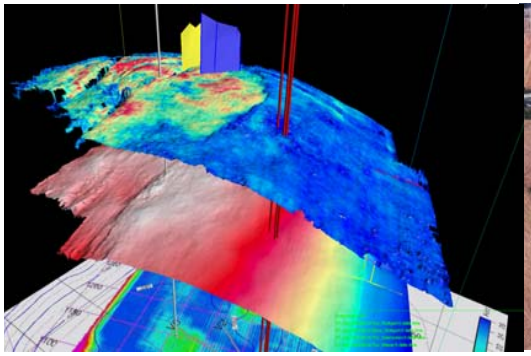
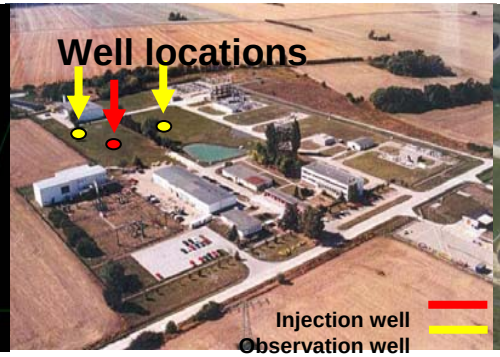
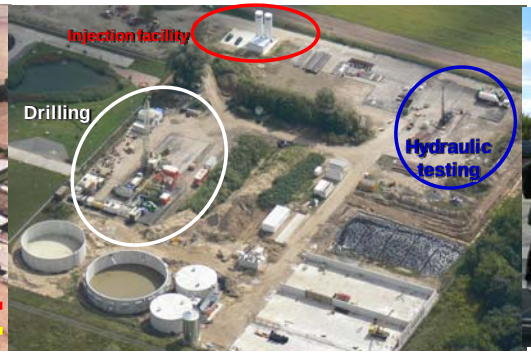
Geologische Speicherung von CO_2, Status, Potentiale, Risiken

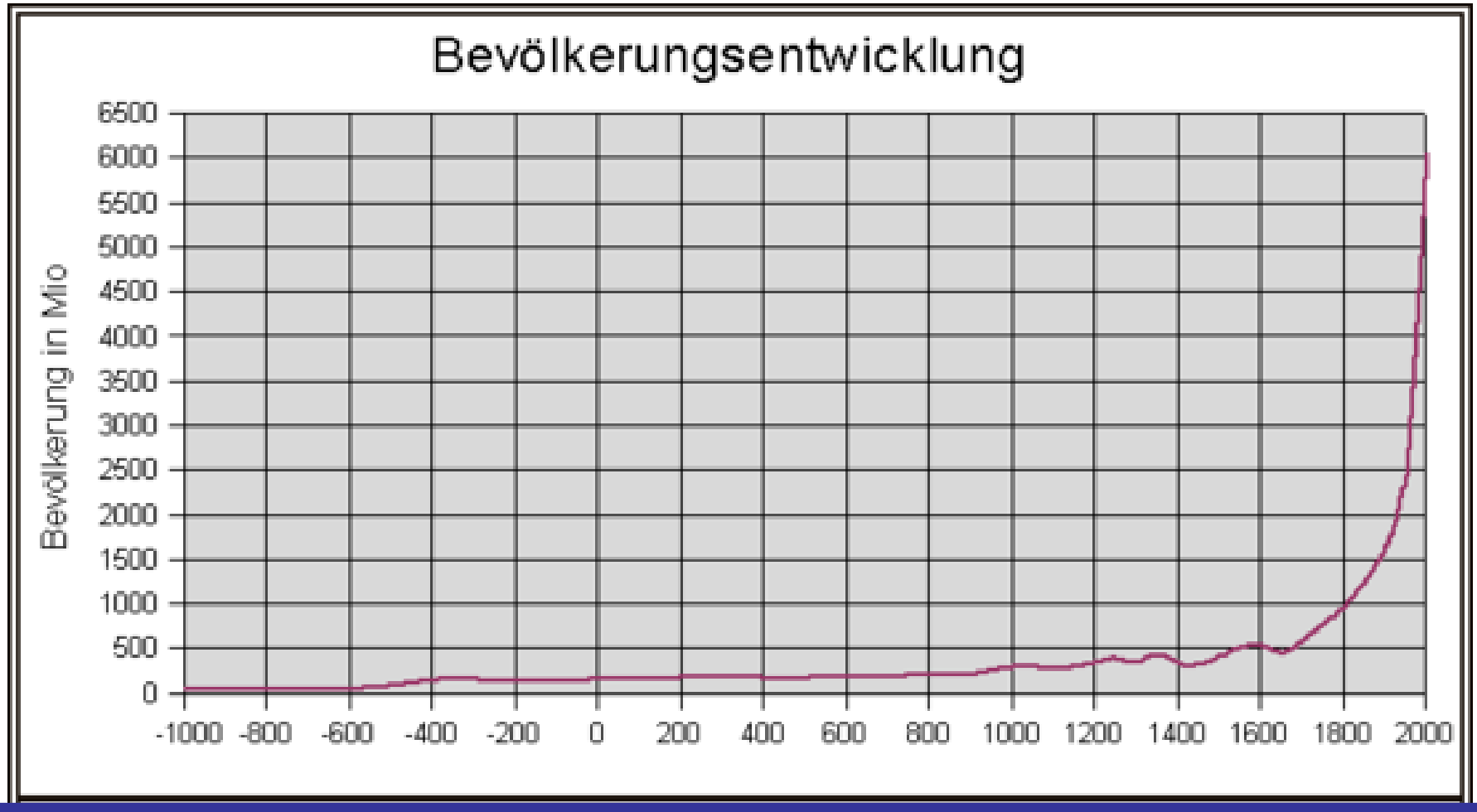
Frank.Schilling@GFZ-Potsdam.de





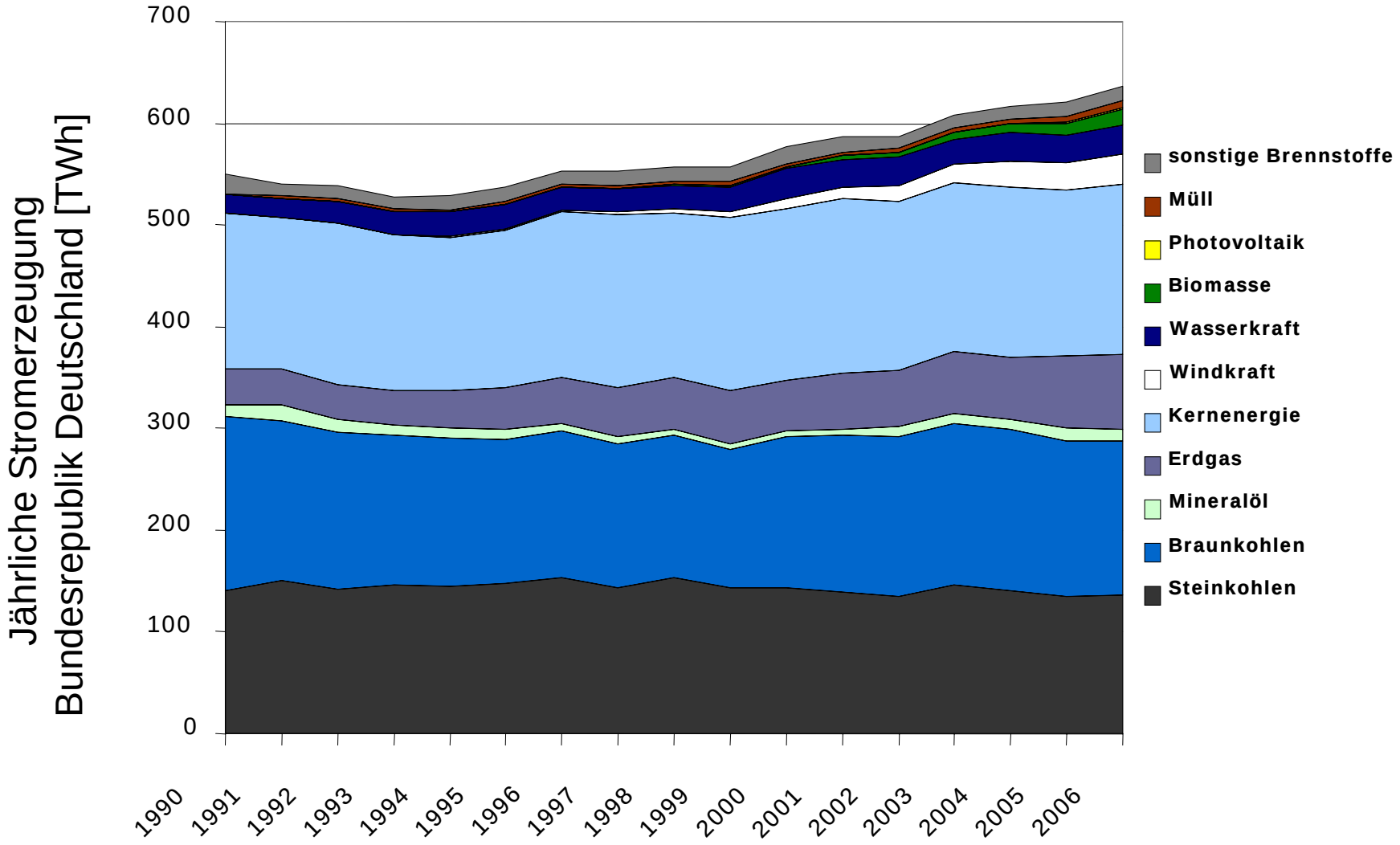


Bevölkerungsentwicklung

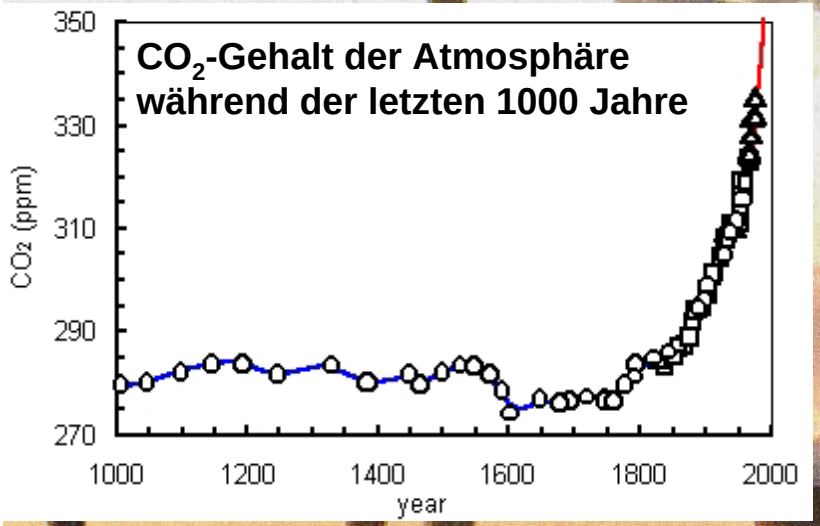


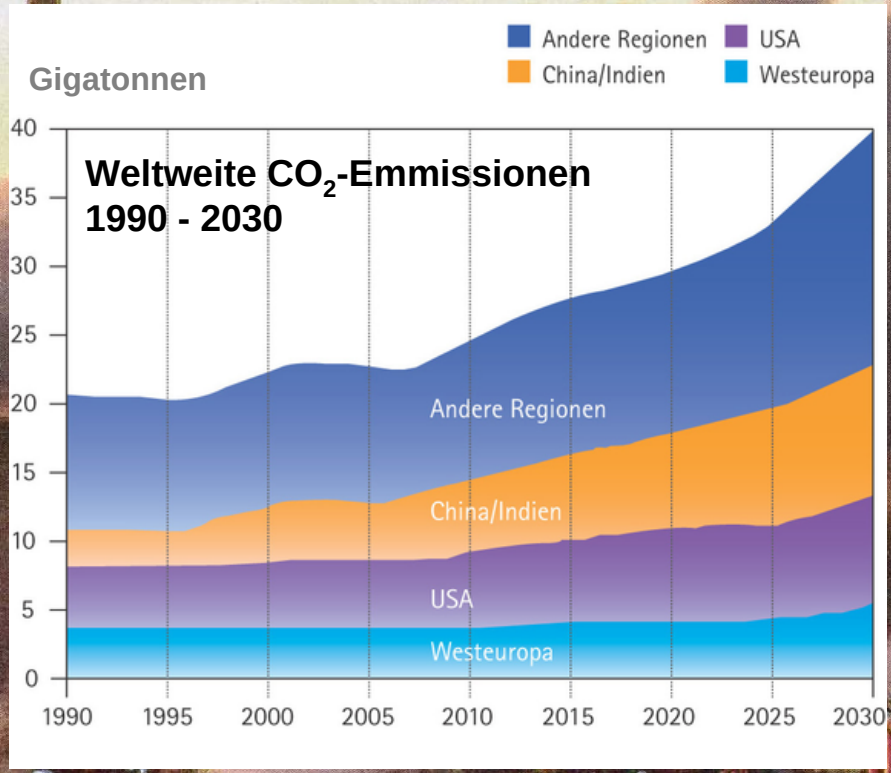
Wikipedia 2007

Energiestatistik 2007, BMWi



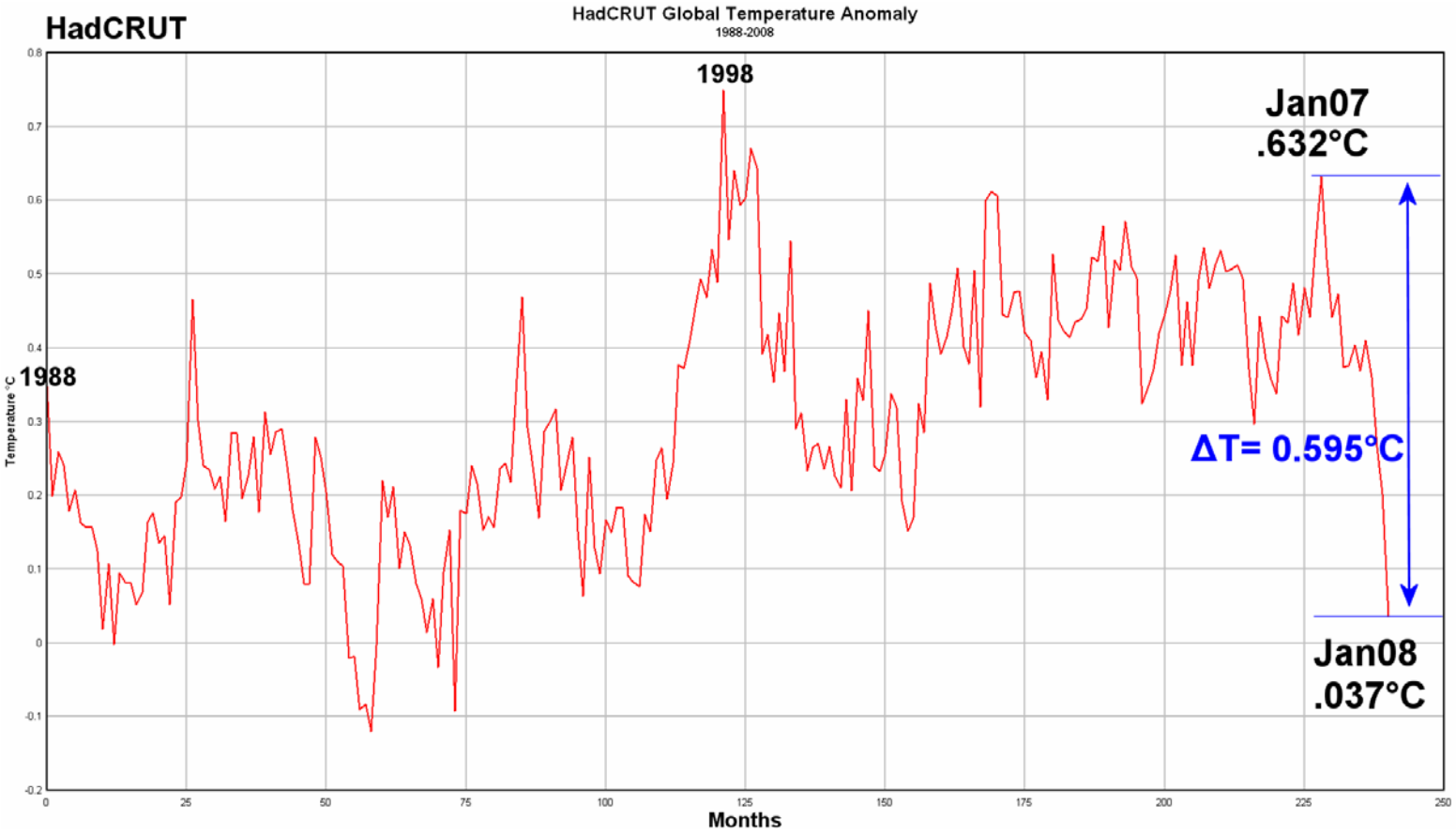
Zielvorgabe: Reduzierung der CO_2-Emission bis 2050 auf 10 % des Wertes von 1990





Strategie: Carbon Capture and Storage (CCS)

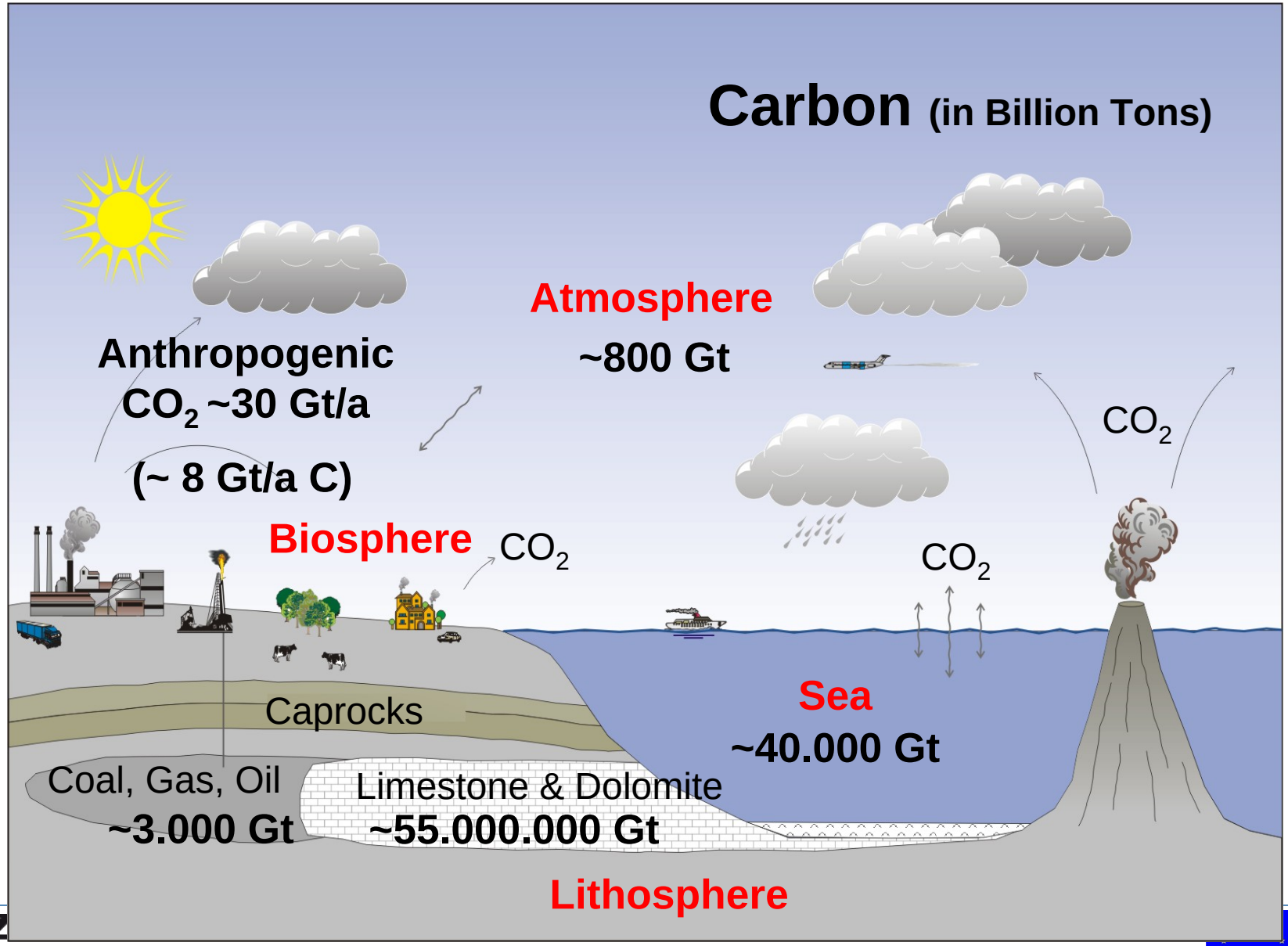
Pause für Klimaerwärmung?



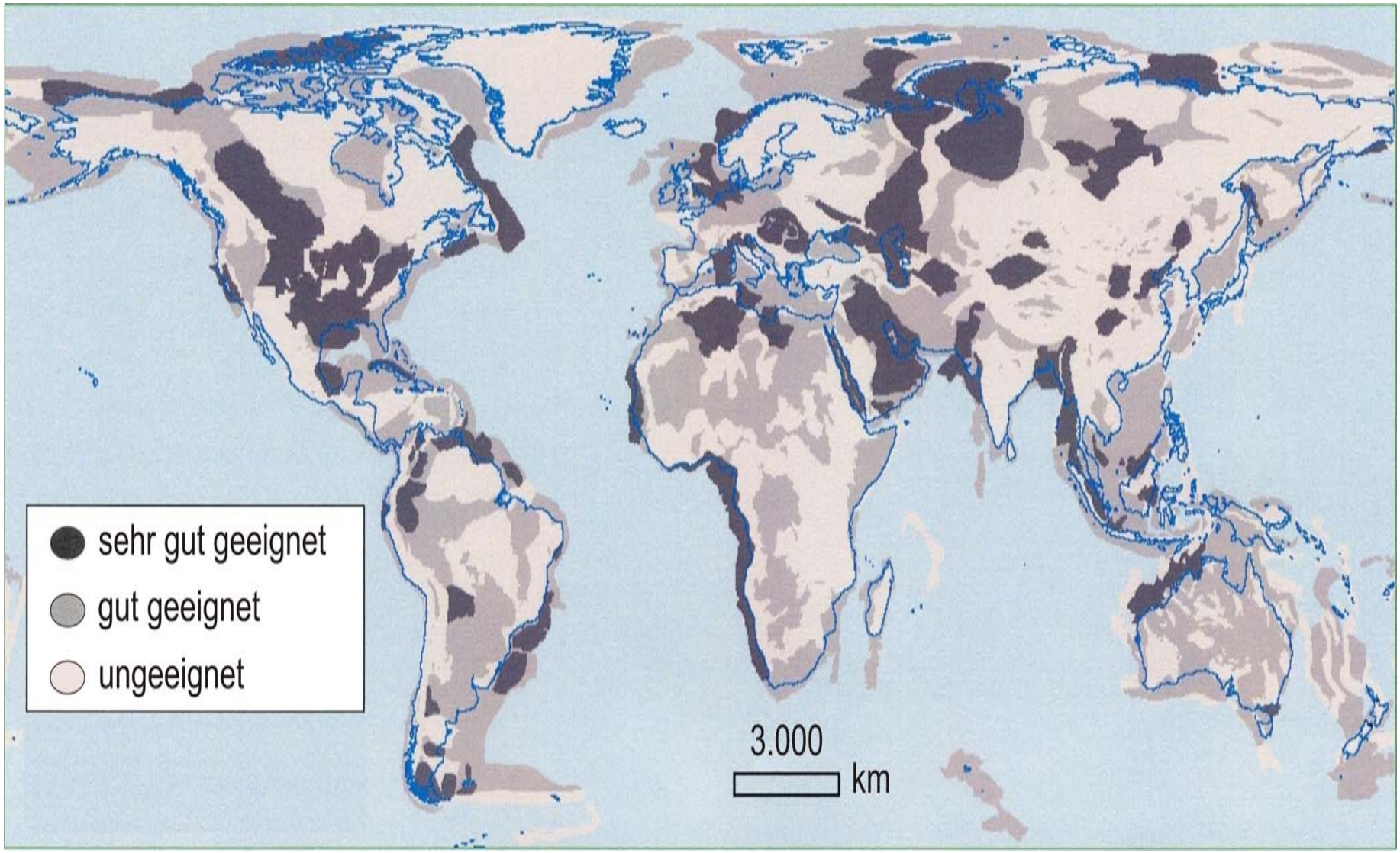
(Daten: UK Hadley Climate Research Unit, Feb. 2008)

Temperaturunterschied (globale Oberflächentemperatur)
Januar 2007 – Januar 2008 = -0,595 °C

Global CO_2-Cycle



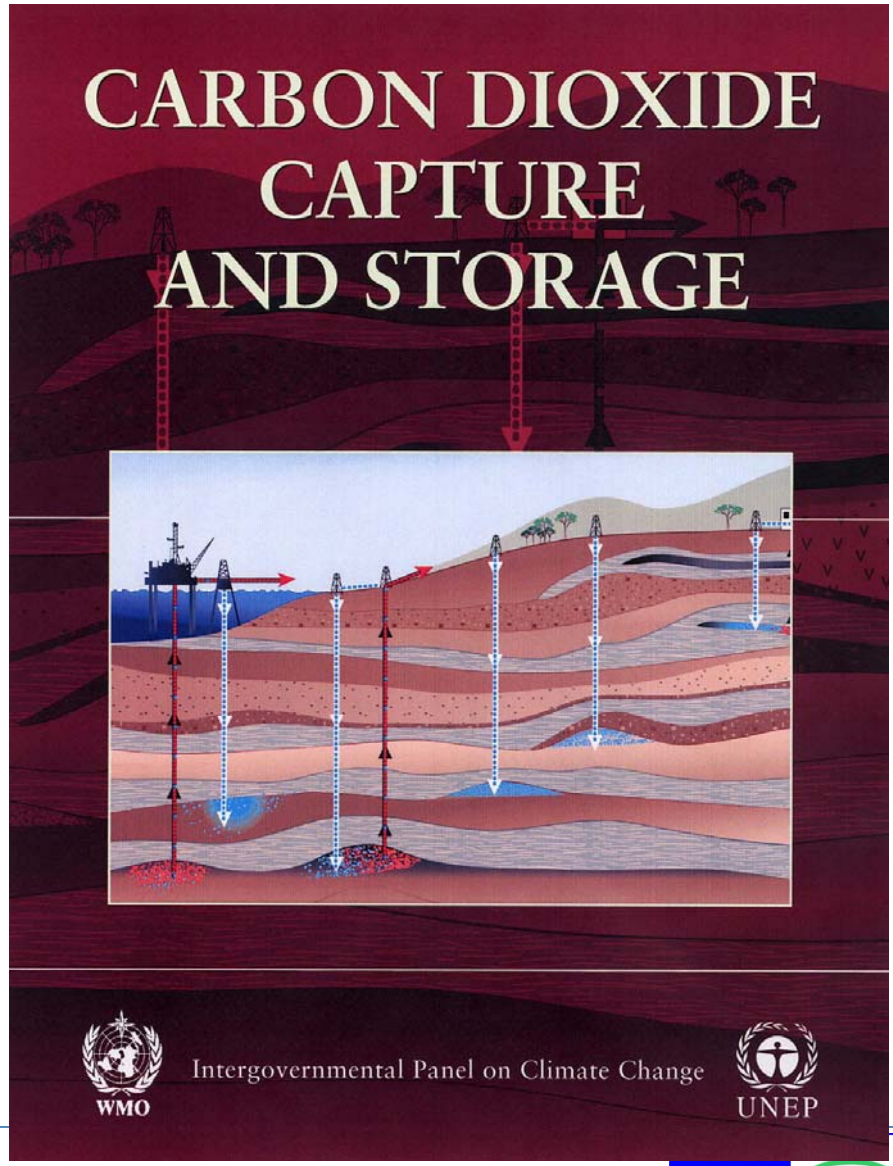
Possible Storage Sites - Aquifers



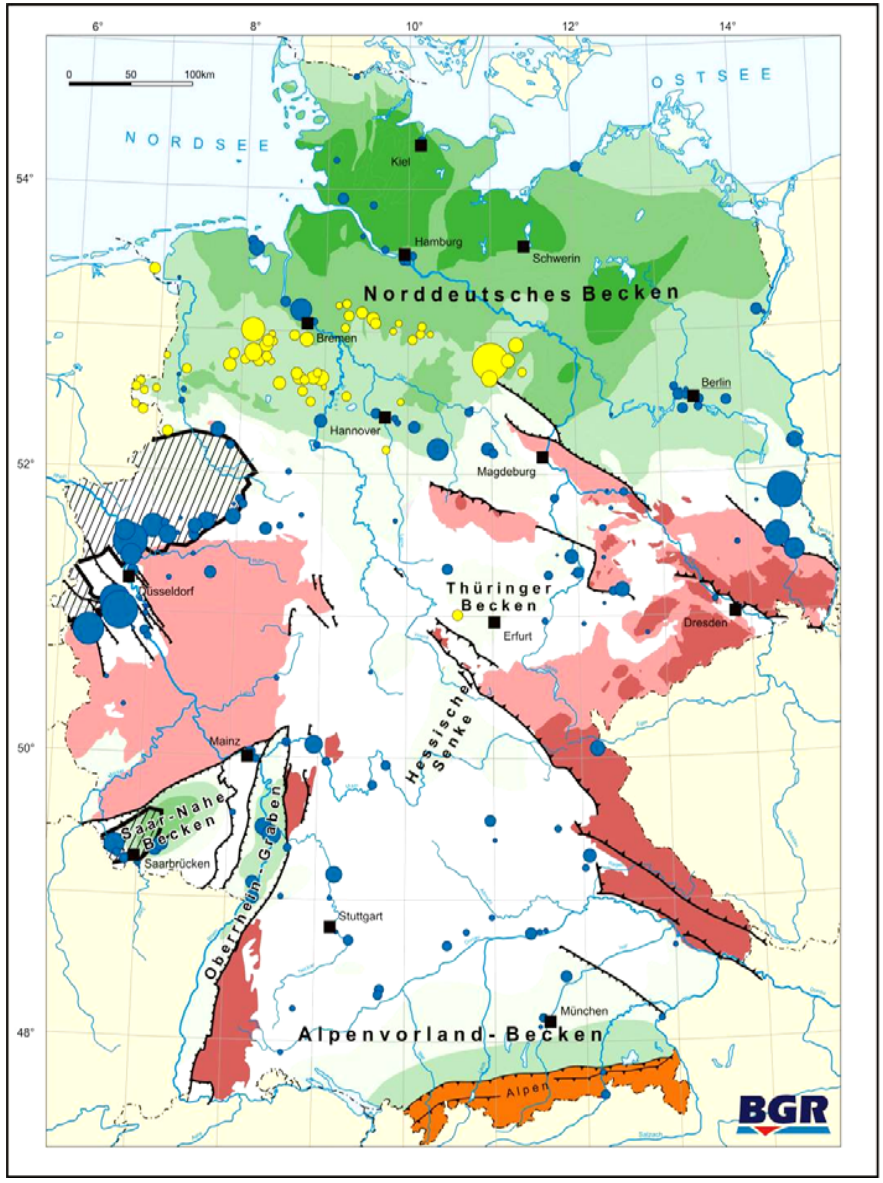
Possible Storage of CO_2 in Germany

CO_2 emissions by
point sources > 300 Mt/a
(in Germany)

- Gas Fields 2.5 Gt
- (Coal Beds 5.5 Gt)
- Aquifers 20 Gt



CO_2 Punktquellen & Senken in D



Bedeutende CO_2 - Quellen

Kraftwerke, Hütten- und Zementwerke, Raffinerien u. a.

• 0,2 → 20 Mt/a

Regionen mit Speichermöglichkeiten

zunehmende Mächtigkeit der Beckenfüllung: 1km, 3km, 5km, 7km, 9km

tiefliegende und Salzwasser führende Speichergesteine (Aquifere) — 20±8 Gt

Steinkohle - Flöze

Erdgas - Felder — 2,75 Gt

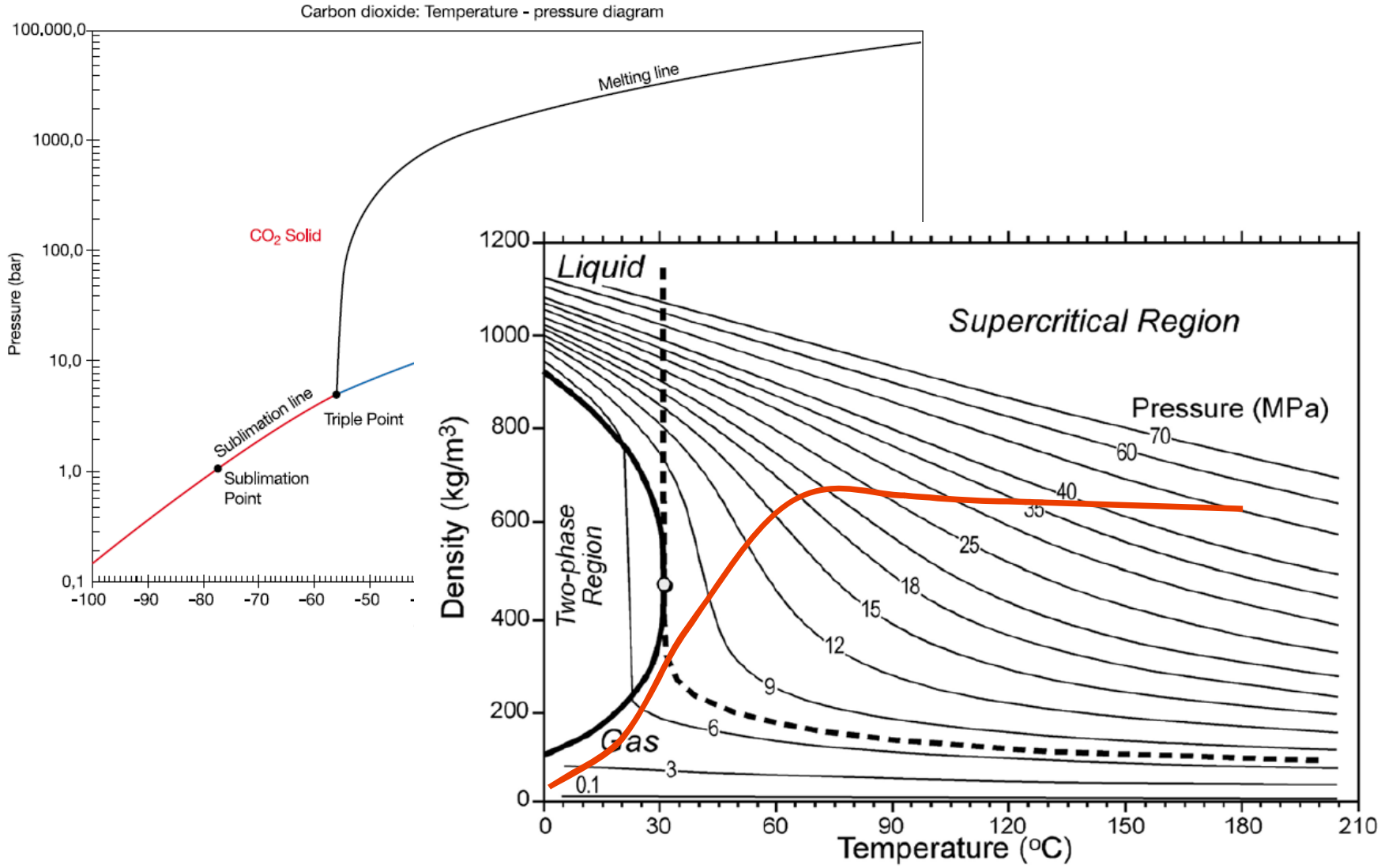
Regionen ohne bedeutende Speichermöglichkeiten

metamorphe Gesteine

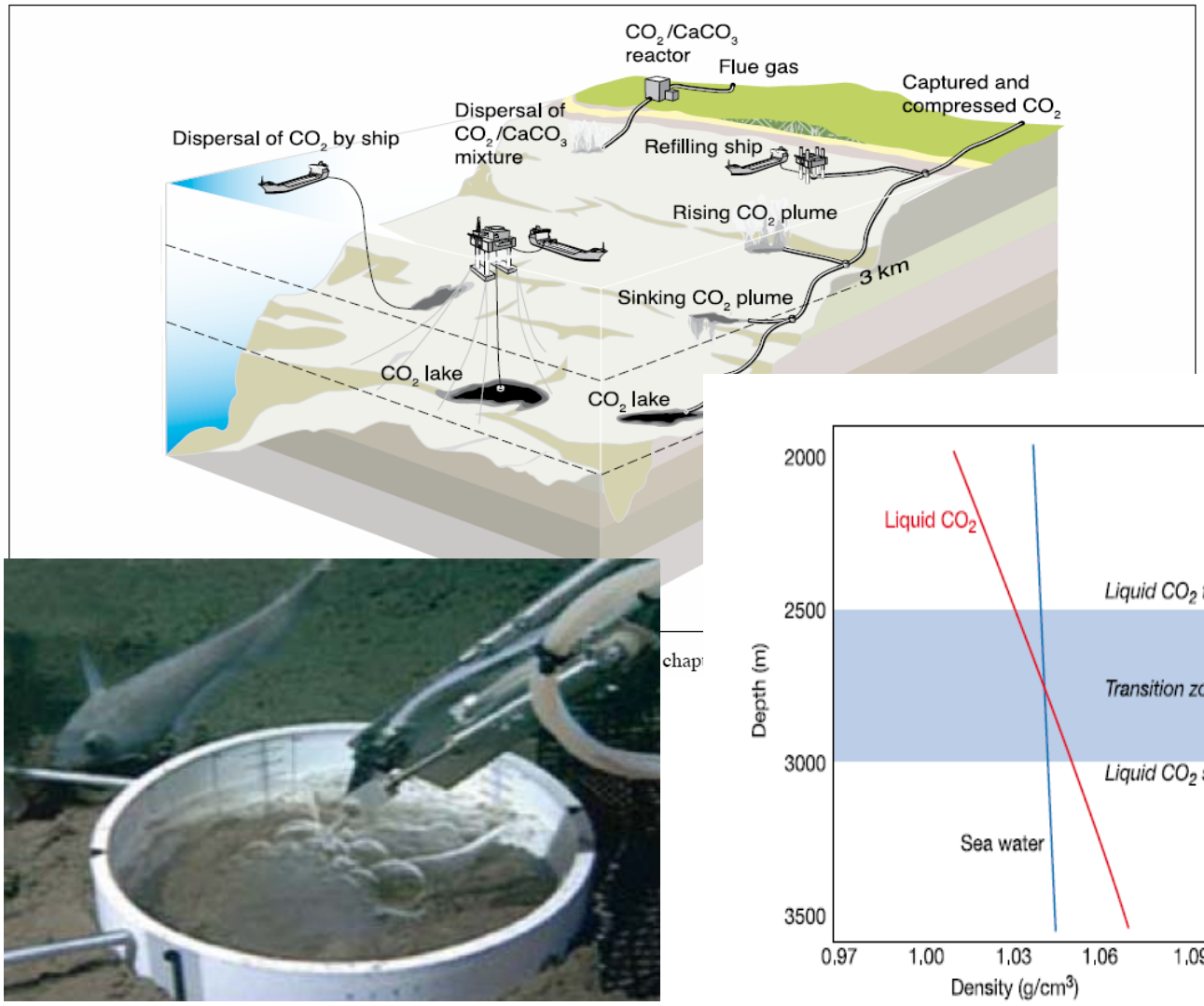
magmatische und hoch-metamorphe Gesteine

Speichergesteine nicht oder in zu geringen Tiefen vorhanden

Properties of CO_2



Ocean Storage



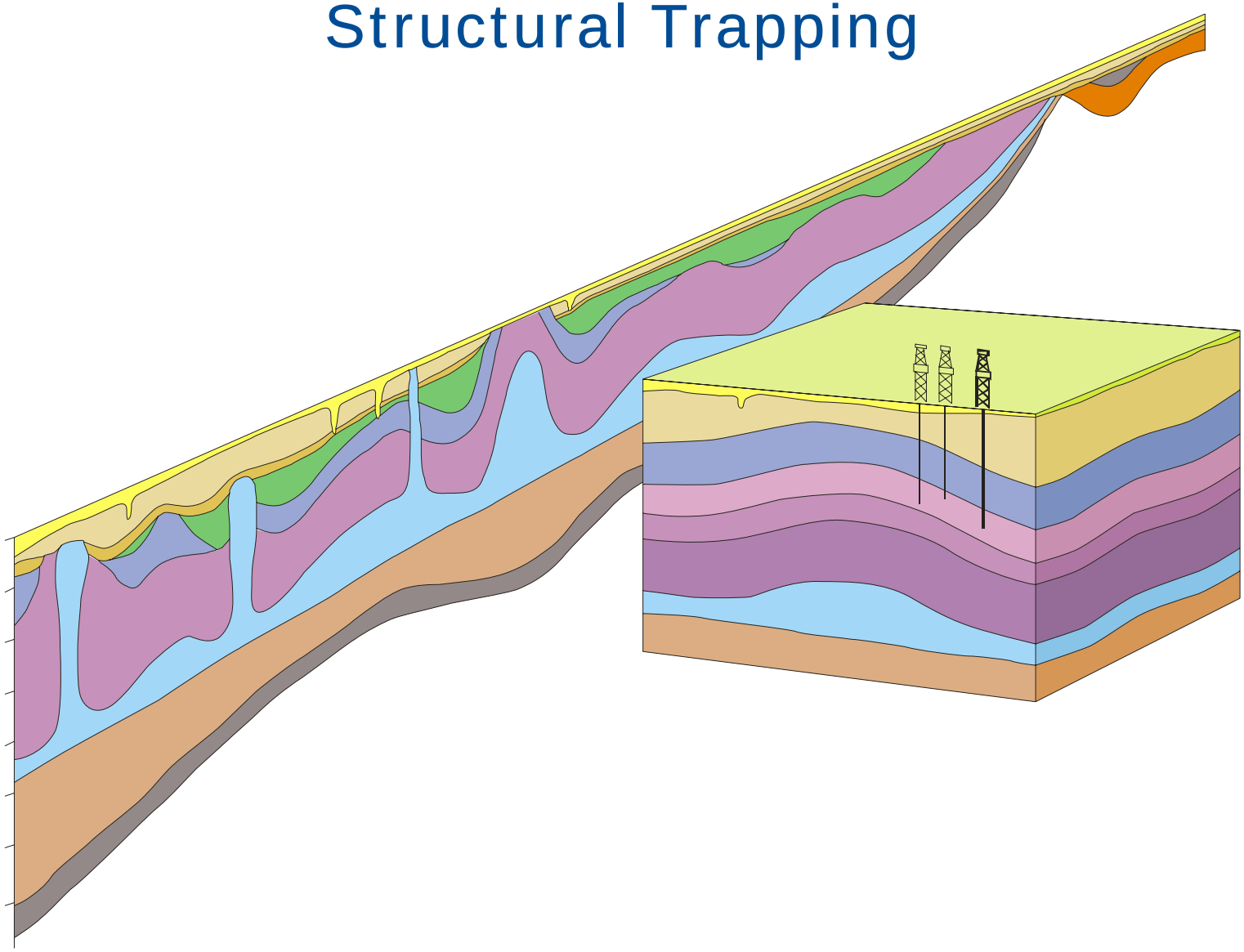
after 500 a…

28% @ 1 km

65% @ 2 km

85% @ 3 km

Salt Tectonics – NE German Basin
Structural Trapping

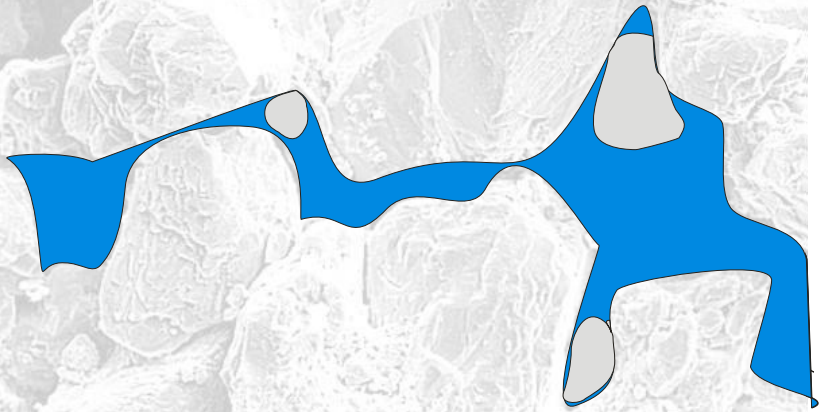


Förster *et al.* – 2006

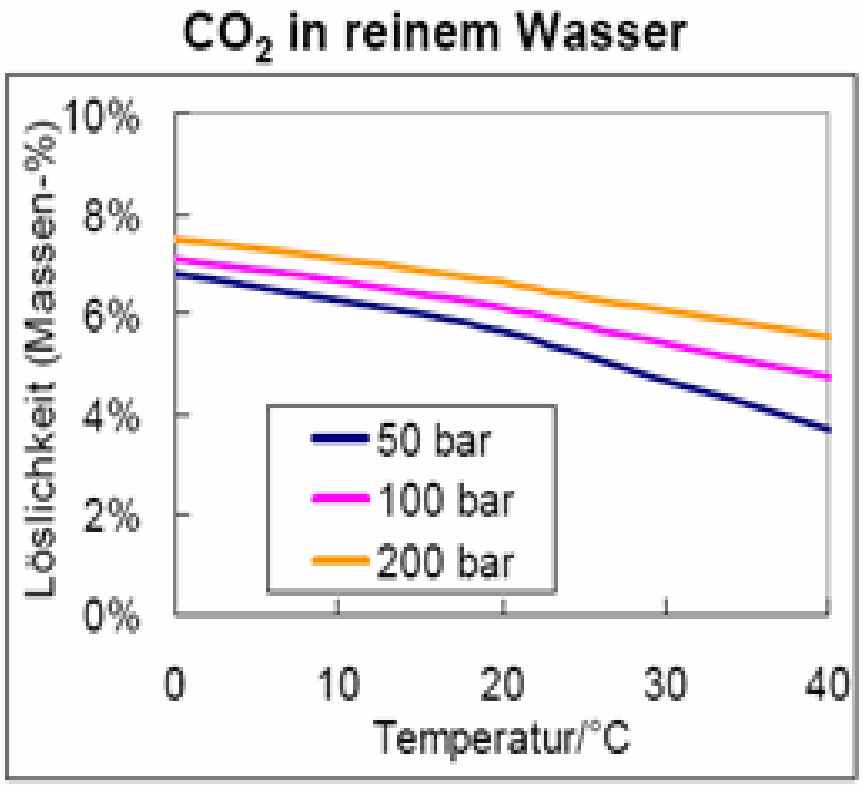
Physical Trapping of CO_2

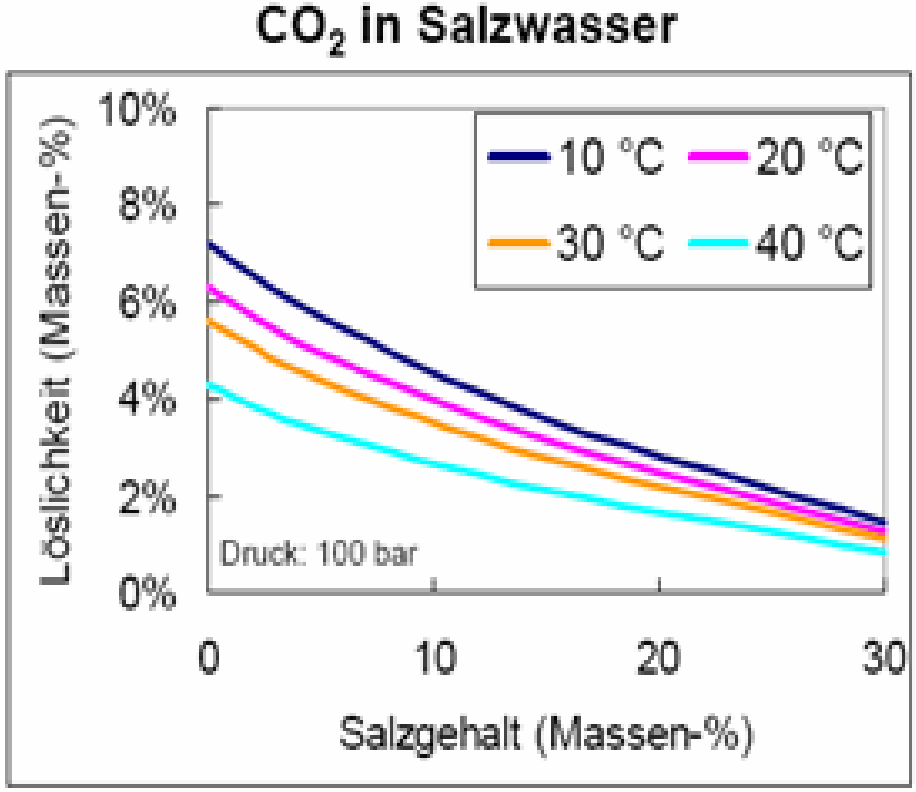
Sandstone - Stuttgartformation

CO_2SINK Ketzin



Fluid Trapping





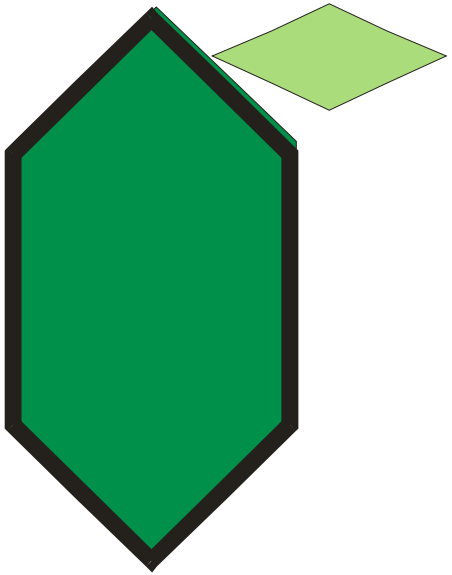
Chemical Trapping – Mineral Reactions

e.g. **Olivine –> Magnesite**

Mg_2SiO_4 + 2 CO_2 => 2 $MgCO_3$ + SiO_2

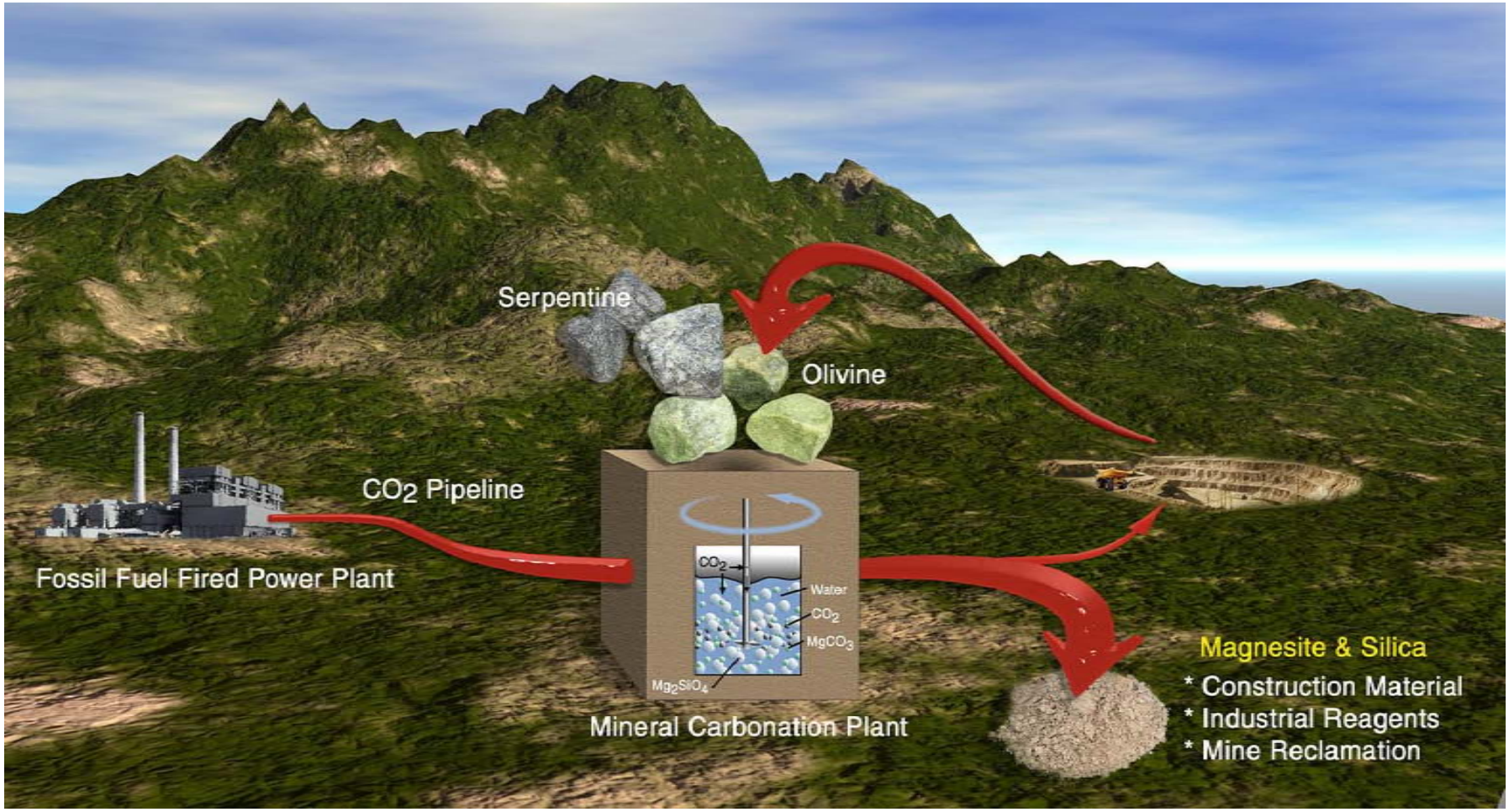
But also Serpentinite, Feldspars,...

Exotherme Reactions!

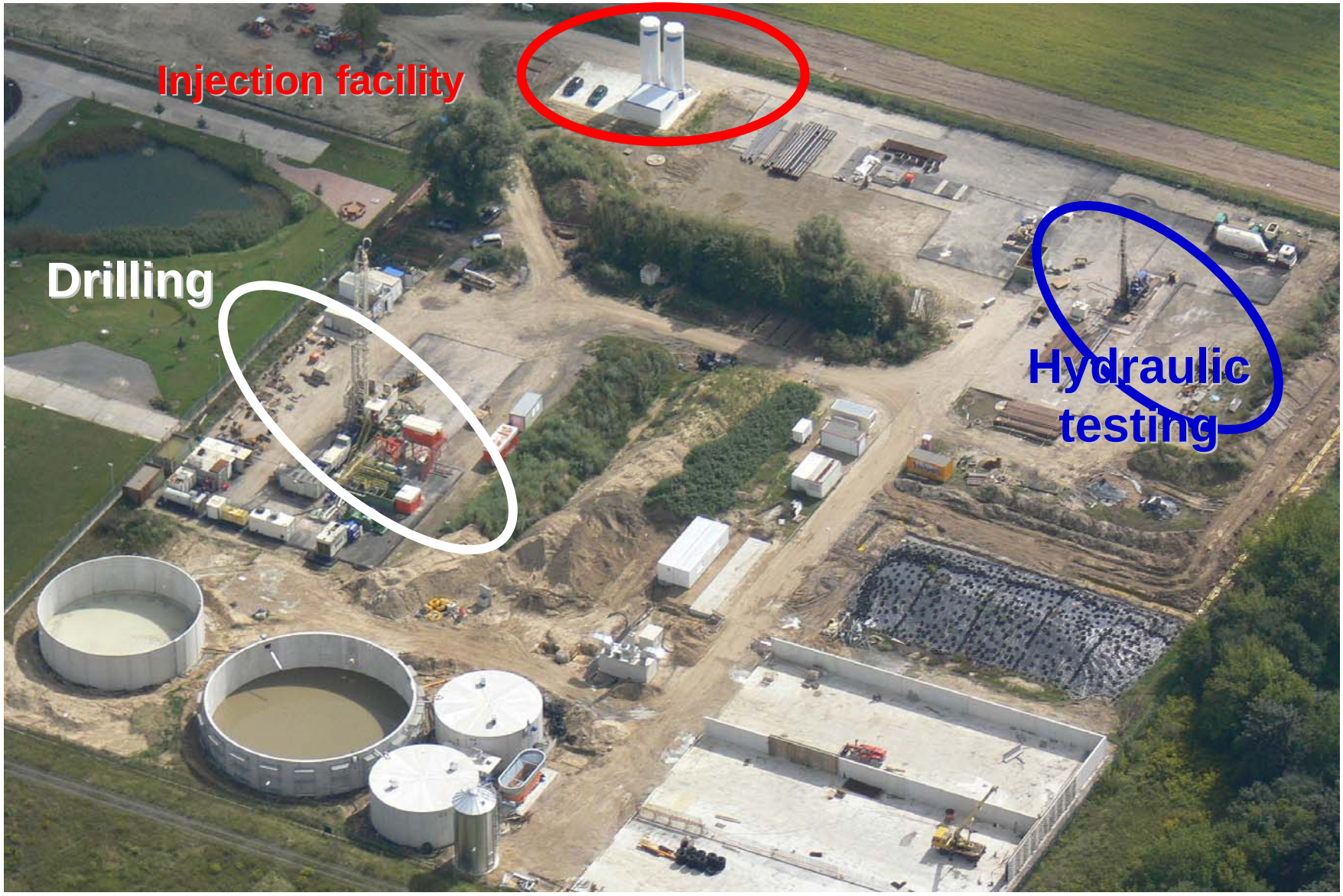


Wikipedia

Mineral Trapping



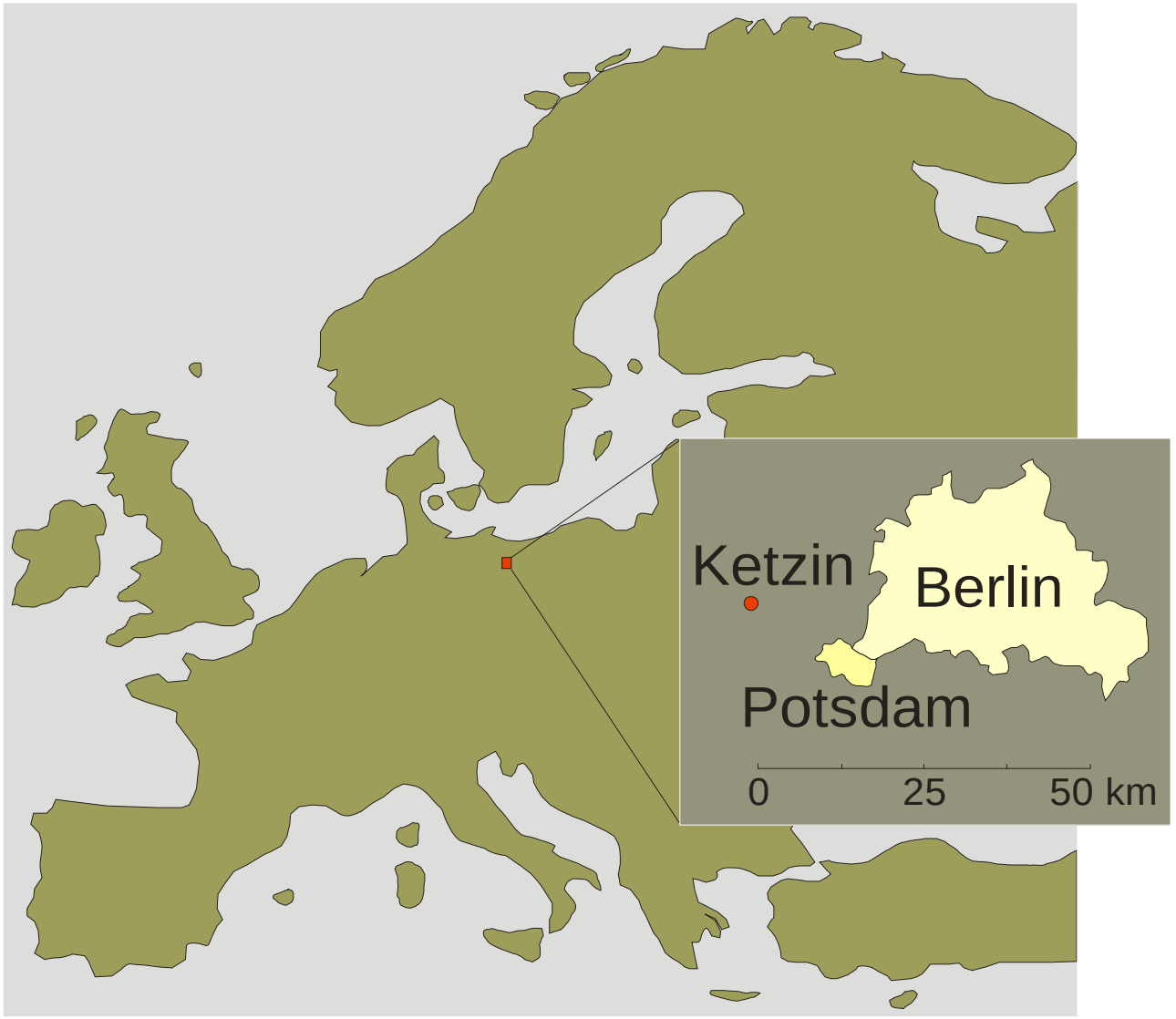
CO_2SINK in Ketzin

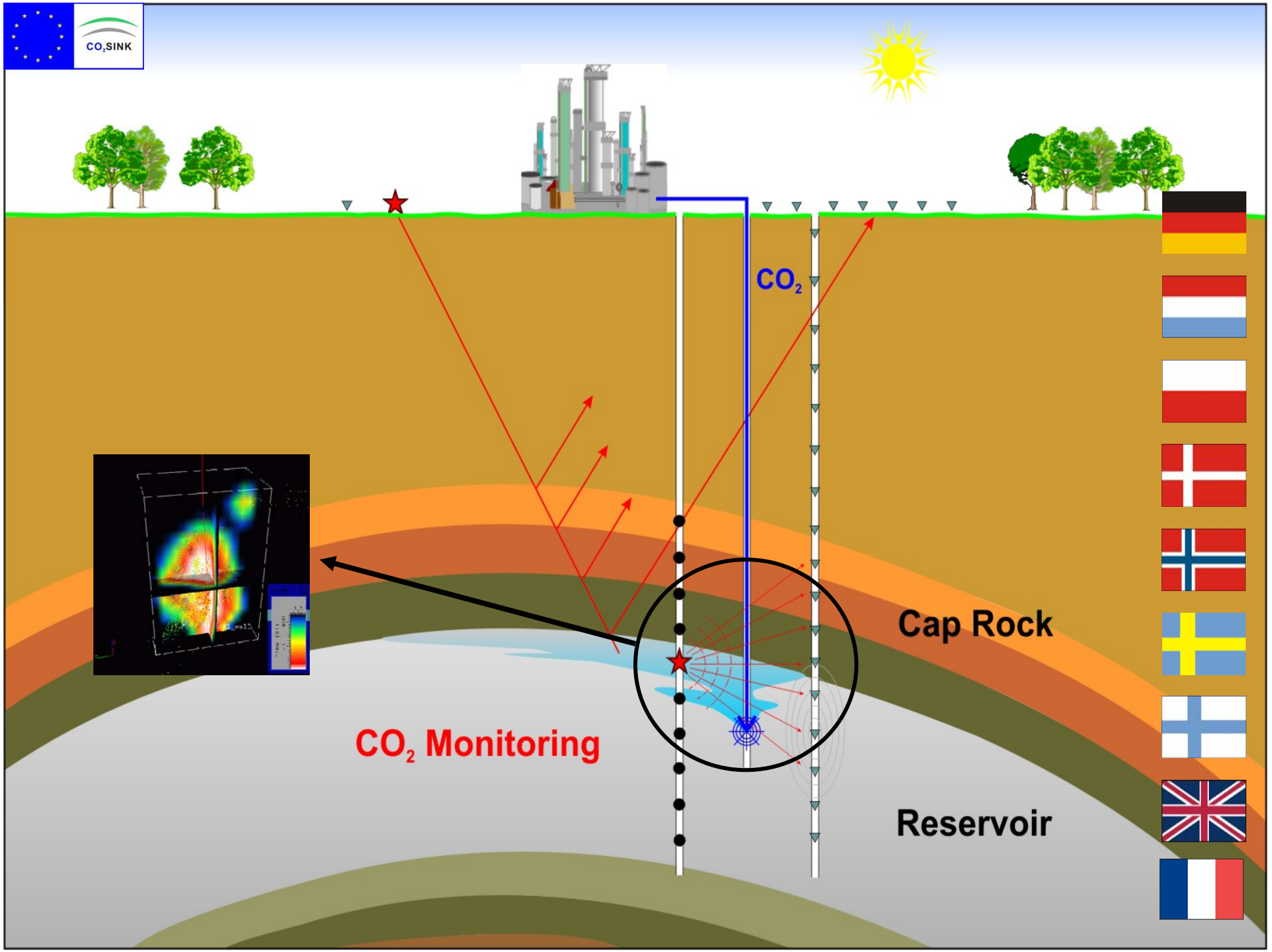


In-situ R&D Laboratory for Geological Storage of CO_2
- CO_2SINK Integrated Project -

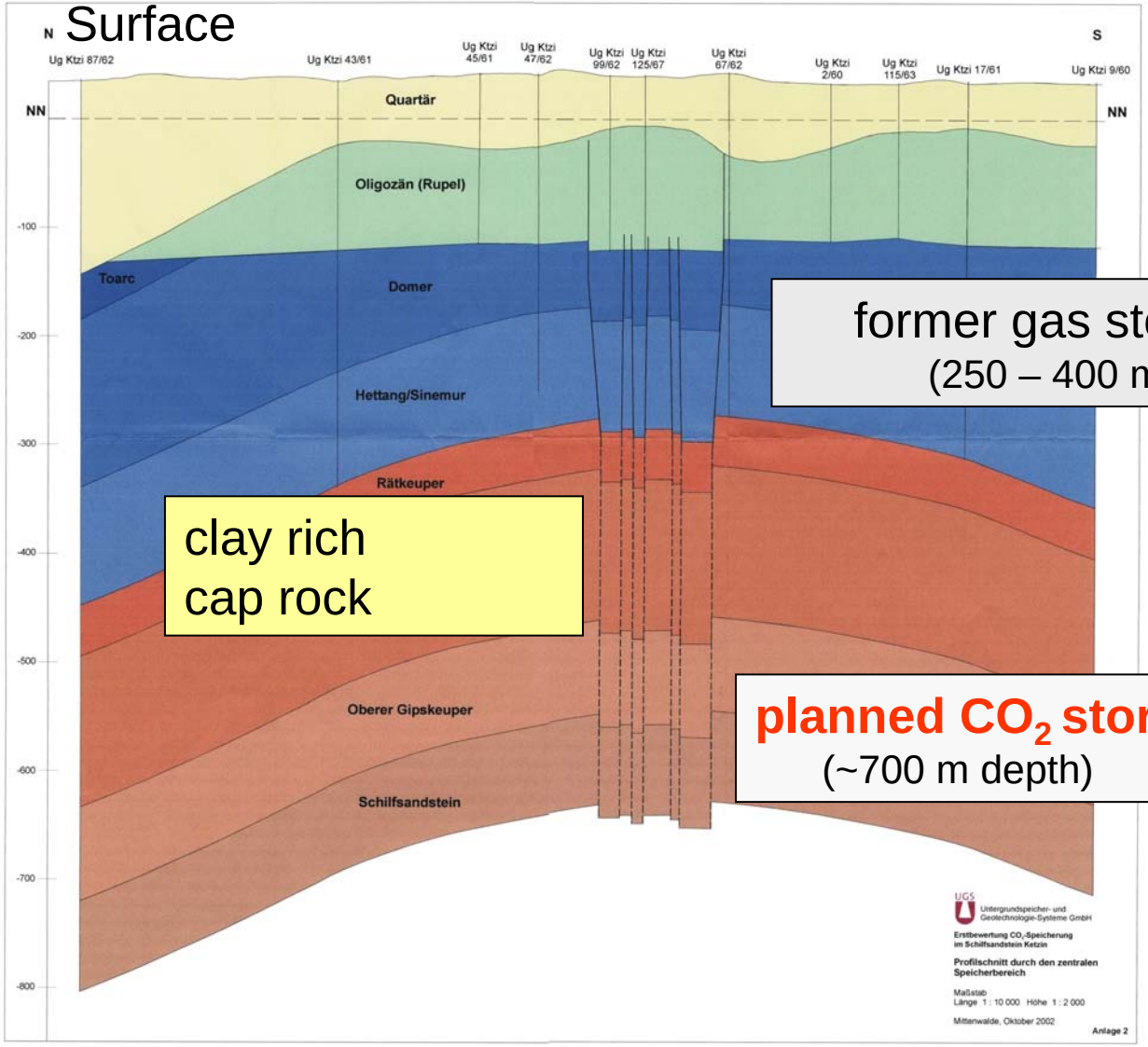
GeoForschungsZentrum Potsdam (D)
G.E.O.S. Freiberg Ingenieurgesellschaft (D)
Geological Survey of Denmark and Greenland (DK)
Mineral and Energy Economy Research Institute (PL)
Det Norske Veritas (N)
StatoilHydro (N)
Shell International Exploration and Production (NL)
University of Stuttgart (D)
Vibrometric Finland (SF)
University of Kent (GB)
Uppsala University (S)
RWE Power AG (D)
International Energy Agency – Greenhouse Gas Programme (GB)
Vattenfall Europe Generation (D)
Verbundnetz Gas AG (D)
Siemens AG Power Generation (D)
E.ON Energie AG (D)
Schlumberger Carbon Services (Fr)

Ketzin – the first “Onshore” storage project in Europe – CO_2SINK

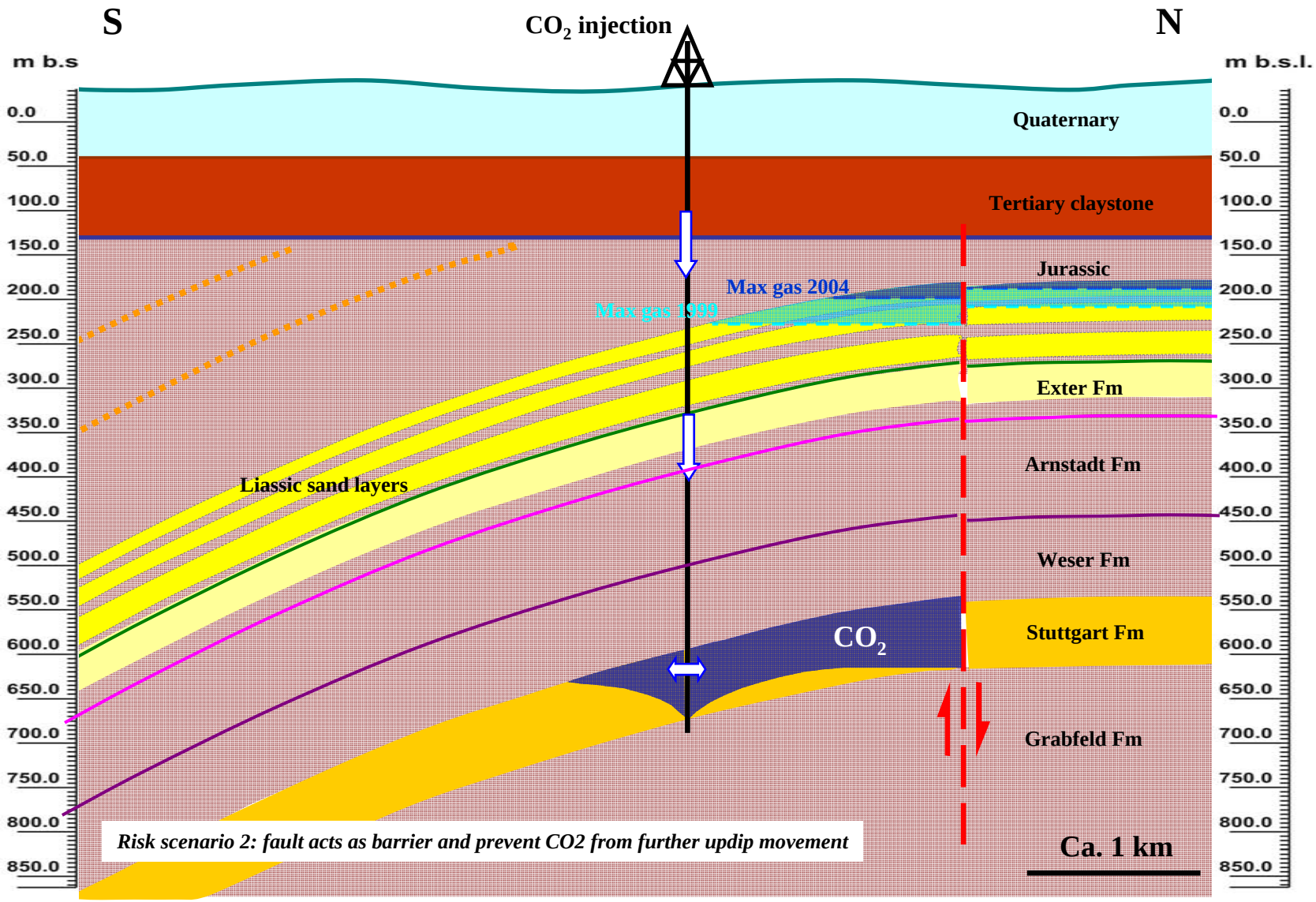



CO2SINK
CO2
Cap Rock
CO2 Monitoring
Reservoir

Geological Cross-Section through the subsurface near Ketzin

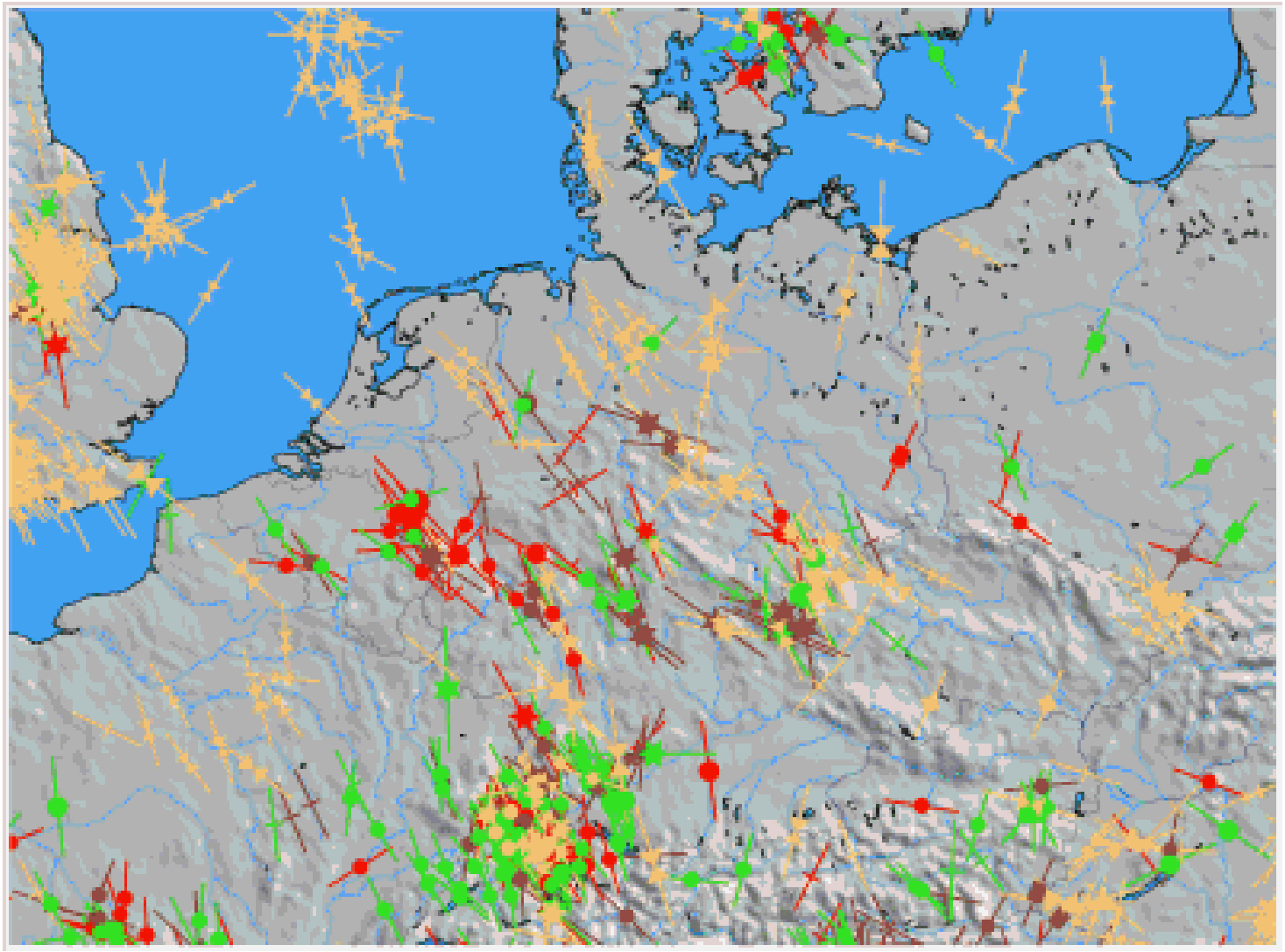


Risk Analysis Scenarios



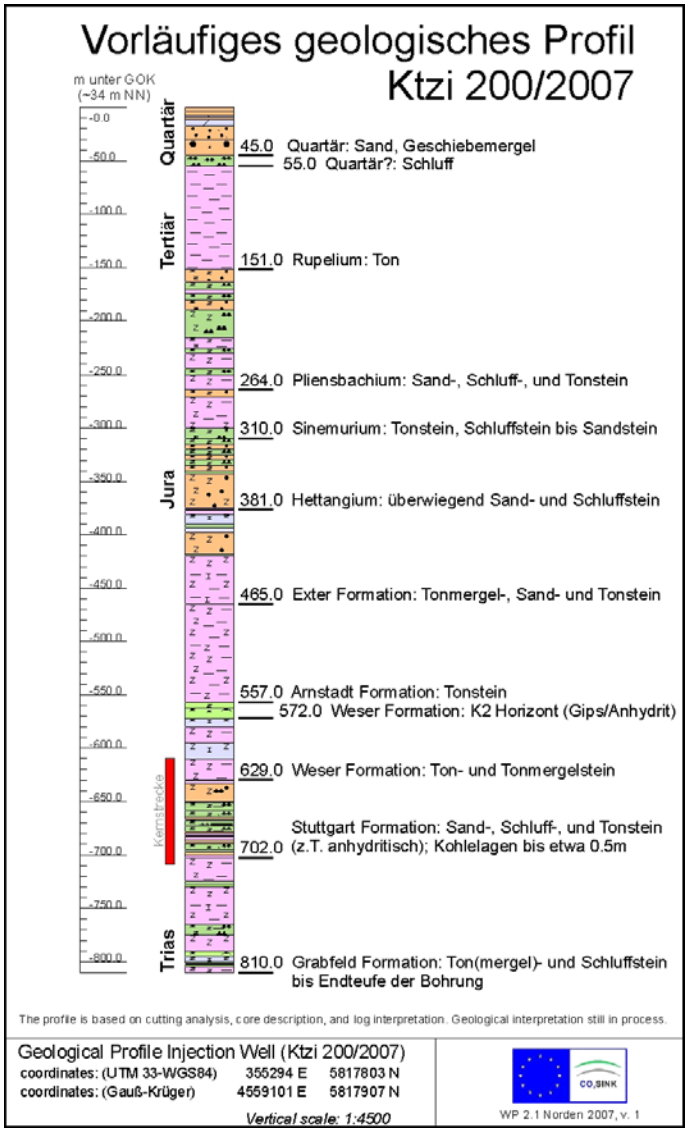
K. Zinck-Jørgensen (GEUS) & M. van der Molen (Shell) 2006

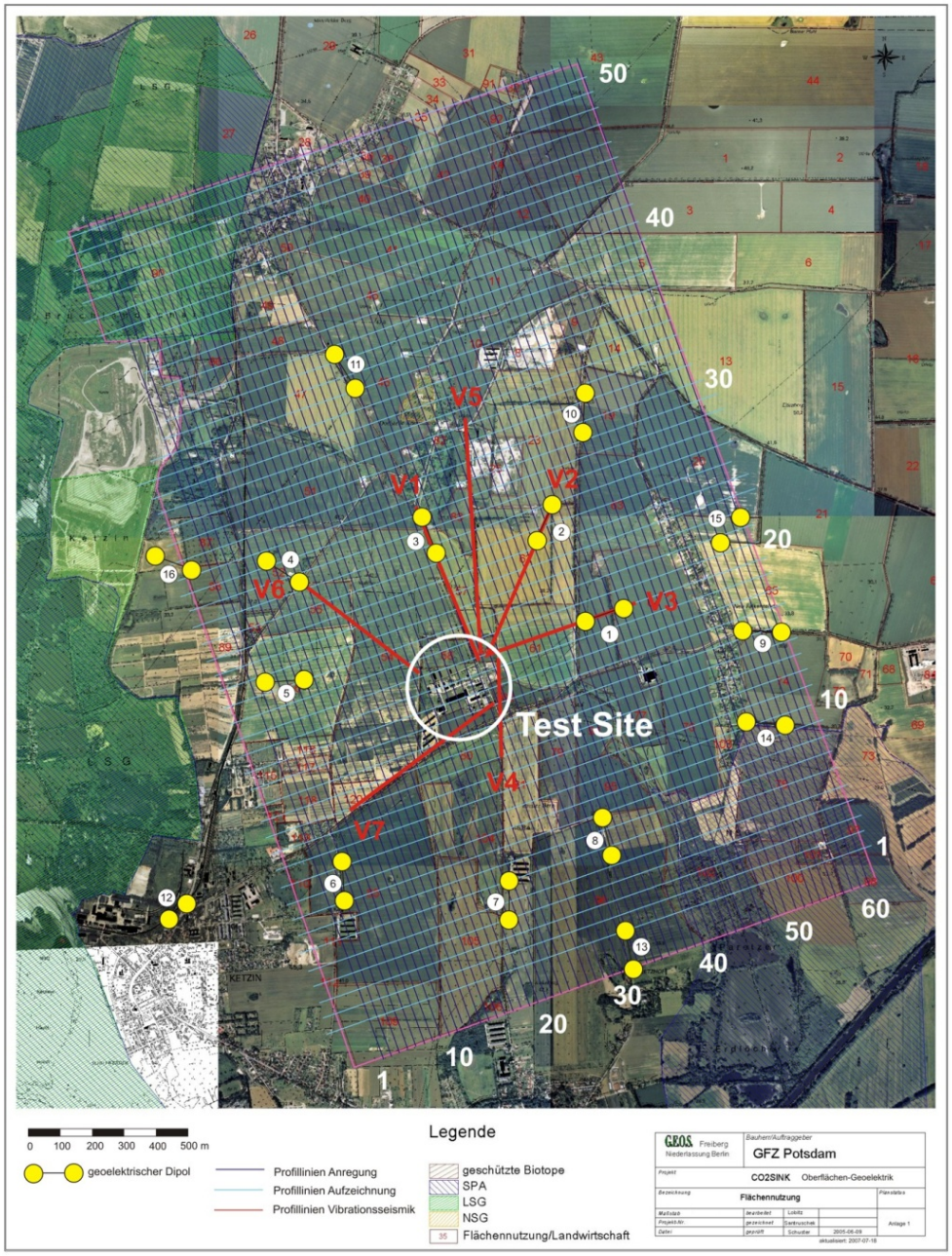
Seismic risk



Grünthal *et al.* @GFZ-Potsdam

Coring – Geological Profile





At the surface:
16 Dipoles @ 2 concentric circles around the boreholes

Dipole length: 150 m

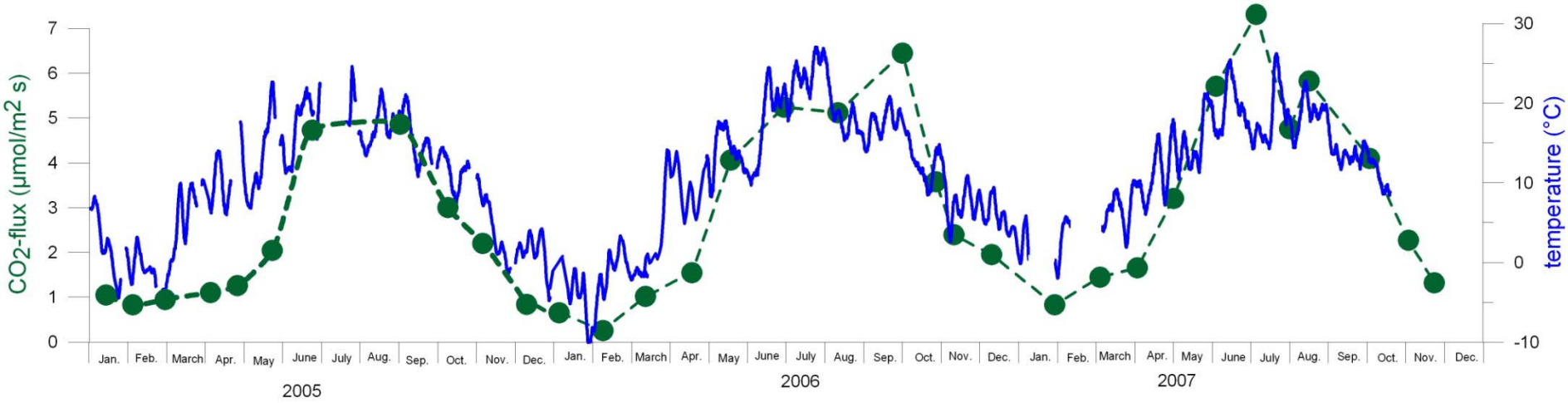
Investigation area:
outside the near-borehole area recording of anisotropical effects

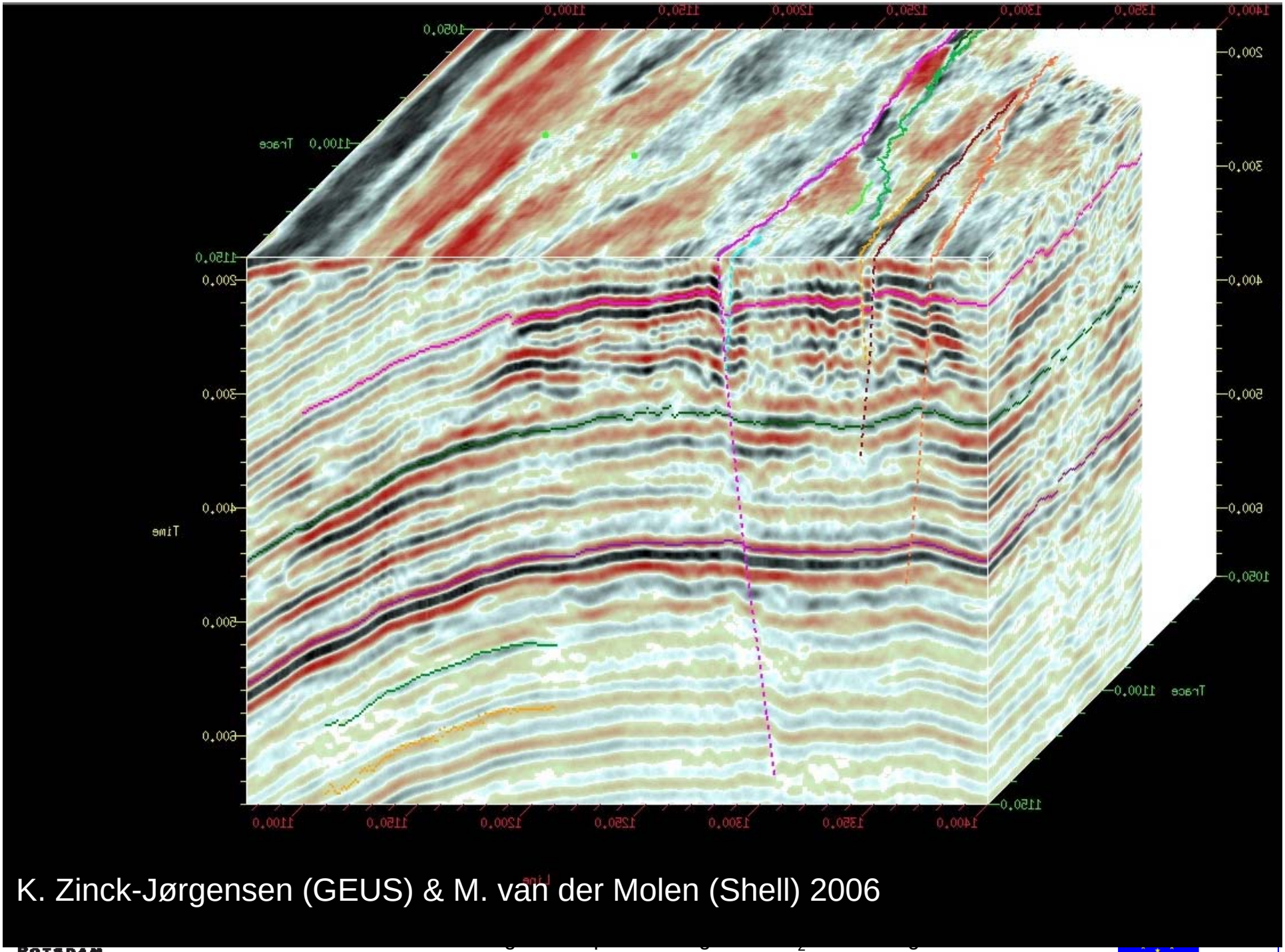
Duration of one complete measurement: 3 – 5 days

Joint field experiments with the seismic surveys:

- Measurement in the pre-injection phase
- Measurement after CO2 break-through (parallel to crosshole seismic)
- Measurement in the post-injection phase

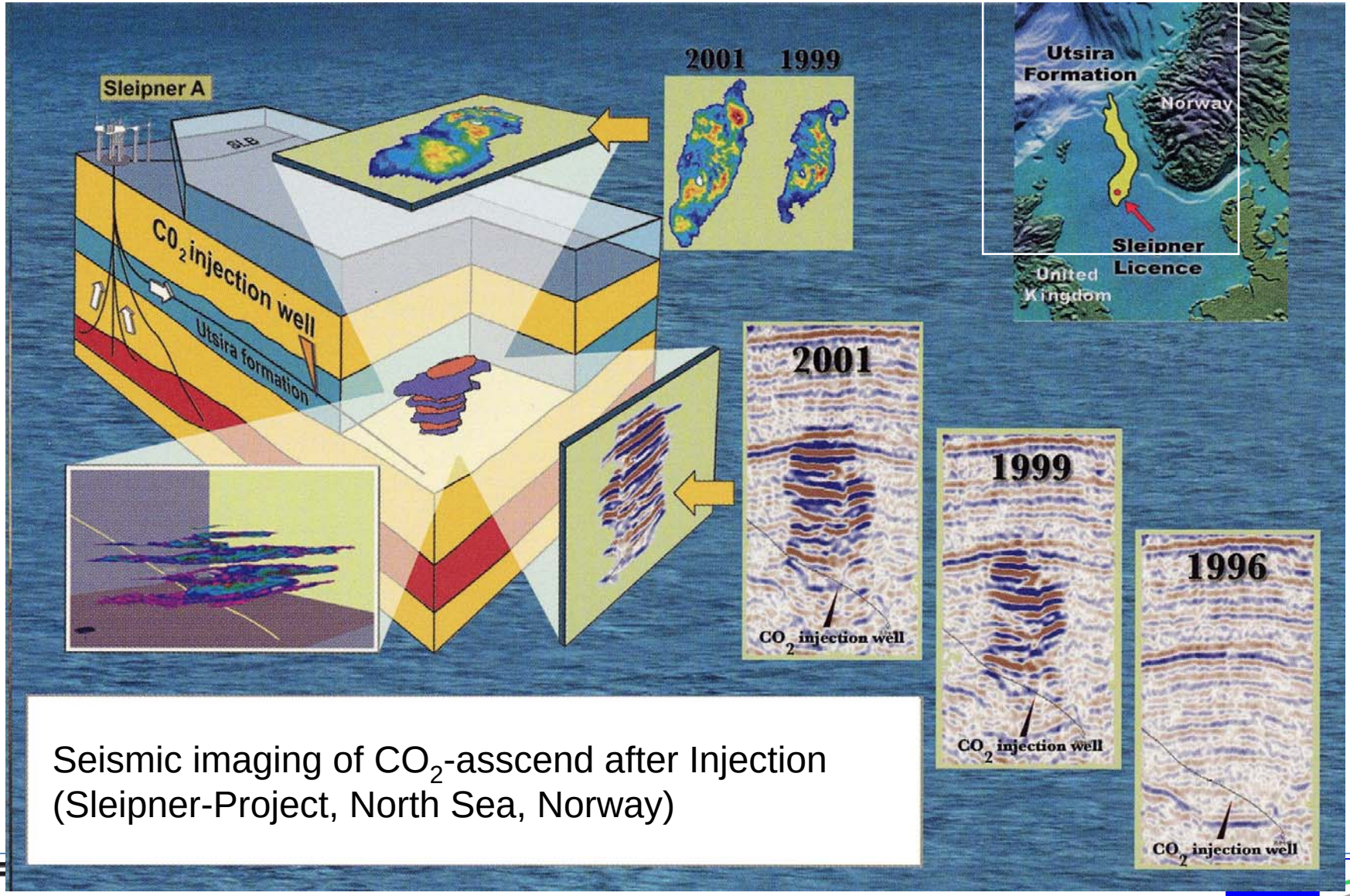
CO_2 Flux (60 cm Depth)





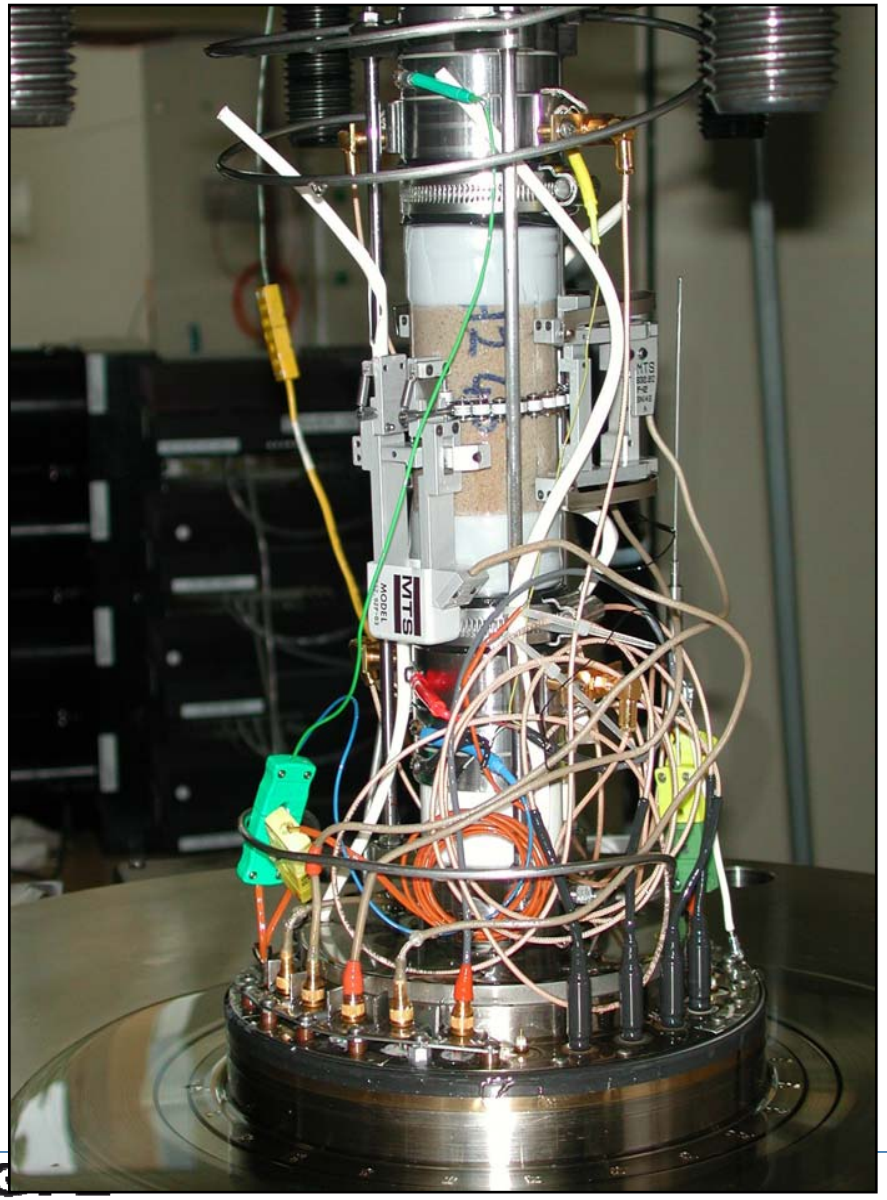
K. Zinck-Jørgensen (GEUS) & M. van der Molen (Shell) 2006

Sleipner Field



Seismic imaging of CO_2-asscend after Injection
(Sleipner-Project, North Sea, Norway)

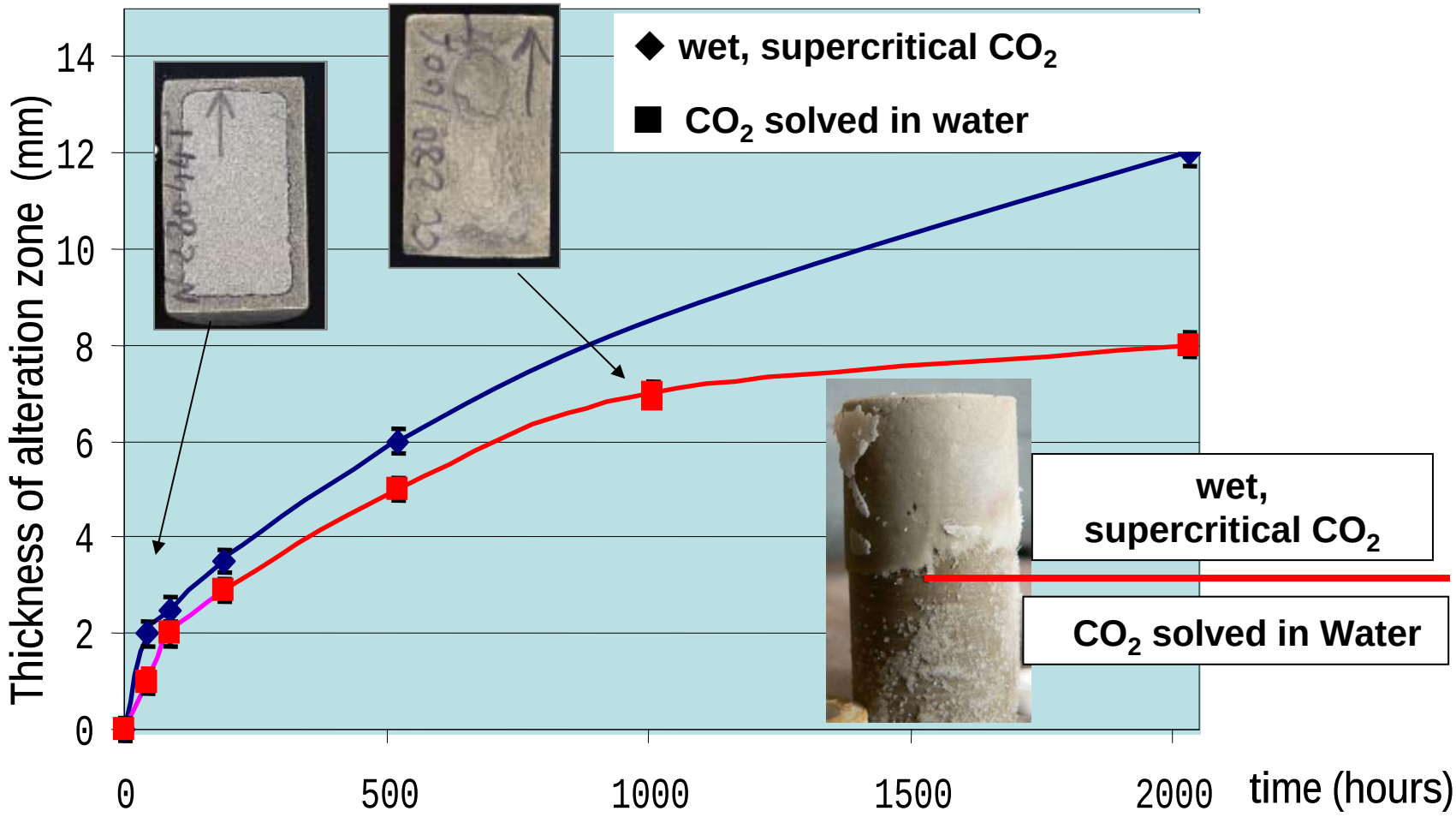
Laboratory Experiments



Triaxial high compression rock testing setup for simulation of CO_2 injection

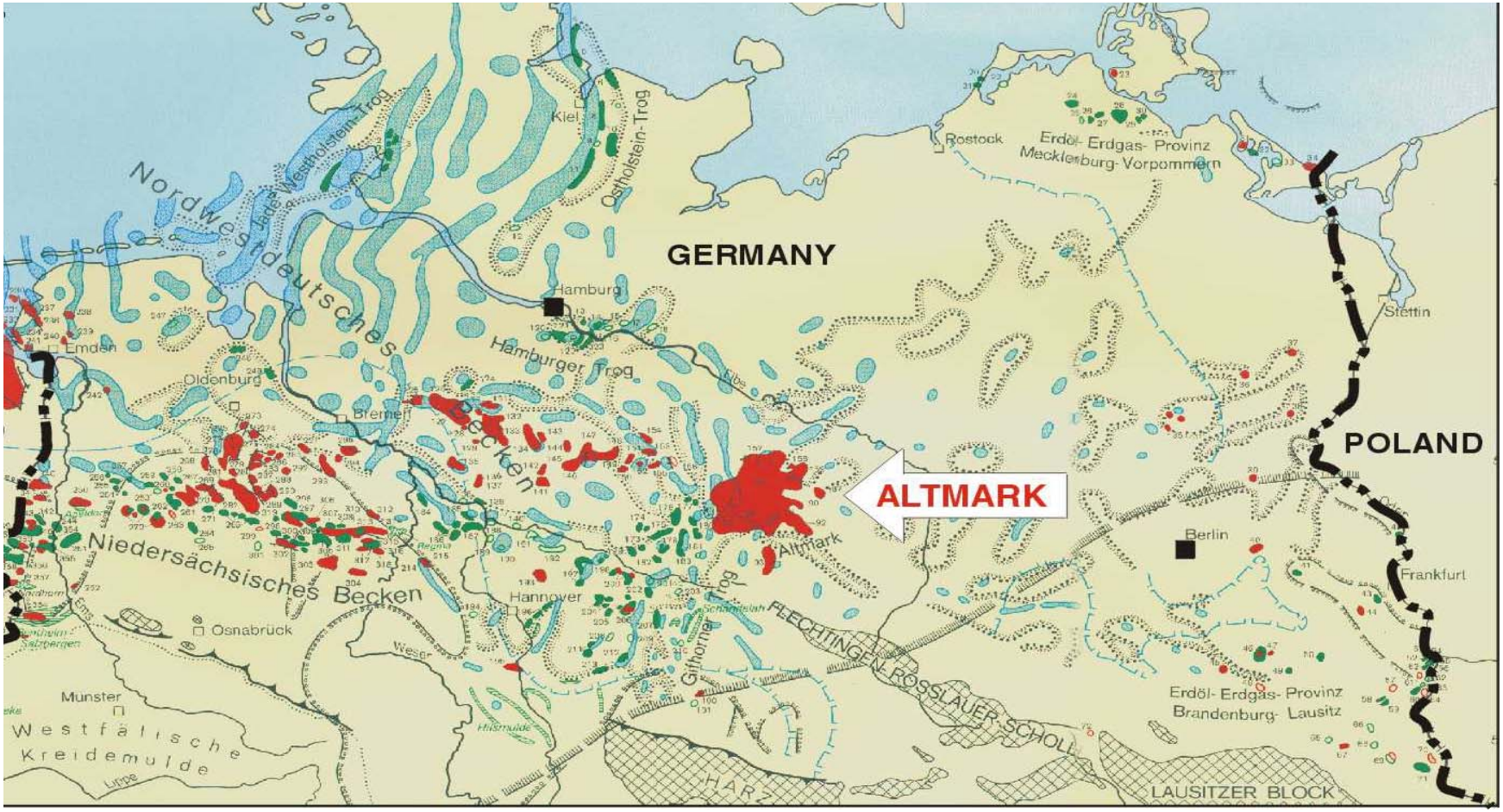
- triaxial cell
- temperature 40°C/60°C
- confining pressure 25 MPa/30 MPa
- pore pressure variable
- 1m brine (NaCl, distilled water)
- supercritical CO_2
- travel times, waveforms
- electrical resistivity
- stress, strain
- flow data
- liquid sampling (geochemistry)

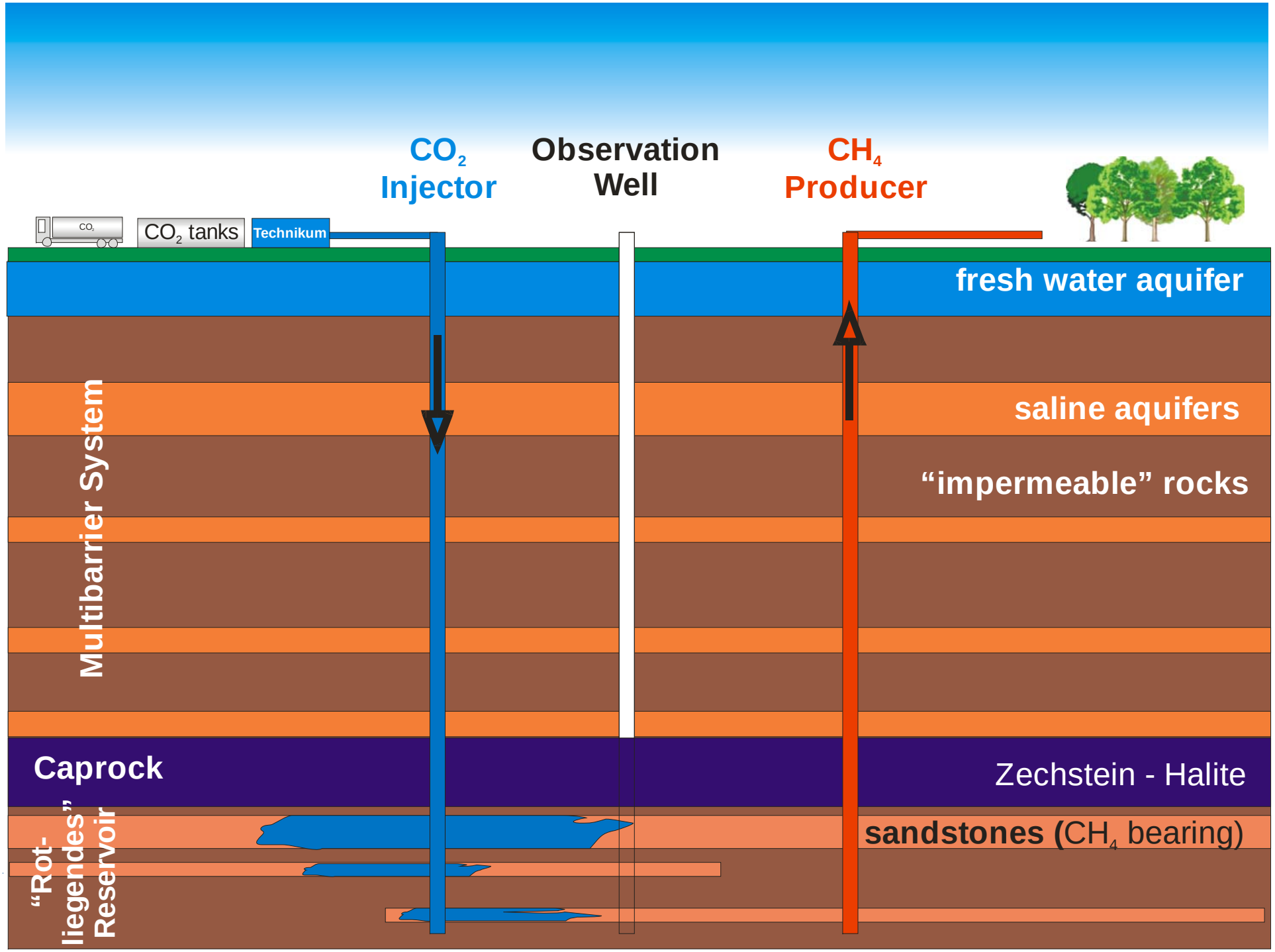
Cement Tests - Abandonment

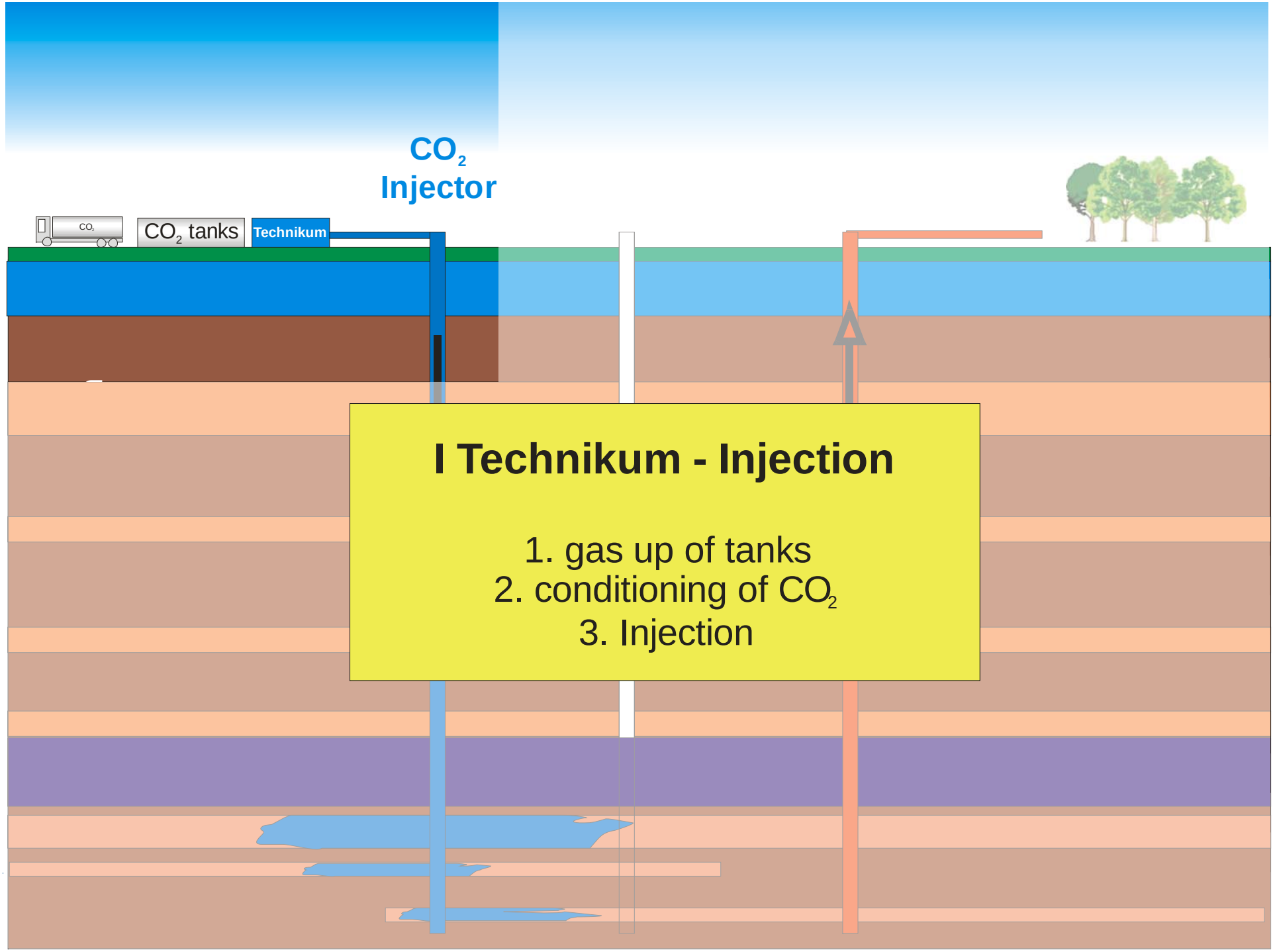


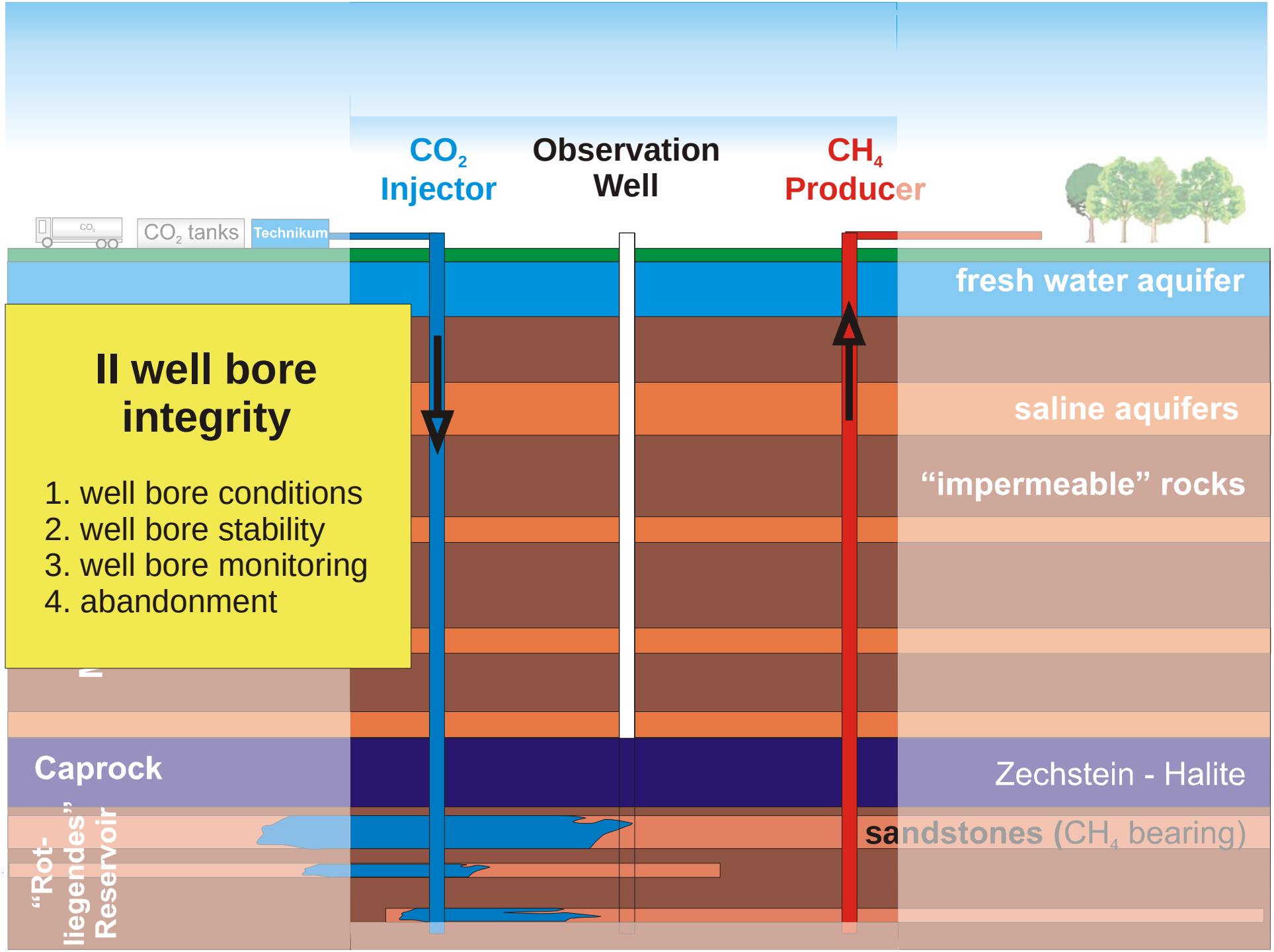
Kinetic study at 90°C, 280 MPa

Das Altmark Gasfeld



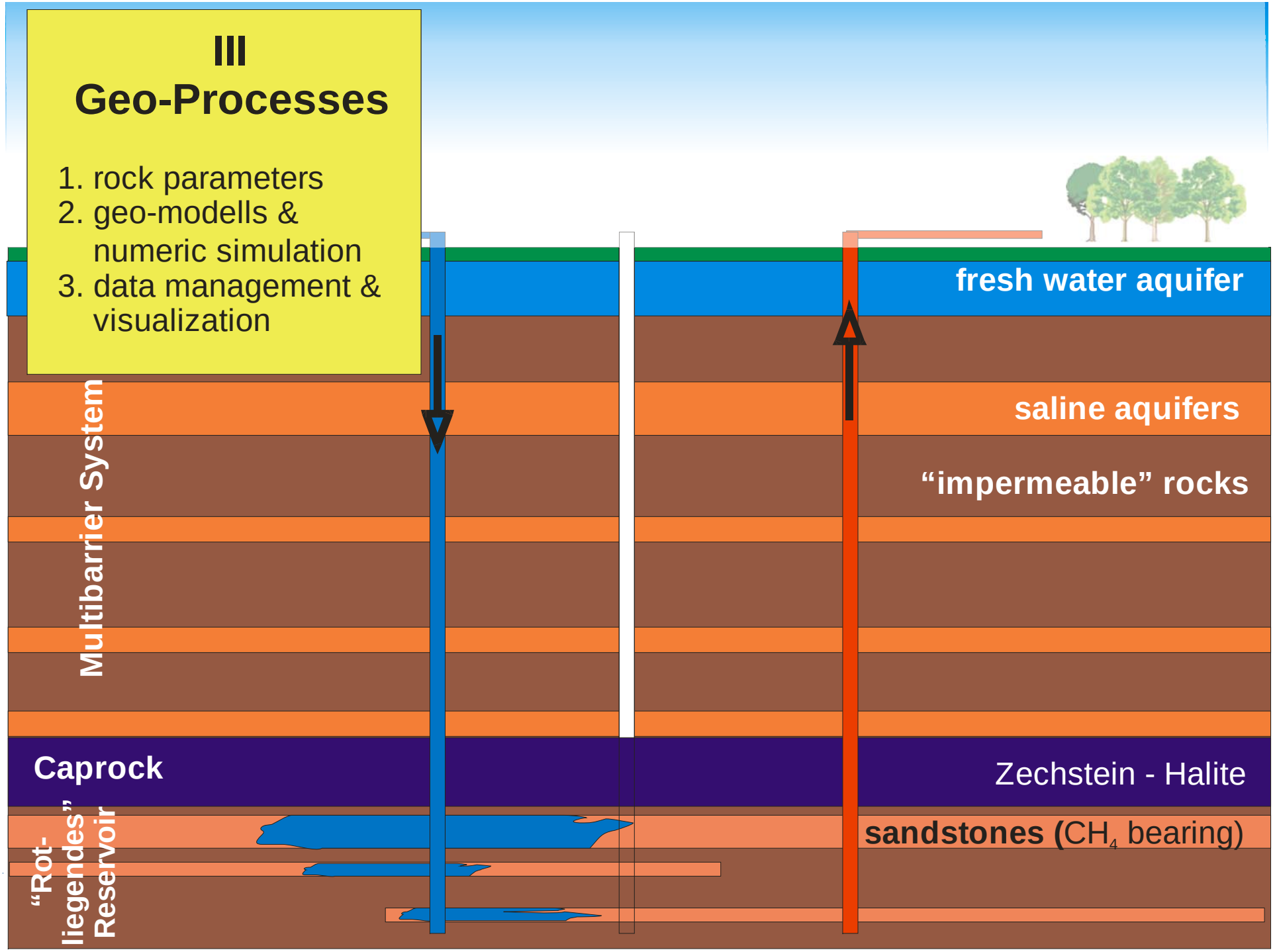

CO_2 Injector
Observation Well
CH_4 Producer
CO_2 tanks
Technikum
fresh water aquifer
saline aquifers
“impermeable” rocks
Multibarrier System
Caprock
Zechstein - Halite
“Rot-liegendes” Reservoir
sandstones (CH_4 bearing)

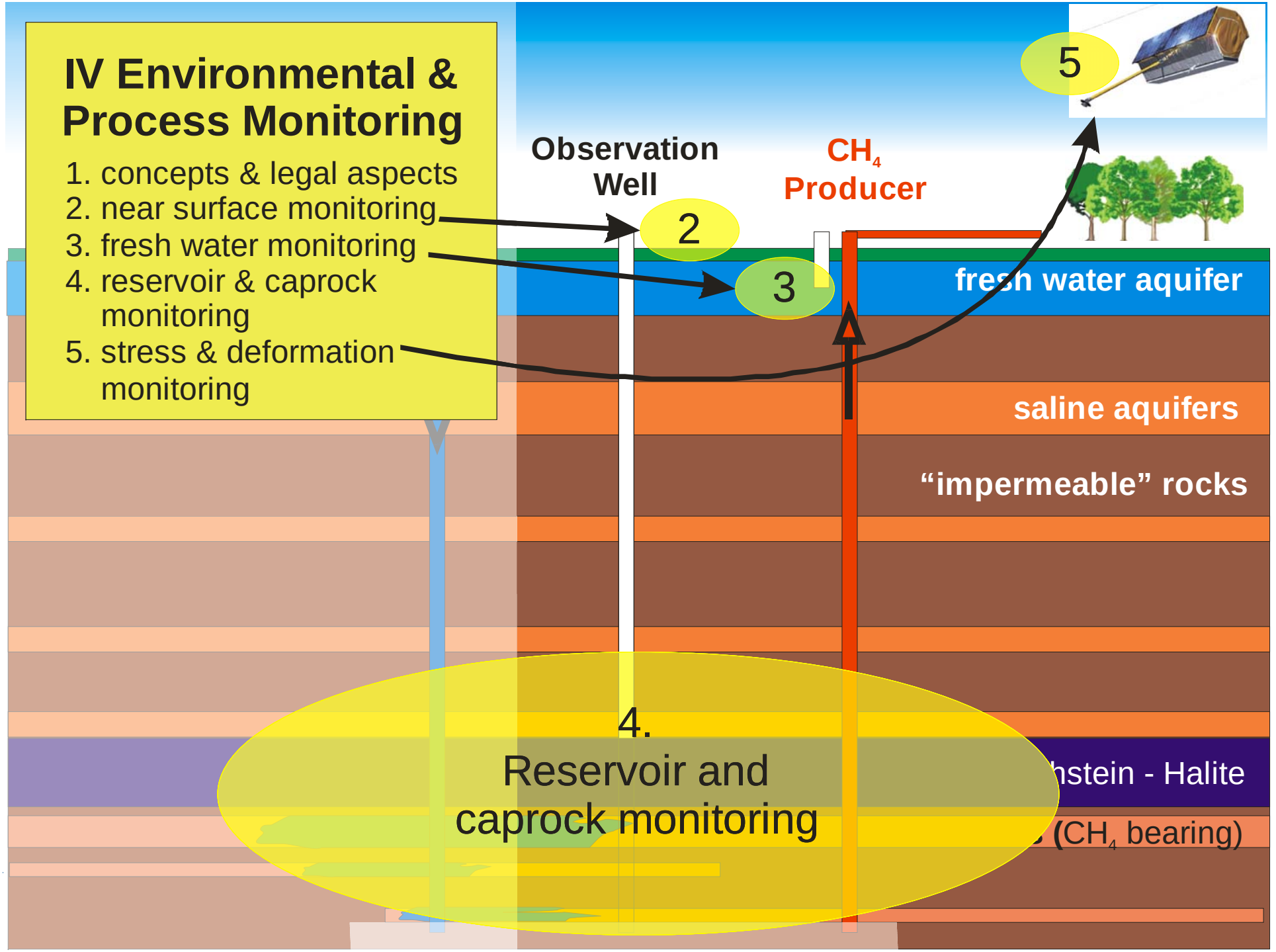

CO_2
Injector
CO_2 tanks
Technikum
I Technikum - Injection
1. gas up of tanks
2. conditioning of CO_2
3. Injection



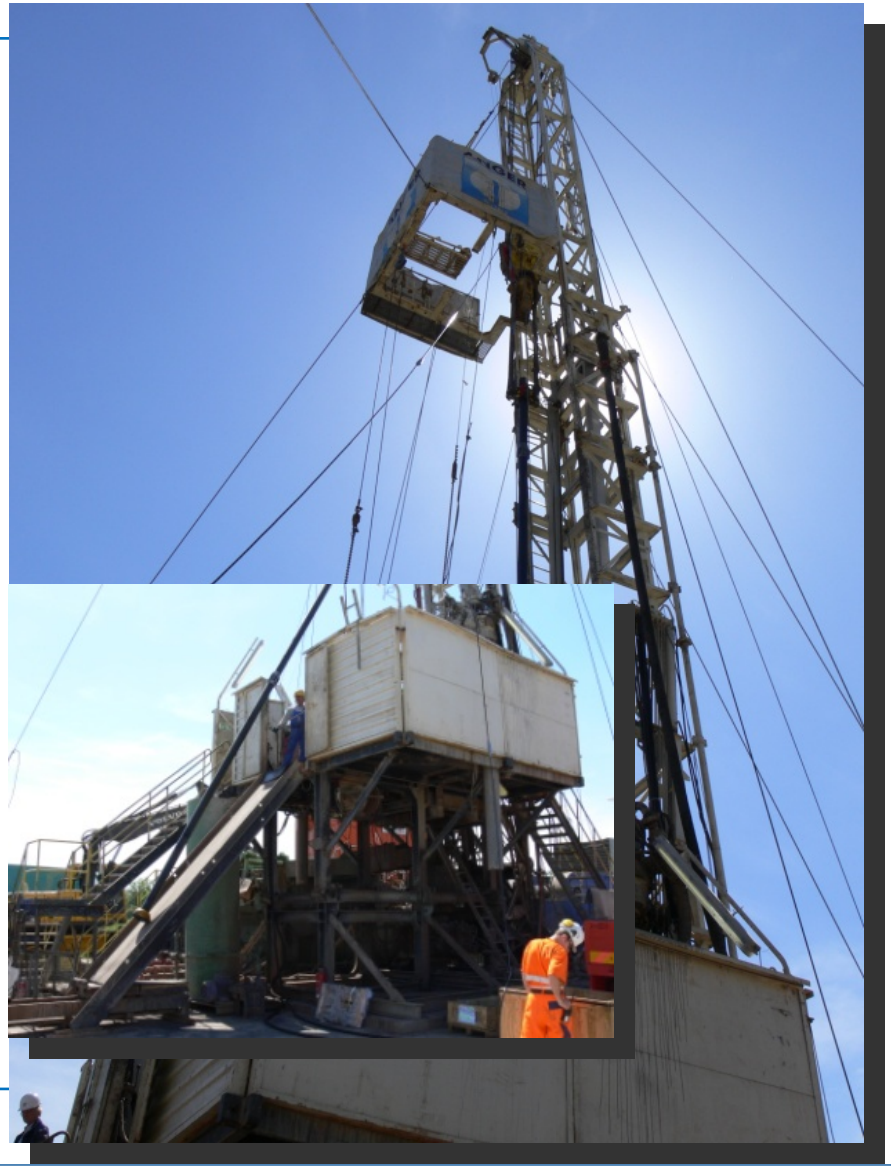
II well bore integrity

1. well bore conditions
2. well bore stability
3. well bore monitoring
4. abandonment


III
Geo-Processes
1. rock parameters
2. geo-modells & numeric simulation
3. data management & visualization
fresh water aquifer
saline aquifers
“impermeable” rocks
Multibarrier System
Caprock
Zechstein - Halite
“Rot-liegendes” Reservoir
sandstones (CH4 bearing)


IV Environmental & Process Monitoring
1. concepts & legal aspects
2. near surface monitoring
3. fresh water monitoring
4. reservoir & caprock monitoring
5. stress & deformation monitoring
Observation Well
CH4 Producer
2
3
5
fresh water aquifer
saline aquifers
“impermeable” rocks
4.
Reservoir and caprock monitoring
hstein - Halite
(CH4 bearing)

Impressions of installation

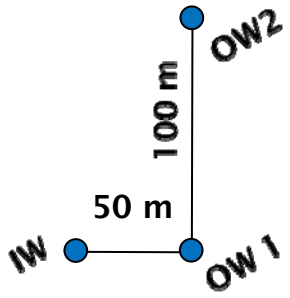


May 2007

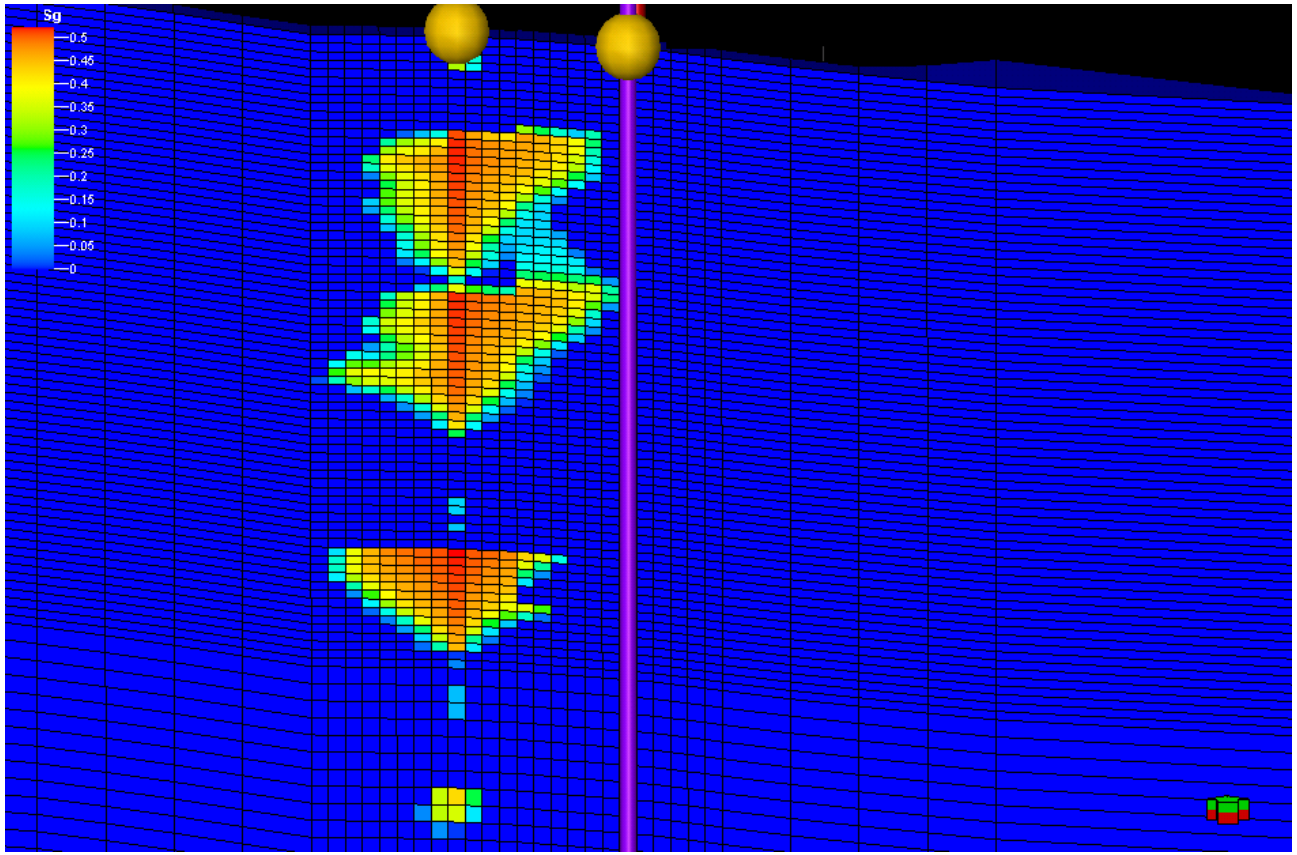
GFZ German Research Centre for Geosciences

CO_2 injection

	Date:	injected CO_2:
Facility test & preparation	24.06.2008	test amount of CO2, Kr-tracer, N_2
Start of CO_2 injection	30.06.2008	~ 0 t CO_2
Arrival of CO_2 at Observation Well 1:	15.07.2008	531,5 t CO_2
Today:	07.11.2008	~ 4000 t CO_2

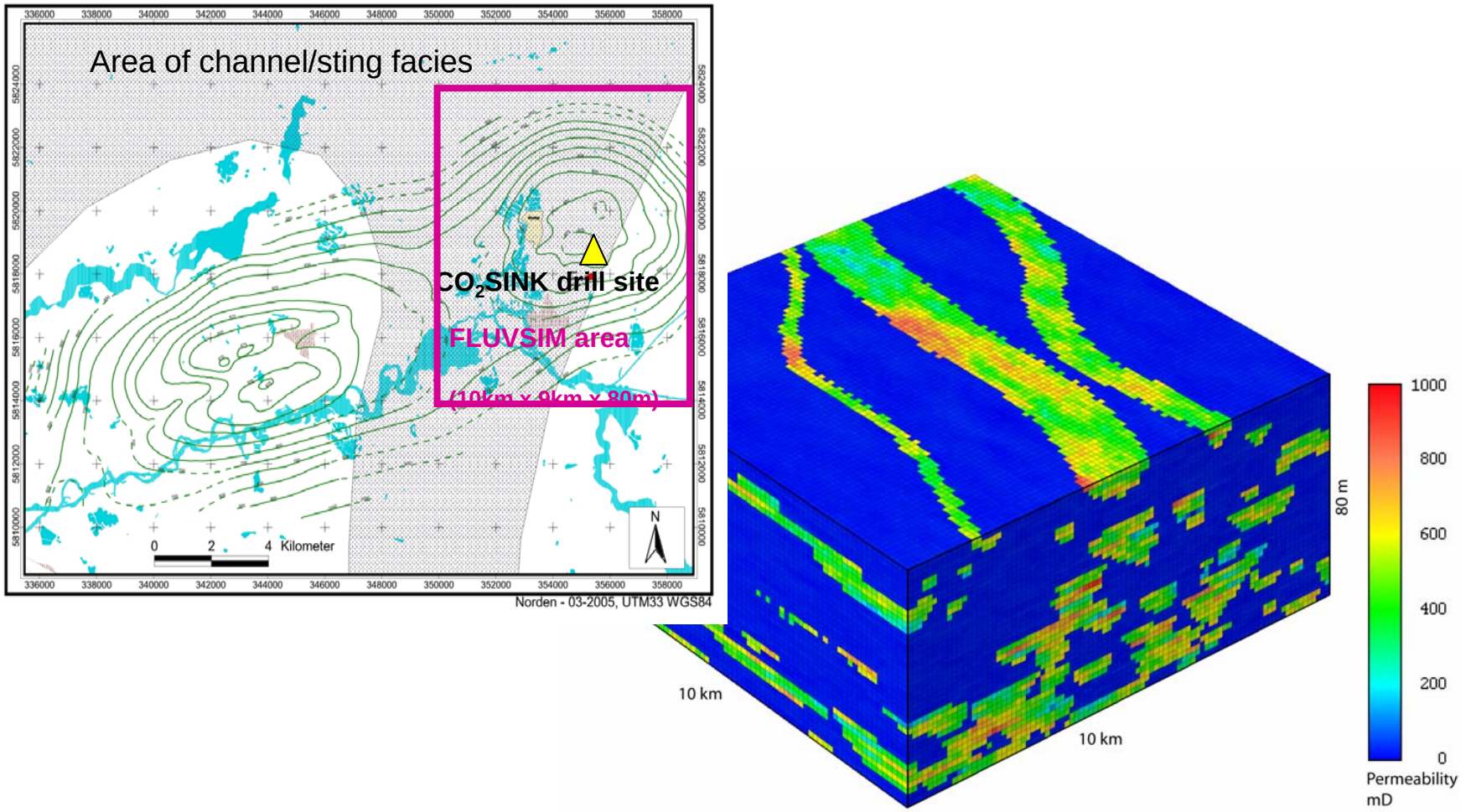


Modeling (P. Frykman, GEUS)



- Further comparision with RST, crosshole seismic, and temperature monitoring still under investigation

Probabilistic Reservoir-Simulation



Methodenspektrum – BioGeoEngineering

- Tracer zur Kontaminationskontrolle
- DNA- und RNA-Isolierungsmethoden
- PCR und Real-Time RT-PCR
- Bioinformatik
- Fingerprinting der MO (SSCP, DGGE, TGGE)
- FISH / CARD-FISH
- Klonierungen
- cDNA-Banken
- Gaschromatographie

Mikrobiologisches Labor im DIFE (Einzug Mitte Juli 08)

GRASP

Marie Curie Actions
Human Resources and Mobility Activity

Ketzin: Erste Ergebnisse der Fluiduntersuchung

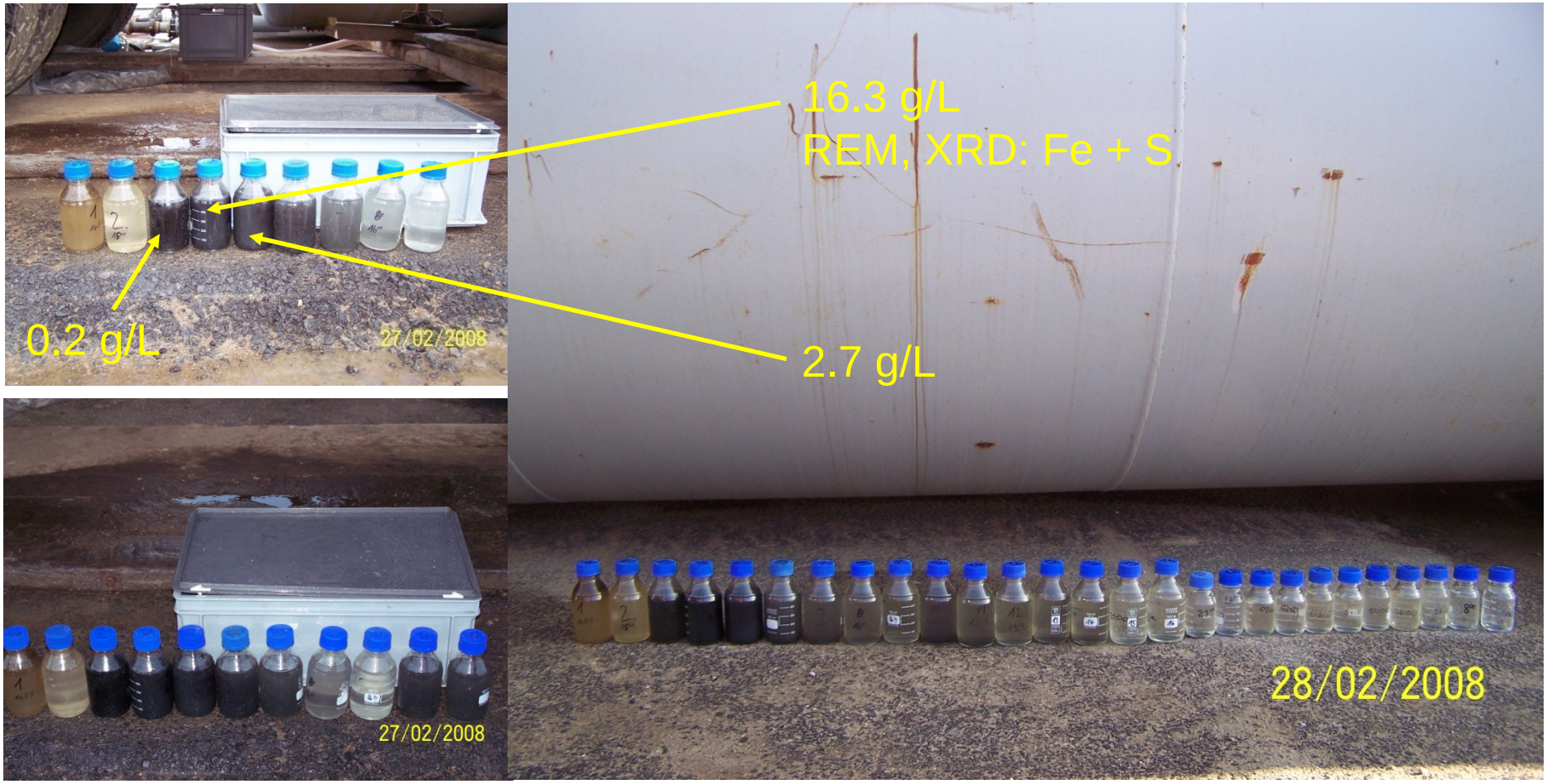
Hydraulischer Test
an Ktzi 200:

Geschlossener Ausbau
zur Entnahme von
Fluidproben

% Bohrspülung + Sole

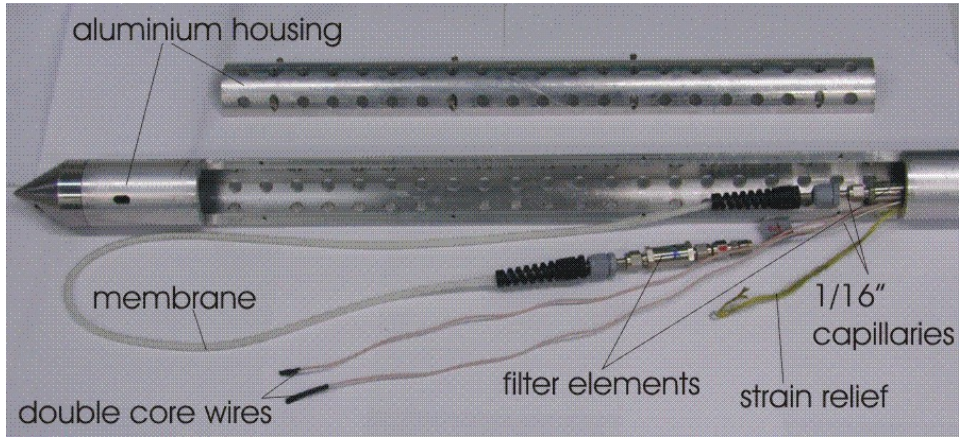
Mikroorganismen
in Bohrspülung
und Tiefenprobe

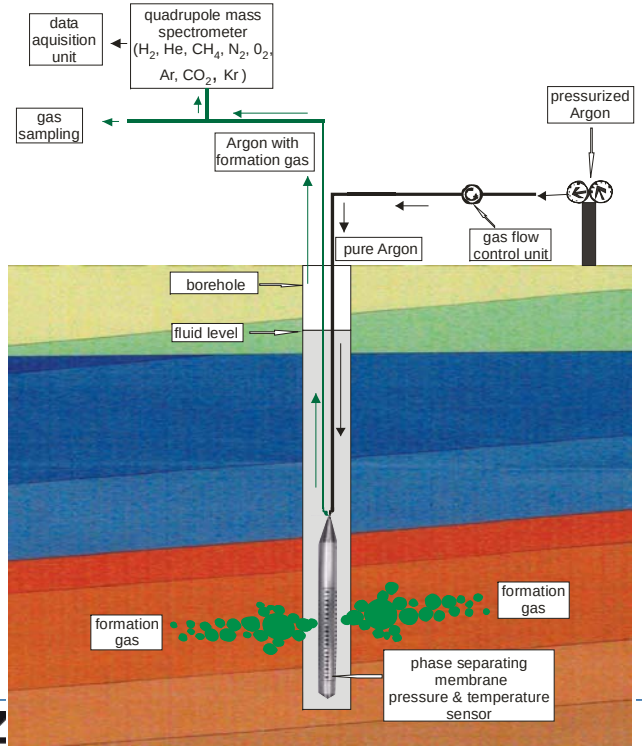
Successful Measure



Fines < 1 mg/L – stop of lifting after production of 100 m^3 water

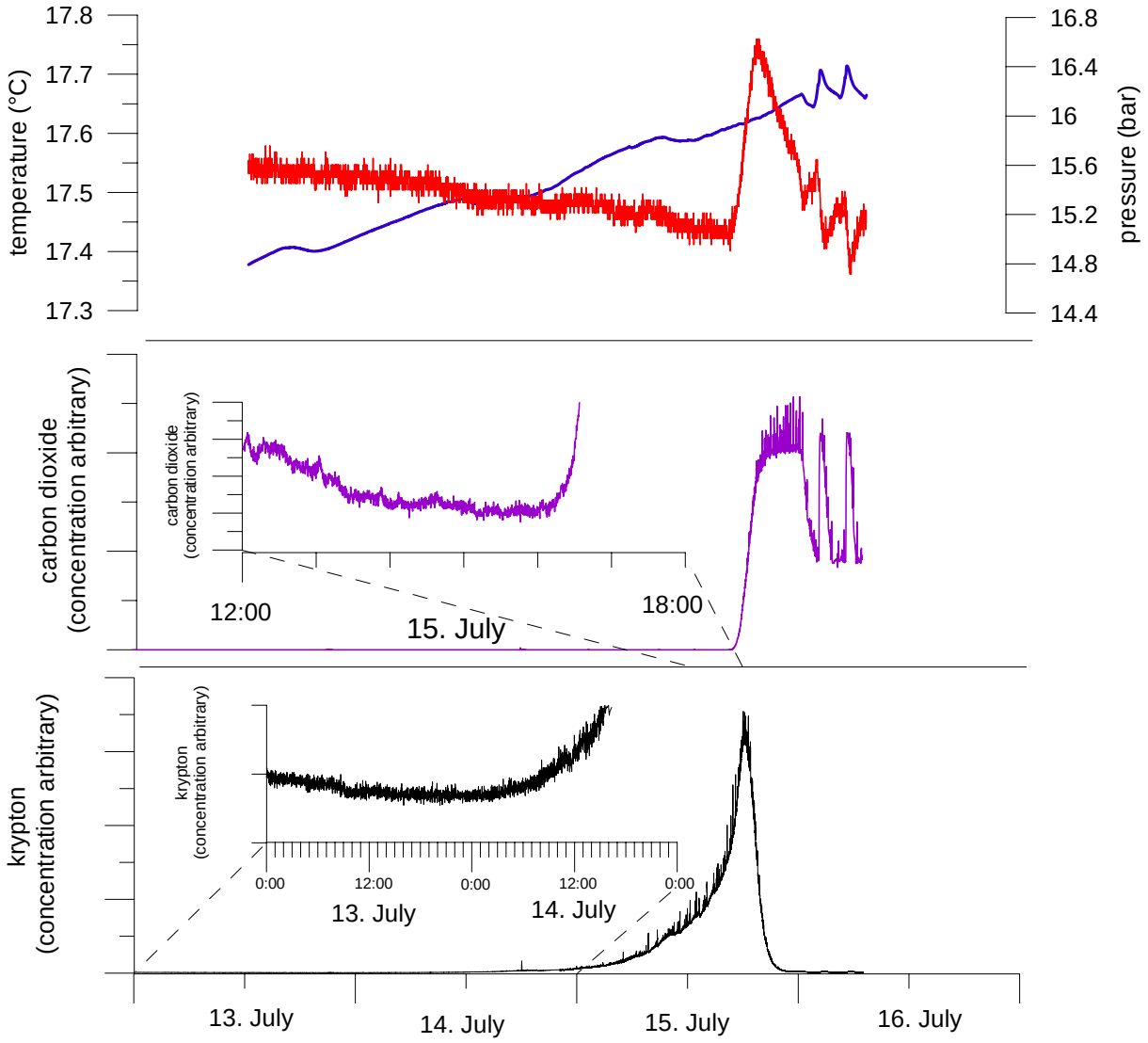
Gas Membrane Sensor - CHEMKIN





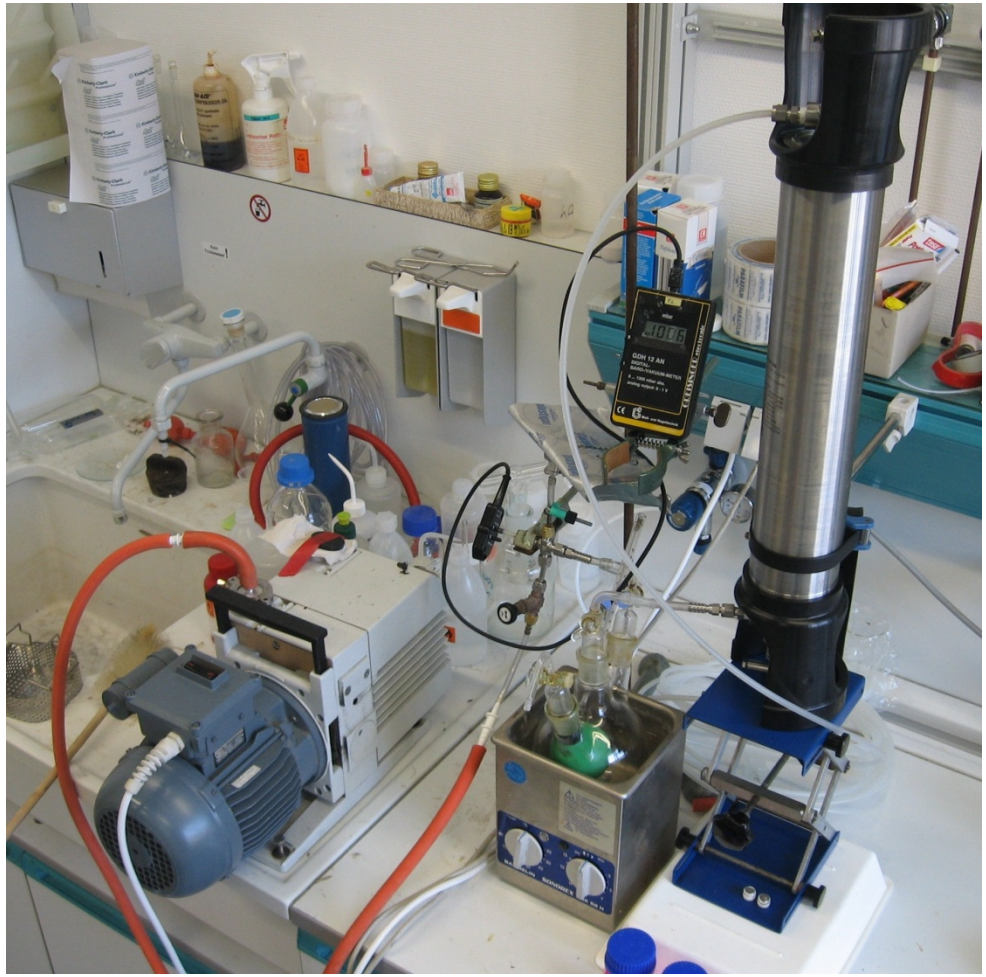
Zimmer et al. 2008

Pressure, Temperature, CO_2 and Kr in Ktzi200/07

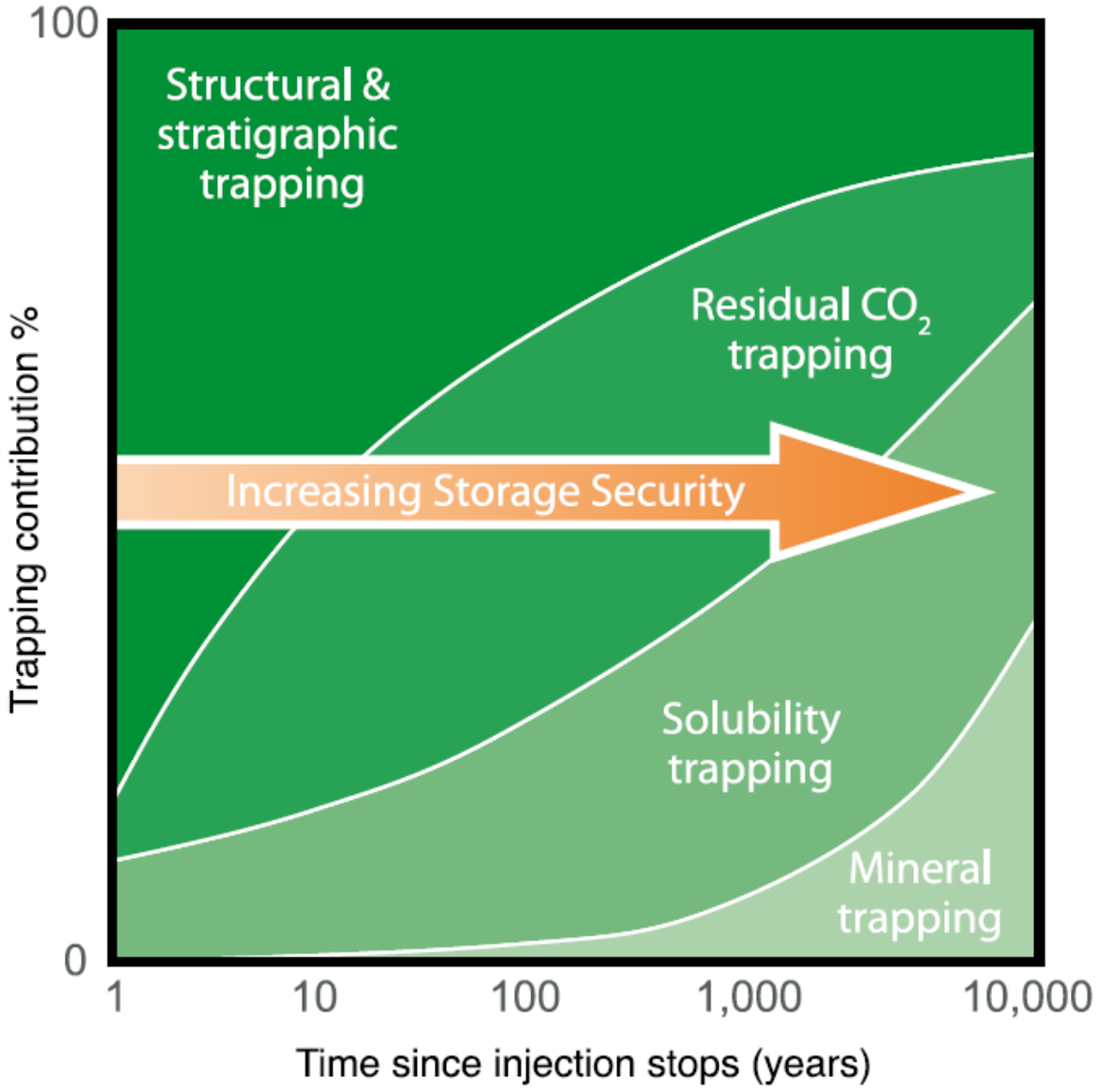


Degassing of Down Hole Sample

64 ml gas / litre fluid



Summary


100
0
Trapping contribution %
Structural & stratigraphic trapping
Residual CO_2 trapping
Increasing Storage Security
Solubility trapping
Mineral trapping
1
10
100
1,000
10,000
Time since injection stops (years)

1st International Workshop of CSLF Pilot Projects, 28-09-2005 @ GFZ

International Cooperations

Wissenschaftspark
Albert-Einstein - Telegrafenberg

Thank you for your attention