



Ketzin, Germany

Closing the life cycle

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Ketzin project – research on onshore storage

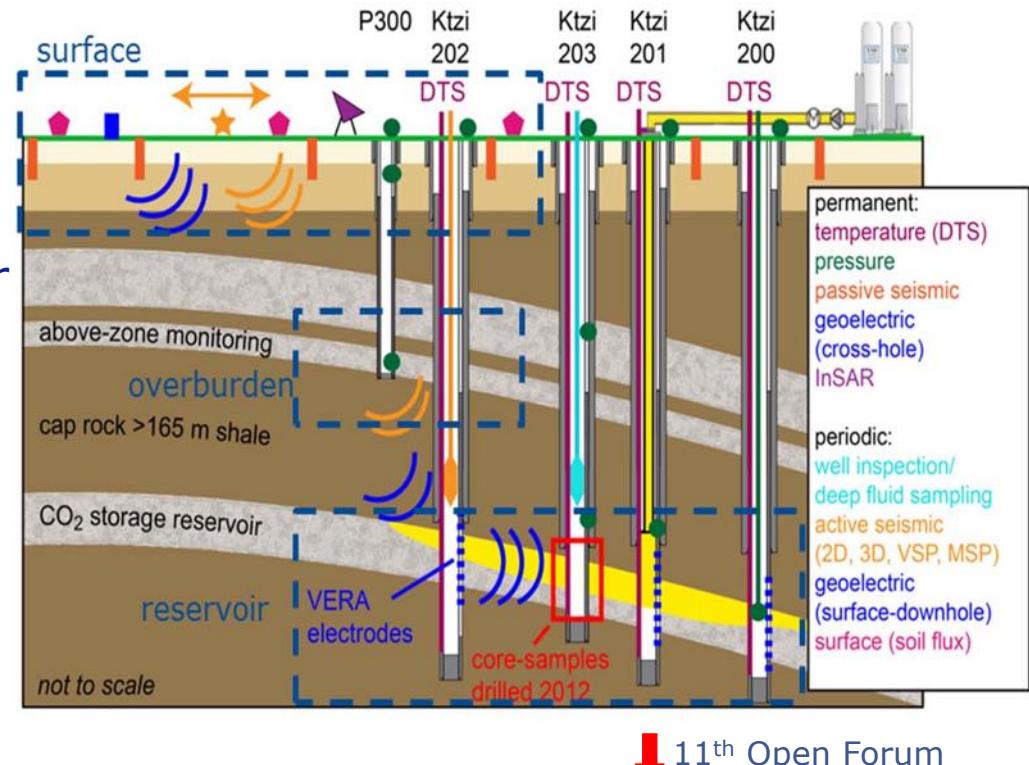
- ➔ as R&D site limited to maximum amount of 100 kt CO₂
- ➔ permitted under German Mining Law

Main objectives:

- ➔ **Study complete life-cycle**
- ➔ Show feasibility of on-shore CO₂ storage in saline aquifer
- ➔ Increase confidence in CO₂ storage

Main tasks:

- ➔ Successful site operation
- ➔ Monitoring & modelling
- ➔ Public outreach



11th Open Forum



April 2004
Start project

July 2007
Operation permit Start injection

June 2008

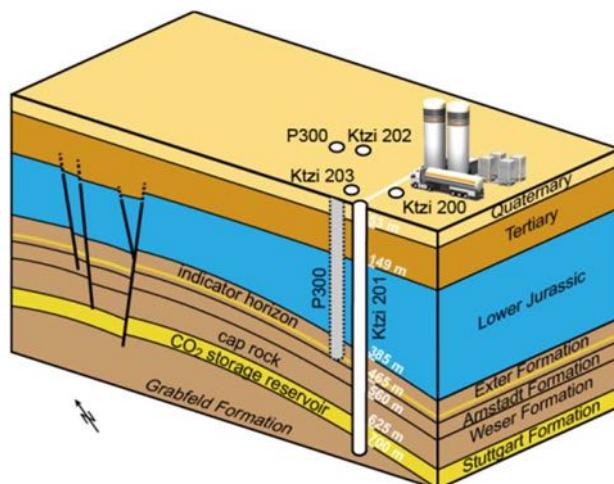
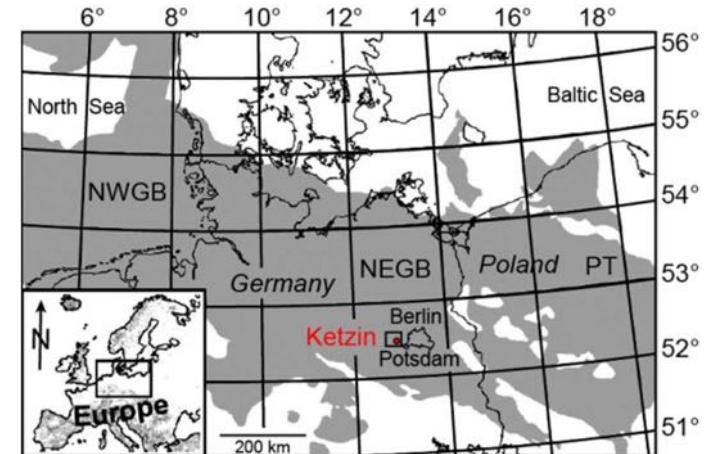
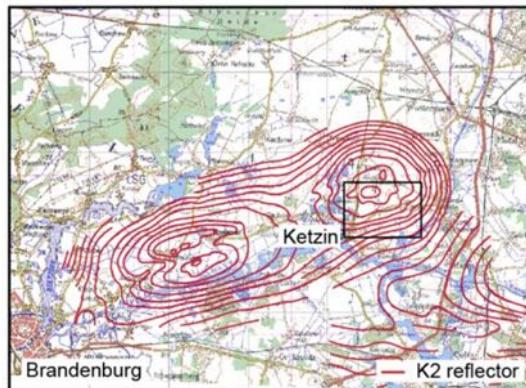
August 2013
End injection

December 2017
Transfer liability



Local geology of the Ketzin pilot site

- ➔ located in the North East German Basin
 - large Permo-Mesozoic sedimentary basin
- ➔ Ketzin-Roskow double anticline above salt pillow



cap-rock:

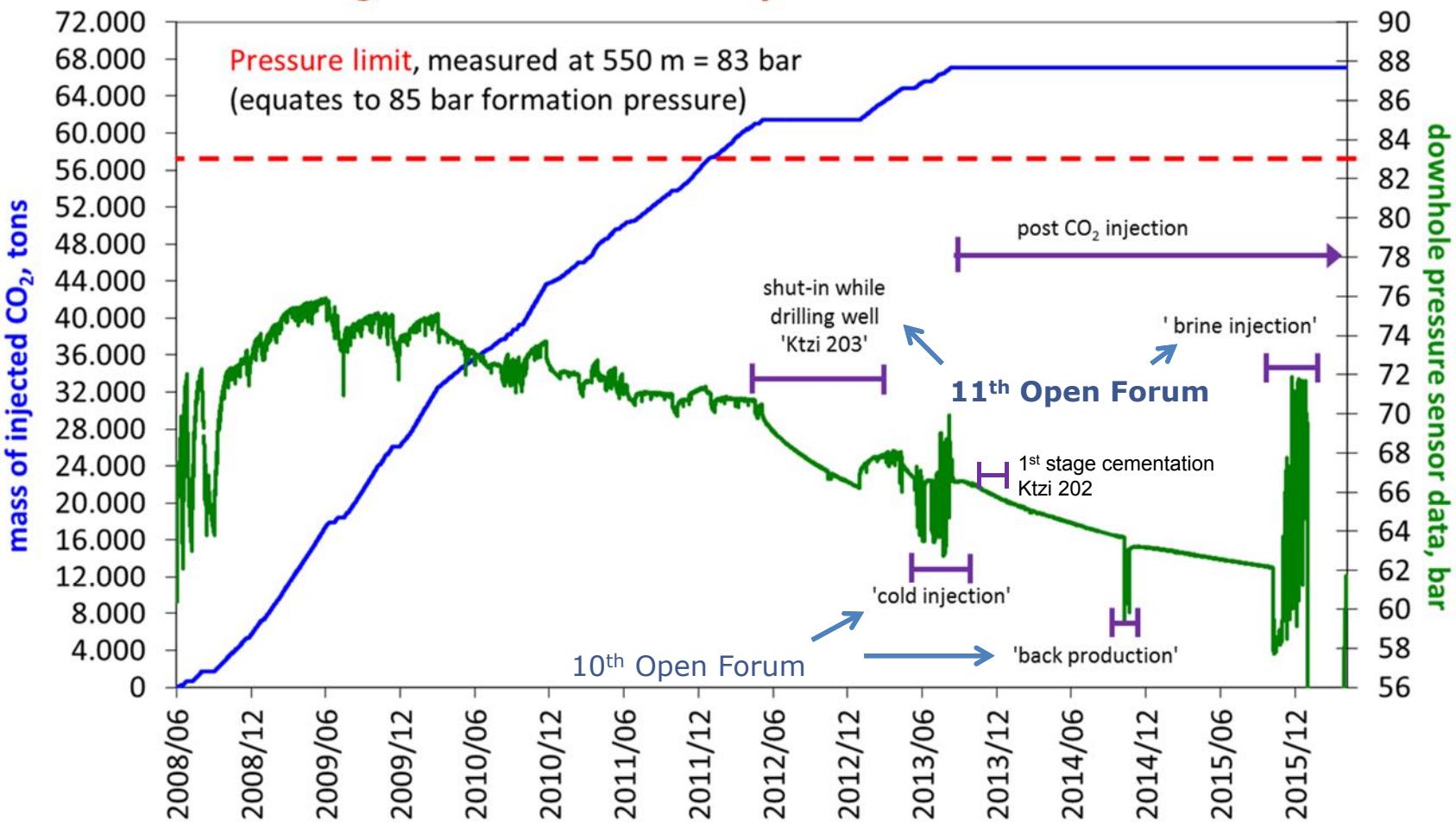
- ➔ Upper Triassic shales, >165 m

reservoir:

- ➔ saline aquifer
- ➔ sandstones of Upper Triassic Stuttgart Formation
- ➔ fluvial system
- ➔ lateral and vertical heterogeneous
- ➔ 620 – 650 m depth



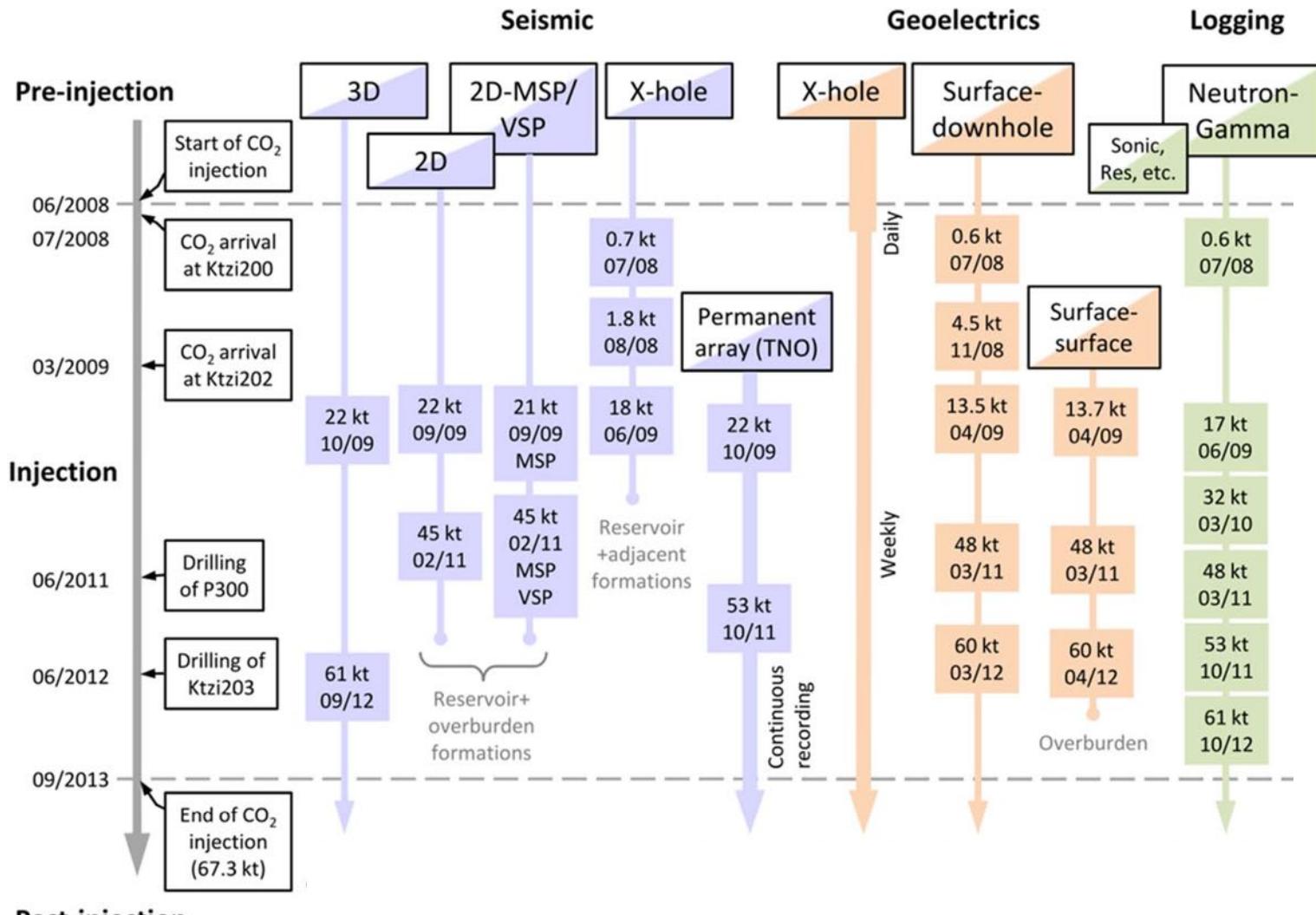
Injection history at Ketzin



- ➔ smooth injection process, maximum P-increase \sim 16 bar
- ➔ no safety issues, $P \ll$ pressure limit
- ➔ continuous P-decline after stop of injection



Ketzin life-cycle monitoring concept



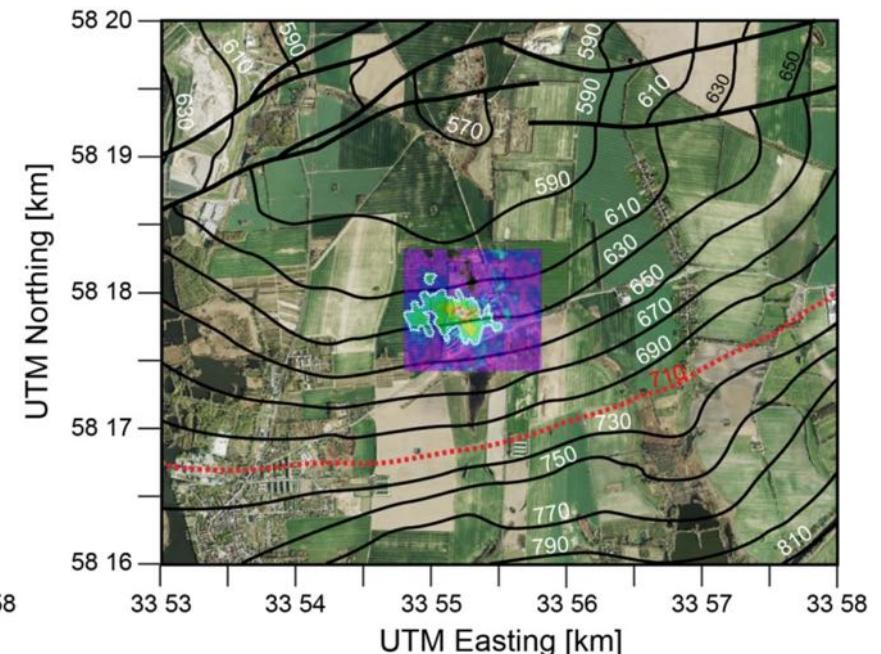
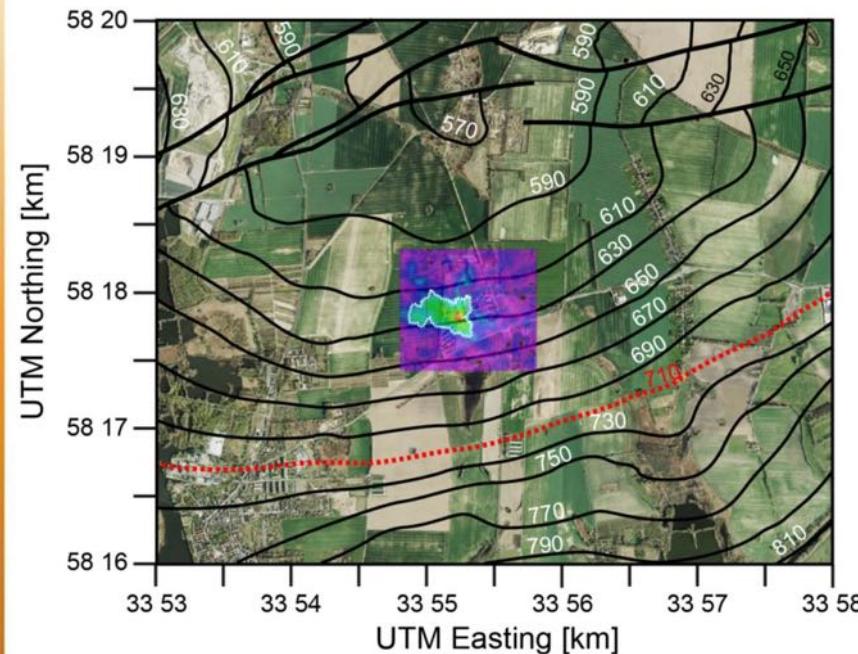
- ➔ monitoring techniques applied from pre- to post-injection
- ➔ during post-injection well-based techniques fade

CO₂ plume evolution, stabilization and shrinkage

normalized 3D-seismic time-lapse amplitude changes:

Baseline – 2009; 22 kt CO₂
~ 0.08 km²

Baseline – 2012; 61 kt CO₂
~ 0.15 km²

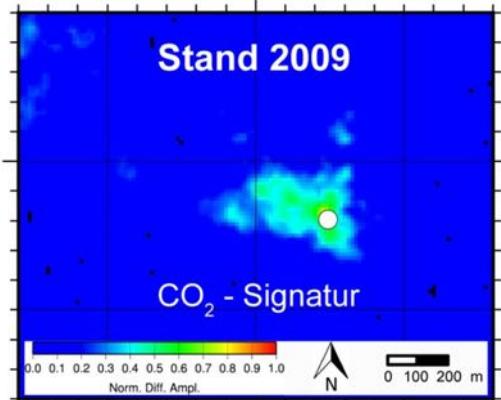


- ➔ CO₂ plume indicate preferred WNW – ESE extension
- ➔ centered @ injection site, far from spill-point and central fault zone

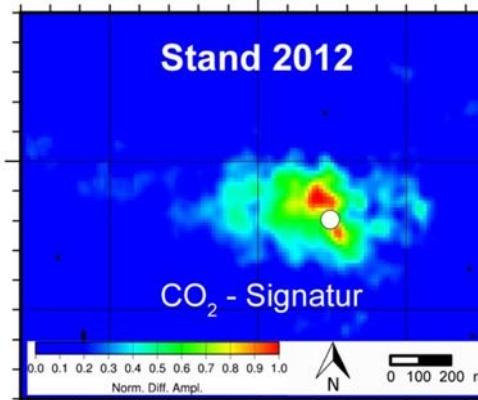


CO₂ plume evolution, stabilization and shrinkage

Baseline – 2009; 22 kt CO₂
~ **0.08 km²**



Baseline – 2012; 61 kt CO₂
~ **0.15 km²**



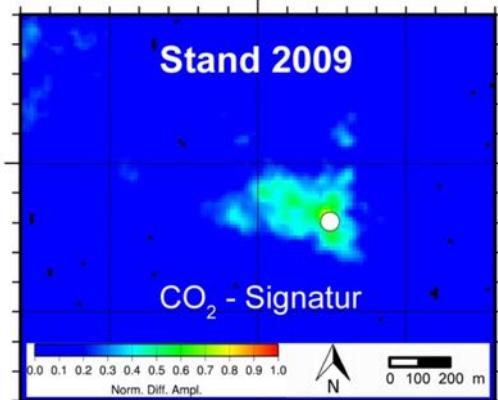
active injection

- lateral and vertical plume growth
- greatest thickness at injection point
- no significant plume migration

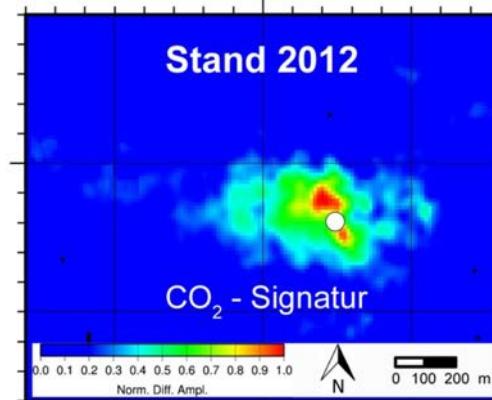


CO₂ plume evolution, stabilization and shrinkage

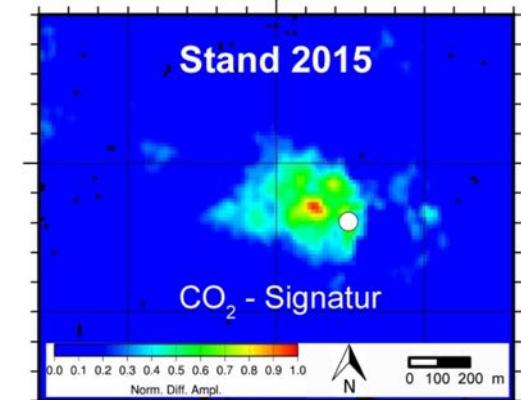
Baseline – 2009; 22 kt CO₂
~ **0.08 km²**



Baseline – 2012; 61 kt CO₂
~ **0.15 km²**



Baseline – 2015; 67 kt CO₂
< 0.15 km²



active injection

- lateral and vertical plume growth
- greatest thickness at injection point
- no significant plume migration

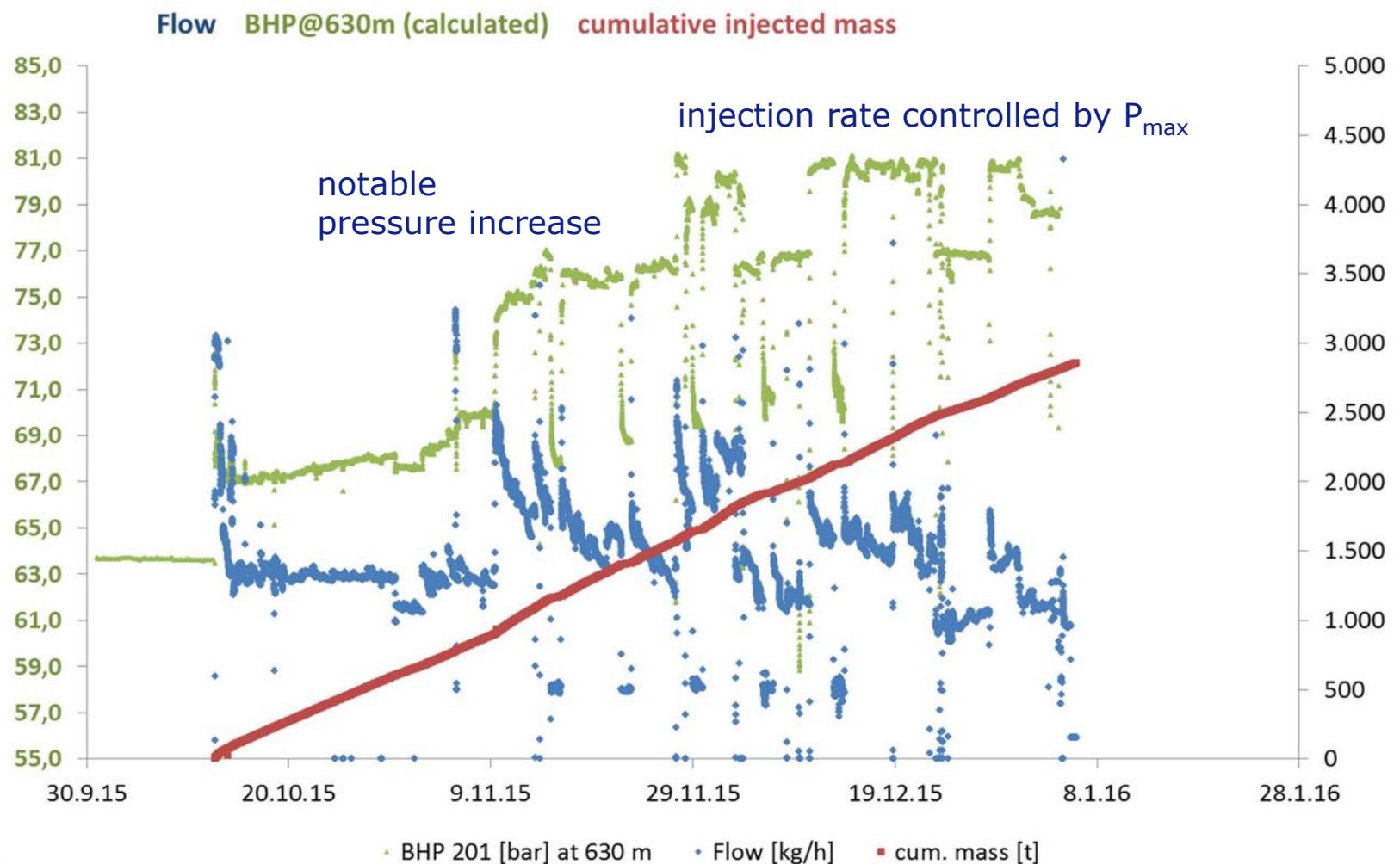
post injection

- shrinkage
- „stagnant“ plume“

- ➔ implied post-injection shrinkage of plume may be due to CO₂ dissolution in formation brine *OR* thinning of plume (seismic threshold)
- ➔ quantification of 3D repeat from 2015 to solve this issue under way



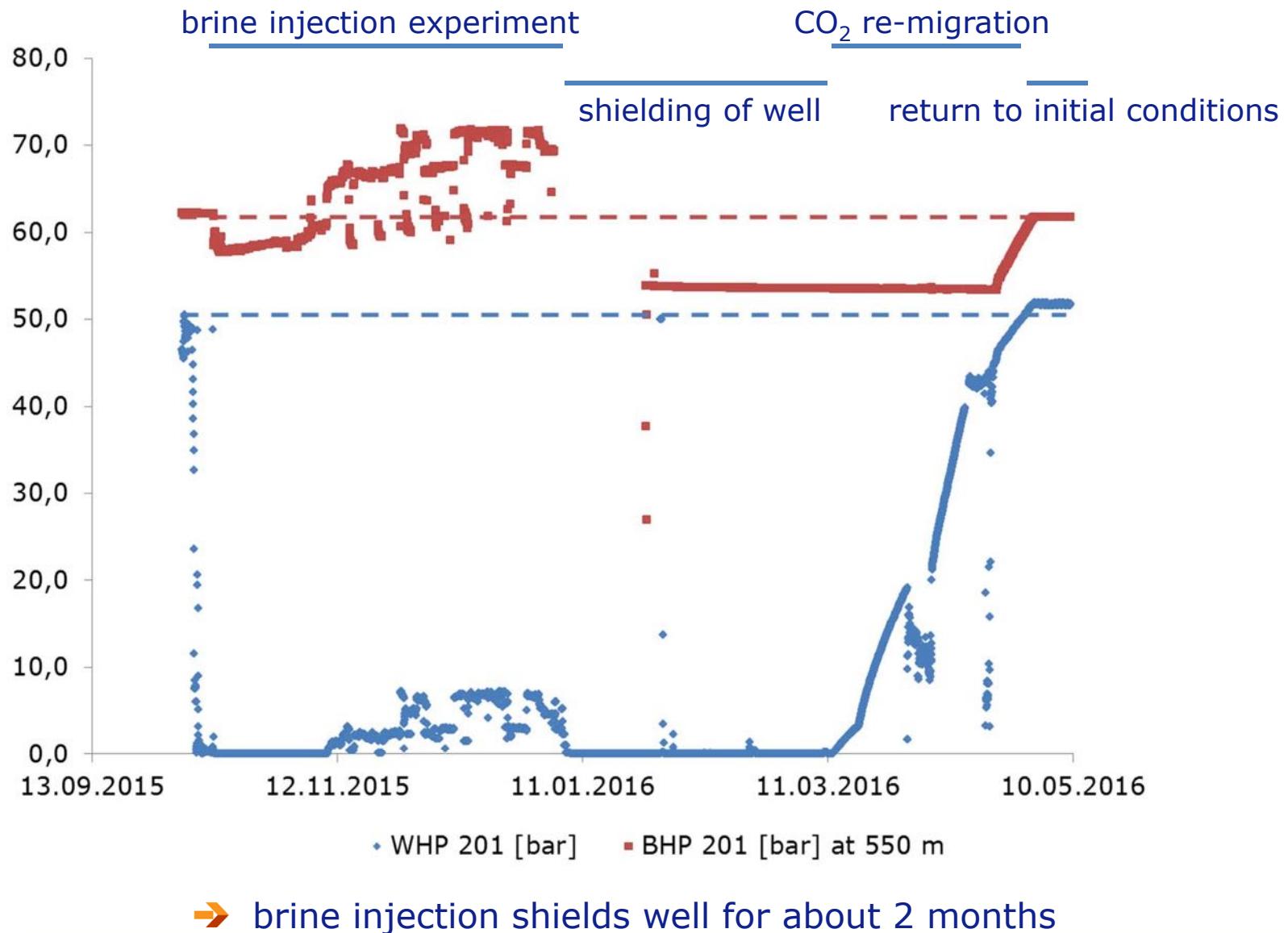
Brine injection as remediation measure



➔ ~ 3000 t of brine injected to test technique for shielding a "leaking" well (MiReCOL Project)

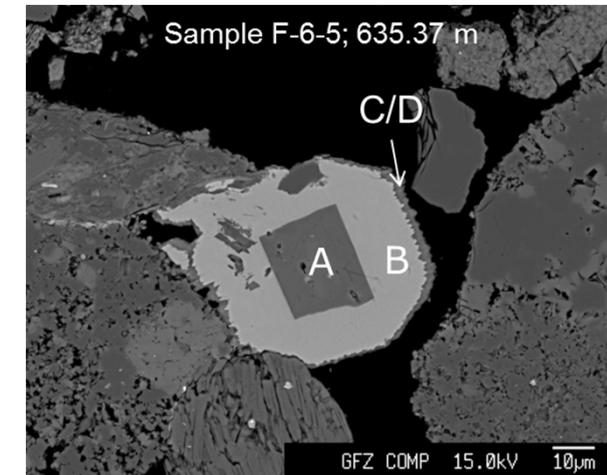
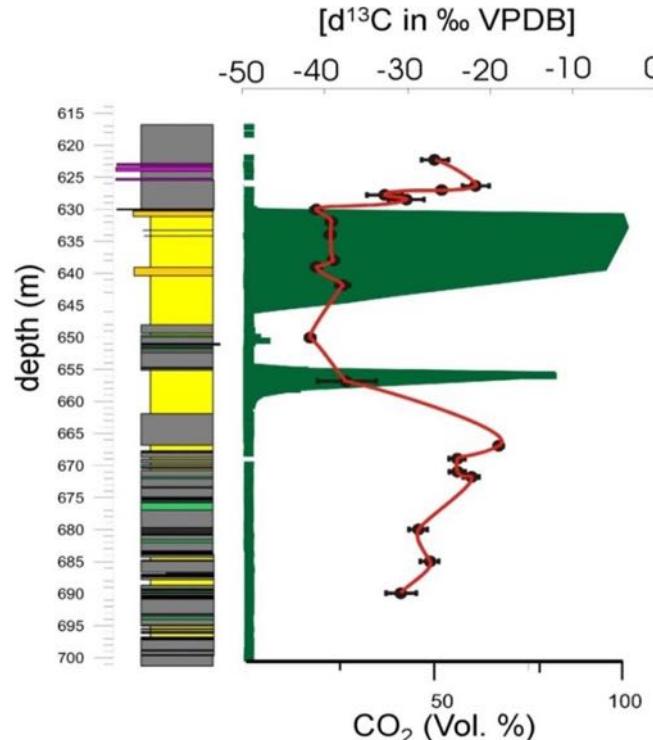


Brine injection as remediation measure



Coring the reservoir – towards final field experiment

Ktzi 203 – drilled in 2012 through the reservoir to study effects of four years of CO₂ injection on petrophysics, mineralogy, geochemistry,



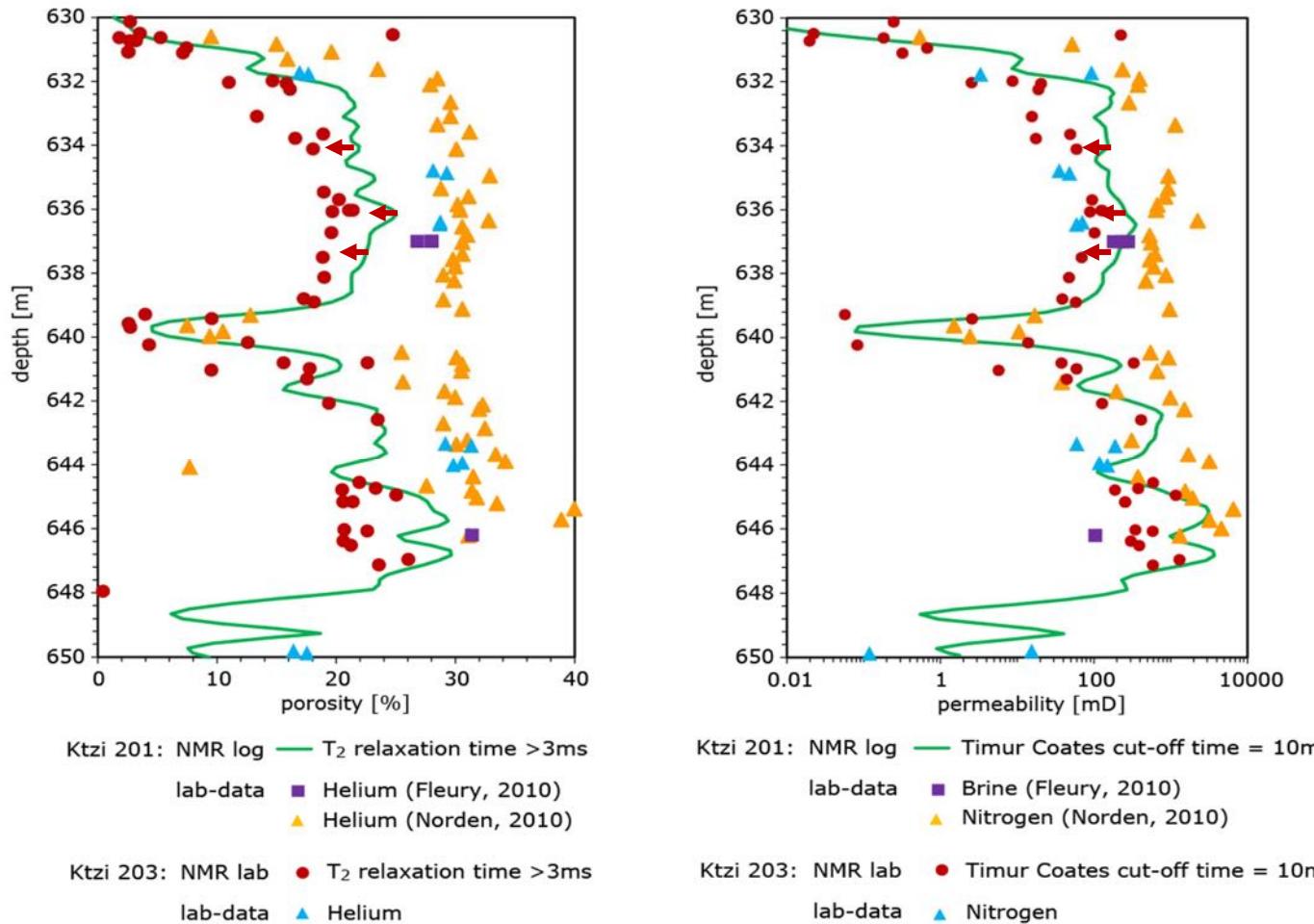
- ➔ carbonate crystallization
- ➔ hematite to goethite transformation

- ➔ 91 m core samples provide unique data base
- ➔ sharp rise in CO₂-concentration in the reservoir (green area)
- ➔ significant shift of $\delta^{13}\text{C}$ values in the reservoir (red line)



Coring the reservoir – towards final field experiment

pre-/post-injection comparison indicative of changes in porosity and permeability?



Increasing momentum for CO₂ storage by pilot site research?

- ➔ Prove safe and secure CO₂ storage operation in on-shore environments? Yes 😊
- ➔ Build local confidence in/awareness of CO₂ storage? Yes 😊
- ➔ Trigger national implementation of CCS on commercial scale? No 😞

Any need for future pilot sites?

- ➔ General feasibility of CO₂ storage proven - urgent need for integrated demo projects
- ➔ Perform specific field tests - only possible at pilot sites
- ➔ Monitoring tool development - pilot sites not essential but an advantage
- ➔ Build confidence in CO₂ storage - pilot sites form a first, essential step

Pilot sites may not increase momentum for CO₂ storage but are essential for implementation – additional, targeted pilot sites are needed

