Fourth Annual Conference on Carbon Capture & Sequestration

Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date

Sequestration of Carbon Emissions in Geologic Formations

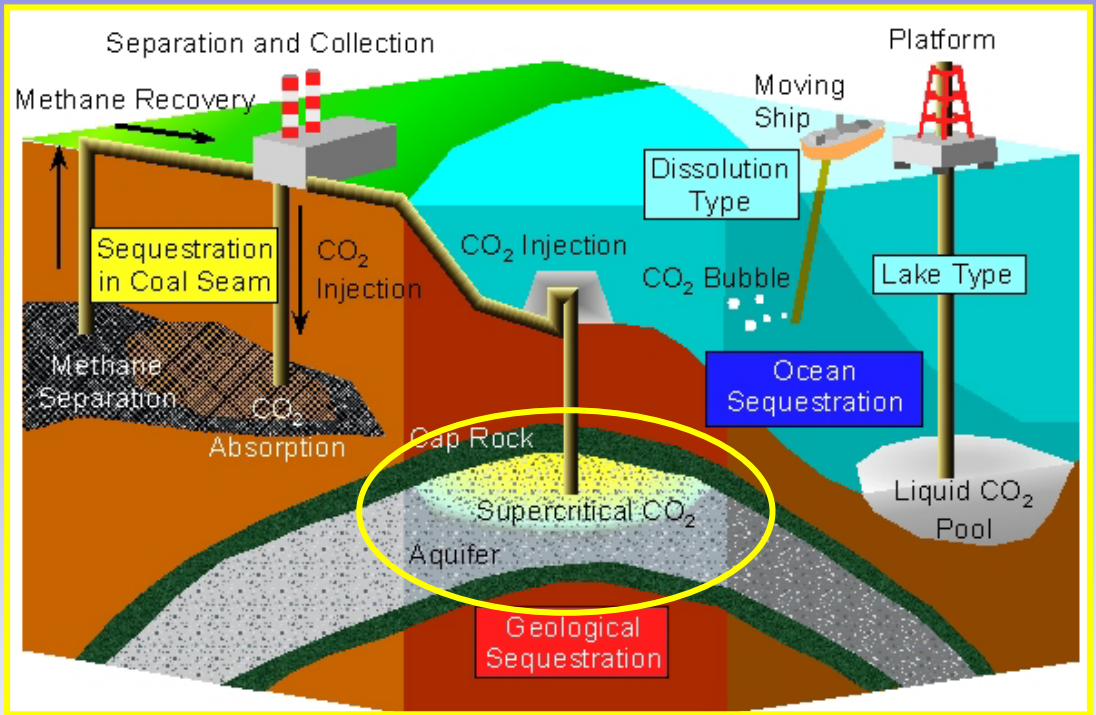
Geochemical Effects of CO_2 Sequestration in Sandstones Under Simulated In-situ Conditions

Marcus Wigand

Hartmut Schuett, Eric Spangenberg

May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

GEOLOGICAL STORAGE OPTIONS

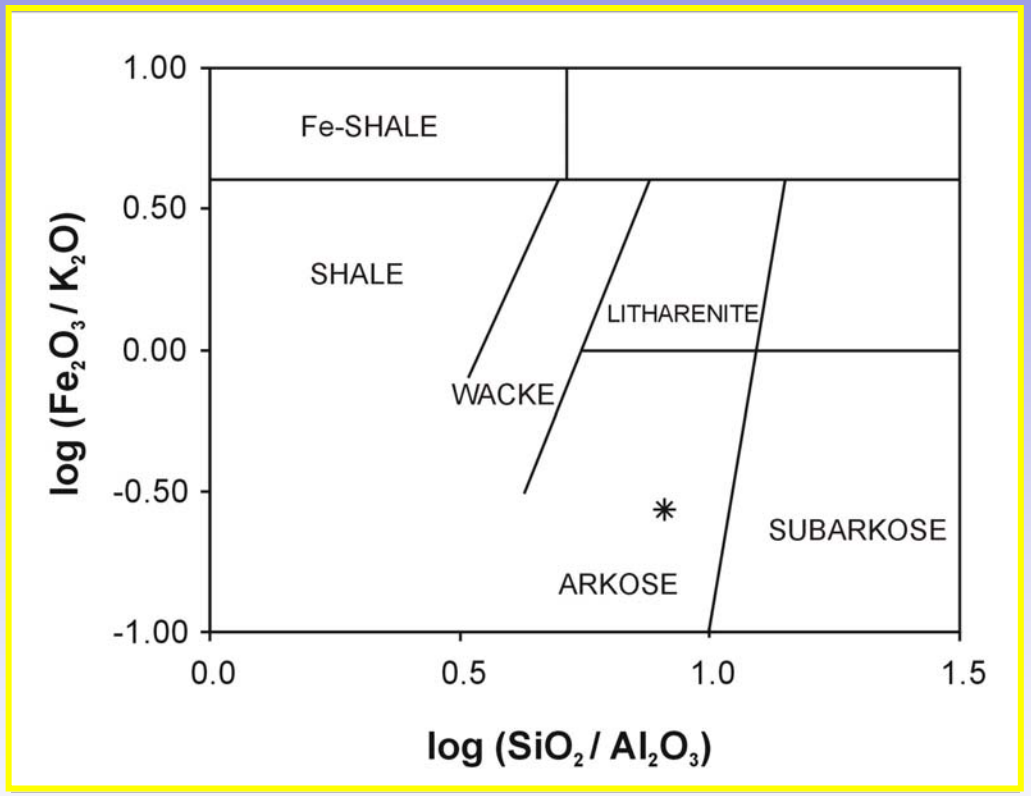


DEEP SALINE AQUIFERS

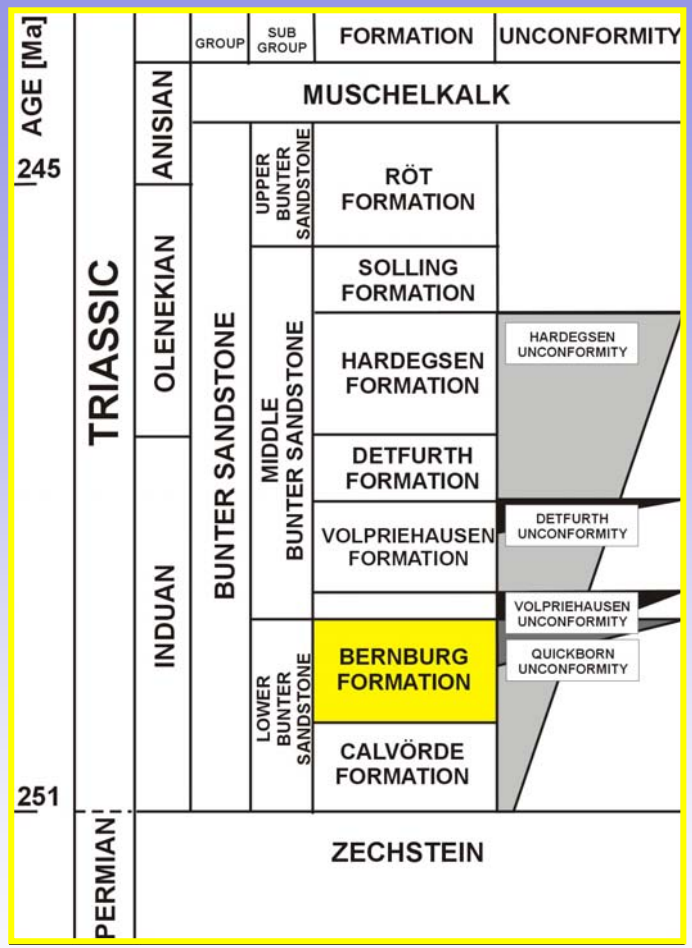
400 – 10000 Gt CO_2 (GLOBAL STORAGE CAPACITY)

394 Gt (STORAGE CAPACITY IN GERMANY)

ROCK CLASSIFICATION



modified after Herron (1988)

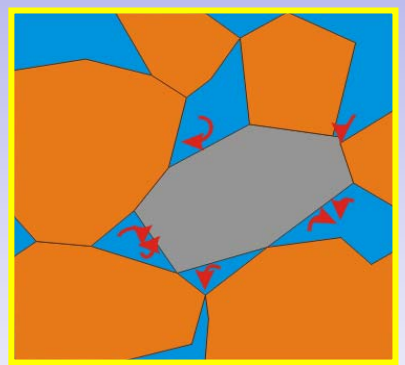


modified after Lepper & Röhling (1998)

WHY IS THIS STUDY IMPORTANT ?

DISSOLUTION OF GRAINS OR CEMENT MATERIAL MAY RESULT IN FURTHER COMPACTION OF THE AFFECTED ROCK

BEFORE



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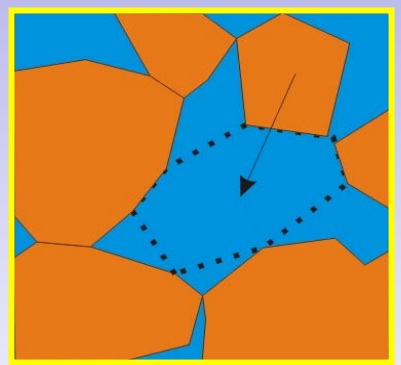


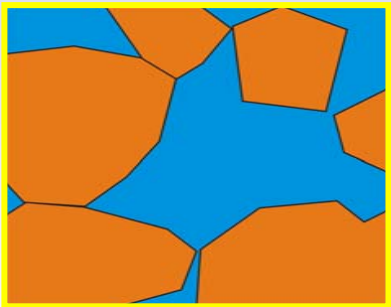
IN THE WORST CASE COMPACTION AND RESULTING SUBSIDENCE COULD DAMAGE THE RESERVOIR ROCK!

WHY IS THIS STUDY IMPORTANT ?

MINERAL TRAPPING

FIXING OF CO_2 IN CARBONATE MINERALS AS A RESULT OF GEOCHEMICAL REACTIONS AMONG AQUIFER BRINES, FORMATION MINERALS, AND AQUEOUS SPECIES OF CO_2

BEFORE



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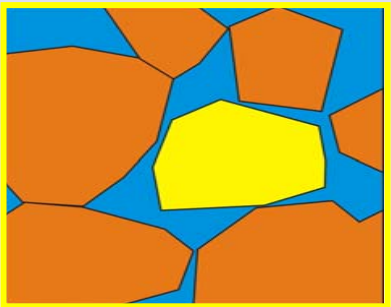
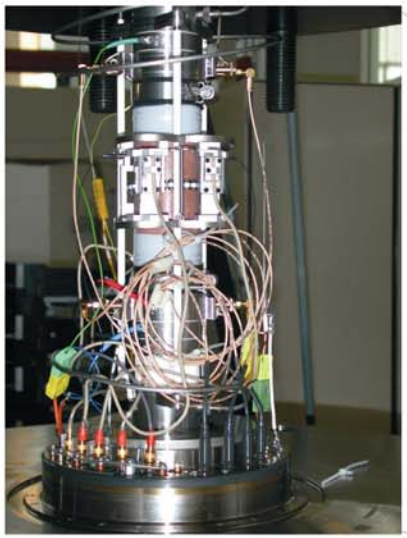
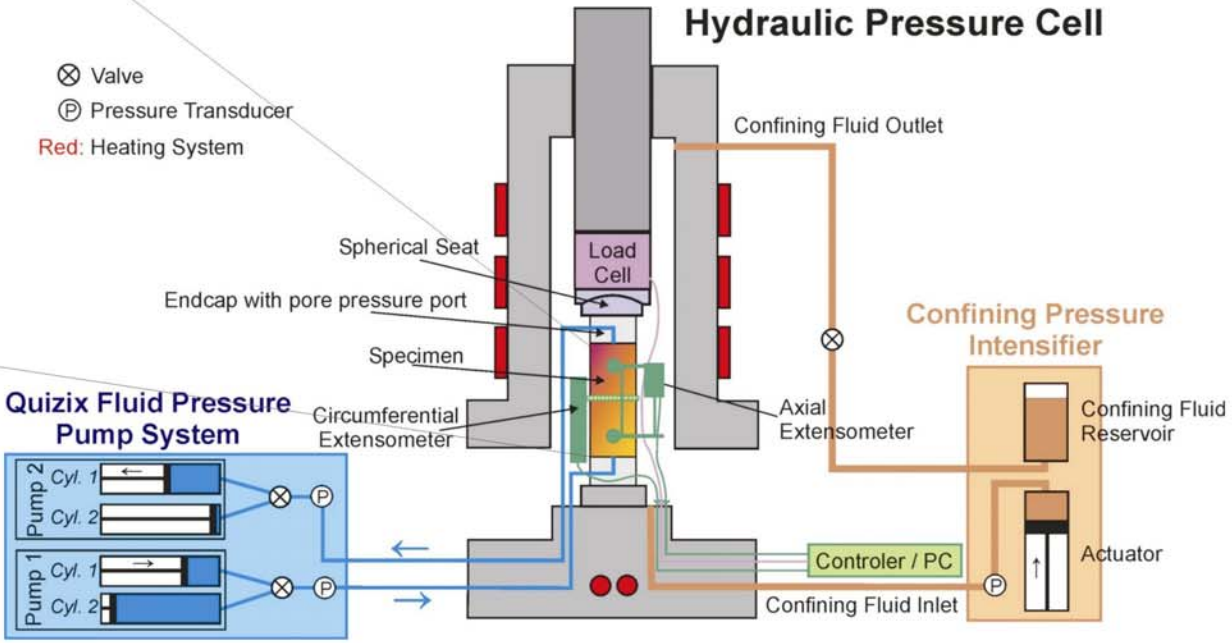


EQUIPMENT

MTS

MAX. TEMPERATURE: 200 °C
MAX. PRESSURE: 140 MPa
MAX. FLOWRATE: 7.5 ml * min $^{-1}$





AUTOCLAVES

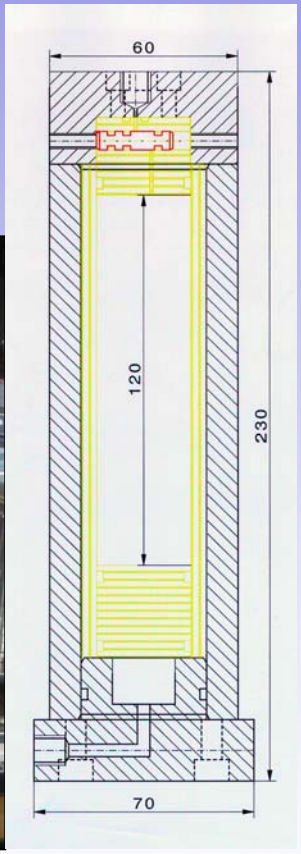
SPECIAL FEATURE:

TEFLON INLET TO AVOID CONTAMINATION

MAX. PRESSURE:
25 MPa

MAX. TEMPERATURE:
150 ^{o}C

ROCK SAMPLE:
POWDER (< 64 µm)
BLOCKS (< 30 cm^3)



EXPERIMENTAL CONDITIONS

TEMPERATURE	60 ^{o}C
PORE PRESSURE	15 MPa
FLUID COMPOSITION	1m NaCl BRINE PLUS SUPERCRITICAL CO_2
DURATION	62 DAYS

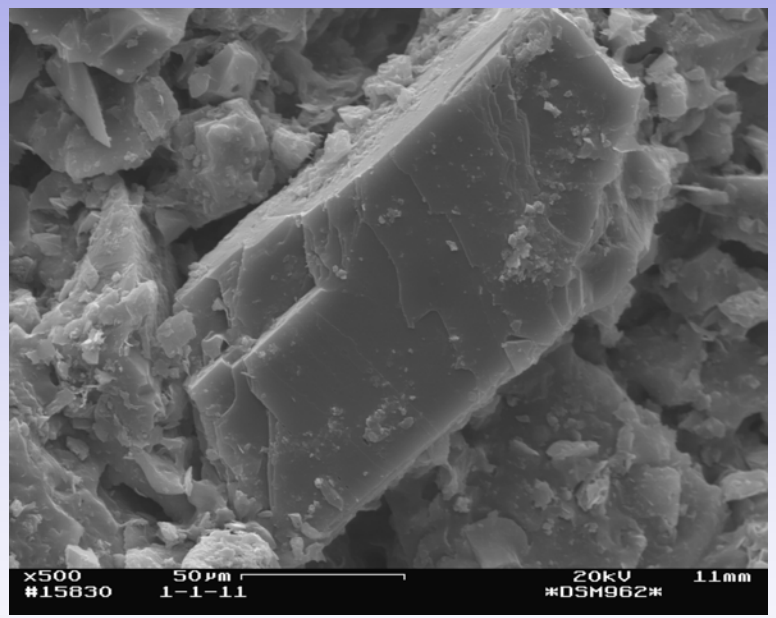
MINERALPHASES INVOLVED

QUARTZ, K-FELDSPAR, ALBITE, BIOTITE, ILLITE, DOLOMITE, HEMATITE, BARITE

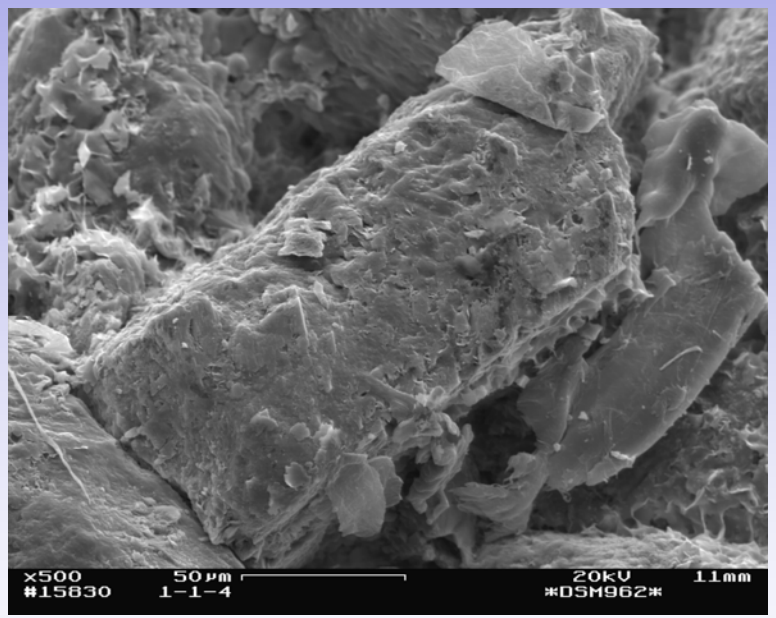
RESULTS

DISSOLUTION OF K-FELDSPAR

BEFORE

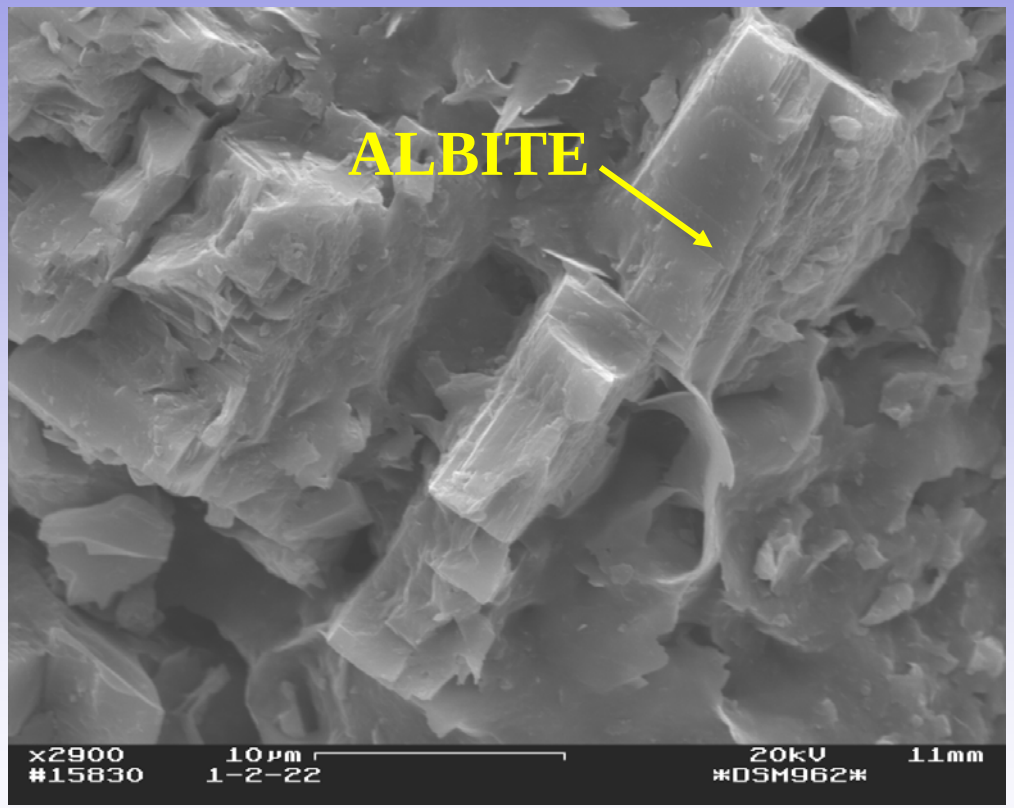


AFTER 62 DAYS



DISSOLUTION OF PLAGIOCLASE

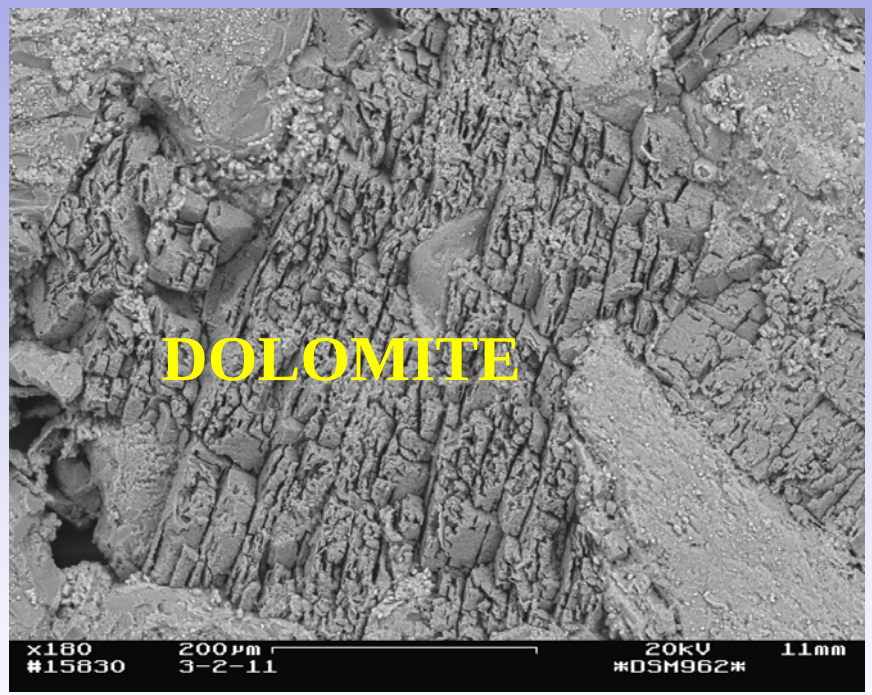
AFTER 62 DAYS



DISSOLUTION OF DOLOMITE

BEFORE

AFTER 62 DAYS



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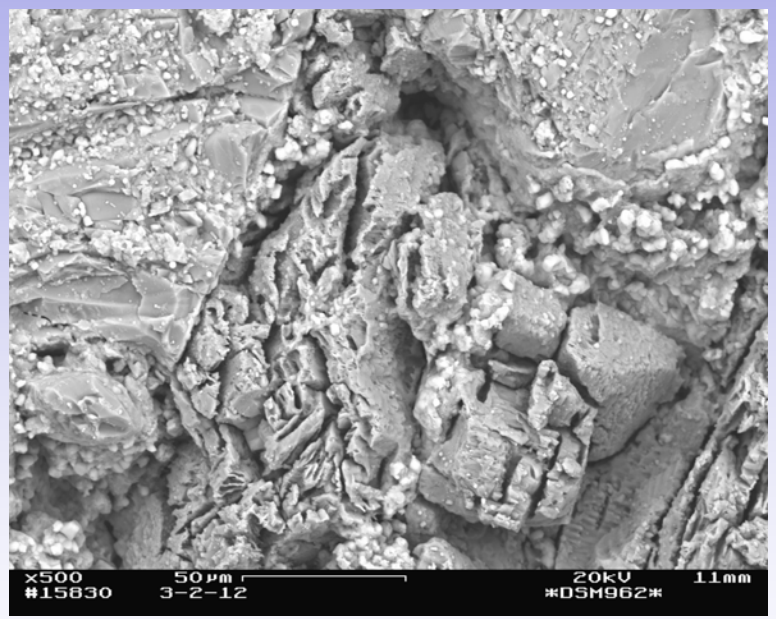
GFZ POTSDAM

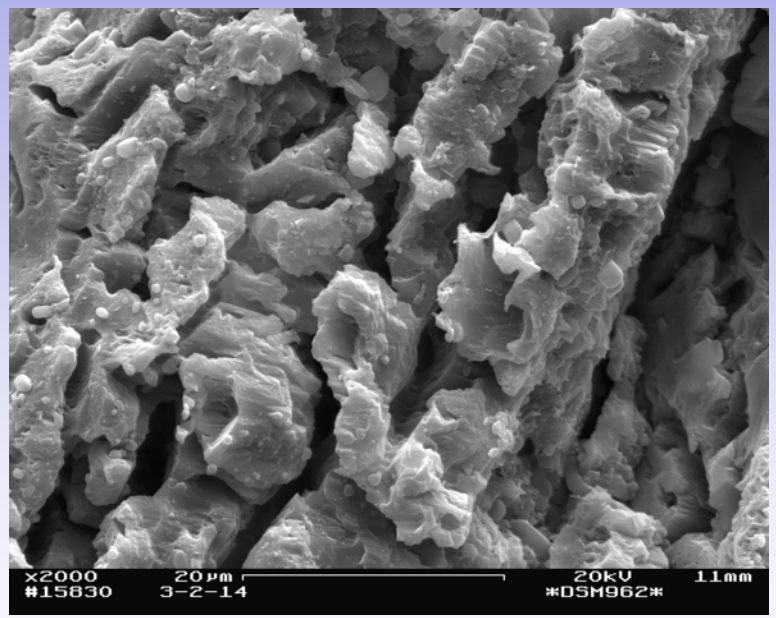
GeoForschungsZentrum Potsdam

CO_2 Capture Project

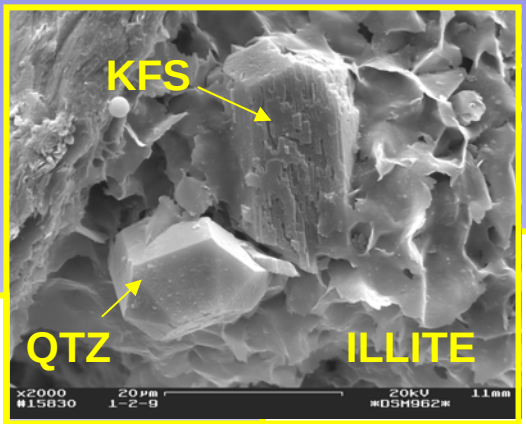
DISSOLUTION OF DOLOMITE

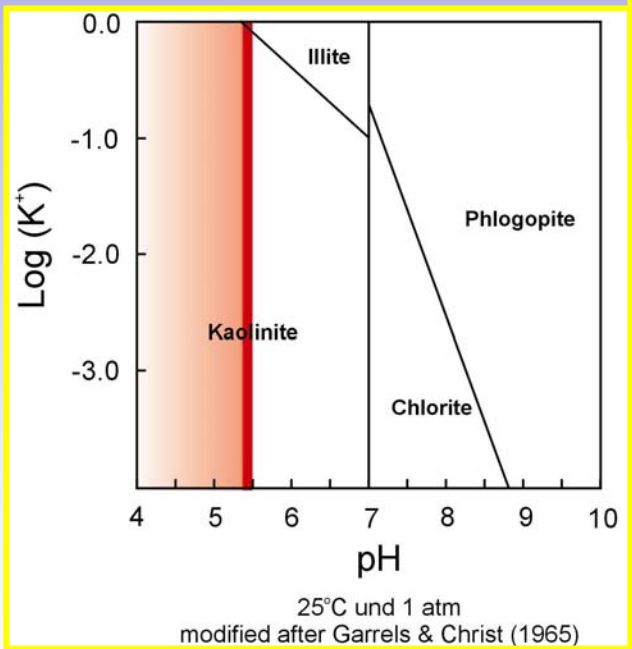
AFTER 62 DAYS

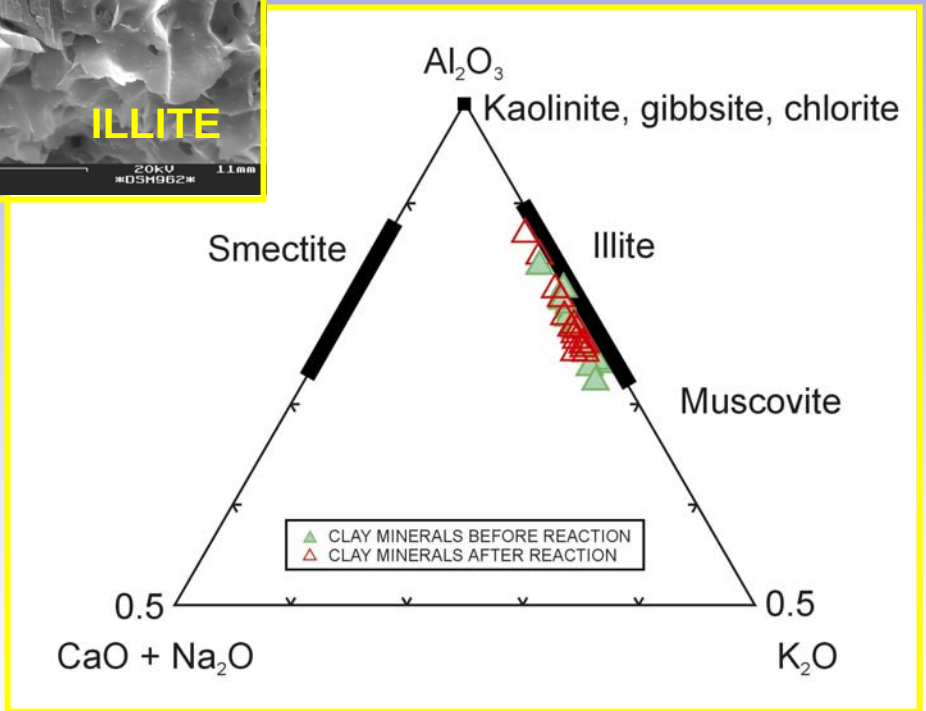




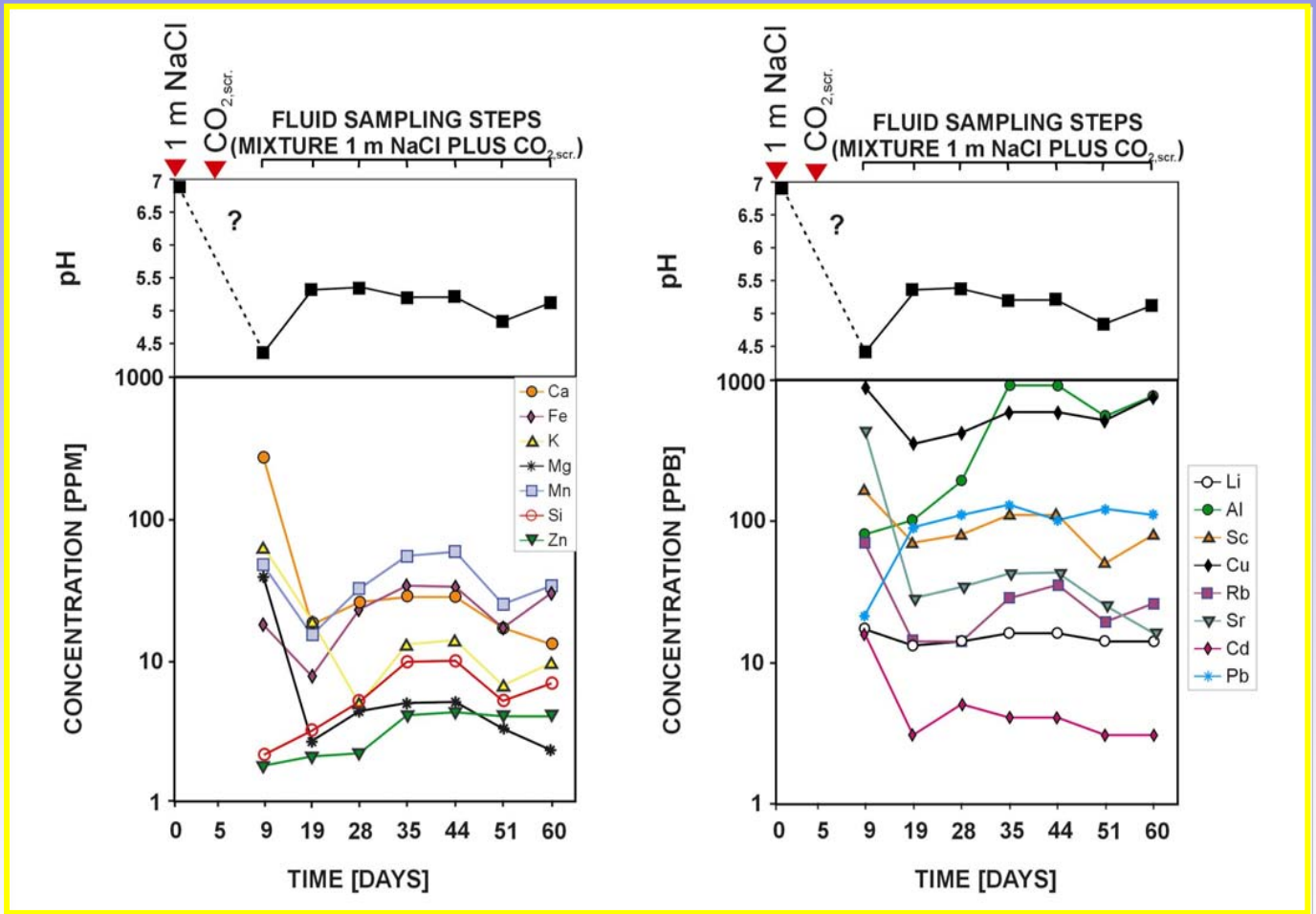
CLAY CEMENT


KFS
QTZ
ILLITE

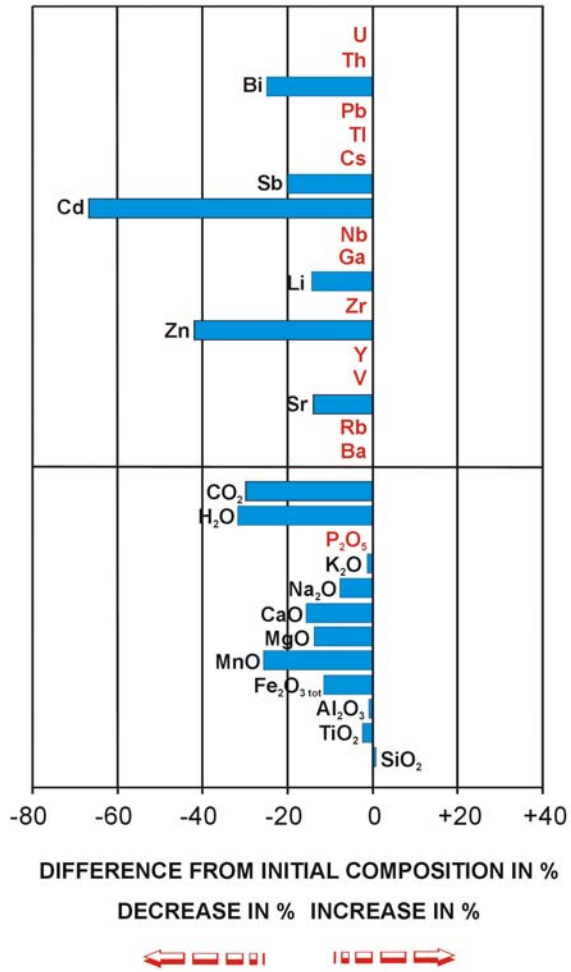

0.0
-1.0
-2.0
-3.0
Log (K+)
Illite
Phlogopite
Kaolinite
Chlorite
4
5
6
7
8
9
10
pH
25°C und 1 atm
modified after Garrels & Christ (1965)


Al2O3
Kaolinite, gibbsite, chlorite
Smectite
Illite
Muscovite
CLAY MINERALS BEFORE REACTION
CLAY MINERALS AFTER REACTION
0.5
CaO + Na2O
0.5
K2O

BRINE CHEMISTRY



WHOLE-ROCK GEOCHEMISTRY



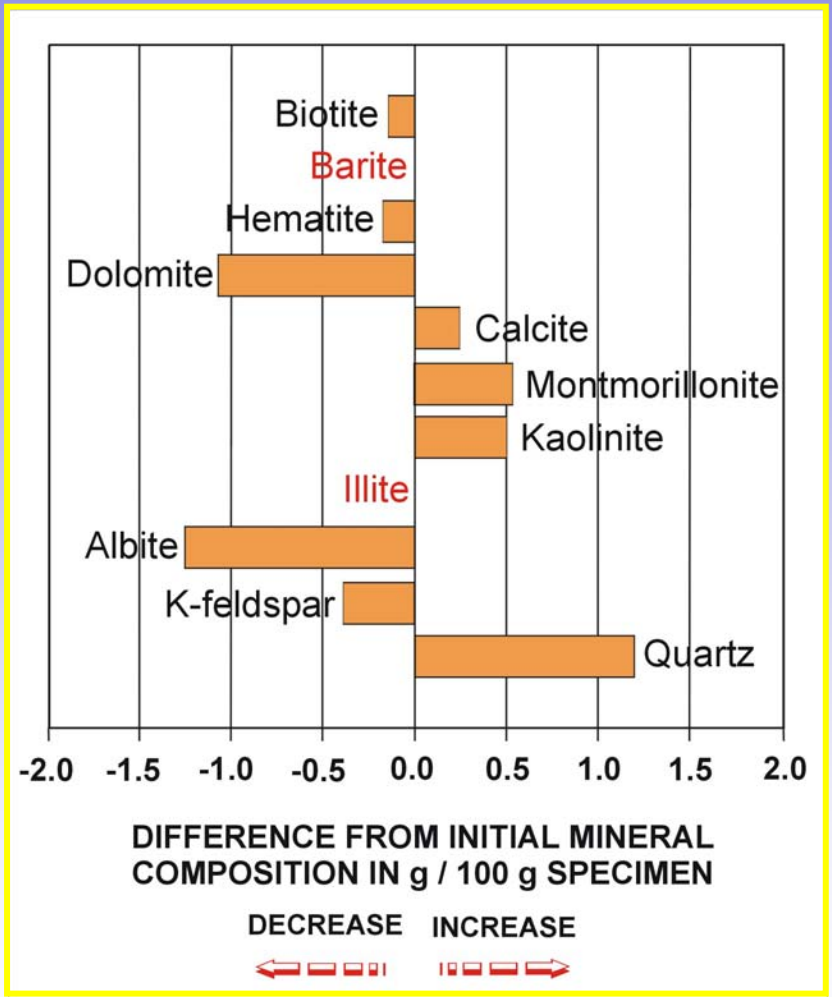
EXPERIMENTAL CONDITIONS

- 1 mol NaCl BRINE + $CO_{2\ SUPERCRITICAL}$
- TEMPERATURE : 60 °C
- PORE PRESSURE : 15 MPa
- DURATION : 62 DAYS

MINERAL PHASES OF THE RESERVOIR ROCK

QUARTZ SiO_2
K-FELDSPAR $K[AlSi_3O_8]$
ALBITE $Na[AlSi_3O_8]$
BIOTITE $K_2(Mg, Fe^{2+})_{6-4}(Fe^{3+}, Al, Ti)_{0-2}[Si_{6-5}Al_{2-3}O_{20}](OH, F)_4$
ILLITE $K_{1.5-1.0}Al_4[Si_{6.5-7.0}Al_{1.5-1.0}O_{20}](OH)_4$
DOLOMITE $Ca\,Mg\,(CO_3)_2$
HEMATITE Fe_2O_3
BARITE $BaSO_4$

GEOCHEMICAL MODELING



MEASURED WEIGHT LOSS:

0.27 g / 100 g SPECIMEN

CONCLUSIONS
MINERAL REACTIONS

DISSOLUTION OF DOLOMITE

$$CaMg(CO_3)_2 + 4\ H^+ \leftrightarrow 2\ CO_2(aq.) + Ca^{++} + Mg^{++} + 2\ H_2O$$

DOLOMITE

REACTION OF K-FELDSPAR

$$KAlSi_3O_8 + 3/2\ H_2O + CO_2 \leftrightarrow 2\ SiO_2 + 1/2\ Al_2Si_2O_5(OH)_4 + HCO_3^- + K^+$$

K-FELDSPAR QUARTZ KAOLINITE

REACTION OF ALBITE

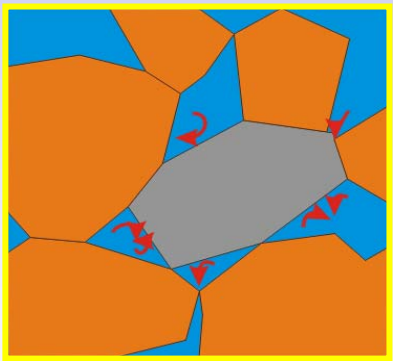
$$3\ NaAlSi_3O_8 + Mg^{++} + 4\ H_2O \leftrightarrow 2\ Na_{0.5}Al_{1.5}Mg_{0.5}Si_4O_{10}(OH)_2 + 2\ Na^+ + H_4SiO_4$$

ALBITE MONTMORILLONITE

CONCLUSIONS

THE DISSOLUTION OF DOLOMITE AND THE ALTERATION OF K-FELDSPAR AND ALBITE RESULT IN AN INCREASE IN THE POROSITY AND PERMEABILITY OF THE AFFECTED RESERVOIR ROCK

BEFORE



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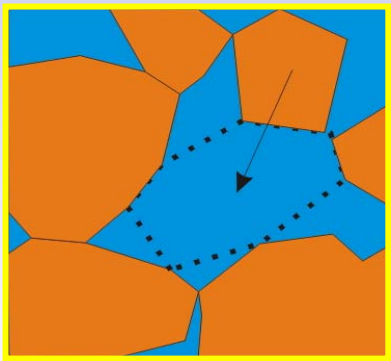

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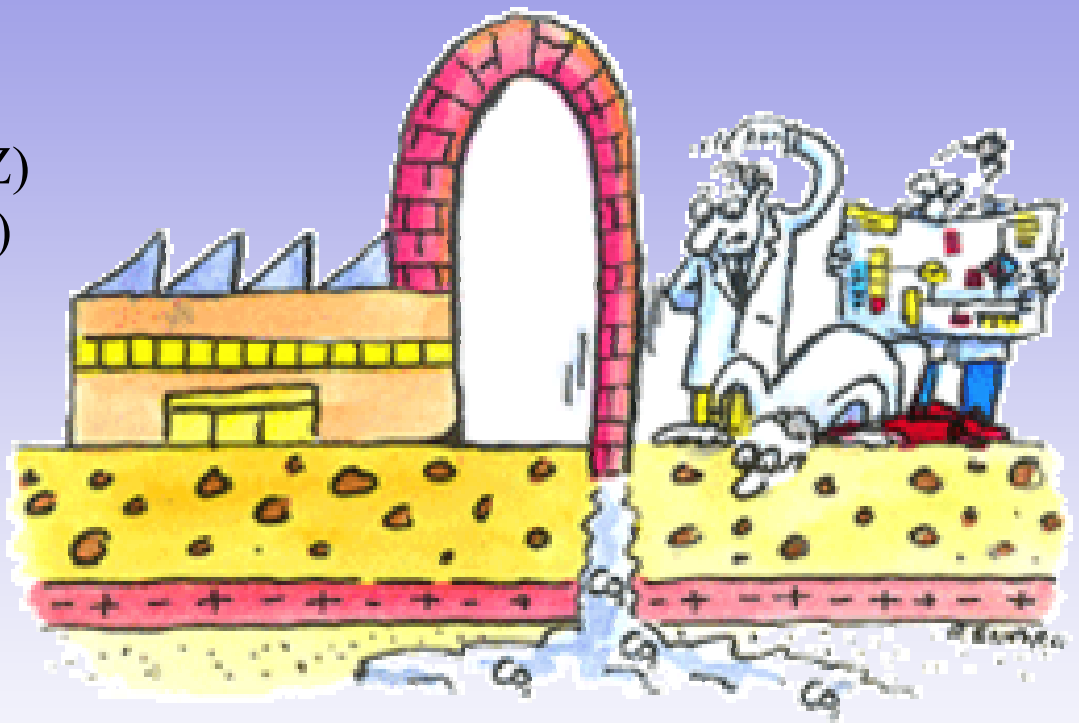

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CO_2 Capture Project

THANK YOU VERY MUCH
FOR YOUR ATTENTION