Synergy between CO_2 storage and utilization of geothermal energy

A case study from Longyearbyen, Svalbard

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I. Background

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II. CO_2 storage and Geothermal; connections

III. Case: The Longyearbyen CO_2 Lab

IV. Visualization challenges; VIRCOLA

What we are going to see in this presentation?

- An overview of the activities to store CO2 in sedimentary rocks below Longyearbyen, Svalbard
- Possibility of combining CO2 injection with utilization of geothermal energy in Longyearbyen

The SUCCESS Centre

http://www.fme-success.no/

SUCCESS= Subsurface CO2 storage – Critical Elements and Superior Strategy

- To provide a scientific base for **CO2 injection**, **storage** and **monitoring**
- 8 postdoctoral students, 24 PhD students, 14 master students
- 7 work packages:

WP1: Site characterization
WP2: Reservoir modeling
WP3: Sealing properties
WP4: Monitoring
WP5: The marine component
WP6: Operations (INJECT)
WP7: CO2 School

- Three collaborating projects:

IMPACT: Studies the impact of fault rock properties on CO2 storage in sandstone reservoirs

MatMoRa: Develop tools to study long-term safety and risk factors related to geological storage of CO2

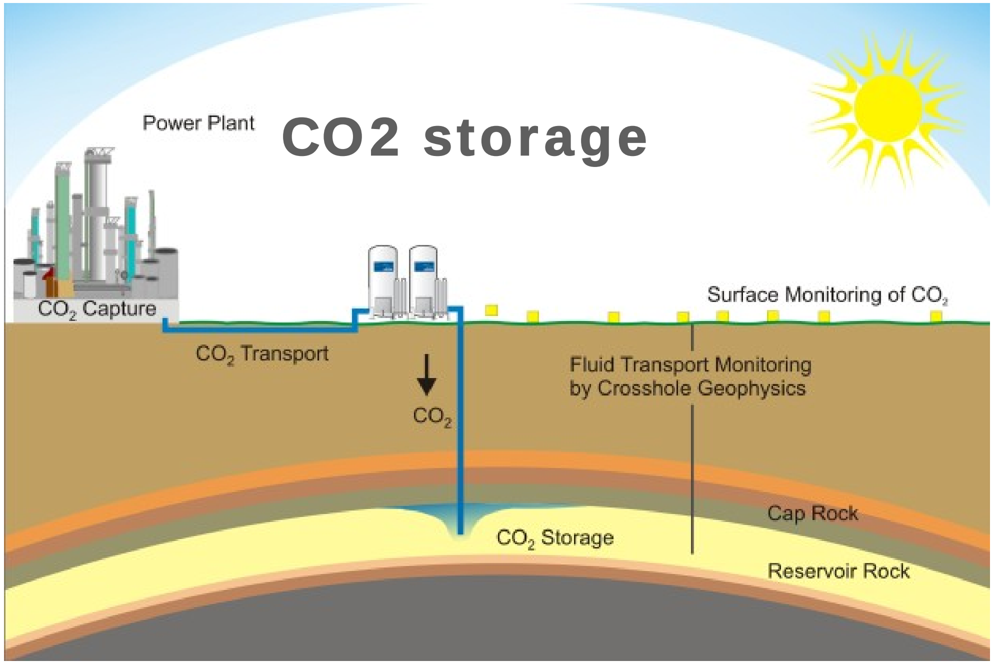
VIRCOLA: Virtual CO2 Laboratory

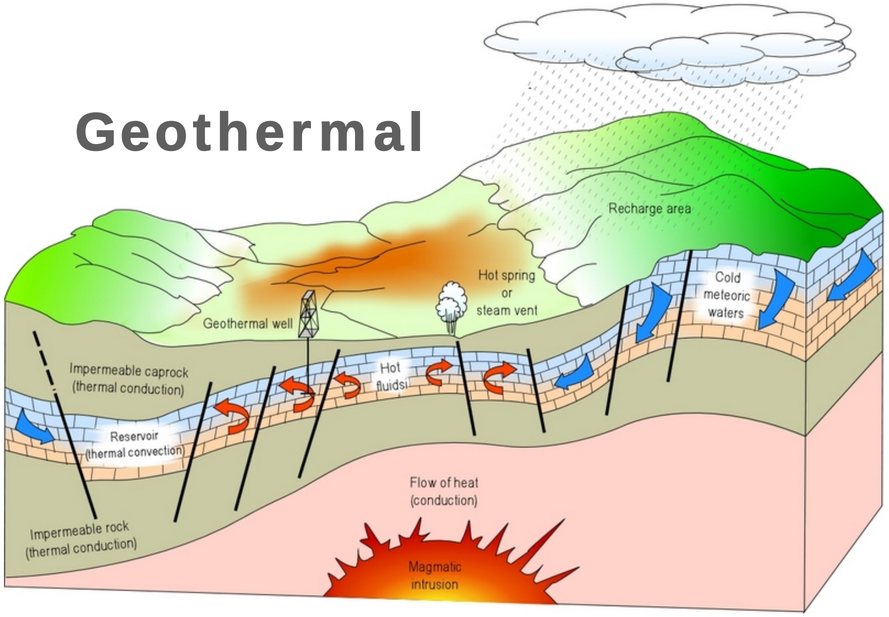
II. CO2 storage and Geothermal; connections

CO2 storage and Geothermal components

- Injection well
- Overburden
- Caprock
- Reservoir

- Production well
- Overburden
- Reservoir



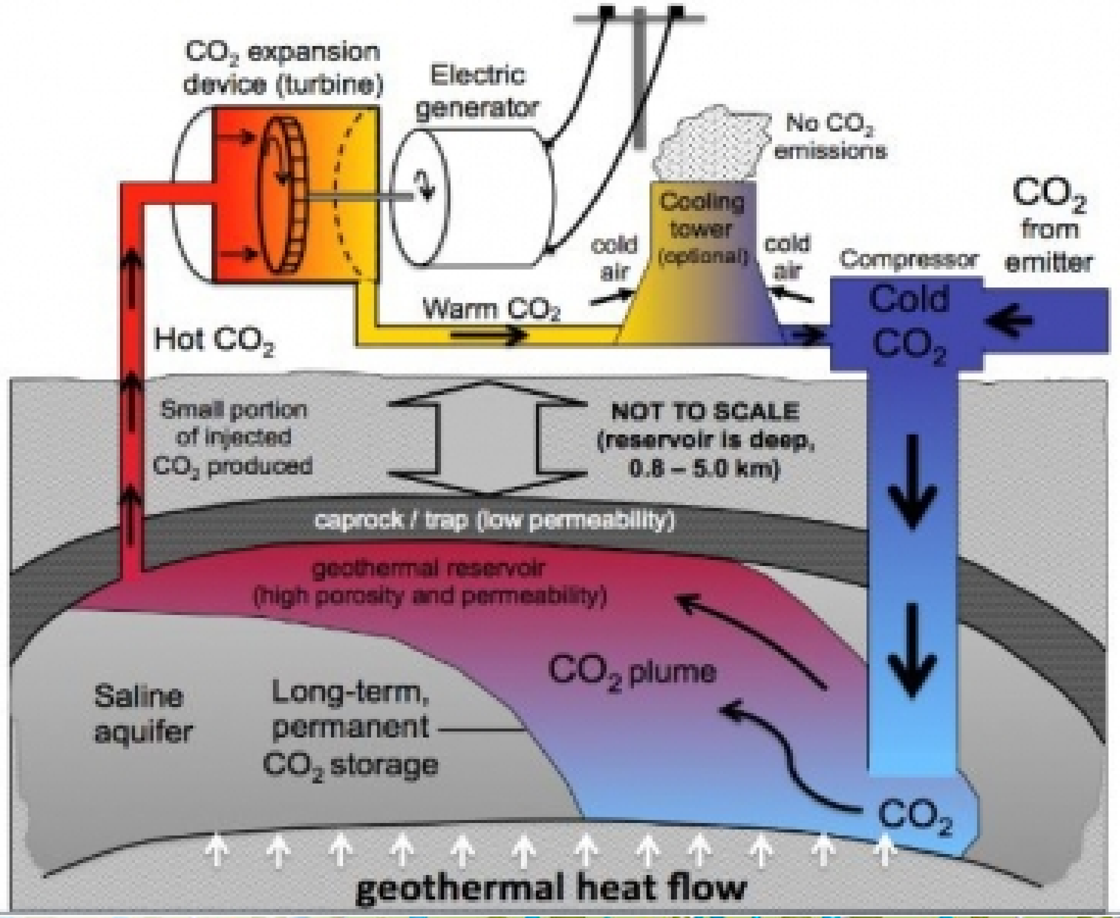


Why injecting CO_2 for geothermal production ?

- To get rid of CO2 !
- CO2 is a more efficient circulation fluid than water
- In regions with lack of groundwater or in water protection areas
- Funding policies -there might be incentives for CO2 storage in future or penalties for CO2 releases (CO2 tax etc.)

CO_2 storage vs. geothermal energy

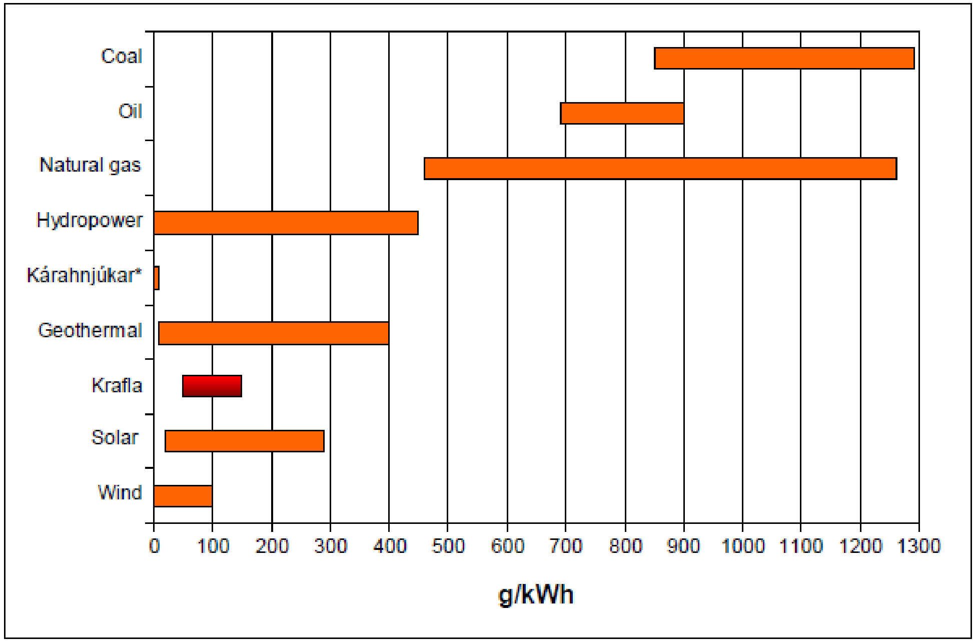
Two conflicting demands in our society: (1) the need to burn fossil fuels for the foreseeable future and (2) the desire to reduce carbon emissions,



Yet not ideal....but better than neglecting it

- Existing geothermal electric plants emit ca. 122 kg/MW·h CO2, a small fraction of the emission intensity of conventional fossil fuel plants

CO_2 emission from various types of power plants (After Hunt 2000)

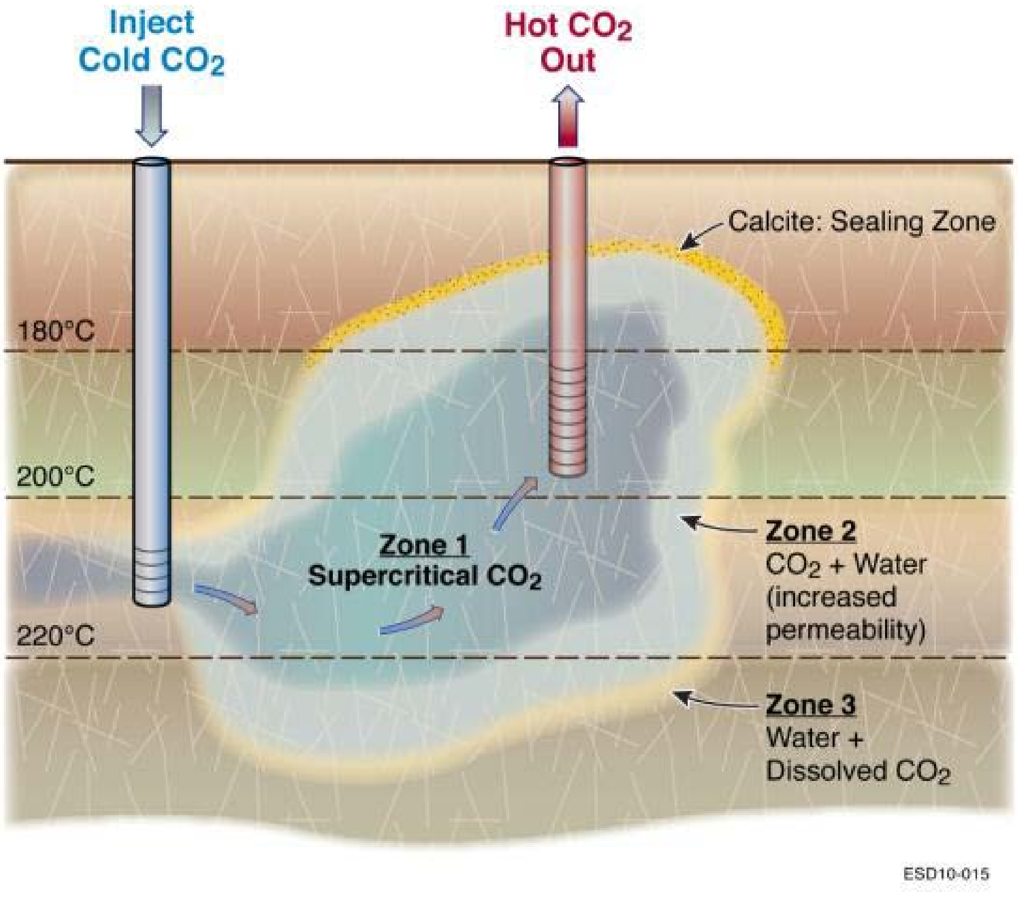


CO2 emmissions from various power plants

Coal-fired	**994 (kg/MWh)**
Oil-fired	758 (kg/MWh)
Gas turbine	550 (kg/MWh)
Geothermal	122 (kg/MWh)

Three zone model

- **Zone 1 (inner zone):** all water has been removed by dissolution into the flowing CO_2 stream so that the fluid consists of a single super critical CO_2 phase. This is the main volume from which thermal energy is extracted by the flowing CO_2.
- **Zone 2 (intermediate region)**: contains a two-phase mixture of CO2 and water
- **Zone 3 (The outer region):** affected by the geothermal system. The fluid is a single phase (water) with dissolved and chemically active CO_2.

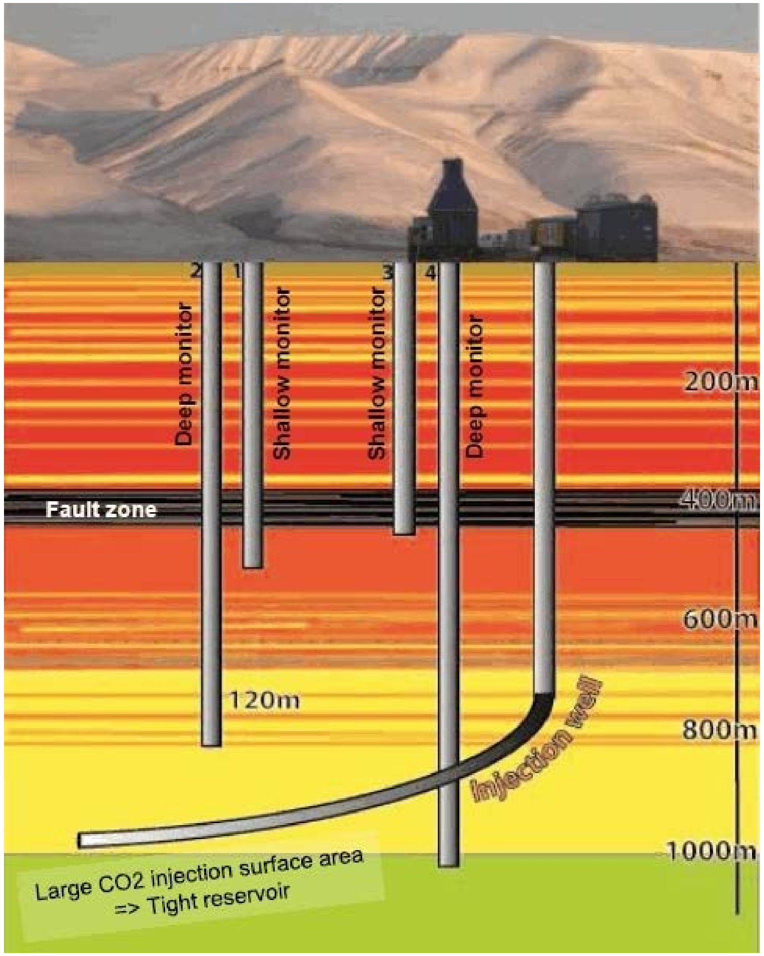


III. Case: The Longyearbyen CO2 Lab

UNIS CO2 Lab, Longyearbyen

- Initiated by UNIS in 2006
- Vision: turn Longyearbyen into a global show case as a community that takes care of its CO2 emissions from the source to the solution.
- 8 boreholes drilled in Adventdalen, from which 5 located close to Longyearbyen, the deepest (Dh4) down to 970 m depth
- Extensive scientific activities have been carried out:

  - geological analysis of drill cores
  - Well-geophysical monitoring
  - seismic acquisition, microseismic
  - water injection and pressure tests
  - reservoir simulations

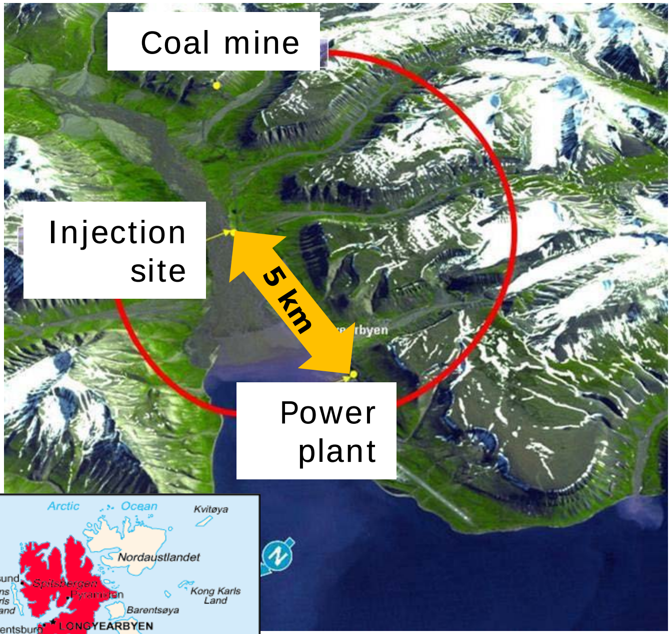


Why store CO2 in Longyearbyen, Svalbard?

- Coal-fired power plant emits approximately 64000 tonnes/year of CO_2 from the combustion of about 26000 tonnes of locally mined coal.

- Suitable geology (ideal storage and cap rock)

- Easily accessible (the coal power plant located only 5 km from the planned injection site



- Proximity to the North pole is a good symbolic example of global warming resulting from emission of CO_2

er Braathen et al. (2012)

Phase I

- Identifying the reservoir (2007-2009)

To identify a suitable saline aquifer near Longyearbyen where CO_2 can be stored (drilling+seismic)

Phase II

- Injectivity tests (2010 - 2012)

To verify the injectivity and storage abilities of the reservoir and predict the overall geometry and size.

Phase III

- Medium scale CCS (2013 - 2017)

To demonstrate medium scale CO2 injection and storage and the response using monitoring wells

Phase IV

- Full scale CCS (2017 - 2025)

To demonstrate full scale carbon capture and storage at the local coal-fired power plant and to use the captured CO2 as a medium for storage. This completes the Longyearbyen CO2 lab concept.

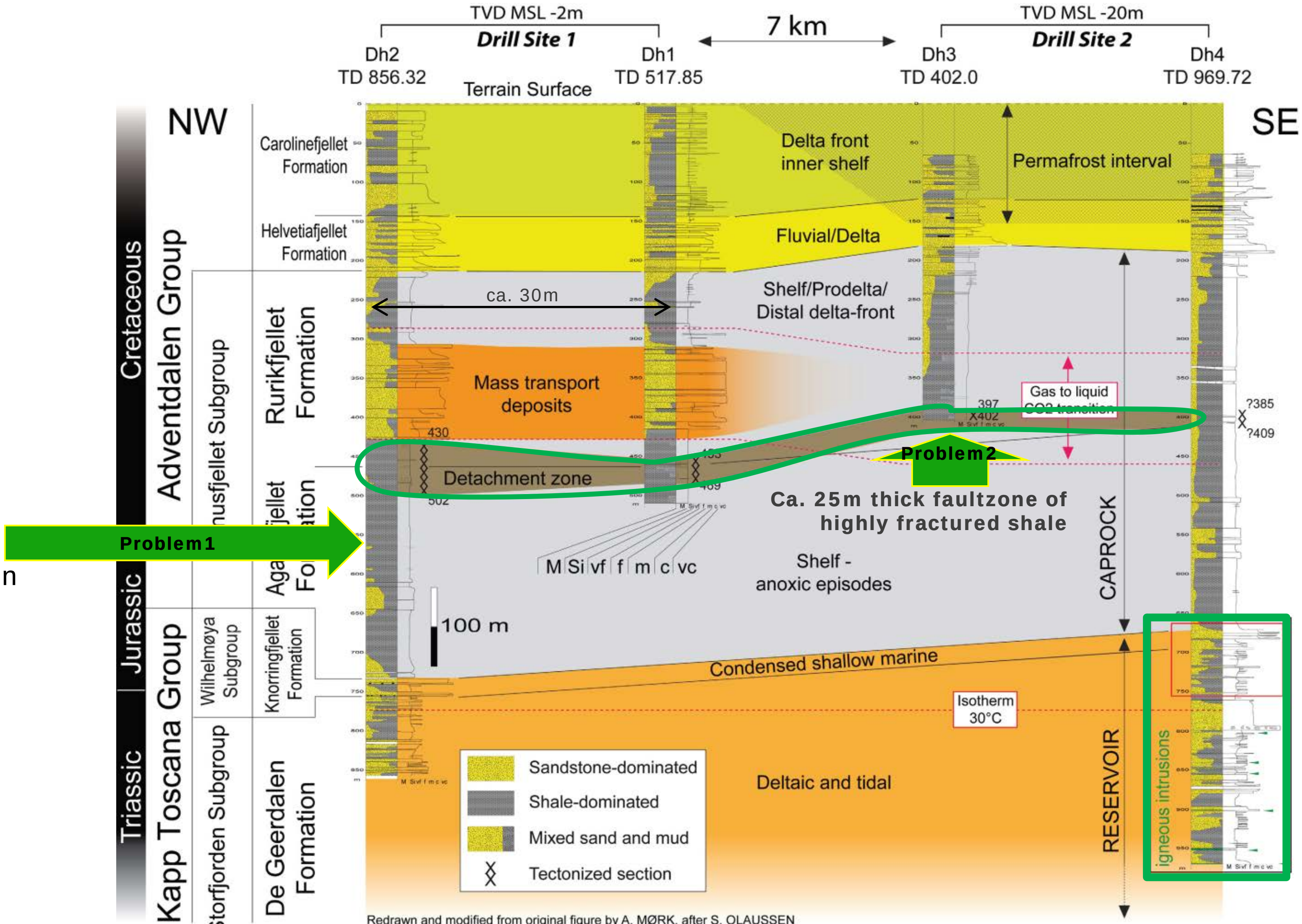
Drilling Operation

- Distance
- Depths
- Problems
- Solution
- Reservoir

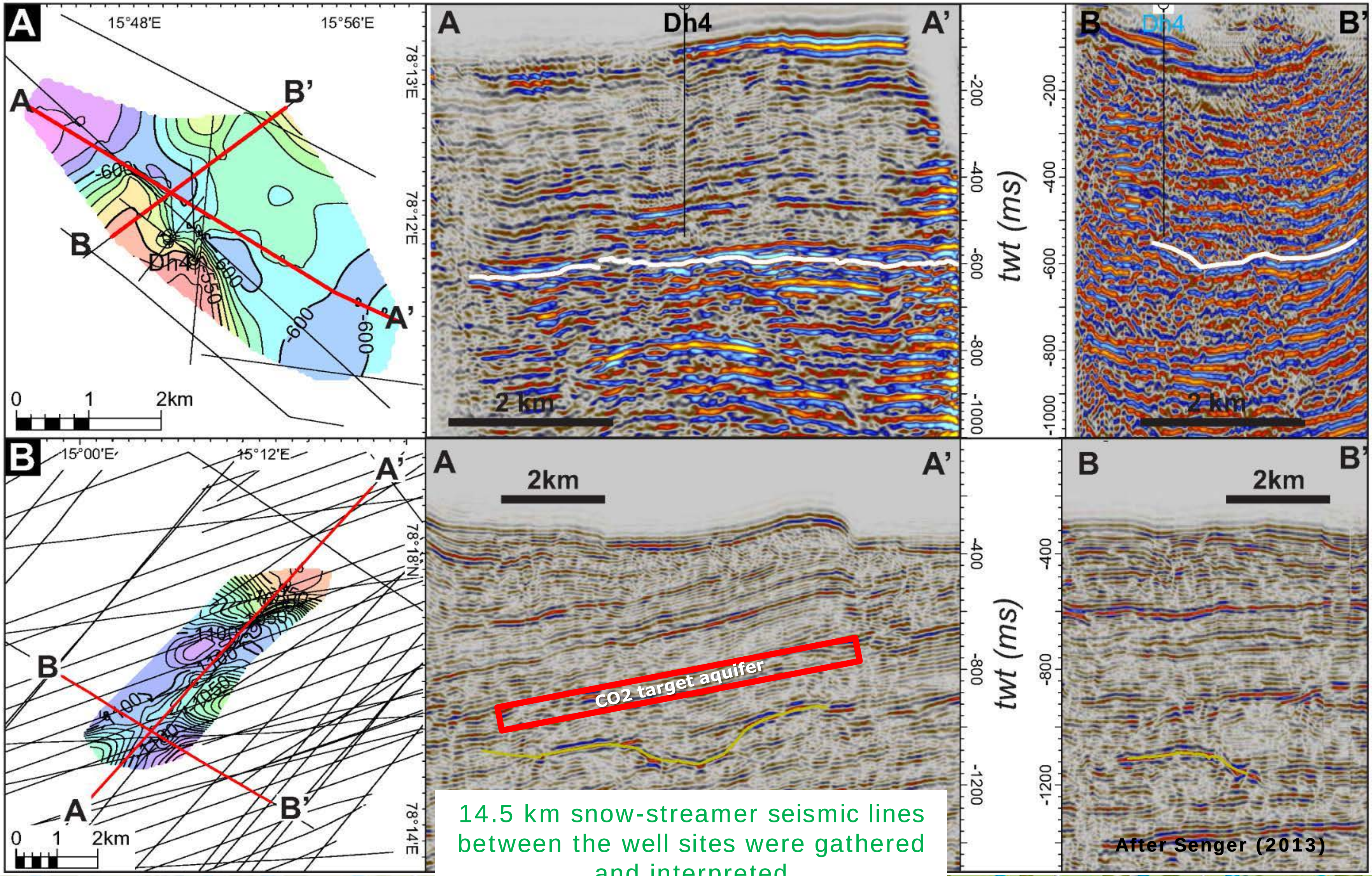
Table 1: Technical summary of wells Dh1–Dh4.

Drillhole nr	Time drilled	Total depth (m)	Type of operation Drill tube type
Dh1	August – October 2007	517.8	Single 56 mm
Dh2 (Dh1A)	November – December 2007	858.8	56 and 66 mm telescope
Dh3	August – September 2008	403	46, 56 and 66 mm telescope
Dh4	August 2009 – November 2009	969.8	Q-tube and 46 mm, 5-level telescope (Table 2)

Cavities arising from outwash of shale by drilling-fluid circulation



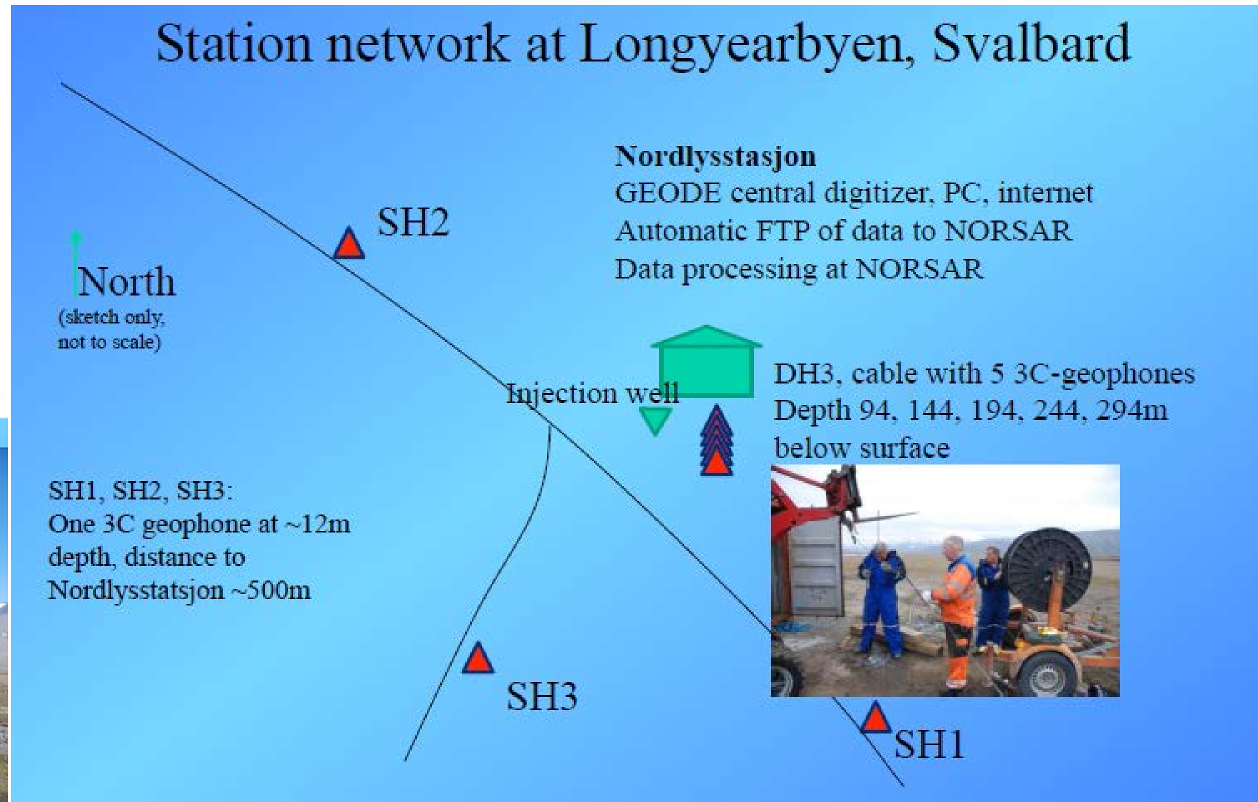
Seismic profiles (A-A' and B-B') and Dh4



14.5 km snow-streamer seismic lines between the well sites were gathered and interpreted

Microseismic data

- Includes string of 3-channel geophones in a vertical observation well (located at depths of 94–294 m). In addition, three shallow boreholes have been drilled in the vicinity (ca. 100-500 m) of the injection well for recording the microseismic events.



After Oye et al., 2010

IV. Visualization challenges; VIRCOLA

CO_2 research – some challenges

- Wide range of different data types
- Cross-discipline research
- Cooperation over distances
- Large data sizes

Our approach: A virtual CO_2 laboratory

Combining CO_2 storage and geothermal energy will add to the addressed challenges

Virtual CO_2 laboratory - VIRCOLA

- **Vision:** Develop a data platform and methodology that can facilitate better data utilization through co-visualization and visual analysis. **Why?** to achieve a better understanding of the storage capacity, injectivity and long term confinement of CO_2.

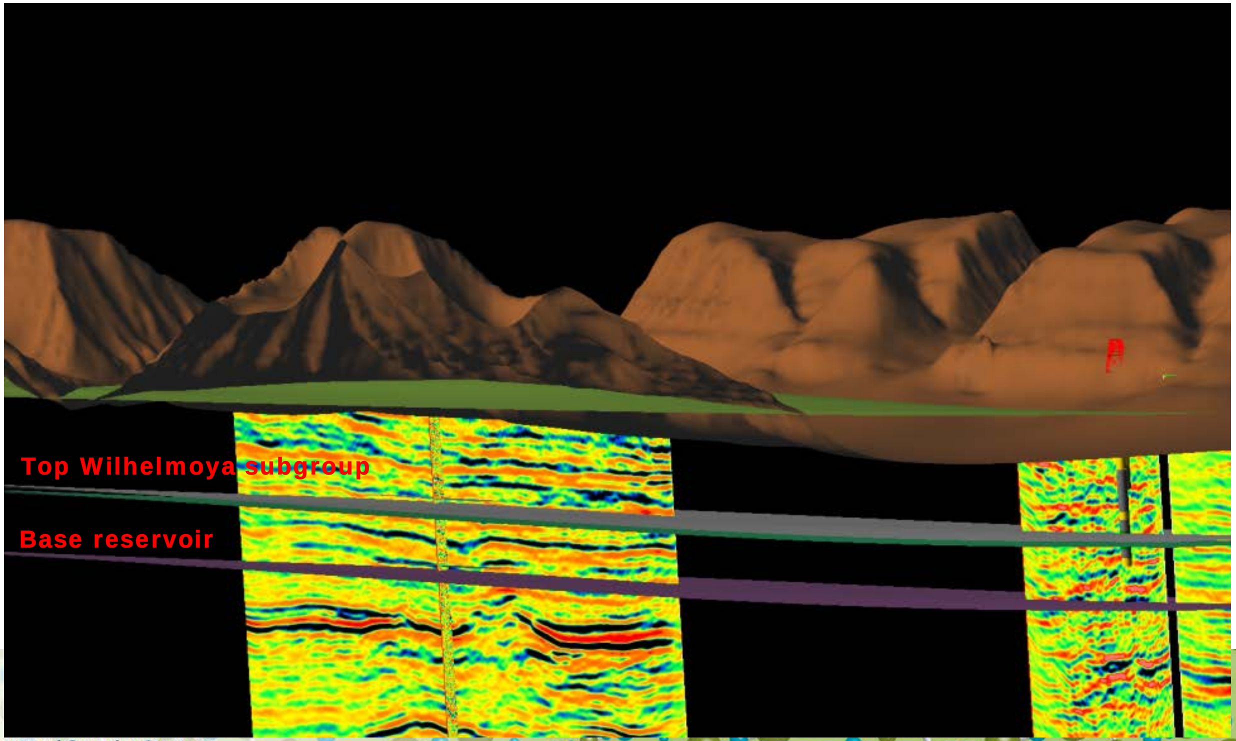
- **Case of study:** Longyearbyen, Svalbard

- **Partners:**

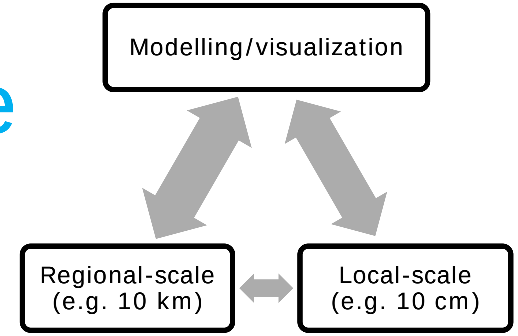
o Christian Michelsen Research (CMR)
o The University Centre In Svalbard (UNIS)
o Institutt for energiteknikk (IFE)
o Statoil Petroleum AS
o CGG Veritas Services (Norway) AS

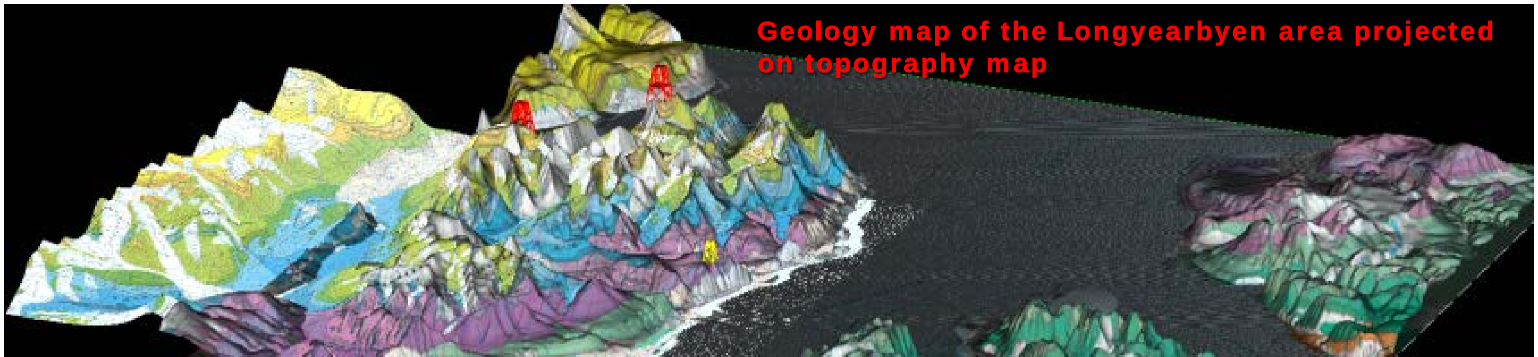
VIRCOLA visualizations

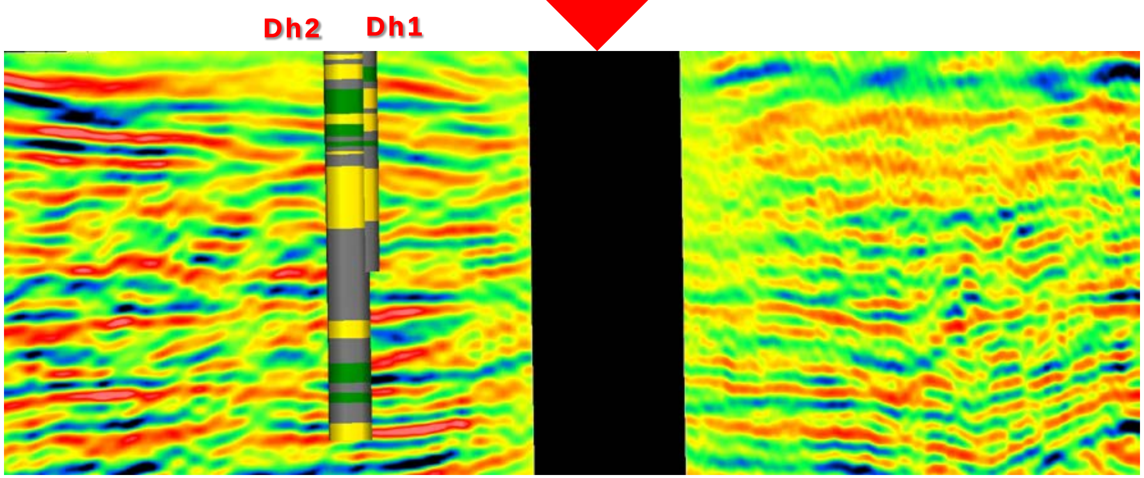
- Local and regional-scale data, diverse datasets, cross-disciplinary communication...
- To explore possibilities for improving data visualization techniques at CO2 Lab UNIS lab

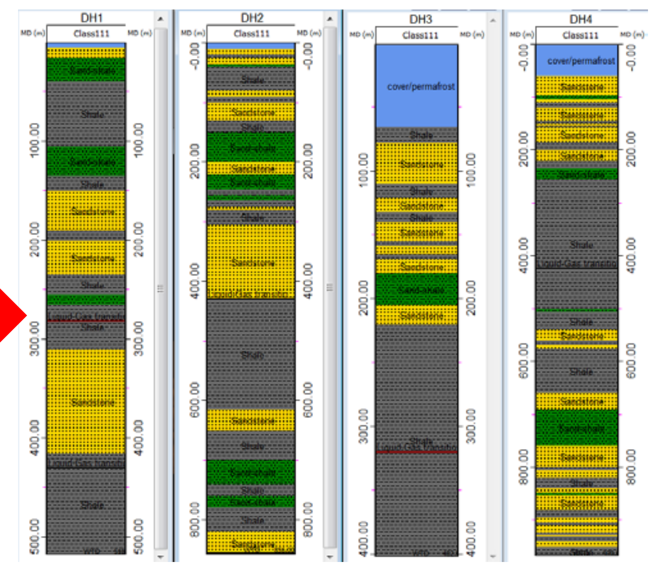


From Regional to Local-scale visualization (Ongoing…)







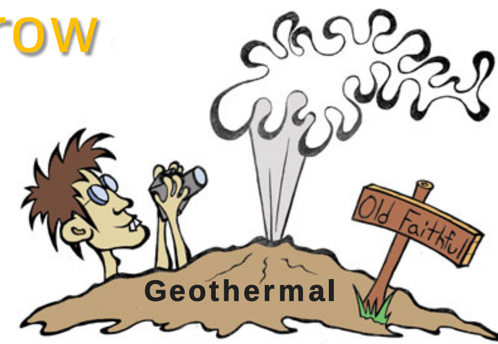


How can VIRCOLA support combined CO_2 storage and geothermal activities in Longyearbyen?

VIRCOLA

Today

Tomorrow



Conclusions and future plans

- Studies in UNIS CO_2 lab have so far proved that CO_2 can be successfully stored in sedimentary rocks in Longyearbyen, Svalbard.

- This project when fully completed, can be a suitable site for demonstration of a small CO_2 – geothermal system in the future in Longyearbyen as it meets both geothermal and geomachanical characteristics of such site.

- Lessons learned from Longyearbyen project (both geothermal and CCS) can be applied elsewhere in the mainland Norway.

- Geochemical simulations will be performed for a geothermal system in Longyearbyen. The storage capacity of CO_2 will be estimated in the site by utilizing CO_2 as working fluid. This will be used for future studies about possibility of a combined CO_2-geothermal exploitation.