DAVID MISCH
Lehrstuhl für Energy Geosciences

Montanuniversität Leoben

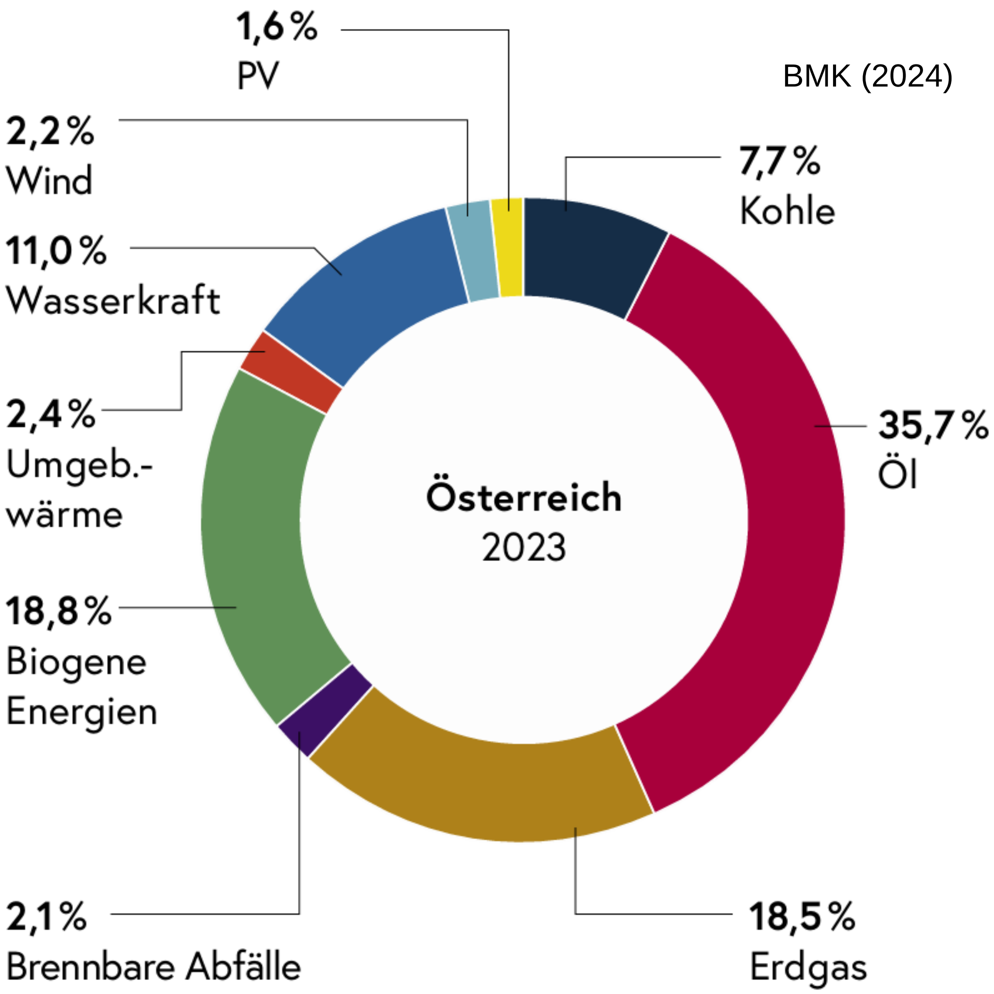
Geologische CO_2-Sequestrierung

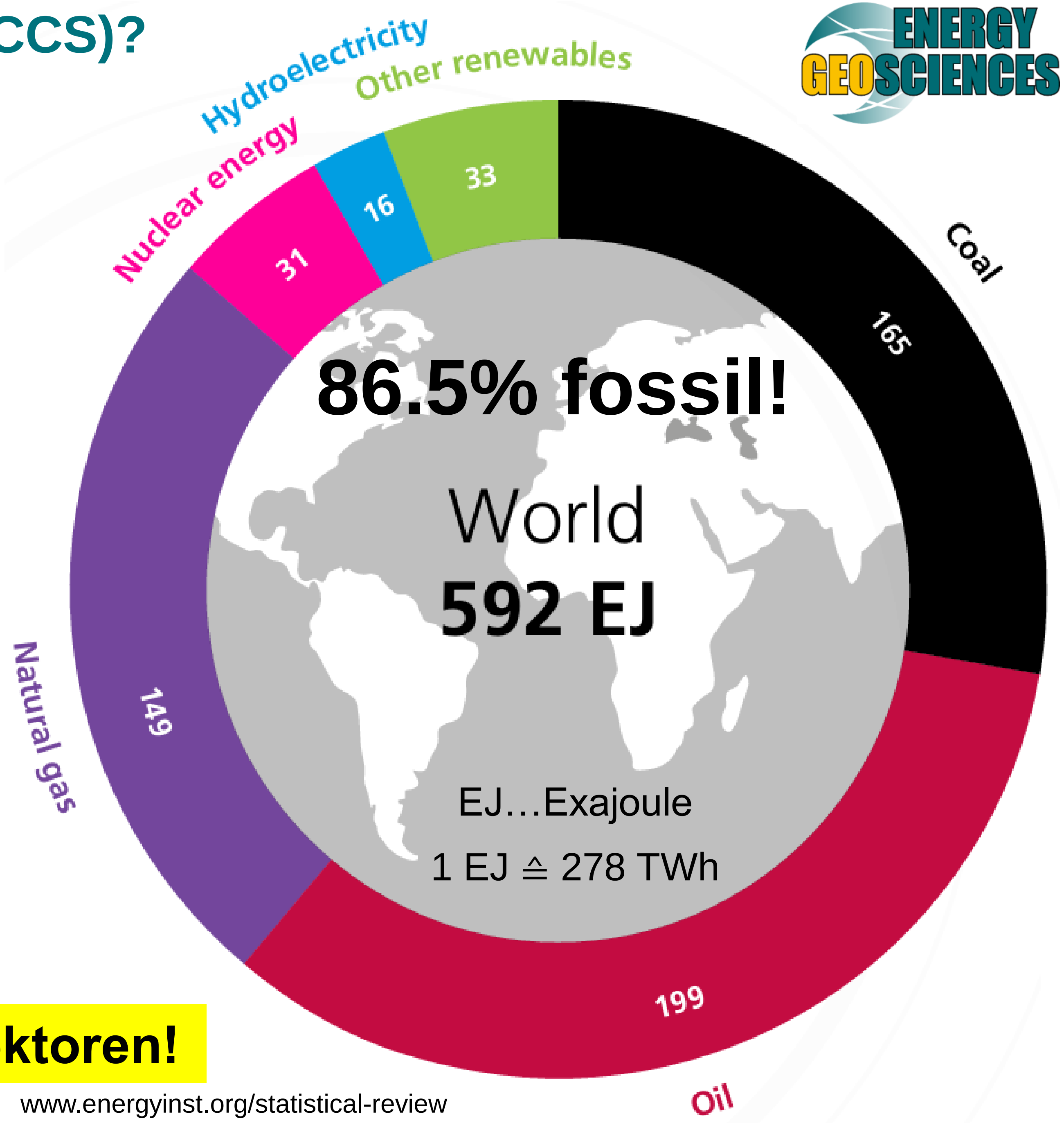
Aktuelle Forschung an der MUL

Versetz' Berge

Warum Carbon Capture and Storage (CCS)?

BMK (2024)





+ CO_2 aus „Hard-to-abate“ Sektoren!

www.energyinst.org/statistical-review

CCS: Status Quo & Ziele

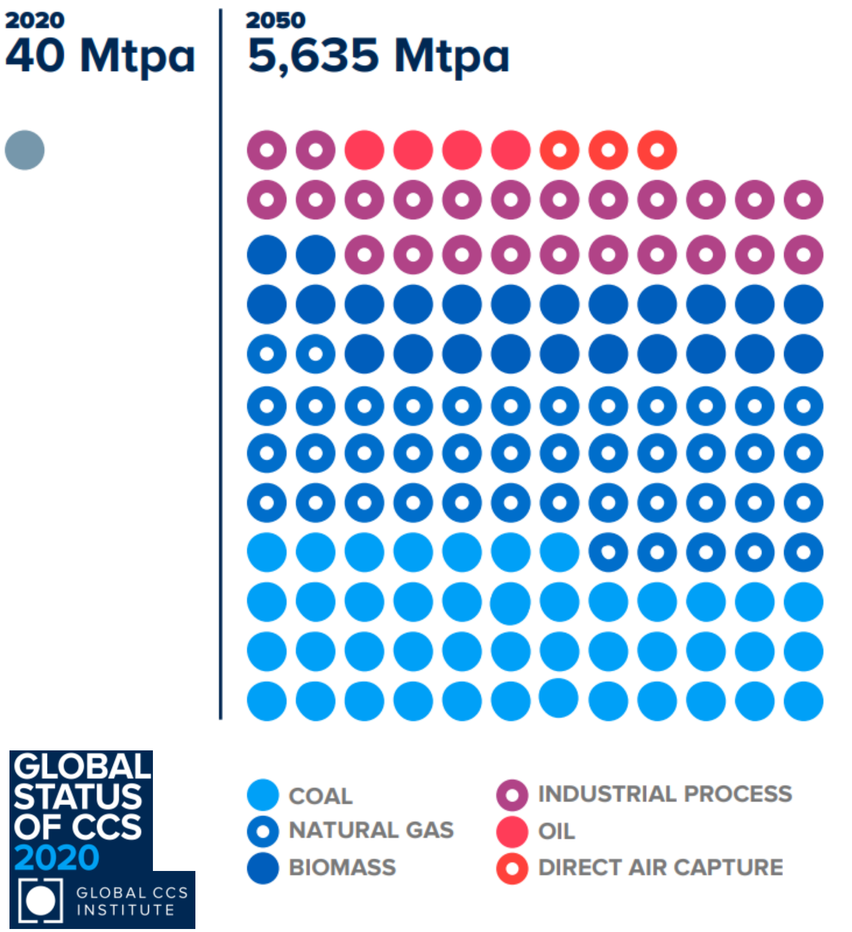
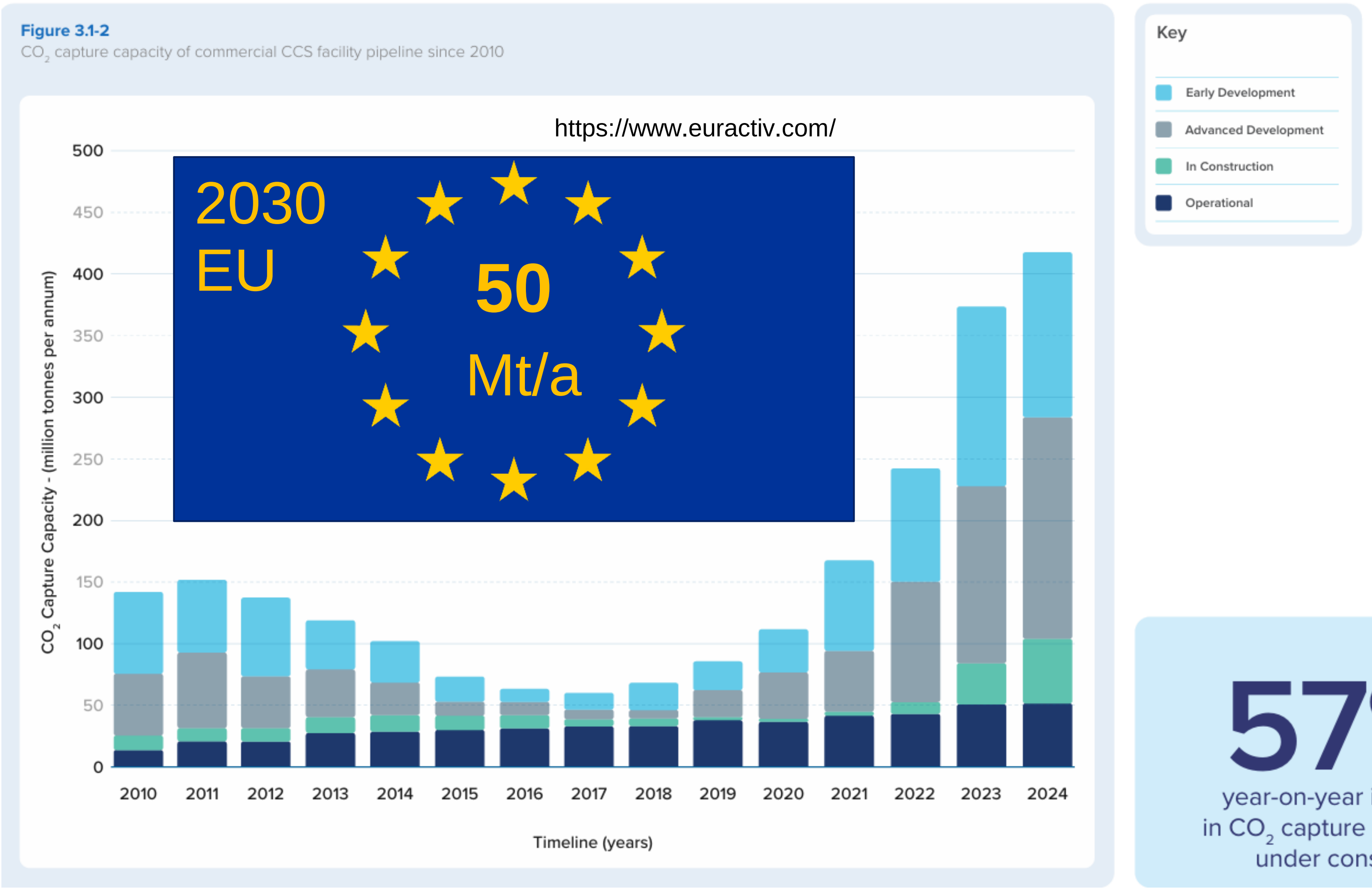


FIGURE 2 CO_2 CAPTURE CAPACITY IN 2020 AND 2050 BY FUEL AND SECTOR IN THE IEA SUSTAINABLE DEVELOPMENT SCENARIO[b]

Includes CO_2 captured for use (369 Mtpa) and storage (5,266 Mtpa) in 2050

GLOBAL STATUS OF CCS REPORT 2024



57%
year-on-year increase
in CO_2 capture capacity
under construction

CCS: Optionen

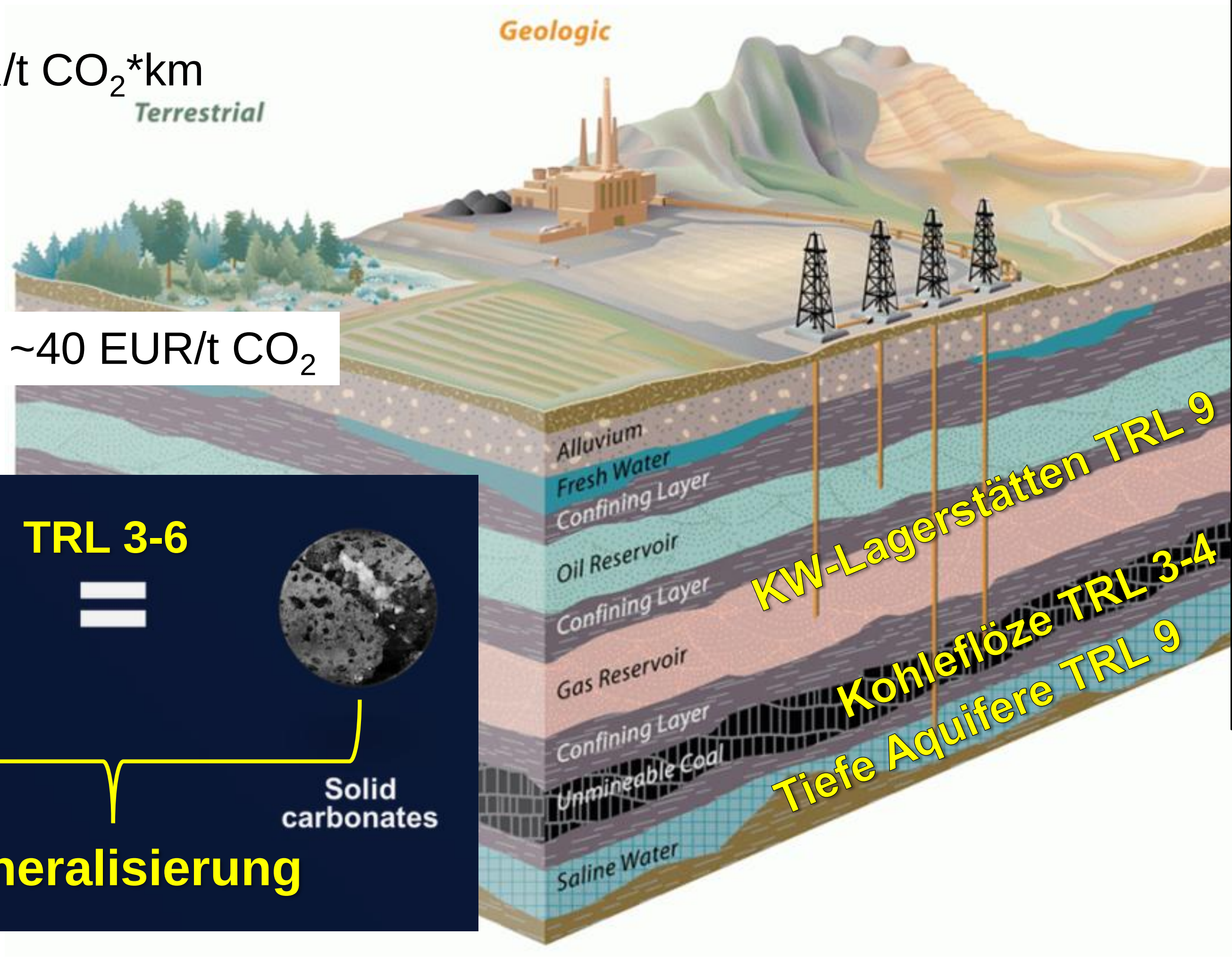
(Minimum-)Kosten pro Tonne CO_2 (2026)

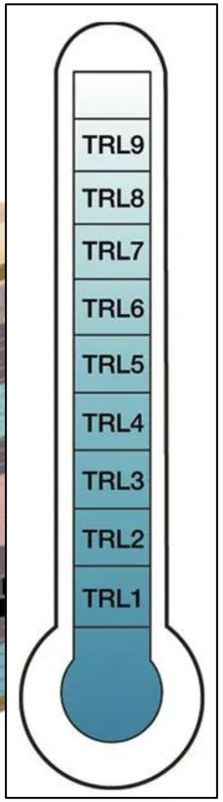
Capture ~90 EUR/t CO_2

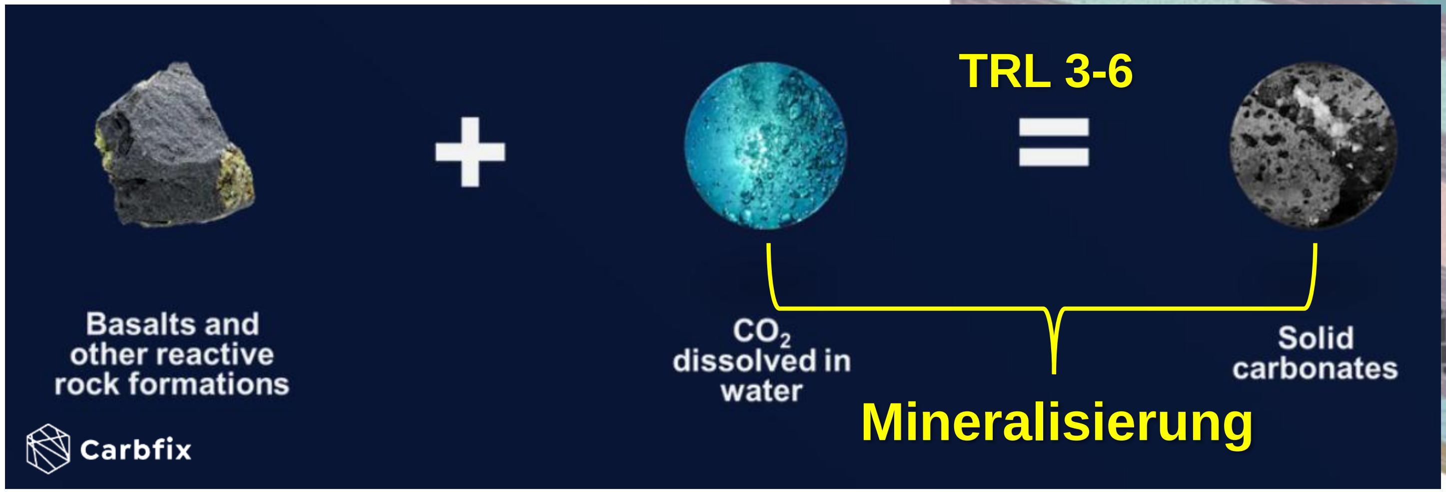
Transport ~0.1 EUR/t CO_2*km

Storage ~40 EUR/t CO_2

+20-30% Emissionen!







CCS: Forschung an der MUL

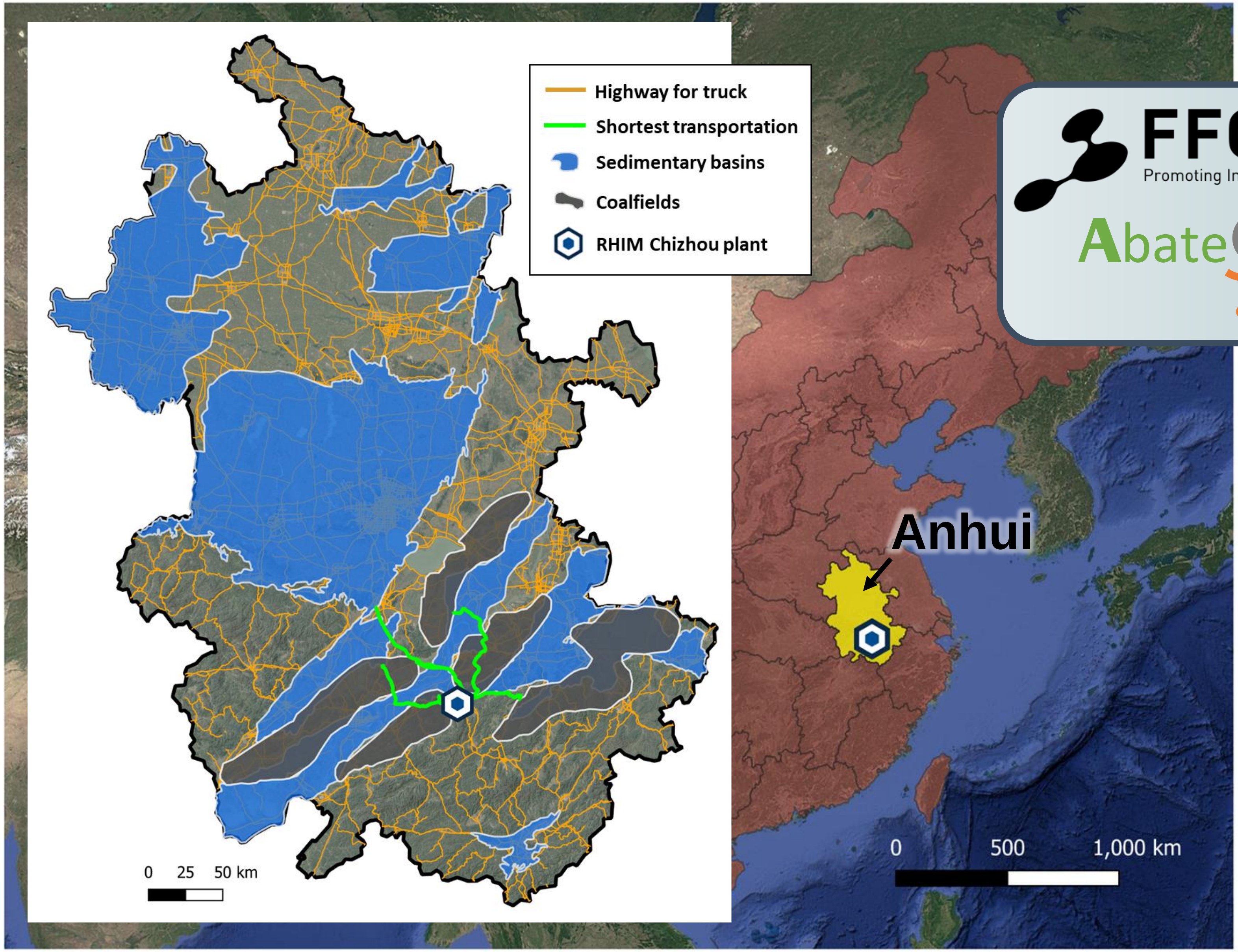
Speichersicherheit

ENERGY GEOSCIENCES

Potentialstudien

Neue Speicherformen

CCS Potentialstudien



FFG
Promoting Innovation.
AbateC

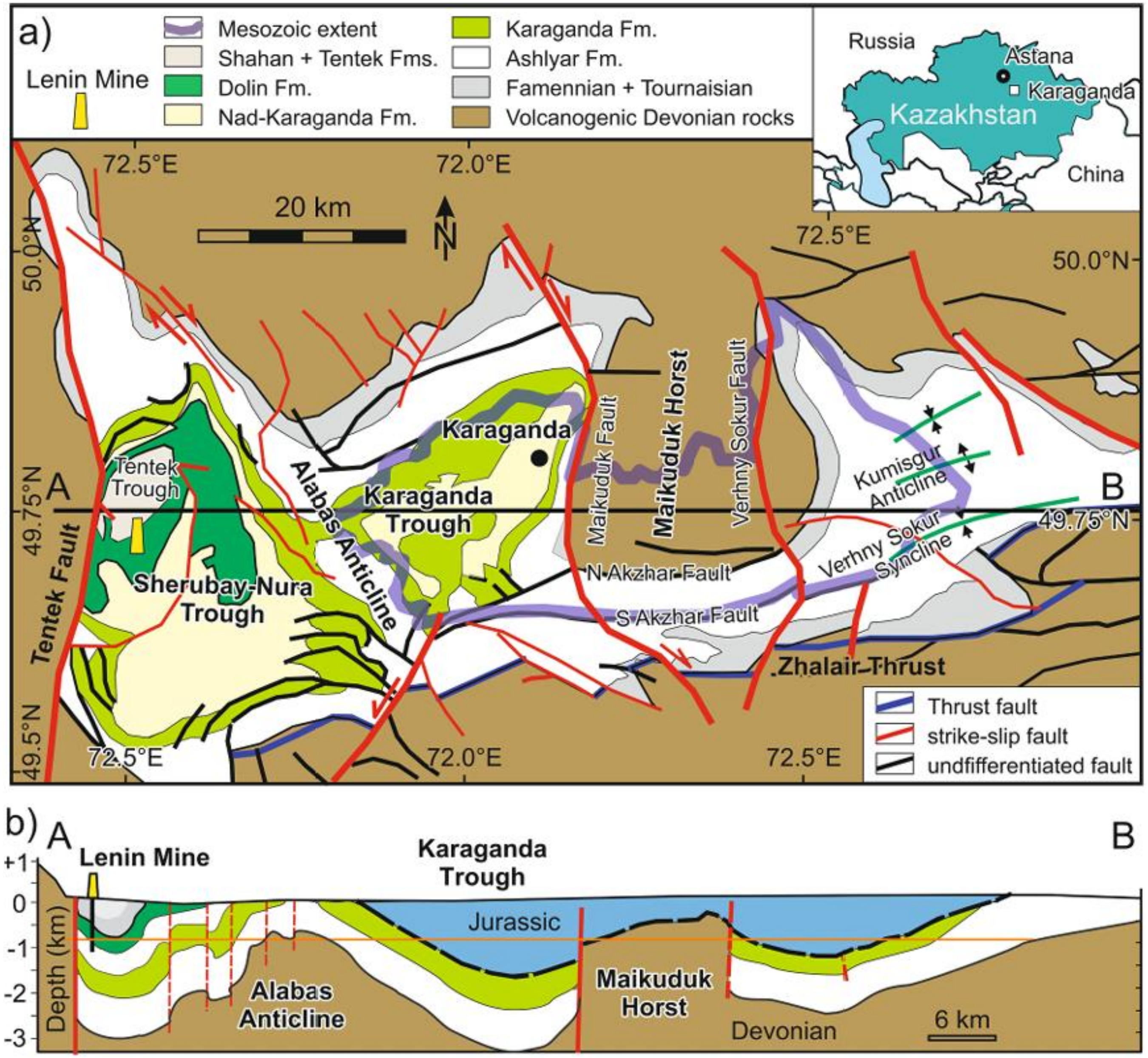
Chinese-Austrian CCS Information & Innovation Hub

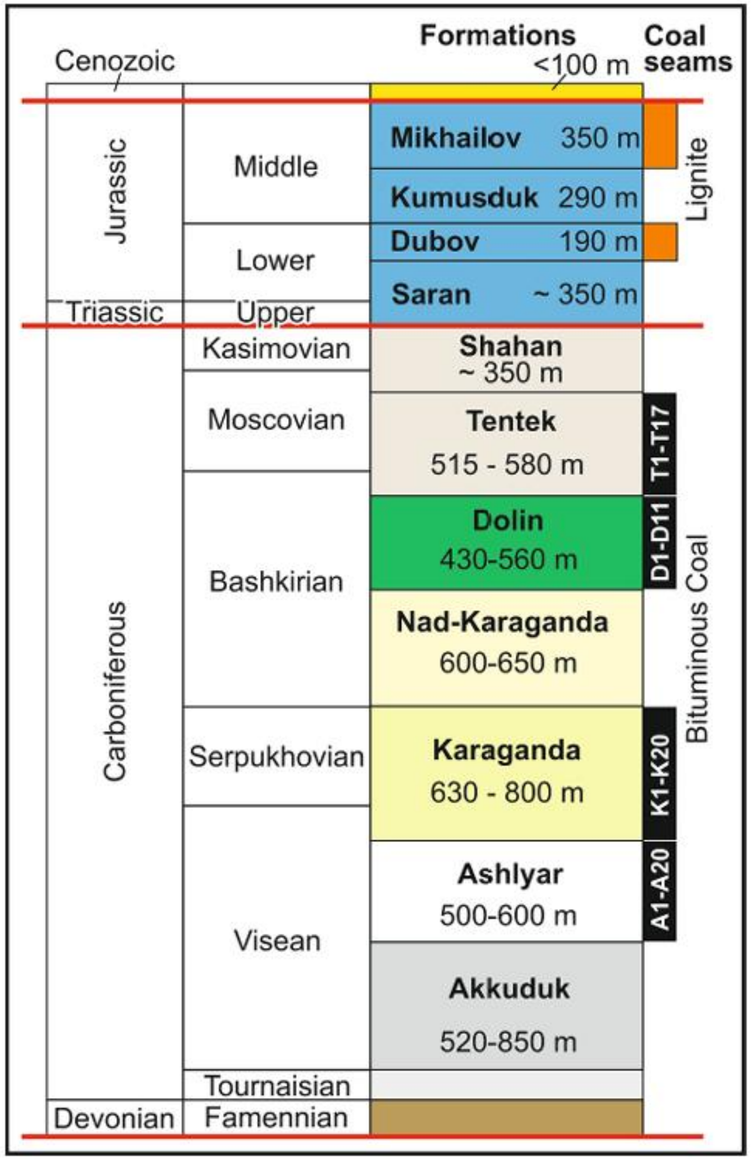
CCS Potentiale Anhui Provinz

Szenarienplanung RHIM Chizhou

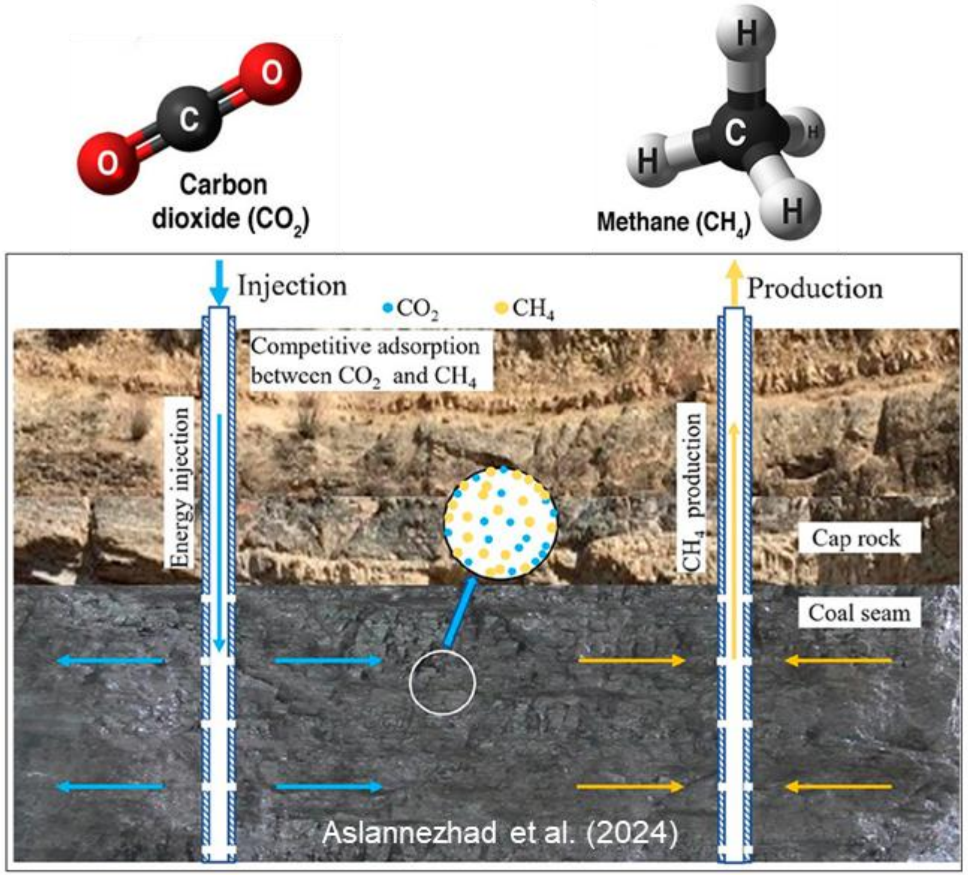
Numerische & experiment. Validierung

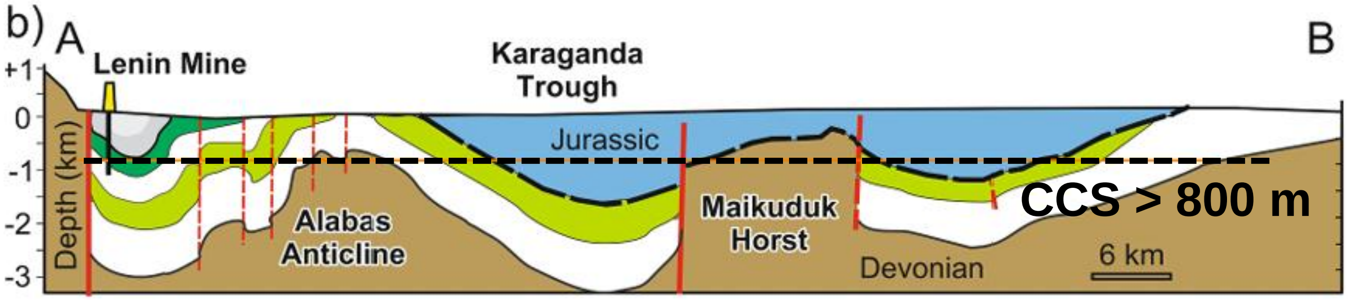
CCS Methodenentwicklung: CO_2-ECBM

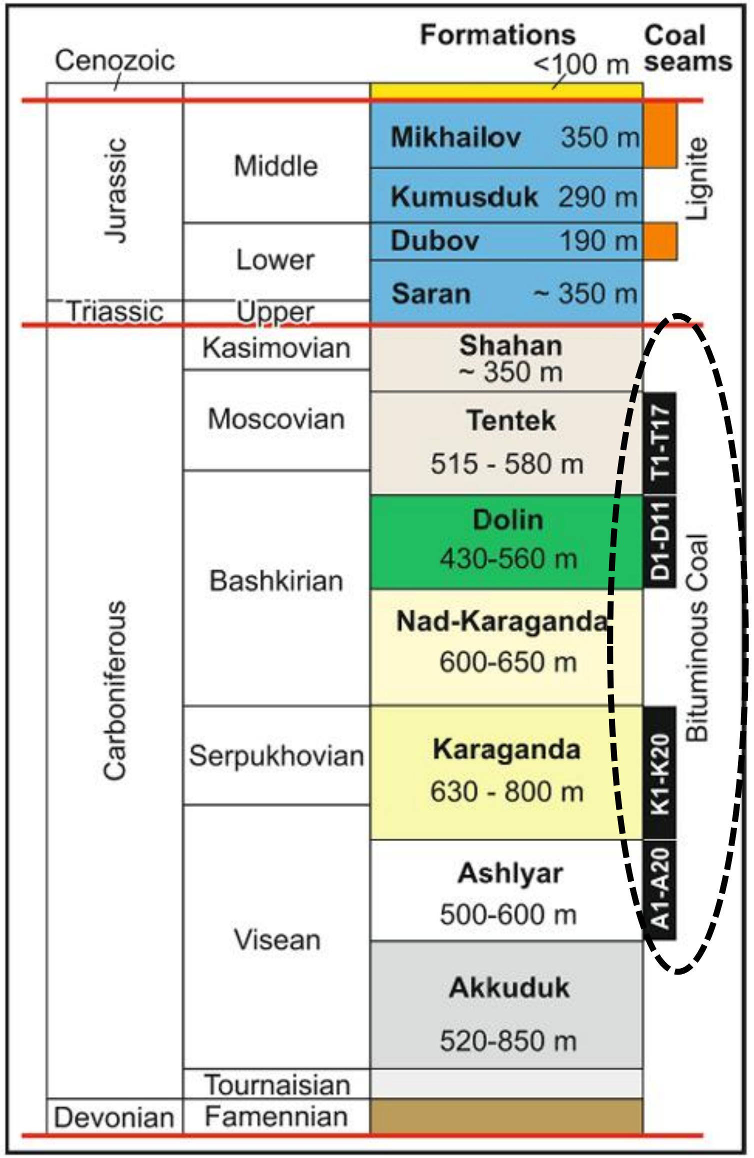




CCS Methodenentwicklung: CO_2-ECBM

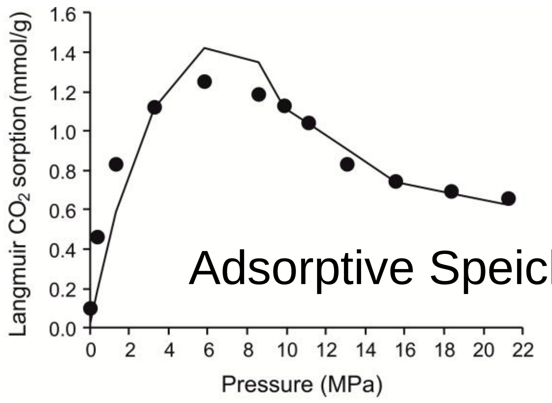




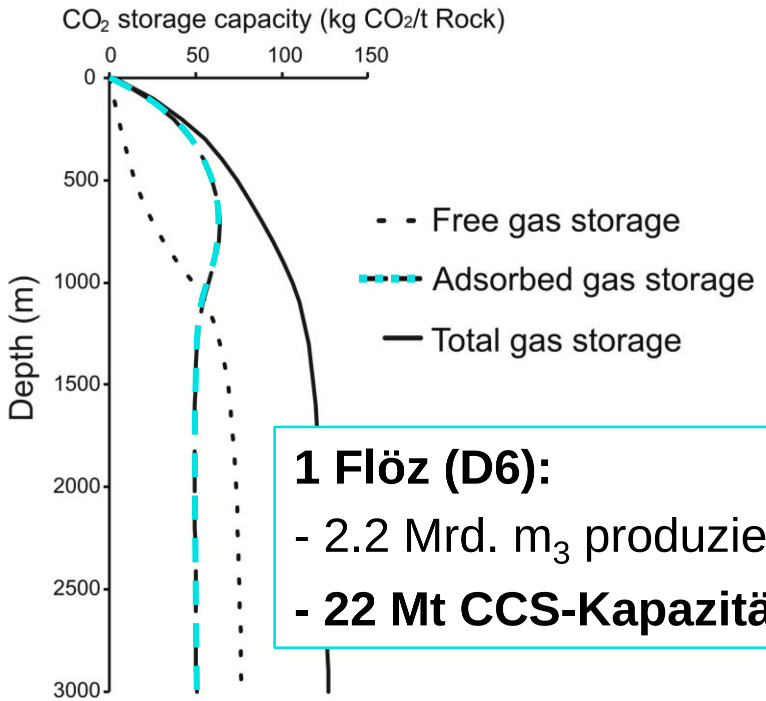


D6 Flöz

CCS Methodenentwicklung: CO_2-ECBM



Adsorptive Speicherung



1 Flöz (D6):

- 2.2 Mrd. m_3 produzierb. CH_4

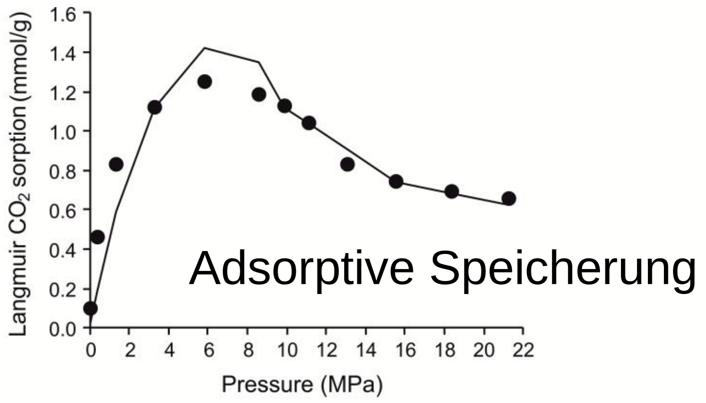
- 22 Mt CCS-Kapazität

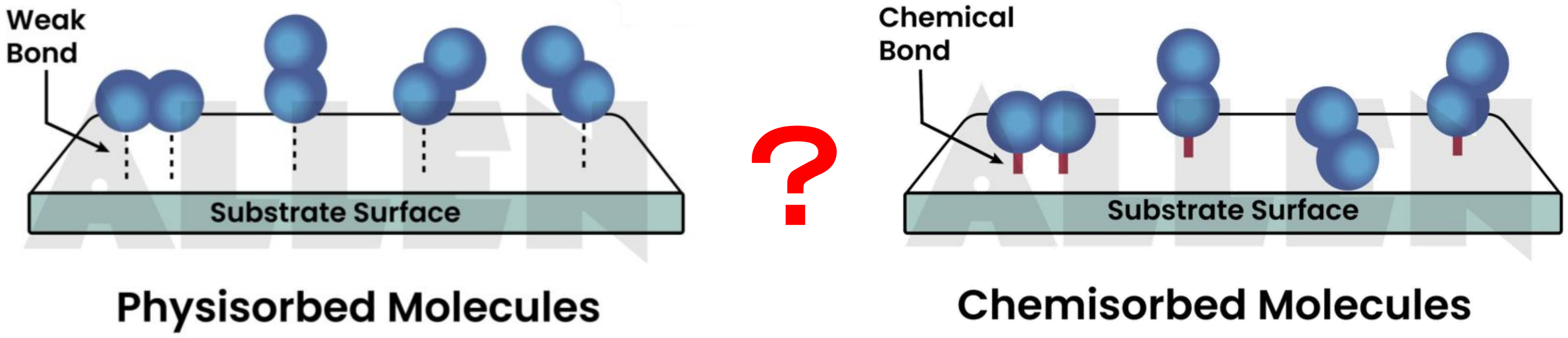
Safaei-Farouji et al. (2025)

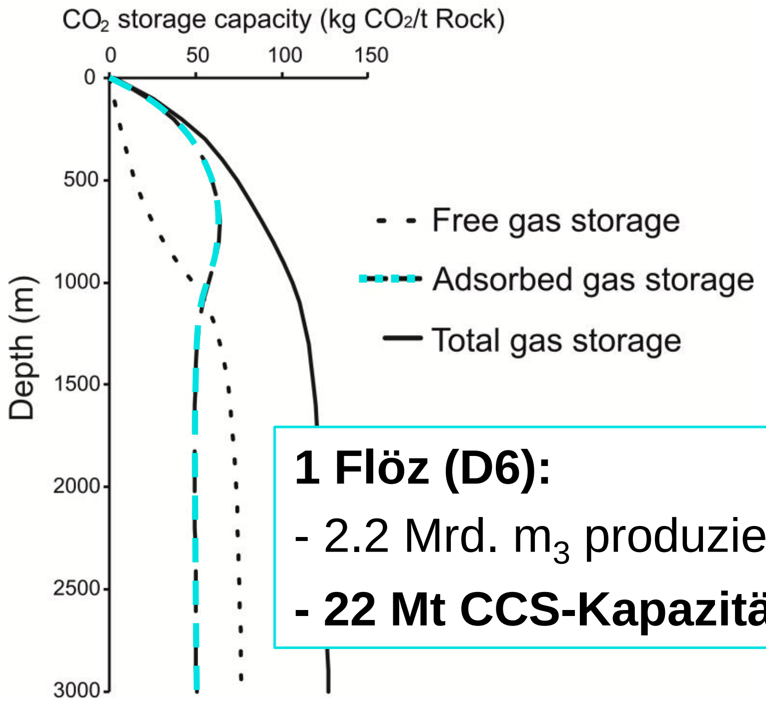
FWF Österreichischer Wissenschaftsfonds

POREMECH

CCS Methodenentwicklung: CO_2-ECBM







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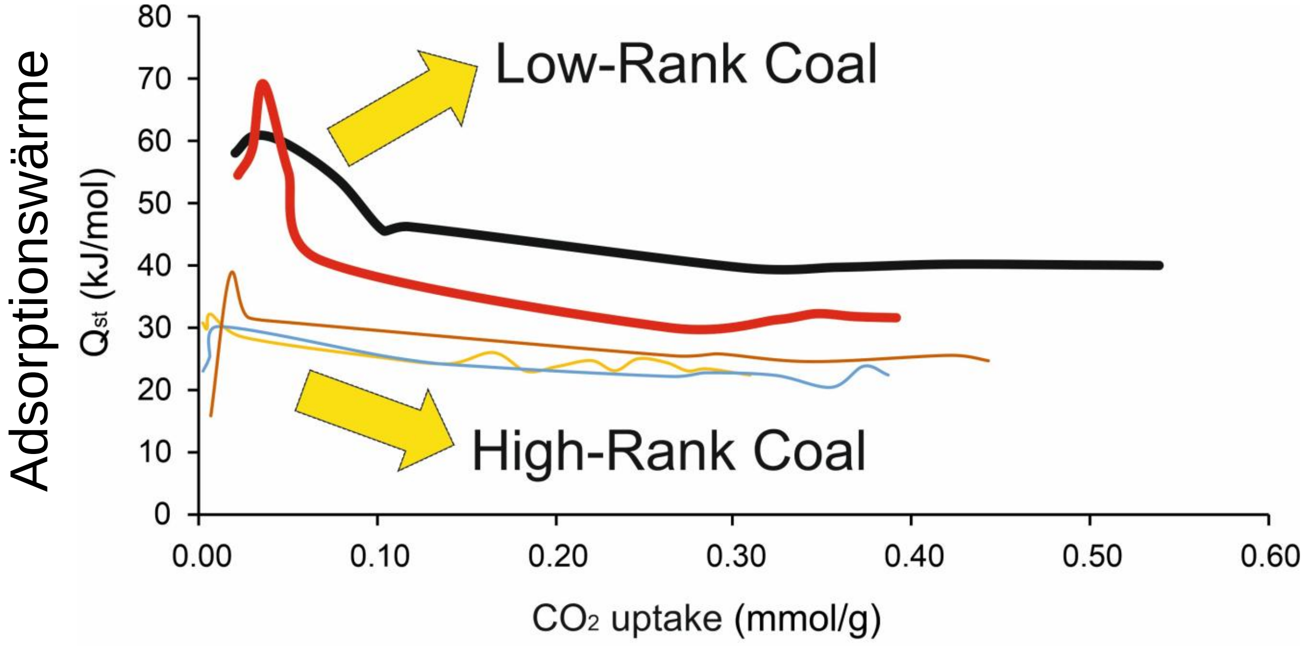
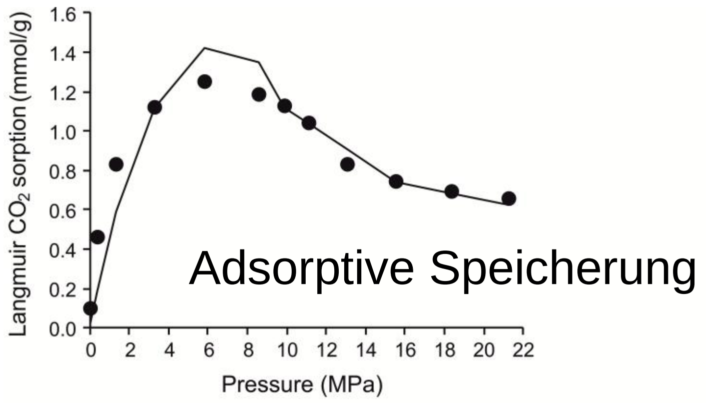


CCS Methodenentwicklung: CO_2-ECBM



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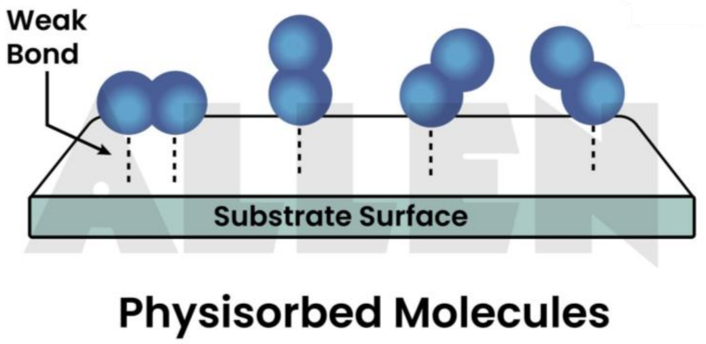
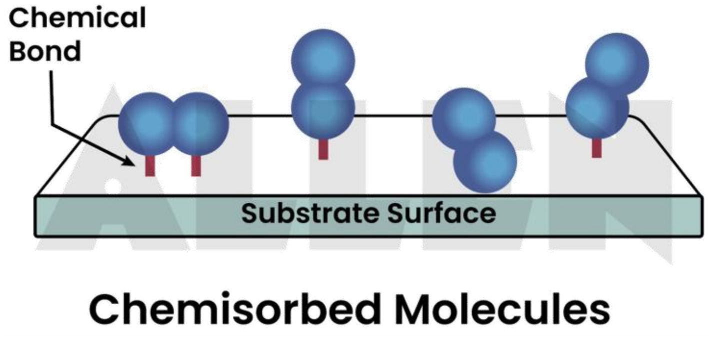
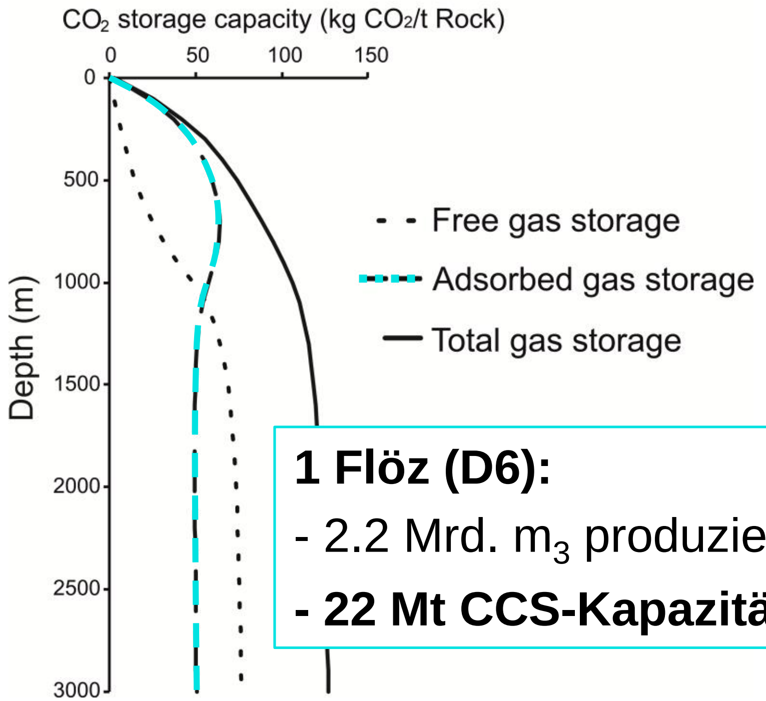


?



Reif

Unreif



1 Flöz (D6):

- 2.2 Mrd. m_3 produzierb. CH_4
- **22 Mt CCS-Kapazität**

Safaei-Farouji et al. (2025)

energy&fuels

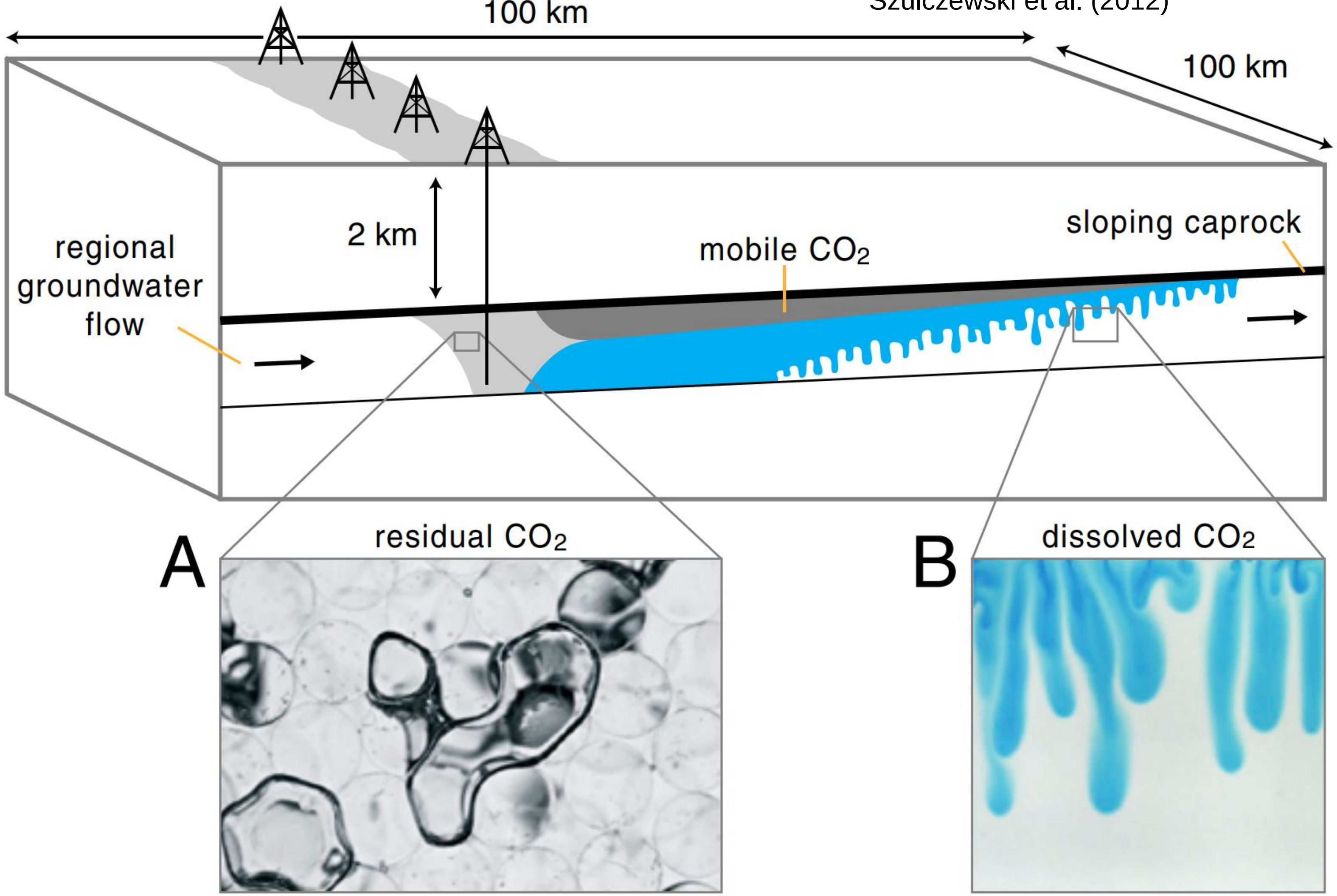
pubs.acs.org/EF Article

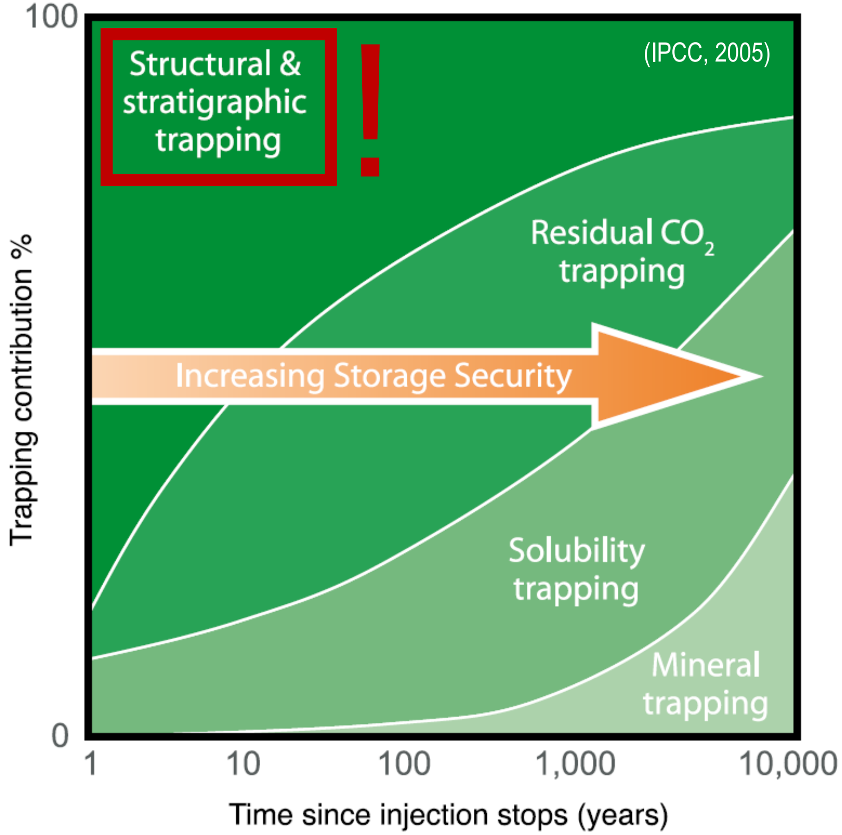
Hybrid Chemisorption−Physisorption of Subcritical CO_2 on Coals: Implications for Safe and Long-Term Underground CO_2 Sequestration

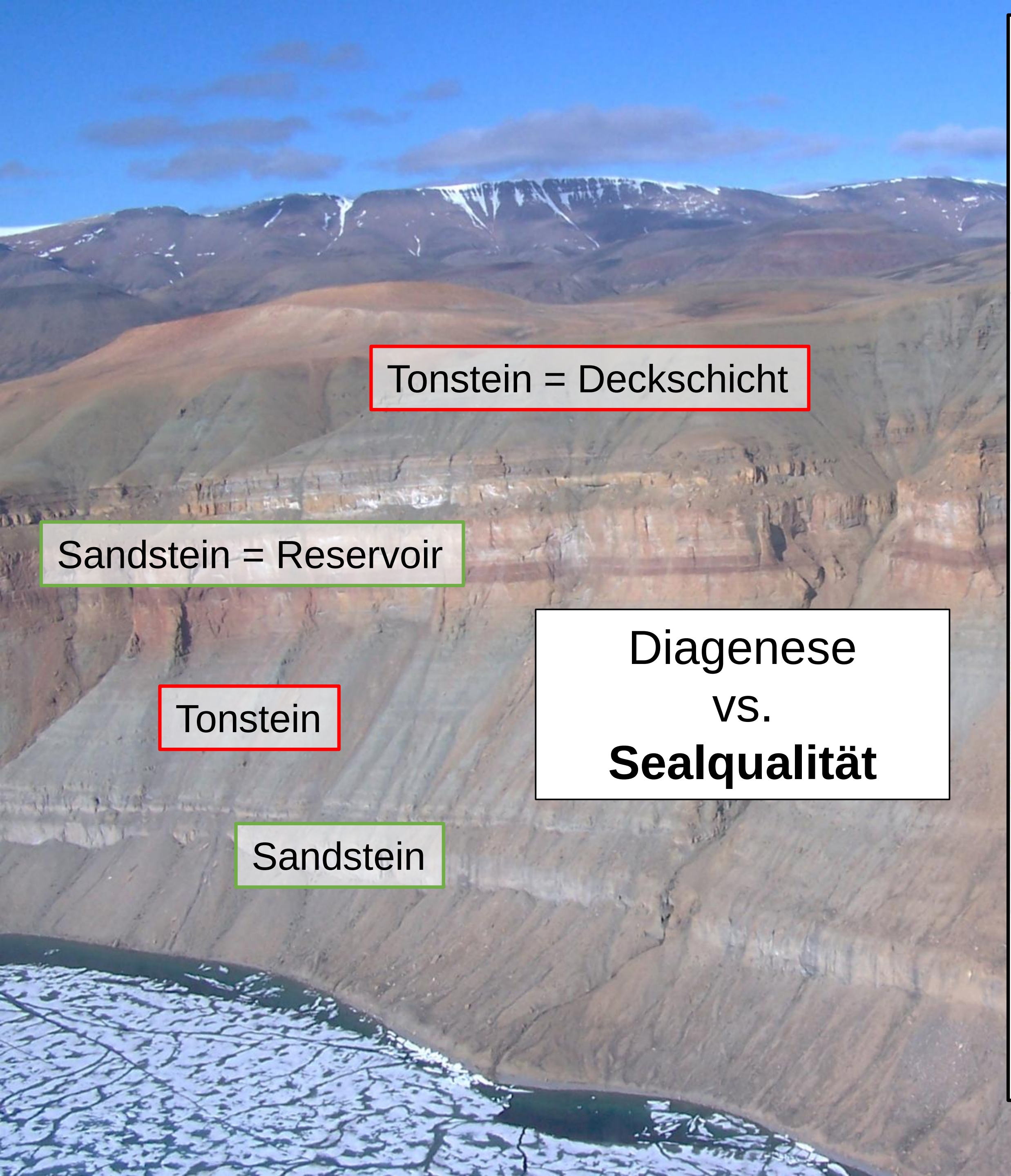
Majid Safaei-Farouji,* David Misch, Reinhard F. Sachsenhofer, Florian Knabl, and Nikolaos Kostoglou

CCS: Sicherheit

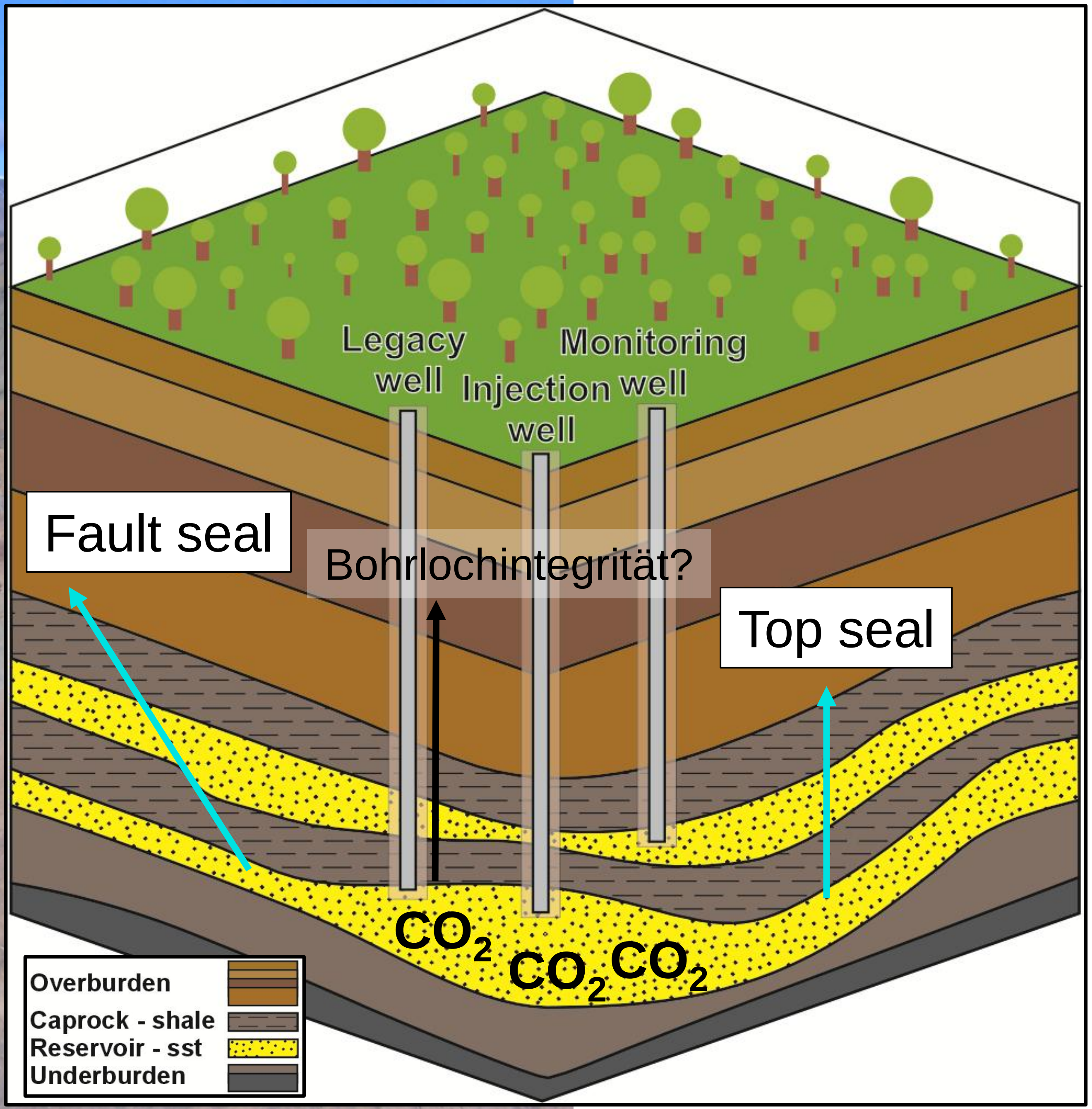
Szulczewski et al. (2012)







Diagenese
vs.
Sealqualität



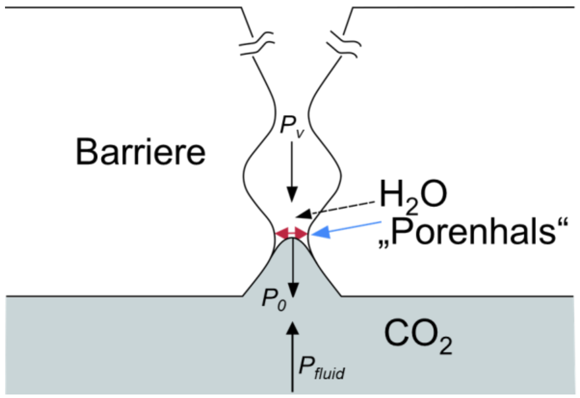
© Joel Bensing

Barrieregesteine

Capillary („membrane“) seals: kontrolliert durch Kapillardruck Watts (1987)

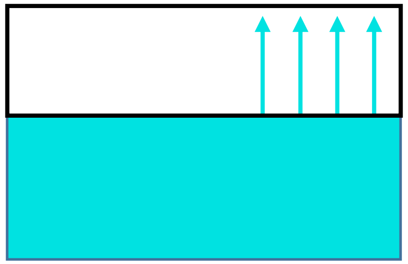
>>>Kapillareintrittsdruck

Hydraulic seals: kontrolliert durch mechanische Festigkeit & Spannungszustand

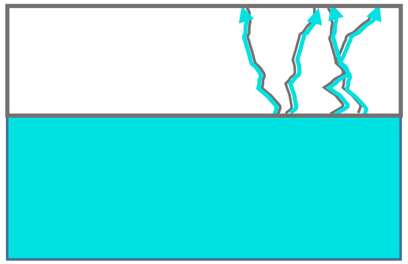


Top seal

$p_{fluid} > p_{displ}$

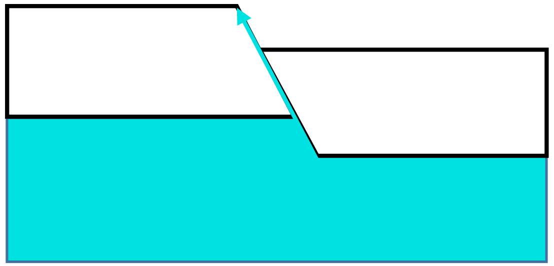


$p_{fluid} > \sigma_{h,\ min}$

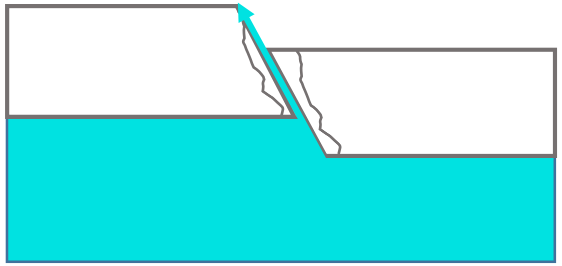


Fault seal

$p_{fluid} > p_{displ}$



$p_{fluid} > p_{crit}$



p_{fluid} – Porendruck (f[Injektionsparameter])

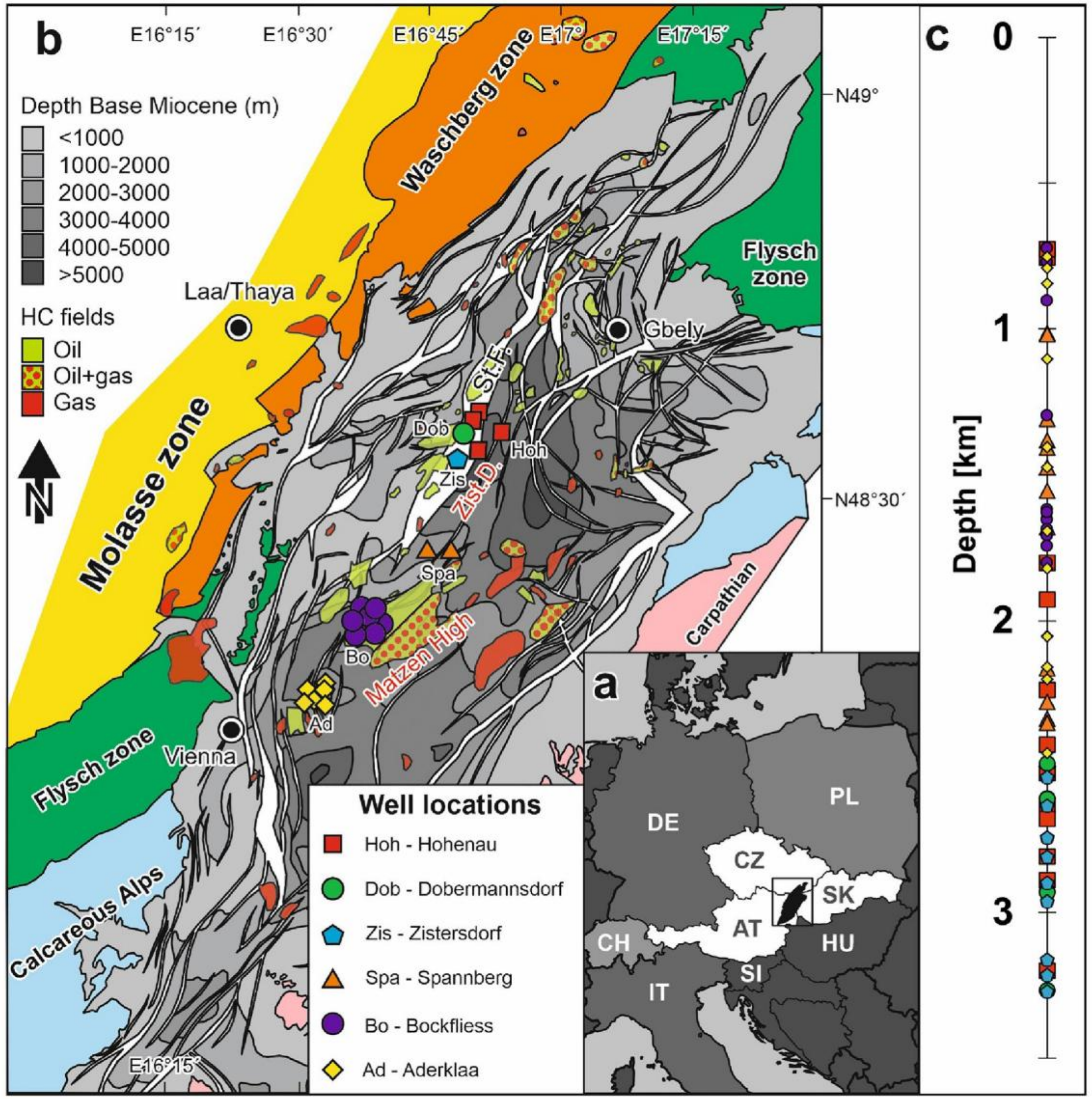
p_{displ} – Kapillareintrittsdruck

$\sigma_{h,\ min}$ – minimale Horizontalspannung

p_{crit} – kritischer Porendruck (f[Spannungsfeld, Störungsparameter])

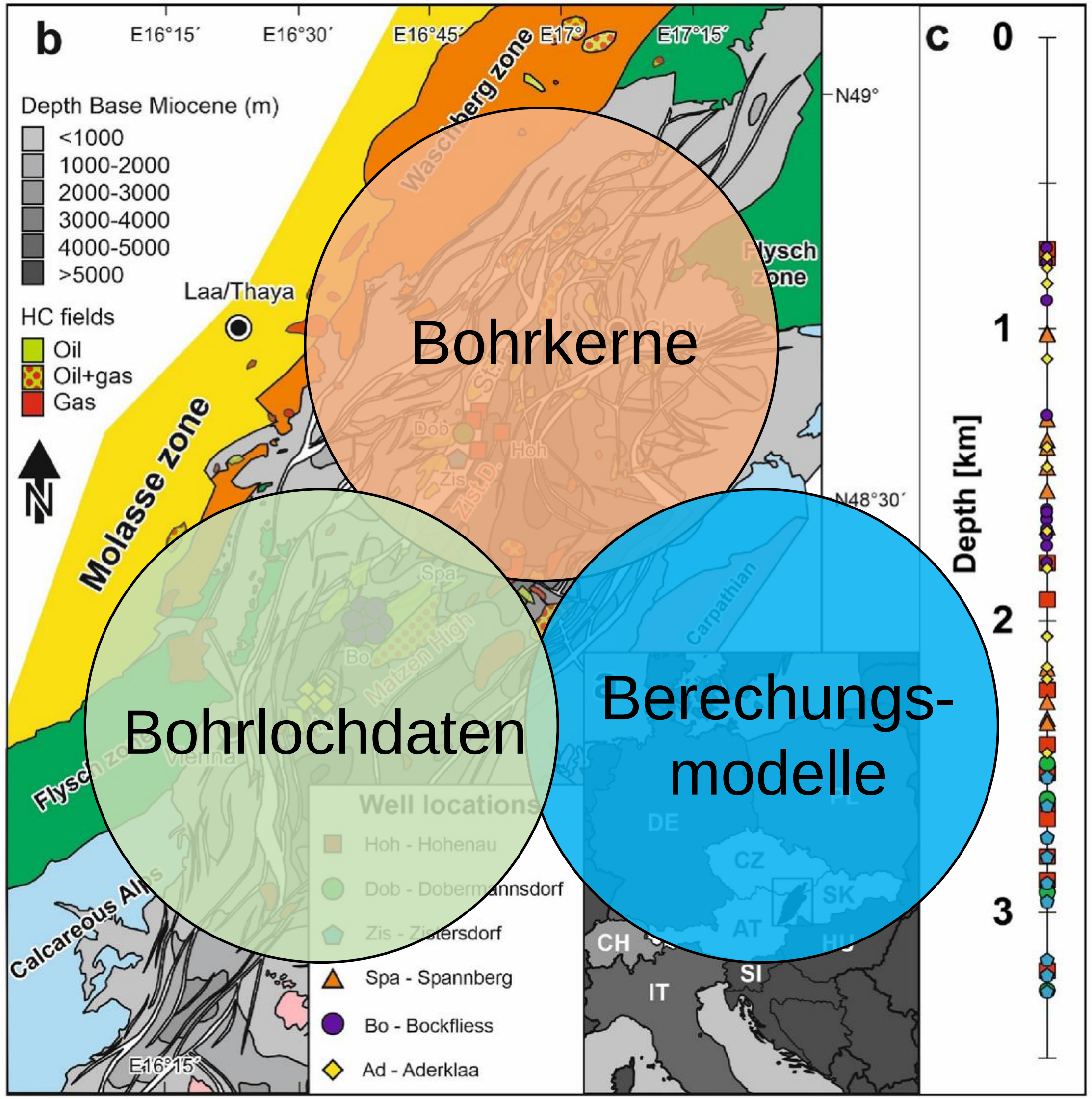
+ zusätzl. Mechanismen (Diffusion,…)

Kompaktionsanalyse

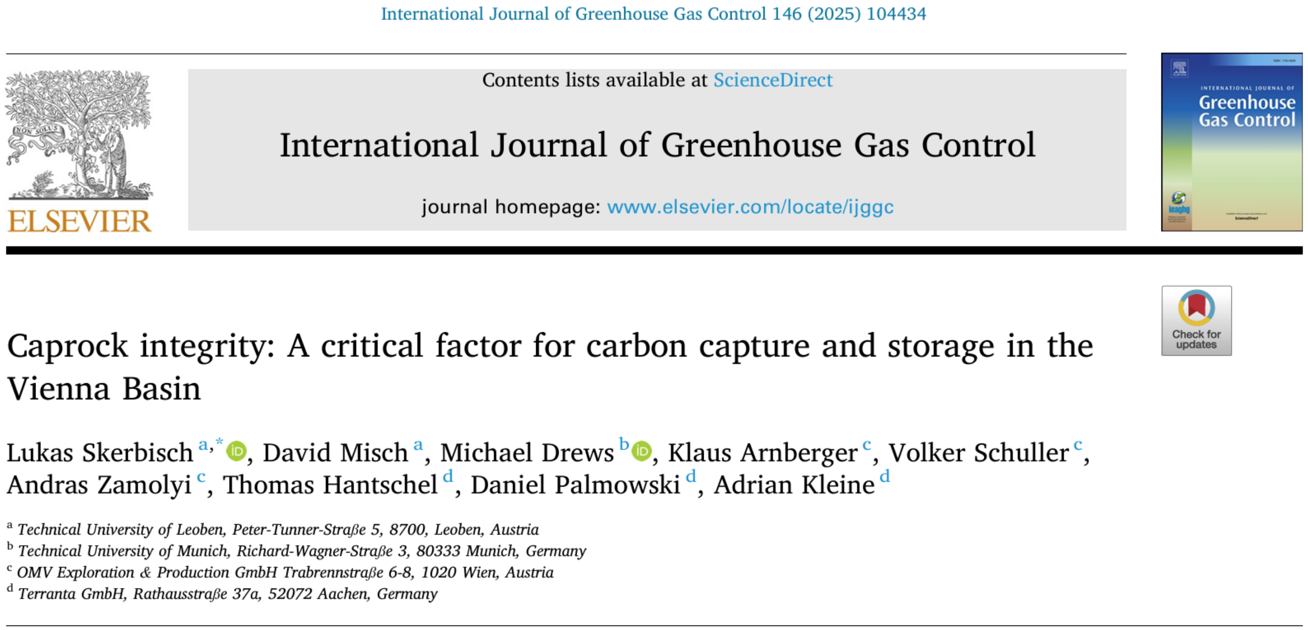


Skerbisch et al. (2023, 2025)

Kompaktionsanalyse



Skerbisch et al. (2023, 2025)



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International Journal of Greenhouse Gas Control

journal homepage: www.elsevier.com/locate/ijggc

ELSEVIER

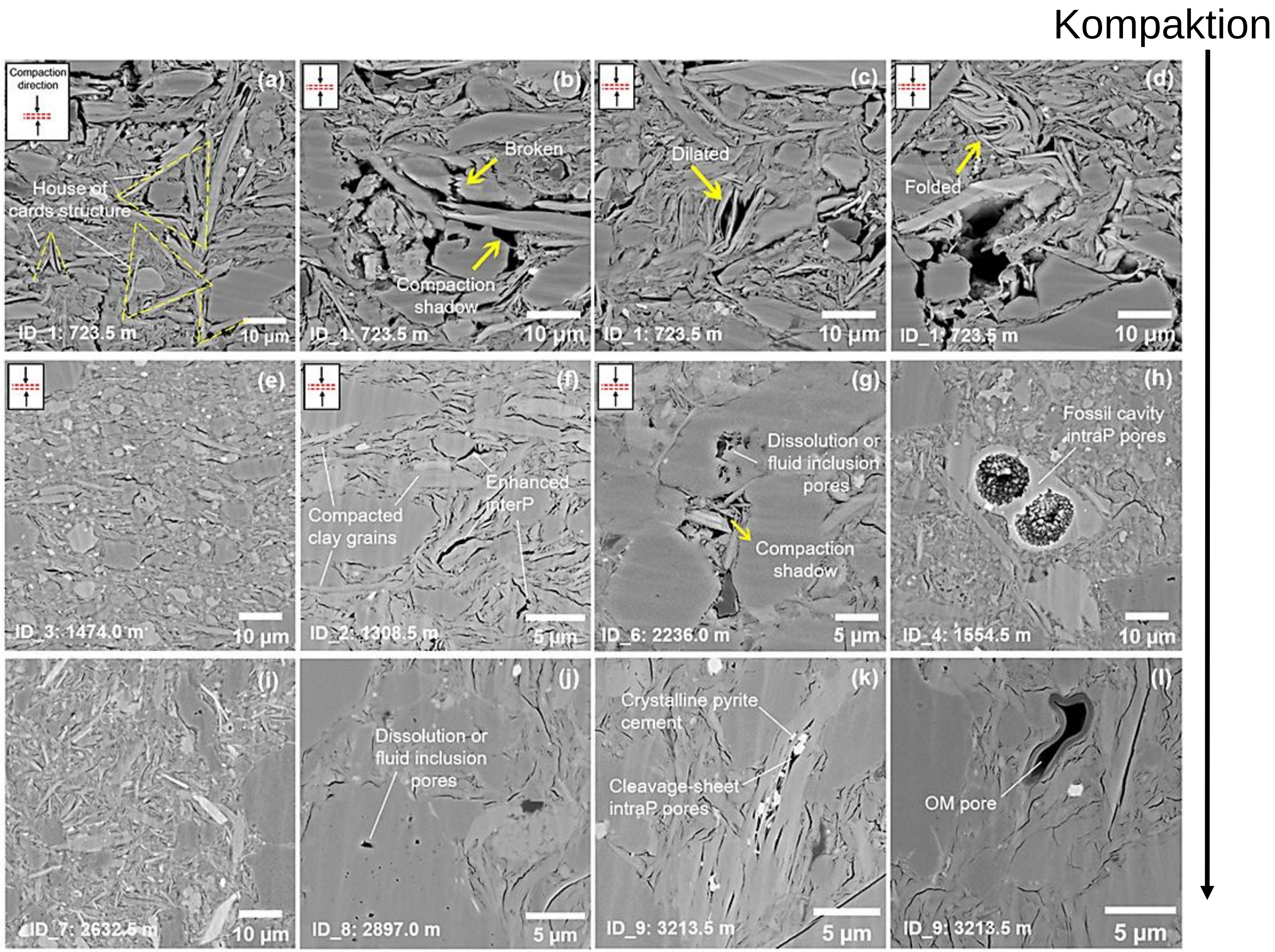
Caprock integrity: A critical factor for carbon capture and storage in the Vienna Basin

Lukas Skerbisch [a,*], David Misch [a], Michael Drews [b], Klaus Arnberger [c], Volker Schuller [c], Andras Zamolyi [c], Thomas Hantschel [d], Daniel Palmowski [d], Adrian Kleine [d]

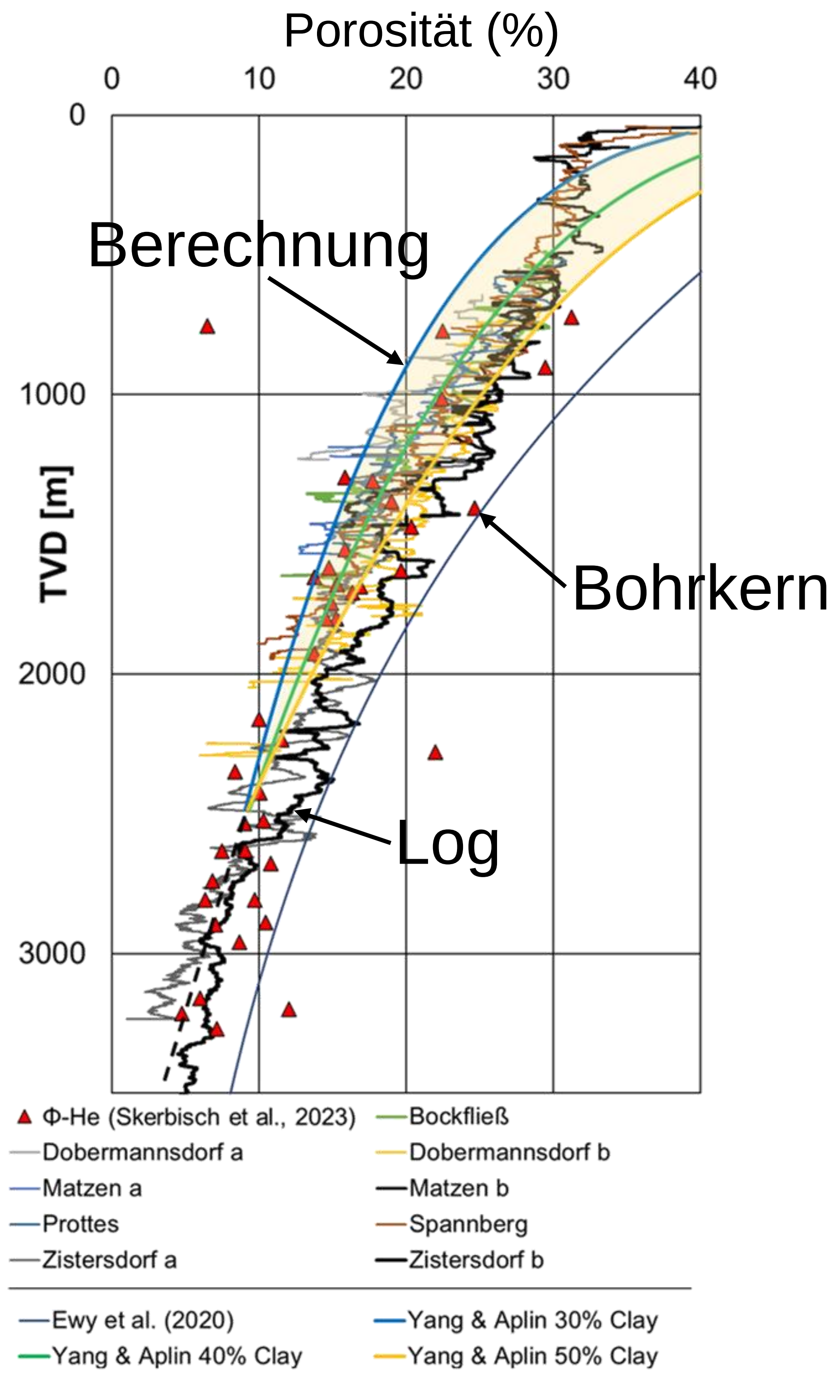
[a] Technical University of Leoben, Peter-Tunner-Straße 5, 8700, Leoben, Austria
[b] Technical University of Munich, Richard-Wagner-Straße 3, 80333 Munich, Germany
[c] OMV Exploration & Production GmbH Trabrennstraße 6-8, 1020 Wien, Austria
[d] Terranta GmbH, Rathausstraße 37a, 52072 Aachen, Germany

- Kompaktionstrends
- Statische Sealkapazität
- Dynamisches Sealing

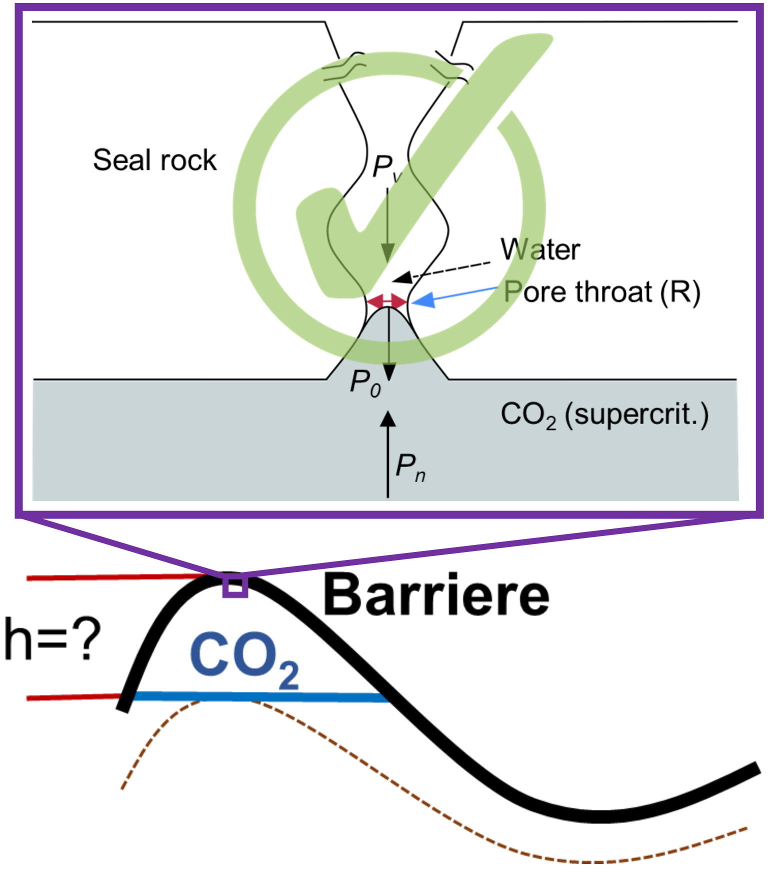
Kompaktionsanalyse



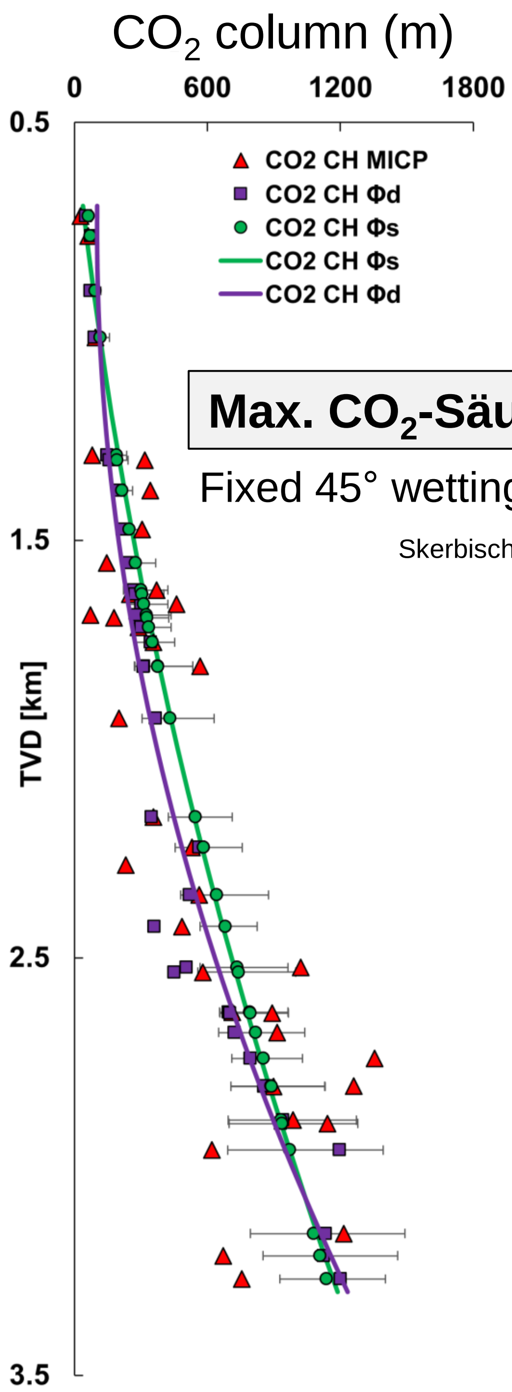
Shi et al. (2024)



Statisches Sealing



$$h = \frac{\left(\frac{2\gamma\cos\theta}{R}\right)}{(\rho_w - \rho_{CO2})g}$$

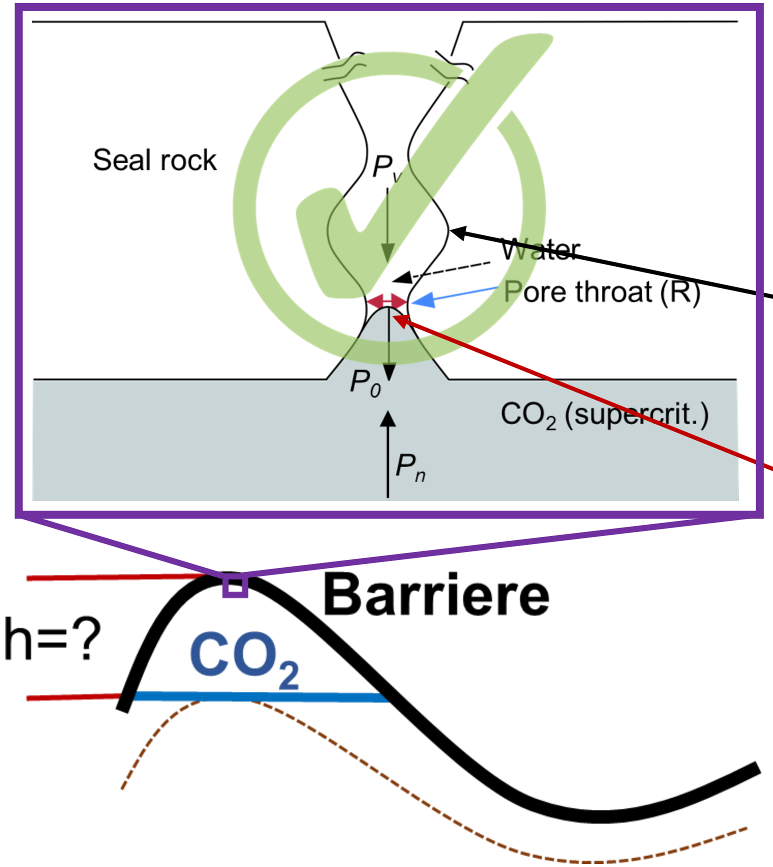


Max. CO_2-Säule (p_{displ})

Fixed 45° wetting angle

Skerbisch et al. (2025)

Statisches Sealing



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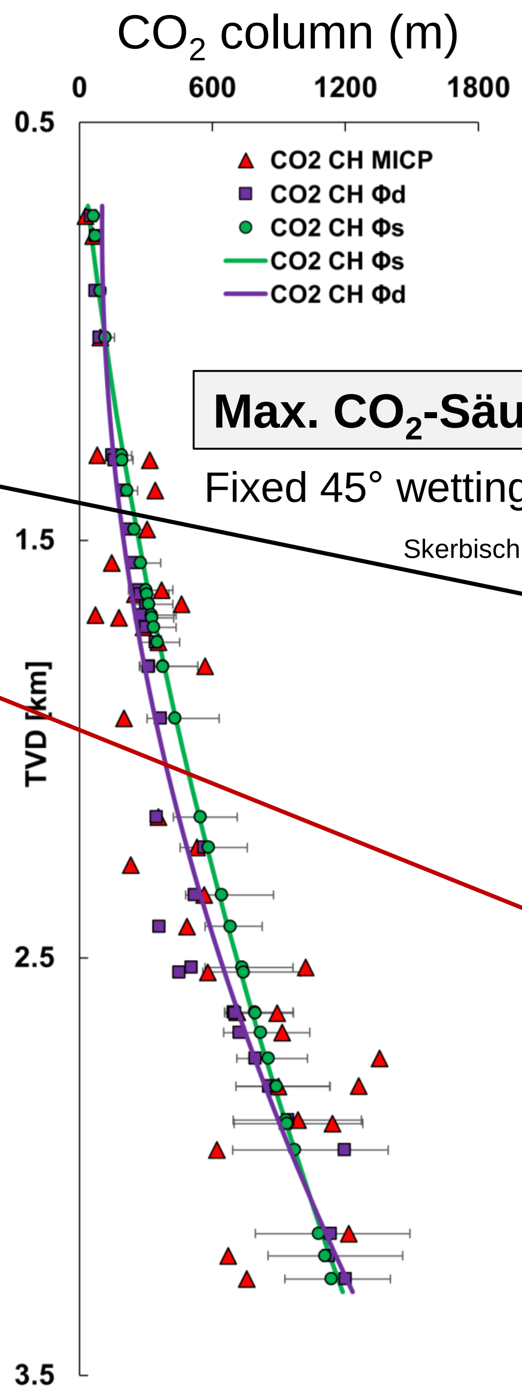

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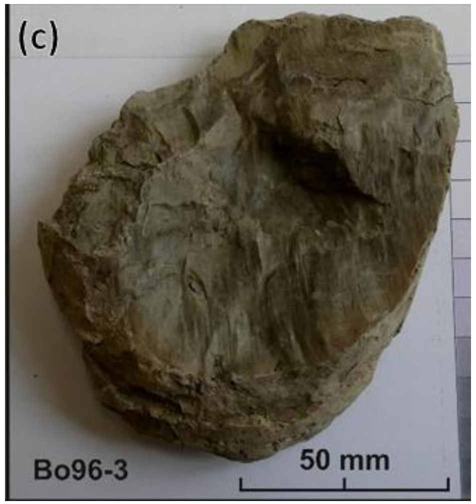
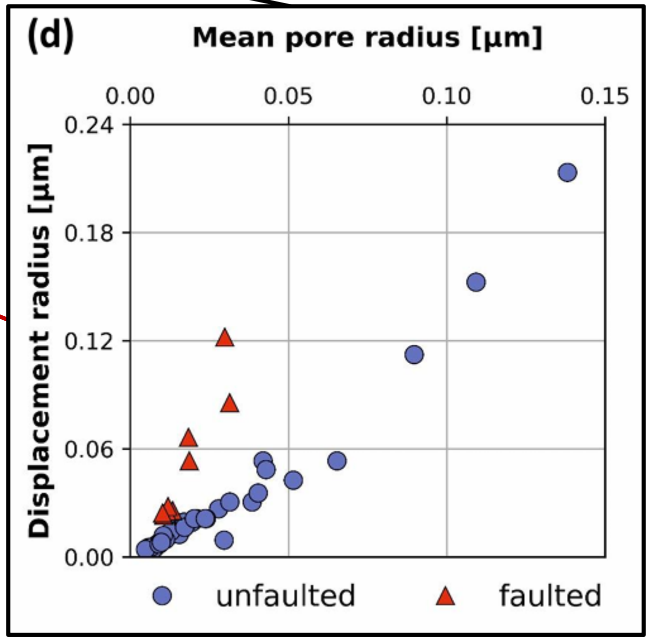




Pengg et al., in prep.

Dynamisches Sealing

CO_2 Massenstrom (nach Durchbruch)

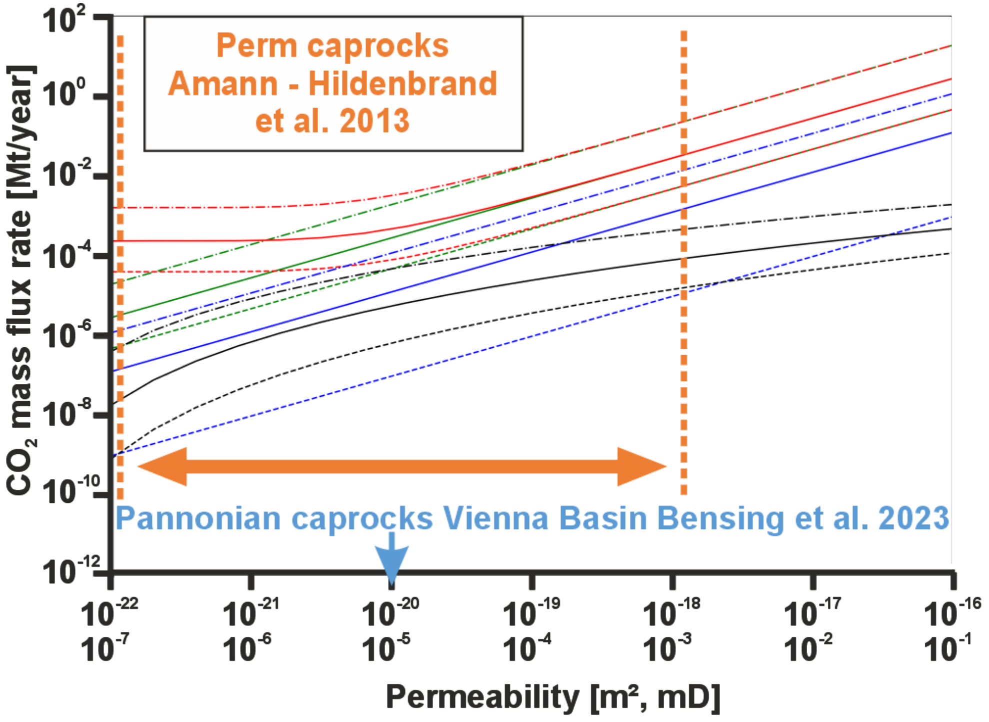
40 Mt CO_2

1% = 0.4 Mt in **200 - 10.000 a**

50 m Barriere

Sicher auch bei CO_2-Durchbruch!

Skerbisch et al. (2025)



Scenario	Thick [m]	Area [km²]	Pres [MPa]
1 ········	150	20	0.1
2 ———	100	30	1
3 -·-·-·-	50	40	3

CO_2 Gasphase (Darcy)

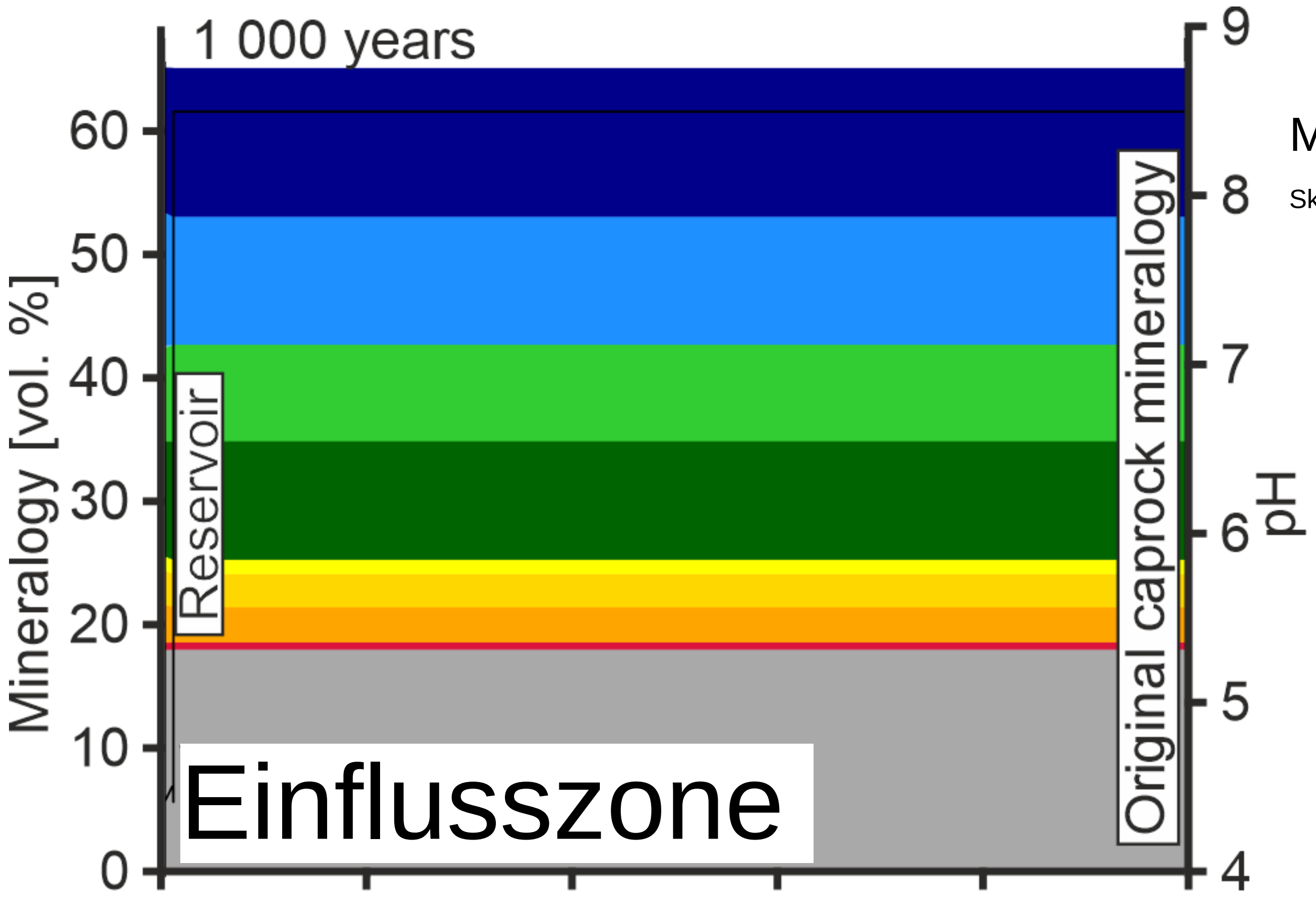
CO_2 Gasphase & Knudsen-Diffusion

CO_2 Gelöst in Wasser

CO_2 Diffusion in Wasser

Langfristige Mineralogie- & Porositätsveränderungen?

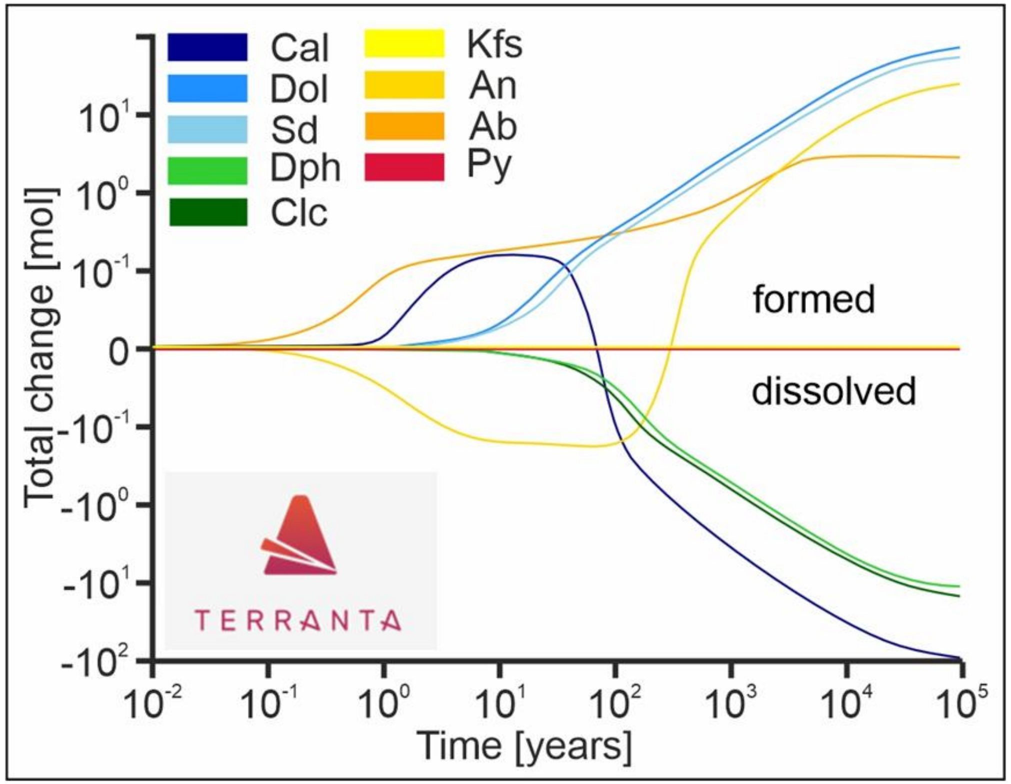
Hydrochemische Modellierung



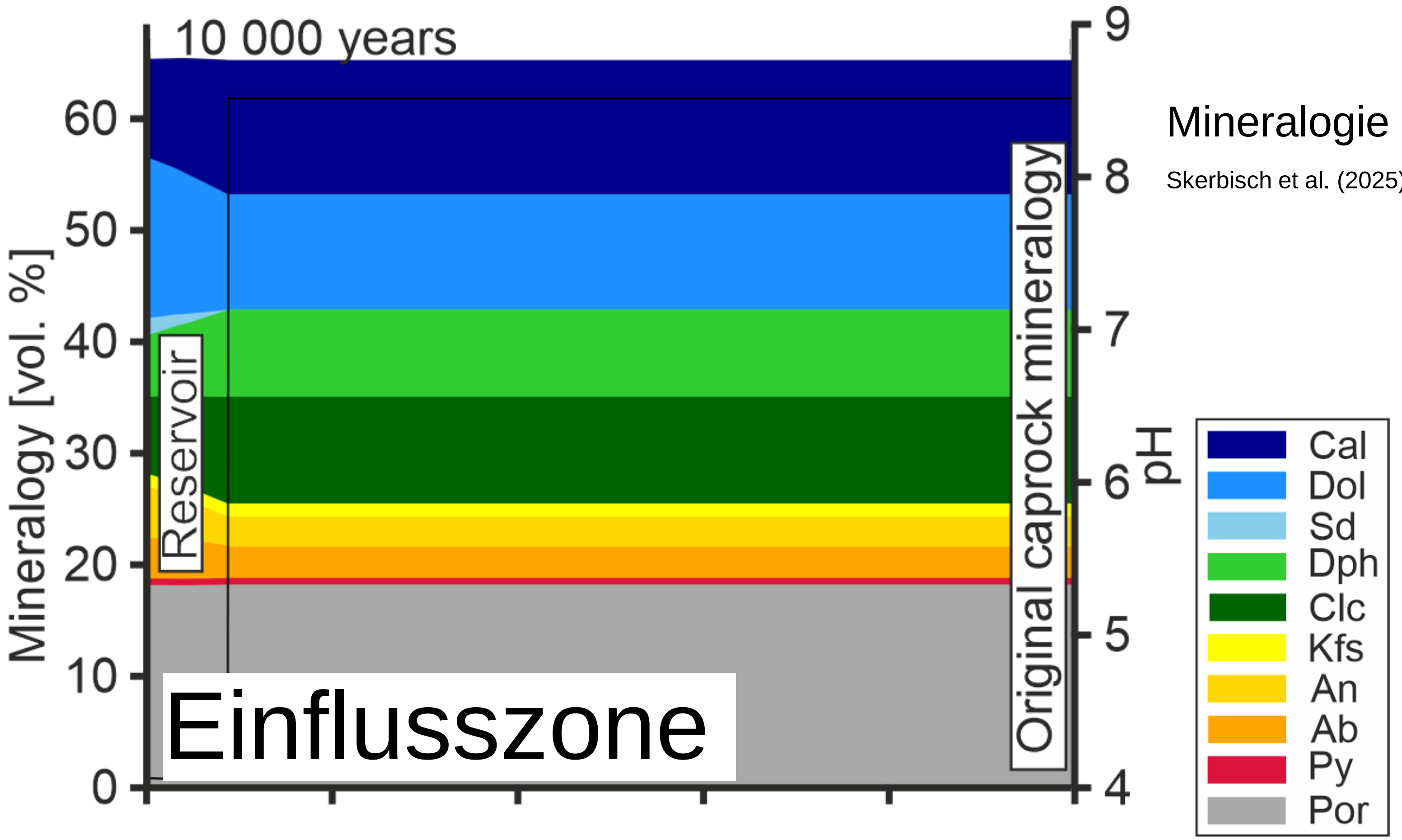
Darcy-Fluss gelöstes CO_2 in Wasser

Mineralogie & Hydrochemie aus Felddaten

Skerbisch et al. (2025)



Hydrochemische Modellierung

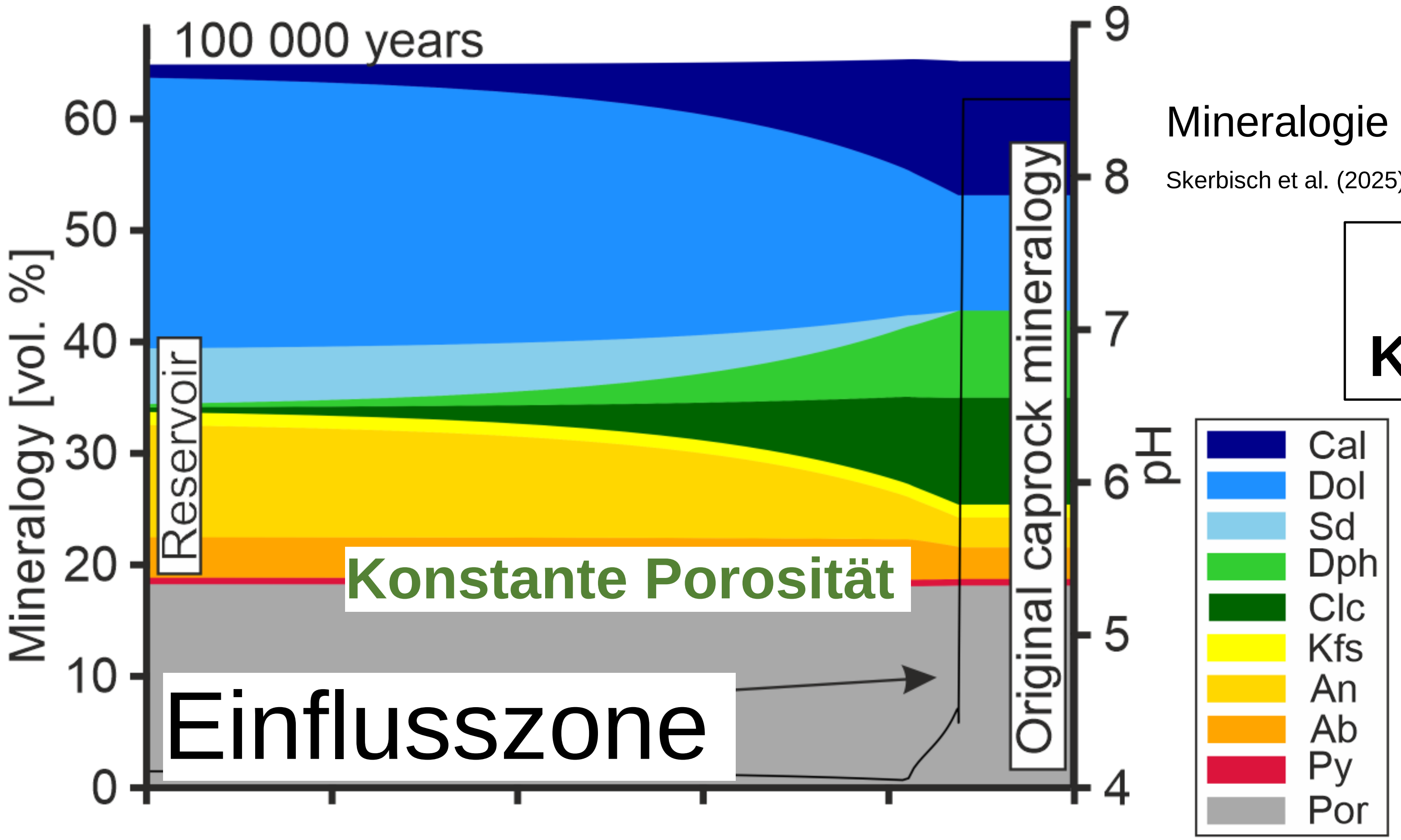


Mineralogie & Hydrochemie aus Felddaten

Skerbisch et al. (2025)

Darcy-Fluss gelöstes CO_2 in Wasser

Hydrochemische Modellierung



Darcy-Fluss gelöstes CO_2 in Wasser

Mineralogie & Hydrochemie aus Felddaten

Skerbisch et al. (2025)

Deckschicht = CO_2 Falle

Kein Porositätszuwachs!

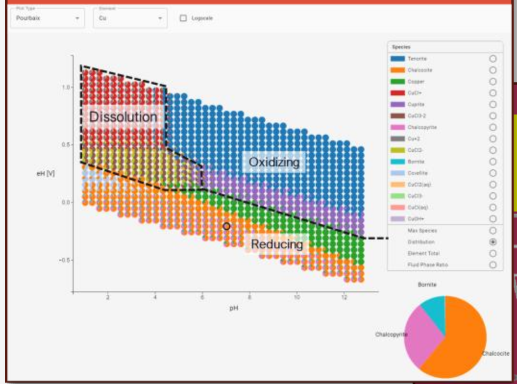
Neue Modellierungsansätze

FFG
Promoting Innovation.

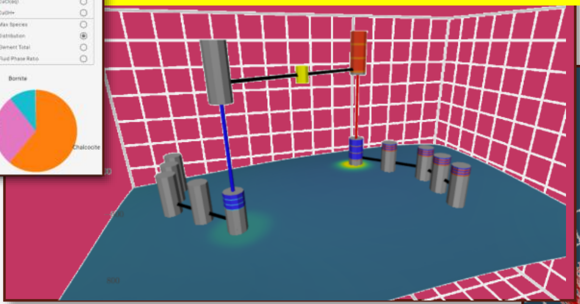
CCSIM

New modelling workflows for CCS safety

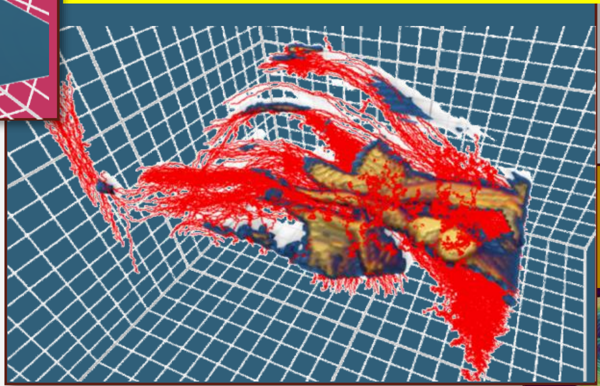
Geochemie



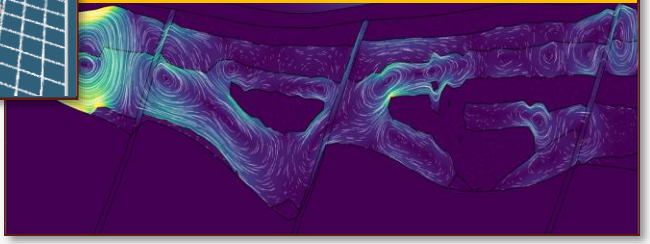
Reaktives Netzwerk



Reaktiver Transport 2D/3D



Wärme- und Fluidfluss



Geochemische Komplexität

TERRANTA

ENERGY GEOSCIENCES

Dimensionen & Geologische Komplexität

Misch et al. (2026)

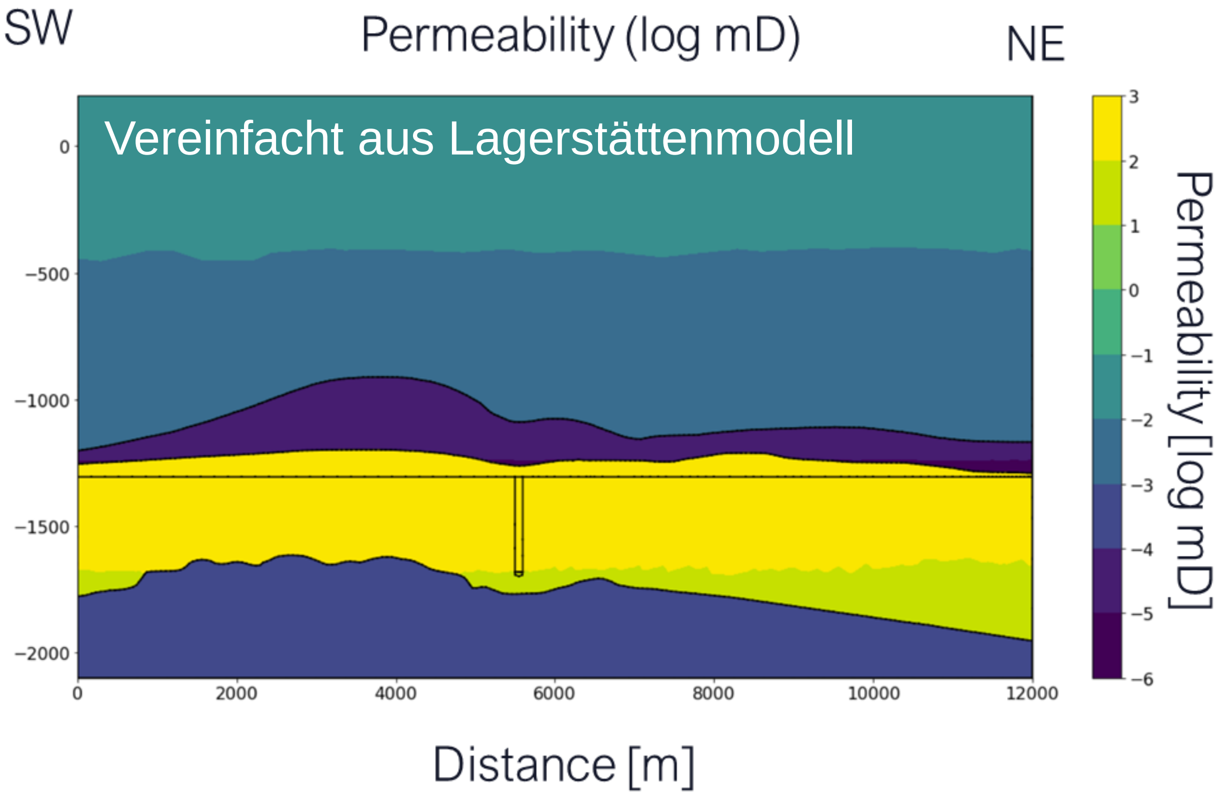
2D Reaktiver Transport

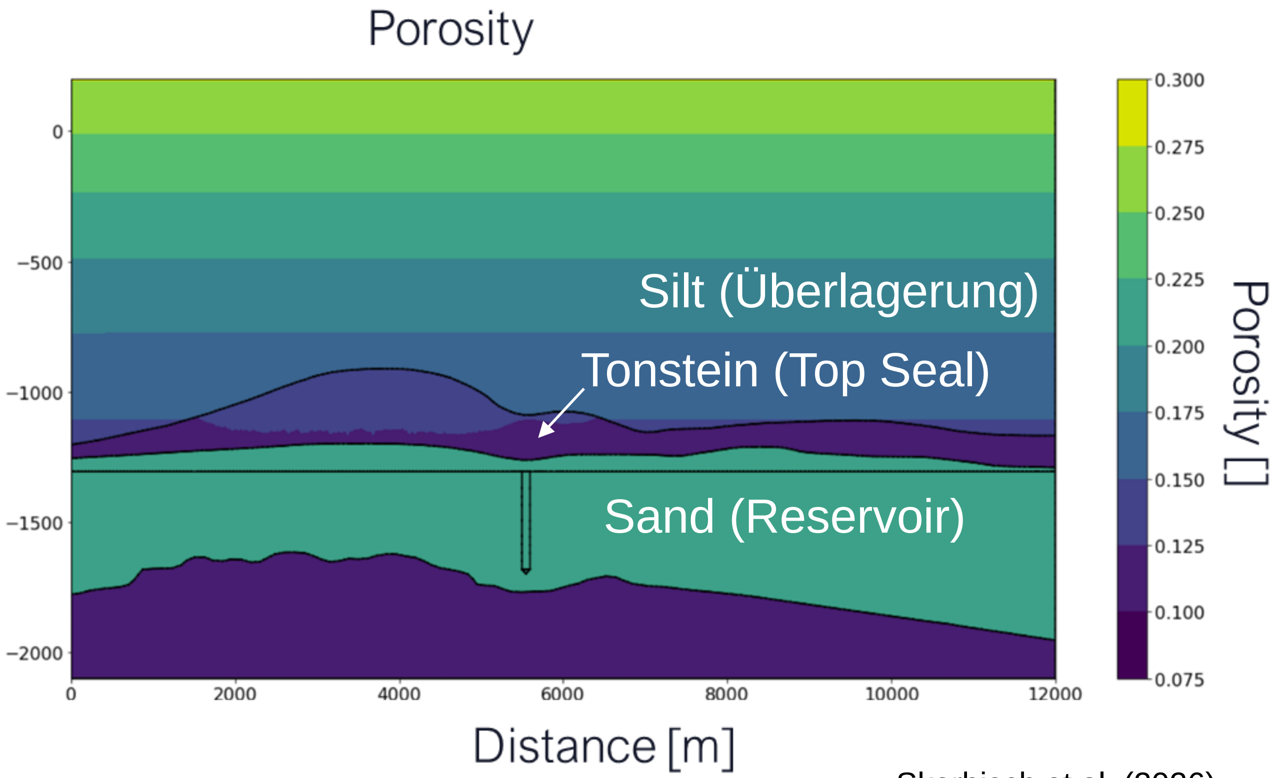
Szenario: Injektion in ausgeförderte Lagerstätte (~1200 m)

Prozesse (CO_2 non-wetting)

Darcy-Fluss H_2O + gelöstes CO_2 // Diffusion von CO_2 in H_2O

Schematisches Profil Testfeld

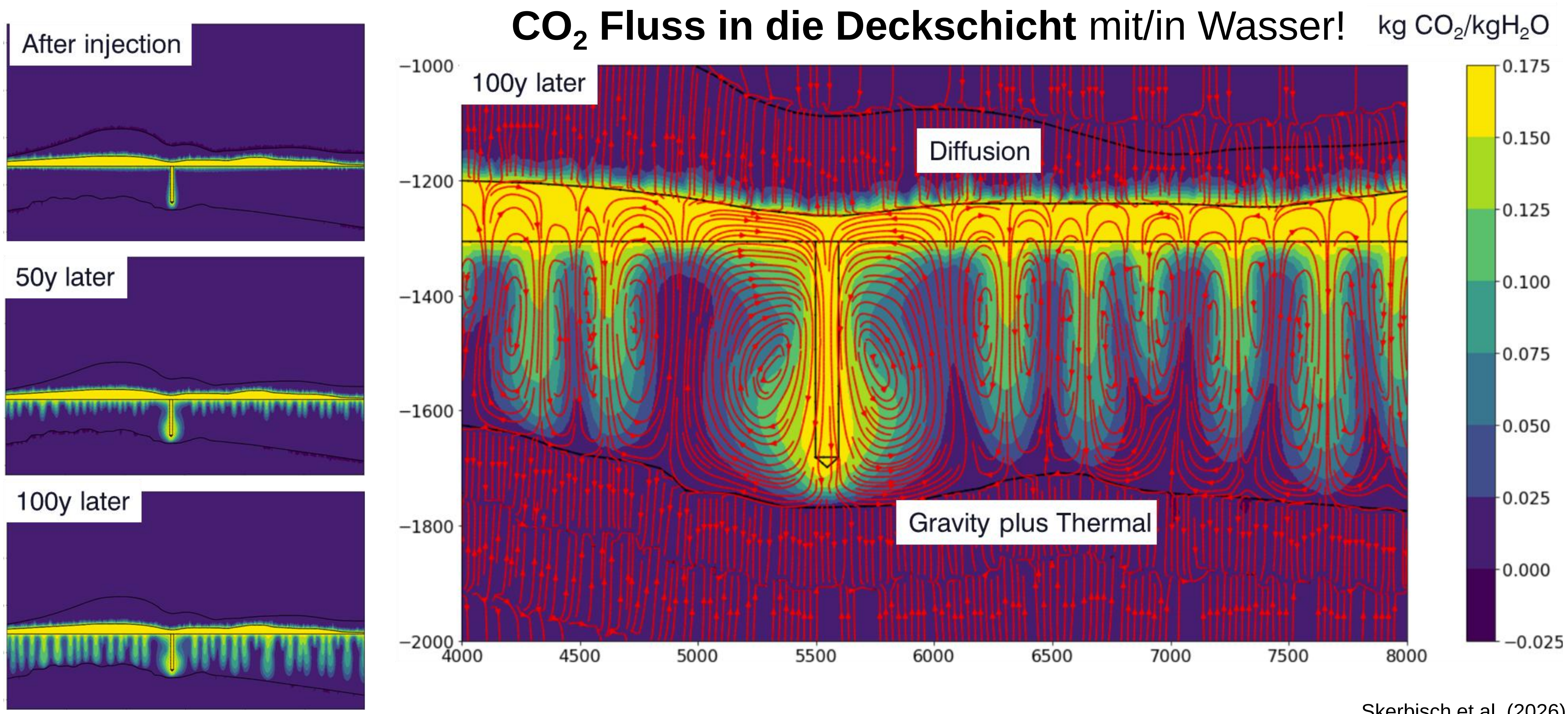




Skerbisch et al. (2026)

2D Reaktiver Transport

CO_2 Fluss in die Deckschicht mit/in Wasser!

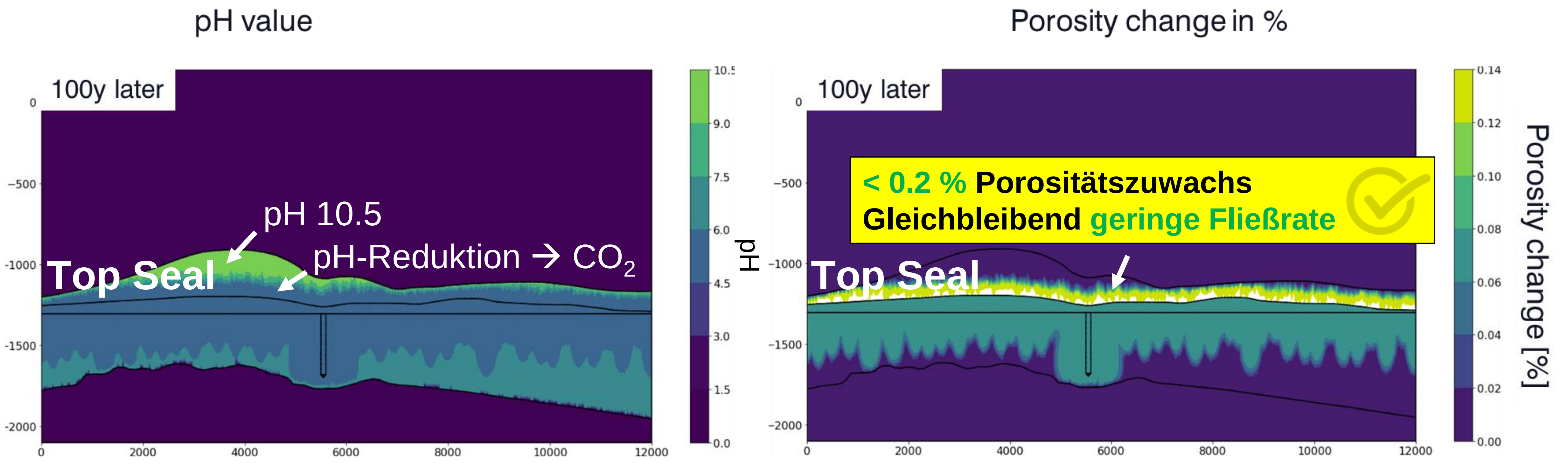


Skerbisch et al. (2026)

2D Reaktiver Transport

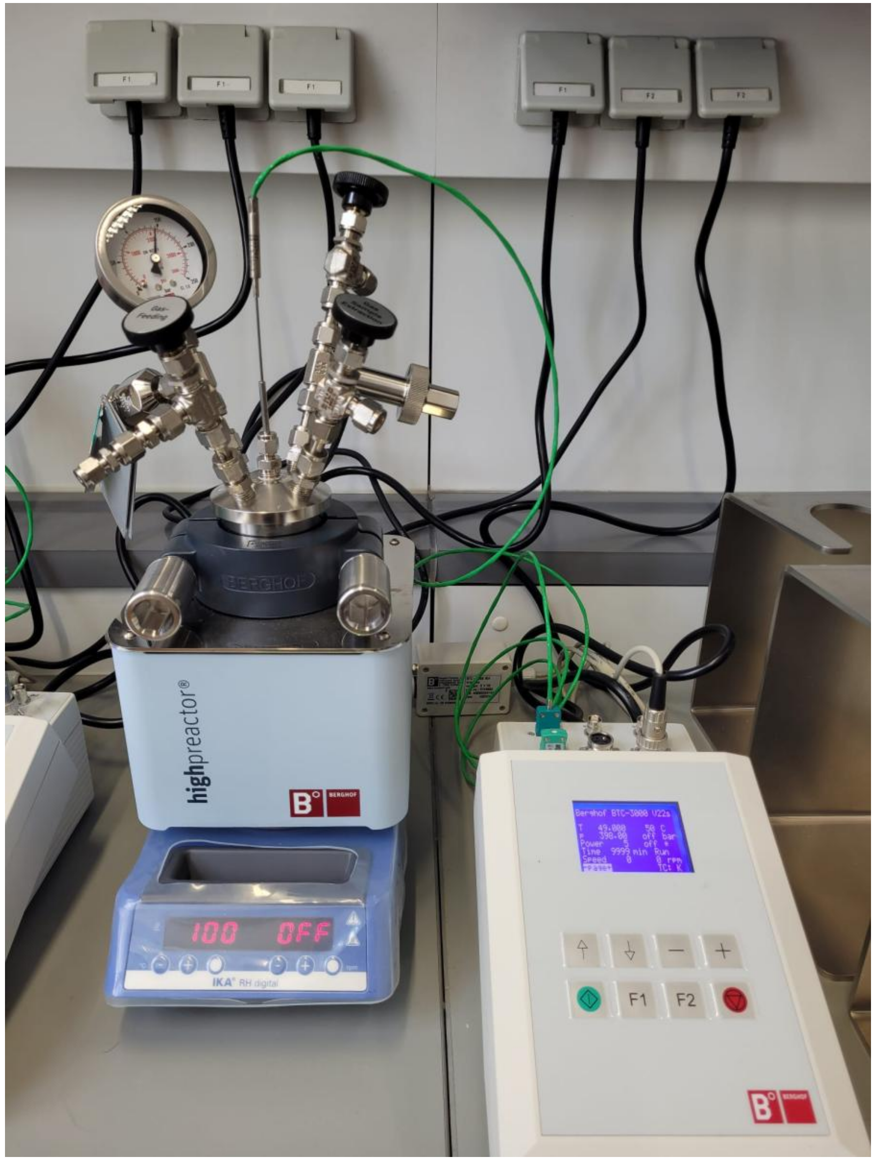
<<< Porositätszuwachs nach **100 J.** trotz pH Reduktion!

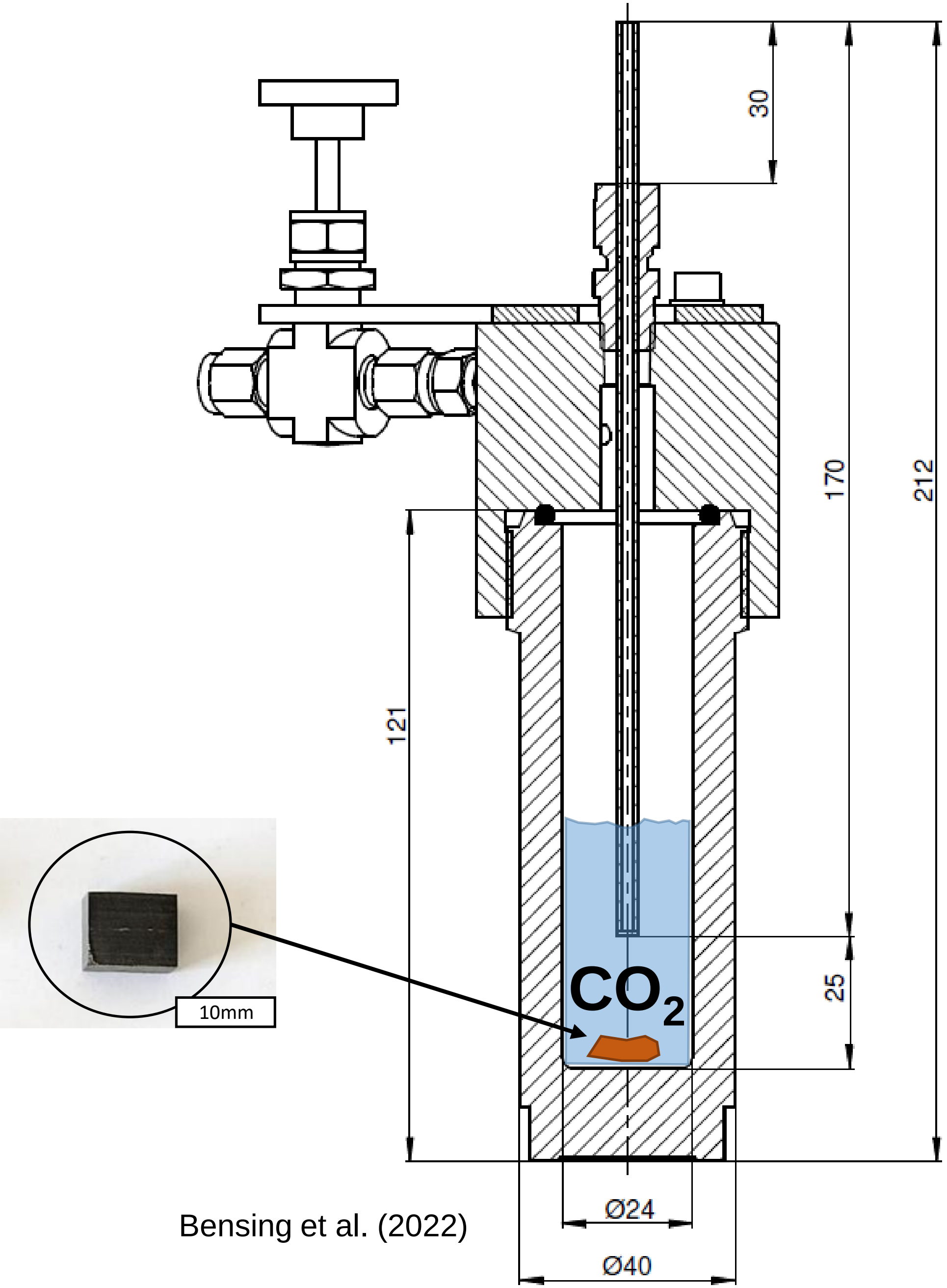
(initialer pH 10.5 ≙ 65 wt.% Silikate / 35 wt.% Karbonate)



Skerbisch et al. (2026)

Experimentelle Validierung



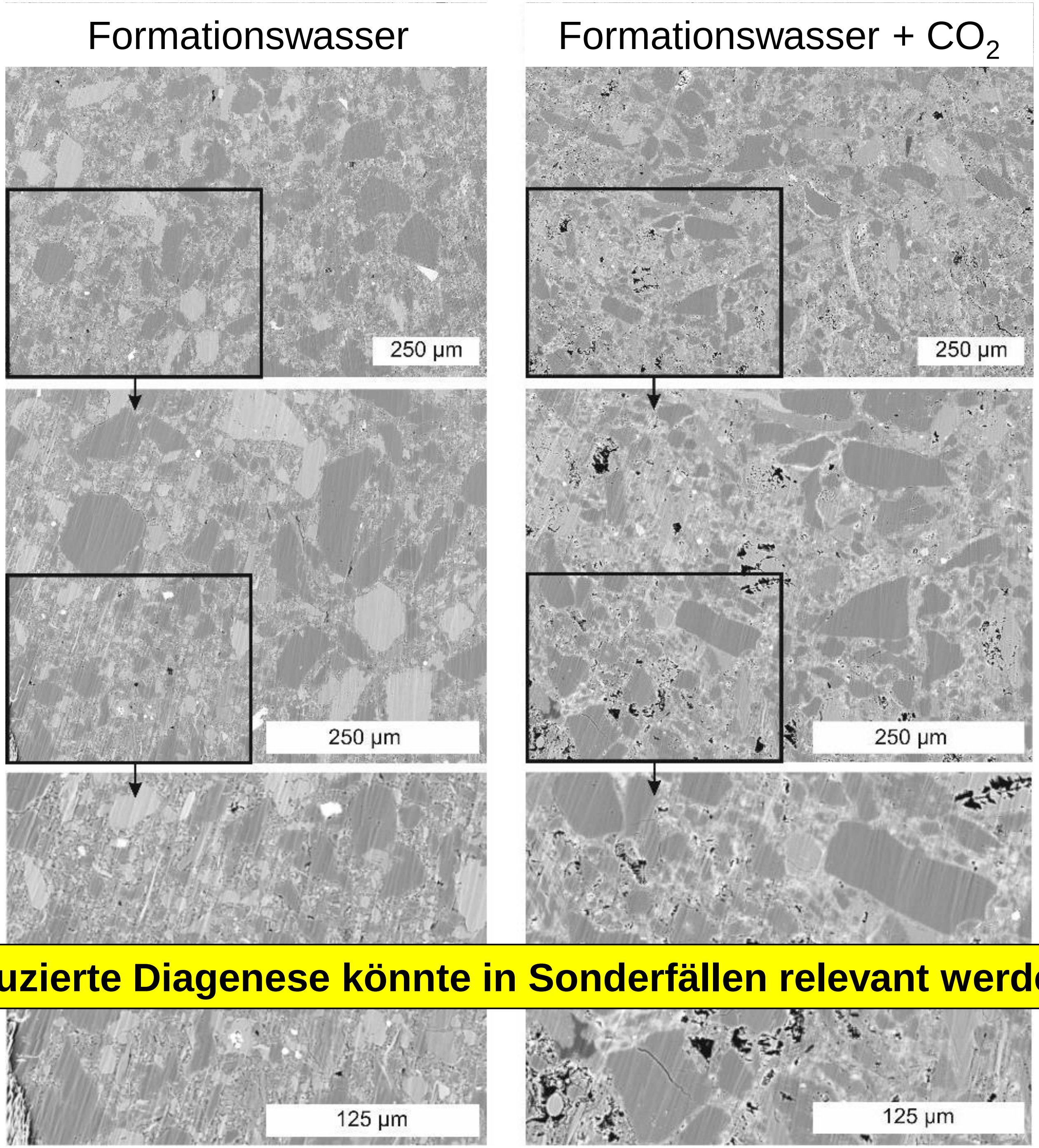


Bensing et al. (2022)

Experimentelle Validierung

Cc-zementierter Silt-/Sandstein

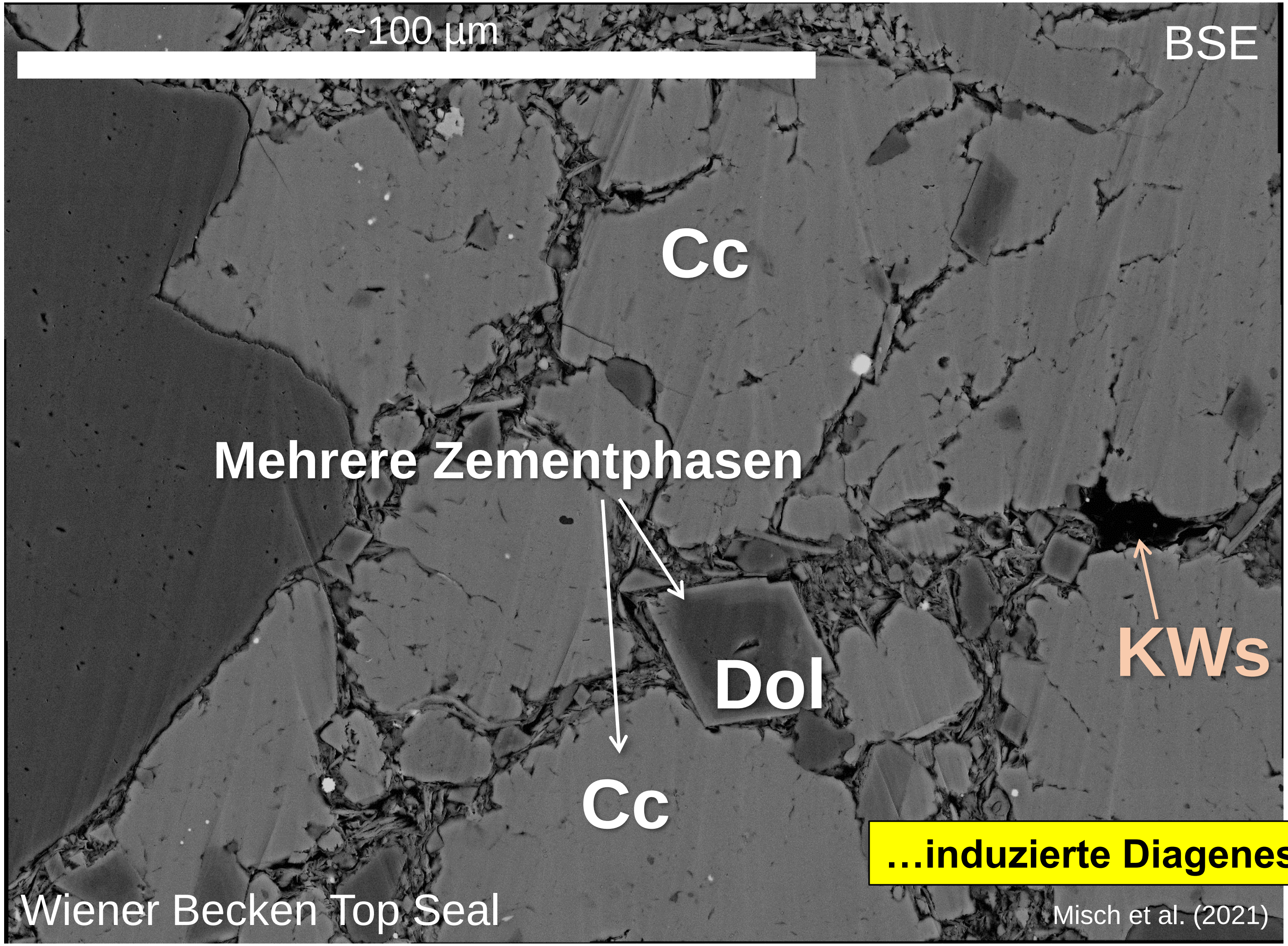
30 Tage: Formationswasser + CO_2



Induzierte Diagenese könnte in Sonderfällen relevant werden!

Analogstudien: z.B. Kohlenwasserstoffmigration

Karbonatlösung & **Re-Mineralisierung als Porenzement**

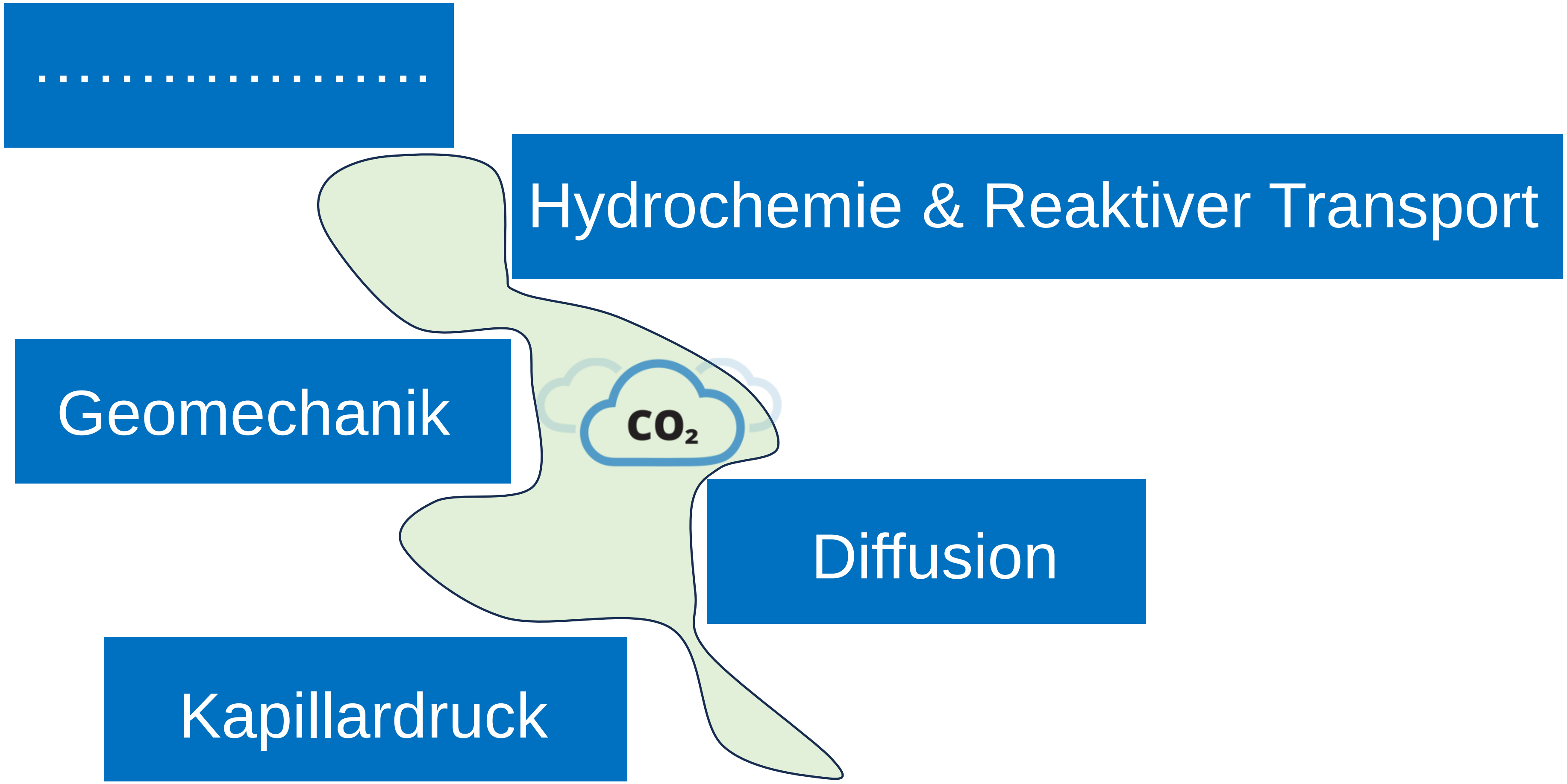


Beobachtungen KW-Migration

…induzierte Diagenese kann Sealkapazität verbessern.

Zusammenfassung

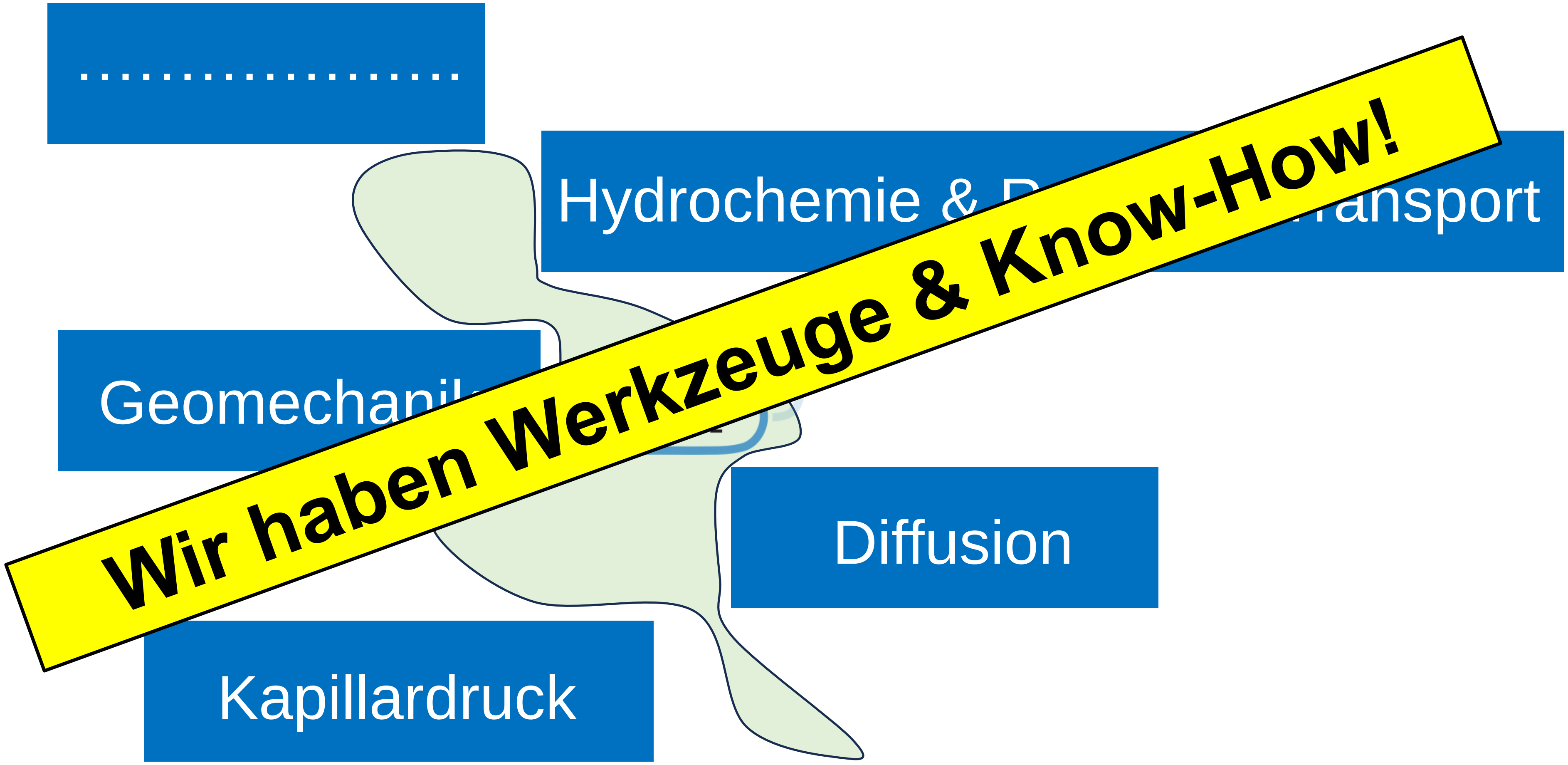
Barrieresicherheit = Betrachtung einer **Vielzahl an Variablen**
(und aller Einflussfaktoren!)



Referenzen zum Vortrag auf Anfrage.

Zusammenfassung

Barrieresicherheit = Betrachtung einer **Vielzahl an Variablen** (und aller Einflussfaktoren!)



Referenzen zum Vortrag auf Anfrage.

Danke! Fragen?

Energy Geosciences

David Misch

Referenzen zum Vortrag auf Anfrage.

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