Geological CO_2 Storage – selection, investigation and storage

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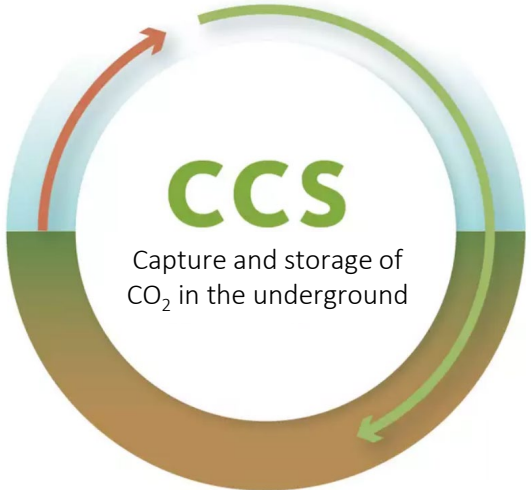
GEUS

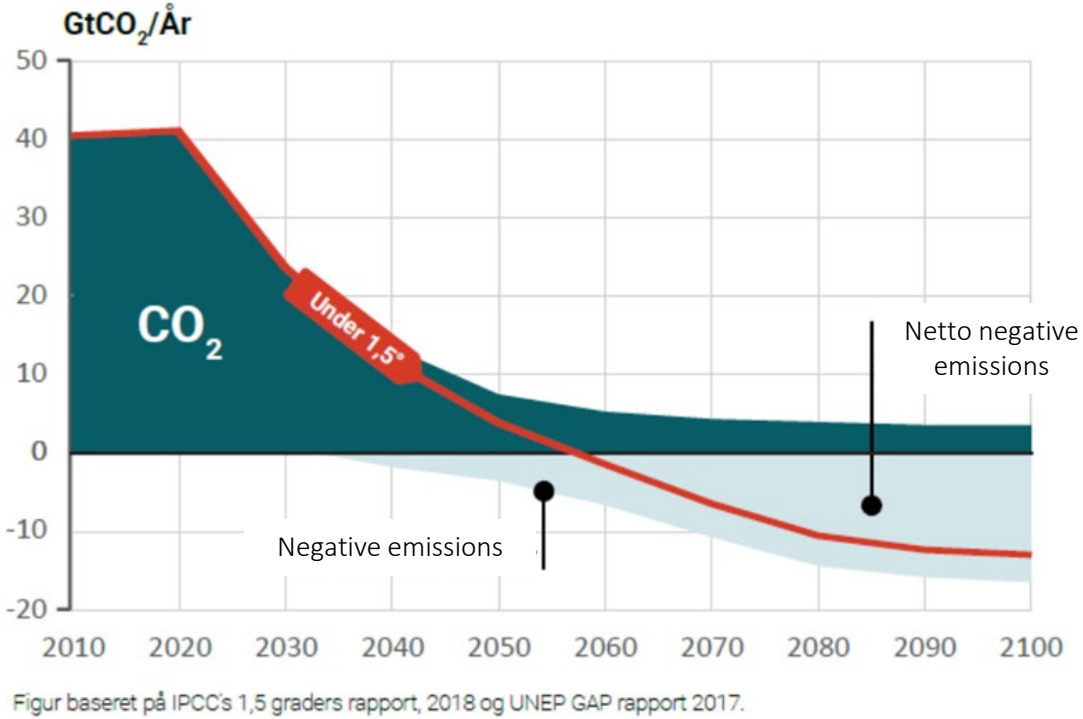
The political process

- Political agreement on storage from 30th June 2021 about investigation of possible storage sites in Denmark
- Enable storage in the Danish subsoil via a new permit regime
- Import and export of CO_2 across national borders
- Map additional potentials for onshore CO_2 storage
- First tender for full-scale offshore CO_2 storage

Why Carbon Capture and Storage



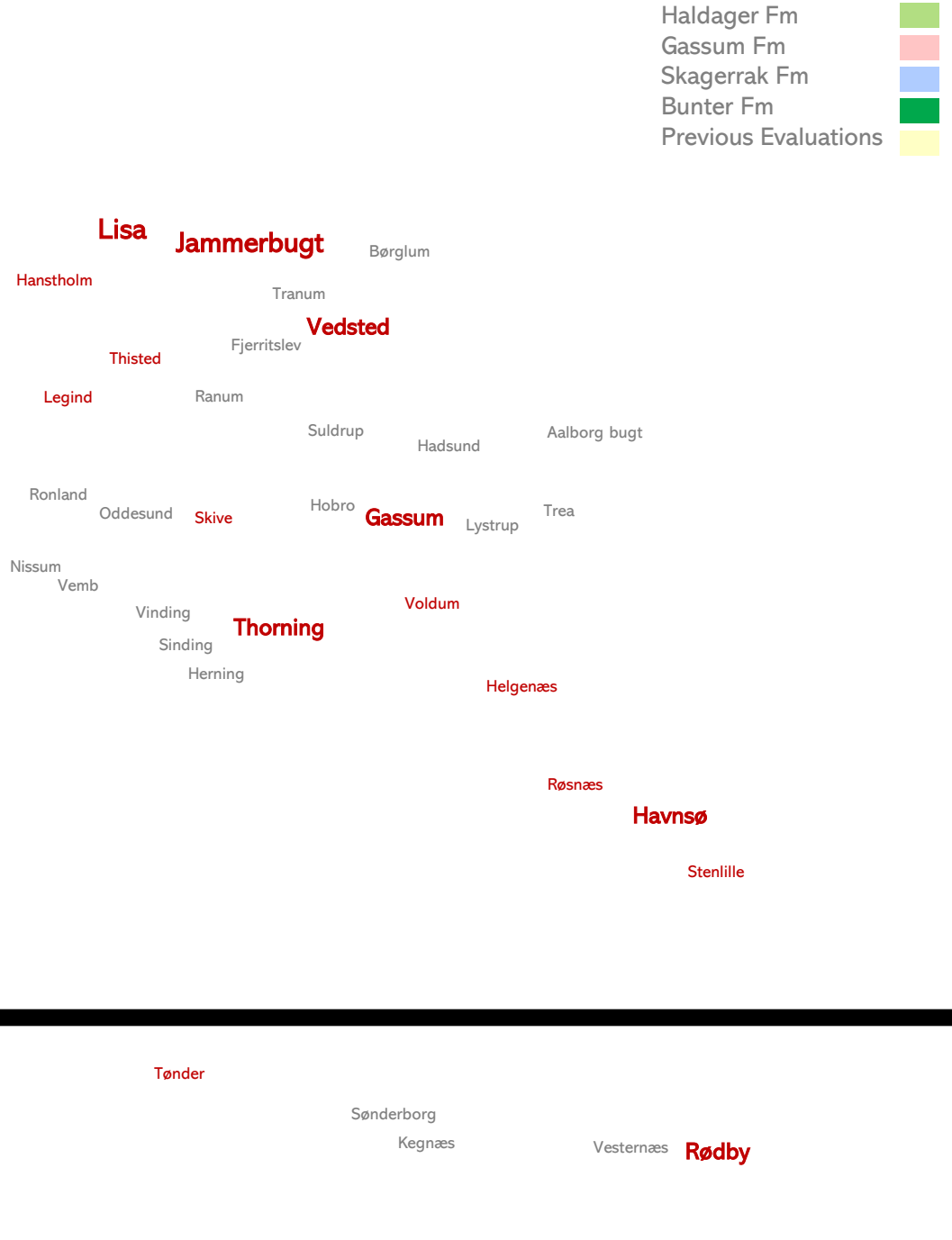
The capture and storage of CO_2 is recommended by the IPCC and the Danish Climate Council as a significant contribution to achieving the CO_2 reductions that are necessary to curb climate change



Figur baseret på IPCC's 1,5 graders rapport, 2018 og UNEP GAP rapport 2017.

GEUS screening study 2020

- GEUS screening study in 2020 for
- A large number of structures were defined (yellow)
- 13 structures were evaluated
- The national Danish Research Act funded in 2021 GEUS for acquiring new seismic data to further evaluate 3-5 structures to define the structure and riscs



Structures	Probability	Storage capacity Mt CO2			
Name	**%**	**P90**	**P50**	**P10**	**Mean**
Gassum GF	*80%*	412	574	777	**586**
Havnsø GF	*80%*	204	294	423	**306**
Hanstholm GF	*80%*	927	1293	1801	**1333**
Rødby BF	*64%*	242	334	449	**341**
Thisted SF	*48%*	1703	2367	3198	**2418**
Voldum GF	*48%*	531	817	1224	**854**
Tønder BF	*80%*	162	224	304	**229**
Vedsted GF	*60%*	18	35	64	**39**
Thorning GF	*56%*	202	290	397	**296**
Røsnæs GF	*57%*	264	410	617	**429**
Hanstholm SF	*48%*	2376	3352	4630	**3441**
Legin SF	*29%*	1090	1564	2222	**1619**
Skive BF	*43%*	241	329	434	**334**
Helgenæs GF	*32%*	187	292	447	**307**

(Hjelm et al. 2022)

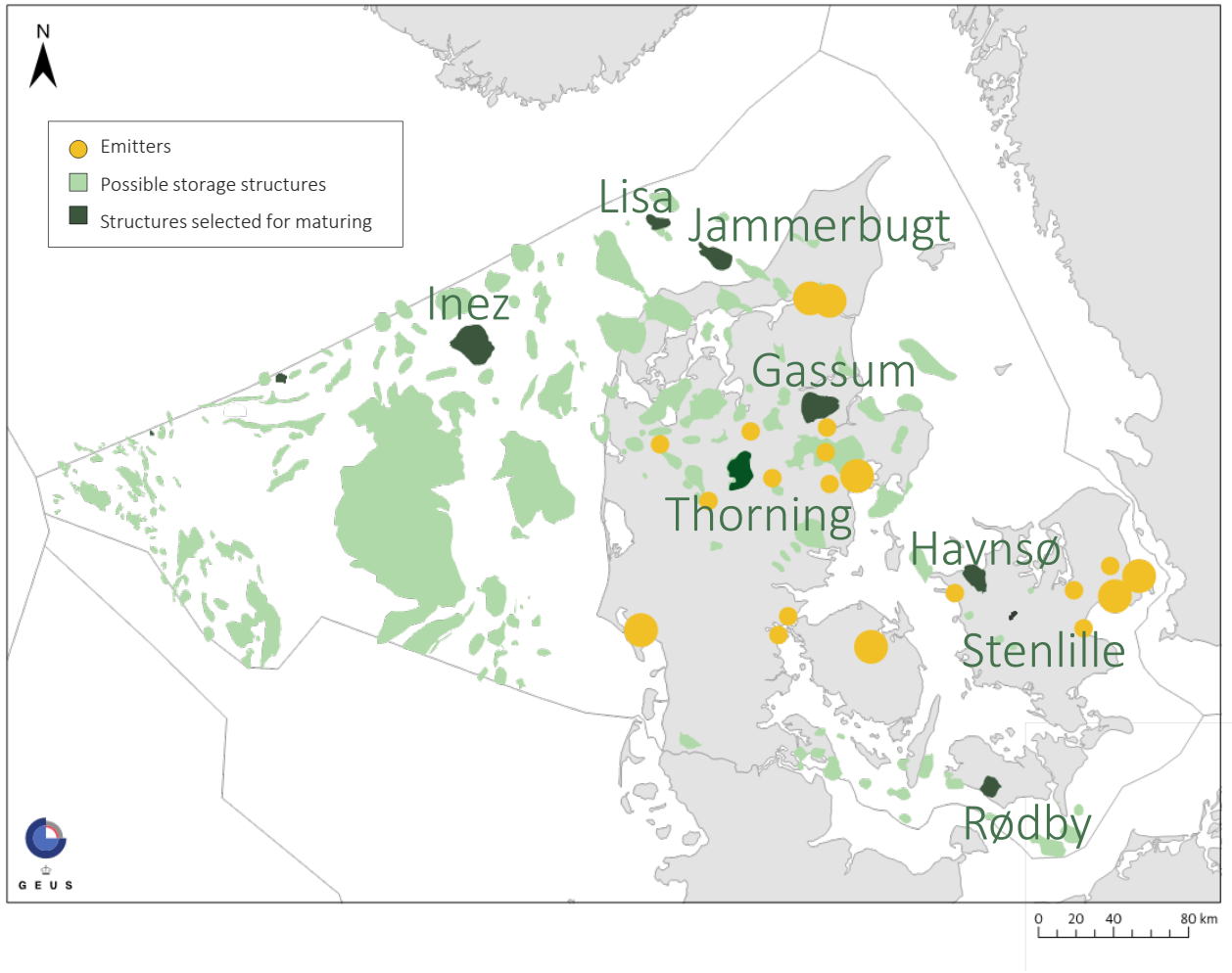
Purpose and background

Denmark's underground probably can contain up to 22 billion tonnes (Gt) of CO_2.

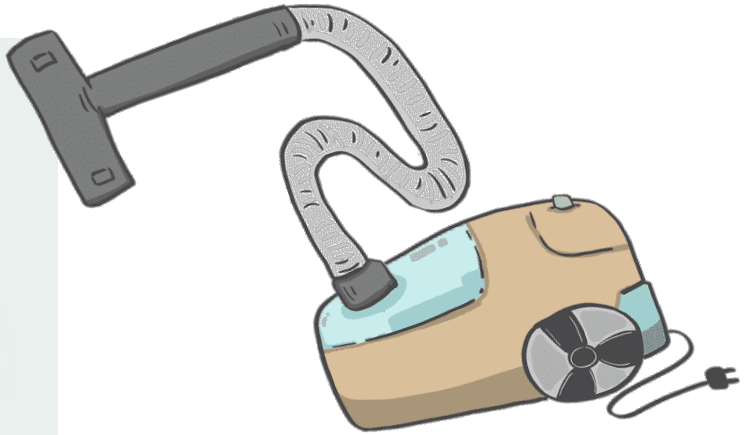
This corresponds to 500 years of total Danish emissions at current levels.

Work is being done to investigate, select and establish CO_2 storage facilities both on land and at sea.

Eight areas have been selected for further investigation, as shown on the map.

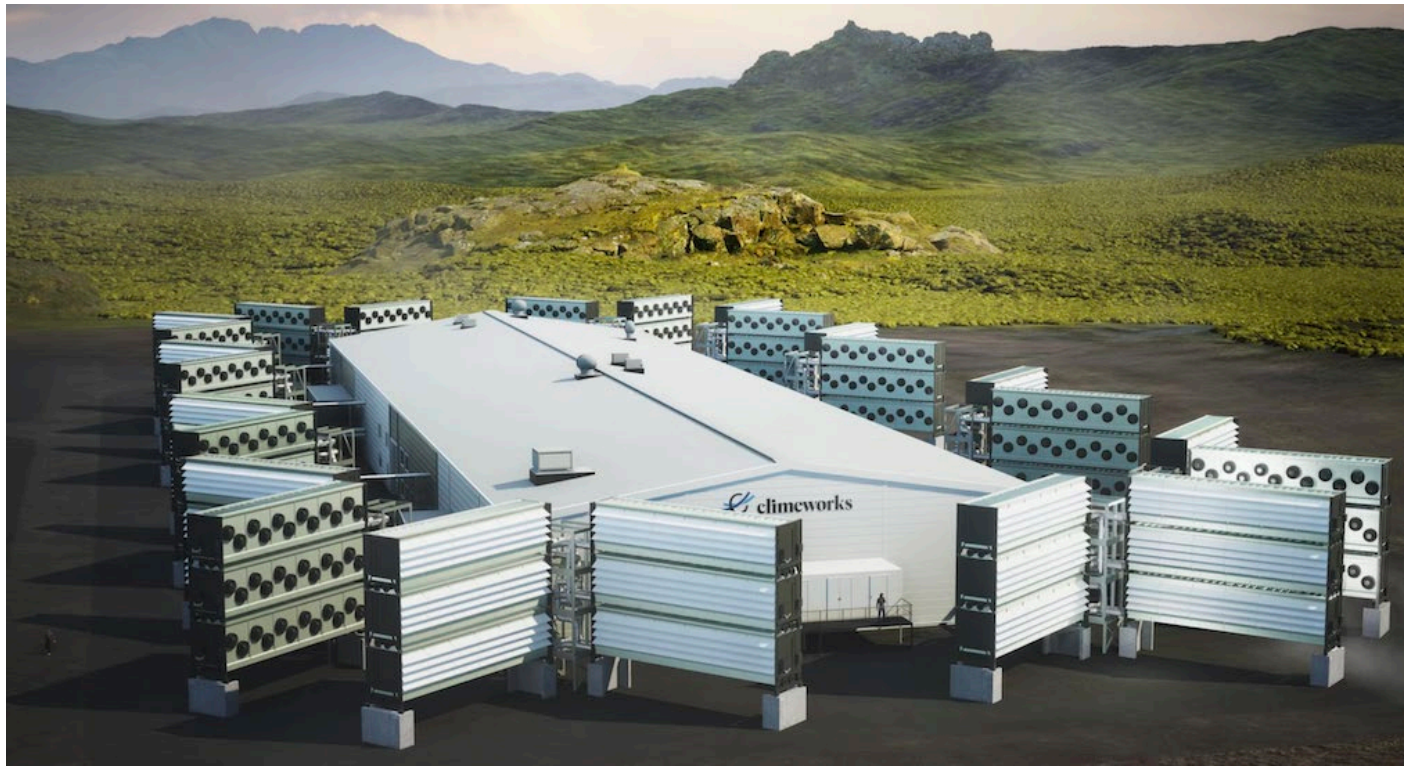


Capture



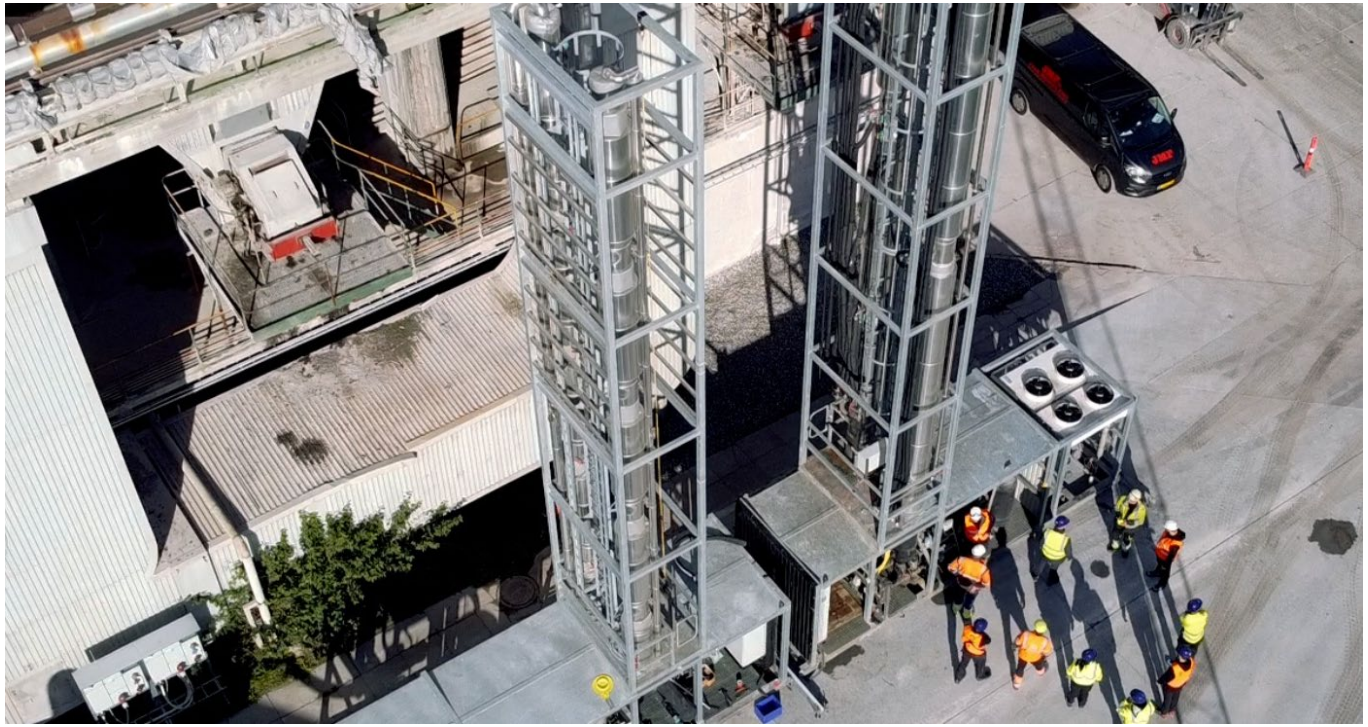
How do we capture CO_2?

Capture – Direct Air Capture



Hellisheidi in Iceland: Capture 36.000 ton/year (as 0,08% of the Danish emission pr. year).

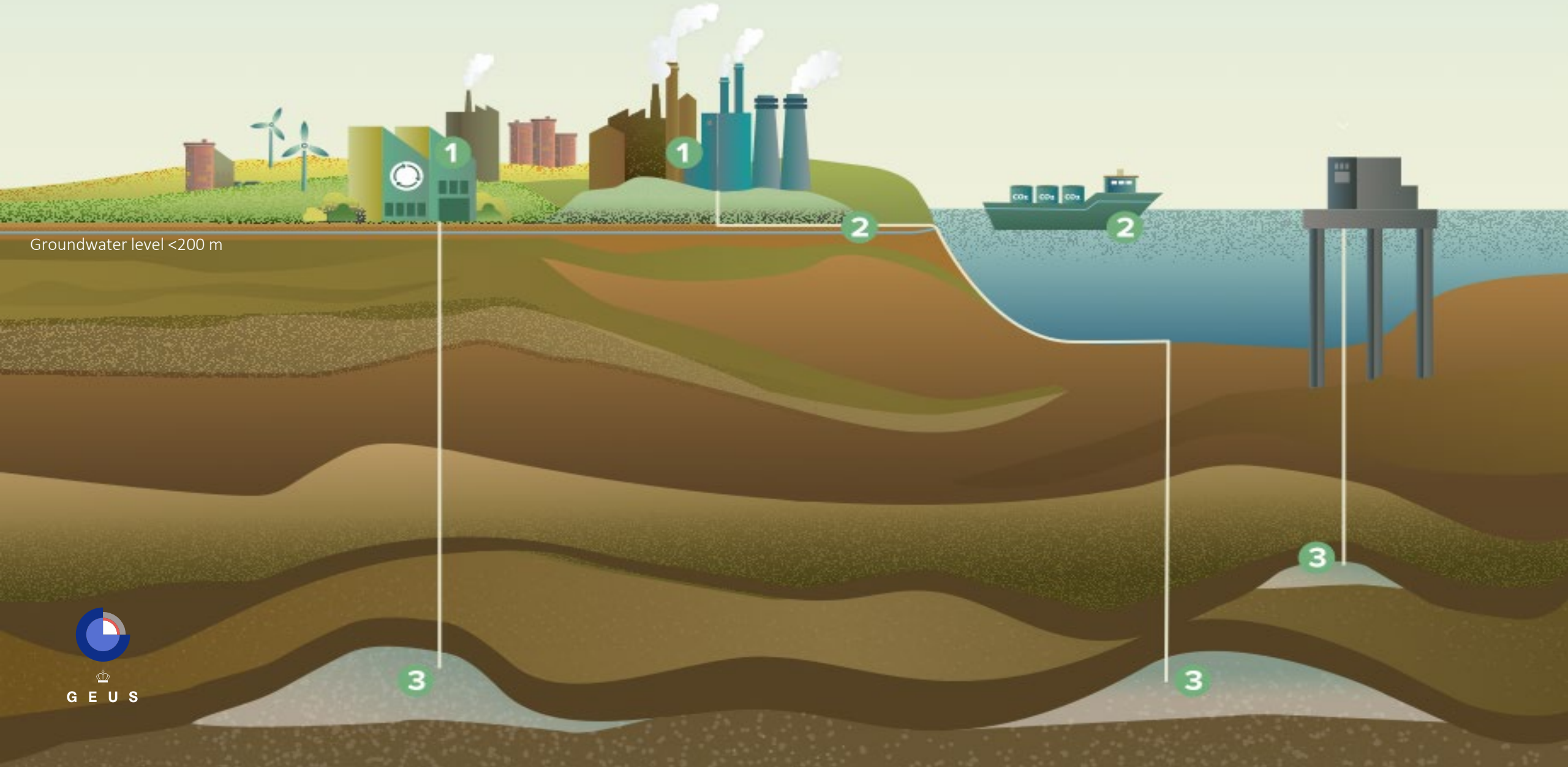
Capture – Directly from the emitter



Demo Capture facility at Ålborg Portland: Capture 24 ton/day (876 ton/year)
– in 2030 at least 0.4 mio ton/year

In 2021 globally ca. 40 mio ton CO_2 were captured in 27 big facilities

What is Geological Storage?

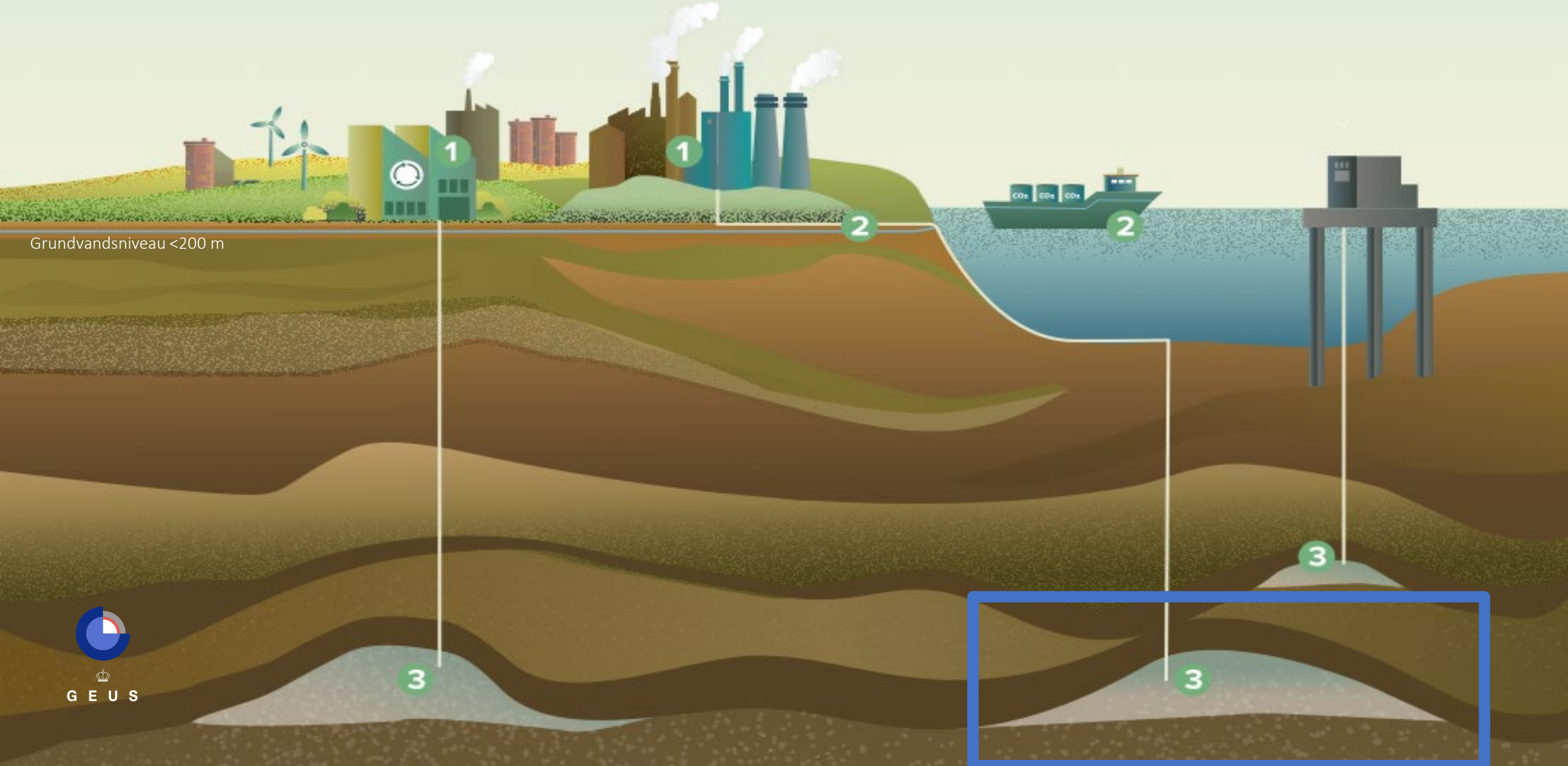


GEUS

1. CO_2 is captured by filtering the flue gas from CO_2 sources such as industry or energy production

2. The gas is compressed and transported via a pipeline, truck or ship to a suitable geological storage structure

3. CO_2 is pumped via deep boreholes into the reservoir in the storage structure, which is gradually filled up

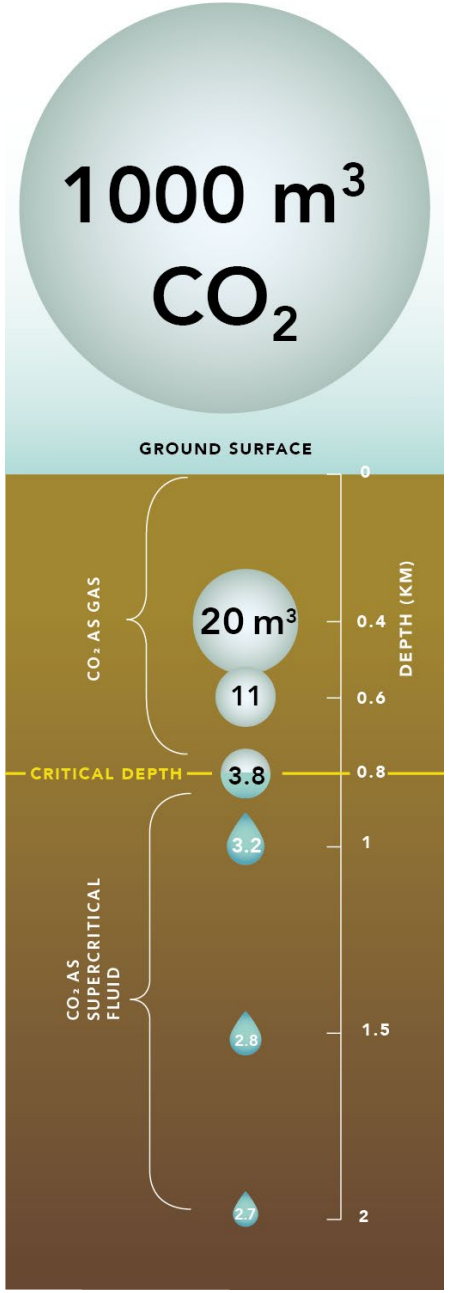


GEUS

How deep does it have to go?

At a depth of 800 m, CO_2 occupies 300 times less than at the earth's surface

At greater depths, CO_2 behaves like a liquid

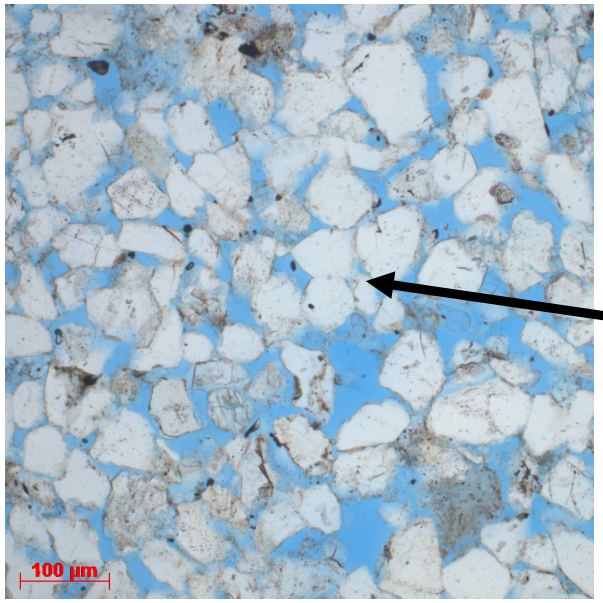


What properties must the subsoil have?

Sandstone with pore space with an overlying tight seal

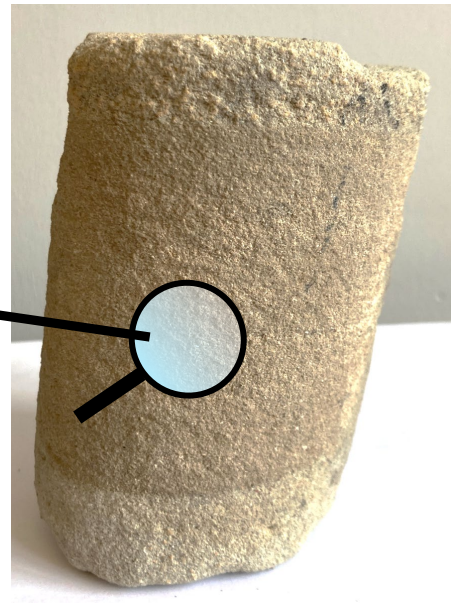
Loose sand with sand grains

Sandstone with quartz grains (grey-white) and connected pore spaces (blue)



20%–25% pore space between grains of sand

Sandstone with pore spaces



Claystone – tight seal

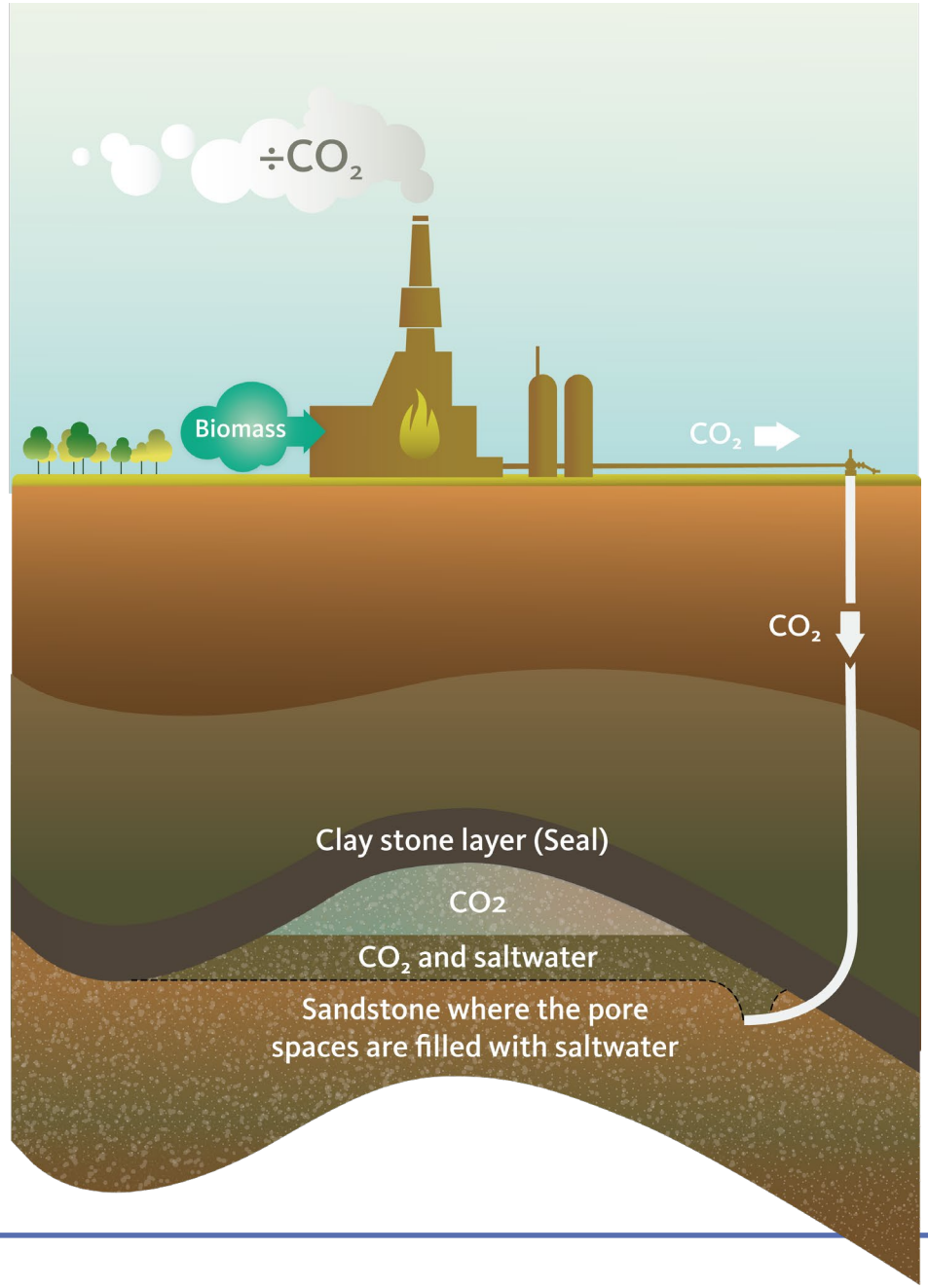
Where can CO_2 be stored?

CO_2 is pumped through a borehole into the sandstone, where it is distributed in connected pore spaces and mixes with the water with which the sand was deposited

CO_2 is lighter than water and will penetrate upwards. Therefore, there must be a layer of dense rock on top, such as claystone, so that CO_2 stays in the reservoir

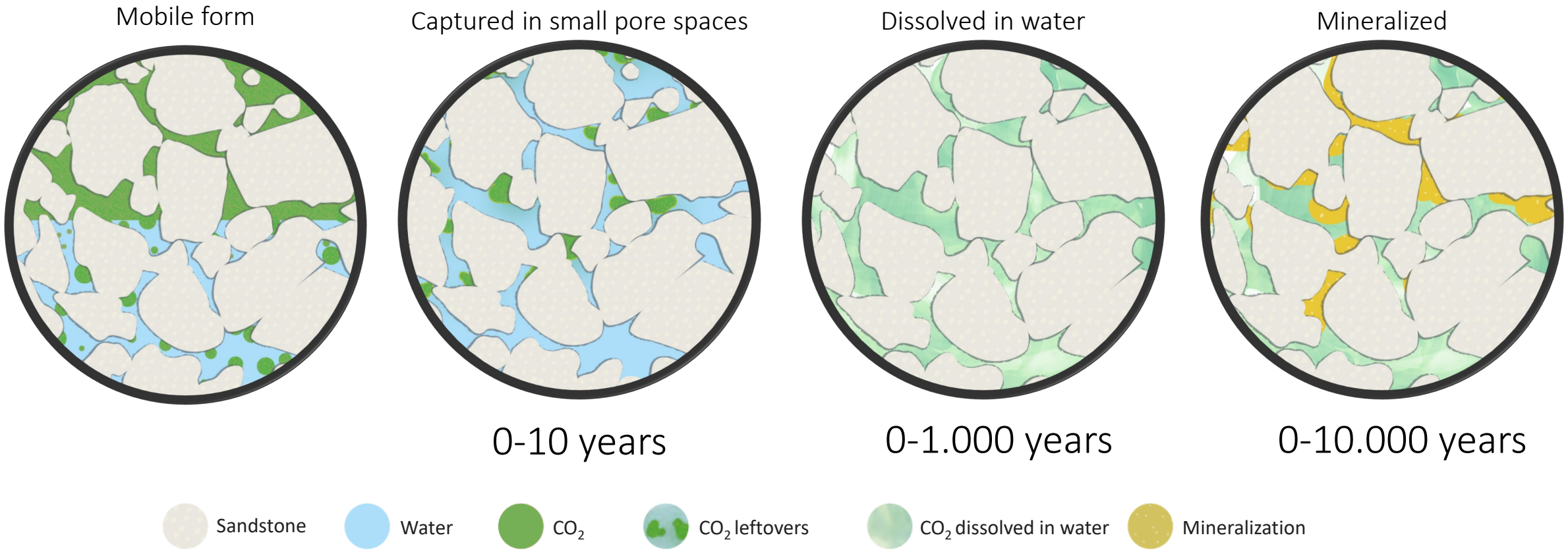
Ideal areas are where there is an enclosed structure such as a dome or inverted bowl shape

The CO_2 storage concept corresponds to the way oil and natural gas have been naturally stored for many millions of years



What happens to CO_2 in the underground?

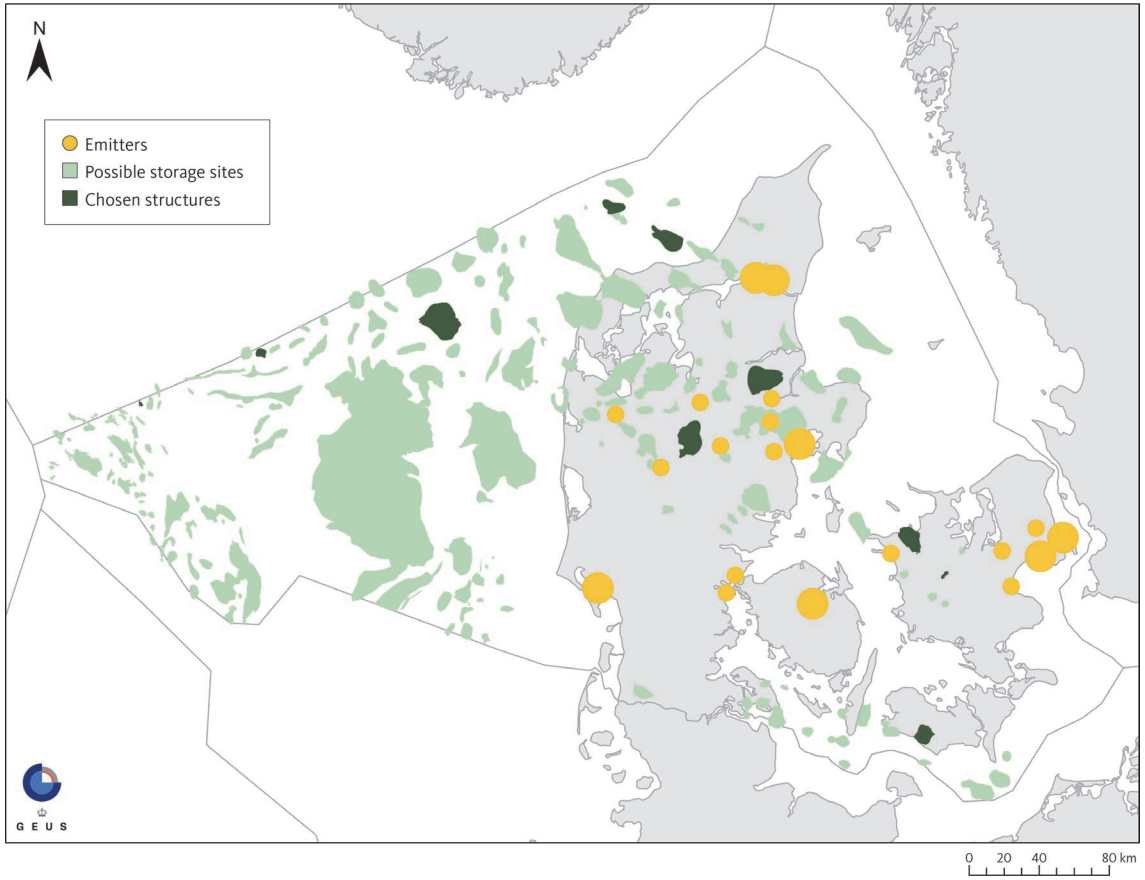
CO_2 is distributed in the pore space of the sandstone, but takes on different forms over time



Onshore and nearshore data acquisition

The ministry and GEUS talked to all the local authorities to feel their interest to be involved in CO_2 storage in their local area

- Described the local geology
- Described what geological storage of CO_2 is
- Described the first steps with preliminary studies and data acquisition

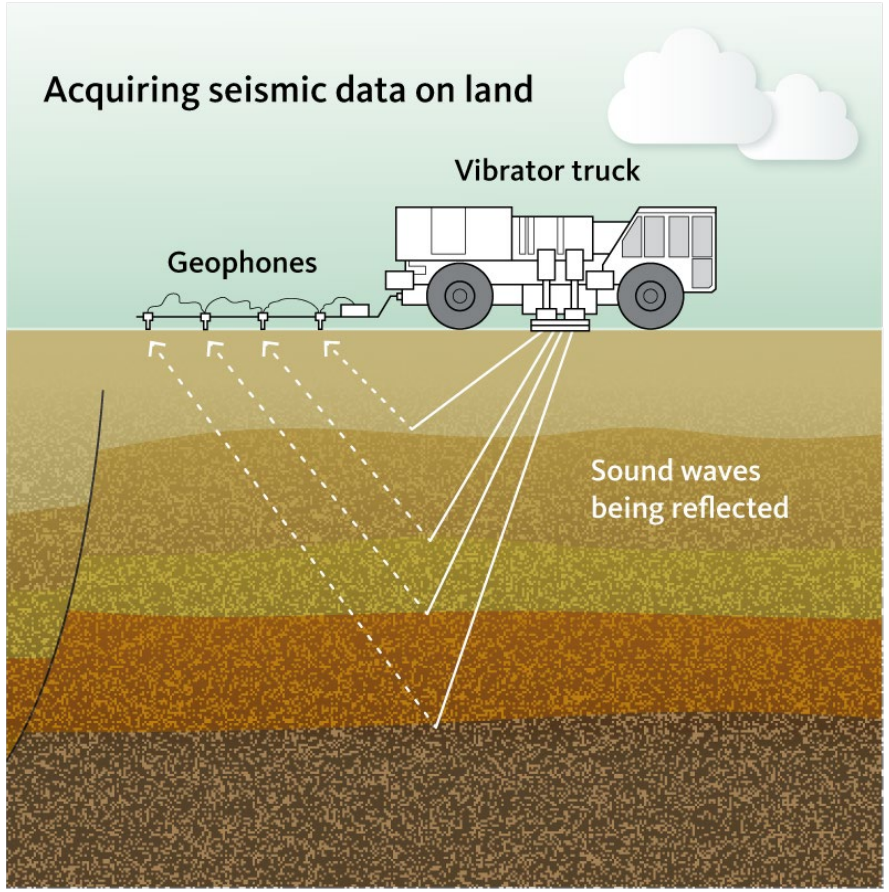


Public acceptance and communication

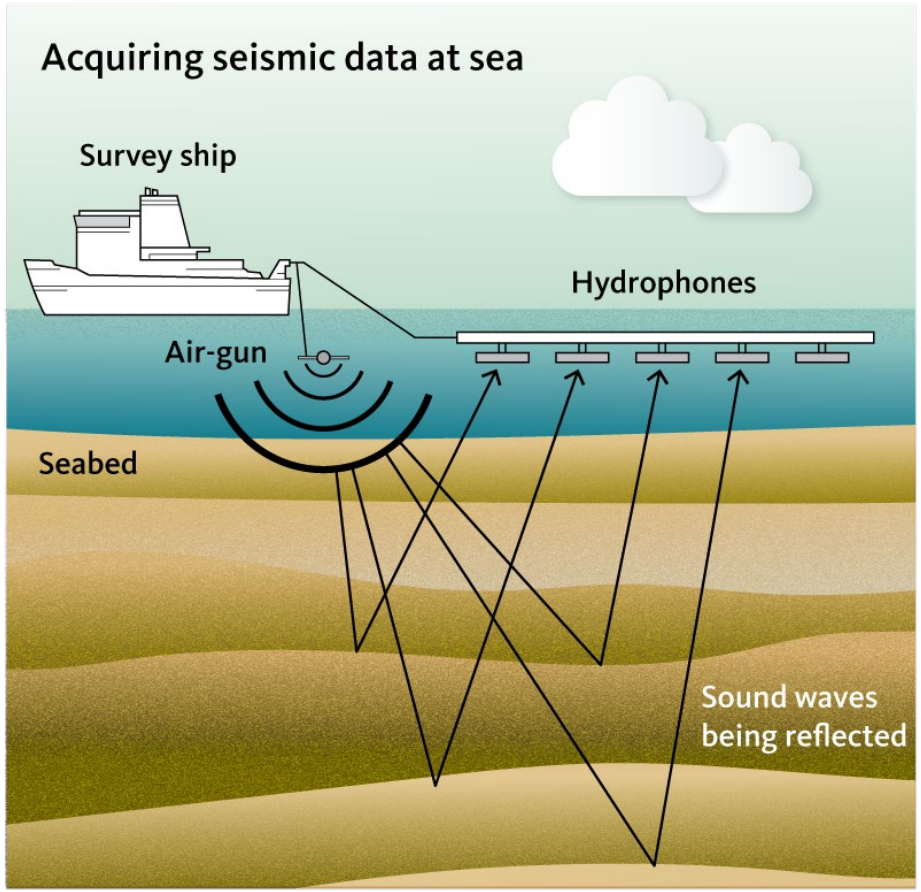
- Public meetings
- Visitors days during acquisition
- Local and nation-wide press

How does the seismic preliminary investigation take place?

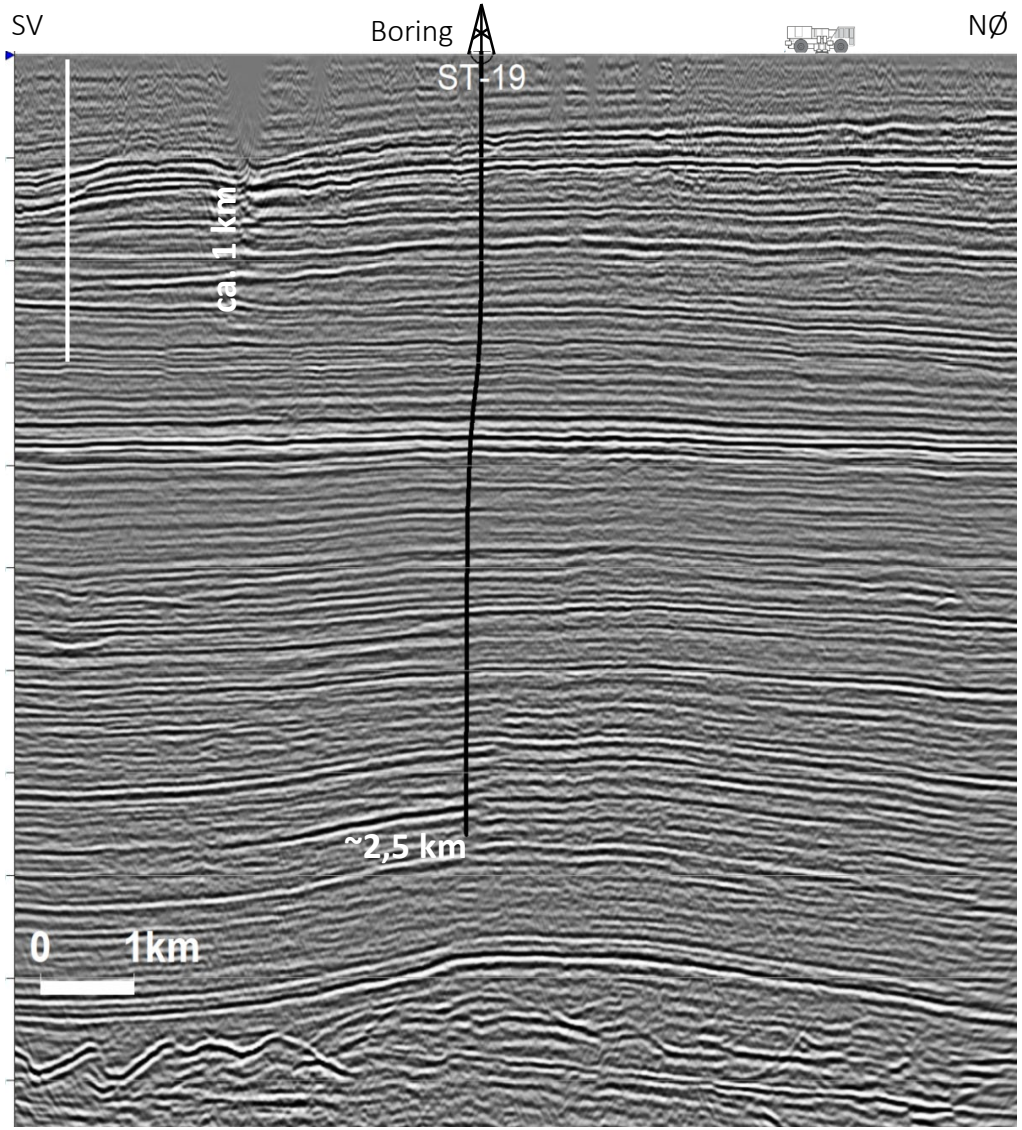
On land where two mini-trucks emit seismic vibrations (sound waves) which are then picked up by geophones along the road



At sea with ship towing air-gun and cable with hydrophones



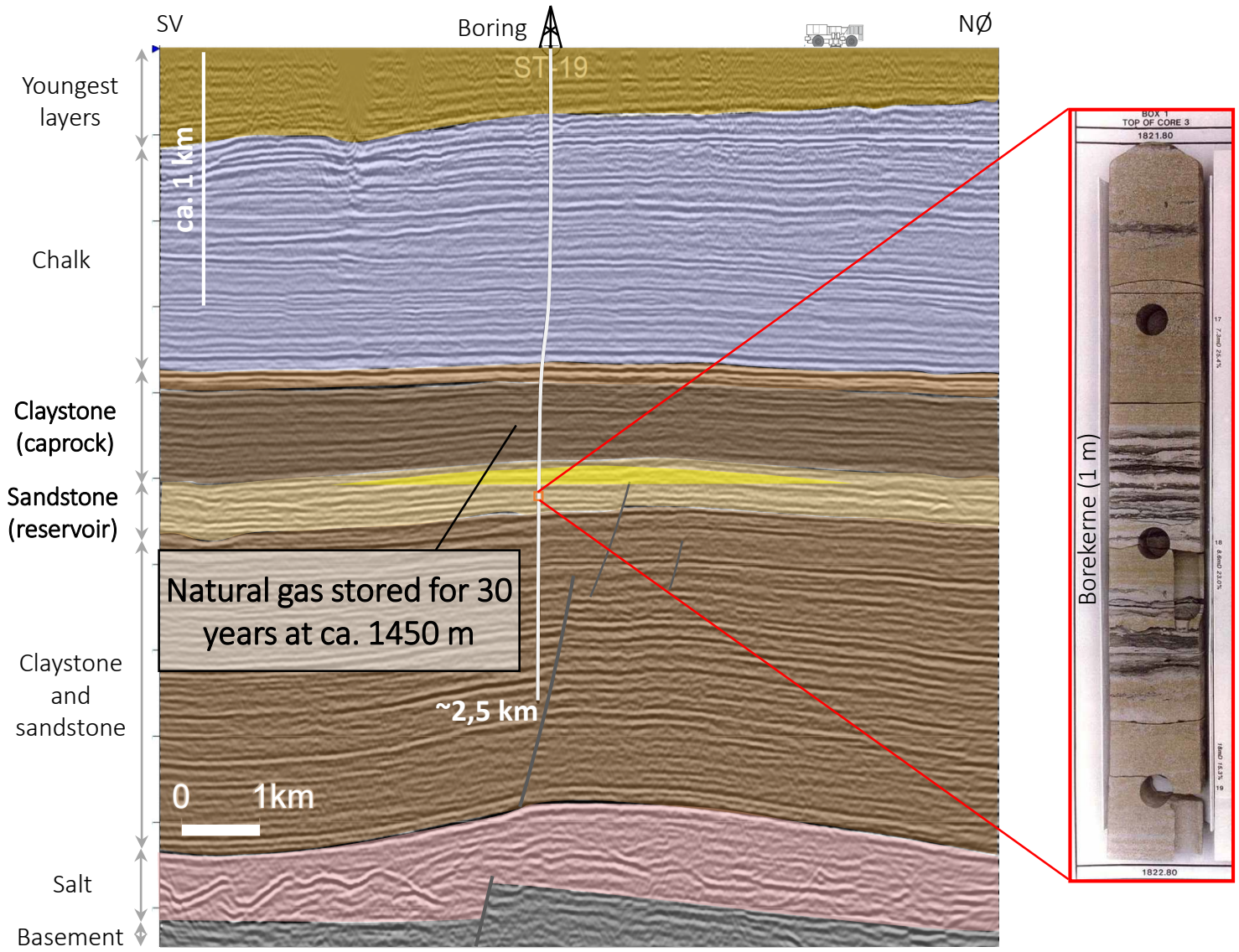
Example from the Stenlille area



Seismic profile

- Shows reflections from layer boundaries
- The geometry of the layers can be mapped

Example from the Stenlille area



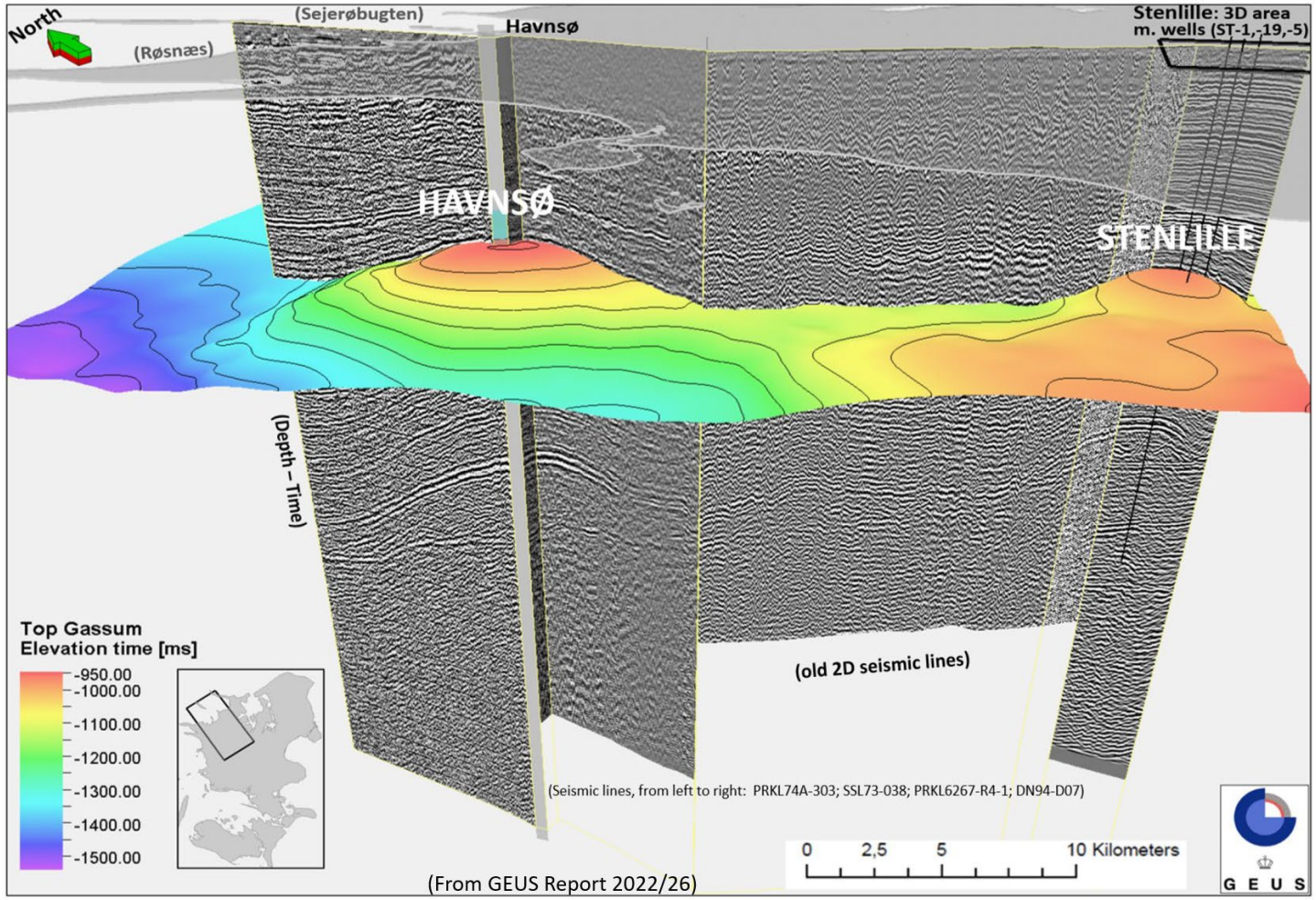
Seismic profile

- Shows reflections from layer boundaries
- The geometry of the layers can be mapped
- With drilling we can understand the geology of the layers

Example from the Stenlille and Havnsø area

Havnsø structure:

- Top Gassum closure area: 119 km^2
- Storage capacity (GF, mean): 306 Mt CO_2
- Gassum Fm thickness: c. 150-200 m
- Fjerritslev Fm thickness: c. 250-300 m

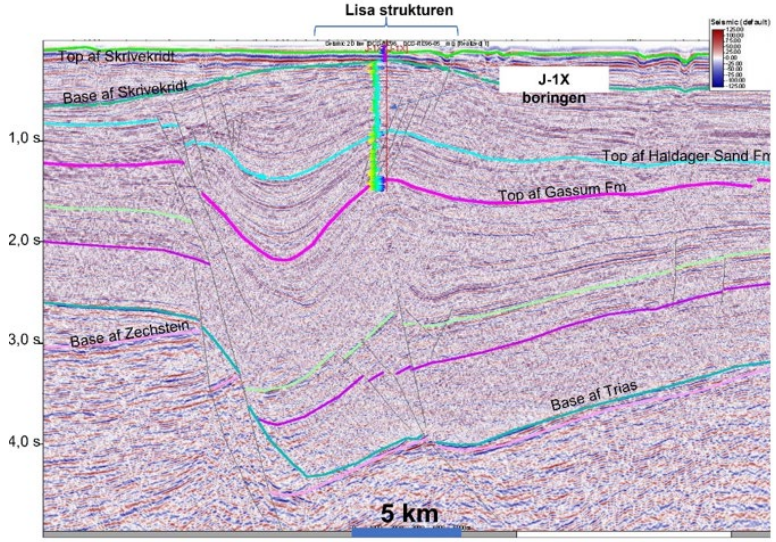


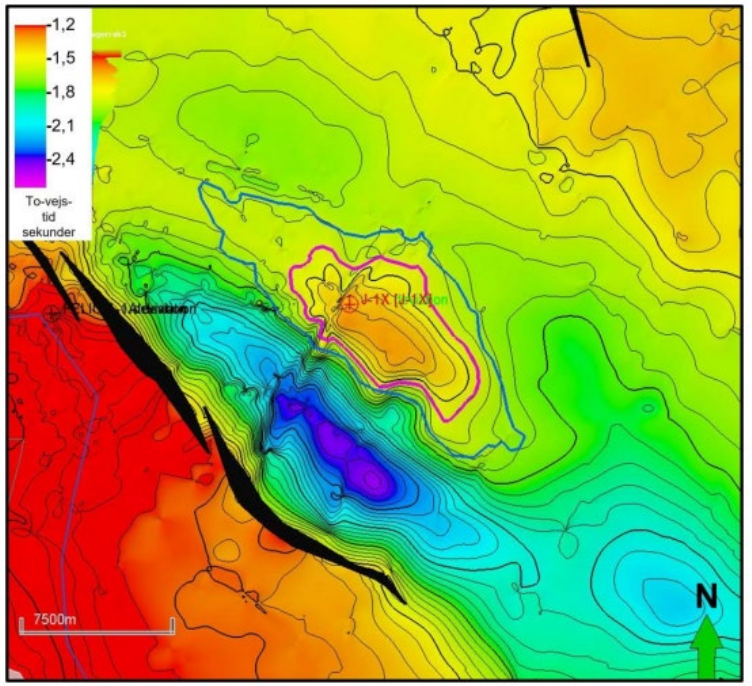
(From GEUS Report 2022/26)

Results of the studies

The studies will provide a better understanding of the structures':

- Geometry (size, bounding)
- Geology (reservoir and seal)
- Possible risks due to the geology, including especially faults, thickness of seal and reservoir
- Storage capacity
- The results are reported to the Ministry of Climate, Energy and Supply, and everyone can access collected data and the reports via GEUS





Forward

Danish Energy Agency:

- Strategic Environment Assessment (almost done)
- Licensing round (planned for December 2023)
- License awards (spring 2024)

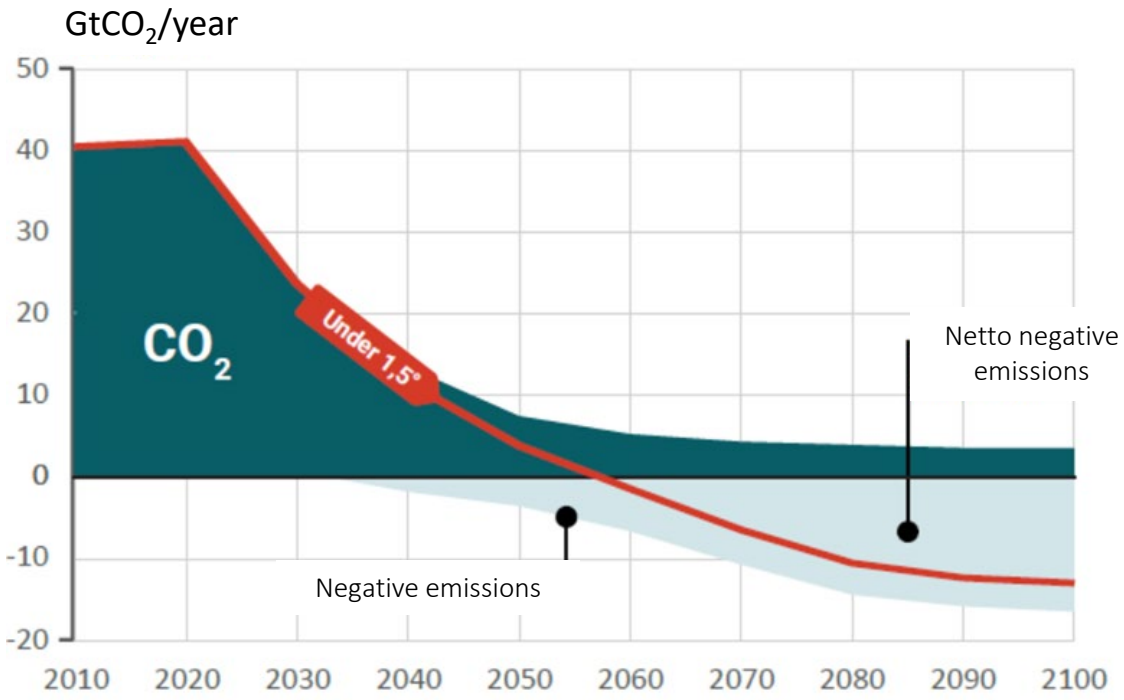
Important tasks

- Monitoring:
  - Seismic
  - Geochemistry
  - Biology
  - Hydrology
- Public communication

Conclusions

CO_2 storage

- Necessary **part** of the solution due to climate change
- It can not stand alone
- PtX, energy savings, forest planting, etc – they can't give us the negative emissions in the long run



Figur baseret på IPCC's 1,5 graders rapport, 2018 og UNEP GAP rapport 2017.