Supported by:

Federal Ministry of Economics and Technology

on the basis of a decision by the German Bundestag

Geochemical and geomechanical behaviour of reservoir rocks during the injection of CO_2 in deep geological formations: results of the project COORAL

Herwig Marbler, Kirsten Erickson, Christof Lempp, Michael Schmidt, and Herbert Pöllmann

Martin-Luther-University Halle-Wittenberg, Germany

EGU 2011 Vienna

COORAL: CO_2 Purity for Capture and Storage




Key question:

What are the **optimum proportions of carbon dioxide and incidental substances** in the separated gas streams of different power plant types to

- ensure long-term, safe geological storage,
- prevent corrosion of equipment and pipelines and
- keep costs of the CCS technology economically acceptable ?

COORAL: CO_2 Purity for Capture and Storage

Funding by BMWi & third-party funding by

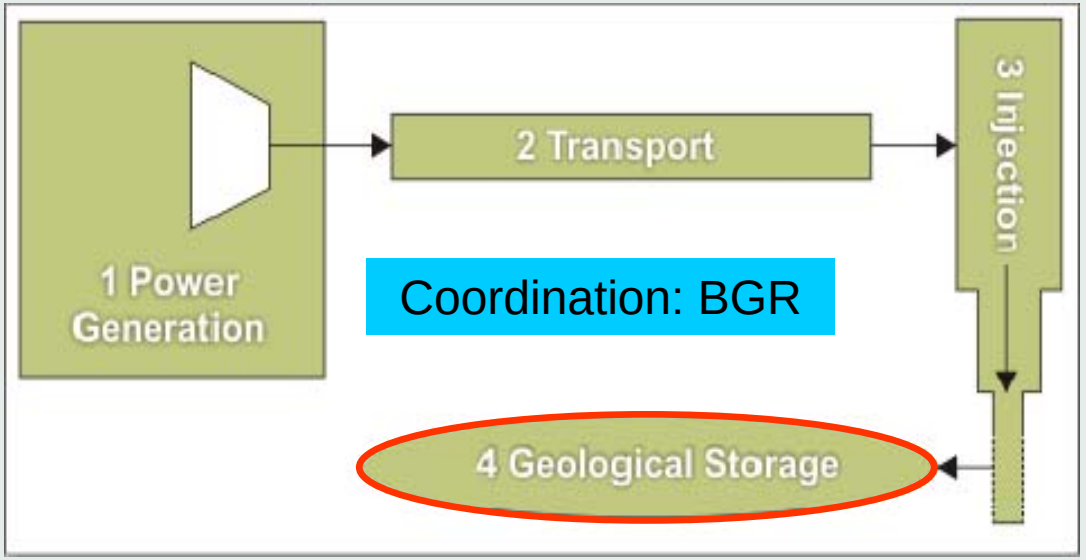
Supported by:
Federal Ministry of Economics and Technology
on the basis of a decision by the German Bundestag

ALSTOM,
EnBW,
E.ON,
Vattenfall,
VNG

Project duration: May 2009 to September 2012

Organisation und Subprojects

To optimize the process chain:
power generation – transport – injection – geological storage.



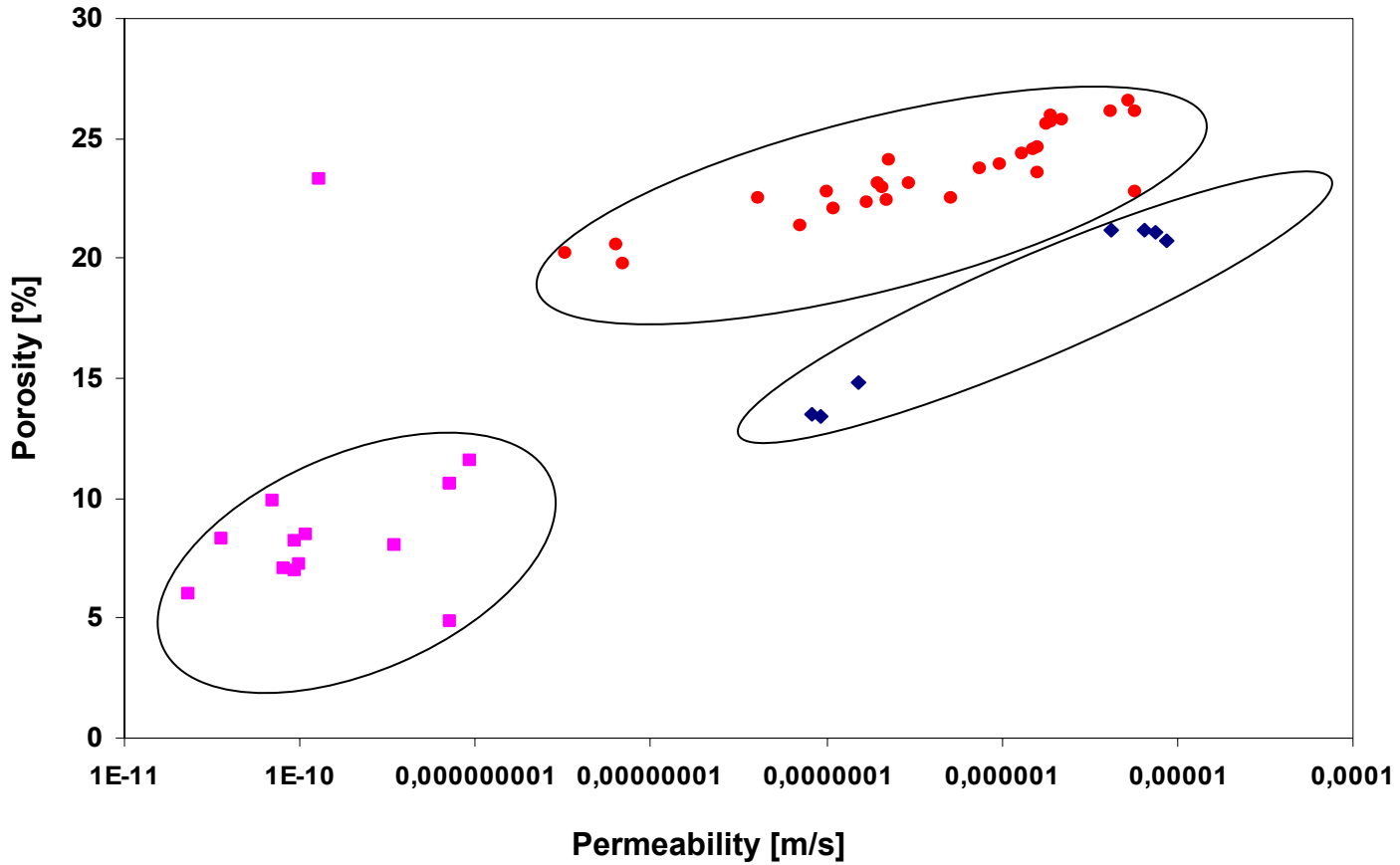
Combined geochemical/ geomechanical investigations

Experiments with:

$scCO_2$ + SO_x, NO_x, O_2

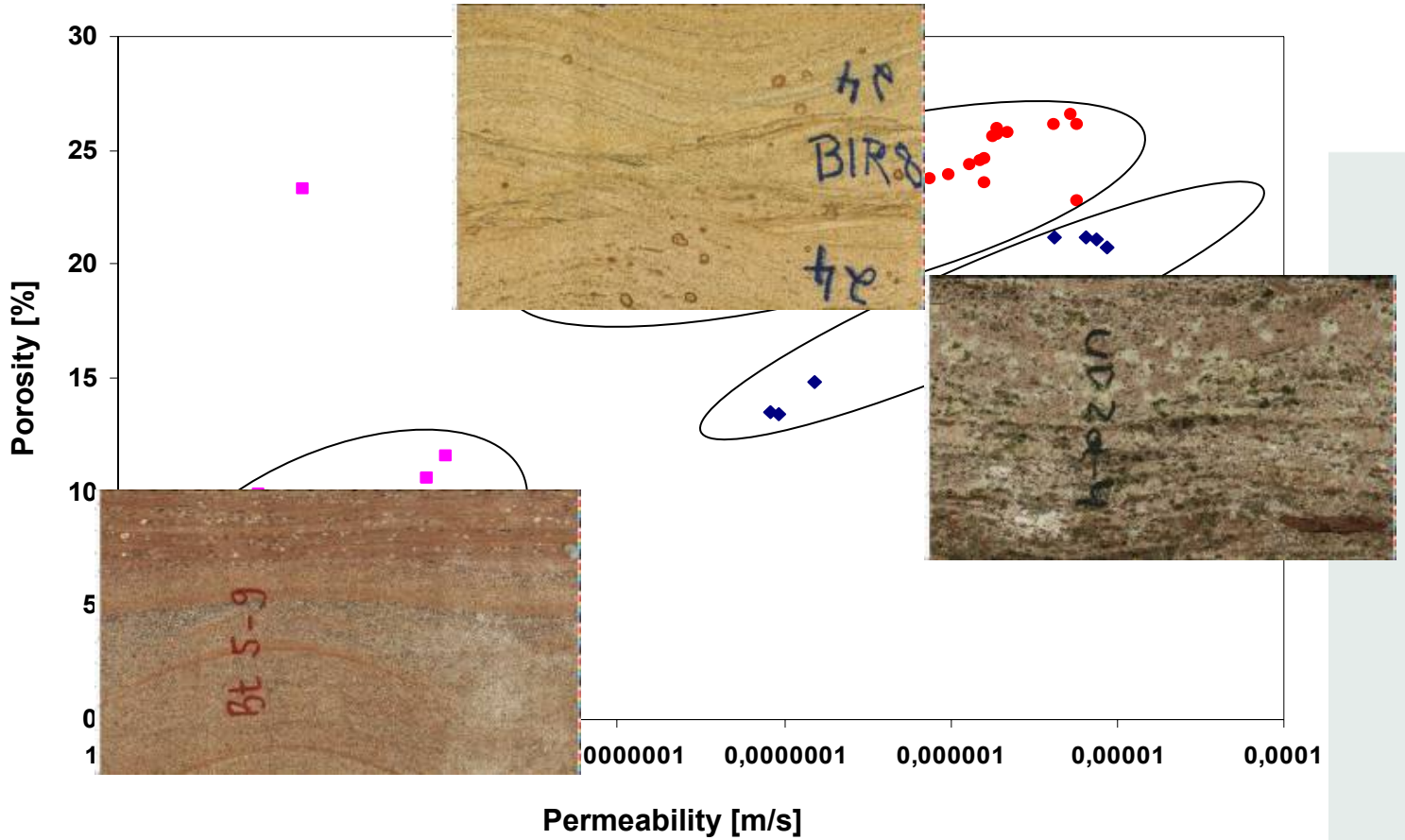
- **autoclave reactor system**
- **heatable triaxial pressure cell**

Classification of lithotypes by reservoir properties: porosity & permeability



lithotype	formation	porosity	permeability
heterogeneous, siliclastic bound sandstone	Sm	high	medium
heterogeneous, carbonatic bound sandstone	Sm	medium	
fine-/mediumclastic siliclastic sandstone	Ro	low	low

Classification of lithotypes by reservoir properties: porosity & permeability



lithotype	formation	porosity	permeability
heterogeneous, siliclastic bound sandstone	Sm	high	medium
heterogeneous, carbonatic bound sandstone	Sm	medium	
fine-/mediumclastic siliclastic sandstone	Ro	low	low

Experimental flow

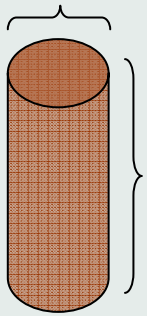
Saturation

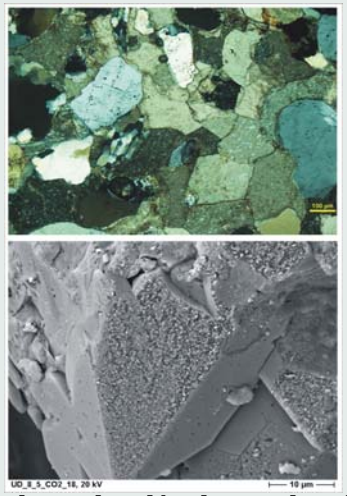
brine composition
Modified Buntsandstein brine
Na: 46 g/l, Ca: 5 g/l, Mg: 2 g/l, K: 1 g/l
(TDS: 173 g/l)

CO_2 treatment in an autoclave system

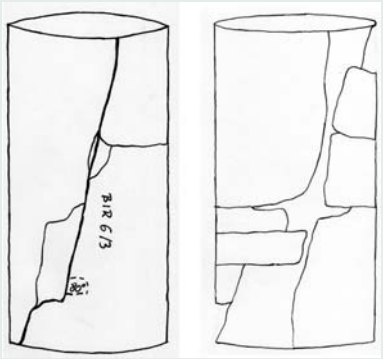
Geomechanical tests in a triaxial pressure cell

Geochemical, mineralogical and geomechanical characterization of samples before CO_2 treatment





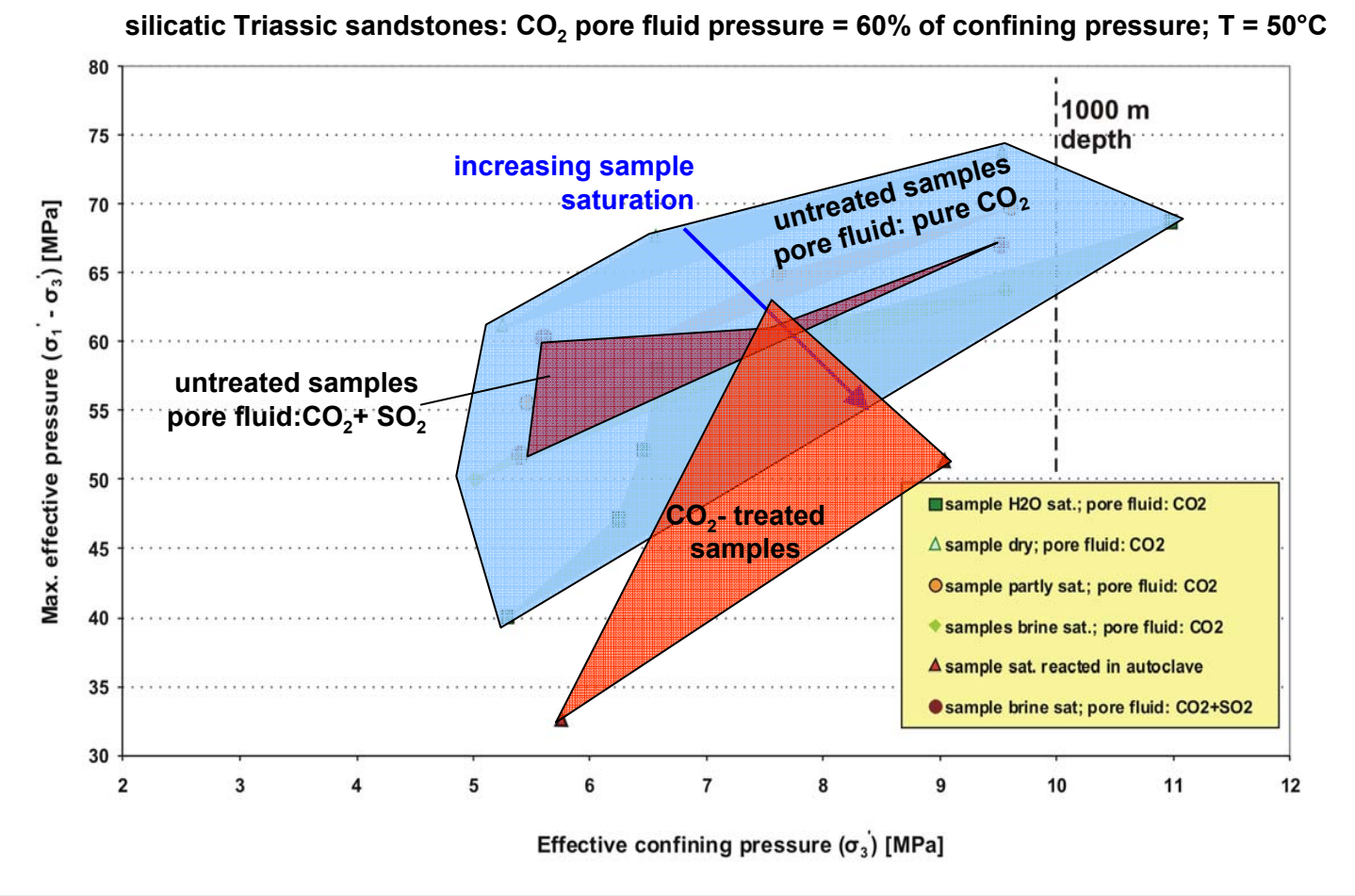
Geochemical/mineralogical characterization after CO_2 treatment



Mechanical characterization

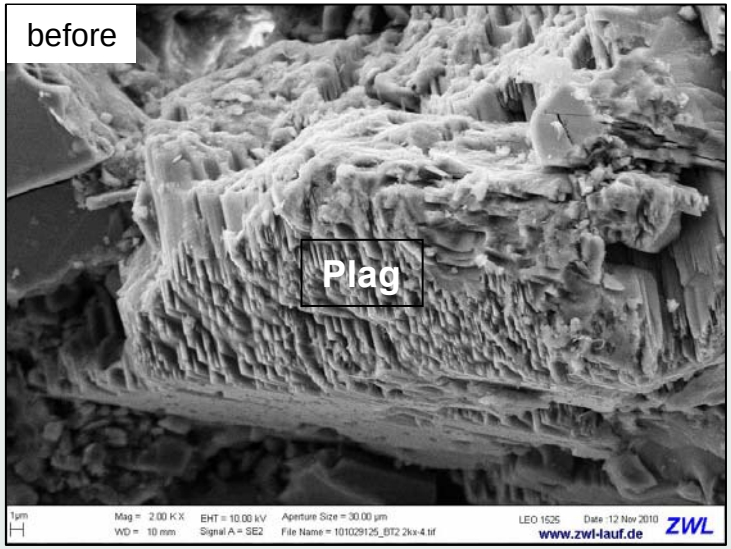
Herwig Marbler et al.:
Geochemical and geomechanical behaviour of reservoir rocks during the injection of CO2 in deep geological formations: results of the project COORAL

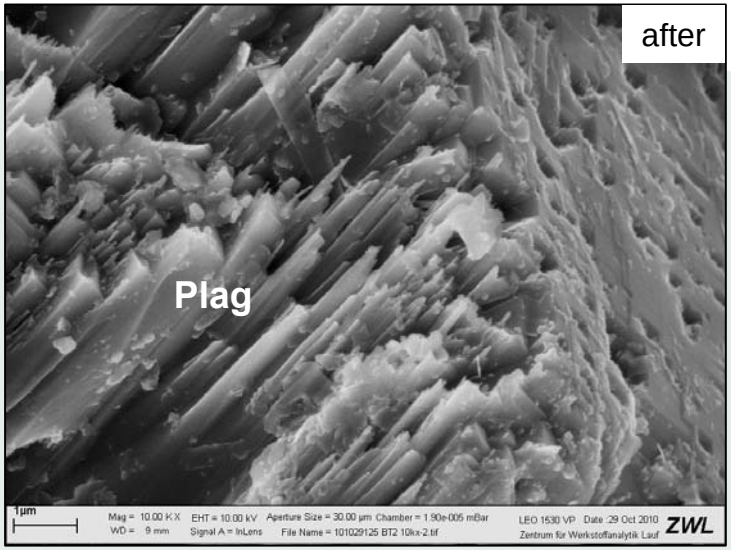
Influence of rock saturation, confining pressure (σ_3), CO_2 pore fluid pressure and alteration on the maximum effective pressure

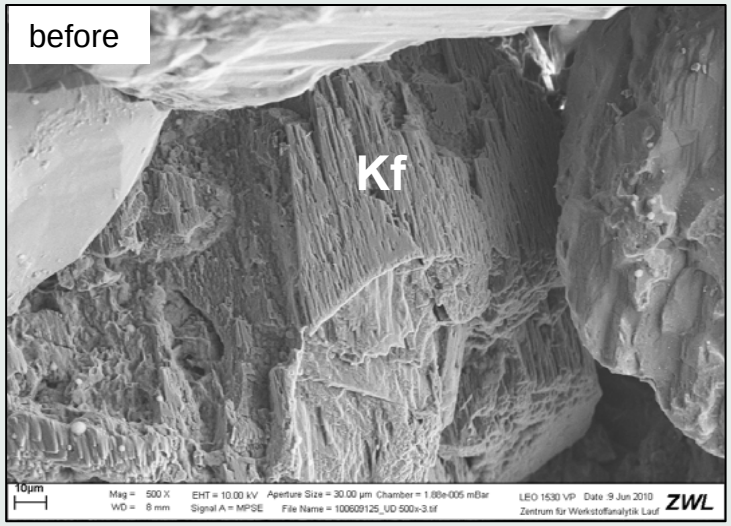


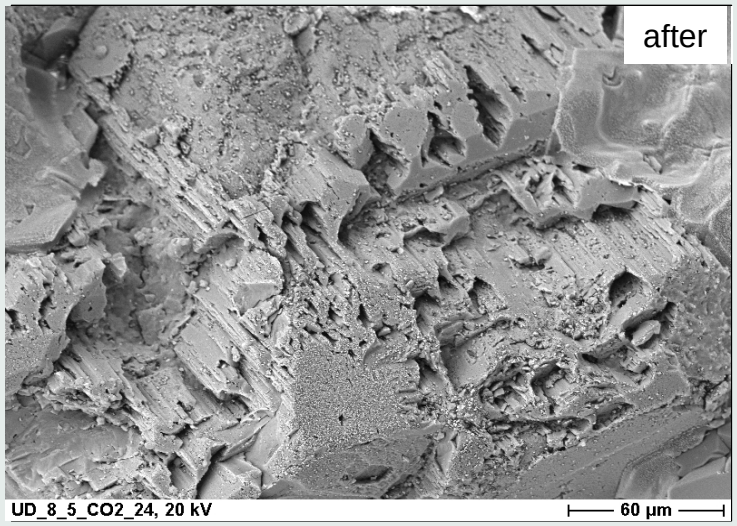
- **Dry rocks can resist higher differential stresses than saturated rocks**
- **No clear differences between pure CO_2 and CO_2+ SO_2 as pore fluid**
- **Trends of chemical induced mechanical weakening of the sandstones**

Alteration effects on the am silicatic sandstone



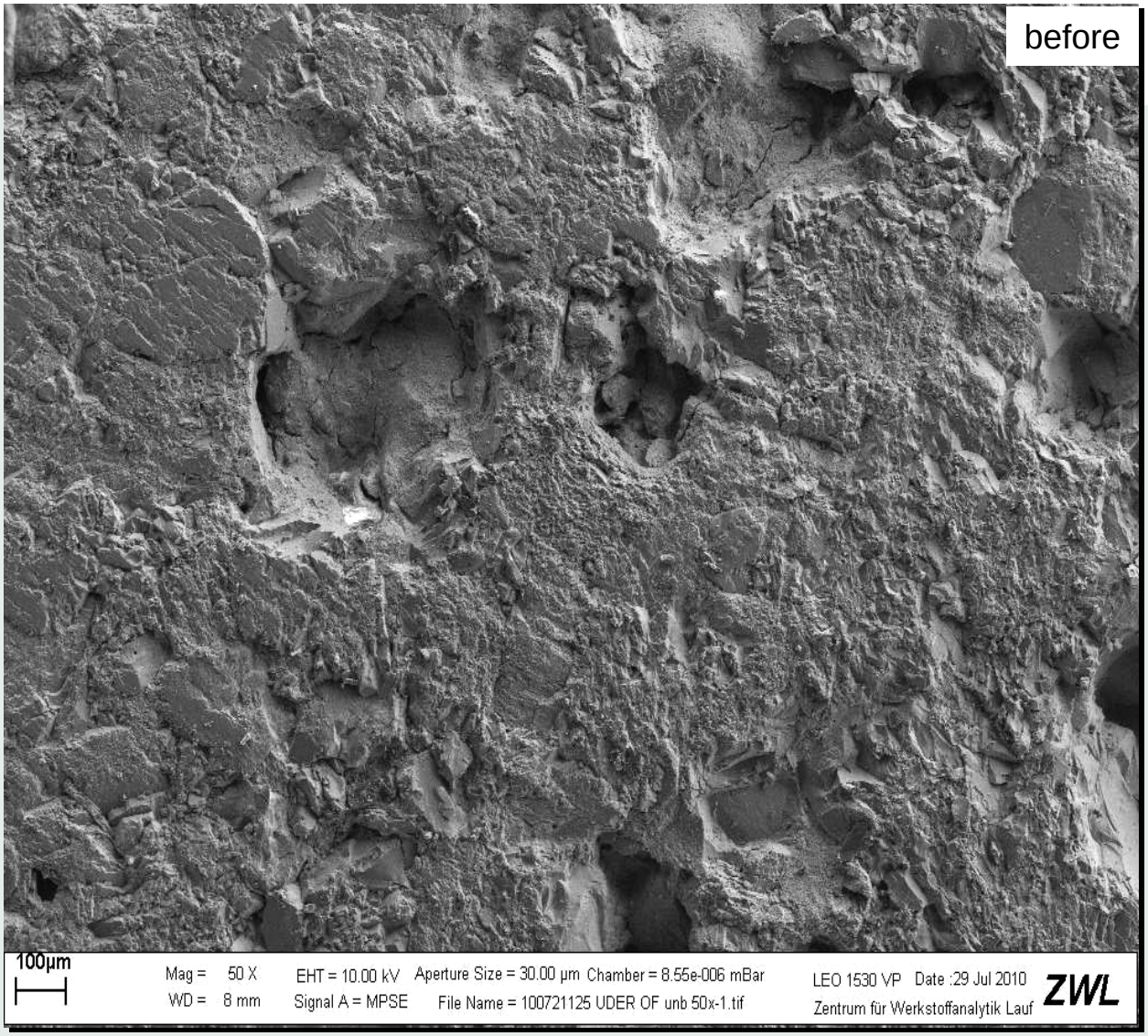






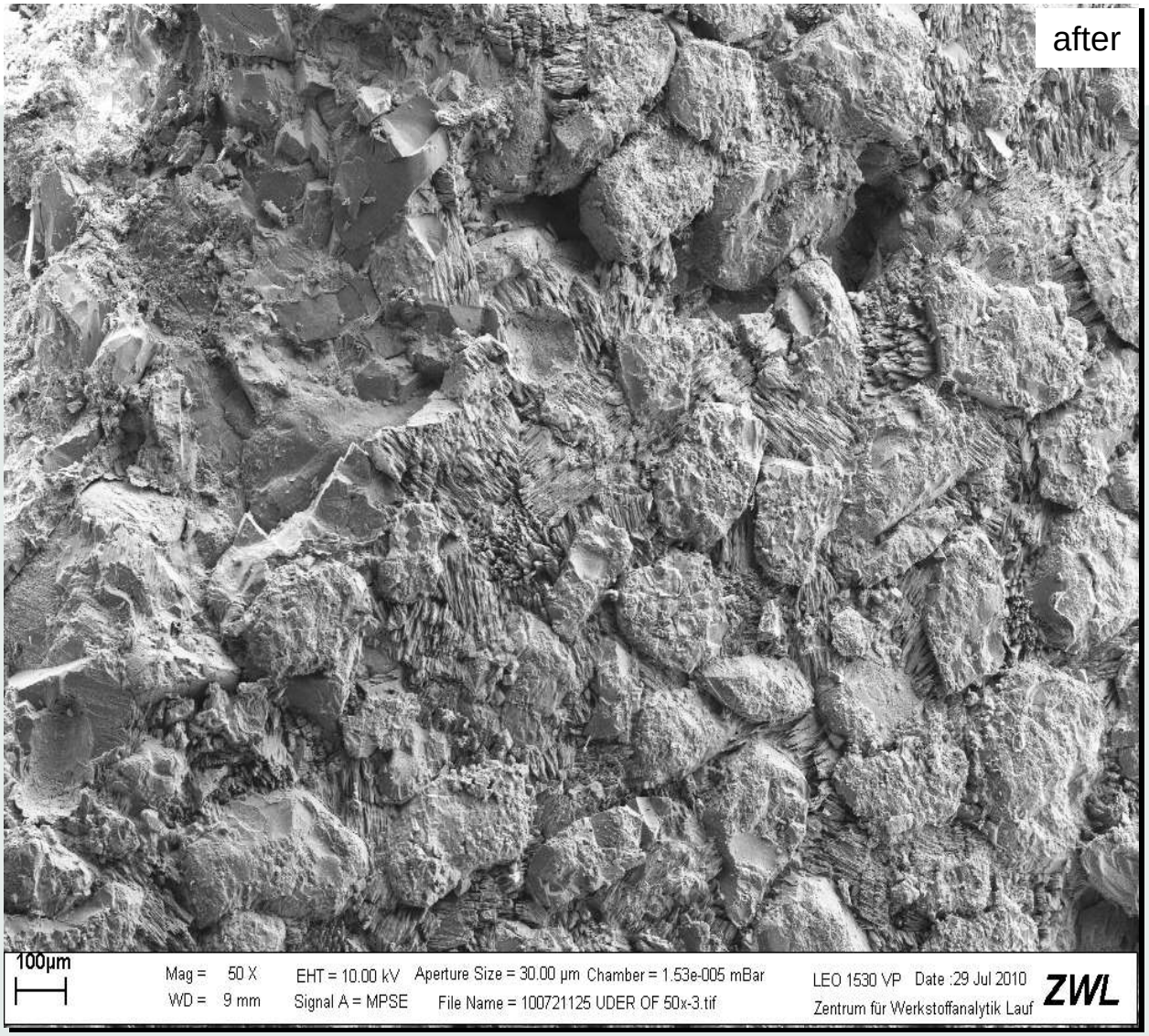
Alteration on the carbonatic sandstone

- **T: 100°C**
- **p: 100 bar**
- **duration: 20 days**



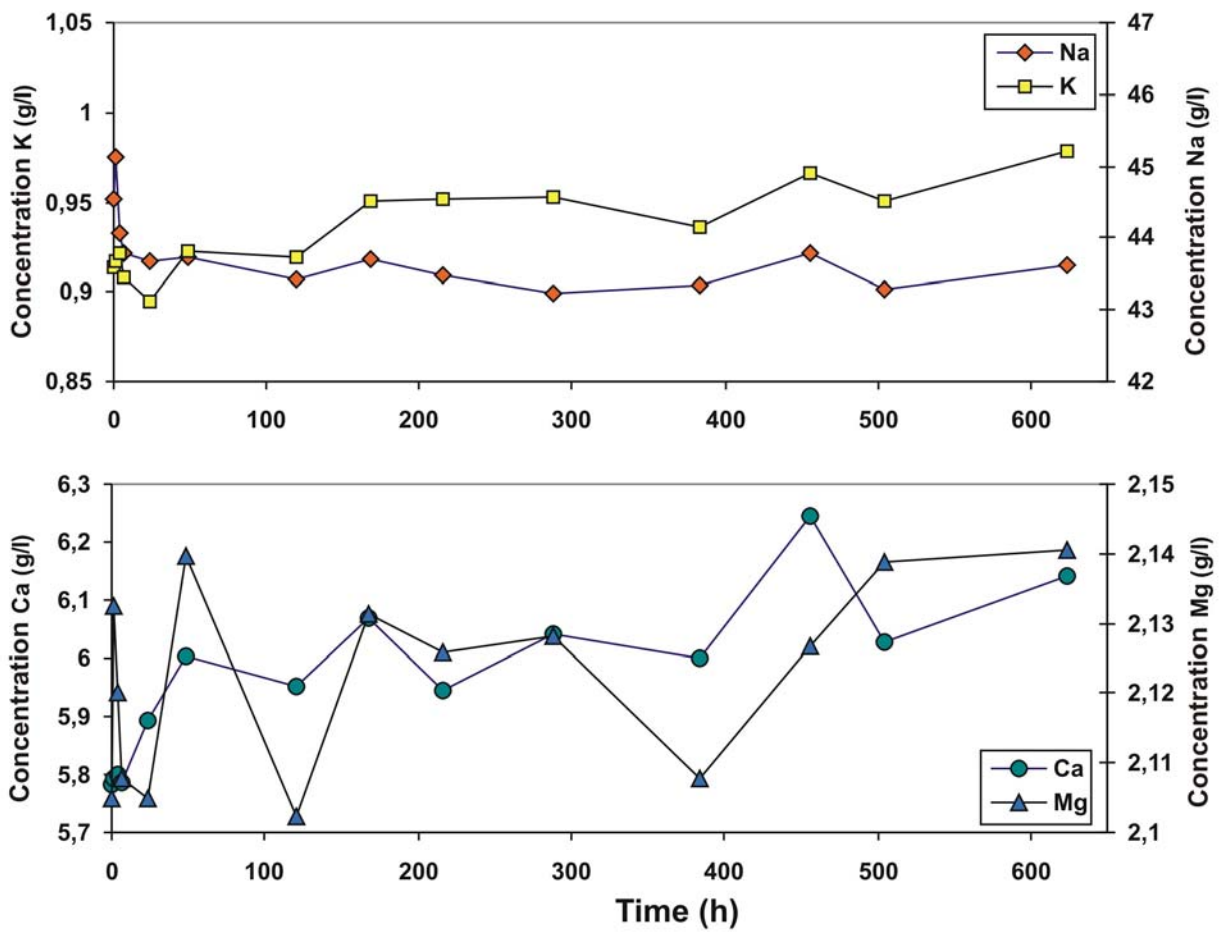
Alteration on the carbonatic sandstone

- **T: 100°C**
- **p: 100 bar**
- **duration: 20 days**



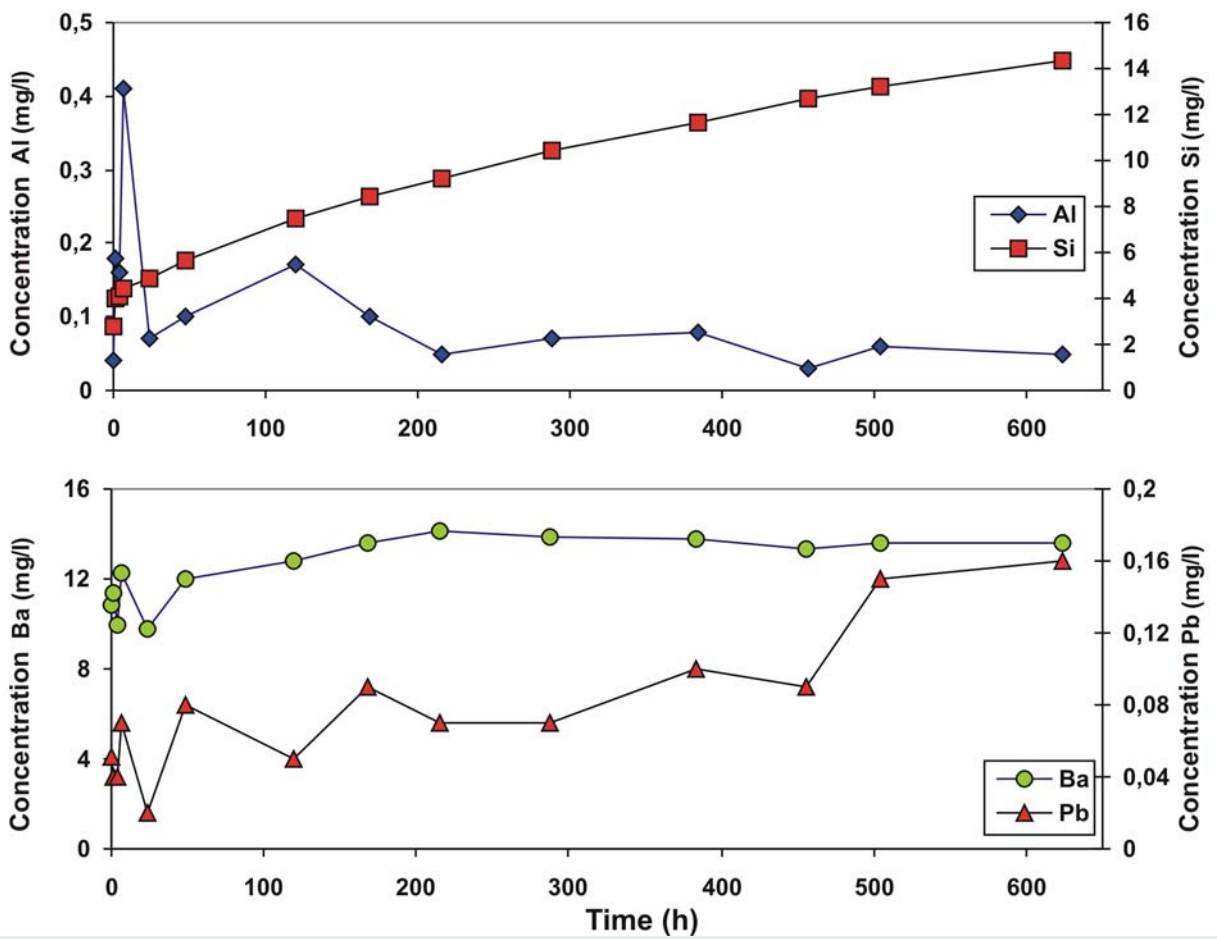
Fluid evolution during the autoklave experiments

Ro-sandstone; 624 h, 100 bar, 100°C; CO_2+ SO_2



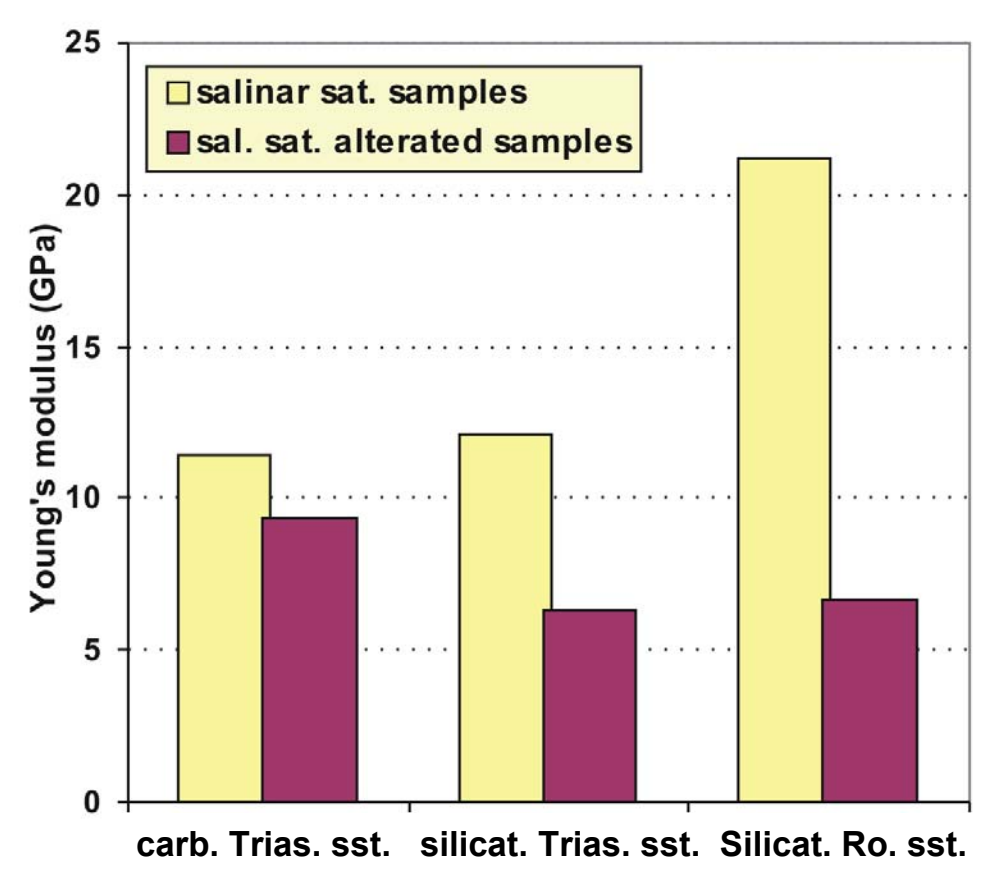
Fluid evolution during the autoklave experiments

Ro-sandstone; 624 h, 100 bar, 100°C; CO_2+ SO_2



Herwig Marbler et al.:
Geochemical and geomechanical behaviour of reservoir rocks during the injection of CO2 in deep geological formations: results of the project COORAL

Influence of rock alteration on the elastic behaviour of the investigated sandstones



- **Clear reduction of Young's Modulus (Deformation modulus) in altered sandstone samples**

Conclusions

- The strength behaviour of different types of sandstones varies with different pore fluids and different degrees of their saturation.
- Various types of fluids (H_2O, brine, $scCO_2$) cause different maximum effective stresses at changing lithostatic pressure conditions. This may be due to different pore space geometries and permeability.
- The experimental determined differences in rock strength and deformability between fresh and altered samples demonstrates trends of chemically induced mechanical weakening of the studied reservoir sandstones.


Thank You!