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Operations at Ketzin

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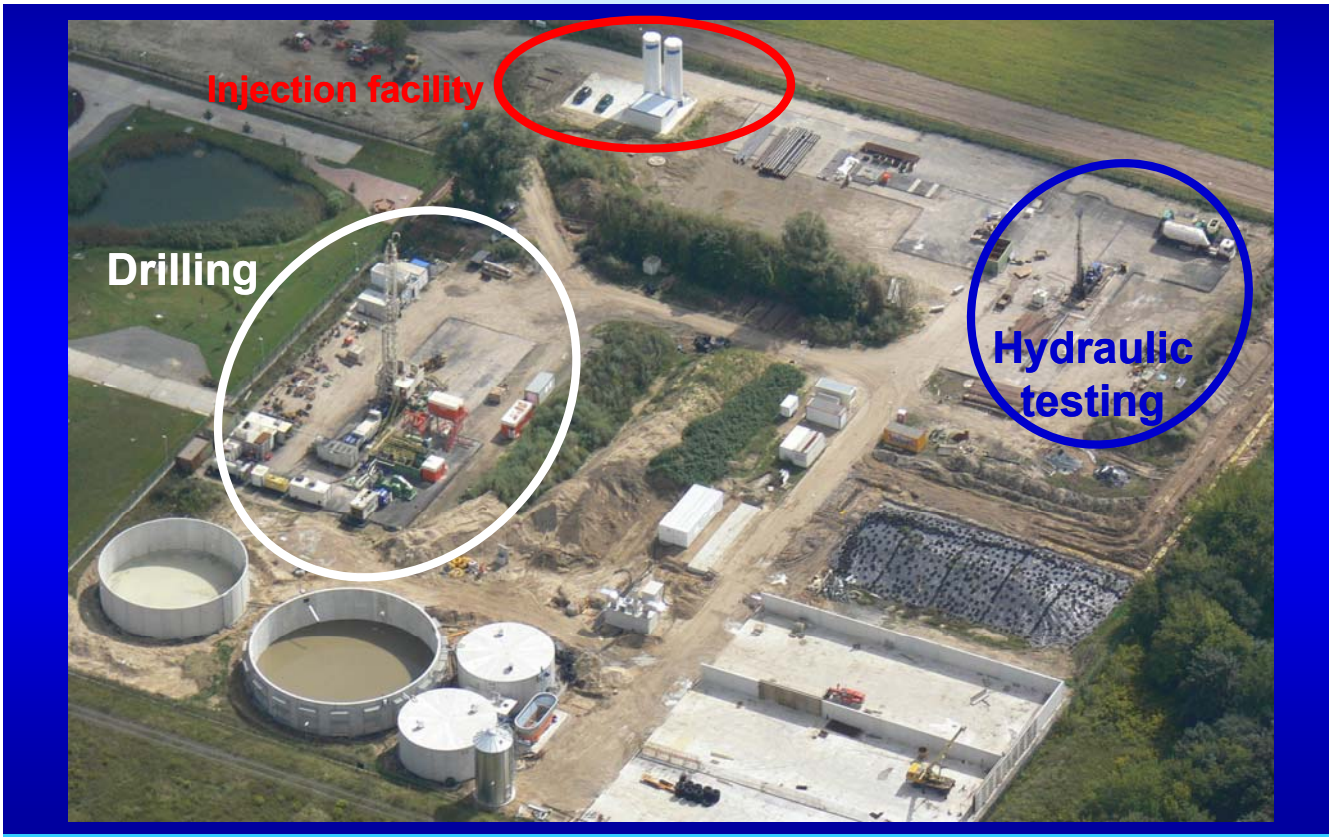

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Motivated Colleagues

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Core Logging Device

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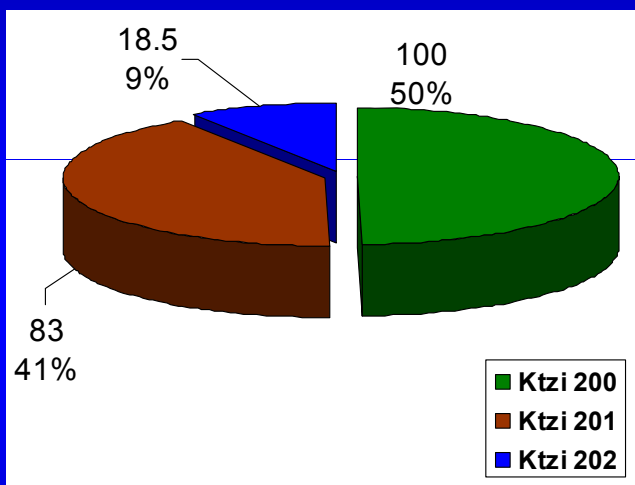
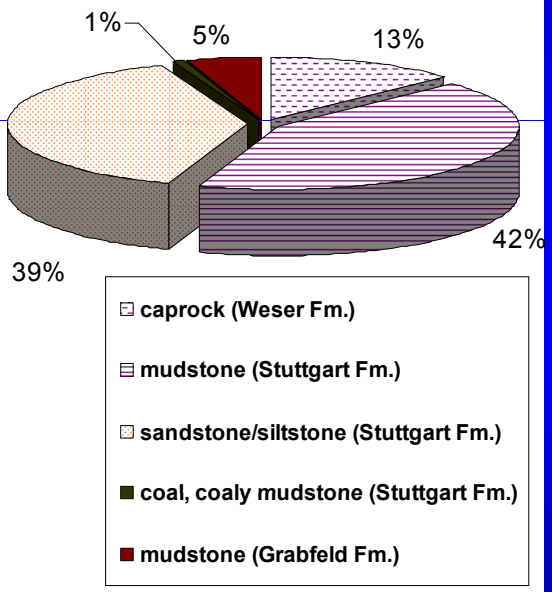
Frontiers in Geosciences 2007-2008, IPGP Paris, 19.03.2008

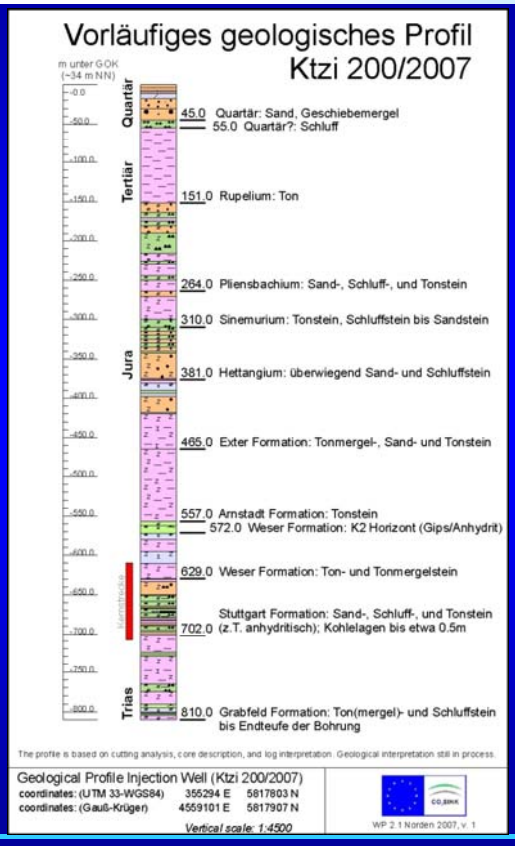
Core Control





total of 201.5 m of cores

Coring – Geological Profile



Norden et al. 2007

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Characterized Rock Types

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- Caprock (Weser and Arnstadt Fm.):
  - Playa-type mudstones (210 m thick)
  - Couplets of mudstone (0.05–1.5 m thick) and dolomite beds (0.01 and 0.5 m thick)
  - Couplets stacked in groups of two to seven
  - Basin wide uniformity
- Reservoir rock (Stuttgart Fm.):
  - Sandstones consist of varying amounts of quartz, feldspar, and rock fragments (graywacke)
  - Fine to medium-grained, well sorted, and weakly cemented by silicates / clay / anhydrite

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Monitoring

Smart Casing

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Smart Casing Concept

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- Sensors placed behind the well casing
- Fully cemented in the annular space between casing and rock formation
- Special protector systems help to avoid damaging the fiber optic cables and sensors

- This concept has a number of advantages:
  1. High data quality due to small distance between the sensors and the target (injected CO_2)
  2. Same coupling conditions in all repeat measurements (time-lapse measurements)
  3. High repetition rate

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Permanent Downhole Monitoring

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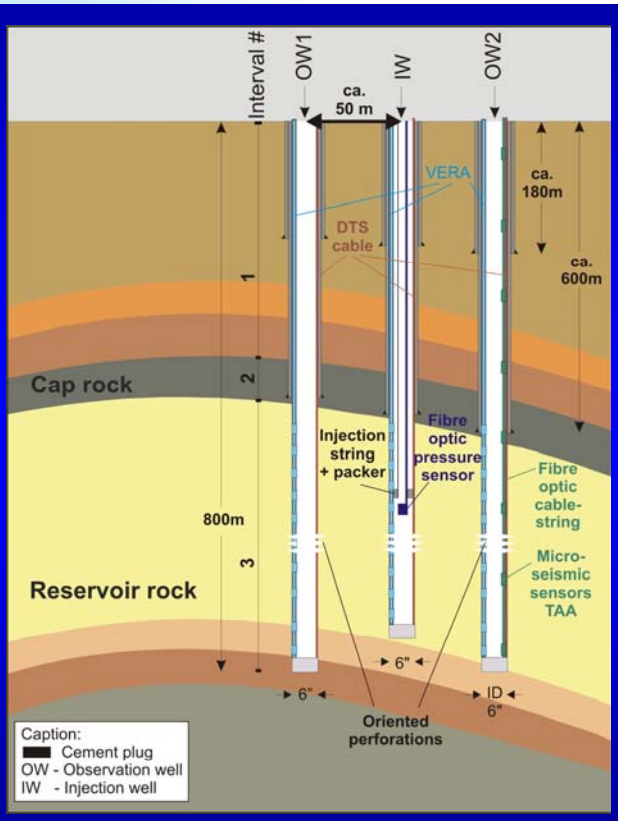
- Temperature
  - Distributed Temperature Sensing (DTS)
- Pressure (+ Temperature)
  - Fibre optic sensor
- Resistivity
  - Vertical Electrical Resistivity Array (VERA)
- Micro seismicity
  - Triple Axis Accelerometer (TAA)



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Smart Casing Installation

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Fibre Optic Pressure Sensor

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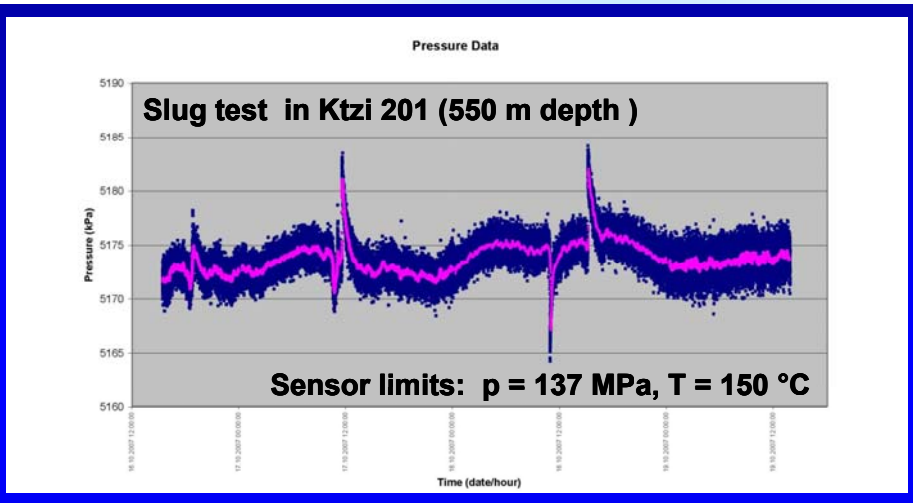
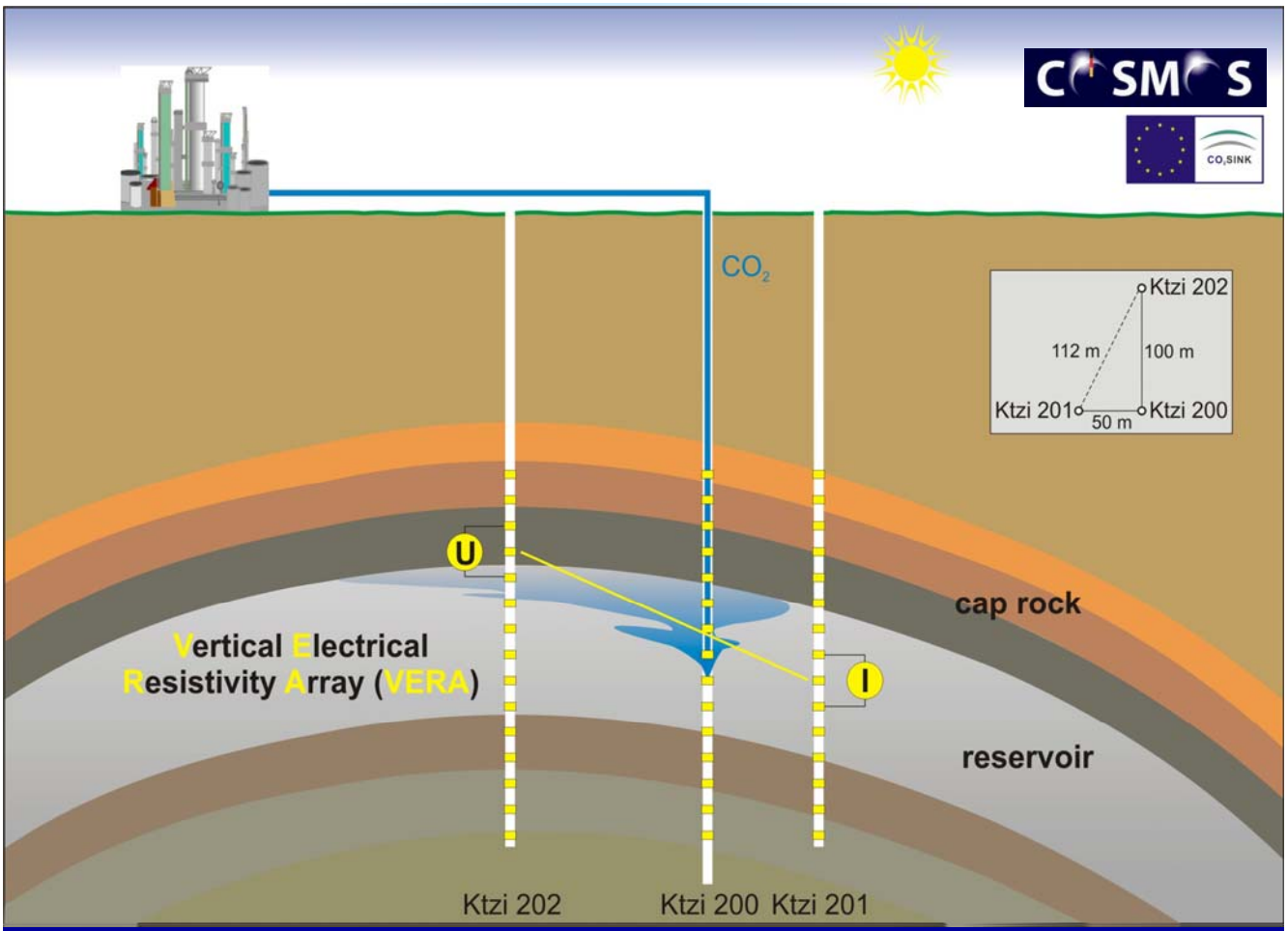


- Remote operation (distance > 10 km)
- No down hole electronics required
- High structural integration
- Reliability in hostile (HT/HP) environments
- Point wise or distributed monitoring

Schmidt-Hattenberger et al. 2007



Krüger et al. 2007

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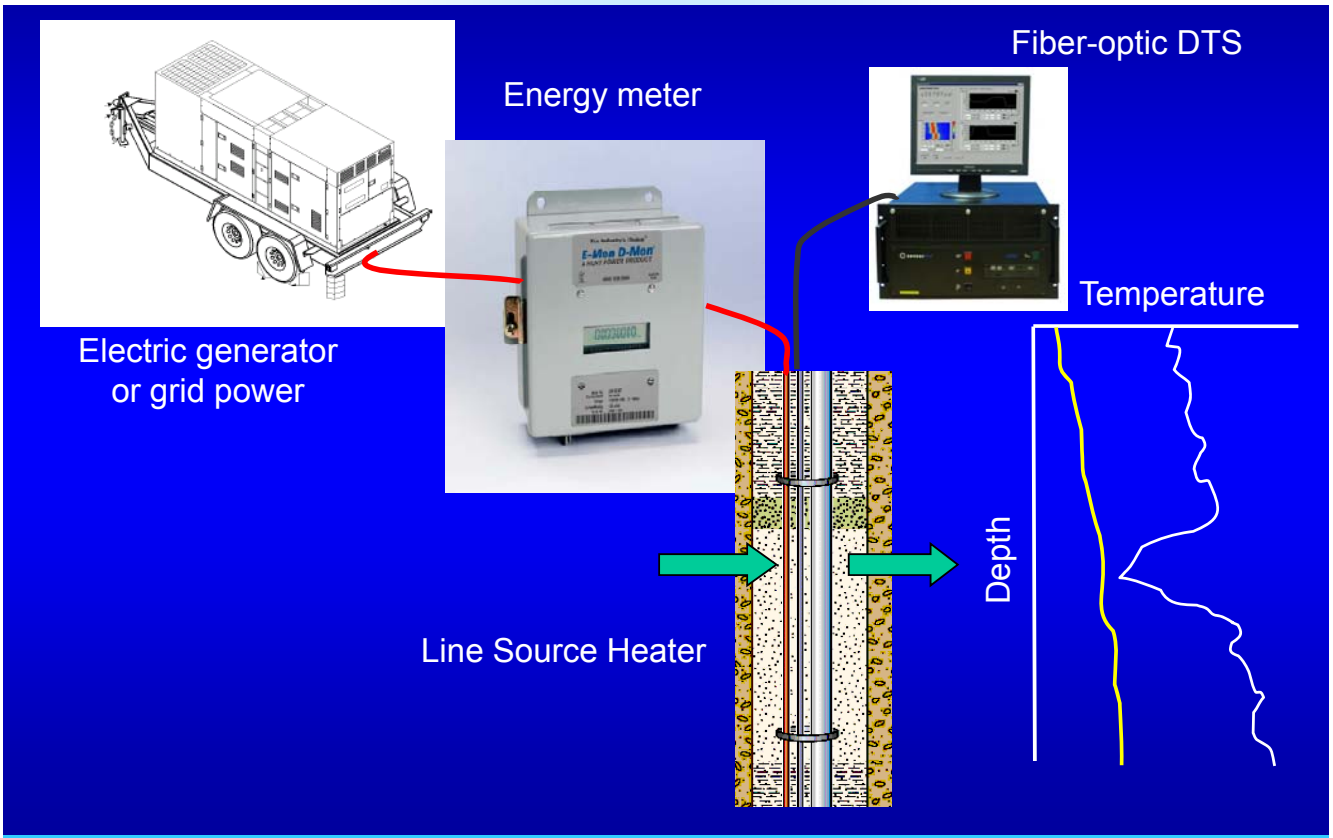
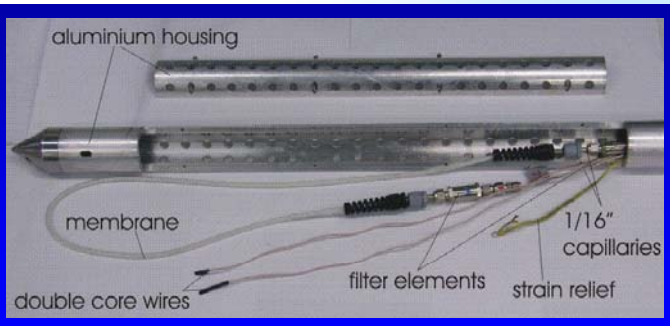
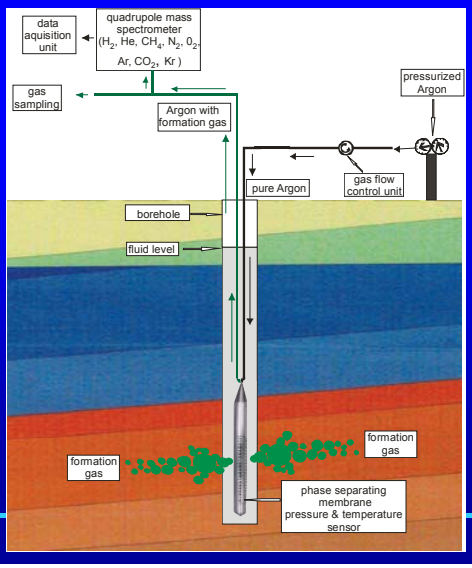
DTS and Heater Cables



Henninges et al. 2007

Gas Membrane Sensor





Non-Permanent Monitoring

- 3D seismics:
  - sources and receivers placed at surface
  - low resolution but reservoir coverage
  - sensitive to low CO_2 (up to 10 %)
  - low repetition rate due to costs (maximum once per year)
- Cross hole seismics and surface to borehole seismics:
  - sources and receivers placed in boreholes (x-hole)
  - source at surface, receivers moving in boreholes (VSP)
  - source at surface (moving), receivers in boreholes (MSP)
  - higher resolution than 3D seismics
  - may interfere with other measurements in well
  - cross-hole tomography and caprock integrity

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Geochemistry

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Baseline - Geochemistry

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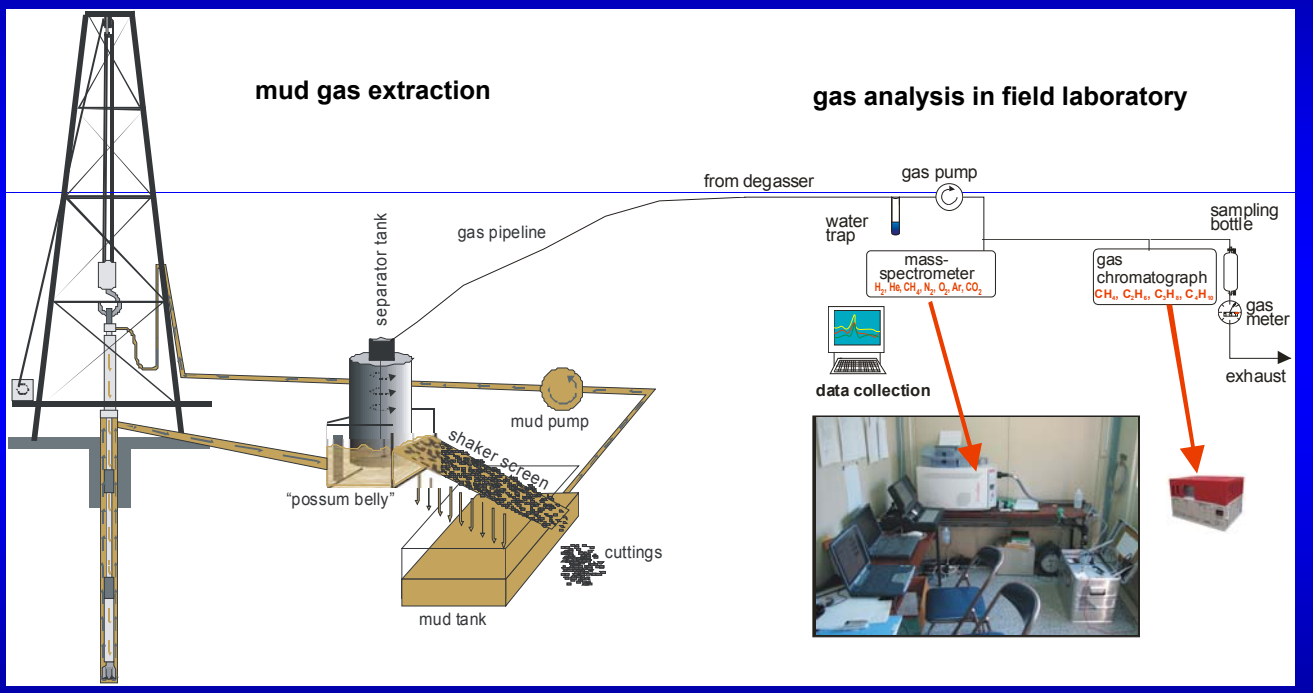
- meteorolgical station
- carbon dioxide surface soil flux determination
- mulitsensor in groundwater well
- methane determination (in 2 meter deep wells)
- graben structure
- isobaths of the Schilfsandstein
- rim of subsurface channels

Mud Gas Monitoring while Drilling



Zimmer et al. 2007

Mud Gas Monitoring while Drilling

- With this method complete depth profiles of relevant gases gained
- Gas rich zones and fluid bearing inflow horizons are indicated by higher gas concentrations in the mud gas

➢ Boreholes in Ketzin:

– No zone with higher gas concentration detected

– Drilled formations generally poor in gas

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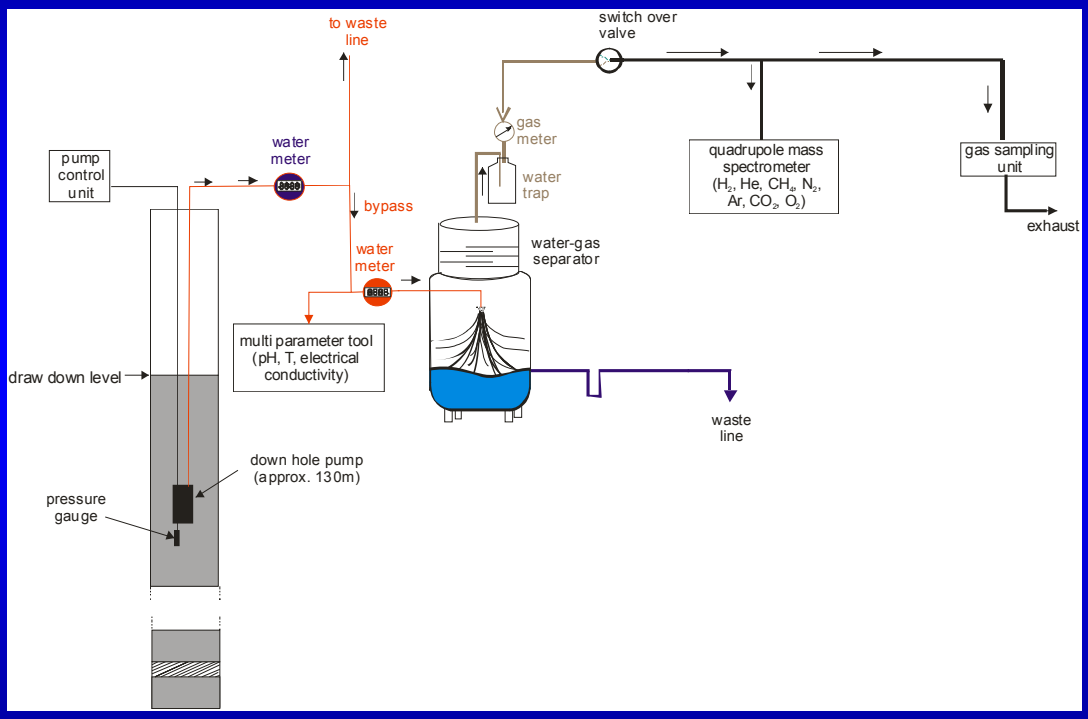
Gas Discharged from Cores

Fluid Monitoring Set Up



Zimmer et al. 2007

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Fluid Sampling Set-up at Ketzin

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Stimulation

N_2-Lift

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Removing Safety Valve

Particle Sampling

Specialist for on site analytic
(Dargel, RWE Dea)

→ Fluid looks already clean after 1 h lifting (5m^3)

Microfiltration (1.2 μm)

→ Stop of lifting after production of 50m^3 ???

Successful Measure

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

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Modelling

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Geological (Static) Model

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1. Pre-drilling reservoir model for general simulation of injection and distribution
   - Nearest well information 5 km away
   - Old core material crumbled, little petrophysics
   - Fluvial sequence, general channel direction assumed to be known
2. Updated and refined model after information from 3 new wells has been included

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Heterogeneity

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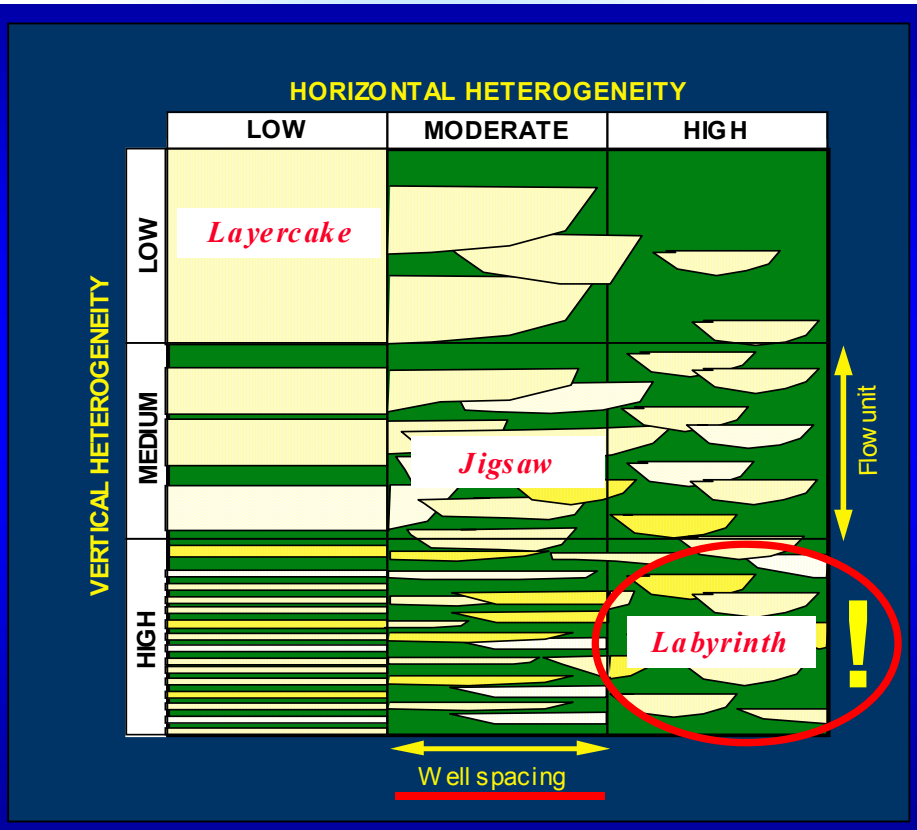
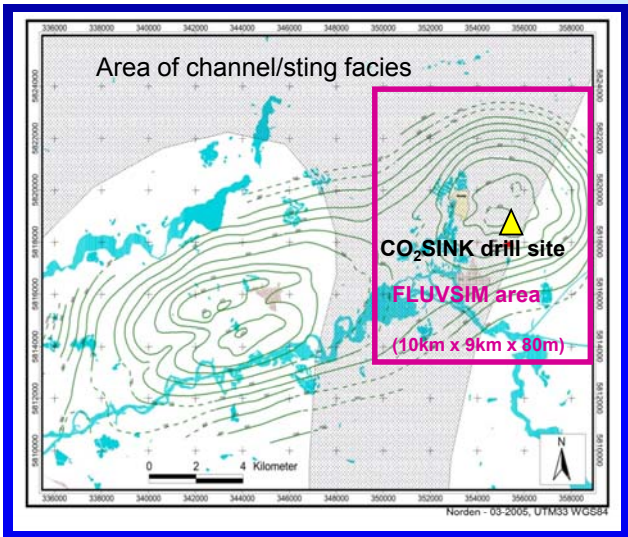
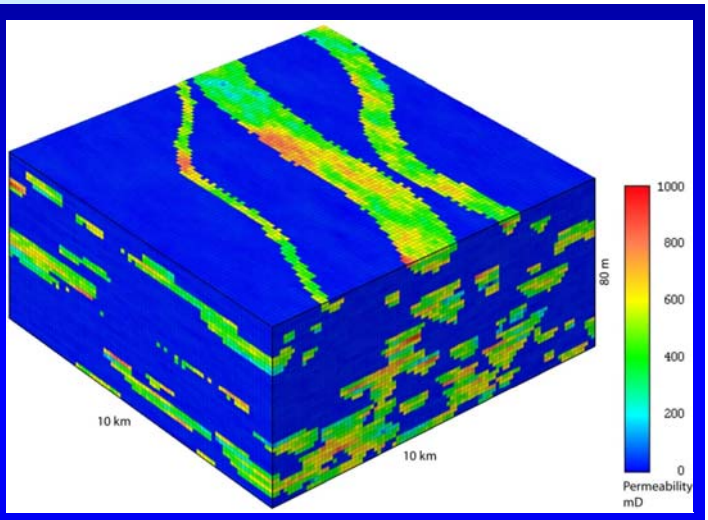


Probabilistic Reservoir Simulation

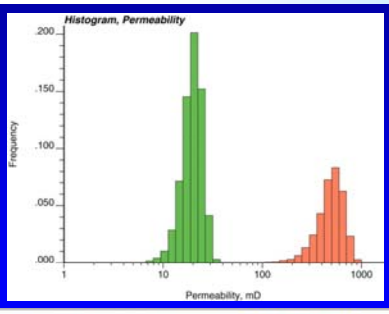


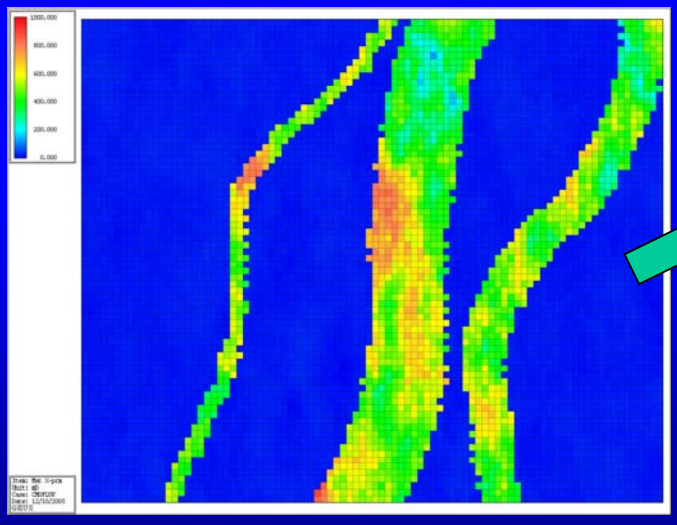


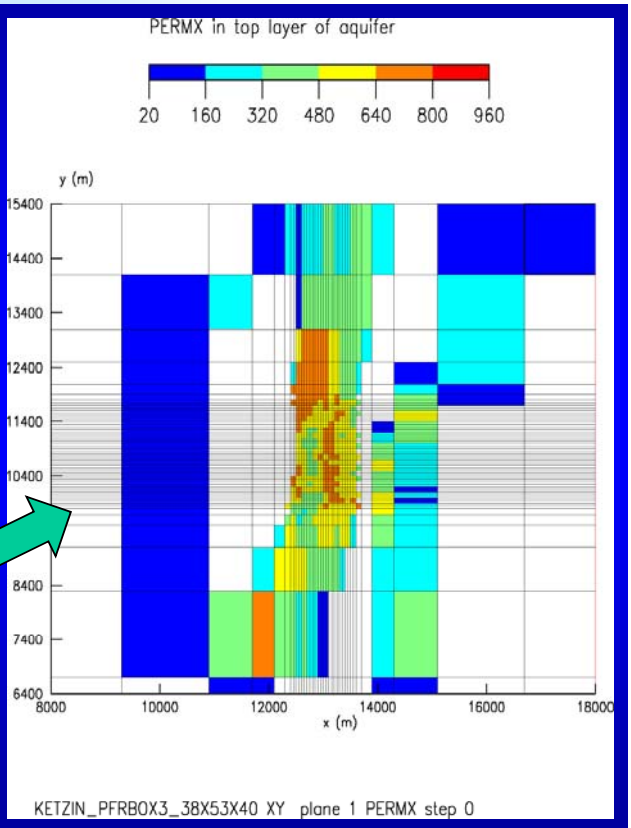
- Bore hole data with channel and non-channel facies
- Vertical proportion curve, account for vertical trends
- Channel parameters (orientation, number, thickness, width)
- Areal variations given as areal proportion map

Frykman et al. 2007

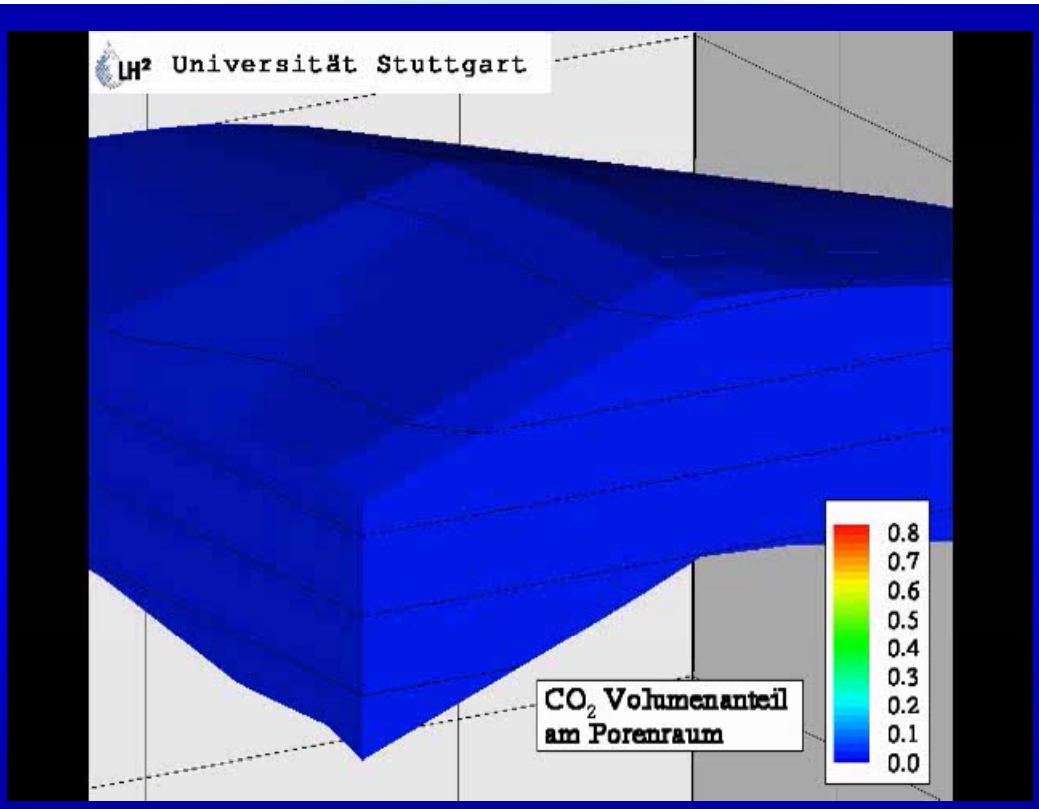
Permeability to Numerical Model





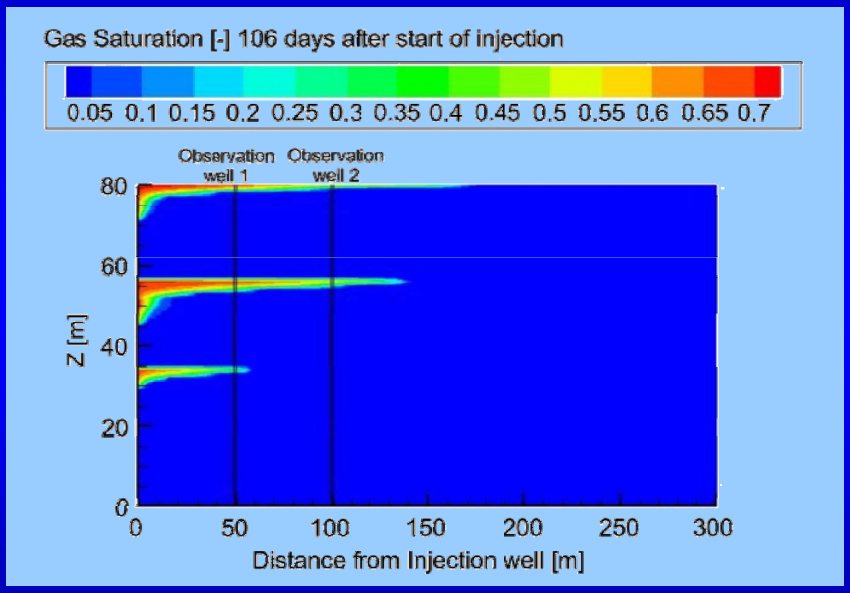


Flow of CO_2 in the Reservoir



Modelling of CO_2 Injection

One example of a scenario of gas



Assumptions: 3 channels ~ 500 m Darcy, Mud flow facies ~ 0,1 m Darcy

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CO_2 migration / temperature effects

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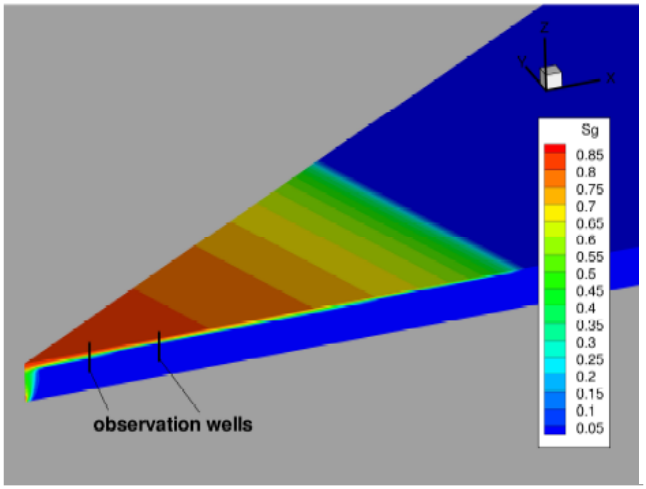
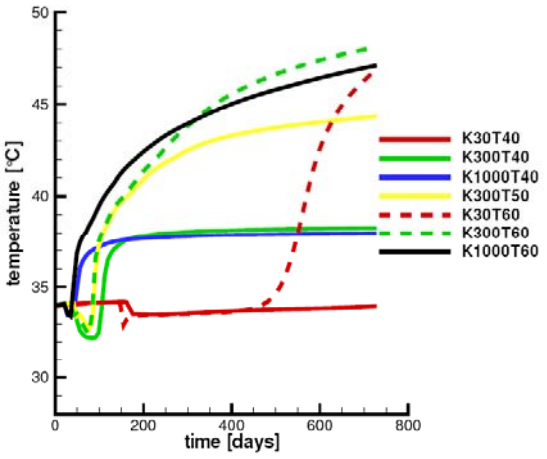
Results of simplified numerical model:





Bielinski et al. 2008

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Media Coverage

CO2SINK

Bohren für den Speicher

Der Techniker Andree Kleitz richtet über dem Bohrloch für den unterirdischen CO_2-Testspeicher des Geoforschungszentrums Potsdam (GFZ) in Ketzin bei Nauen (Havelland) den Bohrkopf ein. Im Rahmen eines europäischen Projekts sollen hier in den nächsten zwei Jahren 60 000 Tonnen Kohlendioxid in über 700 Metern Tiefe gespeichert werden. Mit dieser Pilotanlage entsteht ein „Großlabor", in dem das Verhalten von CO_2 im Untergrund unter realistischen Bedingungen untersucht werden kann.

Foto: ZB/Bachmann

> 1000 articles and around 40 TV-stories

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Conclusions

- Project start: 1st April 2004
- Permissions (> 20) applied for and collected
- Successful completion of 3 wells (1 IW, 2 OW)
- Delay around 1 year (only)
- Injector stimulated
- Baseline measurements completed
- …

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Outlook

CO_2 Injection in Spring 2008

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Wissenschaftspark (scientific park) Albert-Einstein - Telegrafenberg

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Thank you for your attention

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