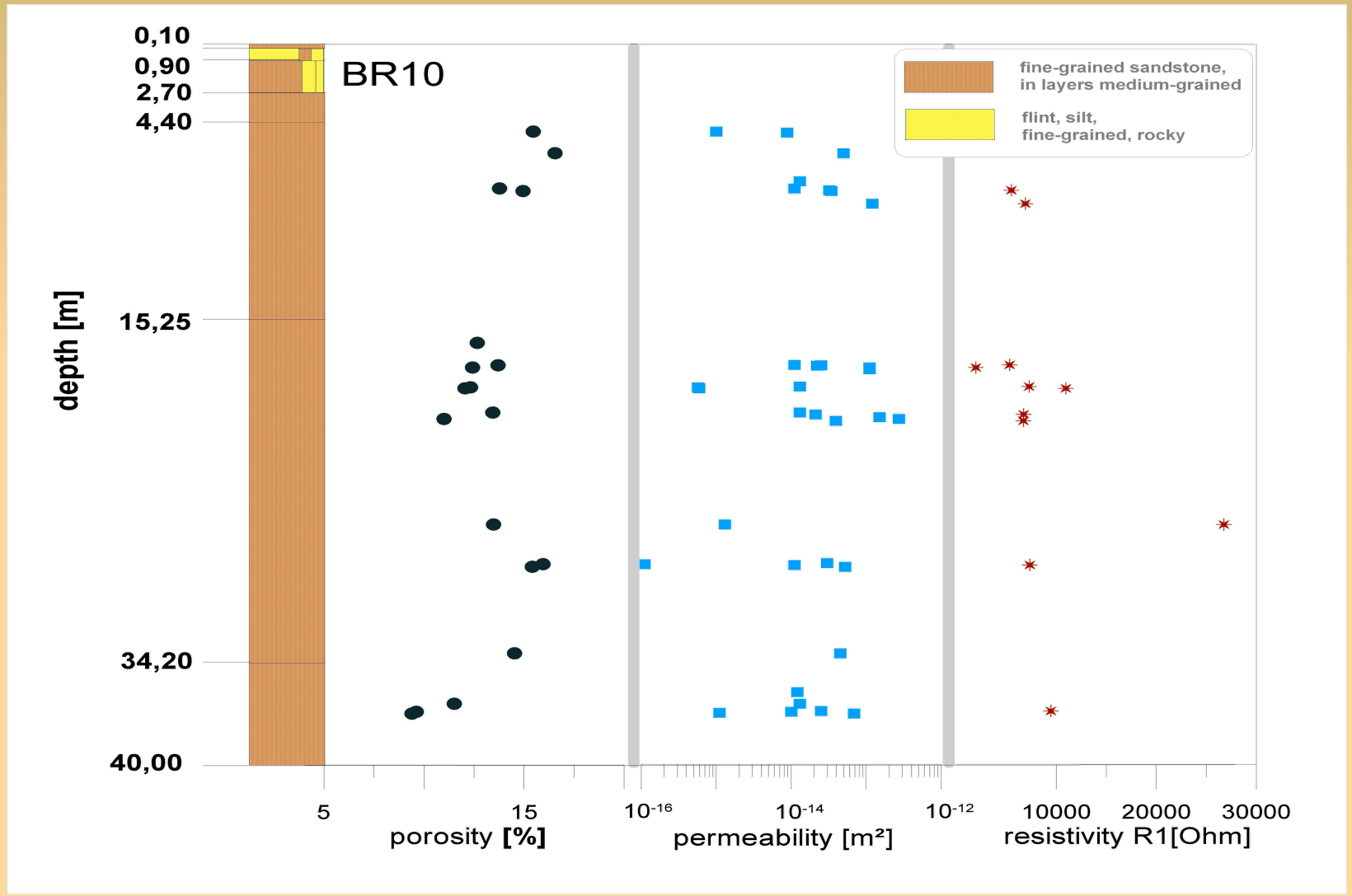
Results of pre-scCO$_2$ characterization:

Drilling Holstein HS172 – layered, ***inhomogeneous***



Results of pre-scCO$_2$ characterization:

Drilling Bubenrad BR10 – layered, ***homogeneous***

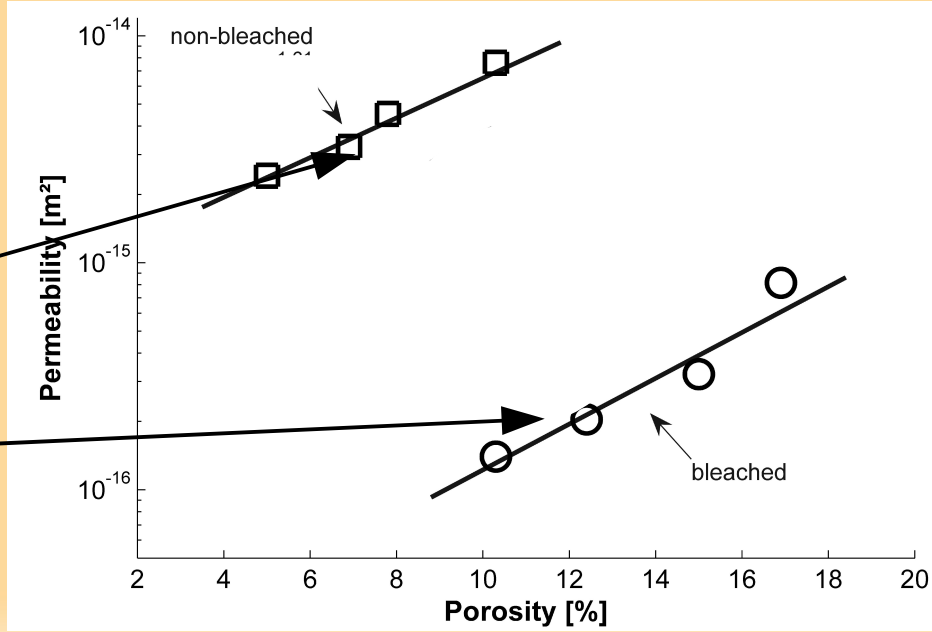


Results of pre-scCO$_2$ characterization:

- Bleached and unbleached samples are different in petrophysical properties
- Permeability and electrical conductivity correlate roughly
- Measurements performed on identical samples are of limited informational value

- Petrophysical properties like porosity & permeability change in less than cm-scale

➡ Measurements must be performed on the same sample in pre- & post-scCO$_2$ experiments



Batch Experiments with $scCO_2$ and 3 M NaCl

Pre-$scCO_2$ characterization

▼

▼

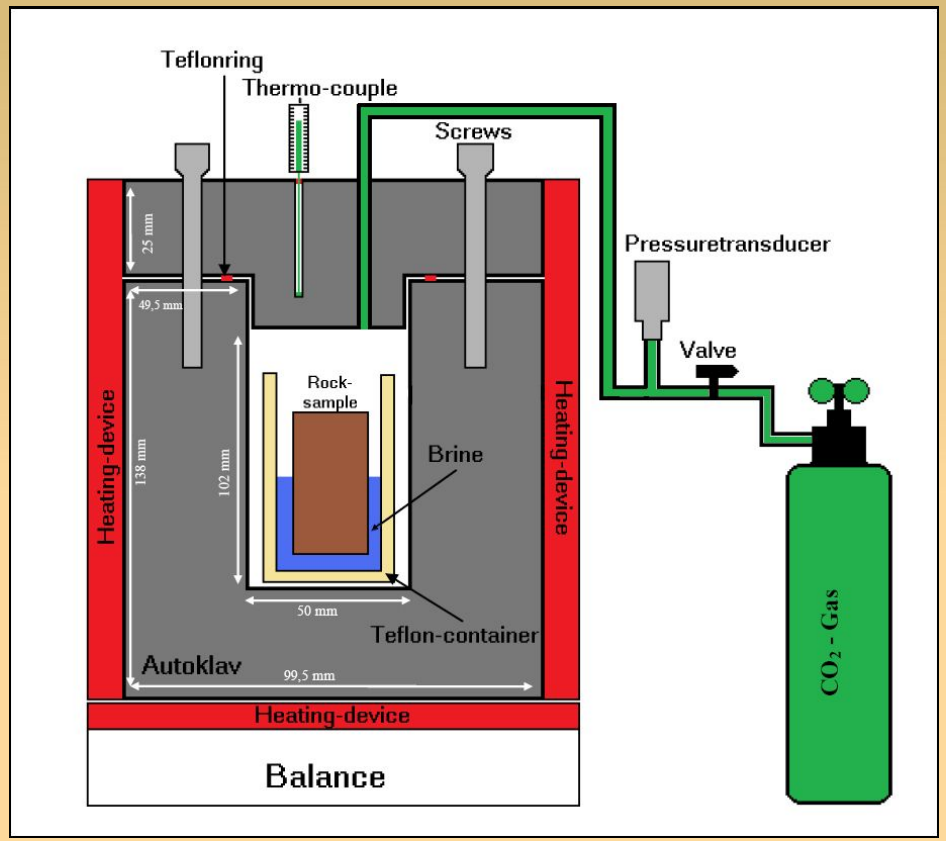
$scCO_2$ experiments

Pressure:	10 – 20 MPa
Temperature:	100-200°C
Fluids:	$scCO_2$ & 3M NaCl solution
Duration:	days up to months
p.T-release	> 10 hours

▼

▼

Post-$scCO_2$ characterization



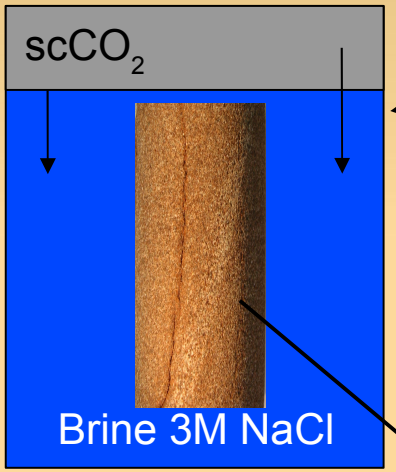
Density
Porosity
Permeability
Electrical conductivity, IS, SIP
XRD, Rietveld
Zeta-potential

XRF
Microprobe
Thin sections
DTA/TG
Fluid chemistry
Rock fabric
Dissolution illite

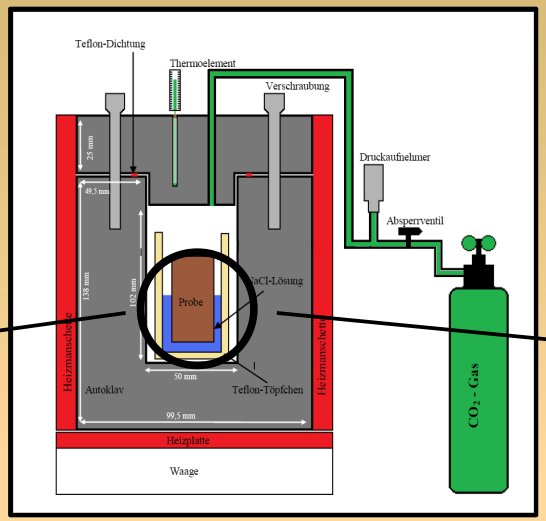
Batch experiments with $scCO_2$ - two experimental setups:

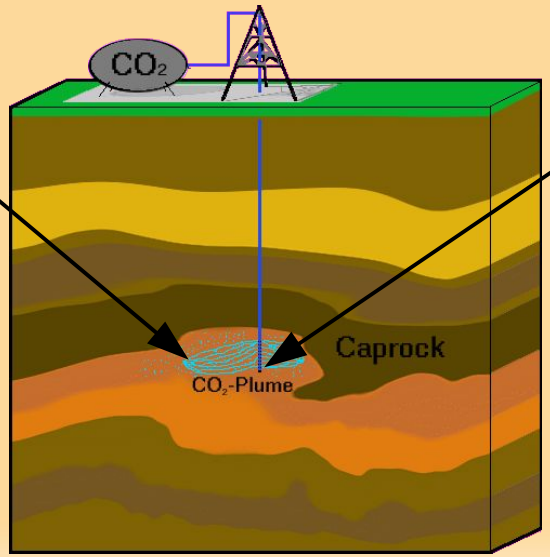
i) fully and ii) partially saturated with 3 M NaCl-solution

Fully saturated
$scCO_2$ penetrates the rock matrix via brine

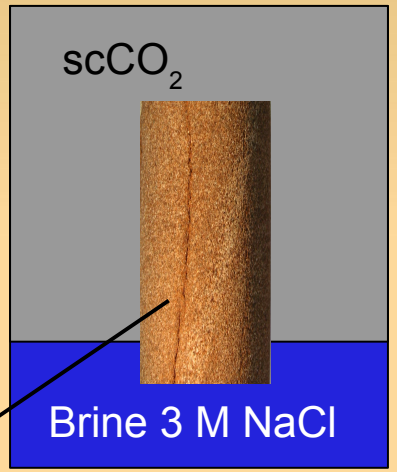


far from injection hole





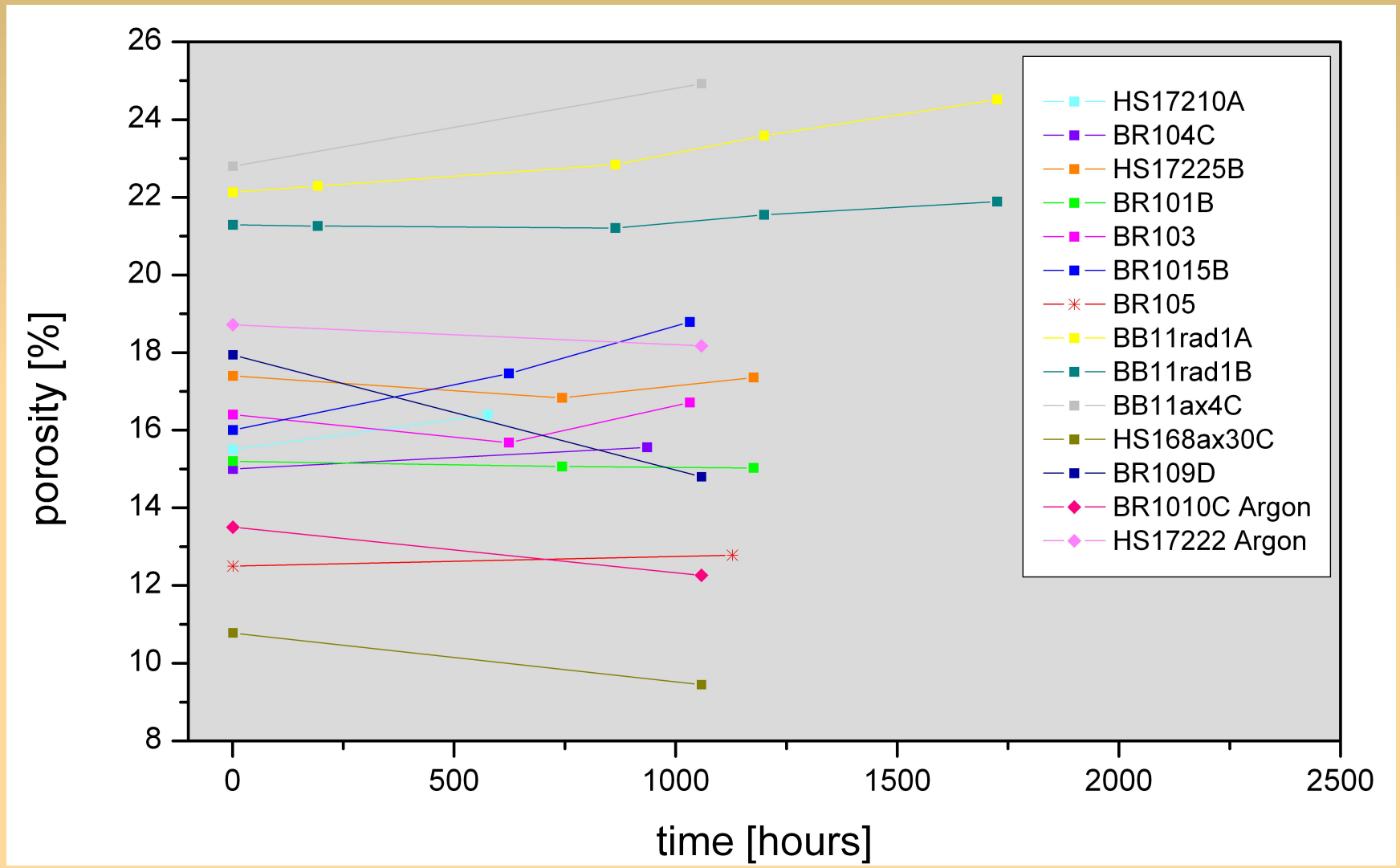
Partially saturated
$scCO_2$ in direct contact with the rock matrix



close to injection hole

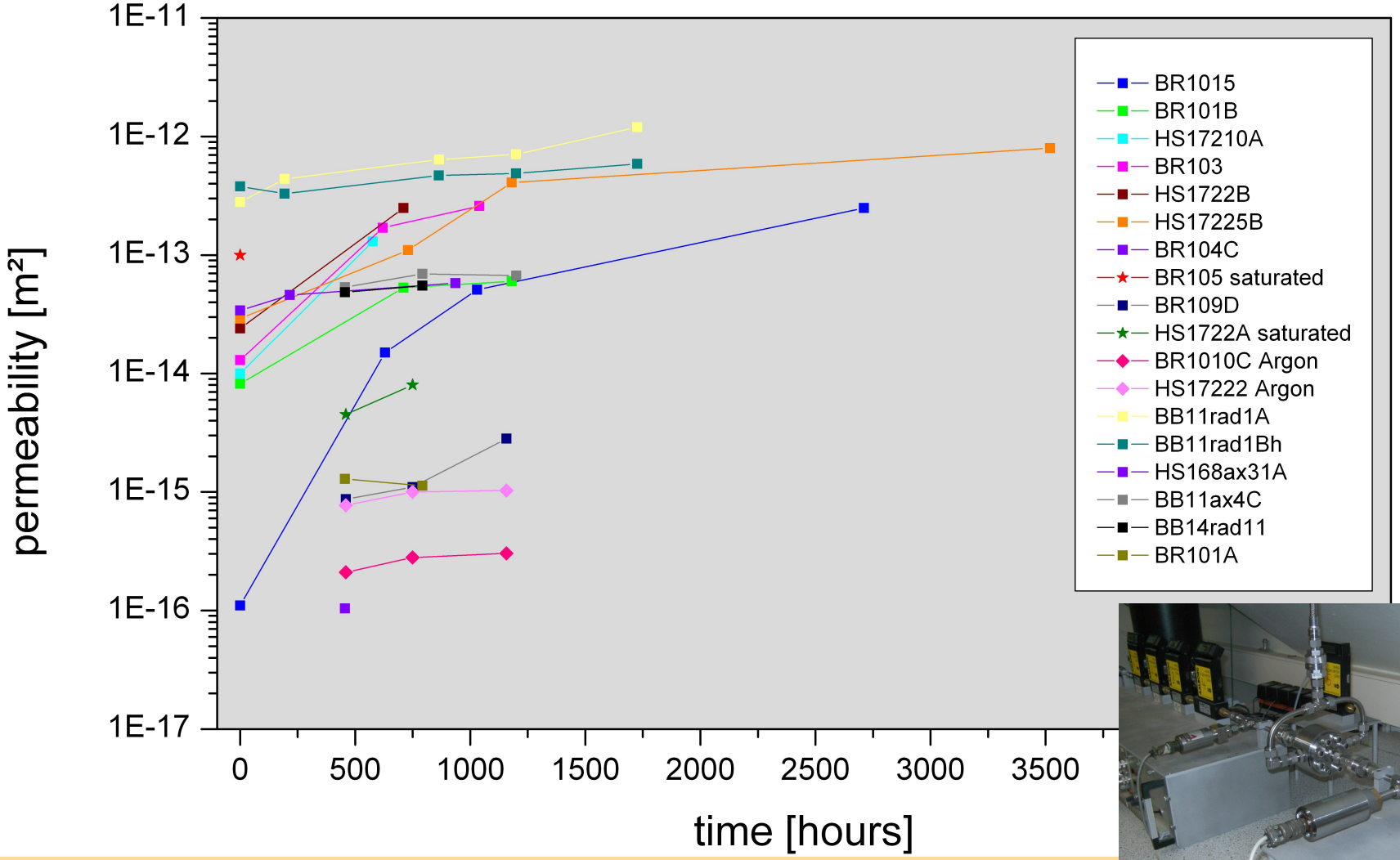
Results of post $scCO_2$ experiments:

Porosity: more or less unchanged



Results of post $scCO_2$ experiments:

Permeability: increase; less pronounced at fully saturated conditions

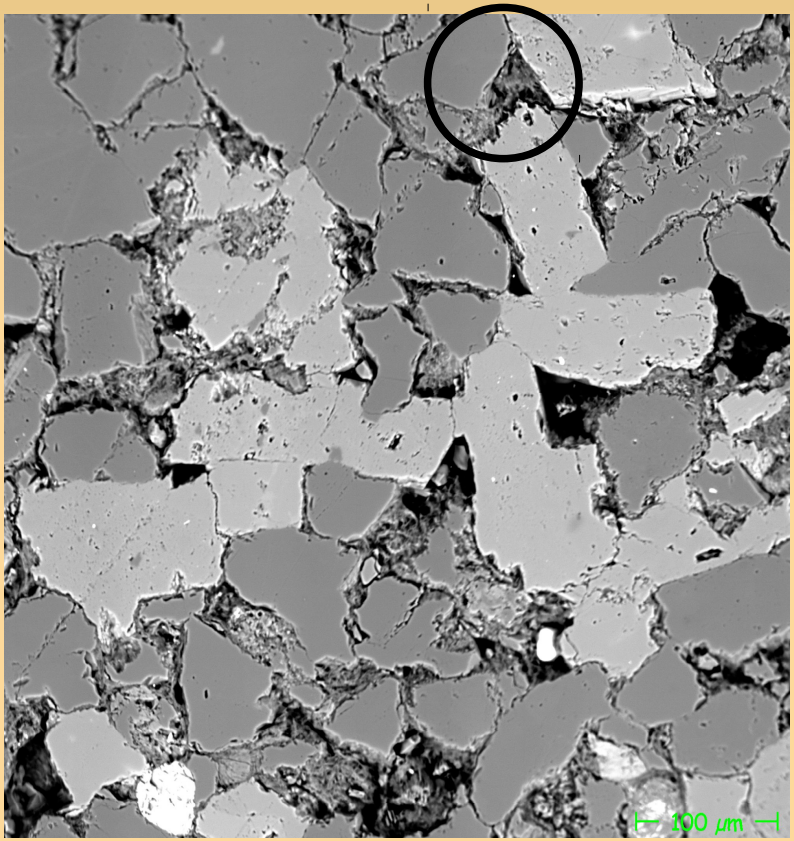


Results of post $scCO_2$ experiments

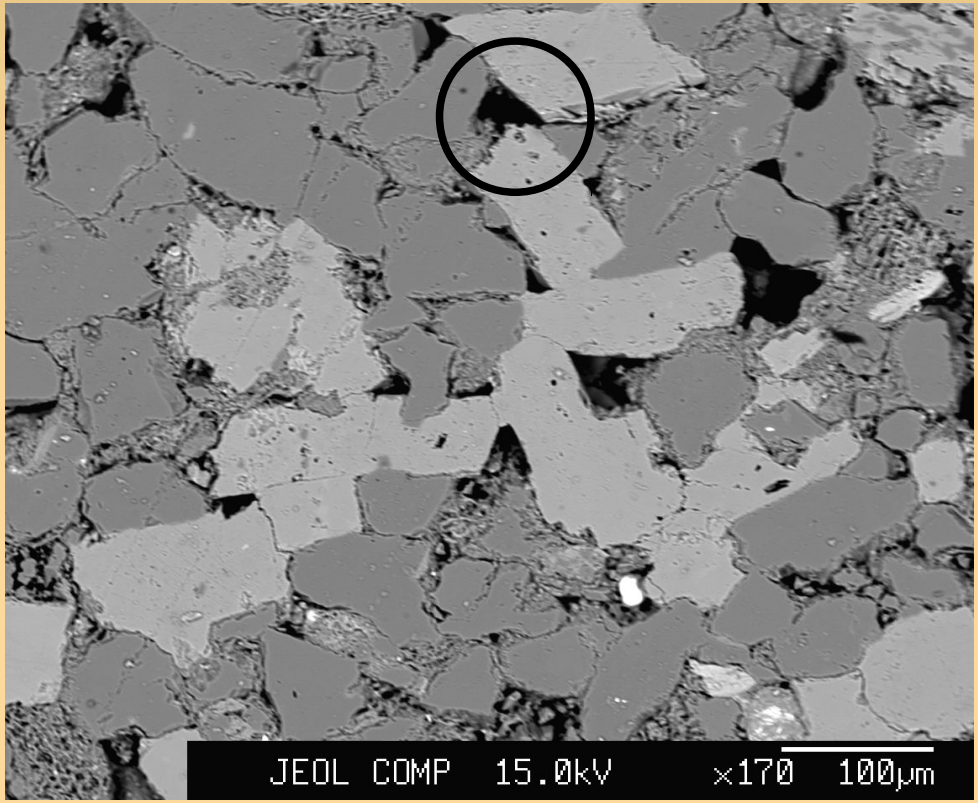
Microprobe analysis of sandstones before and after $scCO_2$ treatment

Sample: Br10-15a : Permeability: 3×10^{-14} m²
Porosity: 12.5 vol%

fresh



$scCO_2$: solution, pore opening



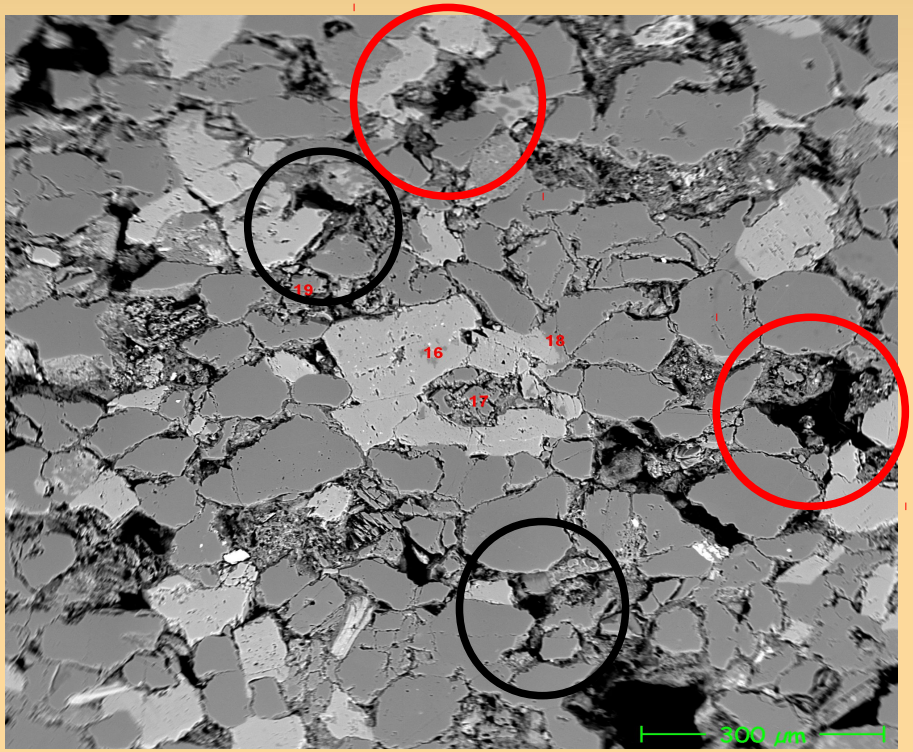
Results of post $scCO_2$ experiments

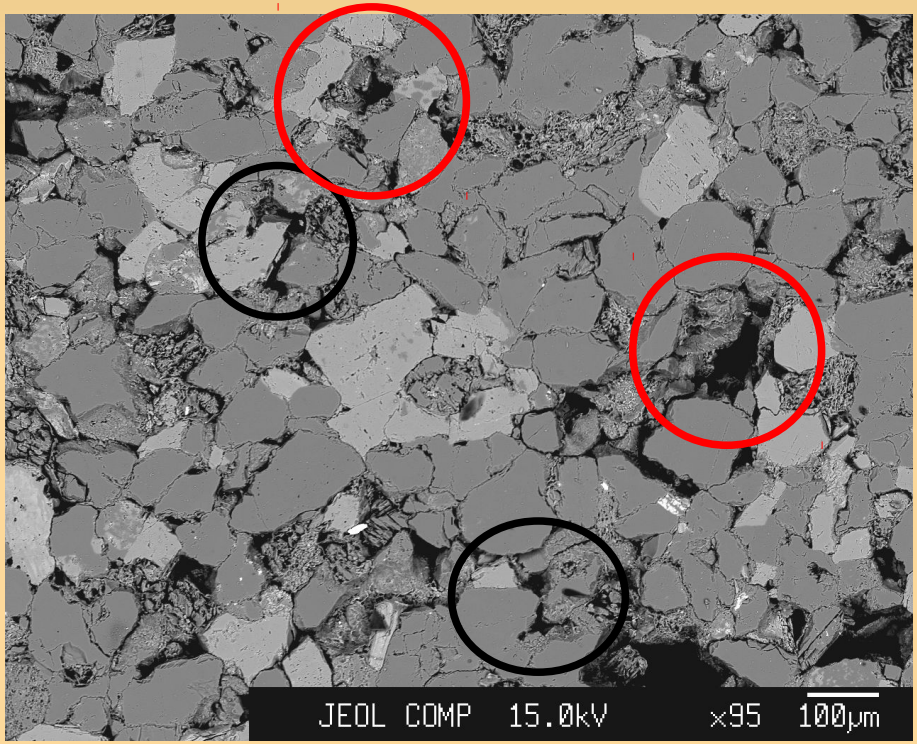
Microprobe analysis of sandstones before and after $scCO_2$ treatment

Sample: Br10-15a : Permeability: 3×10^{-14} m²
Porosity: 12.5 vol%

fresh

$scCO_2$: deposition & solution

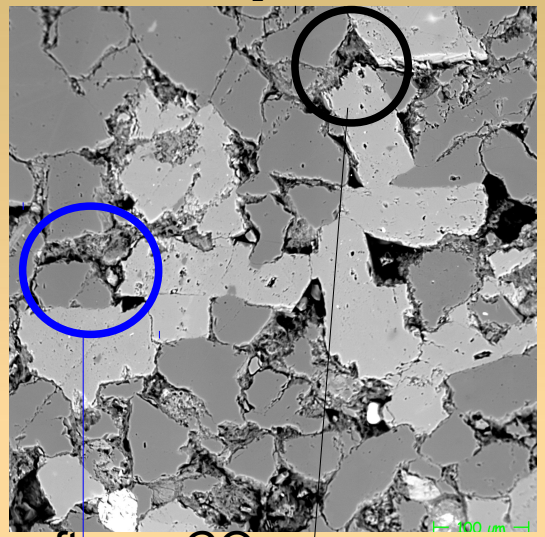




Results of post $scCO_2$ experiments

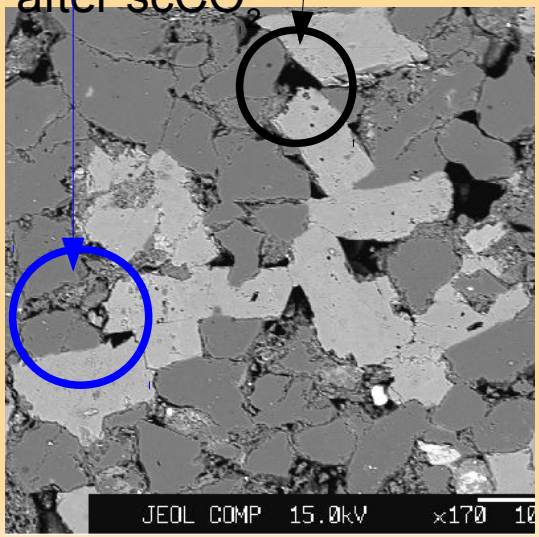
Electrical properties (IS) of sandstones before and after $scCO_2$ treatment; Sample: HS168-30B

Prior to $scCO_2$-treatment

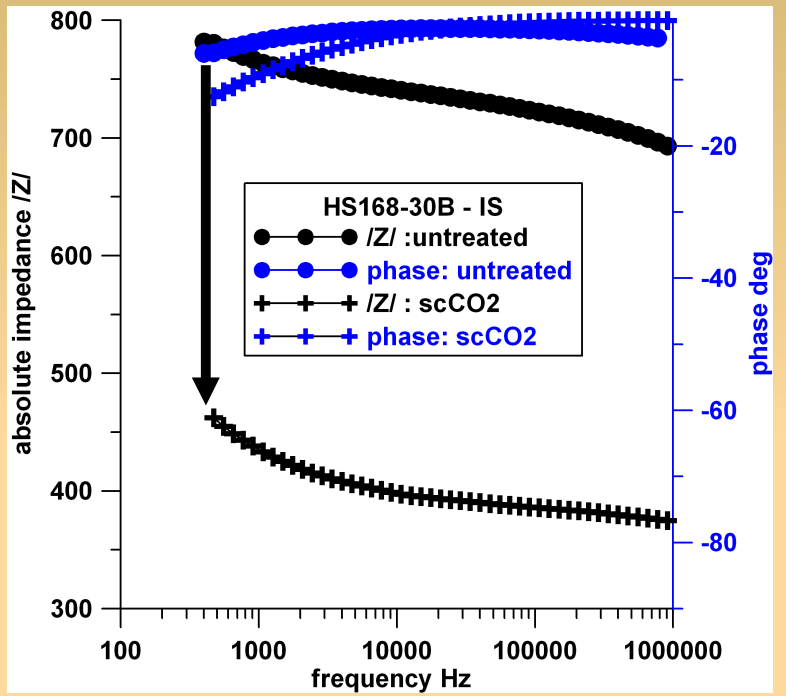


Porosity: 9.43 %
Permeability: 1.92 x 10^{-14} m²

after $scCO_2$



Porosity: 8.50 %
Permeability: 3.65 x 10^{-13}m²



Measured properties	related petrophysical properties
Resistivity	Pore geometry Degree of interconnection
Phase	Inner surface of the pore system Pore size

Results of post $scCO_2$ experiments

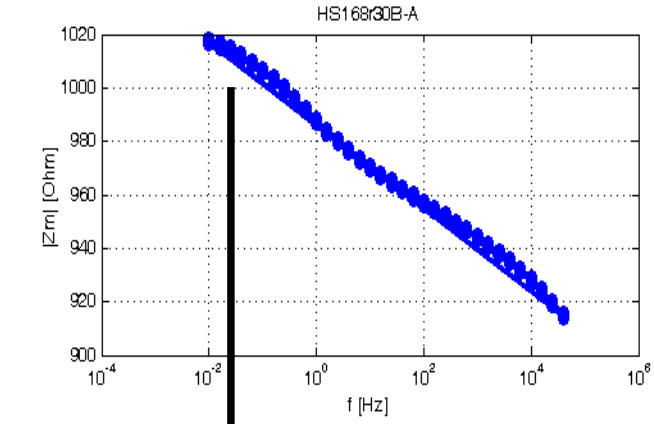
Electrical properties of sandstones before and after $scCO_2$ treatment

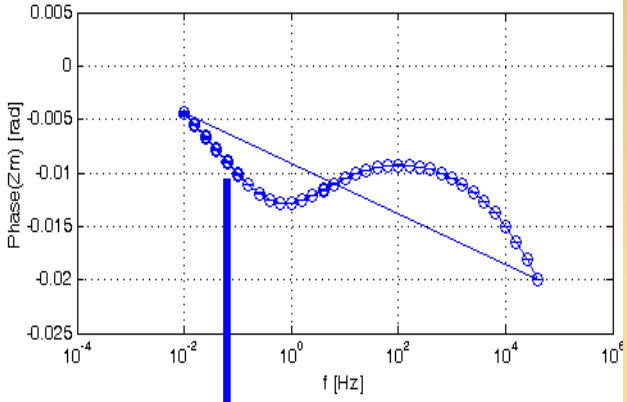
Sample: HS168-30B

SIP: sensitive on inner pore surface variations

Fresh

Porosity: 9.43 vol%
Permeability: 1.92e-14 m²

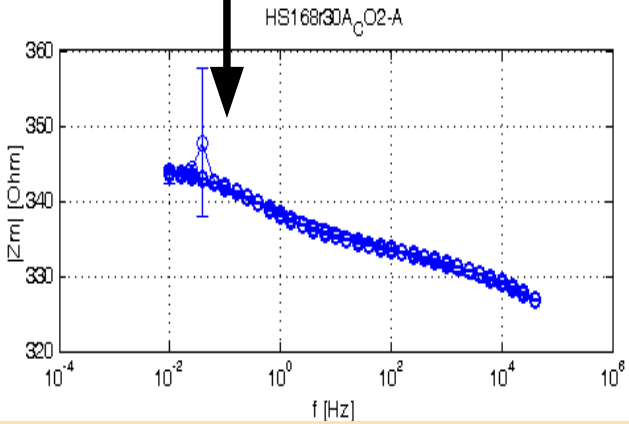


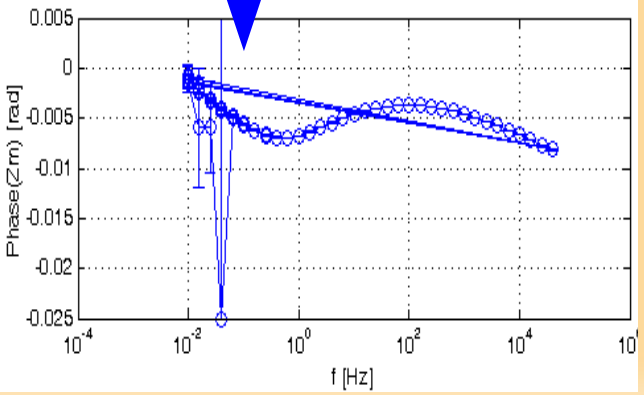


Resistivity decrease - phase shift

$scCO_2$

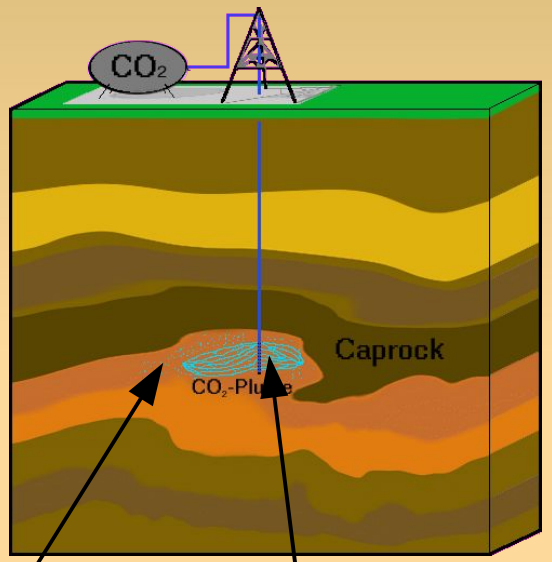
Porosity: 8.50 vol%
Permeability: 3.65e-13 m²





Summary

- Porosity unchanged
  - storage volume
- Permeability increase
  - flow conditions
- Solution of feldspar, mica, clay and carbonate
  - pore surface area
- Electrical properties (IS, SIP) reflect the petrophysical changes
  - monitoring tool
- Microprobe: solution and deposition; relocation of clay particles



Future work
- Flow experiments
- NMR
- BET
- Fluid chemistry ICP-OES+MS: Al, Ca, Li, Na
- Reaction kinetics

	Fully saturated *Far from injection point*	Partially saturated *Close to injection point*
Porosity	± unchanged	increase >> factor 10
Permeability	± unchanged	increase < factor 10

Acknowledgements

- We like to thank the BMBF “Geotechnologien” program for funding this research
- Special thanks to everybody outside the COMICOR team who contributed to the project

Thank you for your attention!

COMICOR

GEOTECHNOLOGIEN

Bundesministerium für Bildung und Forschung