CO_2 sequestration:

Progress in the Elegancy-ACT project

SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Alba Zappone (ETHZ)

with contributions of :

Melchior Grab
Antonio Rinaldi
Anozie Ebigbo
and the ELEGANCY Team

Horw, 14 Sept. 2018

In cooperation with the CTI

Energy funding programme
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

Overview

Efficient generation of renewable H_2 from biomass, while harvesting geothermal heat and enabling negative CO_2 emissions

September 2017-August 2020

*ACT ELEGANCY, Project No 271498, has received funding from **DETEC (CH)**, BMWi (DE), RVO (NL), Gassnova (NO), BEIS (UK), Gassco, Equinor and Total, and is cofunded by the European Commission under the **Horizon 2020** programme, ACT Grant Agreement No 691712.*

Accelerating CCS Technologies

Enabling a Low-Carbon Economy via Hydrogen and CCS

ELEGANCY

ELEGANCY SCCER SoE

Actors

- **ETHZ**
- **SCCER-SoE**
- **PSI**
- **Climeworks**
- **First Climate**
- Energie 360°, Alpiq, Casale, GE, …

RU Bochum

Open Grid Europe

UNIPER Energy Storage

GERG

TNO/ECN

Utrecht University

Shell

Swerea MEFOS

Imperial College

Sustainable Decisions Ltd.

BGS

INEOS

Scottish Enterprise

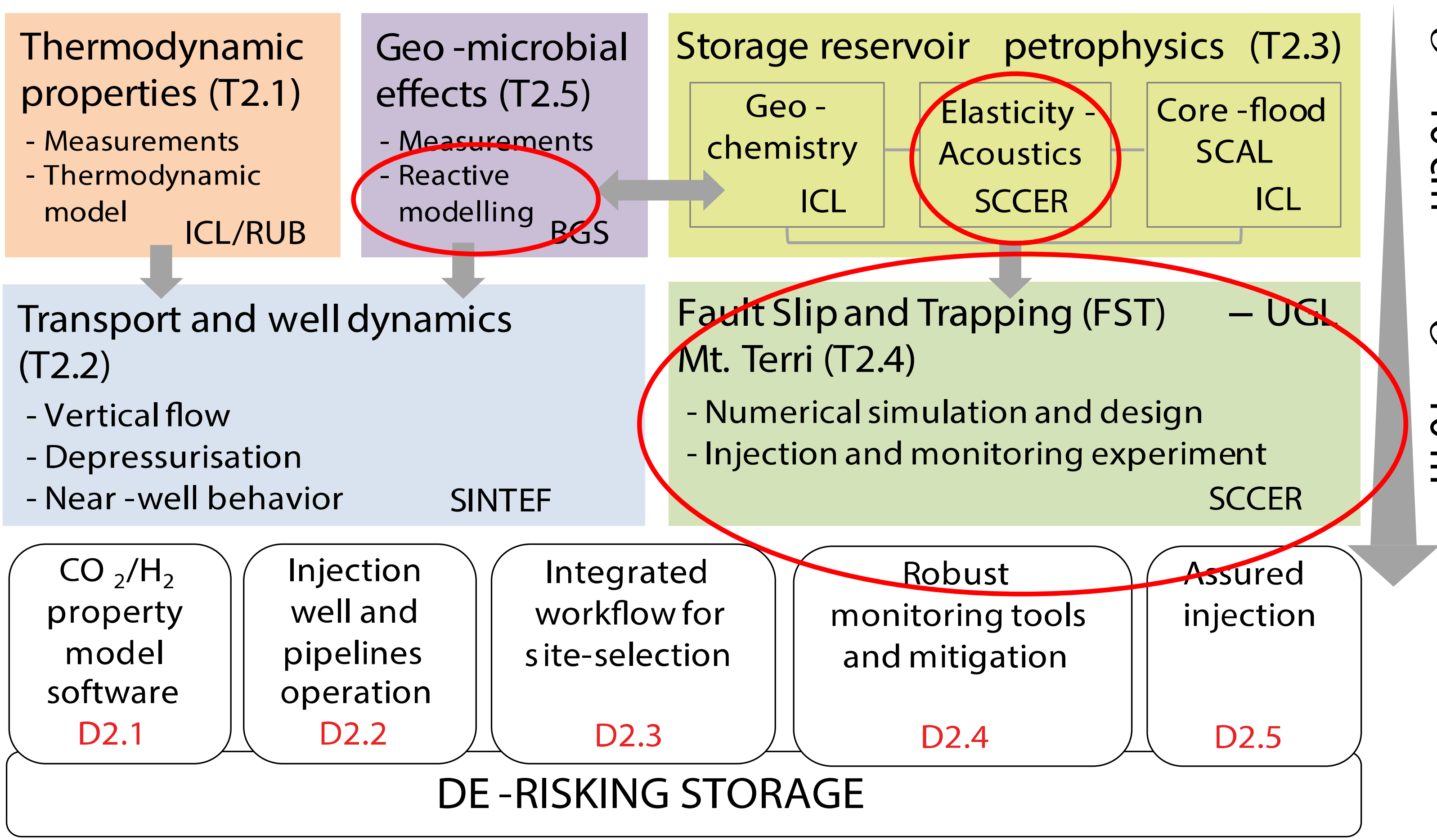
Sintef

Gassco

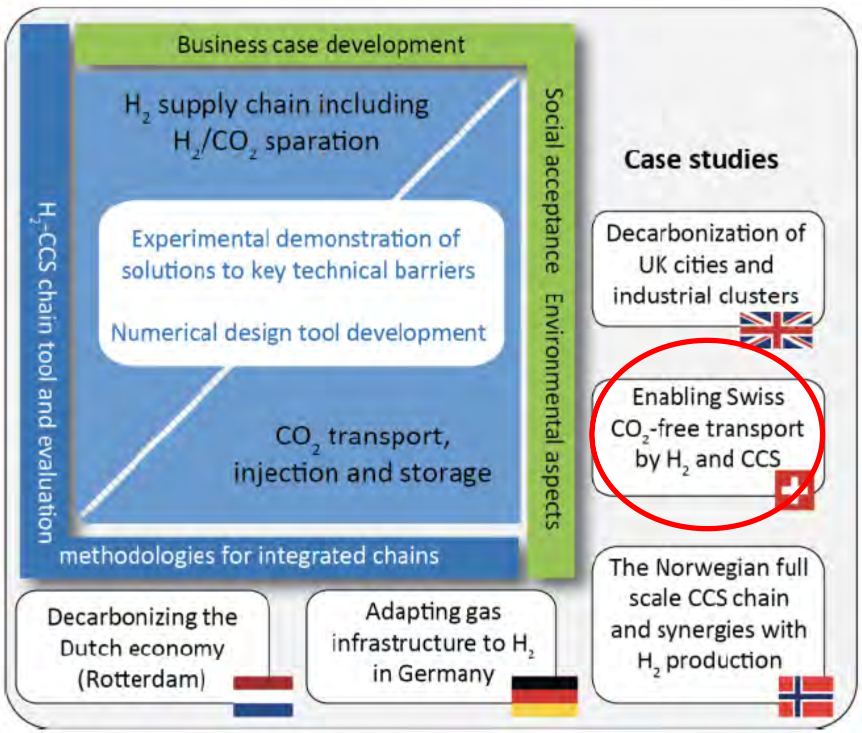
Aker

Arntzen de Besche

WP2: CO_2 transport, injection and storage



WP5 National case studies on the implementation of H_2-CCS chain



[…] continued development of the **Swiss Geothermal/CCS Roadmap**, and SCCER will be integrating the findings into the strategies for the future Swiss energy system, in particular with regards to aspects of **CO_2 storage sites** […]

Table 1 WP5 deliverables with person month (PM) efforts and due month

D5.3.1	Scientific papers on H_2 production from biogas and bio-mass in Switzerland: technical evaluation, potential estimation and comparison with H_2 production from electrolysis, including focus on infrastructure for decarbonising transport	**ETH** (23), PSI (9), E360 (1)	M24
D5.3.2	Scientific papers on screening of underground sites in Switzerland for geothermal and CO_2 storage applications, with emphasis on de-risking storage	**SCCER** (72), ICL (8), BGS (5), PSI (3)	M27
D5.3.3	Scientific papers on scenario modelling for energy production via coupled CO_2 storage and geothermal in Switzerland, including quantification of Swiss H_2-CCS chain performance	**SCCER** (36), PSI (24)	M33
D5.3.4	Scientific papers on improved DACCS for accelerating CO_2 storage and geothermal applications, including life cycle analysis of DACCS compared to biomass-based H_2-CCS	**Climeworks** (60), PSI (2)	M36
D5.3.5	Scientific papers on the potential and role of clean H_2 for road transportation and DACCS as enabler of geothermal and CO_2 storage applications in the Swiss society	**SCCER** (36), PSI (12)	M36

D5.3.2	Scientific papers on screening of underground sites in Switzerland for geothermal and CO_2 storage applications, with emphasis on de-risking storage	**SCCER** (72), ICL (8), BGS (5), PSI (3)	M27

Societal perspective: Data of a first survey on social acceptance of CCS and geothermal energy have been collected by an online survey among the general population in the German and French speaking parts of Switzerland (N = 808). Coordination with the RUB team is on-going

Screening of underground sites for geothermal energy and CO2 storage:
1. Definition of criteria for CCS site selection across the Swiss Plateau
2. Providing quantitative data (subsurface geological model and morphotectonic analysis) concerning a possible CCS site.

Risk management (year 2): series of workshops in coord. with BGS , 1st on Sept 24
Aim: define the scientific objectives we want to test in the injection site (e.g. injectivity, leakage monitoring strategies, remediation strategies, reservoir modeling, etc.)

Table 1 WP2 deliverables with person month (PM) efforts and due month

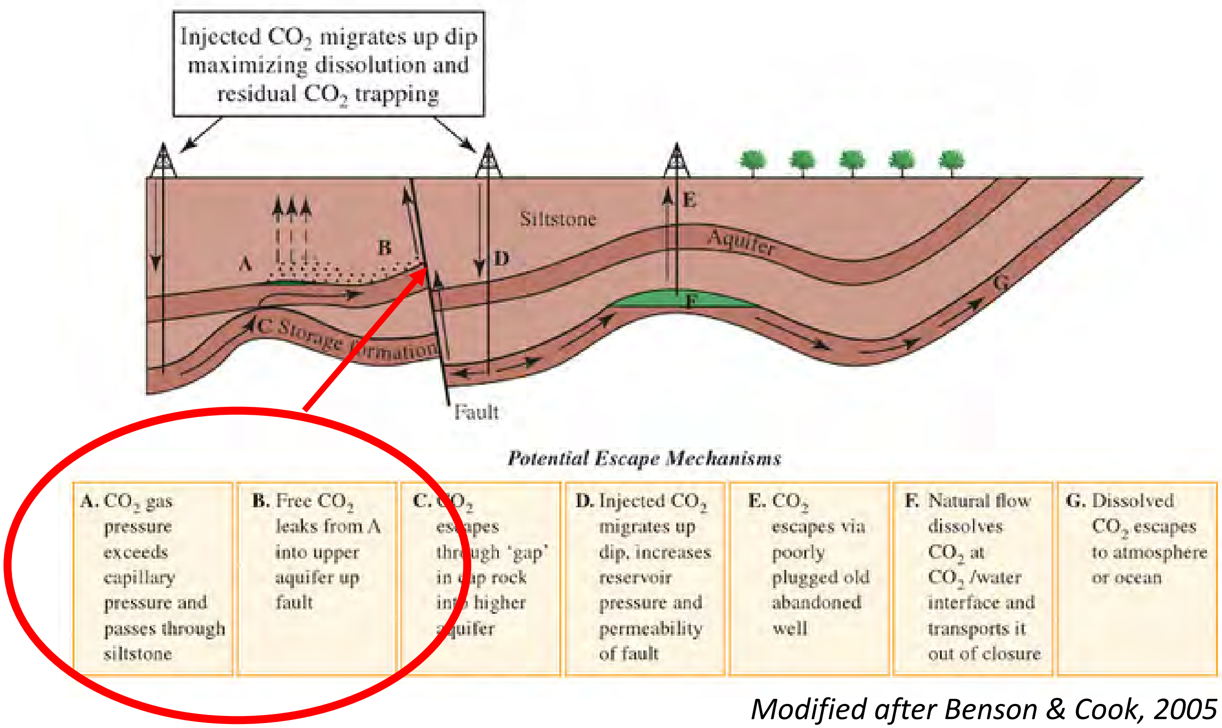
ID	Title	Partners (PM)	Due
D2.3.1	Core-analysis report/paper on reservoir rocks from promising storage sites in Switzerland, including measures of multiphase and elastic properties and incorporating the effect of sub-core scale heterogeneity	ICL (33), SCCER (24)	M33
D2.3.2	Report/paper on dissolution and capillary trapping for scenarios involving ex-solution of CO_2 in response to depressurization ("dynamic" core-floods to design Mt. Terri exp.)	ICL (34)	M30
D2.3.3	Report/paper on the geochemical response of the rocks to the presence of pure and dissolved CO_2, including measurements of reservoir-mineral wettability and dissolution rates in CO_2-saturated brines and sorption on clays	ICL (34)	M33
D2.4.1	Preliminary report on characterization, design, and execution of the Mont Terri exp.	SCCER (48)	M24
D2.4.2	Report/paper on core characterization from related rock mechanics experiment and modelling of Mont Terri experiment	SCCER (24)	M30
D2.4.3	Report/paper on risk assessment and de-risking strategies for future scenarios and knowledge transfer to WP5	SCCER (24)	M30

Table 2 WP2 milestones

ID	Title	Responsible	Due
M2.4.1	Mont Terri experiment design and characterization completed	SCCER	M18
M2.4.2	Mont Terri experiment executed	SCCER	M24
M2.5.1	Construction and operation of suitable geomicrobial set up	BGS	M12
M2.5.2	Completion of geomicrobial experiments	BGS	M30
M2.5.3	Extension of THC simulator capability to support microbiological effects	SCCER	M27

Caprock/fault sealing integrity: Mont Terri CS-D experiment

Scientific objects



Modified after Benson & Cook, 2005

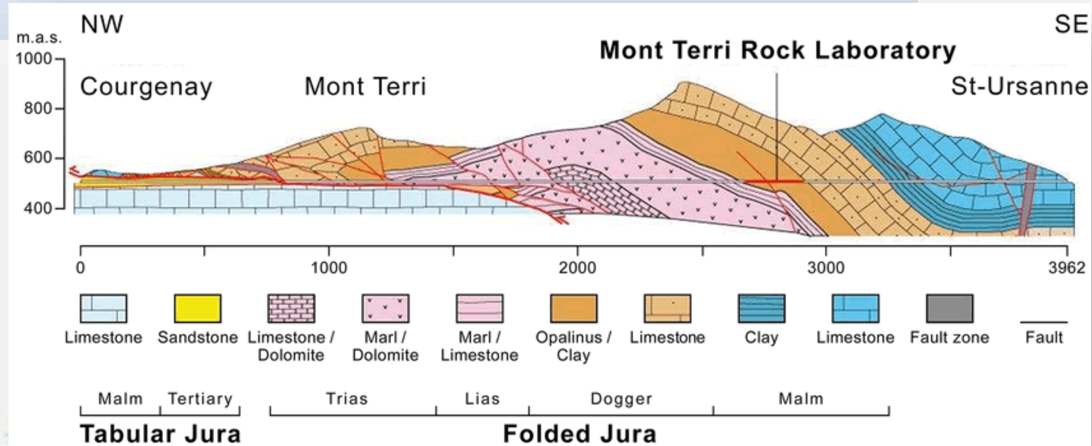
Understanding how exposure to CO_2-rich brine affects **sealing integrity** of caprock (hosting a fault system): **permeability changes** - **induced seismicity**

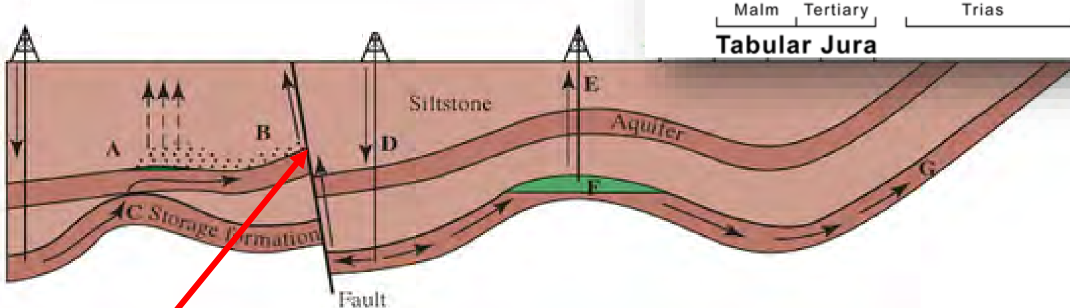
Direct observations of fluid migration along a fault and of its interaction with the surrounding environment

Validate instrumentation and methods for **monitoring** and imaging fluid transport

Validate Thermo-Hydro-Mechanical-Chemical **(THCM) simulations**

Caprock/fault sealing integrity: Mont Terri CS-D experiment





Potential Escape Mechanisms

A. CO_2 gas pressure exceeds capillary pressure and passes through siltstone	**B.** Free CO_2 leaks from A into upper aquifer up fault	**C.** CO_2 escapes through 'gap' in cap rock into higher aquifer	**D.** Injected CO_2 migrates up dip, increases reservoir pressure and permeability of fault	**E.** CO_2 escapes via poorly plugged old abandoned well	**F.** Natural flow dissolves CO_2 at CO_2 /water interface and transports it out of closure	**G.** Dissolved CO_2 escapes to atmosphere or ocean

Testing of a fault subjected to CO_2 injection in Mont Terri

Modified after Benson, S.M. and Cook, P., 2005. Underground geological storage. In: B. Metz, O. Davidson, H. de Coninck, M. Loos & L. Meyer (Eds), IPCC special report on carbon dioxide capture and storage. Cambridge University Press, Cambridge: 195-276.

Caprock/fault sealing integrity: Mont Terri CS-D experiment

Concept

- Inject CO_2 saturated brine and tracers in Mont Terri main fault:
  - Continuous/long term (8-10 month)
  - Pulse/ pressure increase steps (at beginning and at end of the injection phase)

    Scale: 1-10 m^3 brine -> rock volume
- Monitor injection effects:
  - Strain = Extensometer(s)
  - Vp, (Vs), fiber optics and traditional methods
  - Microseismic.......
- Pre and post mechanical & geophysical characterization at lab scale
- Pre and post numerical simulations

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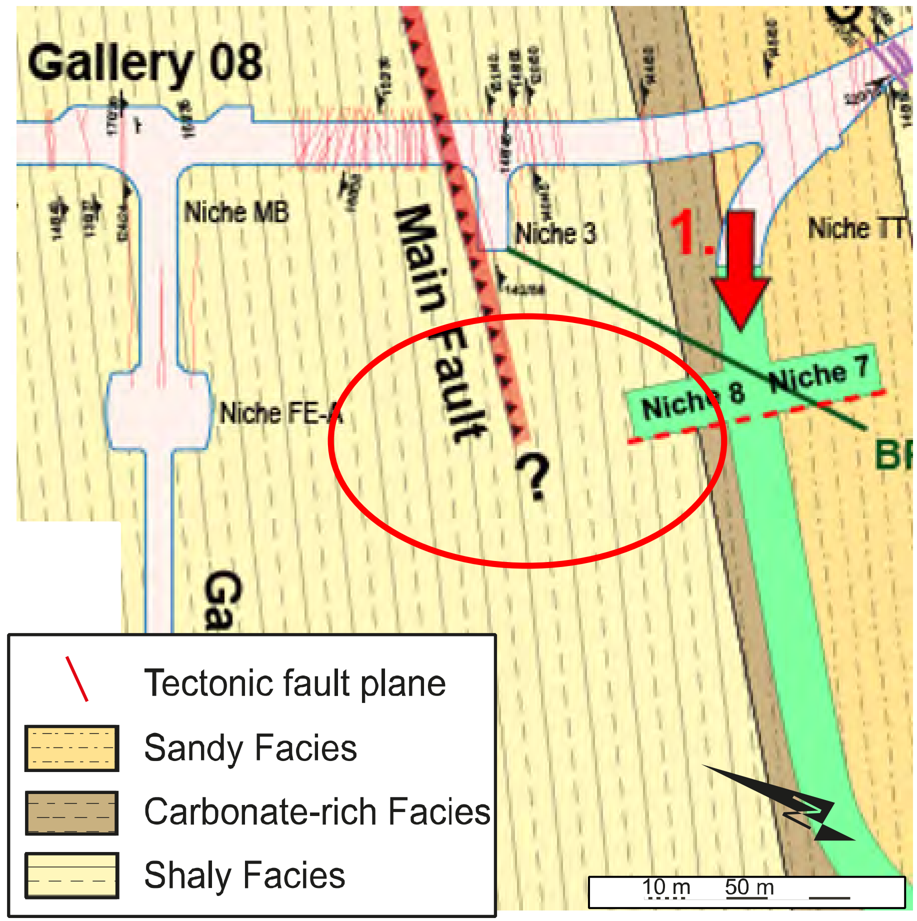
Caprock/fault sealing integrity: Mont Terri experiment

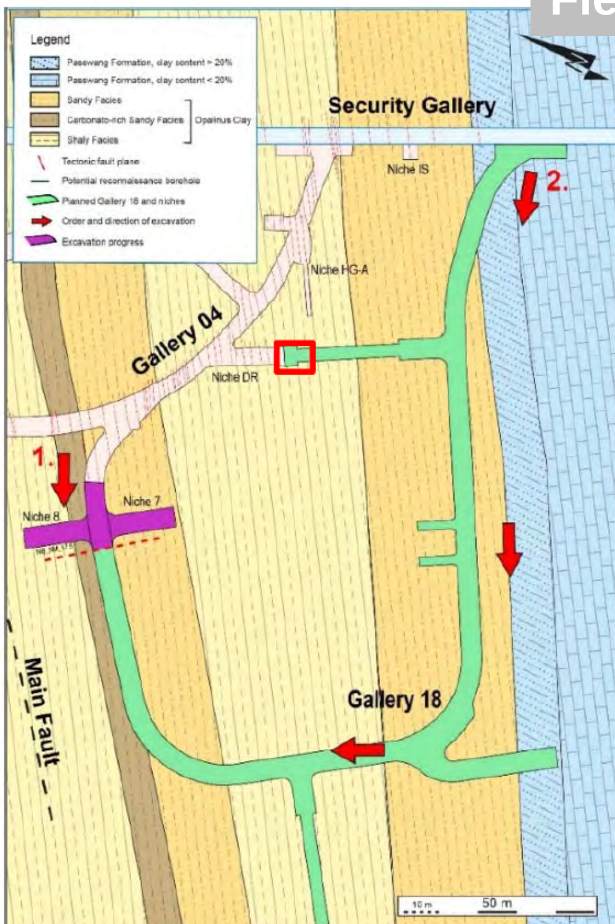
Technical layout one year ago

- Injection borehole
  - 40-50 m long
  - 120 mm diameter
  - 2 separated injection sections
- Parallel borehole for extensometer
- 3-5 Monitoring wells
- Sampling holes



Caprock/fault sealing integrity: Mont Terri CS-D experiment

Field report: May 7th – May 20th 2018 (Phase 23)



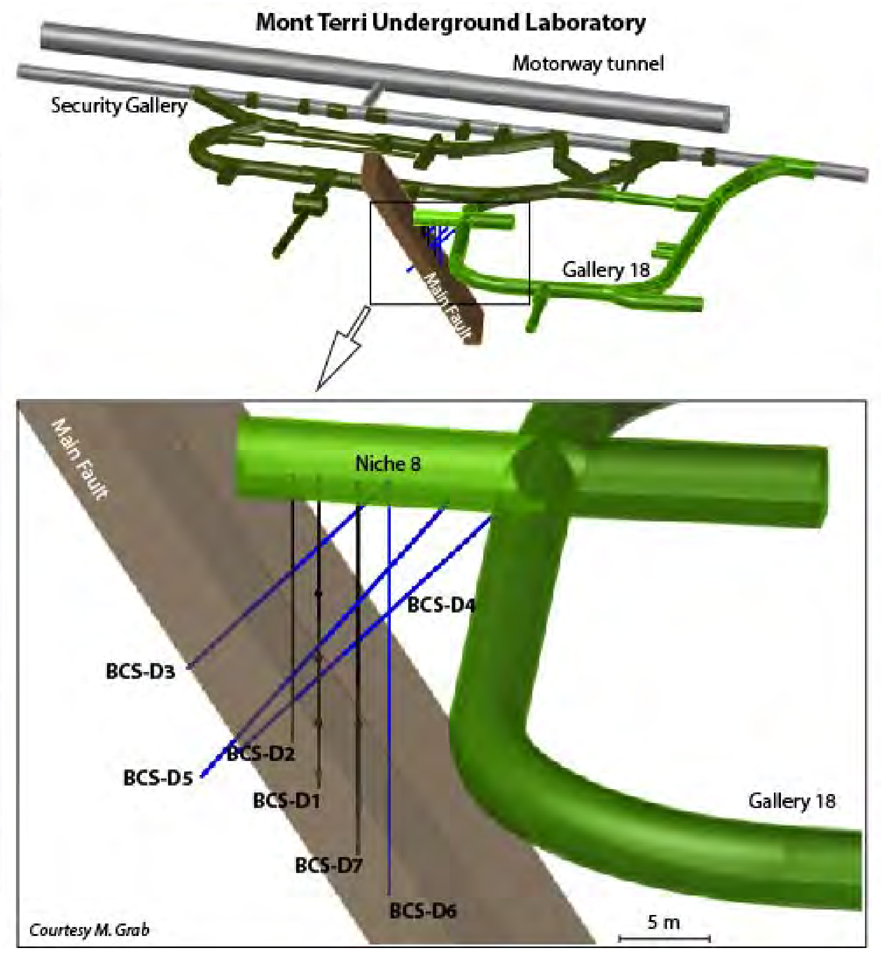
Mont Terri Project

Courtesy Christophe Nussbaum, Swisstopo

Caprock/fault sealing integrity: Mont Terri CS-D experiment

Technical layout

Borehole-ID	Main Purpose	Inclina-tion (°)	Diameter (mm)	Depth (m)
BCS-D1	Injection	0	101	23
BCS-D2	Fluid Monitoring	0	101	20.3
BCS-D3	Active Geop. Mon	42.5	131	27.3
BCS-D4	Active Geop. Mon.	42.5	131	35.2
BCS-D5	Micro-earthq. mon	36.6	146	35.2
BCS-D6	Micro-earthq. mon.	0	131	35
BCS-D7	Slip monitoring	0	101	27.8



Partners with CS-D

Mont Terri Project

swisstopo

Chevron

TOTAL

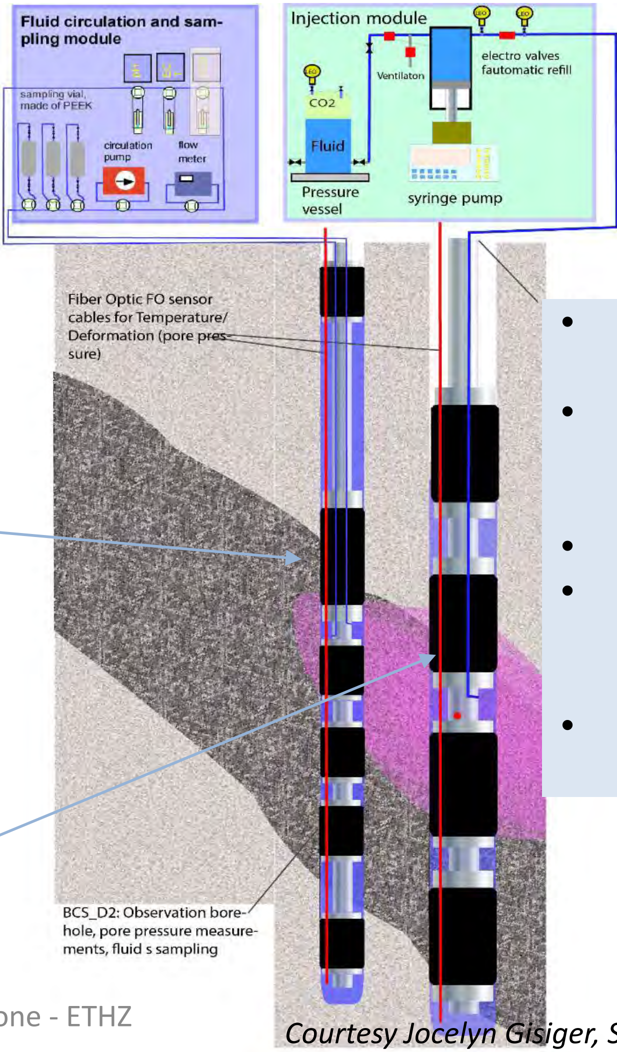
U.S. DEPARTMENT OF ENERGY

Caprock/fault sealing integrity: Mont Terri CS-D experiment

Technical layout

Borehole-ID	Main Purpose	Inclina-tion (°)	Diameter (mm)	Depth (m)
BCS-D1	Injection	0	101	23
BCS-D2	Fluid Monitoring	0	101	20.3

- PT1000 temperature sensor;
- 4 intervals equipped with 3 lines (2 for fluid circulation using sampling module, 1 for pressure measurement) in stainless steel 4



- Packer system control unit
- DTS FO sensor cable integrated within packer system
- 2 injection intervals
- 2 guard intervals above and below the injection intervals
- Packer length: 3x0,5m, 1x1m;

- 4 fold packer system;
- PT1000 temperature sensor;
- Three lines in interval 1 and 4 in stainless steel

Courtesy Jocelyn Gisiger, Solexperts

Caprock/fault sealing integrity: Mont Terri CS-D experiment

Technical layout

Borehole-ID	Main Purpose	Inclina-tion (°)	Diameter (mm)	Depth (m)
BCS-D3	Active Geop. Mon	42.5	131	27.3
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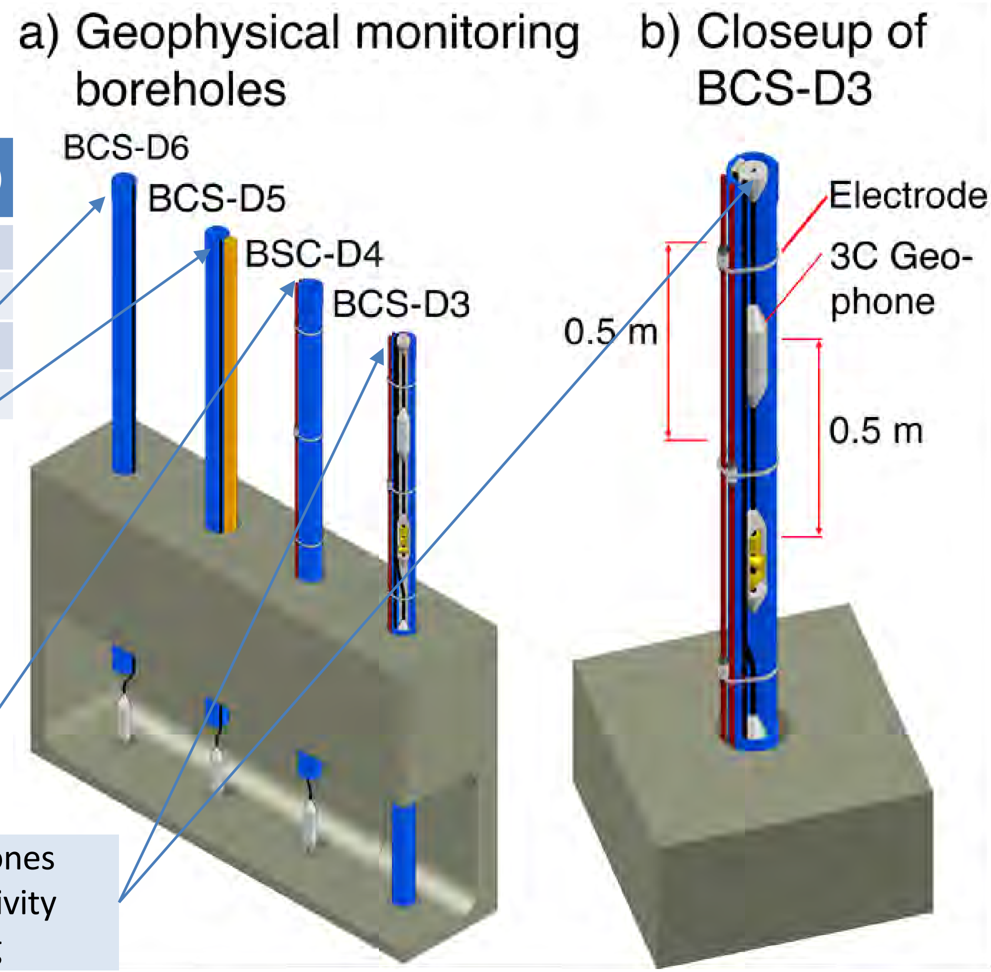
BCS-D5	Micro-earthq. mon	36.6	146	35.2
BCS-D6	Micro-earthq. mon.	0	131	35

- 32 channel GmuG aq. system
- 1MHz sampling rate
- 1-100kHz high sensitivity

- Wilcoxon 736T calibrated accelerometer

- P- and S-wave sparker source

- 24 3C geophones
- 100 Hz sensitivity
- 0.5 m spacing



Caprock/fault sealing integrity: Mont Terri CS-D experiment

Technical layout

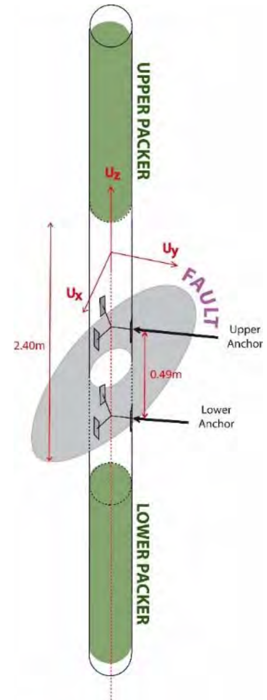
Borehole-ID	Main Purpose	Inclina-tion (°)	Diameter (mm)	Depth (m)
BCS-D7	Slip monitoring	0	101	27.8

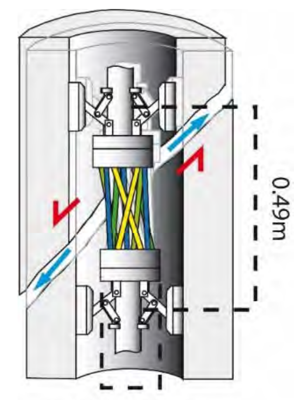
FS-B Partner with CS-D

BERKELEY LAB
Lawrence Berkeley National Laboratory

Borehole coupled pore pressure and strain monitoring:

3-components Displacement sensors (2 SIMFIP sensors)





- Measurement range:
  Uaxial = 0,7mm
  Uradial = 3,5mm
- Resolution of 3µm
- 500 Hz sampling frequency

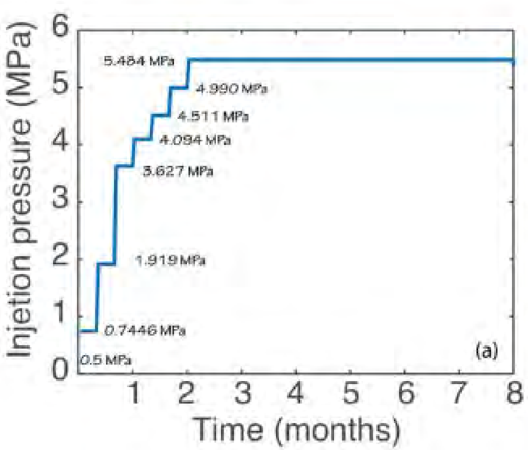
Caprock/fault sealing integrity: Mont Terri CS-D experiment

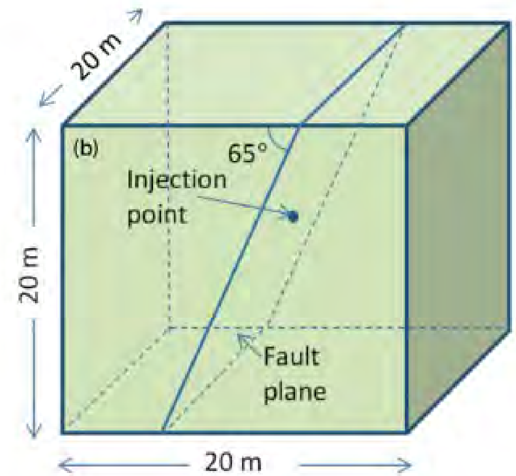
Preliminary modelling TOUGH-FLAC

Sensitivity analysis to assess the max reach of the pressure front and injection brine

- Assumptions:
  - Pure brine, no CO_2
  - Fixed permeability
  - No stress dependency

- injection strategy similar to the previous FS-experiment



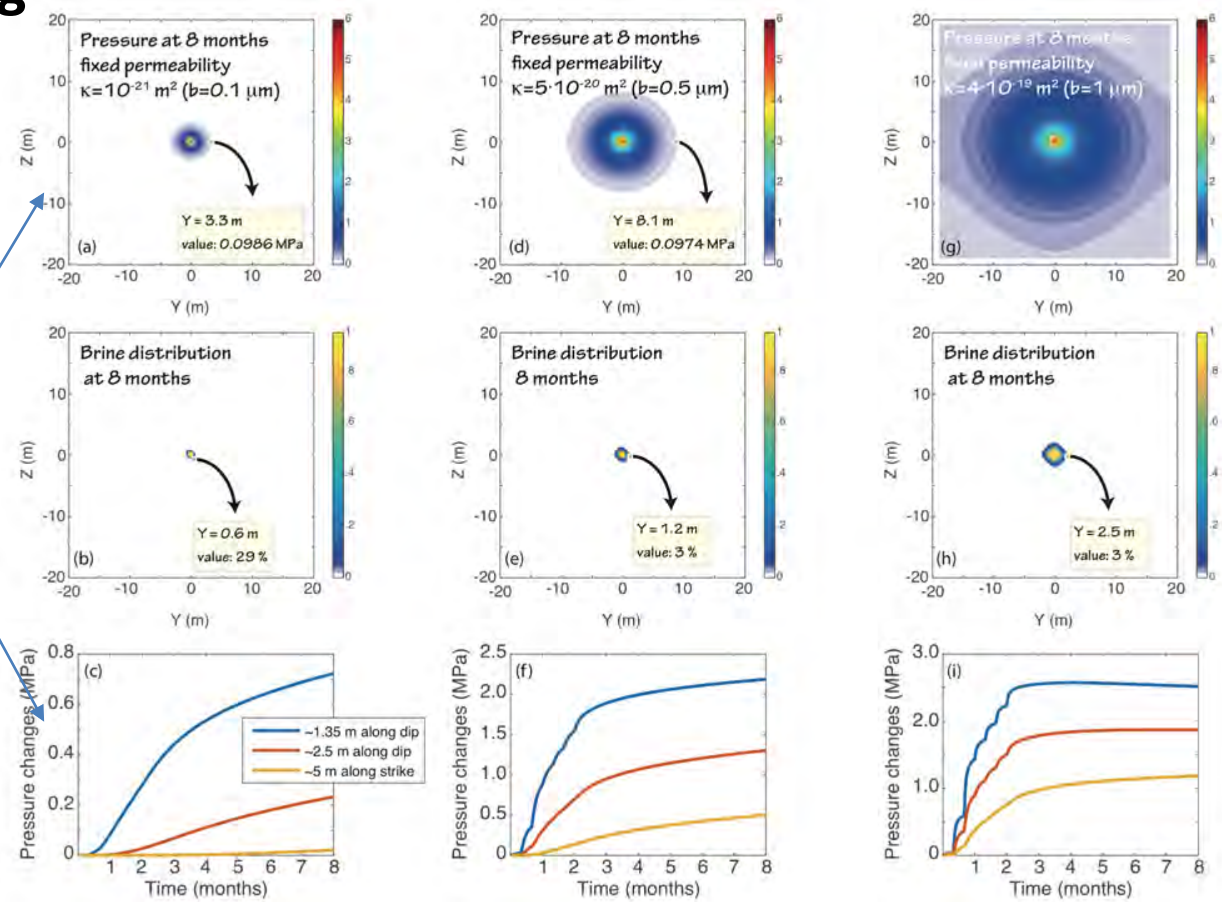


Caprock/fault sealing integrity: Mont Terri CS-D experiment

Preliminary modelling TOUGH-FLAC

By varying the permeability in the range 10^{-21} to 10^{-19} m^2:

- pressure can propagate, in all simulated cases
- with value well above in short time
- the injected brine is reaching above 2 m distance only in the case with higher permeability



Caprock/fault sealing integrity: Mont Terri CS-D experiment

Preliminary modelling TOUGH-FLAC

Two possible cases:

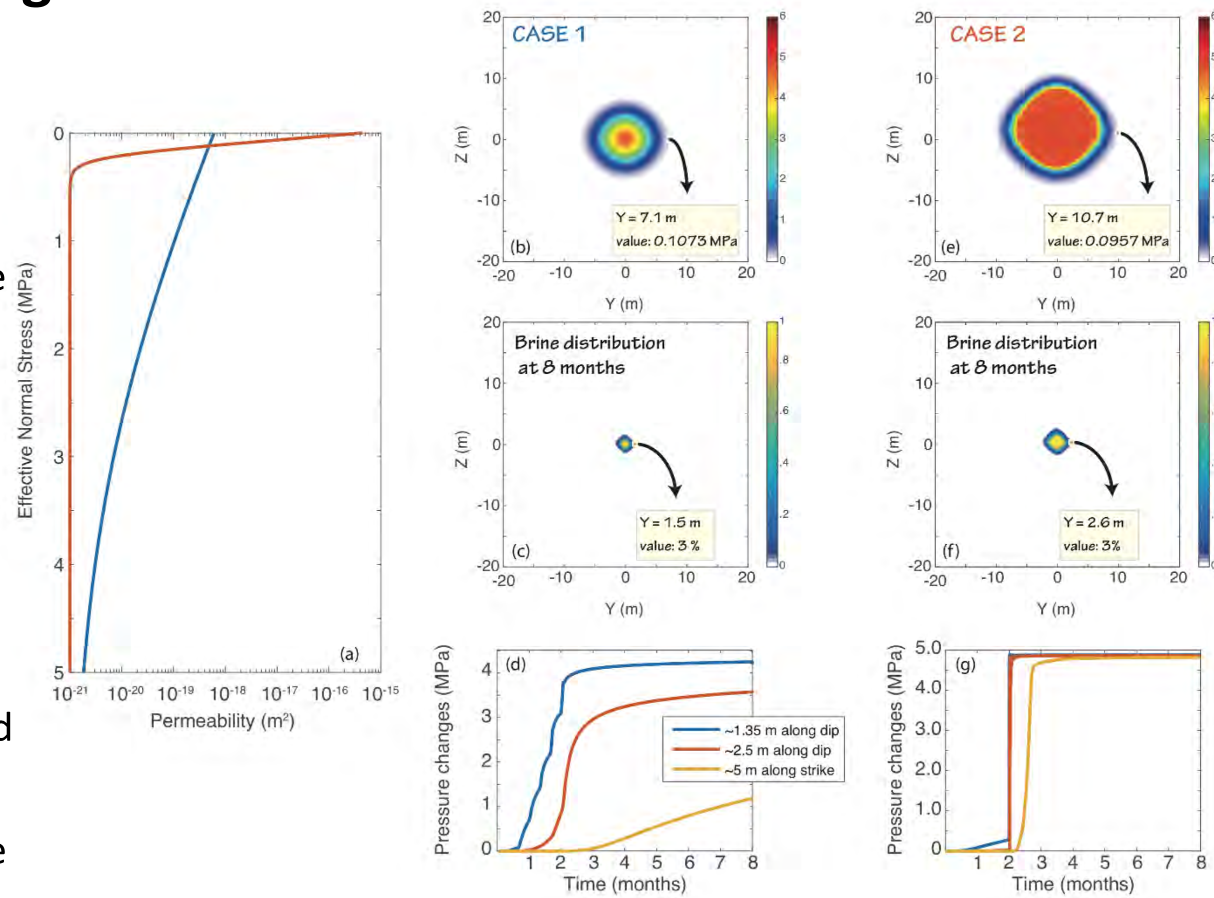
- a constant increase of permeability with decreasing normal effective stress (elastic behaviour)
- fracture jack opens after reaching small value in effective normal stress (opening).

Conclusion:

- In case 2 no pressure changes should be recorded in the first months, and after jacking the pressure should reach a similar value in the entire opened region.

Elastic

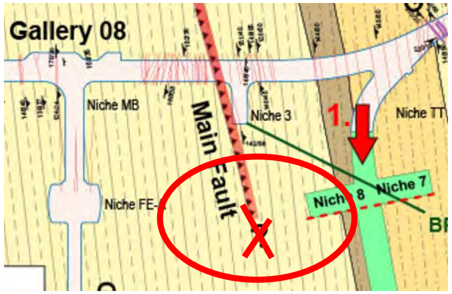
Opening

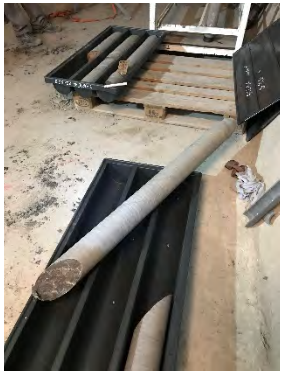


Caprock/fault sealing integrity: Mont Terri CS-D experiment

Operative Phase

- August 28: the drilling company installed and started with the borehole
- Fault encountered at 28.4 m depth. C.a 3 m thikness



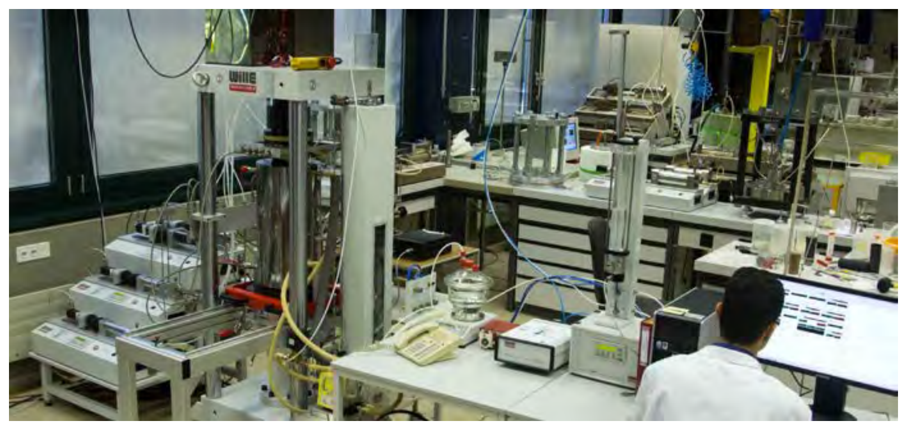


Caprock/fault sealing integrity: Mont Terri experiment

Laboratories

Rock Deformation Lab
(Dr. C. Madonna)

Lab of Soil Mechanics
(D. Alessio Ferrari)



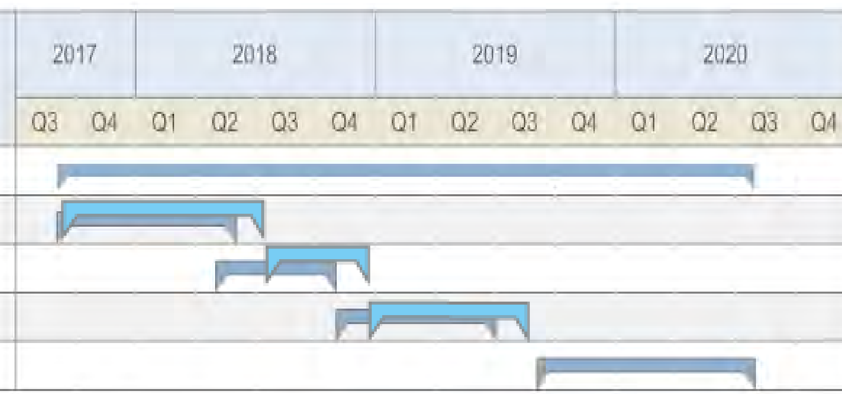
Caprock/fault sealing integrity: Mont Terri experiment

Timeline

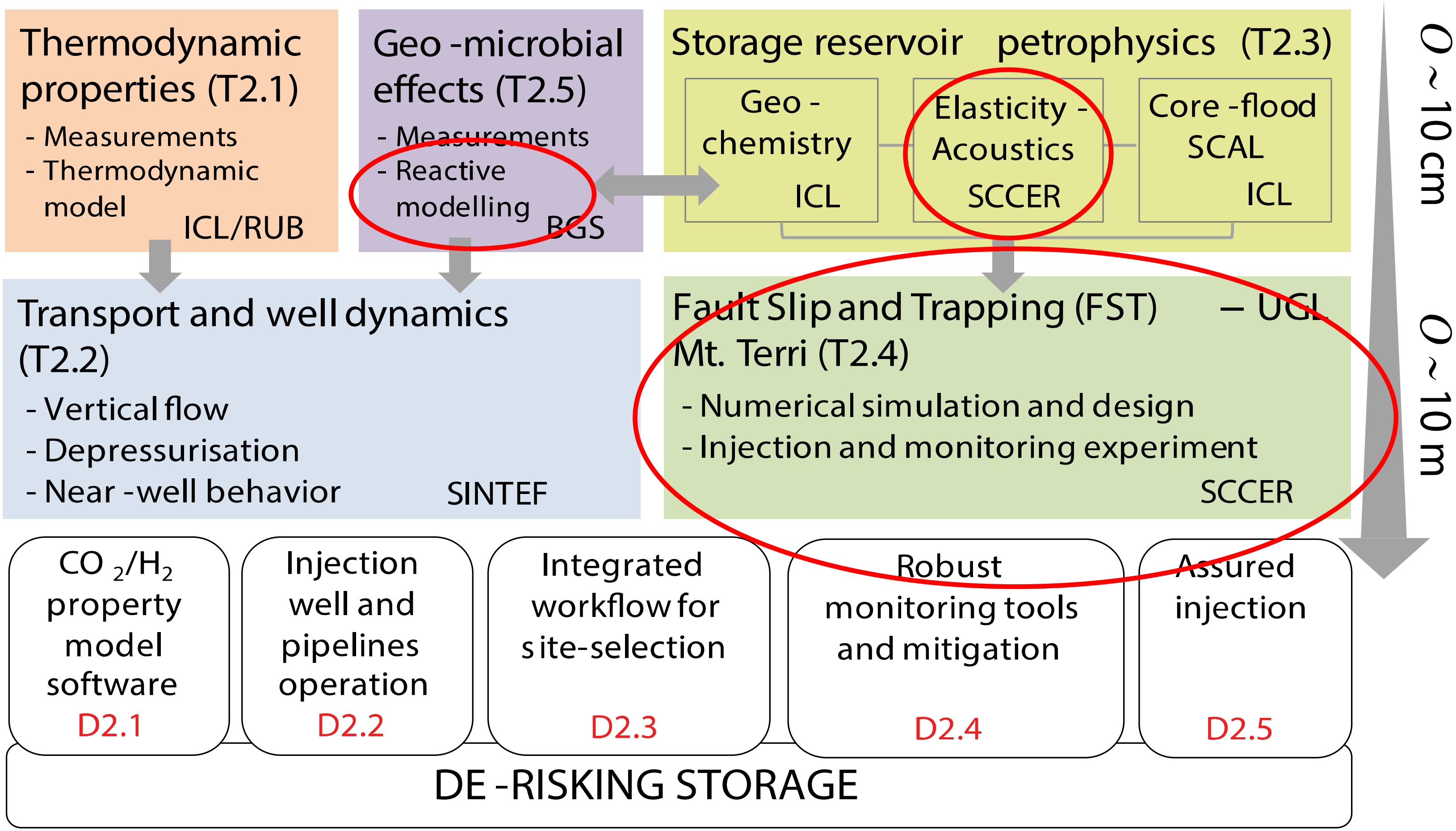
ELEGANCY: 1.9.2017- 31.8.2020

Mont Terri Phase 24-25

#	Task	Assigned To	Start	End	Dur
	Project Fault sealing integrity		1/9/17	30/7/20	759
1	Experimental design and feasibility study		1/9/17	31/5/18	194
2	Experimental installation		1/5/18	31/10/18	131
3	Injection and monitoring		1/11/18	30/6/19	172
4	Post experiment volume characterization		1/9/19	30/7/20	238



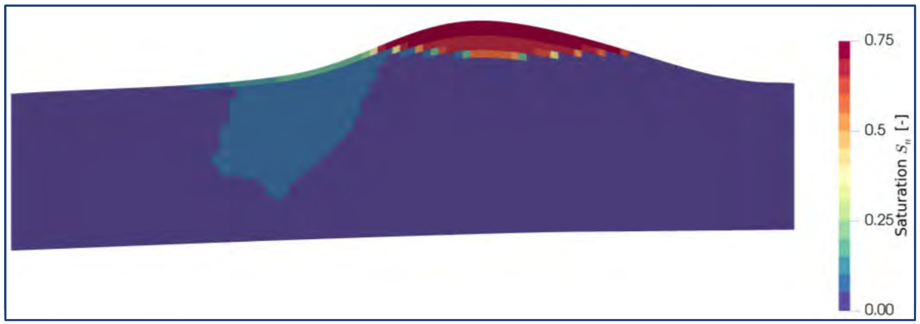
WP2: CO_2 transport, injection and storage



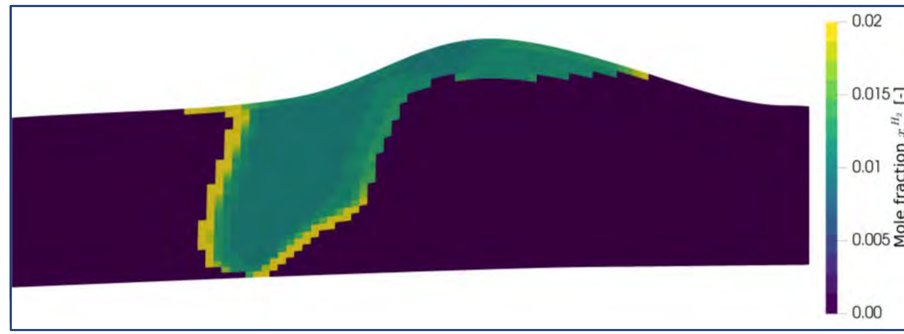
Anwar Al Assadi's MSc, collaborators Uni Stuttgart.

Simulation of injection of impure CO_2 (1% H_2) in a saline aquifer for 1 year

CO_2 saturation

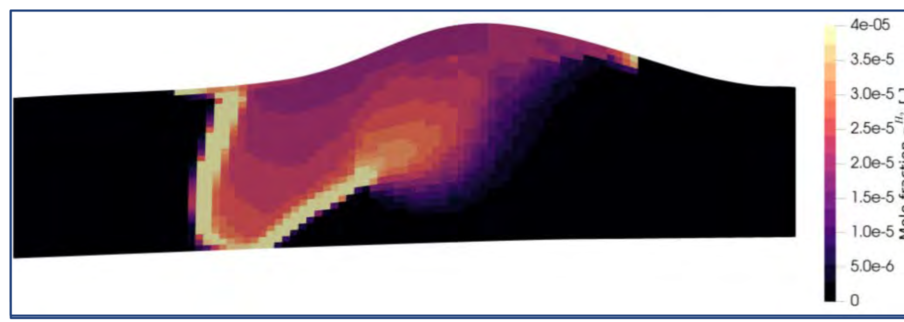


Mole fraction of H_2 in CO_2 phase



time = 40 years (post injection)

- Due to differences in the properties of CO_2 and H_2, there is an accumul-ation of H_2 at the fringe of the plume.
- Higher (double) hydrogenotrophic microbial growth rates are to be expected at the fringe than in the middle of the plume. => future work



Mole fraction of H_2 in water phase

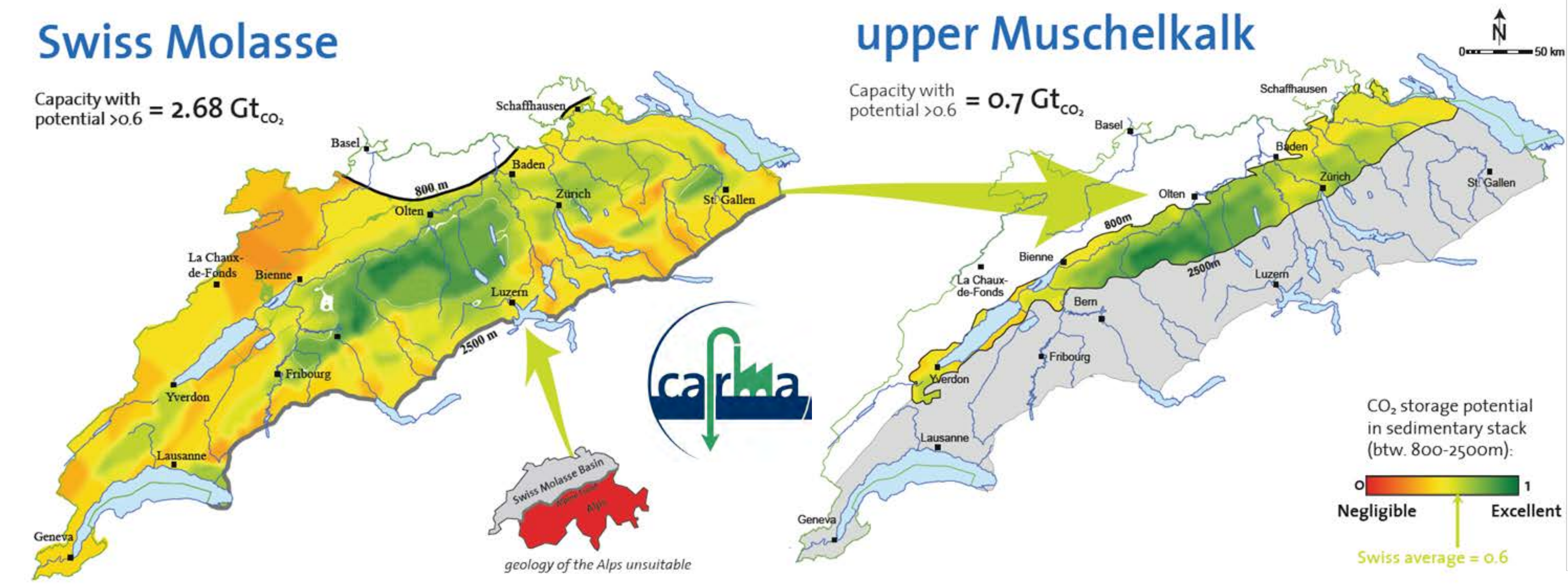
Domain dimensions; ca. 3km x 400m

Progress in the Elegancy-ACT project

Thank you for your attention

ELEGANCY

CO_2 storage site selection



Chevalier G., Diamond L.W., Leu W. (2010) Potential for deep geological sequestration of CO_2 in Switzerland: a first appraisal, Swiss J. Geosciences, 103:427–455

ELEGANCY

CO_2 storage site selection

Final Report 31 May 2013

Roadmap for a Carbon Dioxide Capture and Storage pilot project in Switzerland

2013

Grundlage für Baugesuch CO_2-Pilot Anlage

ENTWURF

Grundlagen zur Einreichung eines bewilligungsfähigen Baugesuchs für eine CO_2- Injektions Pilotanlage

erarbeitet im Auftrag des Bundesamtes für Energie

Autor:

Dr. Markus O. Häring
Häring Geo-Project

Oktober 2015

HÄRING Consulting
Schwienweg 16, CH-4410 Liestal

2015

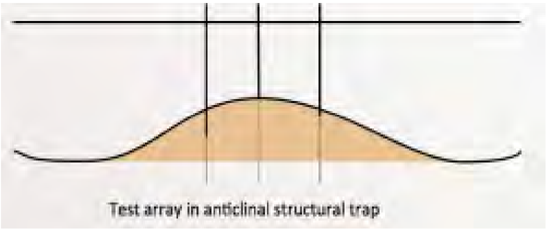
Draft_CO2_Injection_Pilot_291015.docx Seite 1 von 49 28.10.15

ELEGANCY

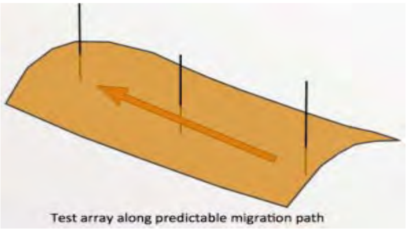
CO_2 storage site selection

Feasible Scenarios for Injection Test

STORAGE



FIELD LAB



STORAGE:

\+ Could be final storage site (small)
\+ Will demonstrate CCS feasibility in CH

\- Long and costly exploration phase

FIELD LAB:

\+ Results on migration process in short time

\- No final storage site, up-scaling problems, public acceptance

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SCCER SoE

CO_2 storage site selection

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

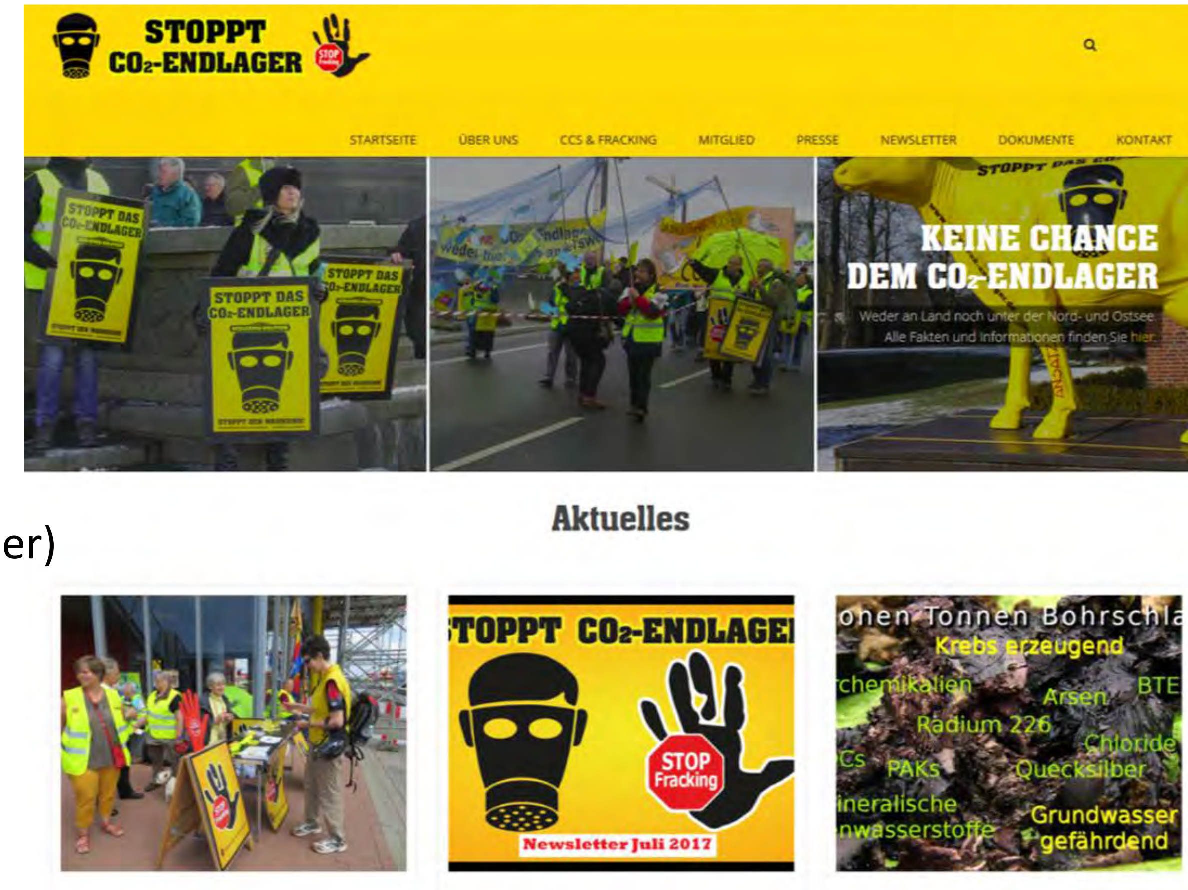
Reservoir Geology and Sedimentary Basin Analysis
(Prof Andrea Moscariello)

GeoMol – Geologisches 3D Modell des Schweizerischen Mittellandes

Wie sieht es im Innern des Hügelzugs aus, auf dem Schloss Aarburg steht? Wo in der Schweiz gibt es Gräben, welche bis 3000 m unter die Erdoberfläche reichen? Wir können es Euch zeigen! Mit dem brandneuen geologischen 3D-Modell der Schweiz sind solche Einblicke in den Untergrund ab sofort möglich.

ELEGANCY

CO_2 storage site selection



USYS TdLab
Department of Environmental Systems Science
Transdisciplinarity Lab · Science-Society Interface

(Prof Michael Stauffacher)

Source: http://keinco2endlager.de/

CCS geological storage pilot

The opportunity of Elegancy

Thank you for your attention

Neue Zürcher Zeitung

Das neue Immobilienportal für Anspruchsvolle

Kohlendioxid-Rückgewinnung

Zürcher Startup-Unternehmen mit Weltpremiere: CO_2 wird aus der Luft gefiltert

von Christian Speicher 31.5.2017, 12:00 Uhr

In Hinwil ist die weltweit erste Anlage in Betrieb genommen worden, die das Treibhausgas CO_2 aus der Luft filtert. Die Technologie könnte zukünftig dazu beitragen, unsere «Klimaschulden» zu begleichen.

Auf dem Dach der Kehrichtverbrennungsanlage in Hinwil steht der CO_2-Filter, der die Gärtnerei mit dem wachstumsfördernden Treibhausgas versorgt. (Bild: Climeworks / Julia Dunlop)

CLIMEWORKS

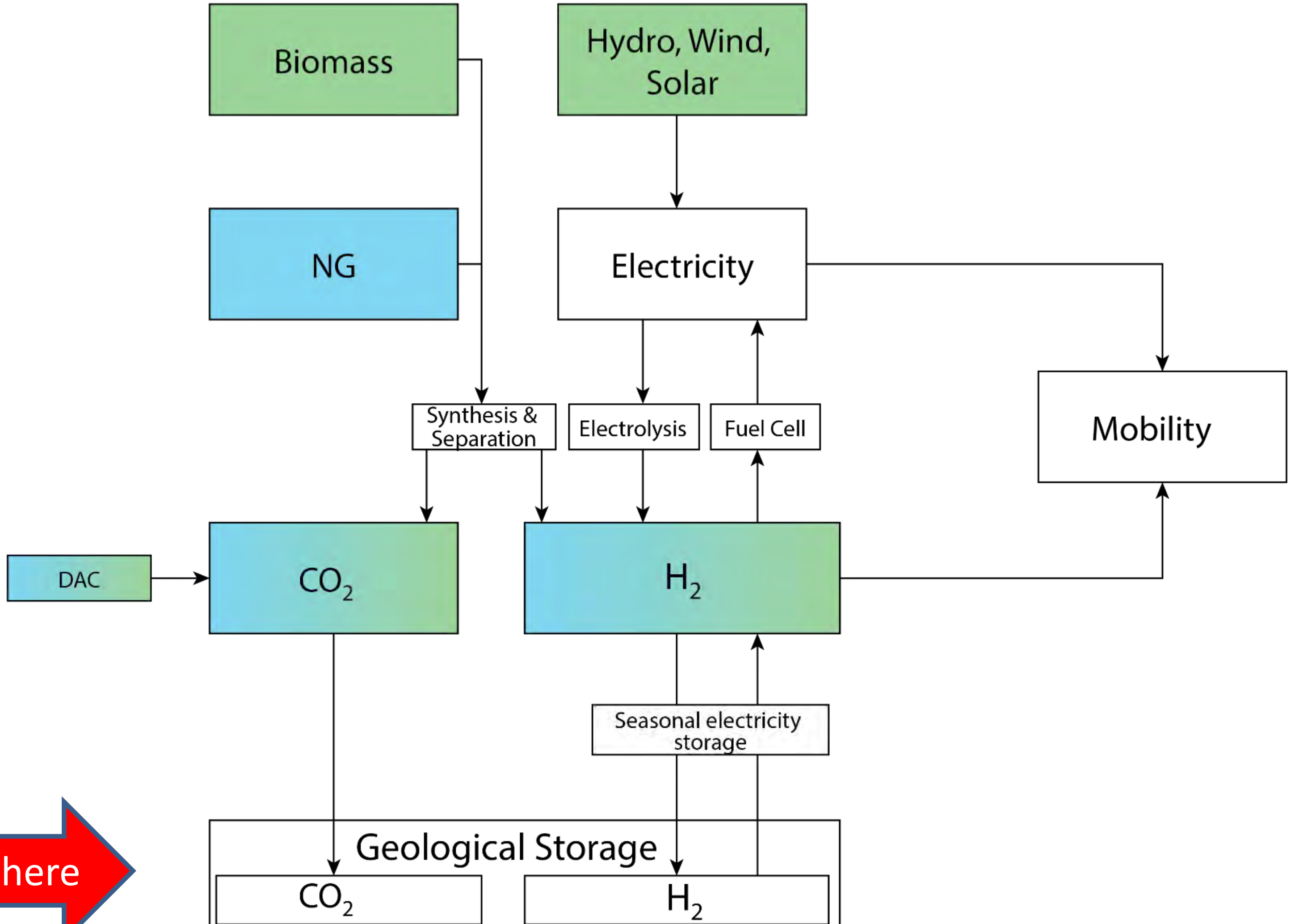
Capturing CO_2 from air

Climeworks makes history with world-first commercial CO2 capture plant

Today Climeworks is unveiling its proudest achievment to date: the world's first commercially operational plant capturing CO2 from the atmosphere.

We'll be bringing live updates from the launch event near Zürich, Switzerland. So check out our Twitter and Facebook feeds and sign up to our newsletter to get the latest updates from our ongoing mission to capture one per cent of global carbon emissions by 2025.

Elegancy - Vision



We are here

Proposal full title:

Enabling a Low-Carbon Economy via Hydrogen and CCS

Proposal acronym:

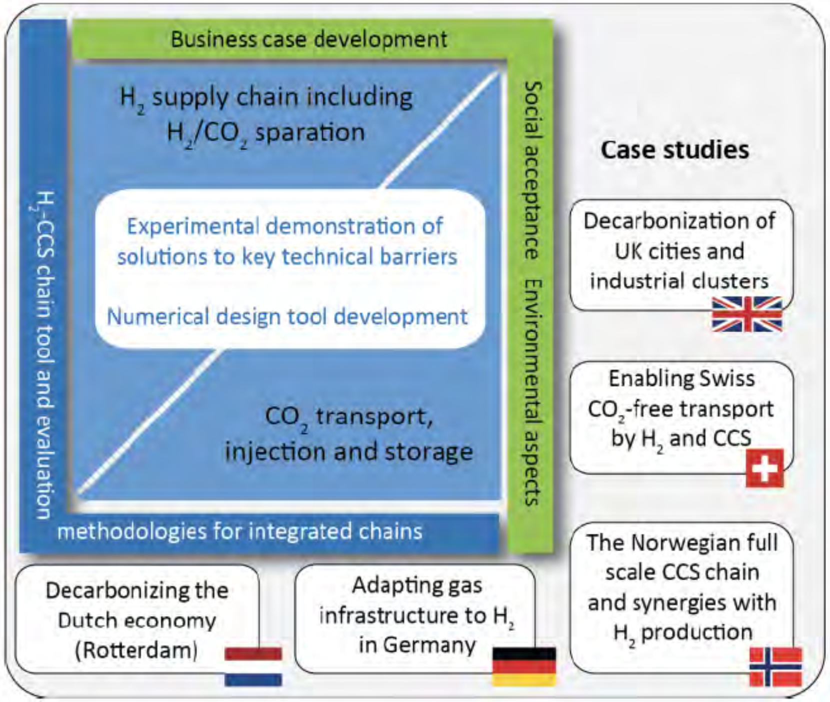
ELEGANCY

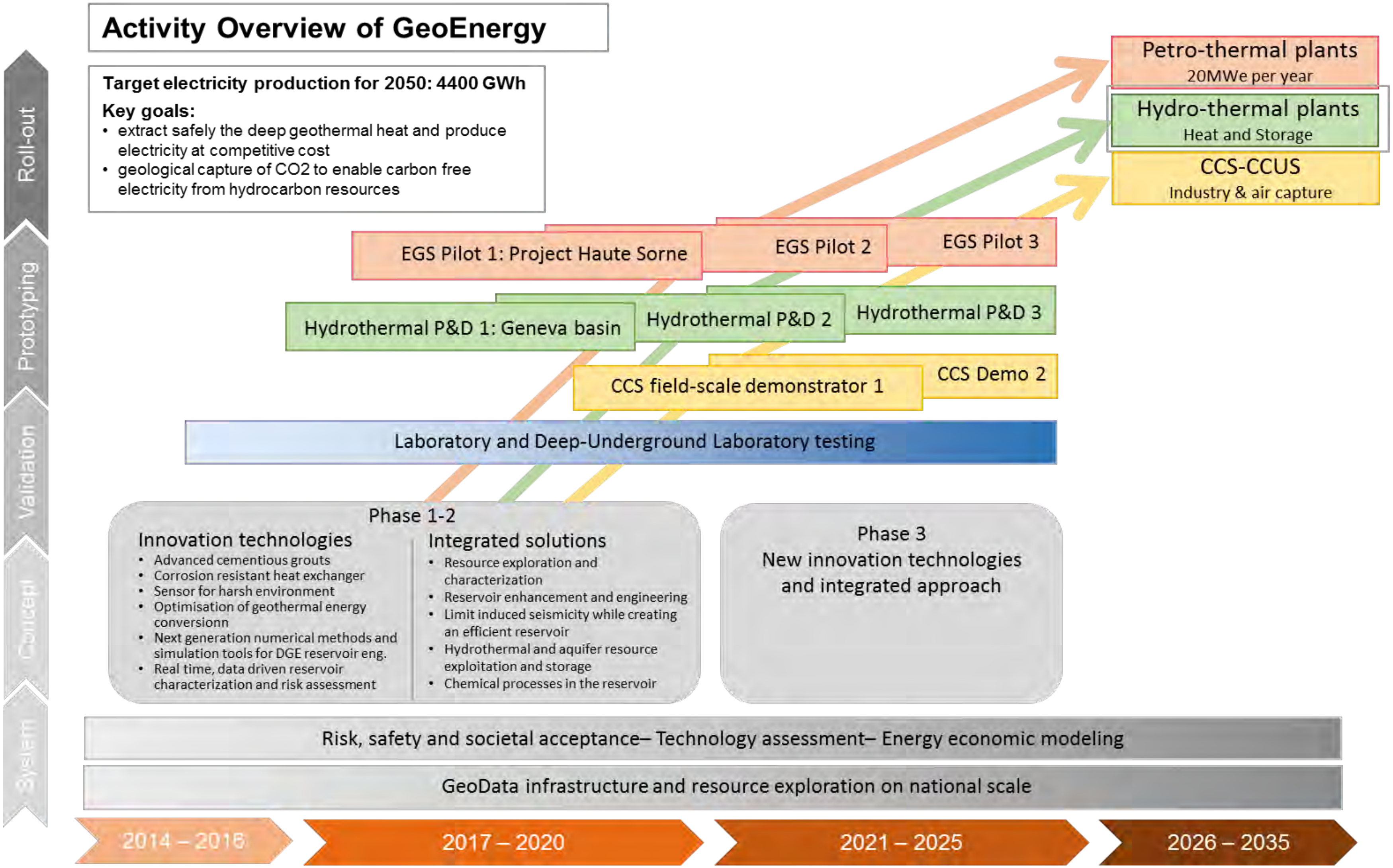
Call: ERA-NET Cofund ACT stage 2, full proposal, deadline 2017-01-16

Project coordinator: Dr Svend Tollak Munkejord, Chief Scientist, SINTEF Energy Research
E-mail: svend.t.munkejord@sintef.no, Mobile phone: +47 47378042

List of applicants

Note	Organization name	Acronym	Country	Organization type
Main applicant	SINTEF Energy Research	SINTEF	Norway	Research institute
	Arntzen de Besche	AdeB	Norway	Law firm
	Aker Solutions	AKSO	Norway	Technology provider
	Gassco AS	Gassco	Norway	Natural gas network operator
National consortium leader, UK	Imperial College London	ICL	UK	University
	British Geological Survey	BGS	UK	Research institute
	Scottish Enterprise	SE	UK	Development agency
	Sustainable Decisions Ltd	SDL	UK	Consultancy firm
	INEOS Chemicals Grangemouth Limited	INEOS	UK	Petrochemical company
National consortium leader, CH	ETH Zürich	ETH	CH	University
	Swiss Competence Center for Energy Research – Supply of Electricity	SCCER	CH	University/Research institute
	Paul Scherrer Institute	PSI	CH	Research institute
	Climeworks AG	CW	CH	Technology provider
	Energie 360°	E360	CH	Natural gas grid operator
	First Climate AG	FC	CH	Consultancy firm
National consortium leader, DE	Ruhr-University Bochum	RUB	DE	University
	Open Grid Europe	OGE	DE	Natural gas grid operator
	Uniper Energy Storage	UES	DE	Technology provider
National consortium leader, NL	Energy Research Centre of the Netherlands	ECN	NL	Research institute
	Netherlands Organisation for Applied Scientific Research	TNO	NL	Research institute
	Utrecht University	UU	NL	University
	Shell	Shell	NL	Energy company
Cooperation partner	Swerea MEFOS	MEFOS	SE	Research institute
Cooperation partner	Groupe Européen de Recherches Gazières	GERG	BE	Industry association




Activity Overview of GeoEnergy
Target electricity production for 2050: 4400 GWh
Key goals:
• extract safely the deep geothermal heat and produce electricity at competitive cost
• geological capture of CO2 to enable carbon free electricity from hydrocarbon resources
Roll-out
Prototyping
Validation
Concept
System
Petro-thermal plants
20MWe per year
Hydro-thermal plants
Heat and Storage
CCS-CCUS
Industry & air capture
EGS Pilot 1: Project Haute Sorne
EGS Pilot 2
EGS Pilot 3
Hydrothermal P&D 1: Geneva basin
Hydrothermal P&D 2
Hydrothermal P&D 3
CCS field-scale demonstrator 1
CCS Demo 2
Laboratory and Deep-Underground Laboratory testing
Phase 1-2
Innovation technologies
• Advanced cementious grouts
• Corrosion resistant heat exchanger
• Sensor for harsh environment
• Optimisation of geothermal energy conversionn
• Next generation numerical methods and simulation tools for DGE reservoir eng.
• Real time, data driven reservoir characterization and risk assessment
Integrated solutions
• Resource exploration and characterization
• Reservoir enhancement and engineering
• Limit induced seismicity while creating an efficient reservoir
• Hydrothermal and aquifer resource exploitation and storage
• Chemical processes in the reservoir
Phase 3
New innovation technologies and integrated approach
Risk, safety and societal acceptance– Technology assessment– Energy economic modeling
GeoData infrastructure and resource exploration on national scale
2014 – 2016
2017 – 2020
2021 – 2025
2026 – 2035

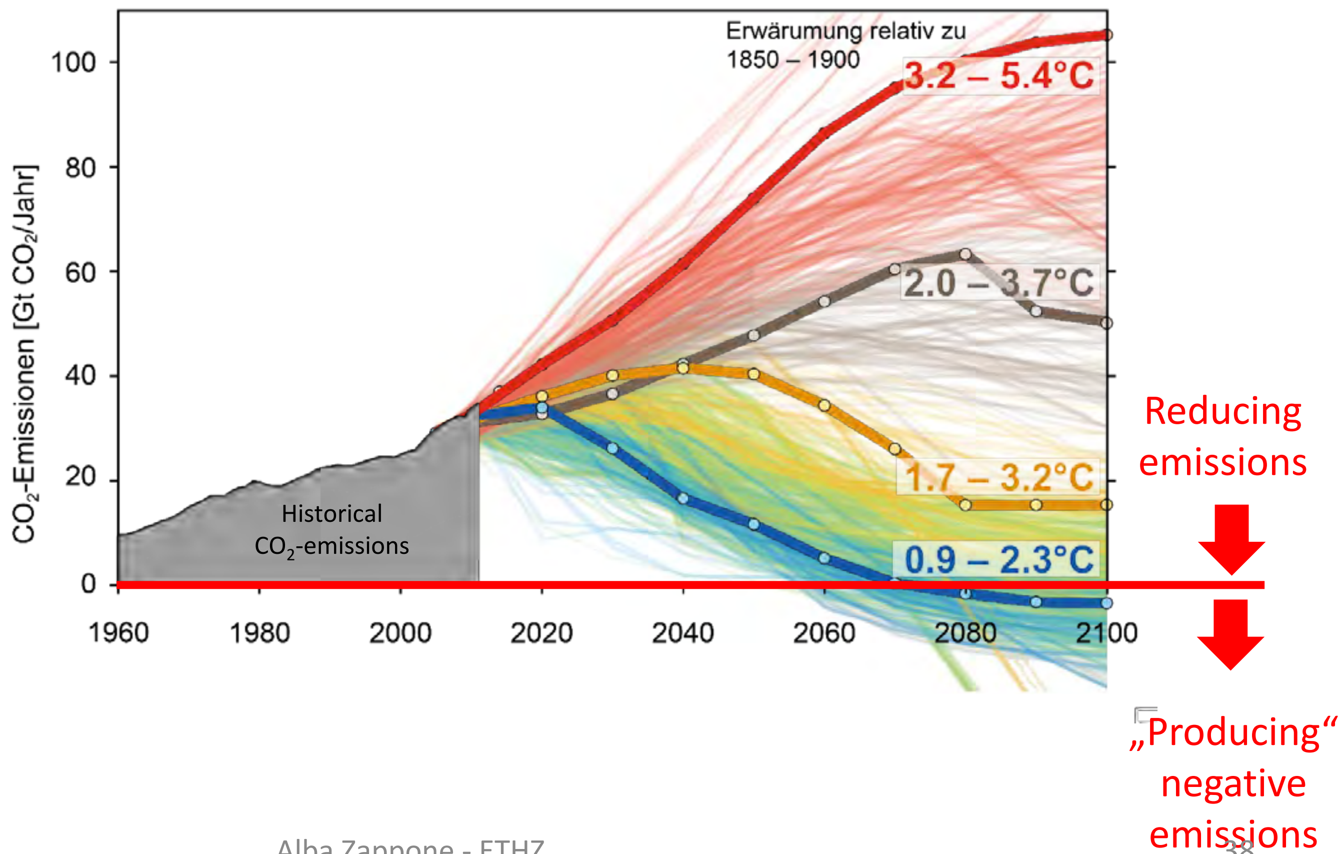
Major roadblocks for CCS from my layman's perspective

- No business or regulatory case for CCS. Little industry in CH-.
- Not the most favorable geology in CH, no hydrocarbon reservoirs.
- Large uncertainty.
- Opposition from supporters of renewable energy.
- No scientific CCS 'hero' (?).
- No funding avenue for a test site.
- Lack of public acceptance (?), NIMBY
- etc.

But: We probably need CCS, DACCS – and/or geo-engineering. And changes may come more quickly than we think

Switzerland is aiming at:

- 20% greenhouse gases emissions reduction by 2020.
- 50% emissions reduction by 2030.

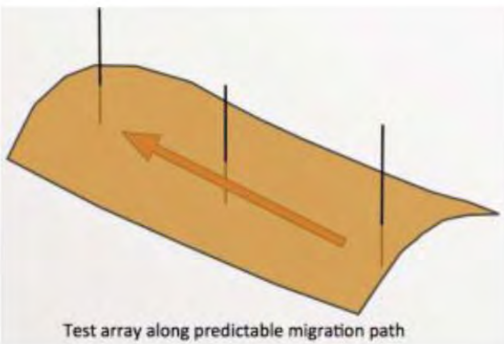


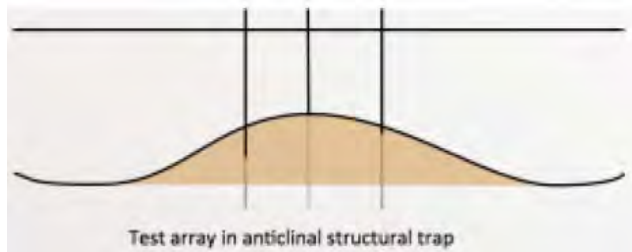
Phases of the storage roadmap

- We had a plan for the next step since CARMA: a test site
- But we cannot afford it. So:

2010-2013

Carbon Management in Power Generation

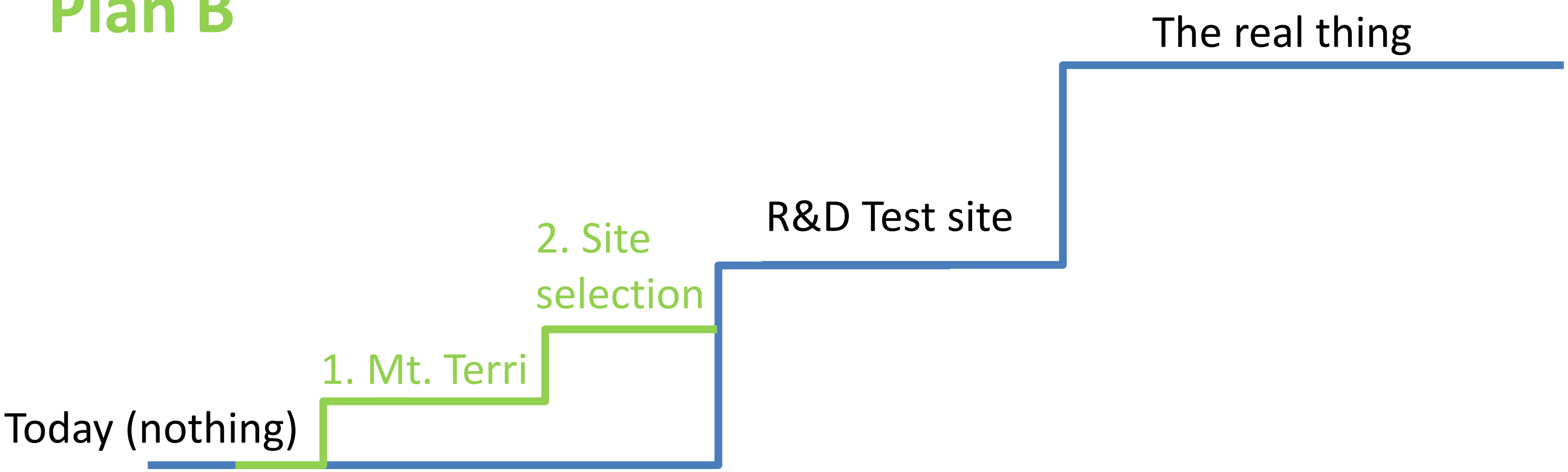




	Year 1	*Year 2*	*Year 3*	*Year 4-5*	*Year 6-7*	*Year 7-post*
	PHASE 1	**PHASE 2**	**PHASE 3**	**PHASE 4**	**PHASE 5**	**PHASE 6**
Co2 storage Explore and drill pilot well in Switzerland (CO2 Transported by Truk)	Test site design Risk Dialogue					
		Risk Dialogue Permitting				
			Seismic exploration			
				Site aquisition Drilling Permit		
					Drilling and Installation Operations	
						Injection & Monitoring

Fig.7: Draft CO_2 storage pilot master time plan.

Plan B



Accelerating CCS Technologies

Enabling a Low-Carbon Economy via Hydrogen and CCS

ELEGANCY

1. Caprock/fault sealing integrity: in situ experiment

Testing of a fault subjected to CO_2 injection

Mont Terri

2. CO_2 storage site selection

ELEGANCY

SCCER SoE

Budget (k€)

3 years

ELEGANCY Switzerland

7741

SCCER SoE

4360

BFE

1320

Caprock/fault sealing integrity: in situ experiment

Testing of a fault subjected to CO_2 injection

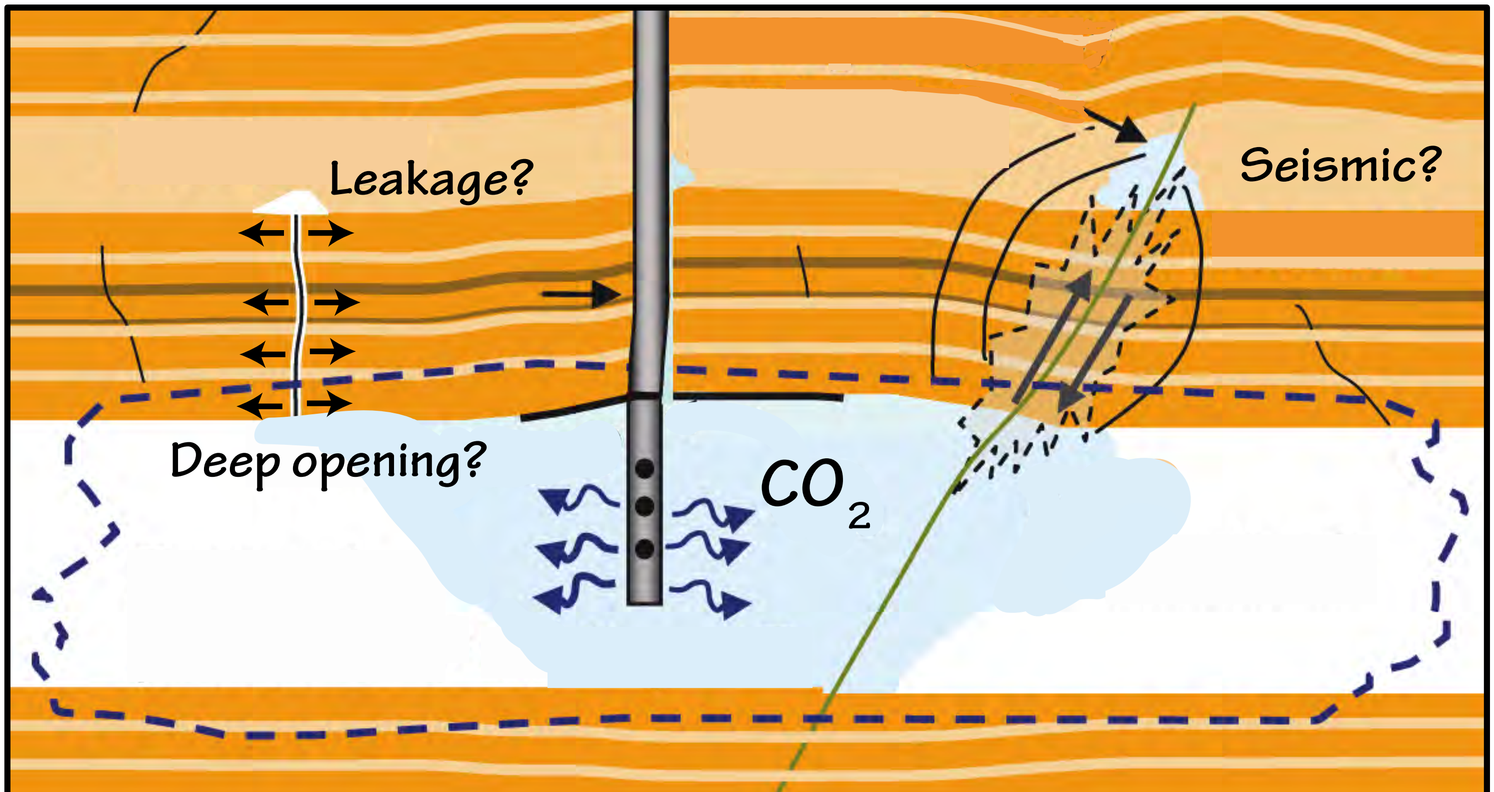
Mont Terri CS-D

- Improve the understanding of the dynamic behavior of caprocks over a range of spatial and temporal scales
- Advance the state-of-the-art by bridging the gap between the laboratory- and the reservoir-scale
- De-risking CO_2 injection operations

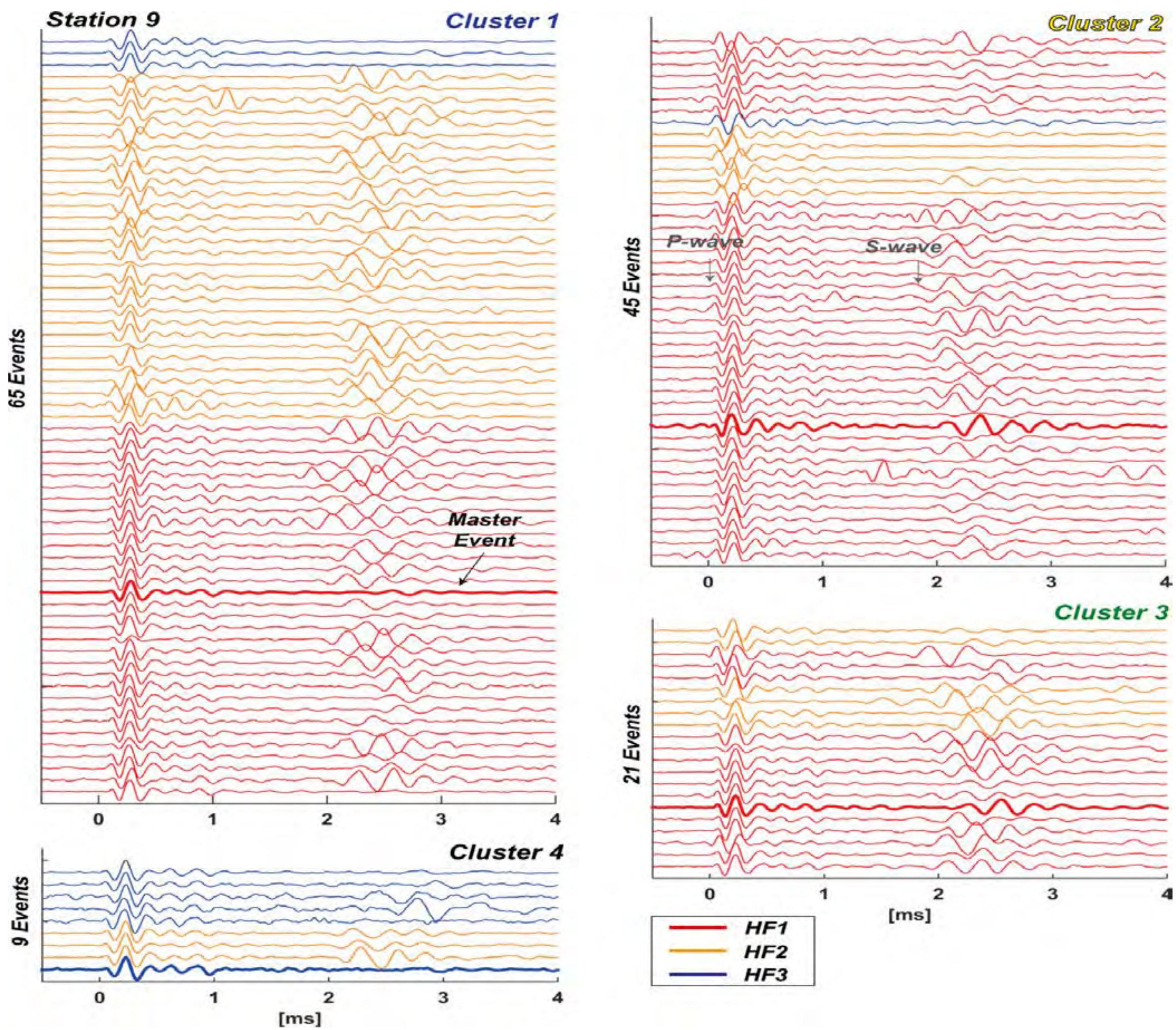
Scaling

- Pilot project implementation or «pilotization».

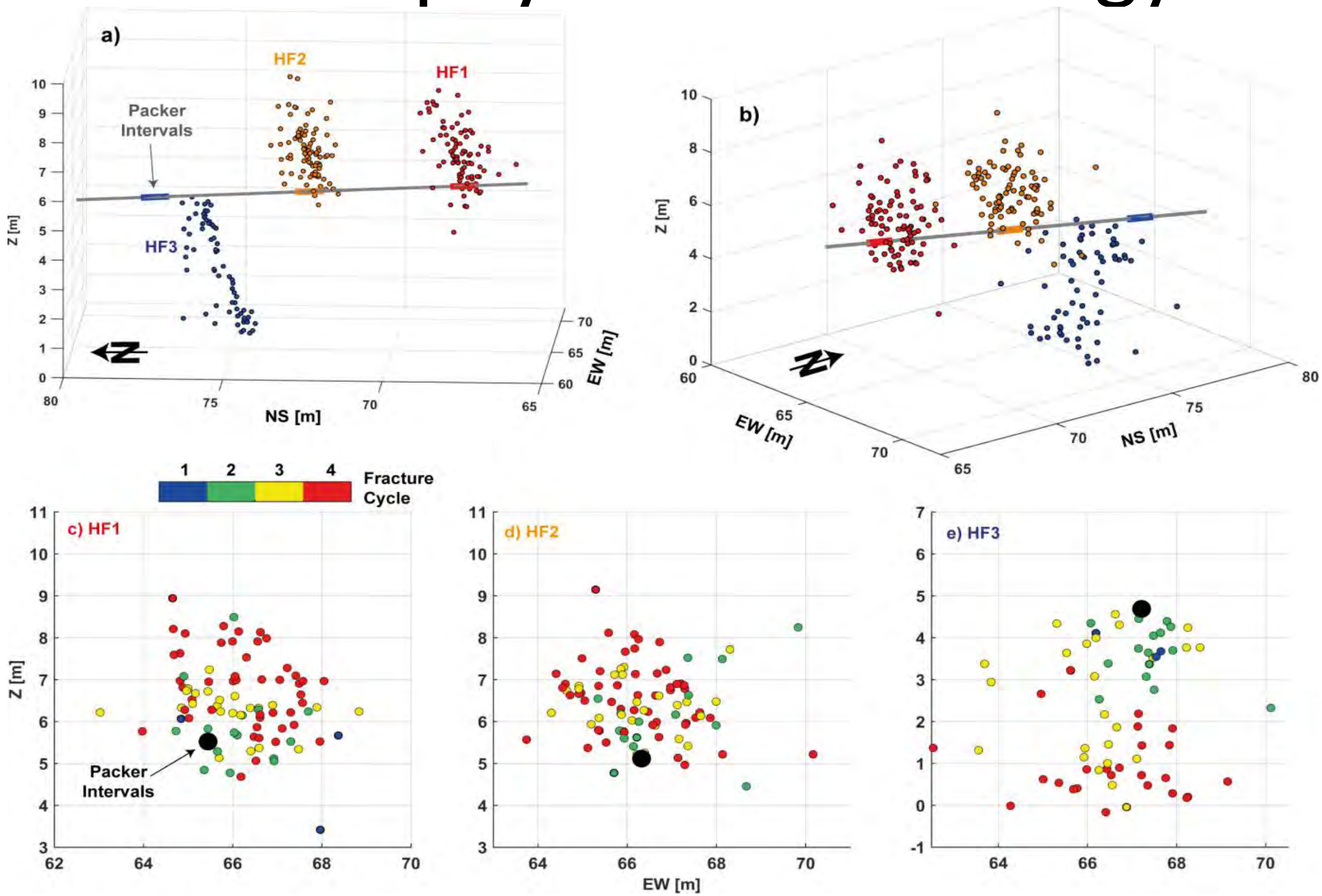
Roles of geophysics?



Geophysics - Seismology



Geophysics - Seismology

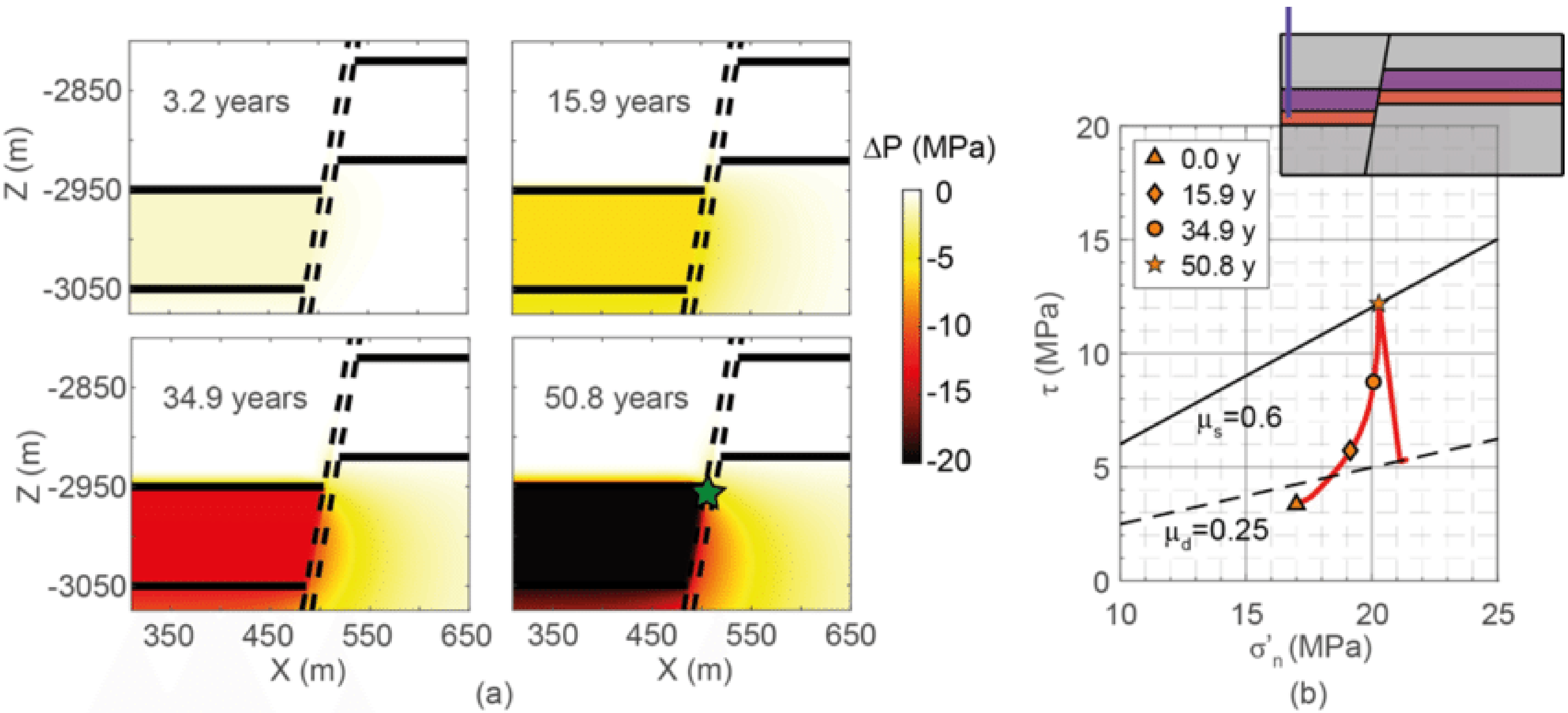


Seismology with no EQs?

- Really?
- What are the conditions under which micro-seismicity or creep dominate? (→ LabQuake, HighStep)
- Is creep only micro-seismicity with very high b and below the detection threshold?
- Can we optimism out detection algorithms to see smaller events (cross-correlation ...)
- Can we track fluid propagation using ambient noise (or coda wave) interferometry?
- Model validation (→ Antonio)

Risk Governance: Monitoring and Mitigation Strategies

Modelling of fault reactiviation potential



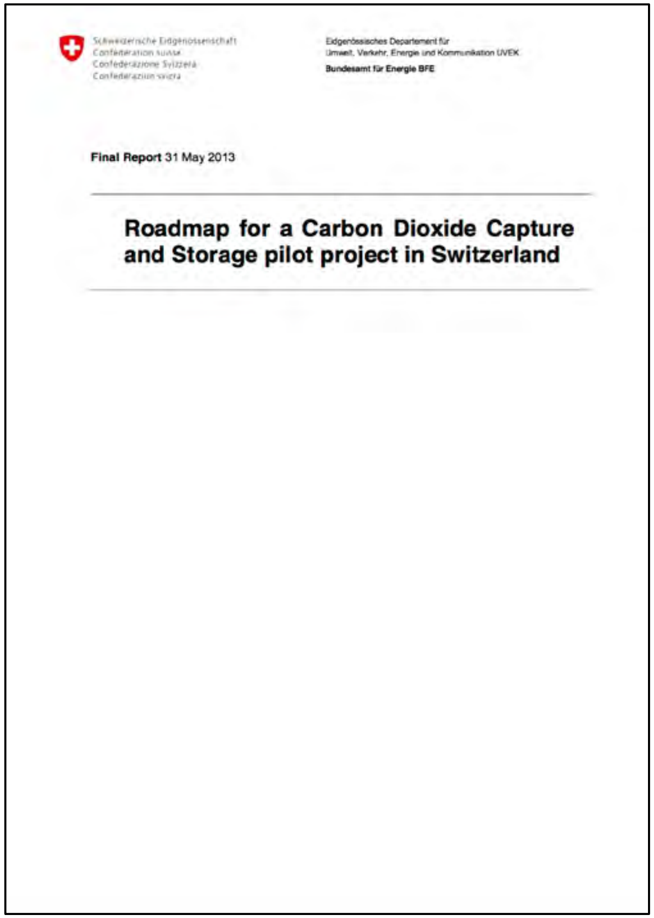
Doing what?

Based on literature study, modeling and expert elicitation continue to define for the Swiss context (‘what would it need’):

- Site characterization
- Risk assessment strategies
- Monitoring strategies
- Mitigation strategies
- etc.

CCS: why are we here?

- Rising CO_2 levels and resulting climate change is deeply worrisome.
- Science in Switzerland, should try to make a difference.
- ELEGANCY: An opportunity to do something, may be not perfect at all, but better than nothing.
- And, hopefully, networking opportunity and a stepping stone.


Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Umwelt, Verkehr, Energie und Kommunikation UVEK
Bundesamt für Energie BFE

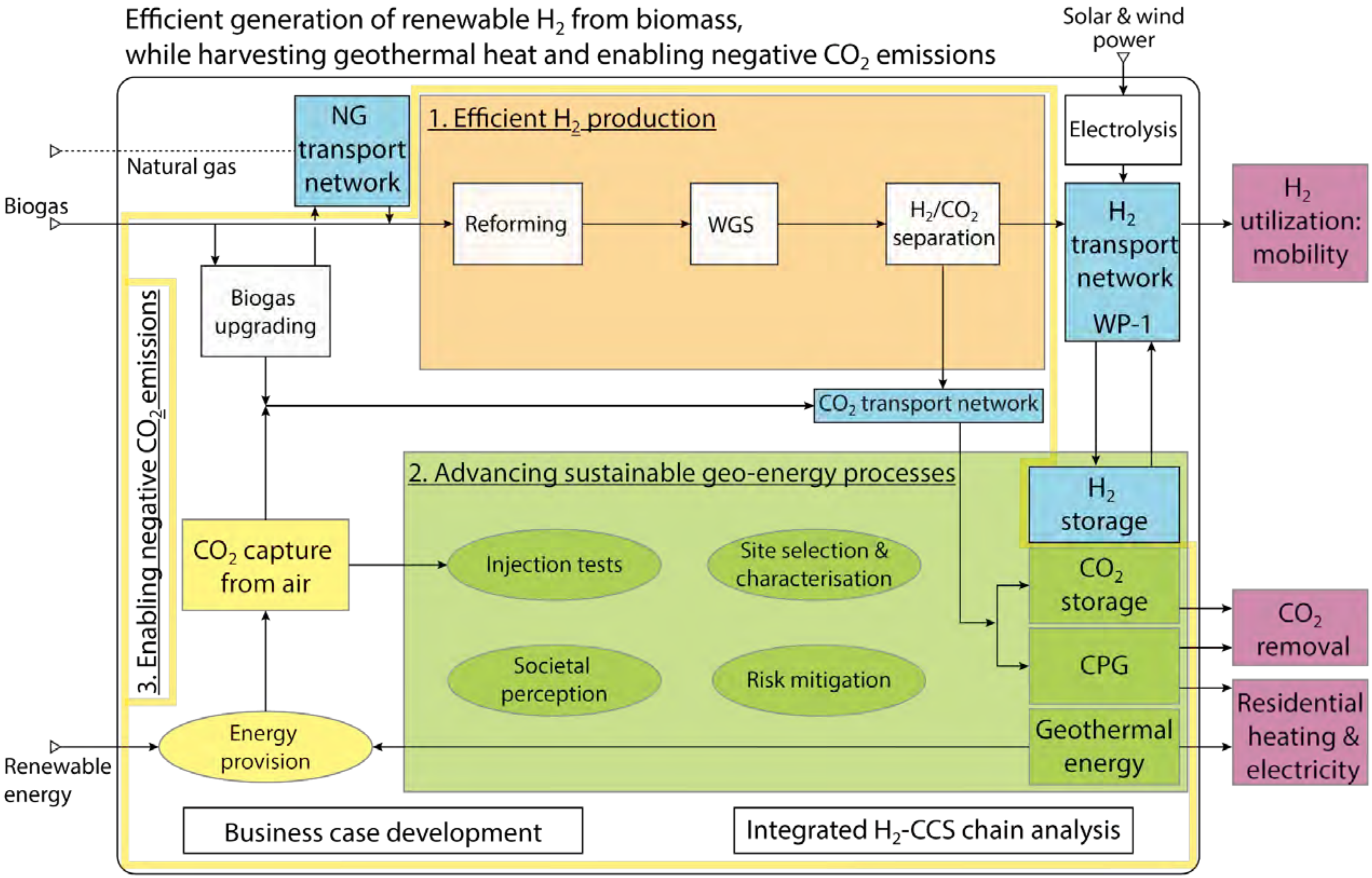
Final Report 31 May 2013

Roadmap for a Carbon Dioxide Capture and Storage pilot project in Switzerland

ELEGANCY

Swiss case study

Efficient generation of renewable H_2 from biomass,
while harvesting geothermal heat and enabling negative CO_2 emissions



Caprock/fault sealing integrity: Mont Terri experiment

Technical layout

- 1 central injection borehole with two intervals in the Main Fault (scaly clay fabric and fractured zone). Injection of a CO_2-rich brine.
- Ca. 7-8 months of continuous injection, with pulse tests before and during injection.
- 3 to 5 monitoring boreholes for geophysical characterisation (active/passive seismic, etc.).
- Post-experiment: 2-3 sampling boreholes for geochemical characterization.