



Schweizerische Eidgenossenschaft
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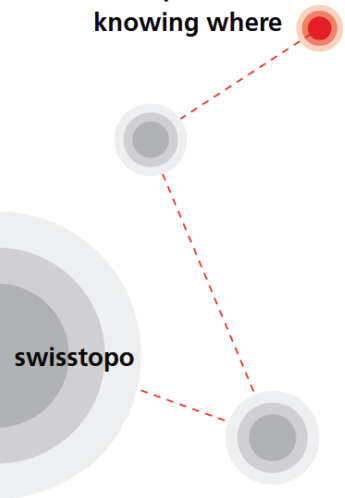
Bundesamt für Landestopografie swisstopo
Landesgeologie

wissen wohin
savoir où
sapere dove
knowing where

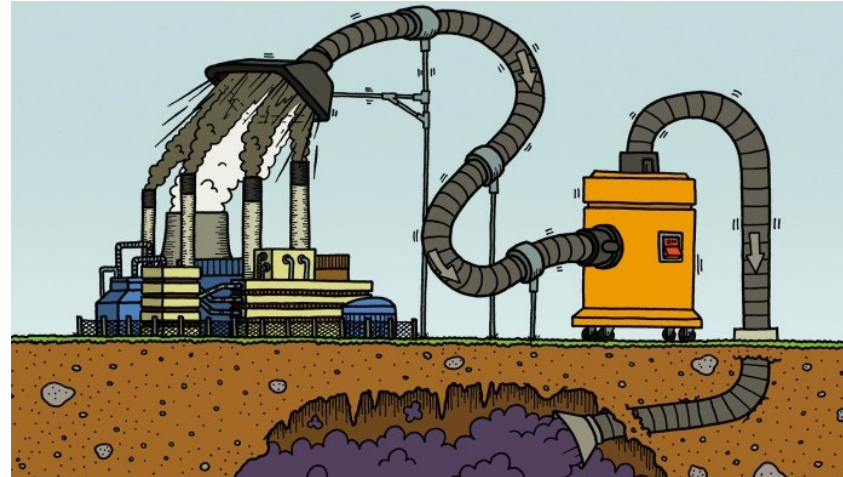
CO₂-Speicherung im Untergrund

Kolloquium swisstopo

02. Februar 2024



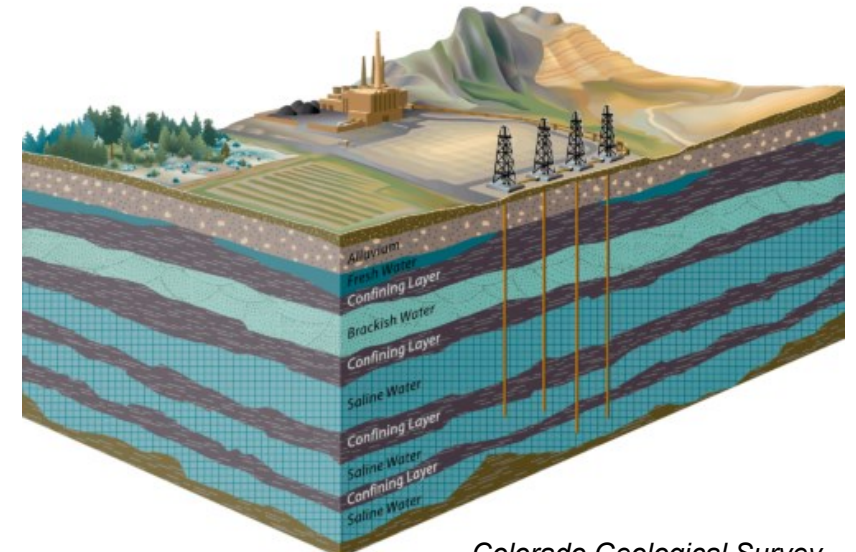
CCS – Carbon Capture & Storage



Financial times



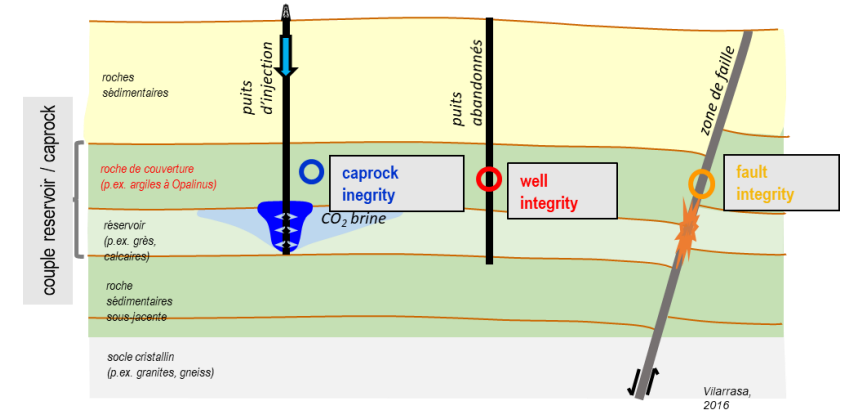
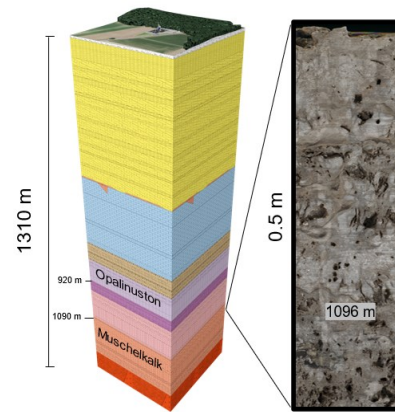
Clima works



Colorado Geological Survey



Warum swisstopo



Wissen über den Untergrund:
Erkundung Untergrund
«Prospektion»

Kompetenzen
Aufbauen:
Eigenschaften

Experimente Mont Terri:
Charakterisierung
Deckgestein



Programm

Sophie Wenger Hintz – Sektion Klimapolitik – Bundesamt für Umwelt (BAFU)

Viola Becattini – Senior Scientist – ETH Zürich / DemoUpCARMA

Christophe Nussbaum – Leiter des Mont Terri Projektes – swisstopo

Herfried Madritsch – Koordinator Geothermie & CCS/NET – swisstopo



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Eidgenössisches Departement für Umwelt, Verkehr,
Energie und Kommunikation UVEK
Bundesamt für Umwelt BAFU
Abteilung Klima

CO₂-Untergroundspeicherung: Bedeutung für die Klimapolitik

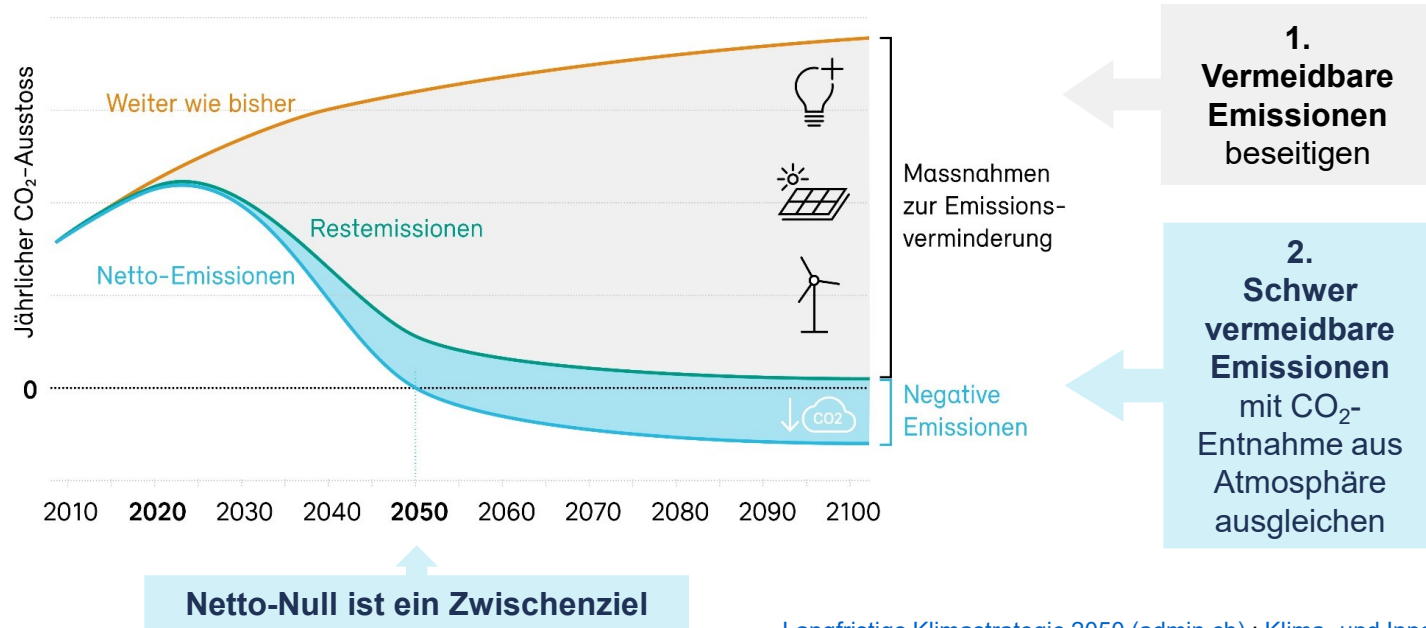
Sophie Wenger, BAFU, Sektion Klimapolitik

swisstopo Kolloquium, 2. Februar 2024



Langfristige Klimapolitik:

Treibhausgasemissionen deutlich senken,
CO₂-Entnahme aus Atmosphäre erhöhen

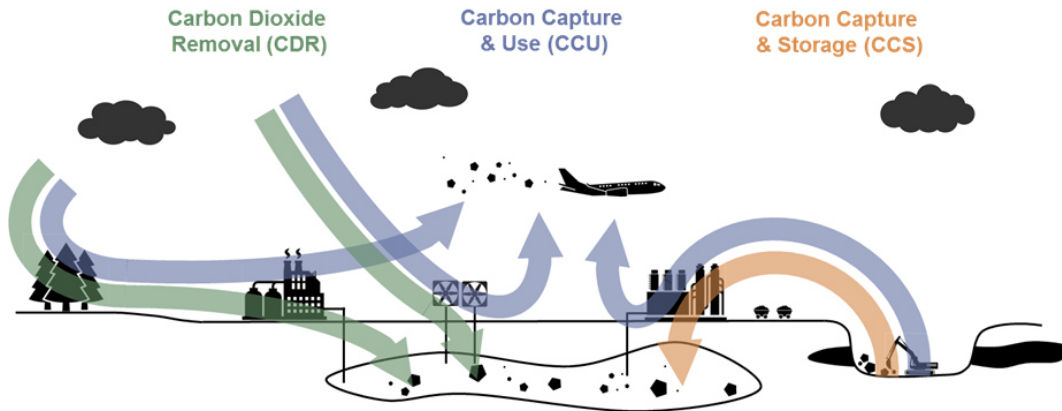


[Langfristige Klimastrategie 2050 \(admin.ch\)](#) ; [Klima- und Innovationsgesetz](#)



Was der Bund unter CO₂-Entnahme und -Speicherung versteht

**Negativemissions-
technologie (NET)**
= dauerhafte
CO₂-Entnahme aus
Atmosphäre



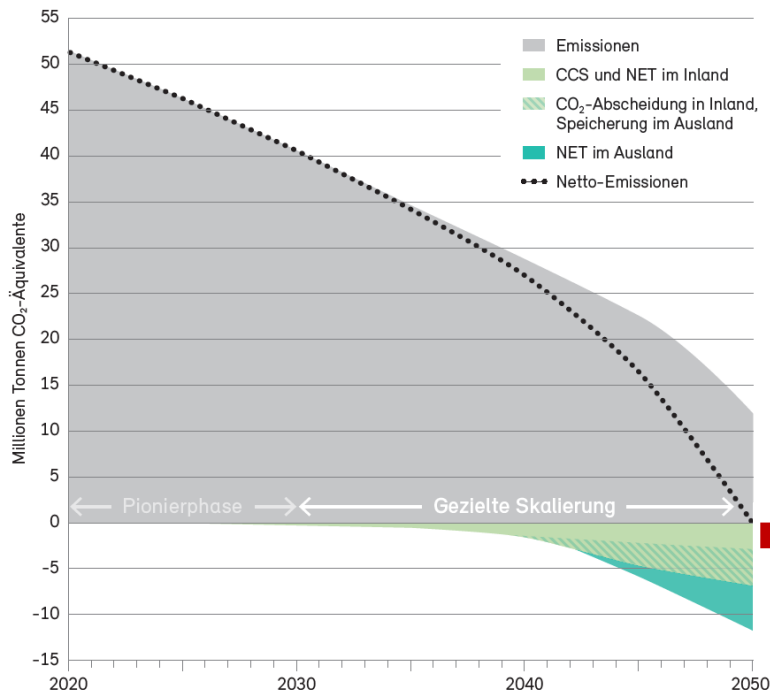
Fossiles CCS
= Reduktion von
CO₂-Emissionen

CO₂-Entnahme und -Speicherung = Sammelbegriff für NET und CCS

Bildquelle: <https://cr-hub.org>



Netto-Null Zielbild ...



... sieht relevante Rolle für
Schweizer CO₂-Untergrundspeicher
vor, sofern erschliessbar.

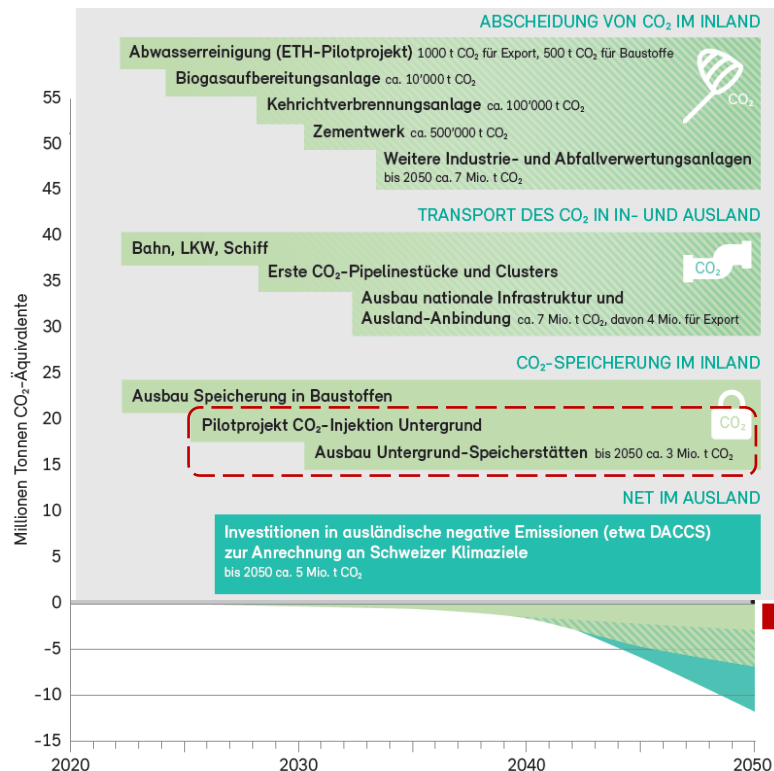
Geschätzte Speichermengen 2050

- Abscheidung von **7 Mt** CO₂ p.a. in CH
→ Speicherung von **3 Mt CO₂ p.a. in CH**
und 4 Mt CO₂ in Ausland
- Und **5 Mt** CO₂ p.a. in Ausland (NET)

[Bericht des Bundesrates vom 18. Mai 2022](#)



Netto-Null Zielbild ...



... sieht relevante Rolle für Schweizer CO₂-Untergrundspeicher vor, sofern erschliessbar.

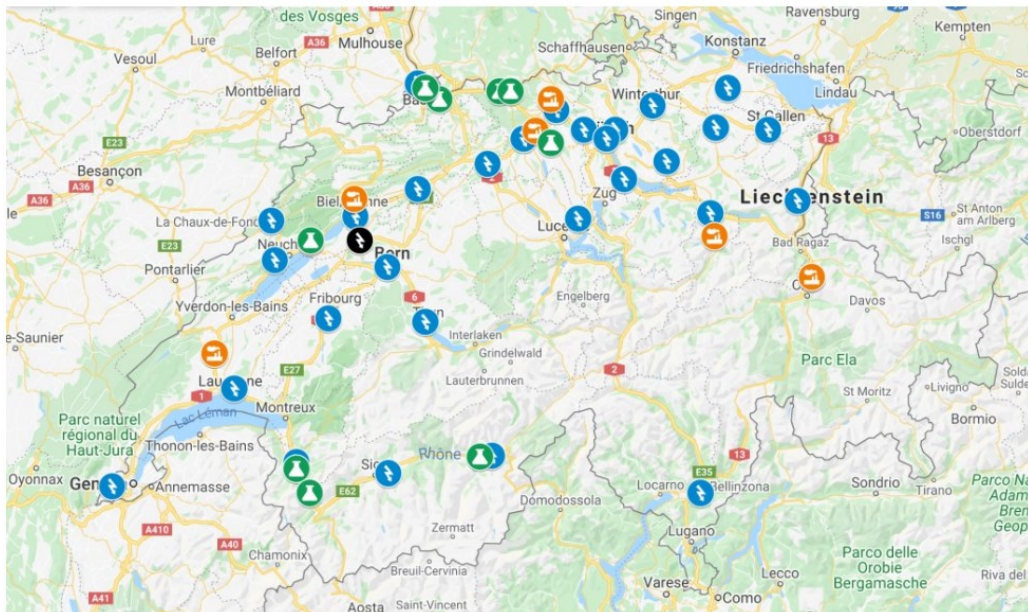
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[Bericht des Bundesrates vom 18. Mai 2022](#)



«Grosse» CO₂ Quellen sind im ganzen Land verteilt (~40)



KVA (29)

Total 4.5 Mt CO₂ p.a.,
50% biogen

Zementwerke (6)

Total 2.6 Mt CO₂ p.a.,
zT. biogen

Chemie/Pharma (9)

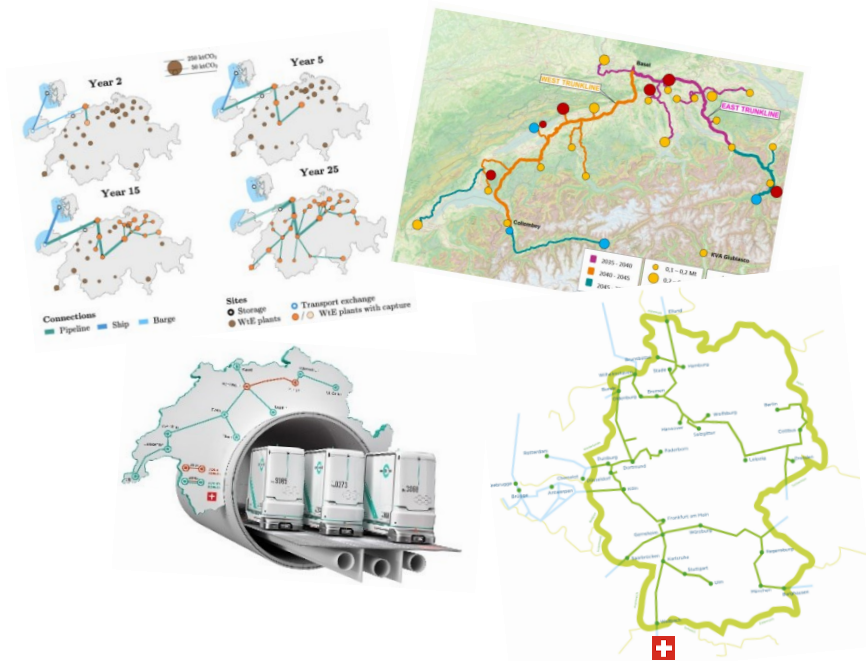
Total 1.1 Mt CO₂ p.a.

(Daten von 2018)

Quelle: [Interim Report](#), DemoUpCARMA



CO₂-Quellen müssen an zukünftiges Transportnetz angeschlossen werden

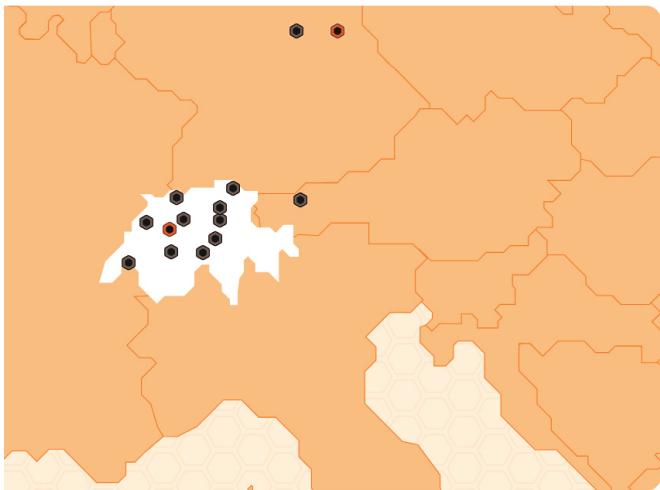


- Umgang mit multimodalem Transport (LKW/Bahn/Schiff)?
- **CO₂-Pipeline**: Wie wird Aufbau organisiert?
- **Anschluss** an in- und ausländische Speicher?

Quellen: V. Becattini et. al. (2022); dena / BAK (2023), Cargo sous terrain (2023), OGE (2023)



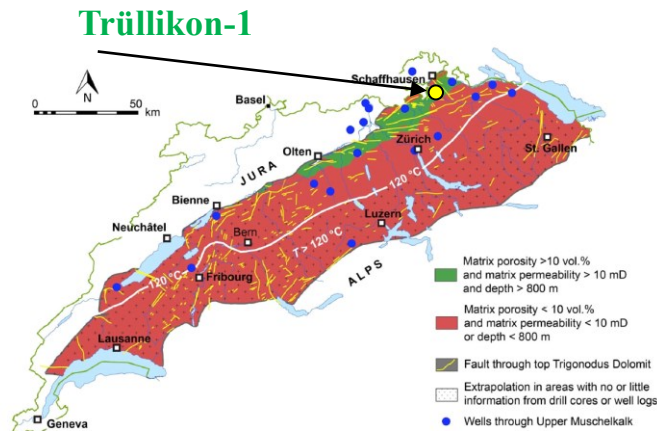
CO₂-Speicheroptionen in der Schweiz



Sites in operation CO₂ source CO₂ storage

CO₂-Speicherung heute in **Beton**
möglich (neustark und andere Anbieter)

Quellen: [neustark](#) | [Get to know us](#);
[Medienartikel](#) zu möglichem CO₂-Injektions-Pilotprojekt in Kt. ZH



Potenzial für **Untergrund-**
speicherung primär im Mittelland
(nationales Erkundungsprogramm in Arbeit,
Pilotprojekt CO₂-Injektion in Prüfung)



Jetzt wichtig: Praxiserfahrung

Aktuelle Massnahmen und Arbeiten



§ Rechtsrahmen	Grundlagen und Projekte
• Klima- und Innovationsgesetz (Art. 6): Förderung geplant ab 2025 • CCS in Emissionshandel: Anrechnung geplant ab 2025 • Internationale Rahmenbedingungen: Klärung durch Behörden • Robuster Rechtsrahmen ab 2030 vorgesehen, Prüfung von Optionen durch Bundesrat Ende 2024 (inkl. möglichst verursachergerechter Finanzierung)	• Nationales Erkundungsprogramm Untergrund (Motion 20.4063) • Pilot CO₂-Injektion (in Prüfung) • KVA: Branchenvereinbarung / CO₂-Kompetenzzentrum Linth • Stiftung Klimarappen: Förderung von fünf CO₂-Speicherprojekten bis 2030 • Nationale Arbeitsgruppe CCS/NET (inkl. Industrie, Kantone, Gemeinden, s. Mandat)



Fazit

- **Pionierphase bis 2030 ist aufgegleist.**

→ *Jetzt brauchen wir Praxiserfahrung!*

- **Robuster Rahmen für die gezielte Skalierung bis 2050 ist gemeinsam zu entwickeln.**

→ *Stakeholder sind eingeladen, sich mit Ideen und Bedürfnissen einzubringen (nationale Arbeitsgruppe, Positionspapiere, Vernehmlassungen etc.).*

Danke. Merci. Grazie. climate@bafu.admin.ch

DemoUpCARMA: Die wichtigsten Erkenntnisse im Überblick

Viola Becattini, Marco Mazzotti

2. Februar 2024

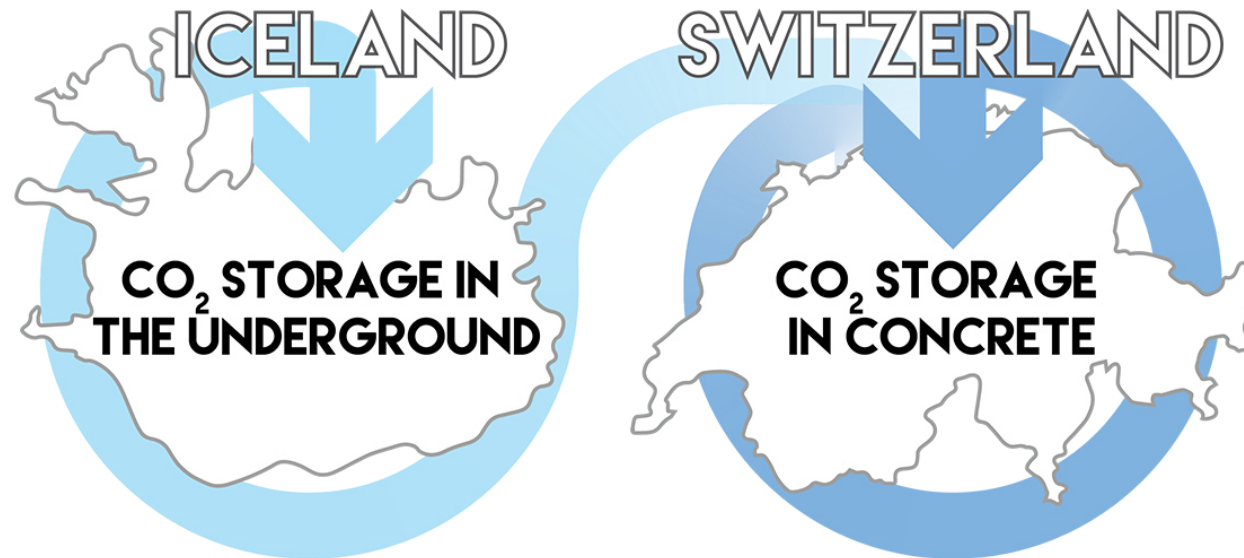
Kolloquium Swisstopo: CO₂ Speicherung im Untergrund

Auf dem Weg zu Netto-Null-Emissionen: Lösungen für das CO₂-Management in der Schweiz

- Im Jahr 2050 müssen **7 Mio. t CO₂** aus kleinen und grossen Punktquellen (zwischen 30 und 400 kt CO₂/Jahr), die über das ganze Land verteilt sind, aufgefangen, transportiert und **gespeichert werden**
- CO₂ kann dauerhaft gespeichert werden:
 - In **Abbruchbeton** in der Schweiz → eine machbare Lösung, mit begrenzter Kapazität
 - Im **Untergrund** im Ausland → keine kurzfristige, gross angelegte geologische Speicherung im Inland; sehr lange Lieferketten zu den Speicherzentren in Nordeuropa
- Um die Lücke zur Erreichung des Ziel für 2050 zu schliessen, müssen **so früh wie möglich** Lösungen aufgezeigt und umgesetzt werden.



Konzept und Partner



ETH zürich EPFL FSO Empa eawag aquatic research UNIVERSITÉ DE GENÈVE FACULTÉ DES SCIENCES RISIKO DIALOG ZUKUNFT GESTALTEN. GEMEINSAM.

Wissenschaft, Forschung,
NGO
Emittenten

JURA materials arxada Lonza anabern scienceINDUSTRIES SWITZERLAND Stadt Zürich Entsorgung + Recycling VBSA ASIR

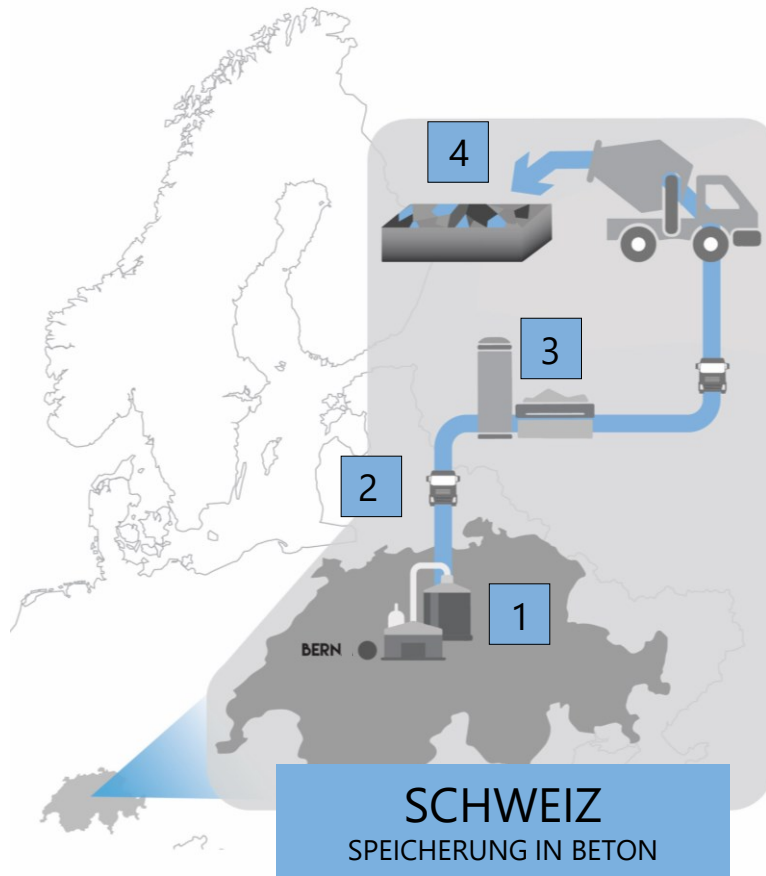
CASALE PLANTS FOR A NEW PLANET. SINCE 1921. ChemOil SBB CFF FFS Cargo CO2 NEUTRAL KSTLI SULZER Salzmann AG TRANSPORTE south pole perspectives climate research

Lösungsanbieter

neustark Carbfix climeworks

Climate-Tech-Unternehmen

Inländische Lösung: CO₂-Nutzung und -Speicherung in Abbruchbeton



CO₂-Abscheidung und -Verflüssigung
in einer Kläranlage mit



Dauerhafte CO₂-Speicherung durch
Karbonatisierung von Recycling-
Betongranulat (RCA) und Betonmischwasser



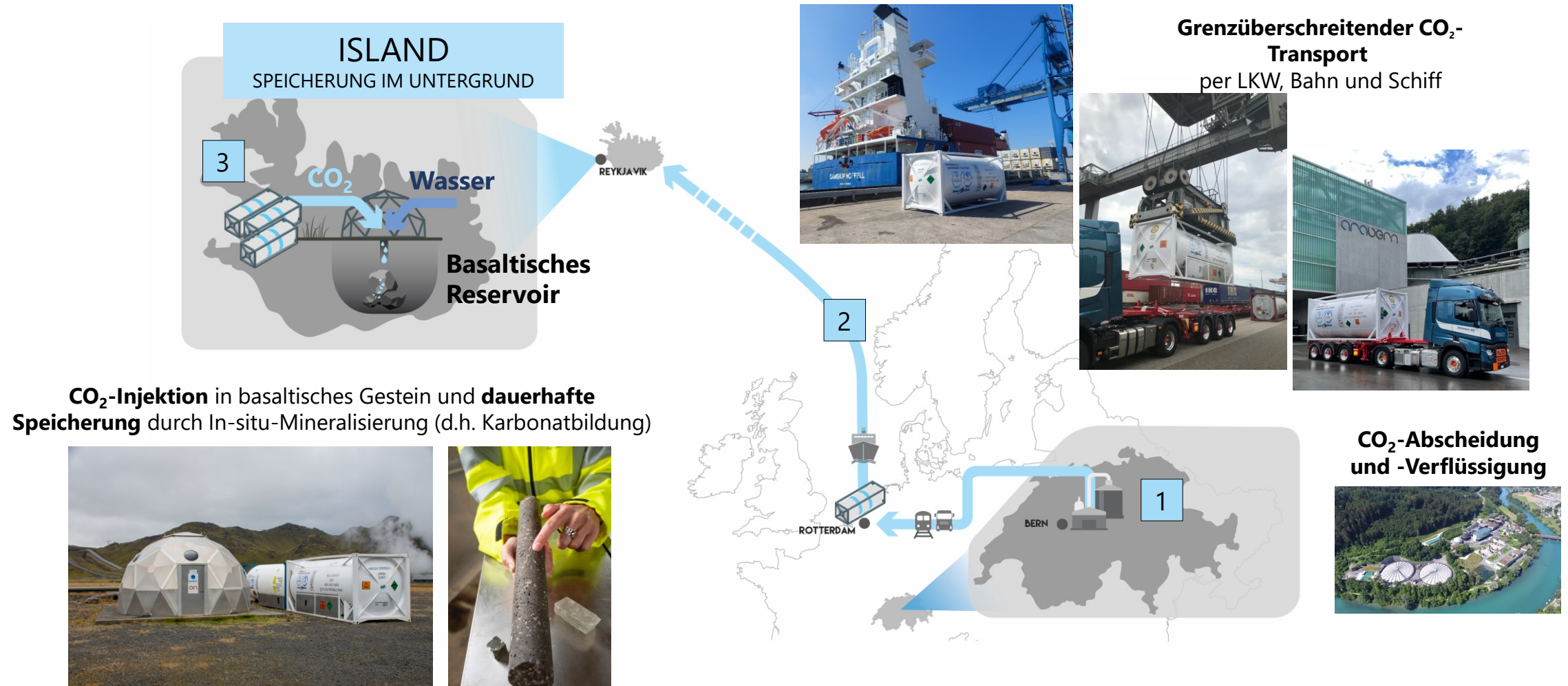
CO₂-Transport zur Betonrecyclinganlage und
Zwischenlagerung



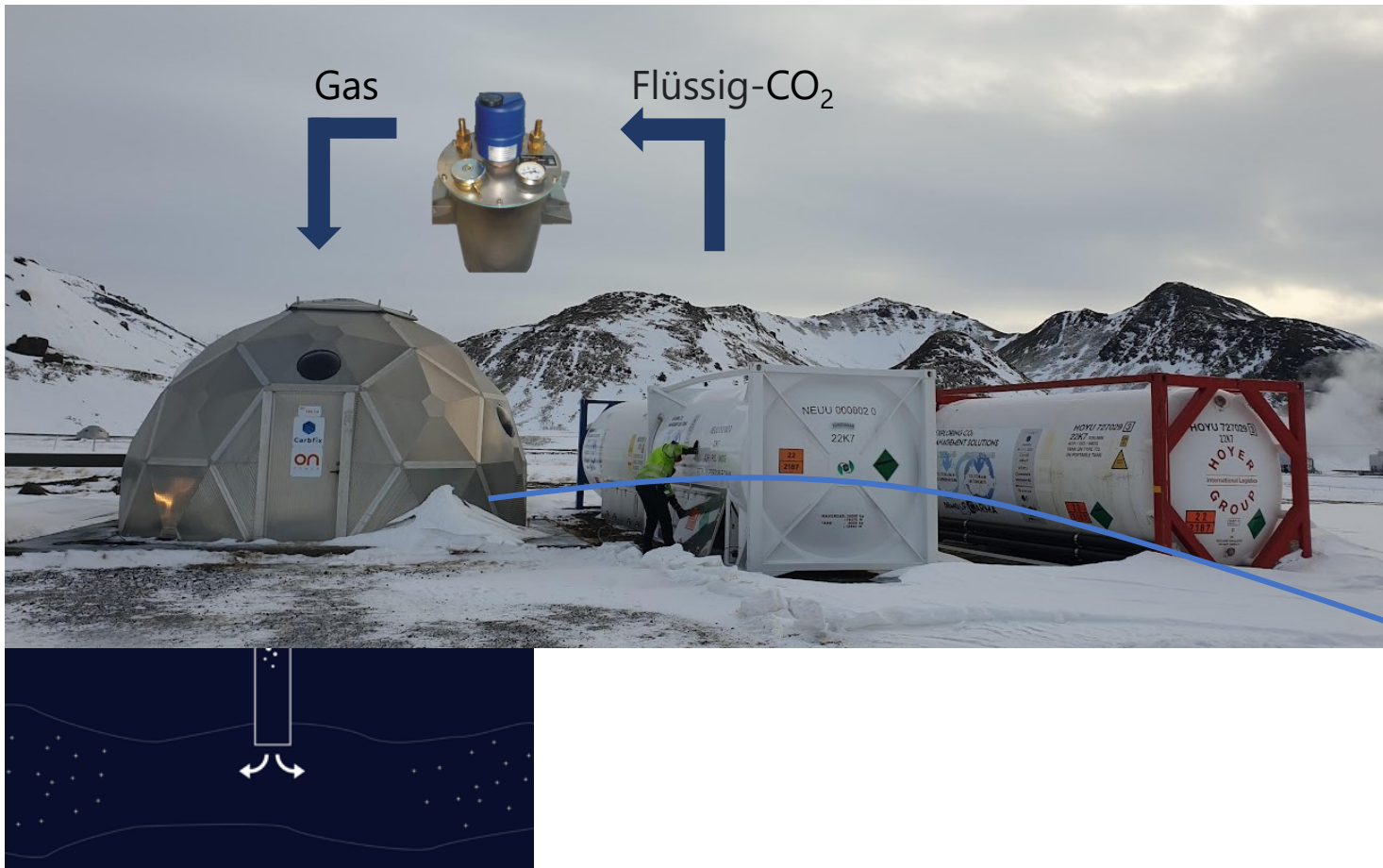
CO₂-Nutzung von karbonatisiertem Recycling-
Betongranulat für Neubauten



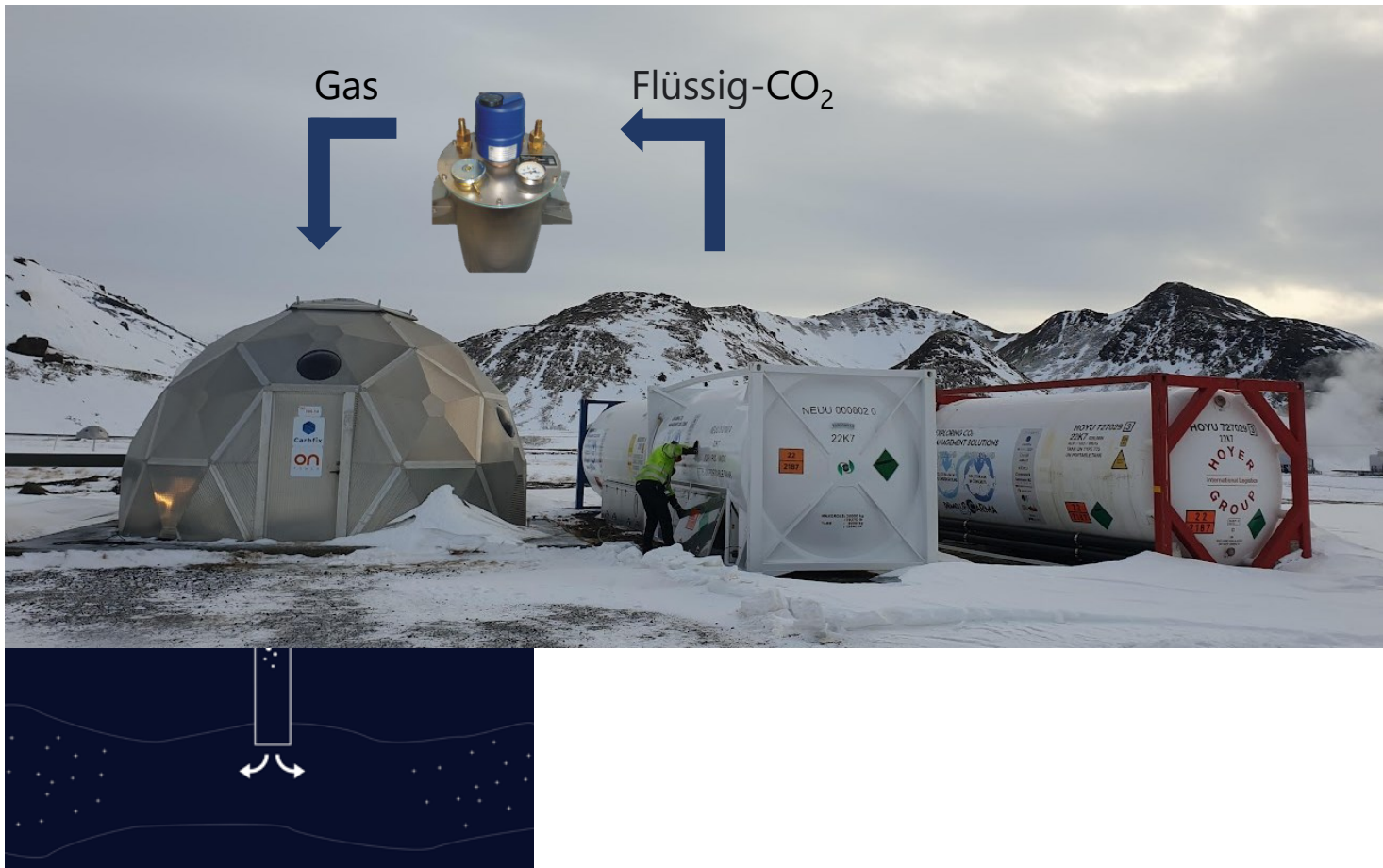
Internationale Lösung: CO₂-Transport und Speicherung im Untergrund



CO₂-Speicherung im Untergrund: Injektion bei Hellisheiði



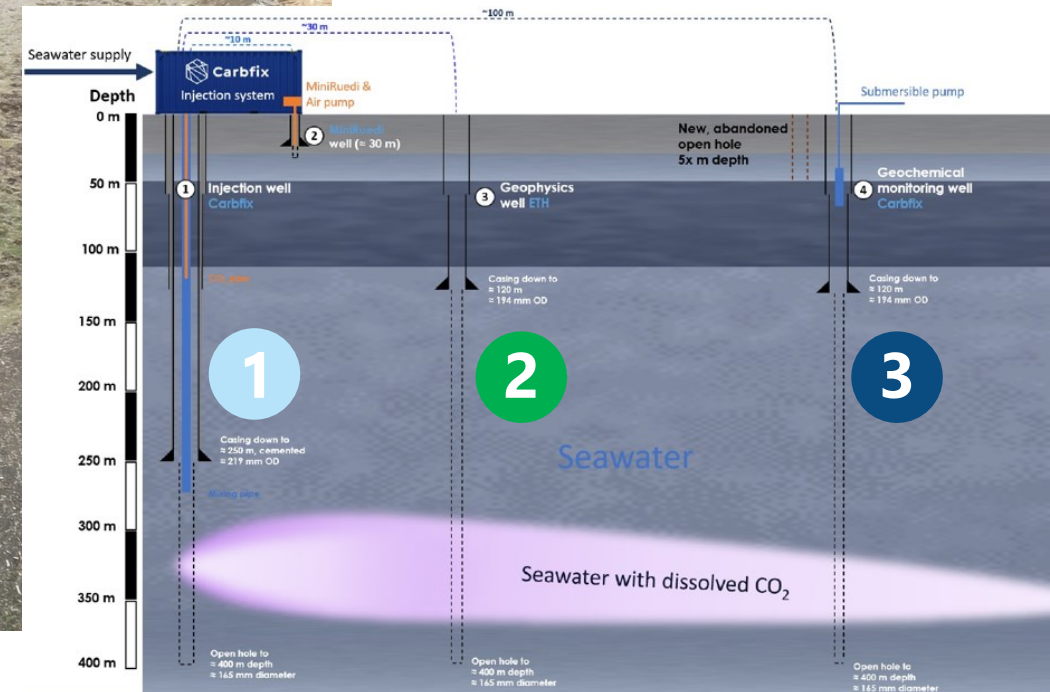
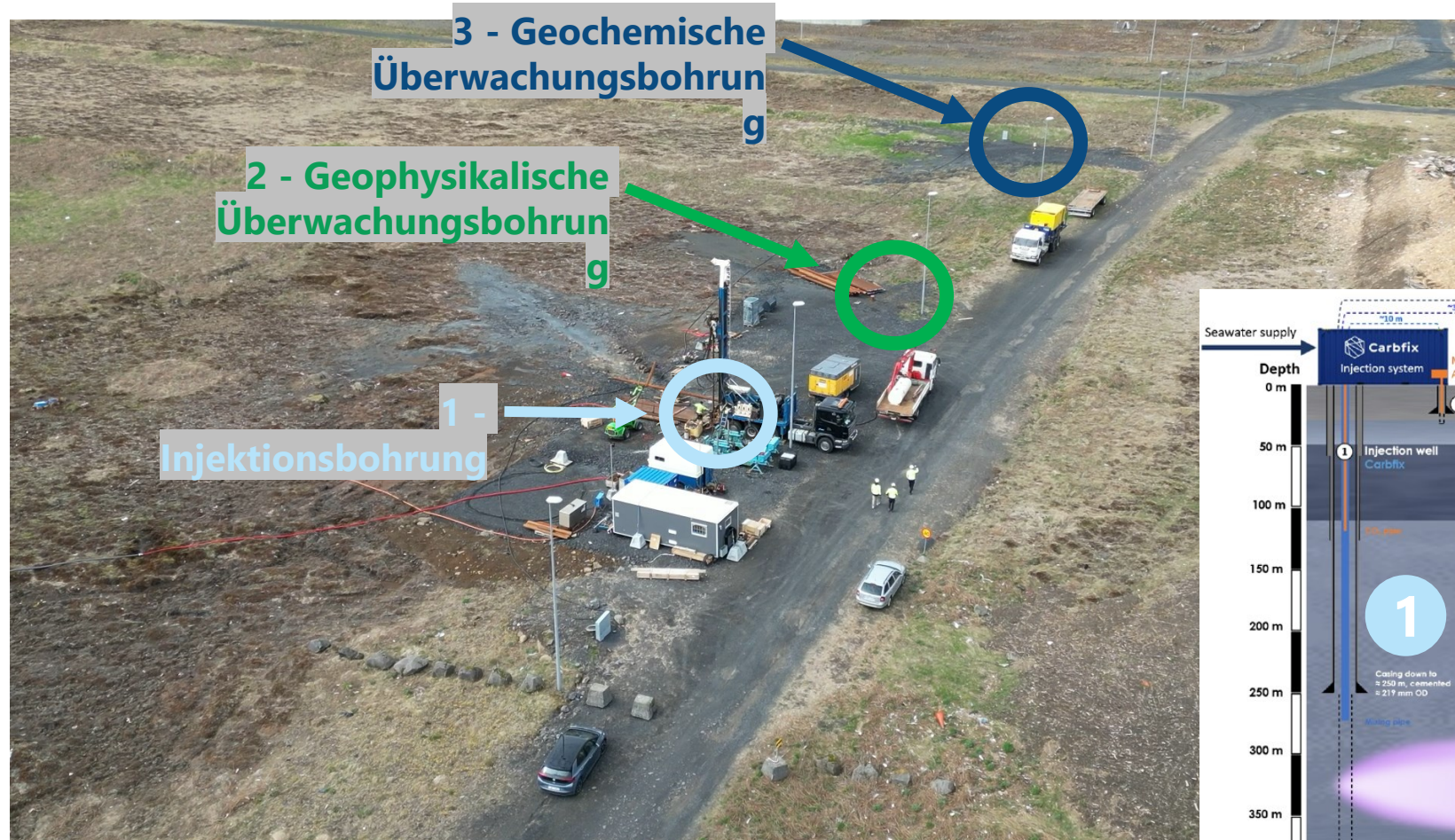
CO₂-Speicherung im Untergrund: Injektion bei Hellisheiði



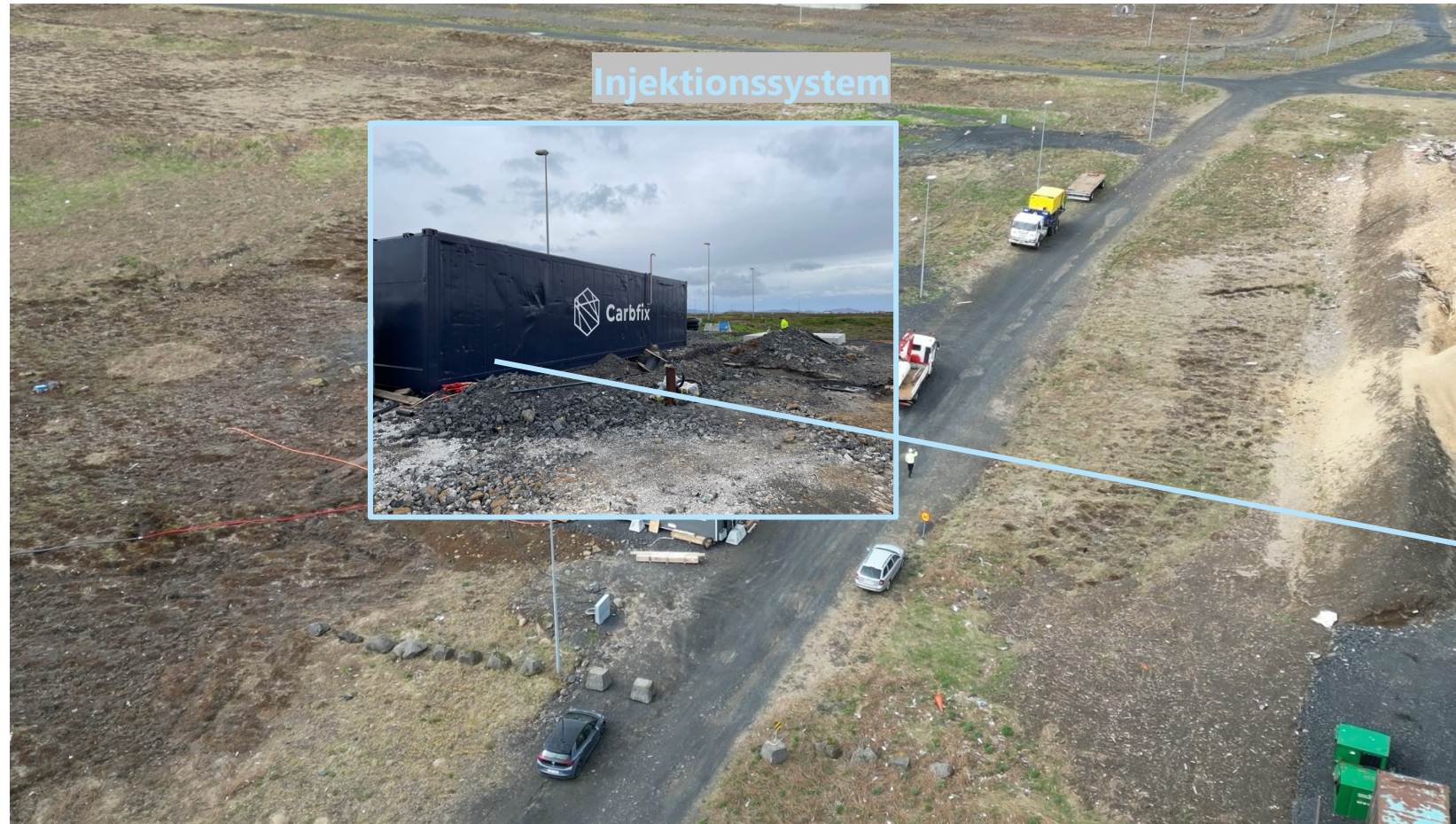
CO₂-Speicherung im Untergrund: Die Injektionsstelle in Helguvík



CO₂-Speicherung im Untergrund: Die Injektionsstelle in Helguvík



CO₂-Speicherung im Untergrund: Die erste Injektion mit Meerwasser



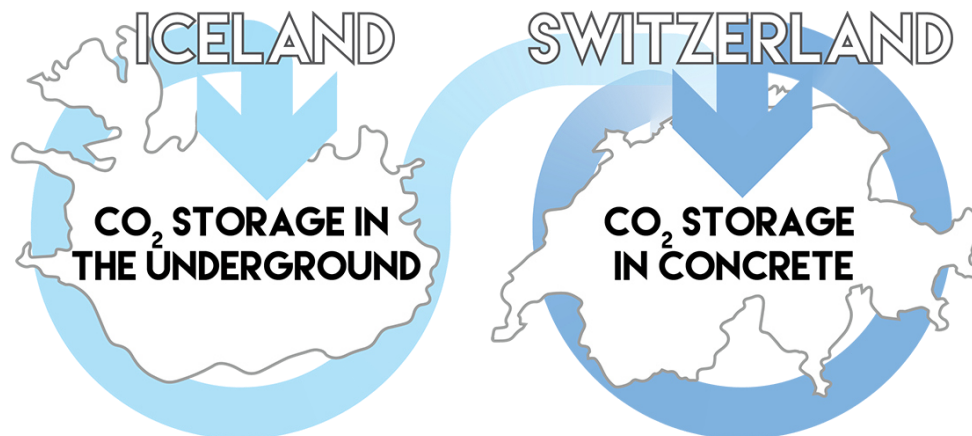
Injektionssystem



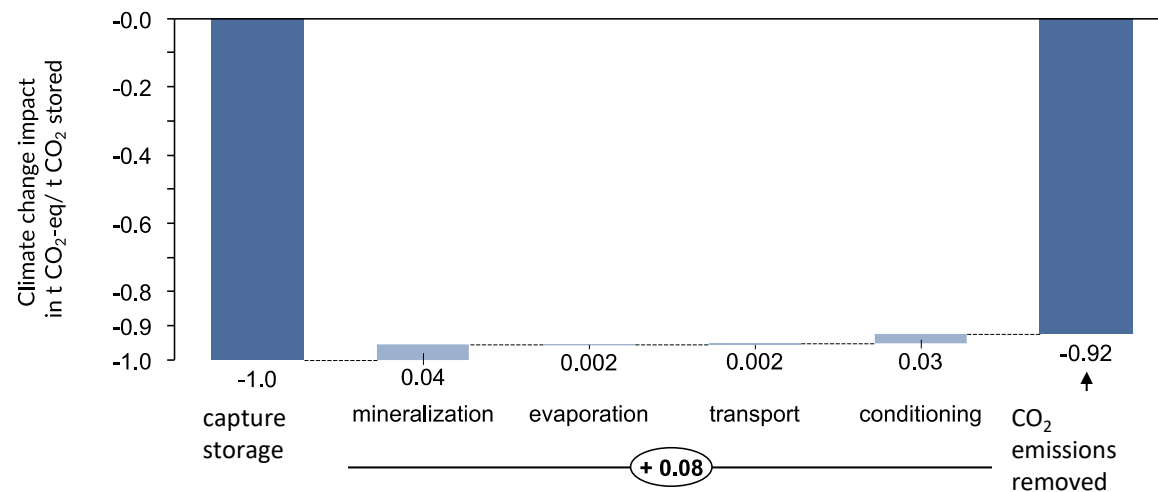
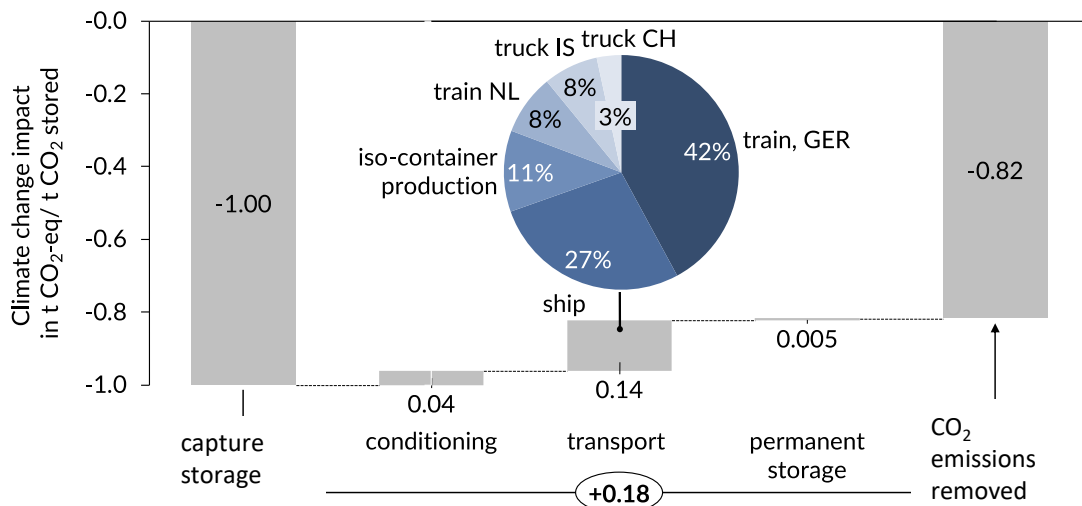
Injektionsbohrung

Sind diese Lösungen effizient?

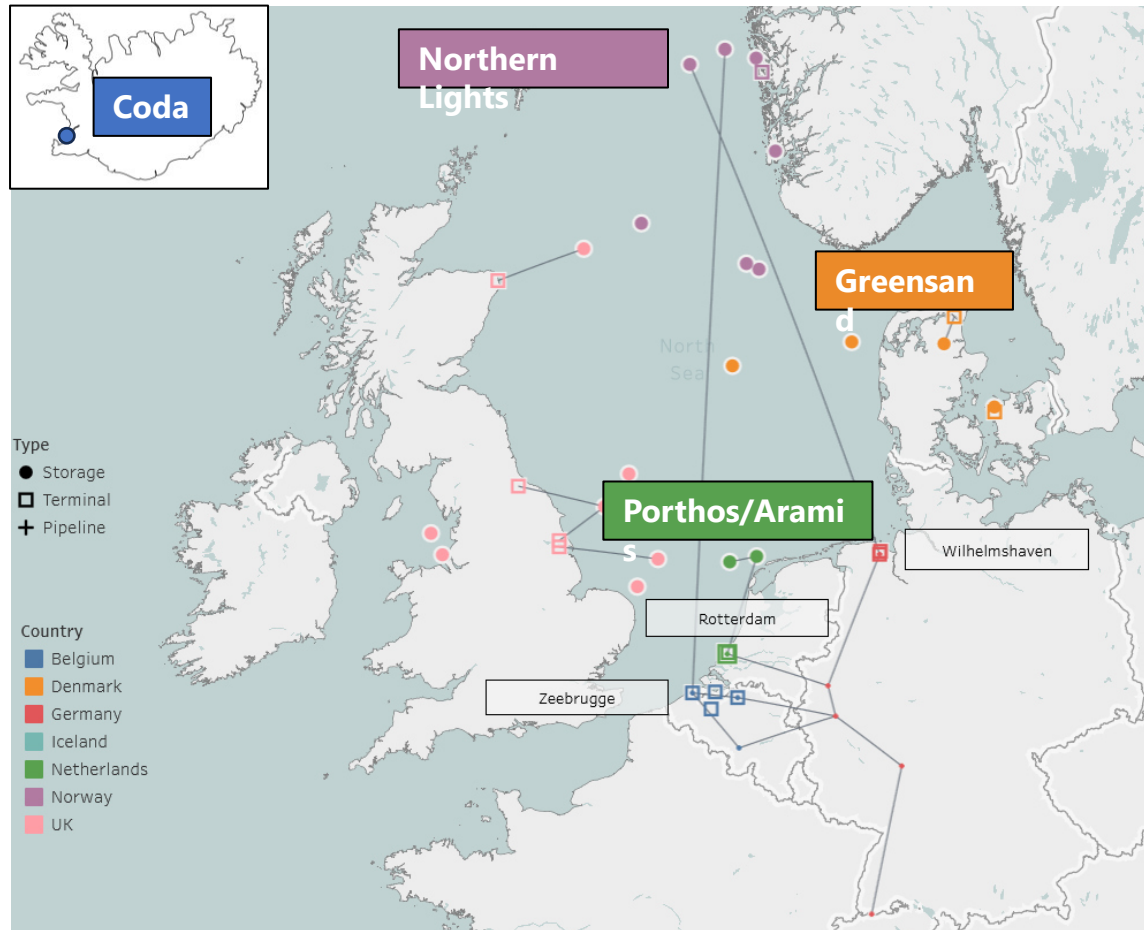
- ✓ Für jede Tonne CO₂, die im isländischen Untergrund gespeichert wird, werden **180 Kilogramm CO₂ wieder freigesetzt**
- Grösster Beitrag durch den Transport, insbesondere Schiff und Bahn in Deutschland
- Mit der Dekarbonisierung des Verkehrssektors werden diese zusätzlichen Emissionen abnehmen



- ✓ Für jede Tonne CO₂, die in Recyclingbeton gespeichert wird, **werden 80 Kilogramm CO₂ wieder freigesetzt**.
- Grösster Beitrag durch CO₂-Aufbereitung und Mineralisierung
- Diese Lösung führt zwar zu einer geringeren Umweltbelastung, ist aber durch die Speicherkapazität von Beton begrenzt (bis zu ca. 150 000 tCO₂/Jahr in der Schweiz)

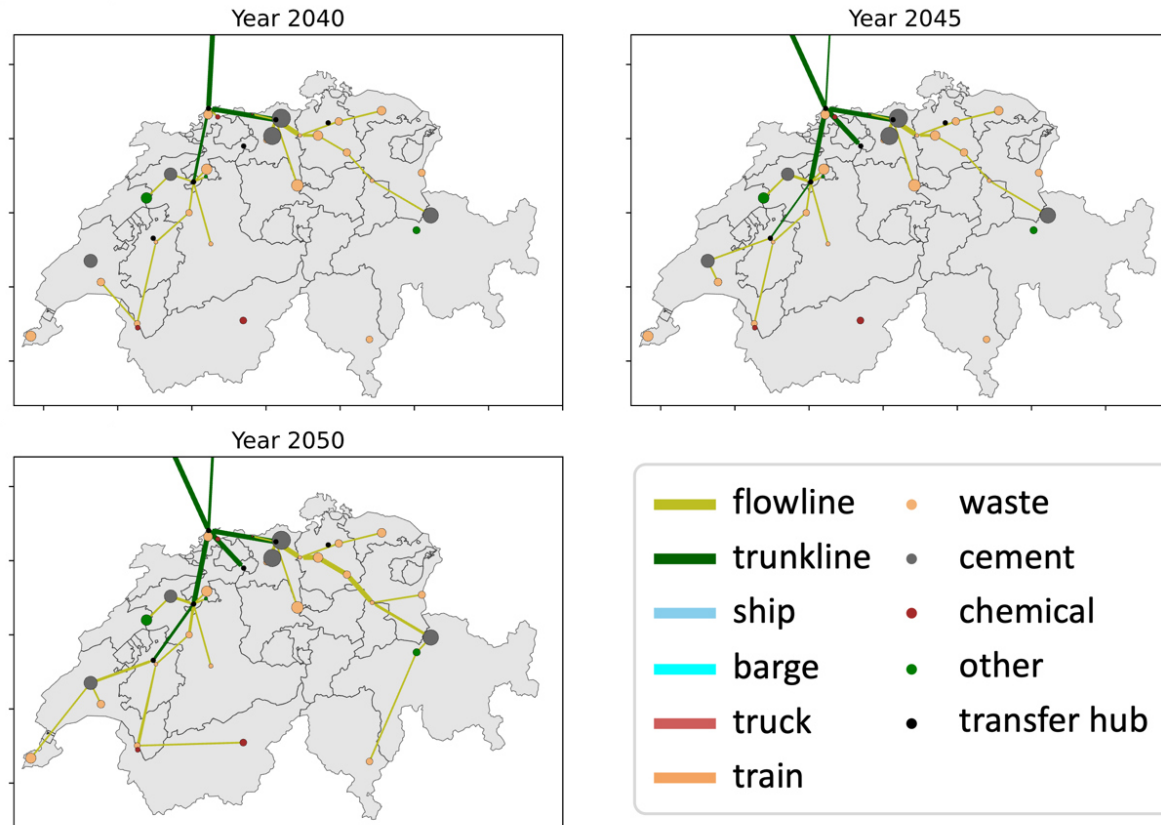


Upscaling von CO₂-Management-Lösungen: ein europäisches CO₂-Pipeline-Netz



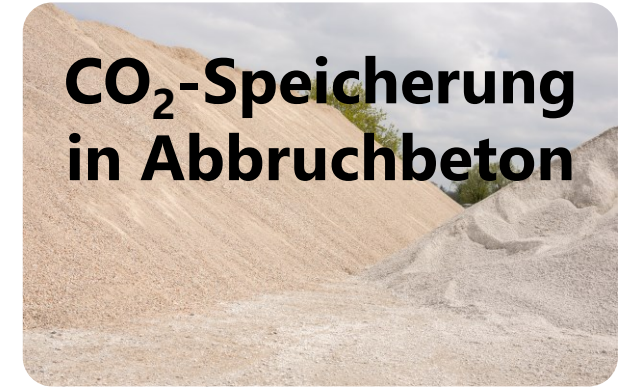
- CO₂-Speicherhubs werden hauptsächlich in Nordeuropa entwickelt
- Die meisten der aktuellen CO₂-Transportpläne in Europa **verbinden Emittenten mit Exportterminals an der Küste** und dann mit der Speicherung
- Das grösste geplante **Onshore-Netz** verbindet Emittenten in Deutschland, den Niederlanden und Belgien über Pipelines mit verschiedenen Export- und Importterminals an der Nordsee
- Von den Exportterminals aus sollen **Hochleistungspipelines** das CO₂ zu den Kontinentalschelfen der Niederlande, des Vereinigten Königreichs, Dänemarks und Norwegens transportieren, wo es **offshore** gespeichert werden soll

Upscaling von CO₂-Management-Lösungen: CO₂-Pipeline-Transport in der Schweiz



- Ein Leitungsnetz innerhalb und ausserhalb der Schweiz: **Senkung der Transportkosten um 65%** im Vergleich zur heutigen Lösung
- **Lange Planungs- und Bauphase**, mit nur sehr vorläufigen Plänen
- **Organisations-, Führungs- und Finanzierungsmodell**: öffentlich, privat oder öffentlich-private Partnerschaft
- **Strategische internationale Ausrichtung** für Planung, Bau und Betrieb eines europäischen Pipelinenetzes **erforderlich**

Upscaling von CO₂-Management-Lösungen: systemischer Ansatz



Schlussfolgerungen und Erkenntnisse

- Die Lösungen für das CO₂-Management sind sowohl **technisch als auch ökologisch tragfähig**; beide Lösungen werden benötigt, um die Klimaziele zu erreichen
- Pilotprojekte ermöglichen die **Ermittlung von Schwachpunkten** und bieten entscheidende Erkenntnisse für den Aufbau einer neuen Industrie
- Die Umsetzung von CCTS/CCUS in grossem Massstab birgt mehrere Herausforderungen, die einen **systemischen Ansatz zur Lösung** erfordern
- Das Projekt hat wesentlich dazu beigetragen:
 - Schaffung einer **Plattform für nationale Stakeholder** zum Austausch über dieses Thema sowohl auf Länderebene als auch mit internationalen Stakeholdern
 - **Aufbau von Kapazitäten**: 30+ Studenten, die sich mit CO₂-Management-Lösungen im industriellen Massstab beschäftigen



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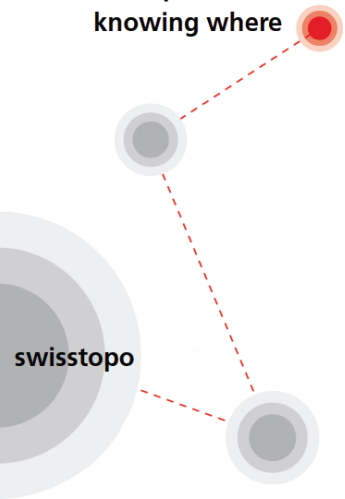
wissen wohin
savoir où
sapere dove
knowing where

Mehr als 12 Jahre Forschung im unterirdischen Felslabor Mont Terri zur Speicherung von CO₂

Kolloquium swisstopo

Christophe Nussbaum, Landesgeologie (swisstopo)

02. Februar 2024

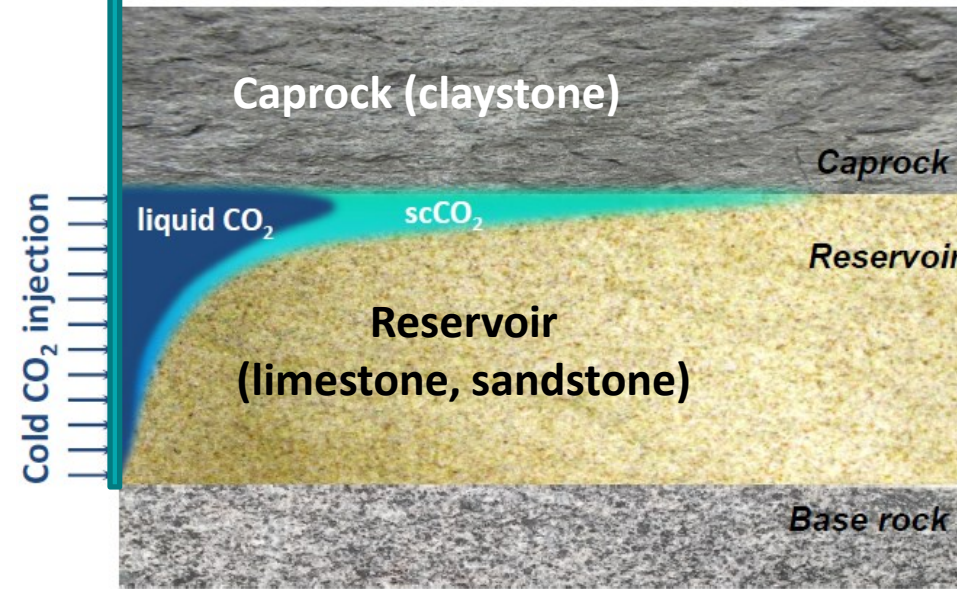
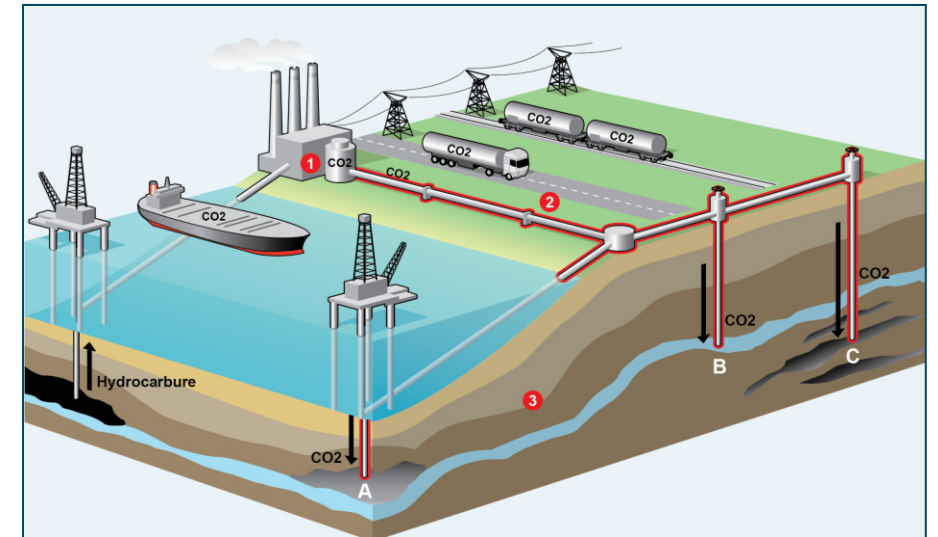
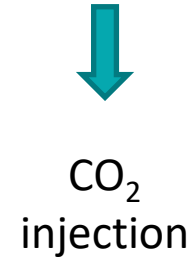




Concept of geological storage of CO₂

CO₂ can be sequestered in deep **saline** aquifer:

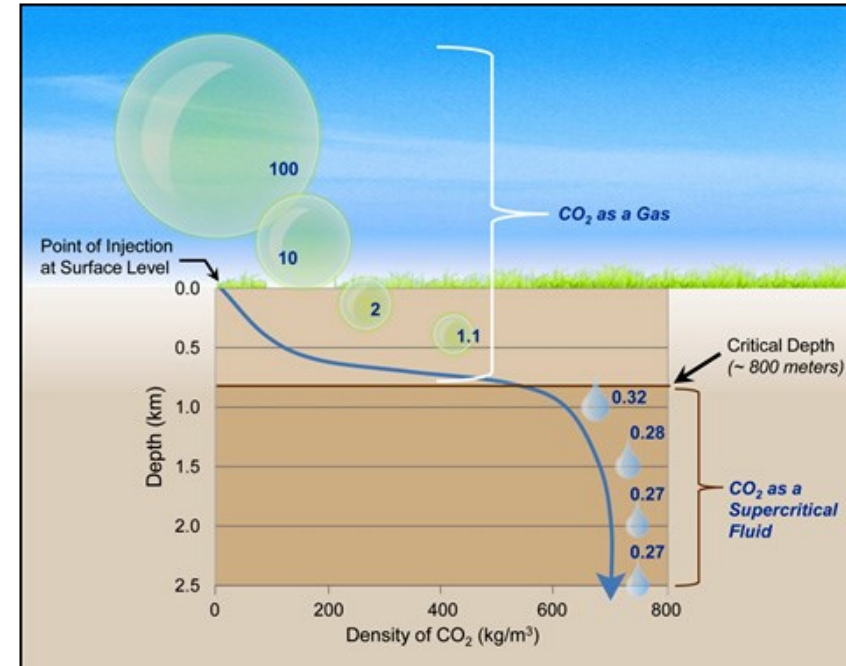
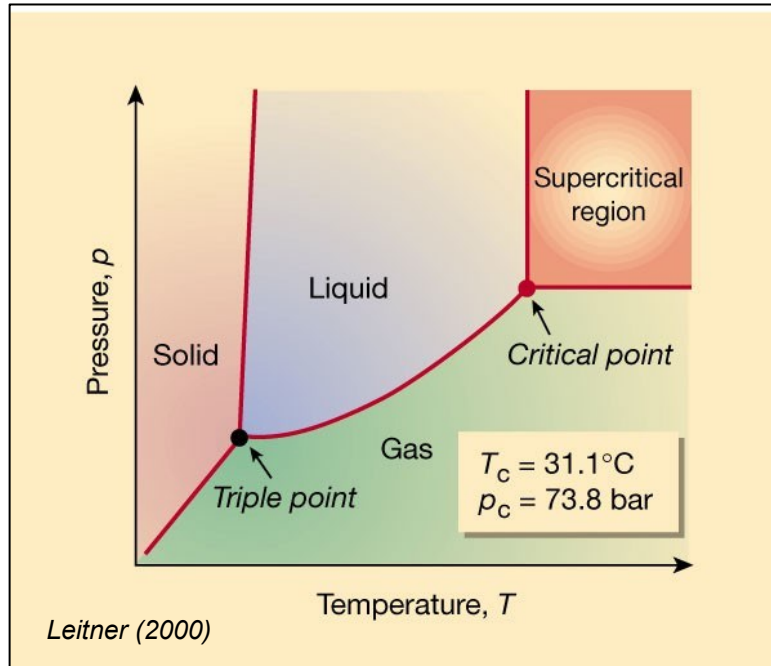
- highly permeable and porous rocks
- >800m depth and saturated with undrinkable water
- widespread and available practically anywhere





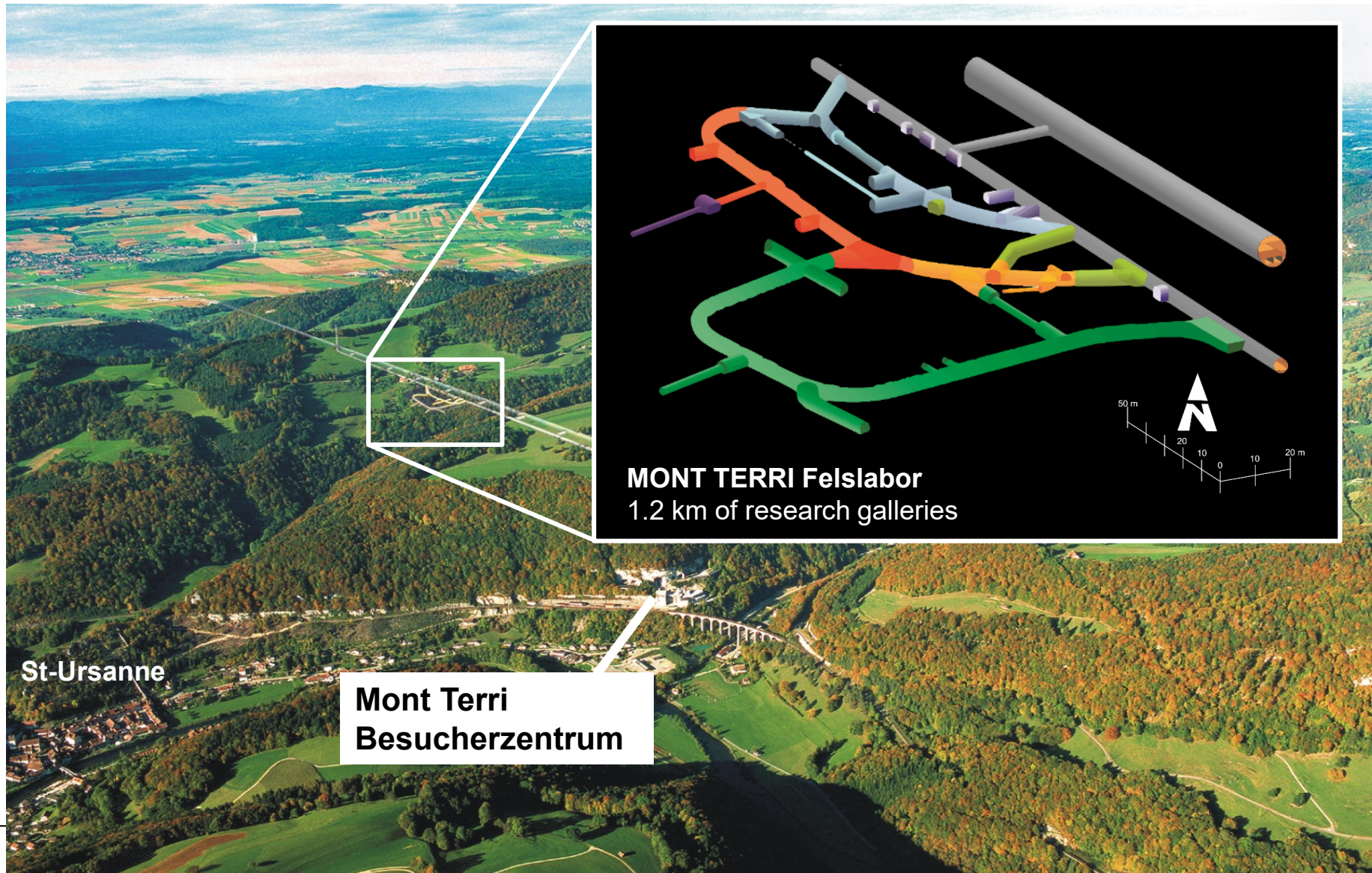
Phase diagramme of CO₂

Beneath 800m underground CO₂ exists in the supercritical state:
temperature > 31.1 °C, pressure > 7.4 MPa, density > 600 kg/m³





Felslabor Mont Terri, Saint-Ursanne (Kanton Jura)





28 Jahre Grundlagen- und angewandte Forschung im Felslabor Mont Terri

The Mont Terri Partners



- swisstopo operates the rock laboratory and directs and coordinates the research programme
- Huge radwaste community since 1996 with 22 Partners, growing CO₂-community since 2011
- Rock laboratory scale is a key to bridge small-scale laboratory experiments to pilot-scale

Mont Terri partners and external sponsors for the CO₂ research at Mont Terri



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Bundesamt für Landestopografie swisstopo
Office fédéral de topographie swisstopo
Ufficio federale di topografia swisstopo
Uffizi federal da topografia swisstopo



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Bundesamt für Energie BFE
Swiss Federal Office of Energy SFOE



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Swiss Confederation

Eidgenössisches Nuklearsicherheitsinspektorat ENSI
Inspection fédérale de la sécurité nucléaire IFSN
Ispettorato federale della sicurezza nucleare IFSN
Swiss Federal Nuclear Safety Inspectorate ENSI



SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

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ultimateco2.eu



Mont Terri Rock Laboratory: An International Research Facility for Deep Geological Disposal and CO₂ Storage

Claystone

host rock

caprock

Implementers

Geological
Disposal of
Radioactive
Waste

Regulators

Researchers

Climate
Change

Energy
Organisations

Researchers

Finding Solutions to Big Societal Challenges



Mont Terri - a generic rock laboratory on an intermediate scale

Laboratory
experiments

Well defined boundary
conditions, simulated
environment

Underground
Rock
Laboratories

Defined but complex
boundary conditions,
realistic environment

Natural analogues
Pilot-/industrial-scale

Boundary conditions less
well defined, realistic
environment

Dimension & duration of the „experiments“, observation period

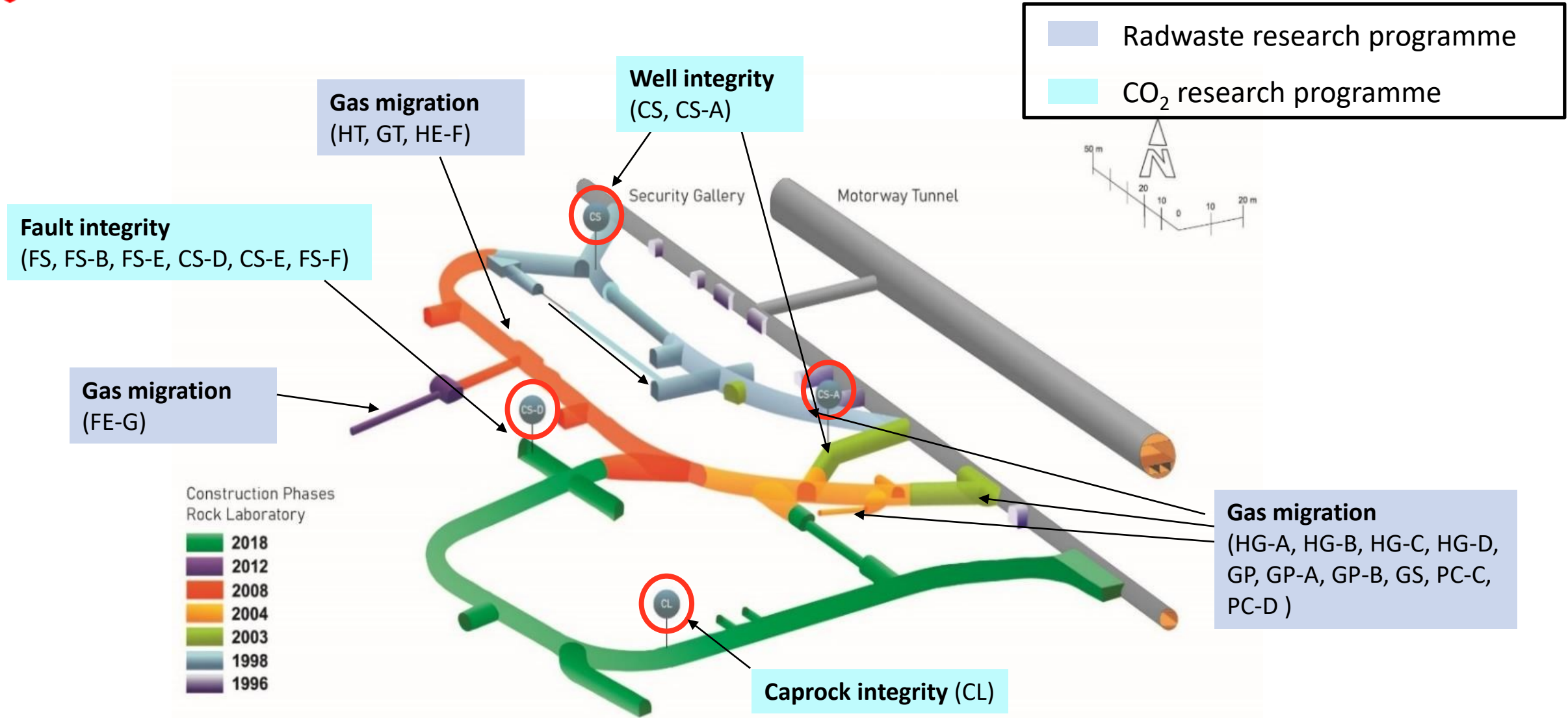
Weeks to years
mm / cm

Several years
to decades
cm / m

Up to millions
of years
100m / 1km

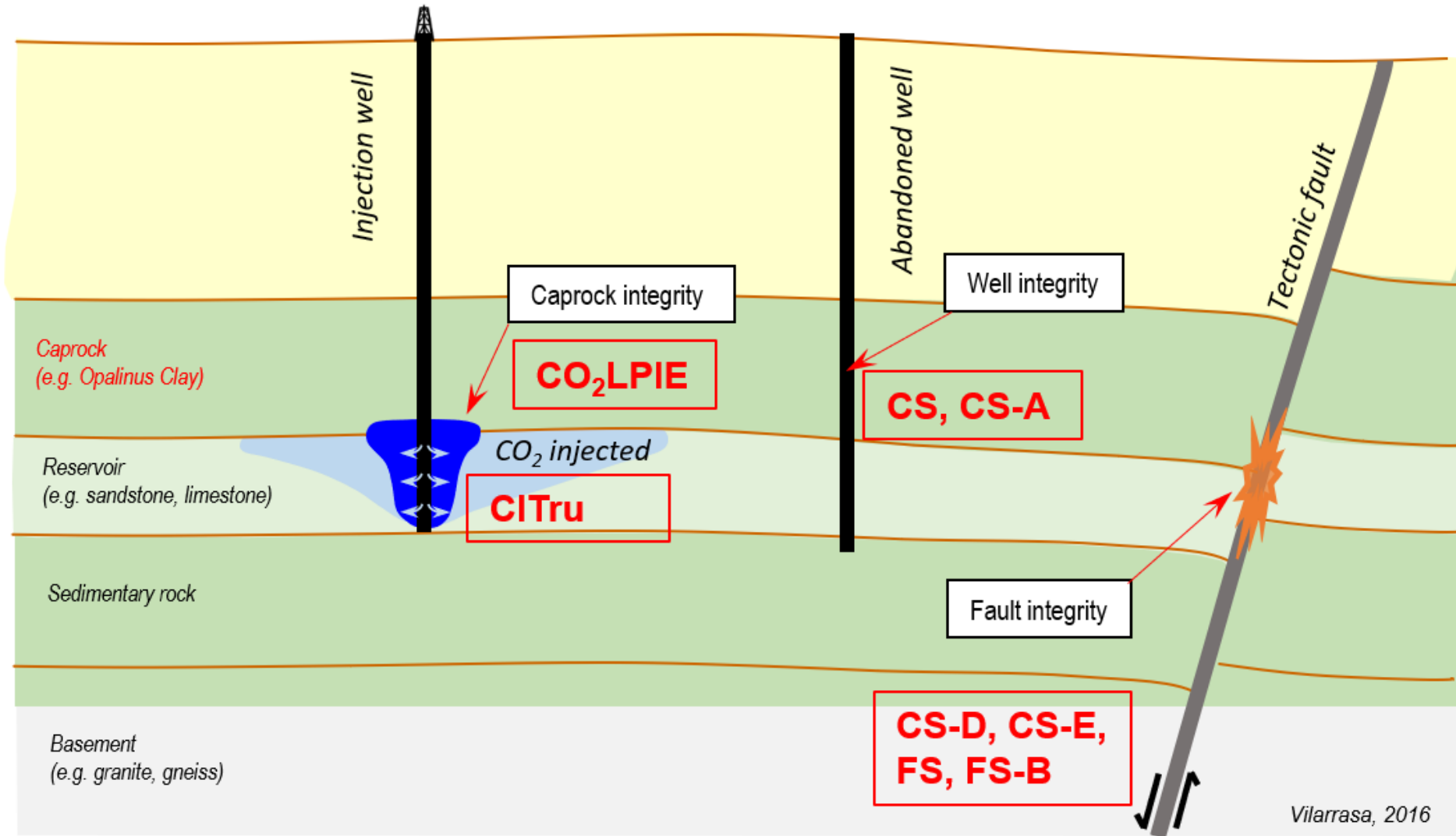


In-situ gas and caprock integrity experiments @ Mont Terri





CO₂-experiments at the rock laboratory scale since 2011



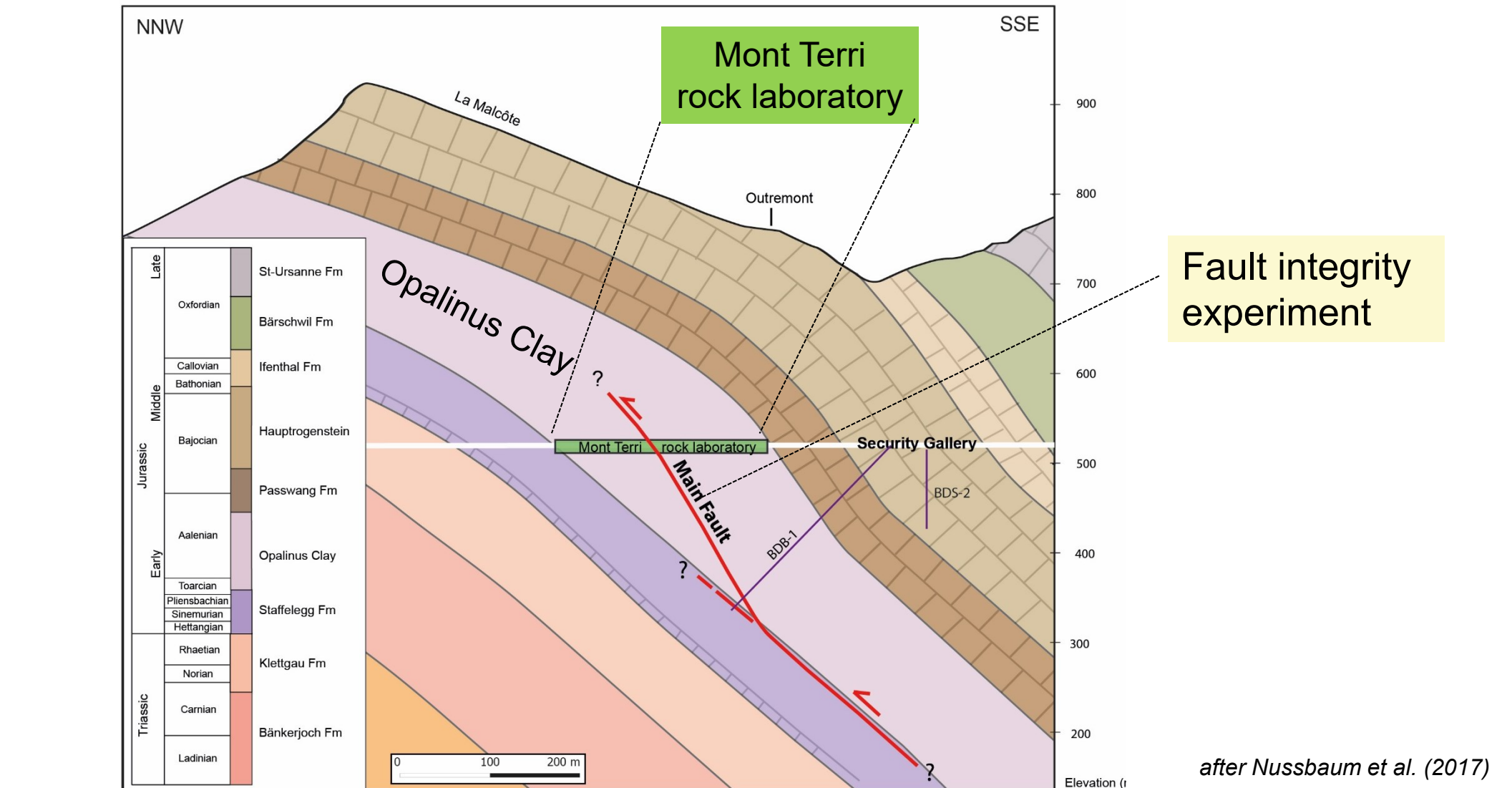


Some of the basic concerns raised by the scientific community and by the general public, with regard to geological storage of CO₂, are:

- Will the CO₂ stay underground? For how long? Or will it leak from its storage location in quantities that might prove hazardous or ultimately ineffective?
 - What dangers are associated with storing CO₂ in the subsurface?
 1. Will it affect the quality of ground water?
 2. Could it cause earthquakes?
-



Geological context (overburden: 300 m)

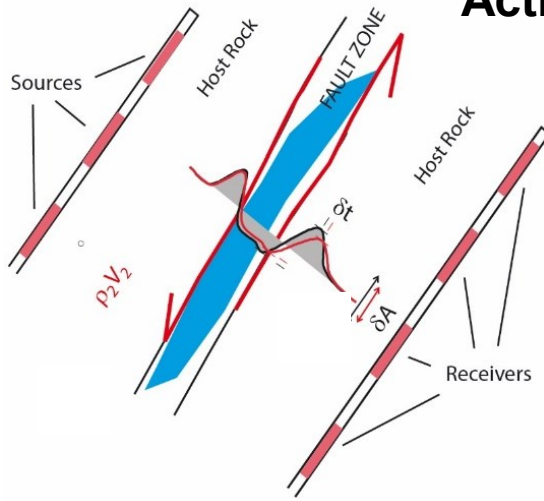




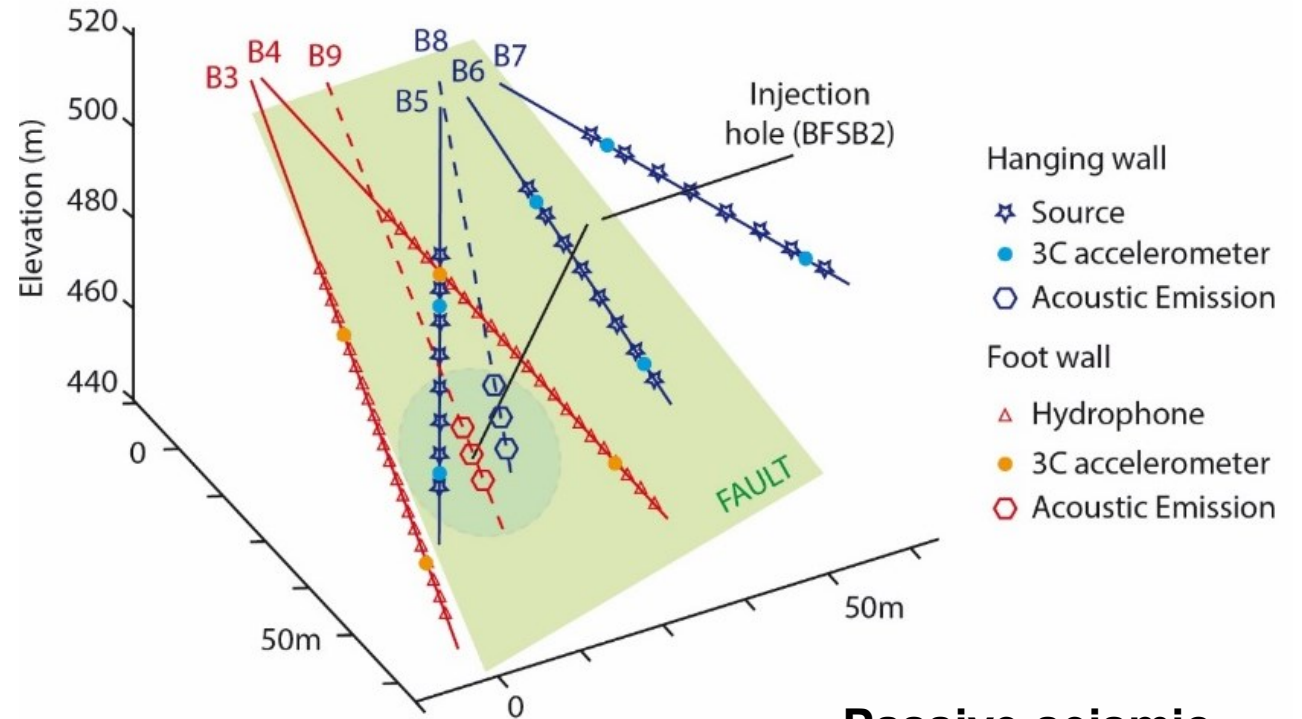
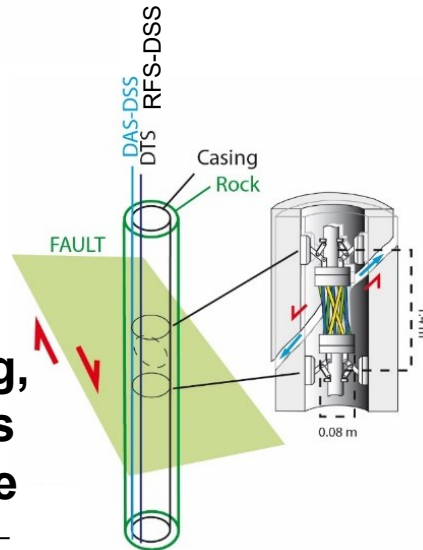
Fault integrity

Different monitoring techniques are deployed to hydromechanically and chemically characterize a leakage pathway created in an initially very low permeable fault zone

Active seismic



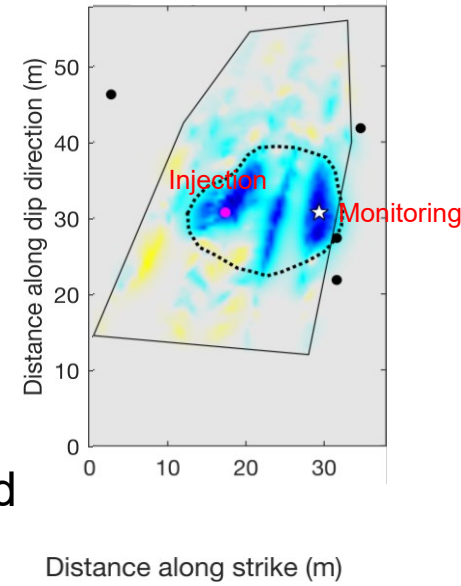
Fault slip, opening,
Distributed strains
And pore pressure



Passive seismic



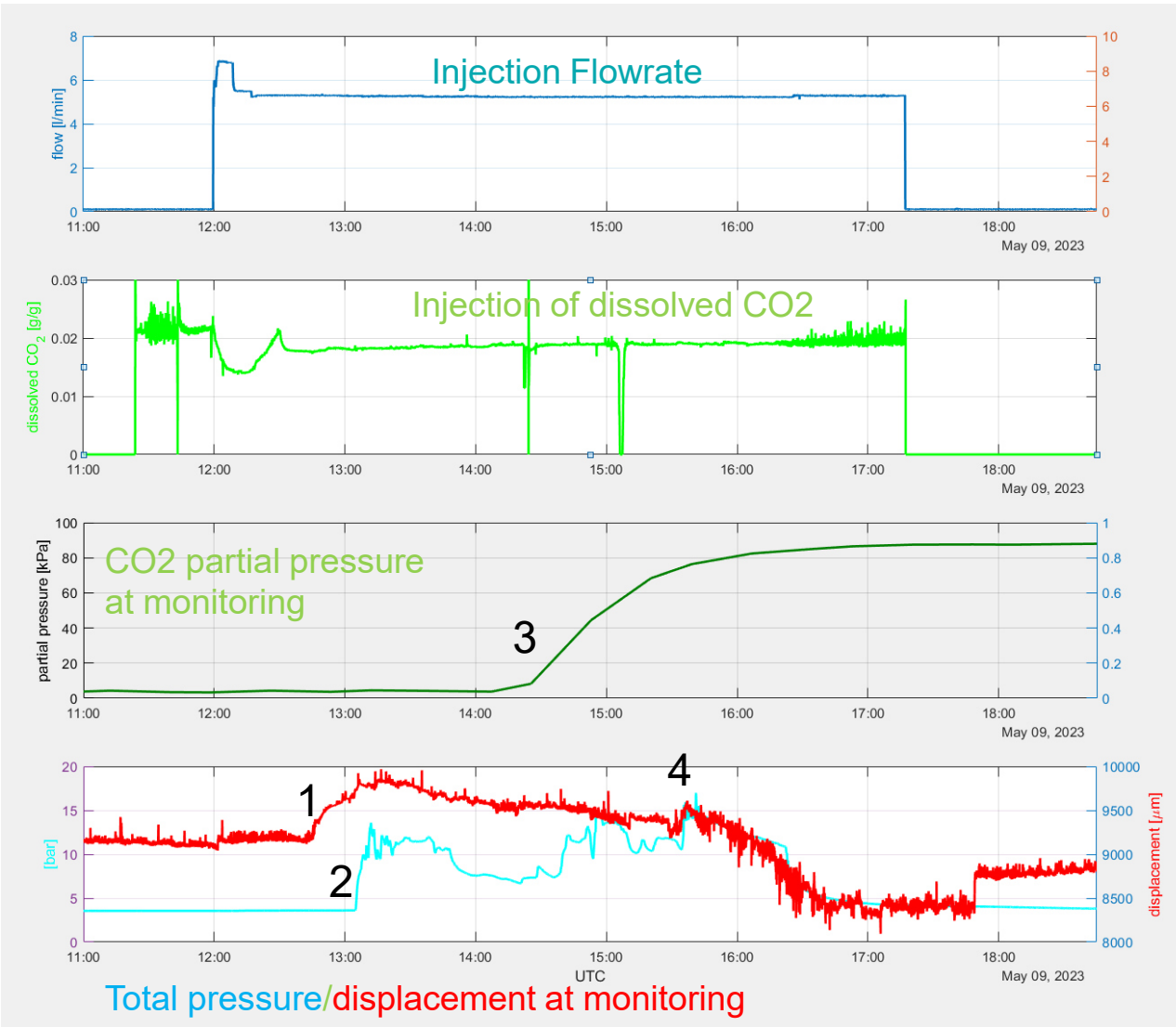
Fault activation with CO₂ dissolved in water



Relative chronology of leakage

- 1 – Fault mechanically activated
 - 2 - Increase in fault pore waters pressure in the mechanically activated patch
 - 3 - CO₂ arrives in the patch > 1h after activation starts
 - 4 - CO₂ may generate depressurization of fault inducing closing and decrease of slip
- This might be associated to desaturation induced by dilation

**Fault activation may reduce
But strong residual opening favors long term leakage**



CO₂LPIE (CO₂ long-term periodic injection experiment)

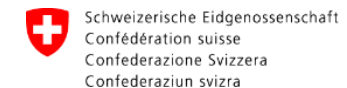
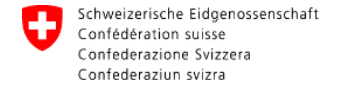
New demonstration experiment — long-term caprock integrity

Aim

- The sealing efficiency of the clay shale matrix is key for long-term safety of the caprock (several ka)
- Assessment of influence of CO₂-saturated fluids on the integrity of geological barriers under realistic in-situ conditions
- Robust characterization of the test volume and high temporal and spatial resolution monitoring with novel systems

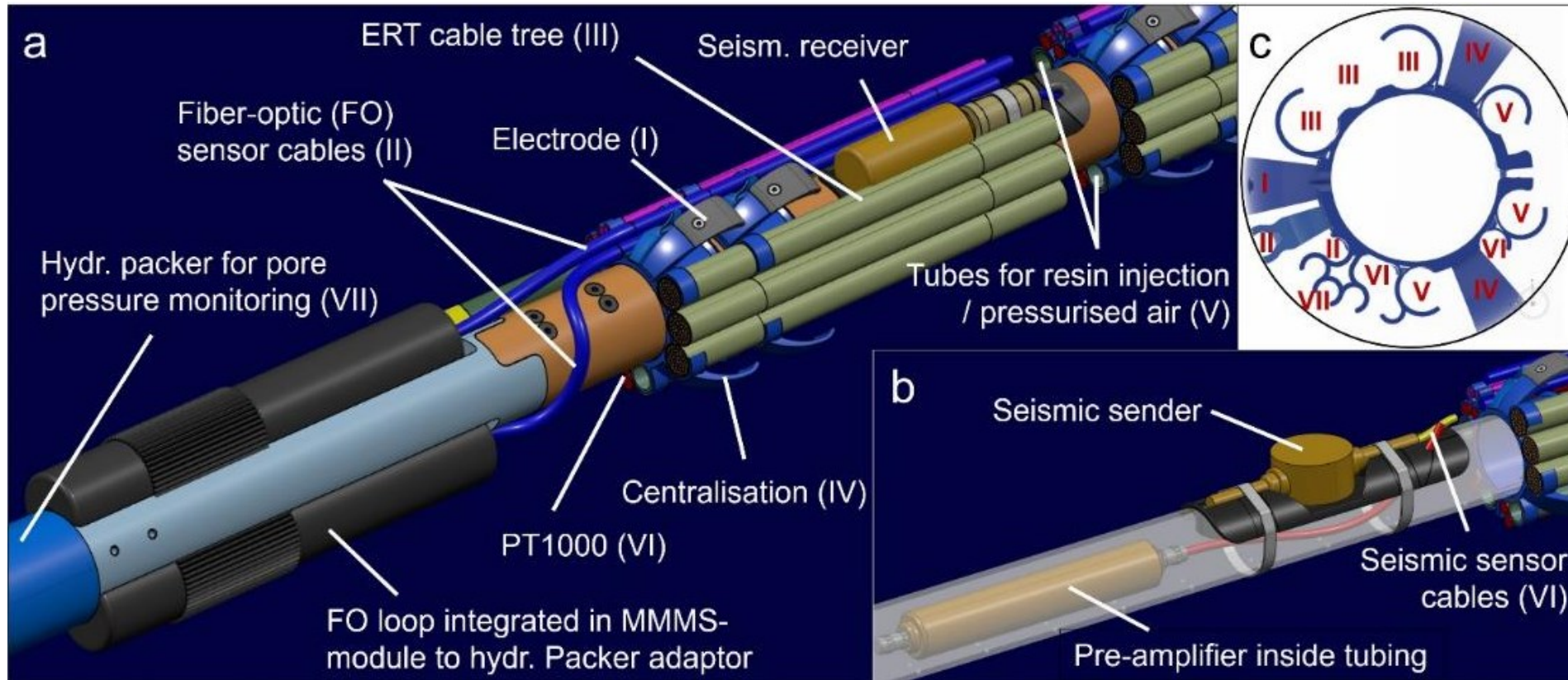
Concept

- Periodic CO₂-injection over a longer term (4+ years)
- Combined investigations on different scales (in-situ and lab analysis), combined with numerical modeling
- Development of Modular Multisensor Monitoring System (MMMS)
- High resolution temporal and spatial monitoring of CO₂-migration





CO₂LPIE – development of MMMS with



- Sensors: ERT, acoustic, FO strain/T, point T, pore pressure, orientation
- Resin with low viscosity, long polymerization and low T, const. volume, elastic properties close to OPA
- Other topics: system stiffness, tightness, redundance, long-term chemical stability, coupling to rock, flexibility with modules, installation,



Caprock Integrity & Gas Storage Symposium

24–25 January 2024
St-Ursanne – Switzerland

- Full house, 100 participants for the 1st CIGSS
- Strong international participation
- 44% of participants came from Europe and North America



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Why CIGSS? What is our motivation?

The Caprock Integrity & Gas Storage Symposium (CIGSS) aims at providing and establishing a platform for the exchange and discussion of scientific, technological, industrial, and regulatory advances related to the integrity of caprocks in the context of geological storage of CO₂ and gas storage in general.

www.cigss.ch



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28 years of research at Mont Terri in a nutshell: an experience like no other in the world

- Mont Terri is a world-renowned scientific and technological platform for studies on claystone with the contribution of 22 partners from radwaste management agencies, federal administration, academic world and industry (energy organisations)
 - Invaluable contribution, know-how, knowledge and expertise of the radioactive waste disposal community, transferable to the CCS community
 - 28 years of experiences with many experiments on gas migration in low-permeable claystone
 - Last but not least: more than 12 years of research into the integrity of claystone **as safe caprock in the context of the geological storage of CO₂**
 - Important for public acceptance. Without the approval of the people, nothing will be possible in Switzerland.
-



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Federal Department of Defence,
Civil Protection and Sport DDPS
Federal Office of Topography swisstopo
Swiss Geological Survey

wissen wohin
savoir où
sapere dove
knowing where

Assessing the repurposing of an existing exploration borehole for a pilot CO₂ injection test in Switzerland

Herfried Madritsch

Swiss Geological Survey (swisstopo)

A. Möri (swisstopo)

V. Becattini M. Mazzotti, S. Wiemer (**ETH-Zürich**)

A. Rinaldi, R. Schultz (**Swiss Seismological Survey**)

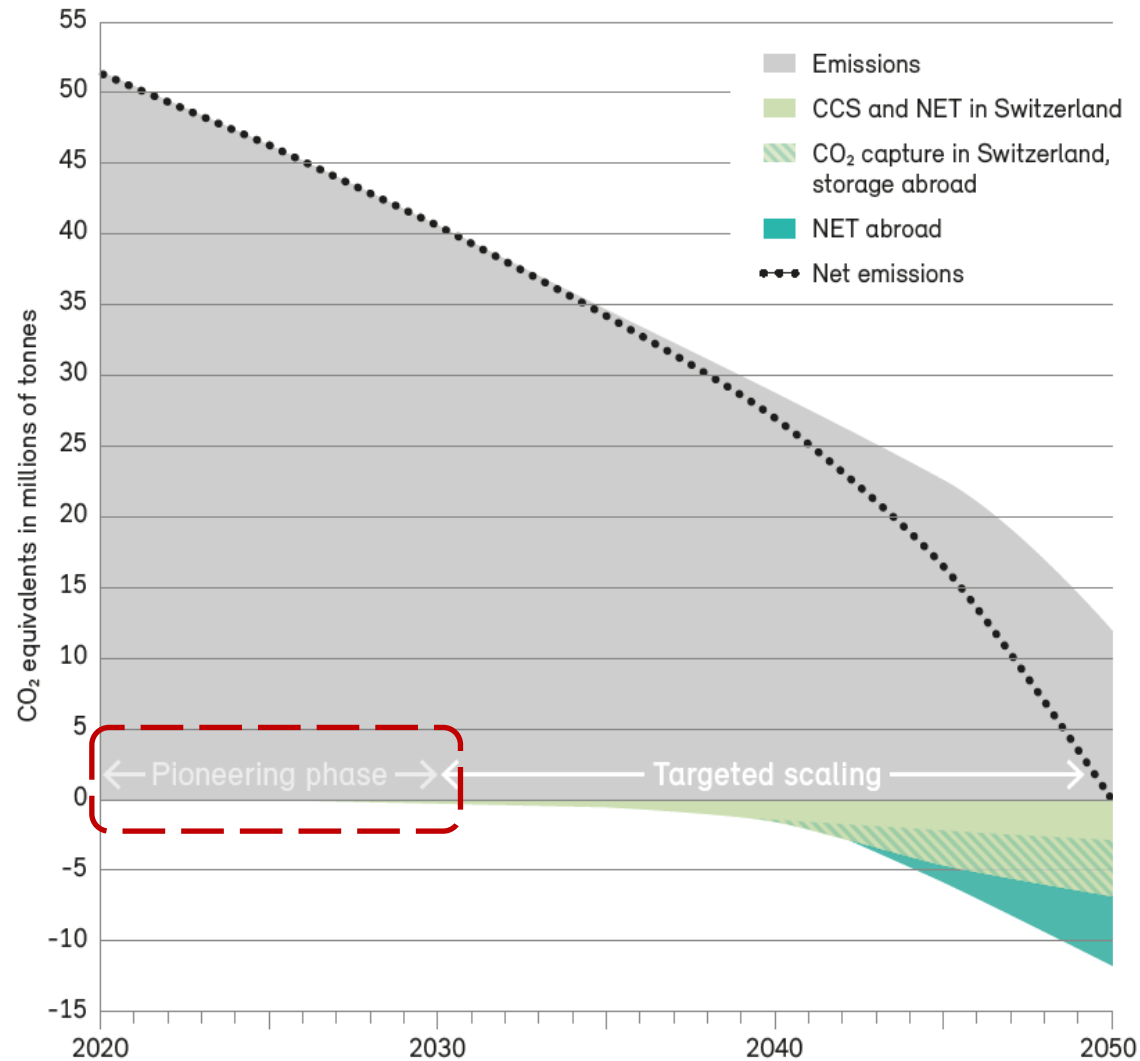
P. Alt-Epping, A. Brett, L. Diamond C. Wanner (**University of Bern**)

G. Siddiqi (**conim AG**; formerly Federal Office of Energy)





«Recap: Switzerland Net-Zero 2050 Strategy ...



... .. foresees a **relevant role of underground CO₂-storage within its borders**

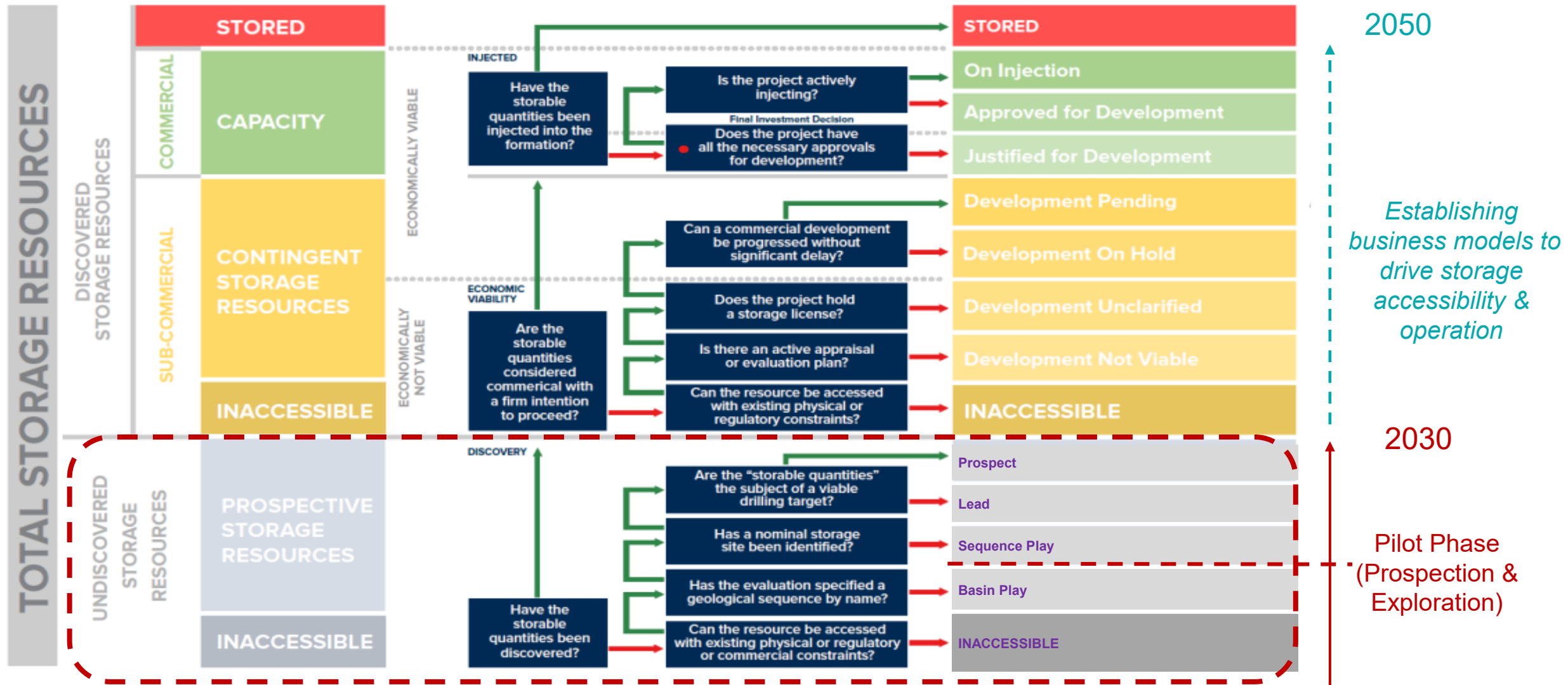
➤ 2050: Storage of **3 Mt CO₂ p.a. in Switzerland**

➤**provided storage options become accessible!**

➤ related **exploration of thunderground** is yet **still in a very early stage**



Geological CO₂ Storage in Switzerland: Status quo



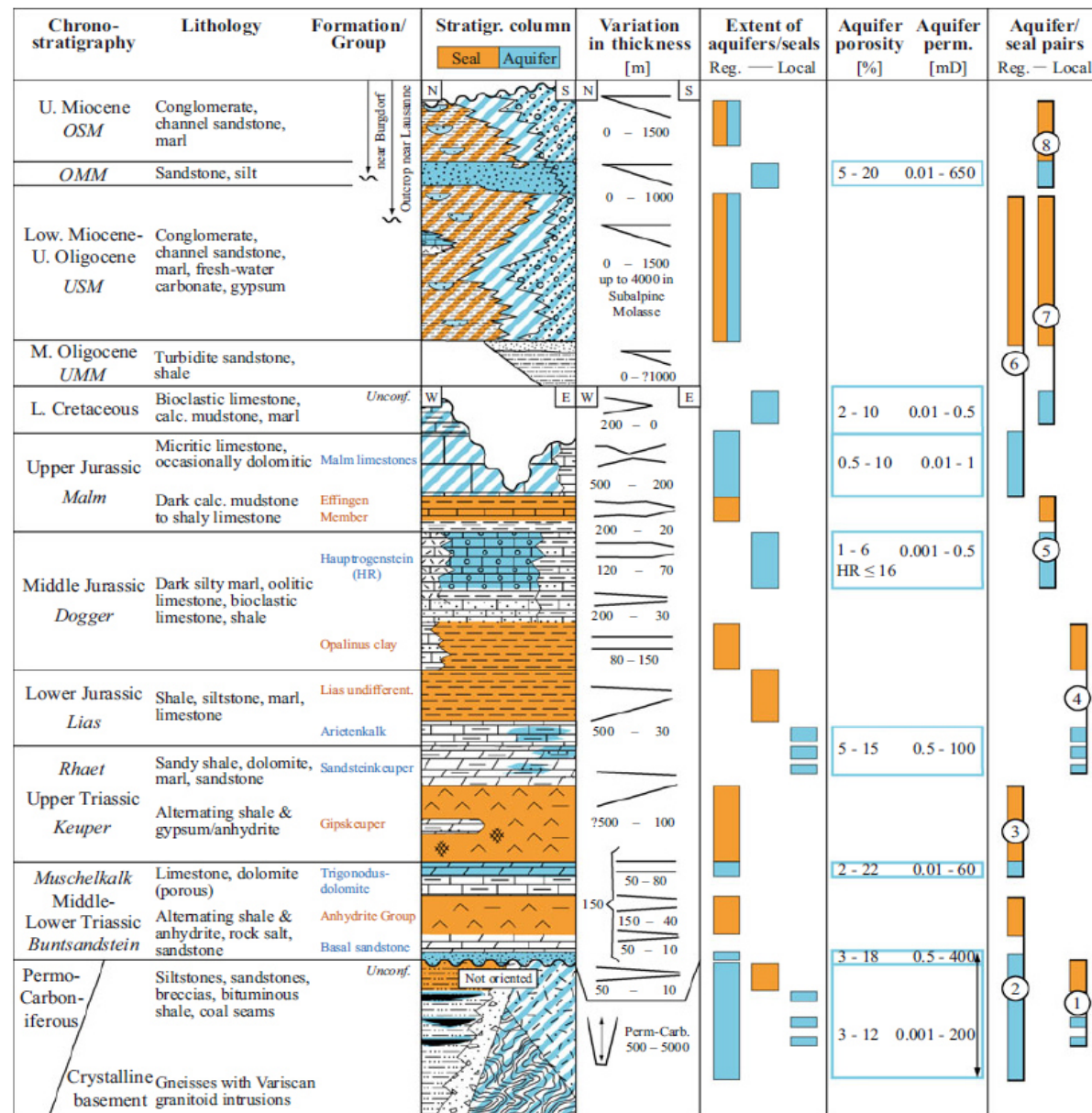
Flowchart for classification of storage resources according **Storage Resources Management System** guidelines



A detailed, **in-situ characterization/verification** regarding the **storage potential is yet missing (undiscovered resources)**.



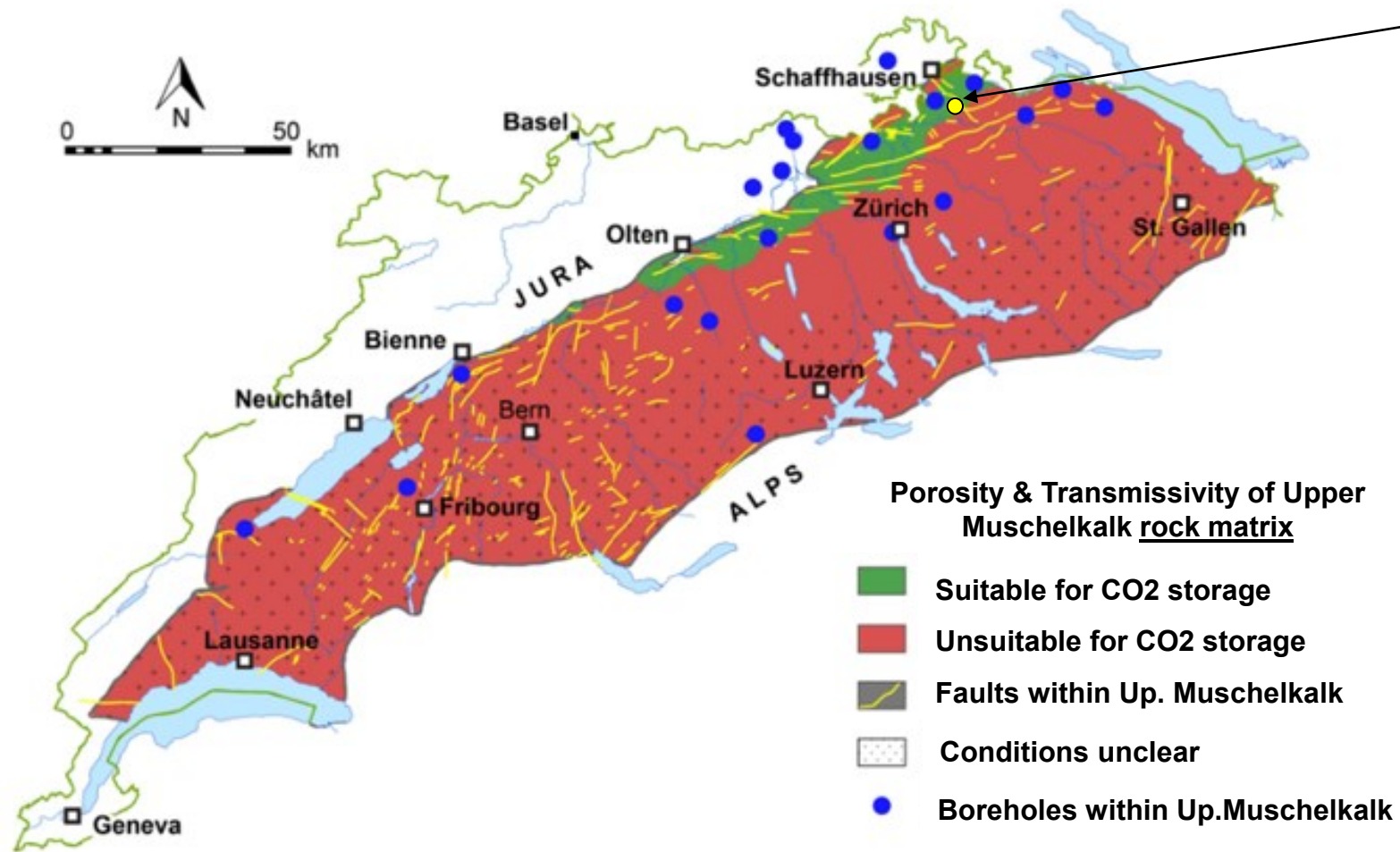
(Chevalier et al. 2010)



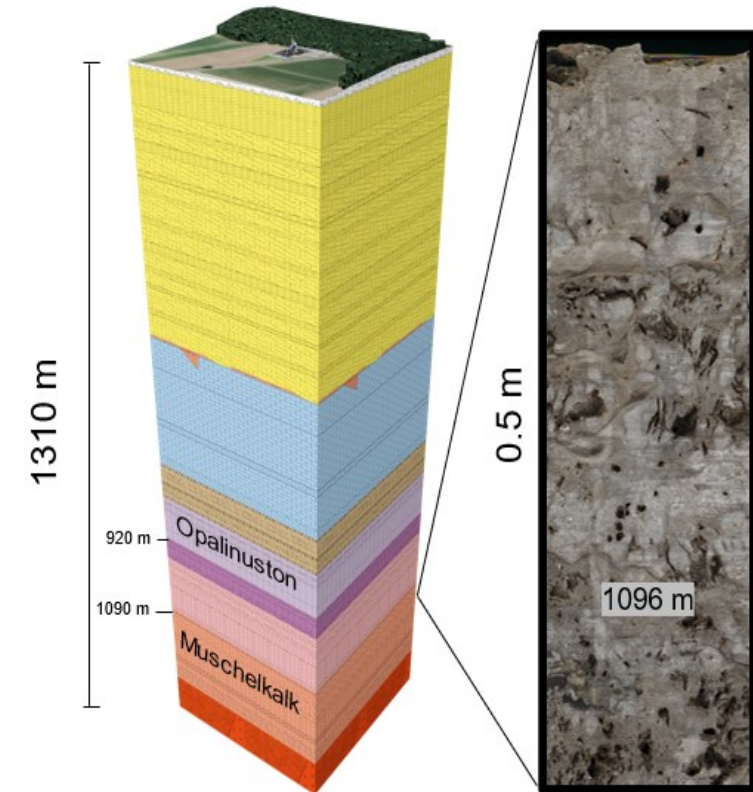


CCS storage option «Upper Muschelkalk»

Switzerland's largest saline aquifer



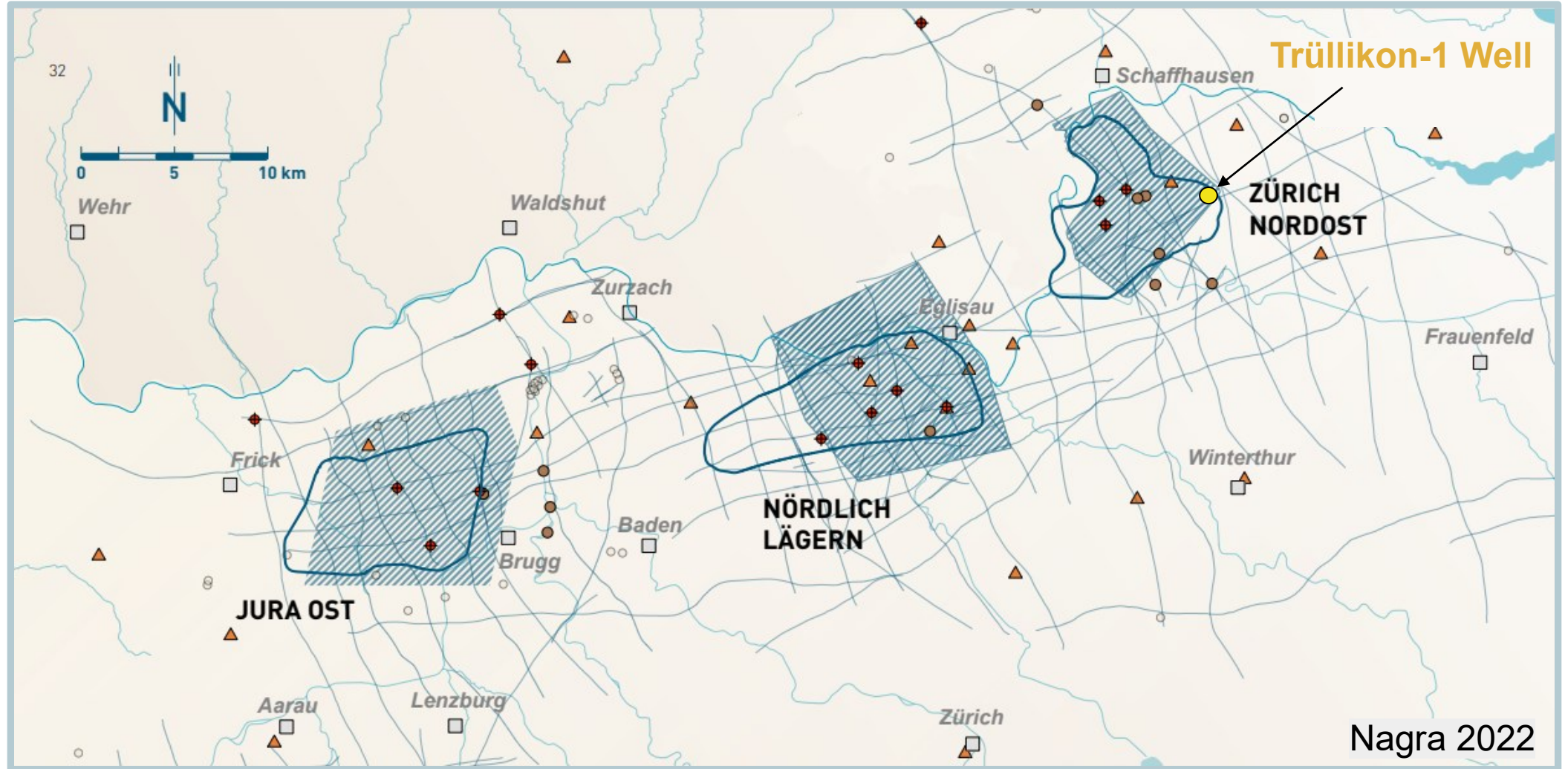
Trüllikon-1 Well



Map of reservoir properties of the “Upper Muschelkalk” with respect to CO₂ storage (Diamond et al. 2019)



Where is Trüllikon?



.....in a region very intensively investigated since 40 years concernig possibilites for radioactive waste disposal.

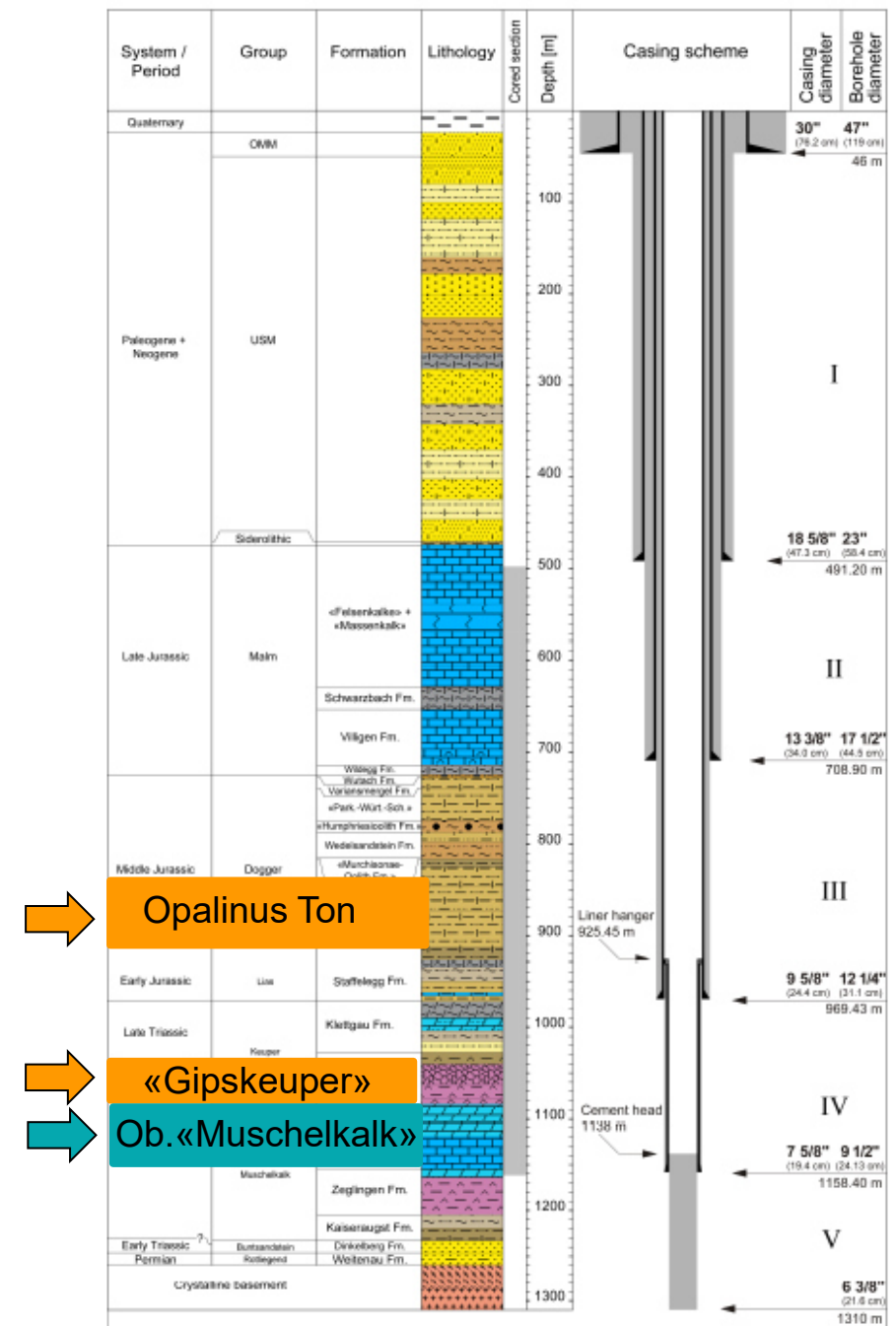


The Trüllikon well (Tru-1): An Opportunity

- The **well is technically & geoscientifically very well documented**, the formations of interest already exposed.
- The **tectonic regime around the well is well understood** (local 3D and regional 2D seismics)
- A **geomechanical & hydrogeological characterization** is already available (in-situ & lab testing)
- Static geological as well as hydraulic & geomechanical **models around the well have already been established** (different purpose).

**Could this borehole be repurposed
and host a CO₂ injection test?**

CITru (CO₂ Injectionpilot in Tru-1) -> a feasibility study





Goals & Significance of ClTru

- **Premises:**

«To exploit a low-cost opportunity to pilot test the CO₂ injectivity of a nationally important CO₂-storage complex (comprised of storage and seal unit) in a highly explored region of Switzerland».

- **Goals / Significance:**

- **Operational Implementation :** To inject for the first time in Switzerland CO₂ into a saline aquifer at a modest scale (max. 50 000 tons of CO₂) and to monitor behaviour and extent of the resulting CO₂ plume.
 - **Skills & Competency Development:** in the fields of CO₂ injection, monitoring & measuring of CO₂ in the subsurface as well as in the areas of regulation / regulatory processes
 - **Communication & Outreach:** “light house” project to improve the social perception of the challenges and solutions for «CO₂ removal and storage» and to demonstrate the feasibility of safe and permanent storage of CO₂ in the geological subsurface.
 - **Research & Innovation:** enable the testing of new technologies and methods to address societal concerns and to encourage the interaction between the private sector and research providers.
-



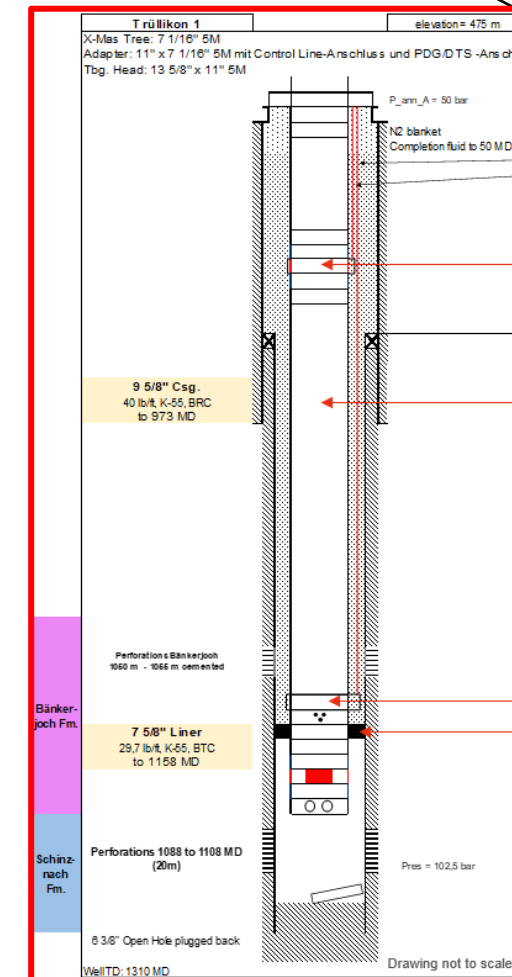
Borehole Integrity & «Recompletion» for CO₂ Injection

Technical review to verify if the current **casing and wellhead an cementation** are **suitable** for the planned use as CO₂ injector.

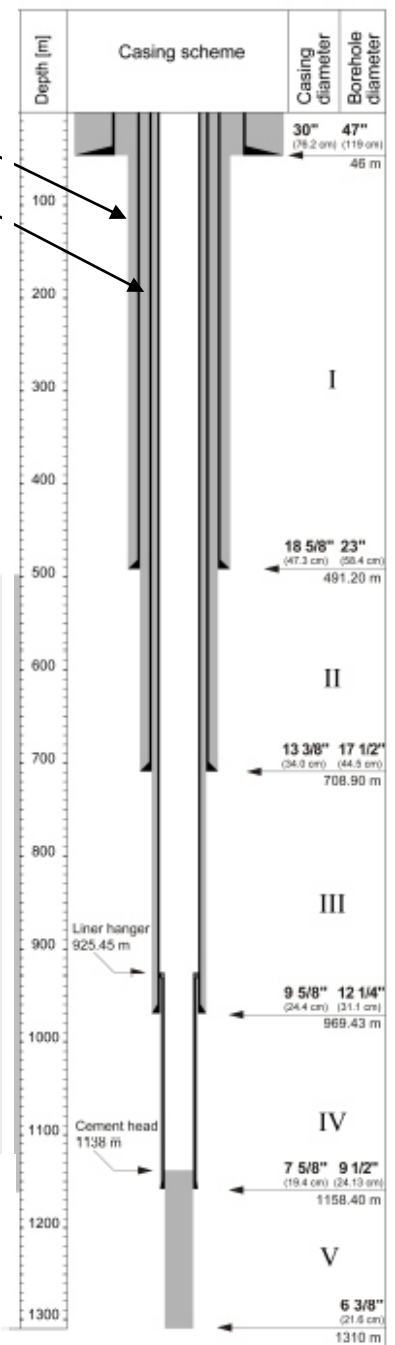
- Assure **compliance with initial injection scenario** (respective loads): **15–18 MPa BHP**
- Establish a **completion design concept for CO₂ injection and monitoring**
- Probabilistic time and **cost modelling**

Positive Results:

- The **casing/cement** and **proposed tubing are sufficiently designed** to withstand the expected loads.
- The **cost to re-complete the well** for CO₂ injection is **estimated <10% of the borehole value** (excl. site preparation and monitoring equipment).



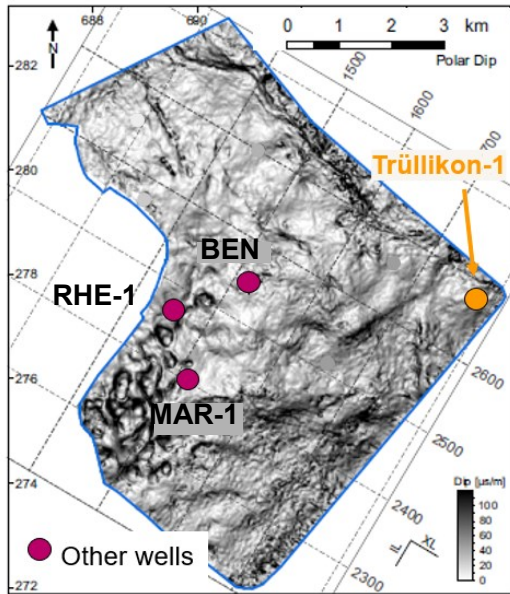
Recompletion Concept



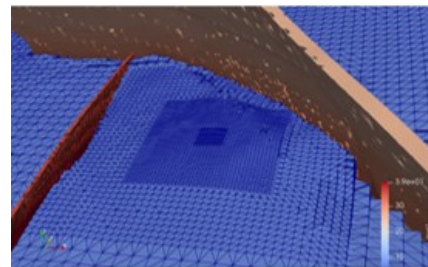
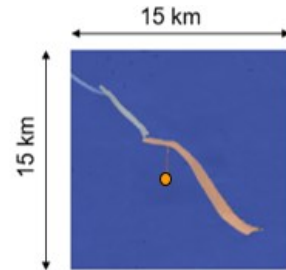


Geological Characterization & Modelling

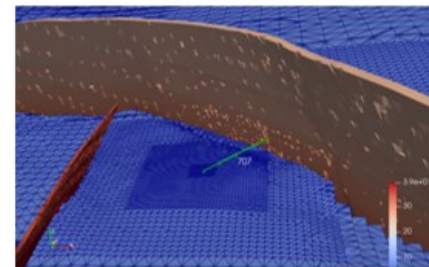
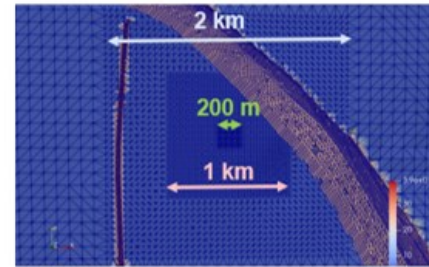
- In-depth analysis and review of geological borehole data
- Static geological modelling (based on seismic data);
- Numerical modelling of CO₂ injection & migration considering regional conditions (THM & reactive transport THC Modelling)
- Fracture network characterization (DFN Modelling)



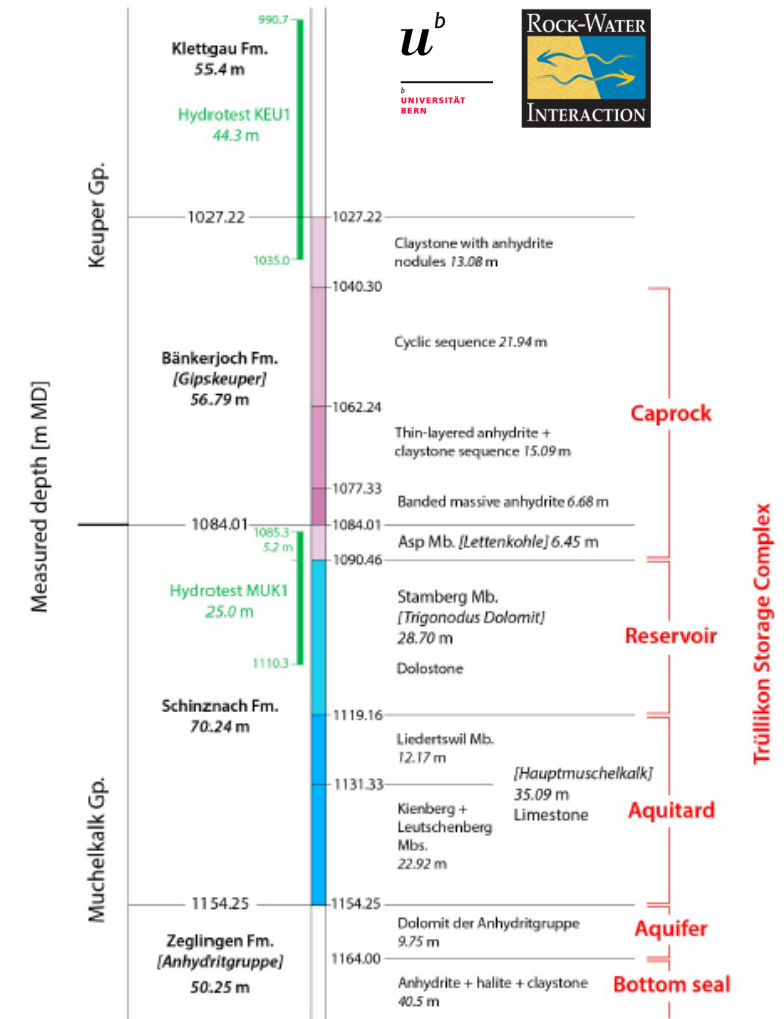
3D seismic polar dip seismic attribute of horizon Top Muschelkalk (Nagra 2019)



Static model including local tectonic faults



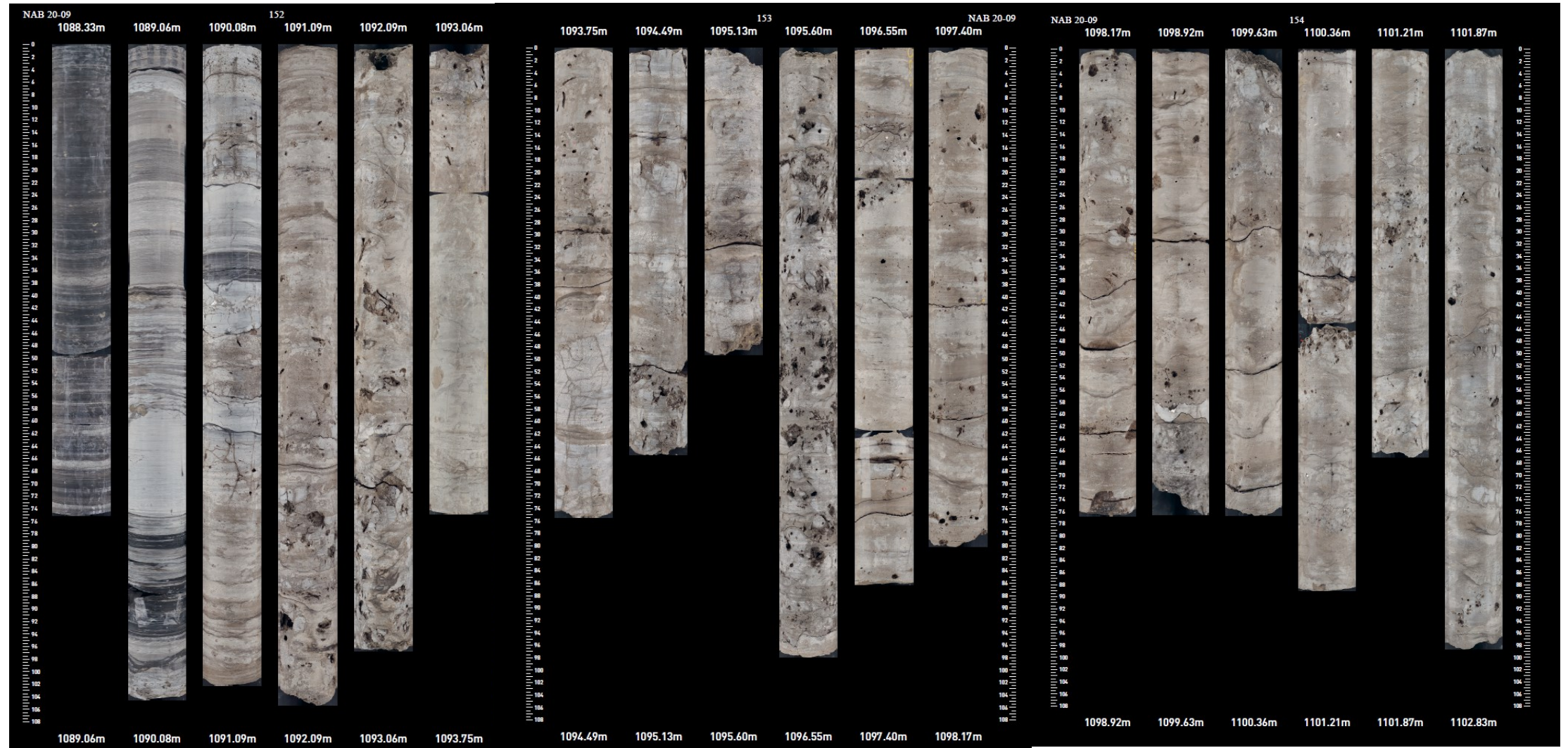
ETH zürich



Geology of Storage Complex
Diamond et al. (in prep.)



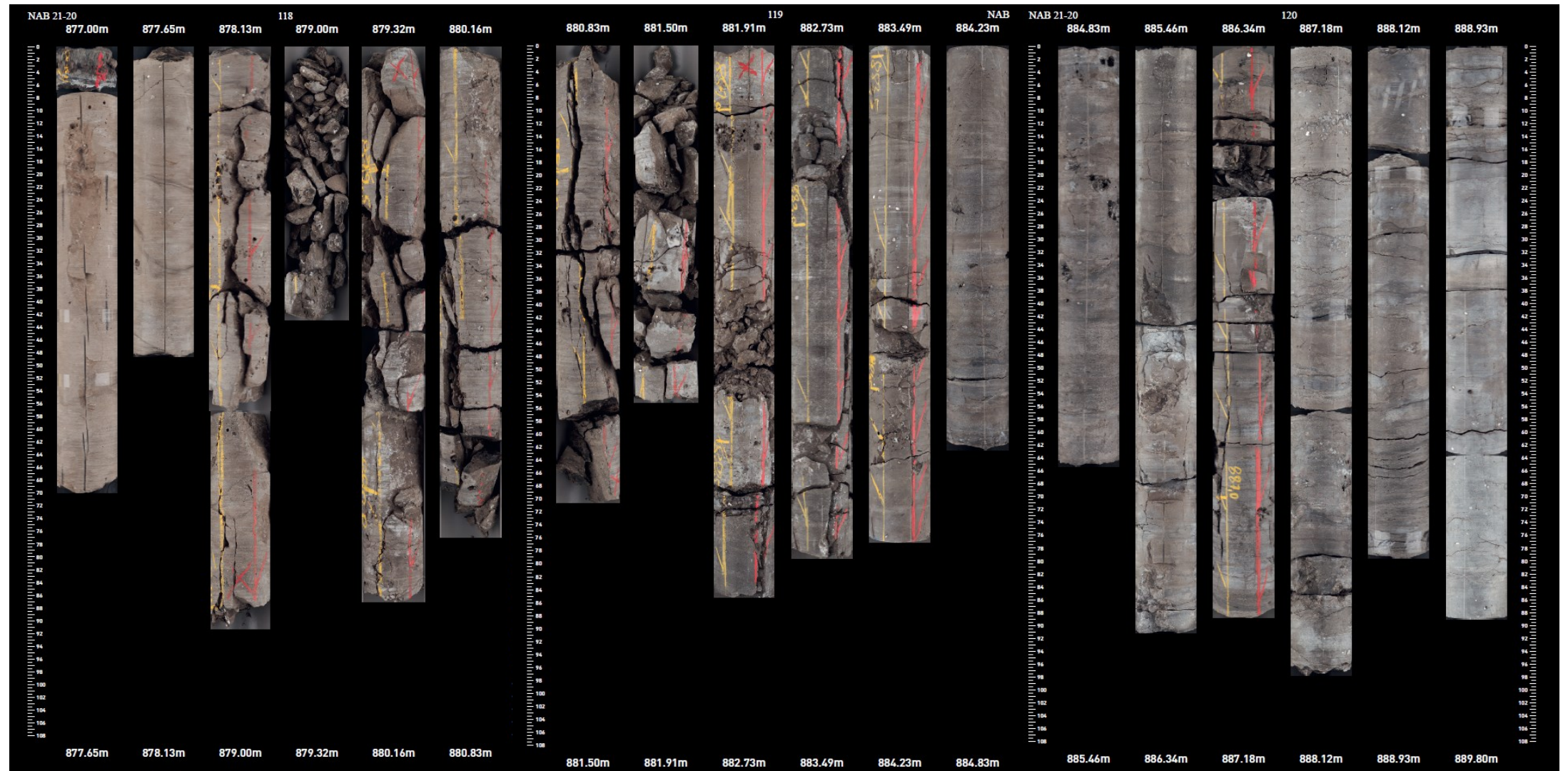
TRU-1: non-fractured Stamberg Member



(Nagra 2021)



MAR-1: intensively fractured Stamberg Member



(Nagra 2021)

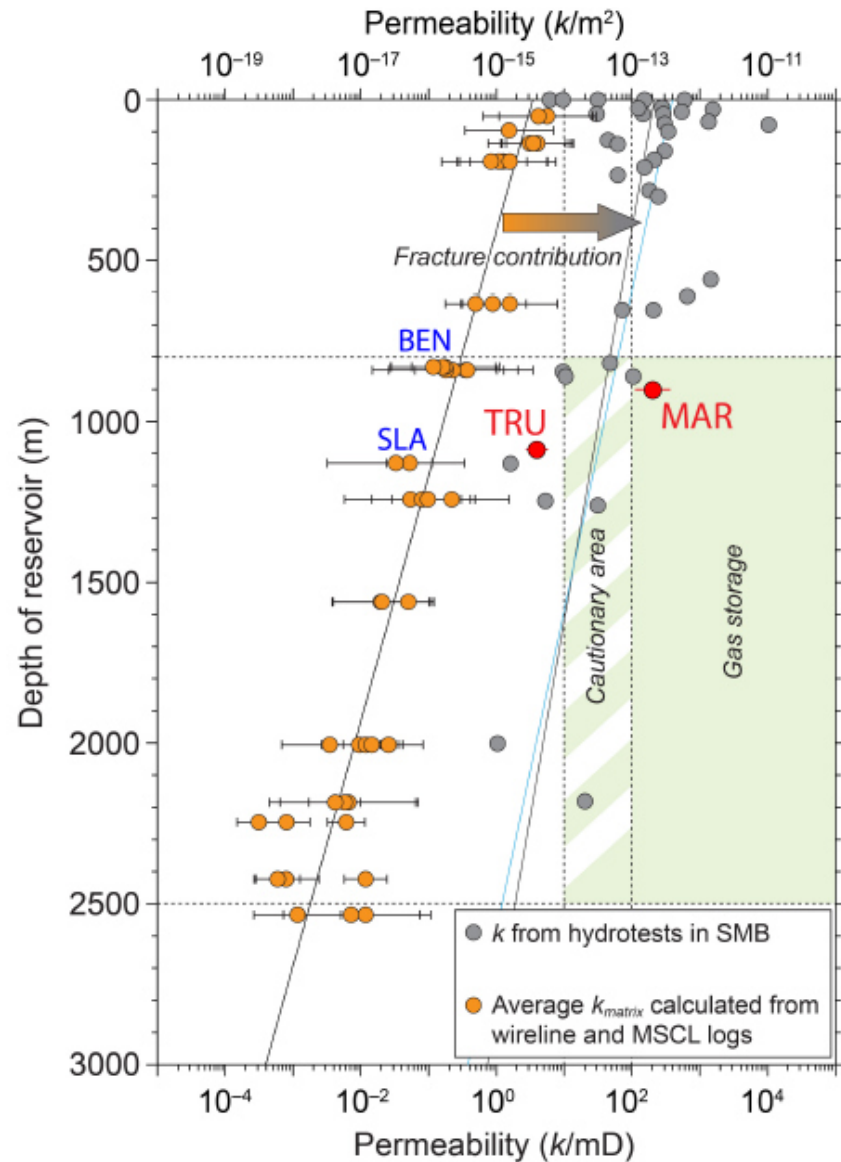


The «Muschelkalk»: a fractured reservoir



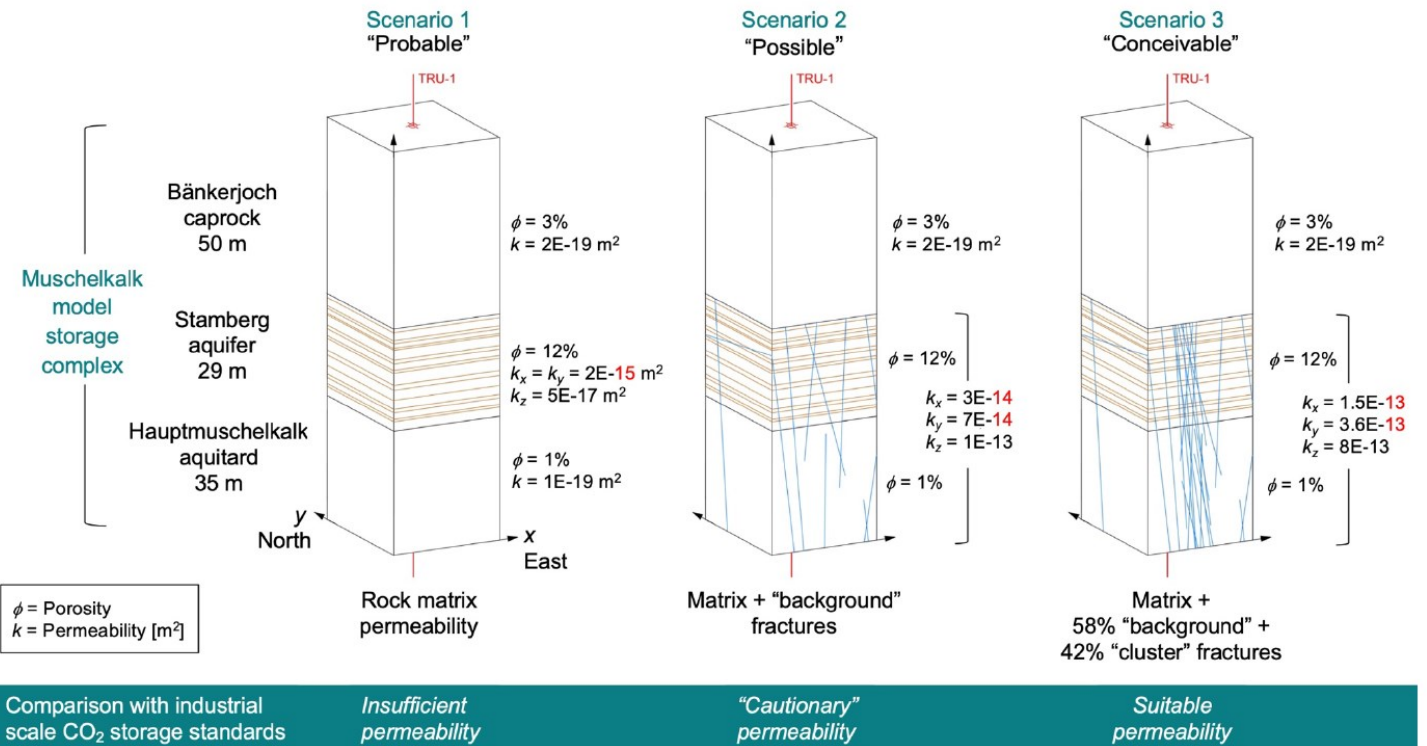


Geological Characterization (in a nutshell)



→ The analyses of several suggests three permeability scenarios to be taken into account

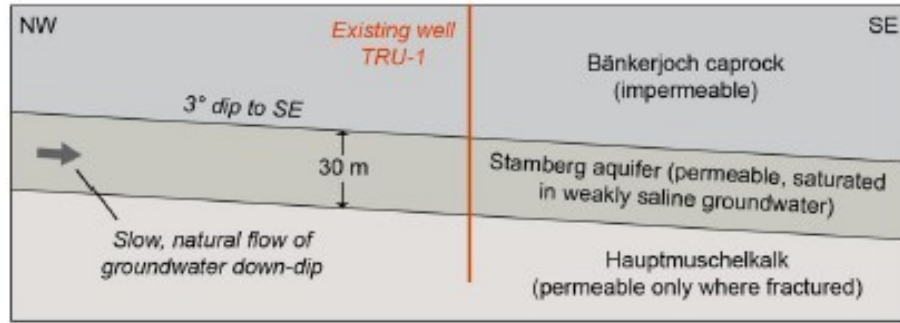
Diamond et al. (in prep)



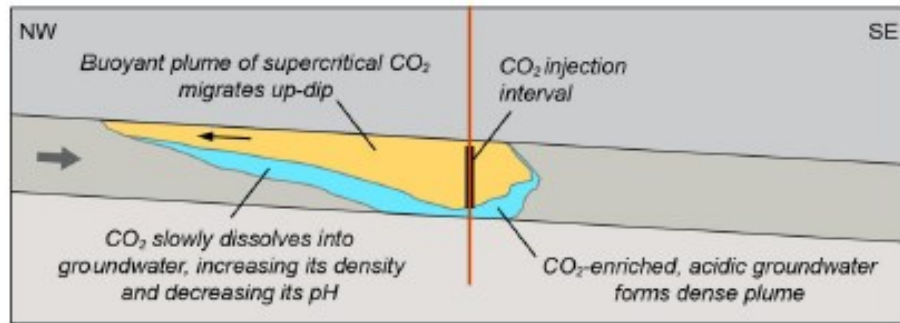


Conceptual Understanding of CO₂ Injection

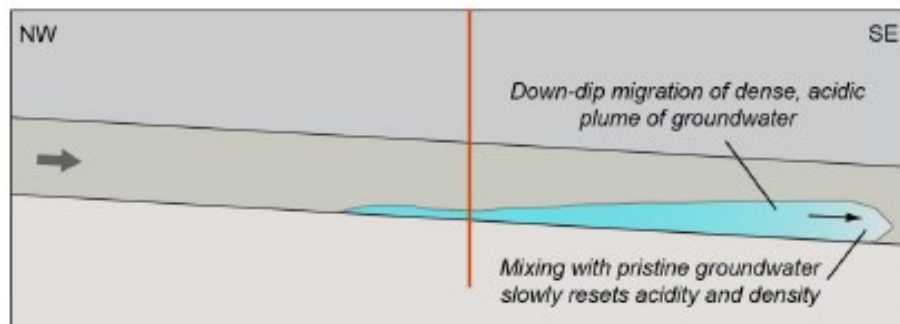
(a) Pre-injection state



(b) During and short-term after injection

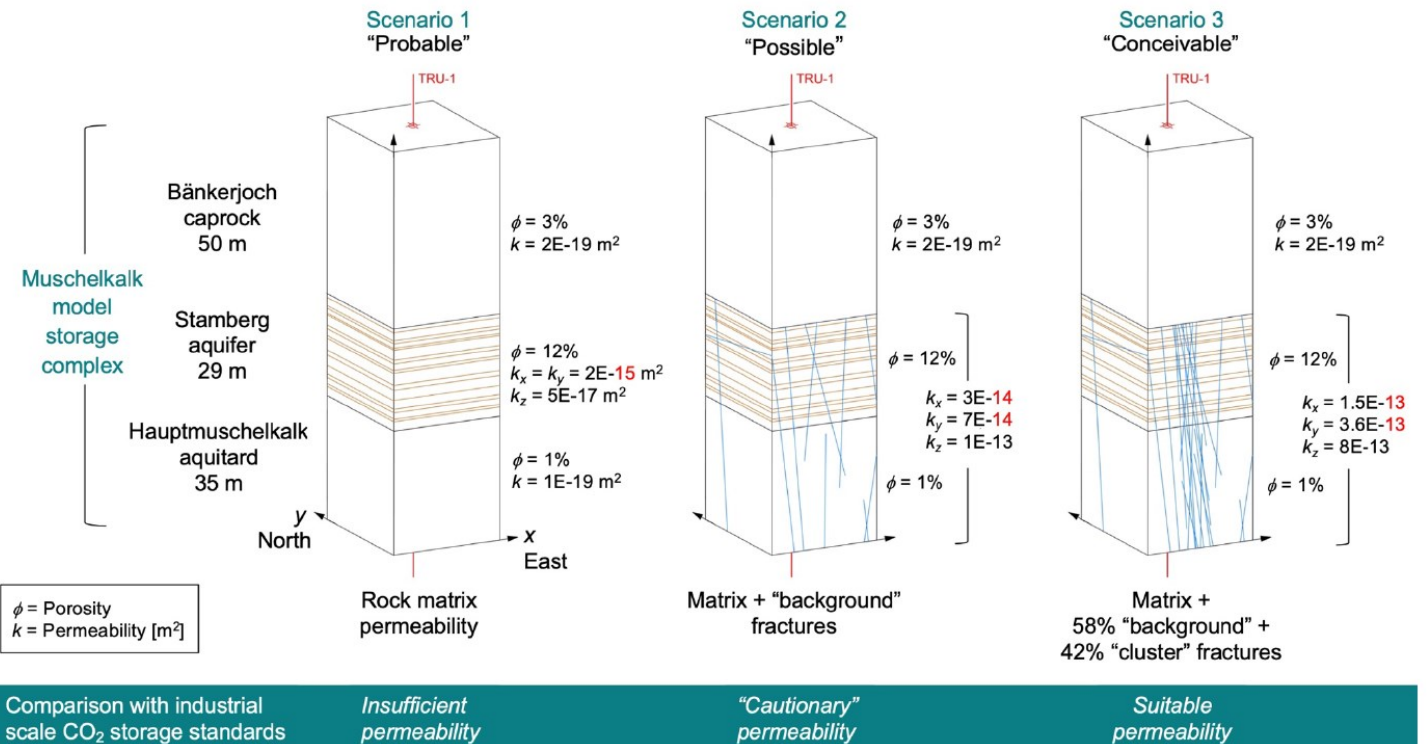


(c) After injection, long-term



suggests a **small plume of dense CO₂** around TRU-1 (250-1000m depending on scenario and injection rate/duration), **gradually dissolving in groundwater**

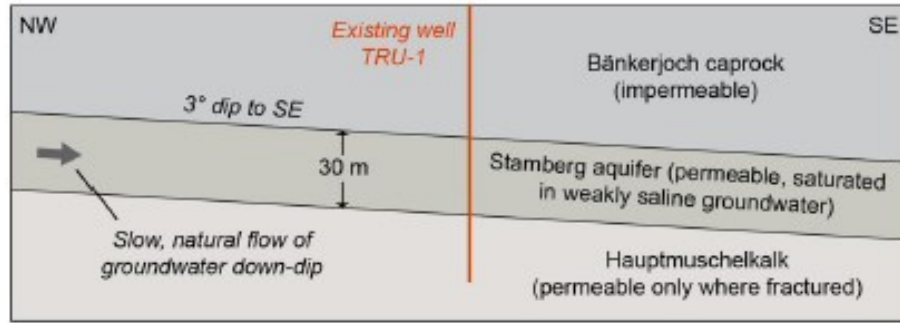
Diamond et al. (in prep)



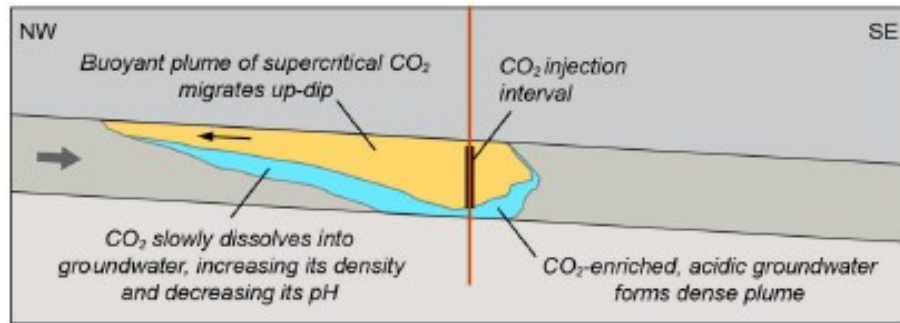


Conceptual Understanding of CO₂ Injection

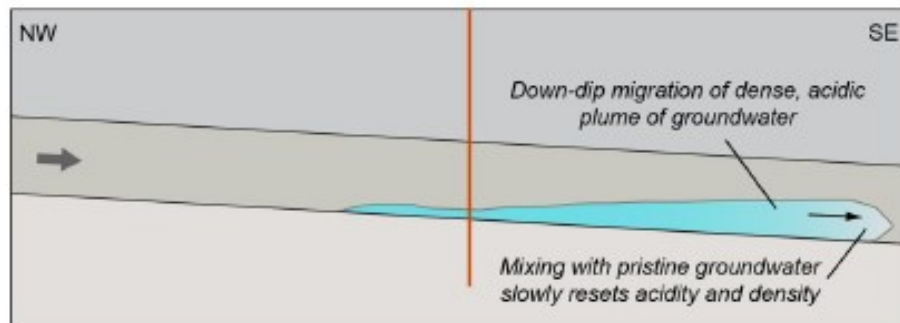
(a) Pre-injection state



(b) During and short-term after injection

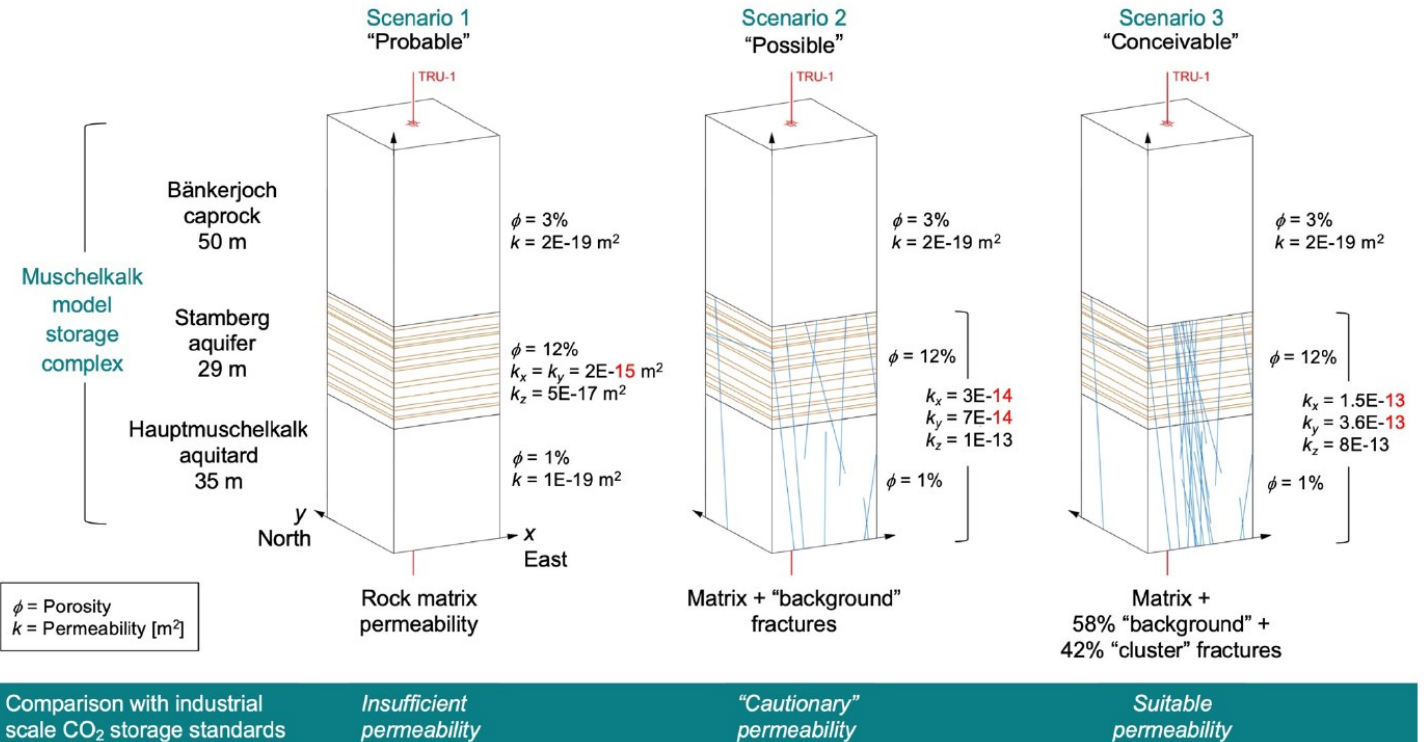


(c) After injection, long-term



- ...suggesting a **small plume of dense CO₂ around TRU-1** (250-1000m depending on scenario and injection rate/duration), **gradually dissolving in groundwater**

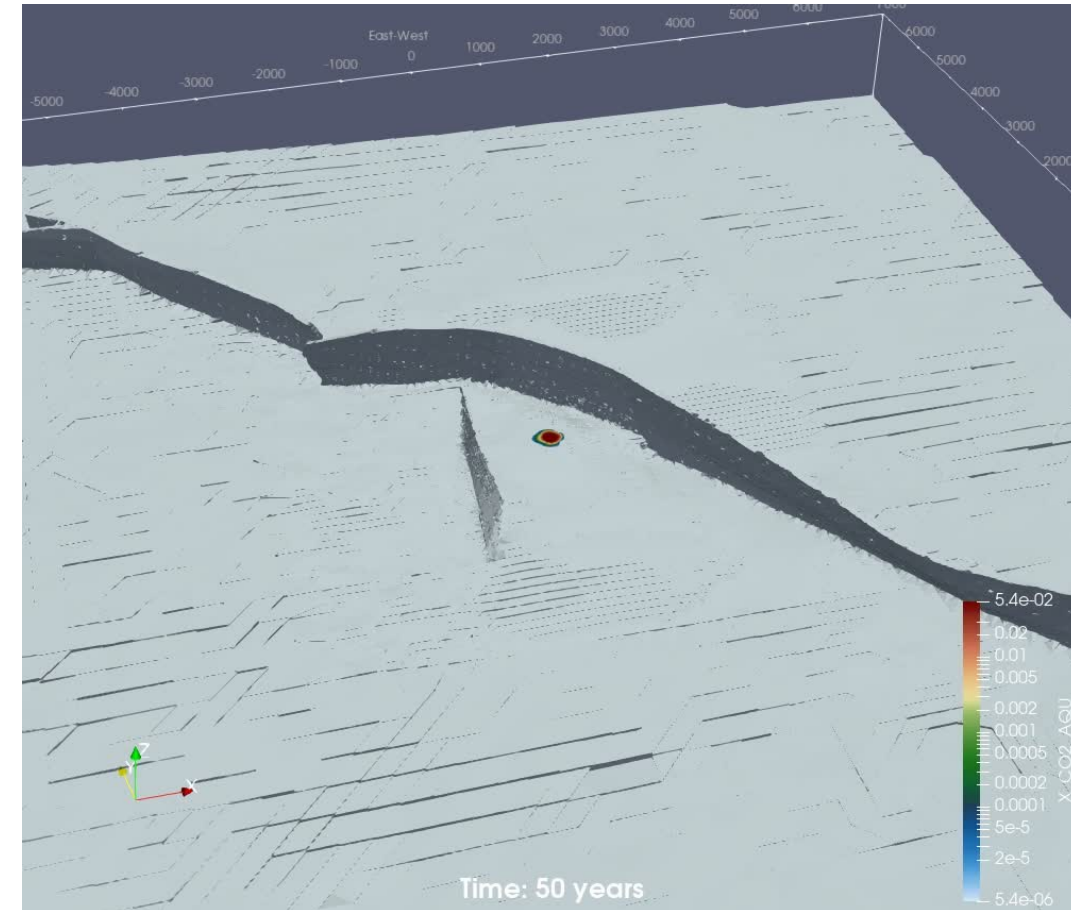
Diamond et al. (in prep)





Dynamic THM Modelling of CO₂ Injection: First Results (10'000 tons over 2 years)

- Conceptual understanding is **confirmed by independent THM modelling**.
- **Pressure increase is expected to be low** (only 2.5 MPa above initial conditions)
- **~150 m maximum distance of CO₂-saturated aqueous plume after 2 years, ~200 m after 20 years**
- The **CO₂ is expected to not reach the neighboring fault in 20 years**. The fault is **only very slightly pressurized** → induced seismicity very unlikely
- Over time, the dissolved **CO₂ is expected to move** downward (higher density) and **to the SSW** (with the ground water flow of 1m/year)





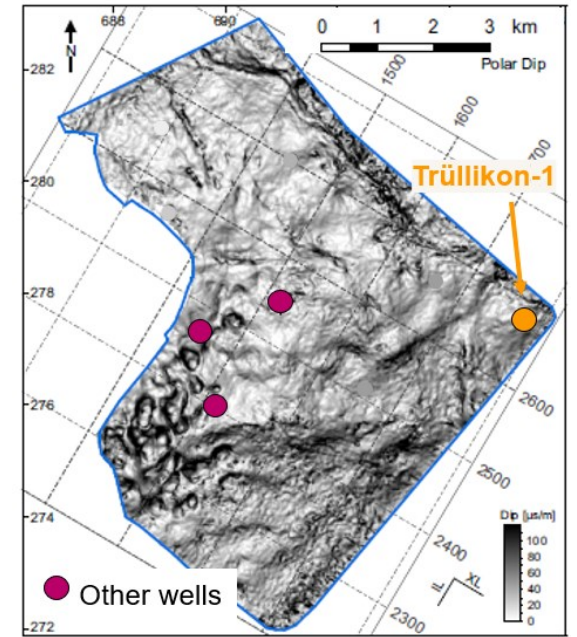
Current CITru Appraisal

- **No technical «show stoppers»** for the realization of **CITru** were identified.
- From a commercial and scientific point of view, **CITru is an opportunity offering limited possibilities** (mostly due to its given location), with **monitoring being** identified as a **major challenge**.
- Nevertheless, **CITru is regarded a potentially great CCS catalyst and capacity building point** for the scientific and technical community in Switzerland.
- So far, **the idea of a non-commercial pilot** has **witnessed strong community support**.
- The **assessment and clarification if** and how the TRU-1 **borehole could be taken over** from Nagra by the confederation **continues**.
- The **planning of the next exploration steps should happen in parallel**.



Concluding remarks

- The effective **CO₂ storage potential in Switzerland is still little known**. Initial estimates vary considerably and are subject to major uncertainties.
- The **possibilities of geological storage need to be properly investigated in situ** in order to be able estimate future dependence on foreign storage capacities.
- A **systematic national prospection campaign**, as called for by a parliamentary motion, **could provide a remedy** here and **improve the level of knowledge** about potential storage in Switzerland.
- In the mean time, a **non-commercial pilot project like CITru could pave the way for the further assessment and development of CO₂ storage possibilities** in Switzerland.





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Swiss Geological Survey

wissen wohin
savoir où
sapere dove
knowing where

swisstopo



Thank you for your attention!

swisstopo Kolloquium / 2nd February 2024



Fazit

- Die Zeit drängt – **Pilotphase bis 2030** und **Netto-Null bis 2050** sind ambitionierte Ziele
- **Lösungen im Ausland** (z.B. offshore in der Nordsee) sind möglich. Künftige Preise, Transportkapazitäten und der Wille, CO₂ aus der Schweiz anzunehmen, sind jedoch unklar.
- Ein gewisses **Speicherpotenzial im schweizerischen Untergrund** ist vorhanden, dessen Grösse ist aber unbekannt.
- Sämtliche Optionen zur **CO₂-Speicherung** müssen weiterhin verfolgt werden.



Nächstes Kolloquium – 1. März 2024

Schulungen, Seminare & Workshops | 1. März 2024

Programm «Nationales Geologisches Modell» (NGM) – Aktueller Stand

Investitionen in den Untergrund sind mit Risiken behaftet. Die digitale Verfügbarkeit von geologischen Daten hilft, Risiken von Investitionen zu senken. swisstopo wurde mit der Umsetzung von Massnahmen beauftragt.

Geologie

