

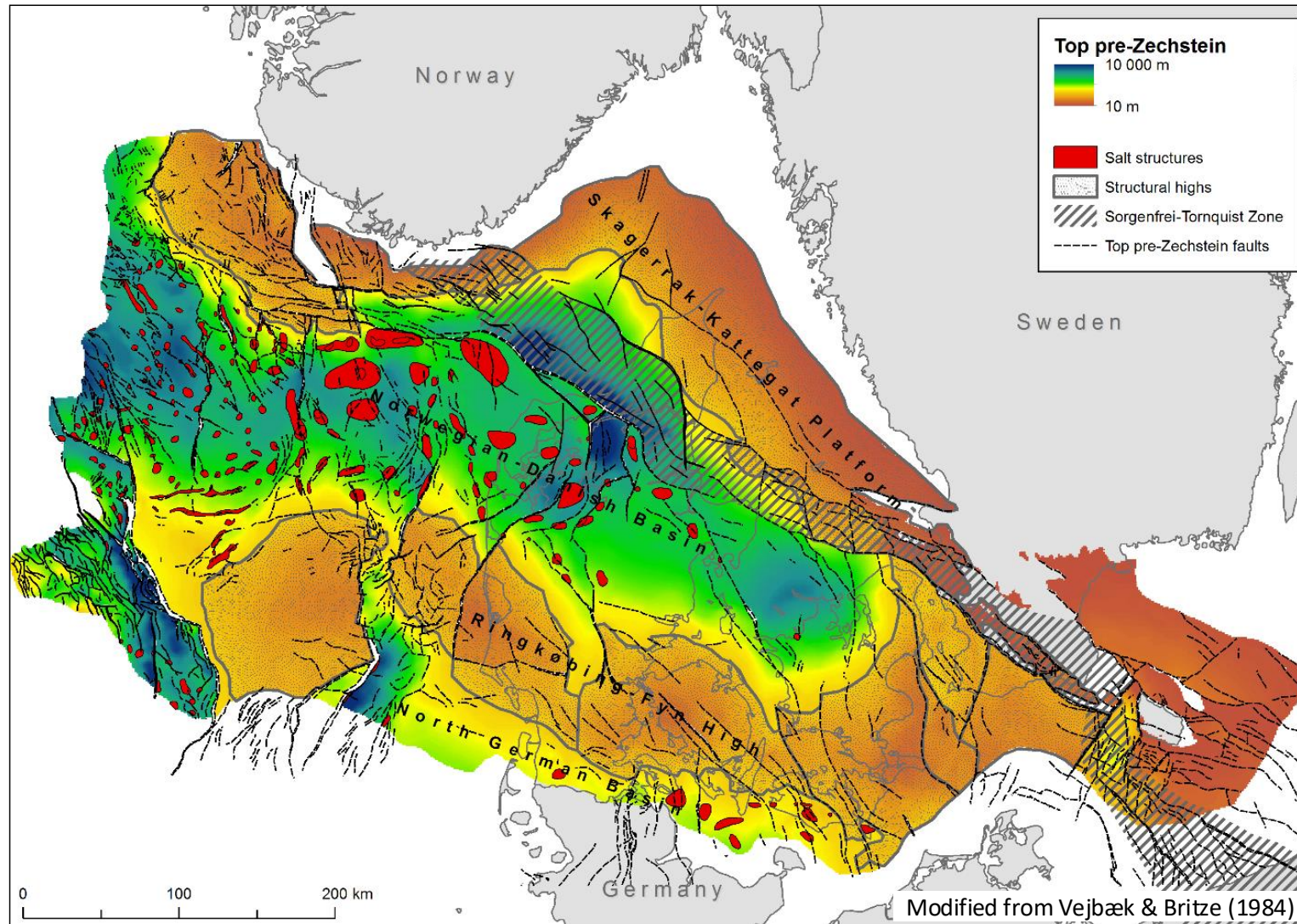
# Status for technical challenges and barriers for CO<sub>2</sub> storage in Denmark

*Carsten M. Nielsen*



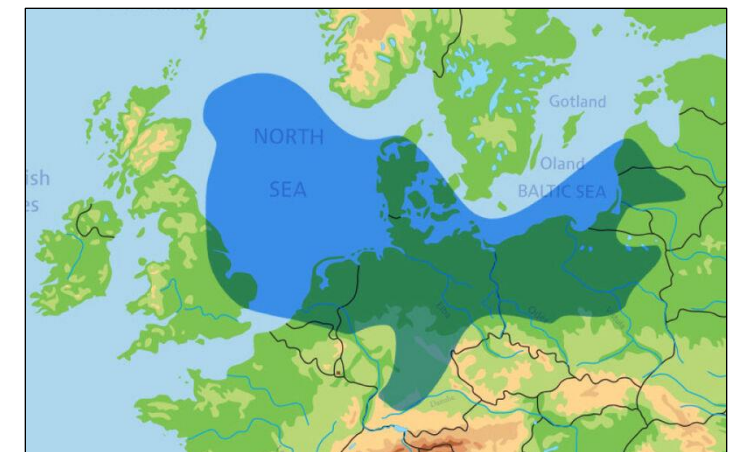
**G E U S**

# The Danish subsurface



Thick successions of sedimentary layers (sandstone, mudstone, chalk) in the Norwegian-Danish Basin and North-German Basin

Domal structures forming stratigraphic traps due to movement of salt below

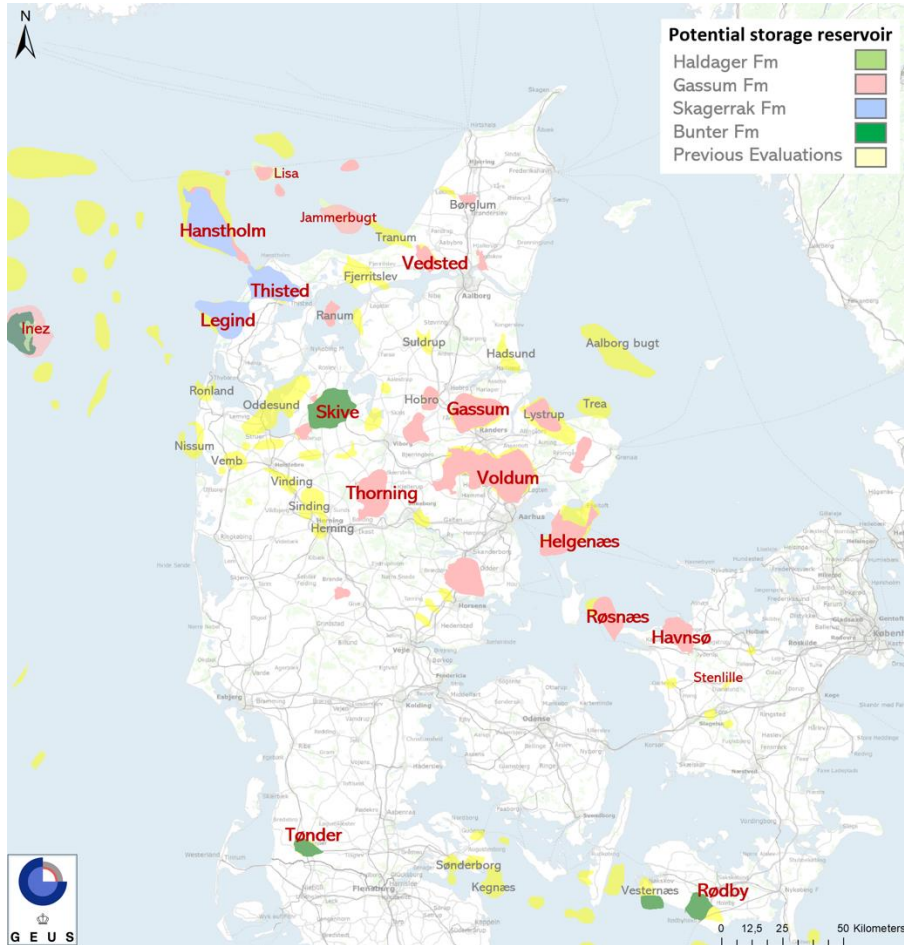


Zechstein salt (250 million years old)

# National funding to GEUS

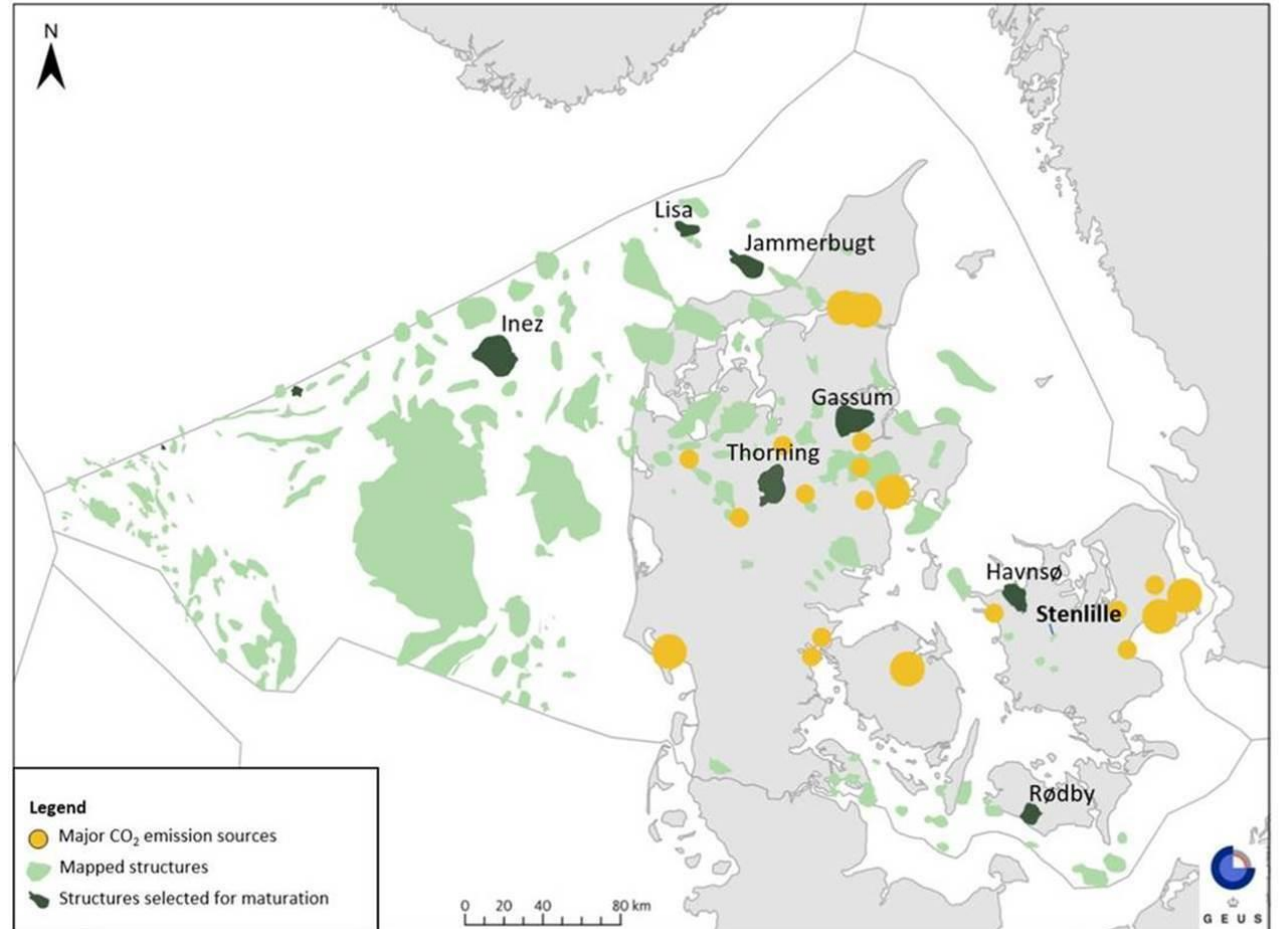
## GEUS Project CCS 2020

Screening study (2020), 13 structures were evaluated;  
CO<sub>2</sub> storage complex and storage potential

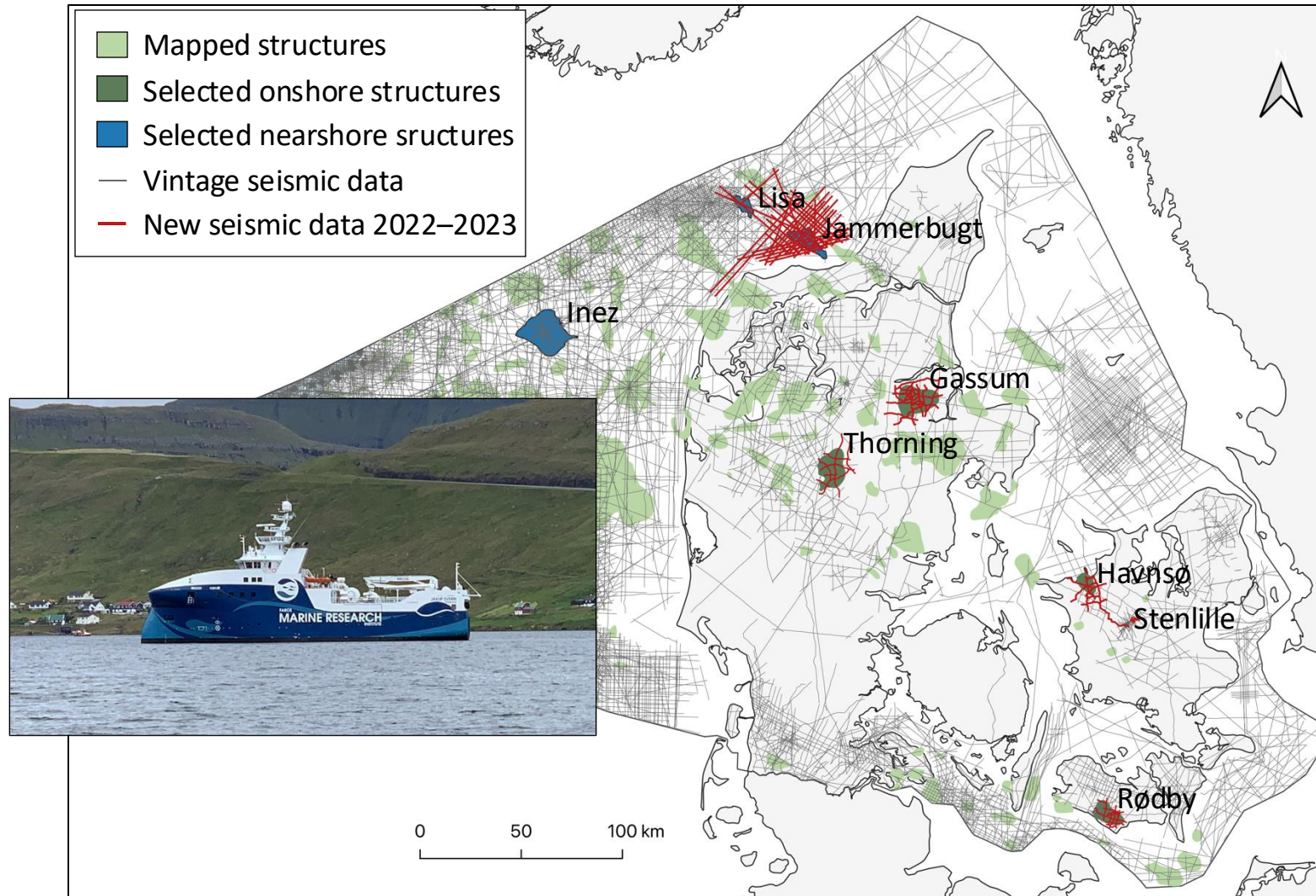


## GEUS Project CCS 2022-2024

Maturation with seismic acquisition & mapping of 8 structures  
(5 onshore and 3 offshore/nearshore) as basis for the further  
process towards selection for licensing.



# Seismic acquisition – new surveys Government funded



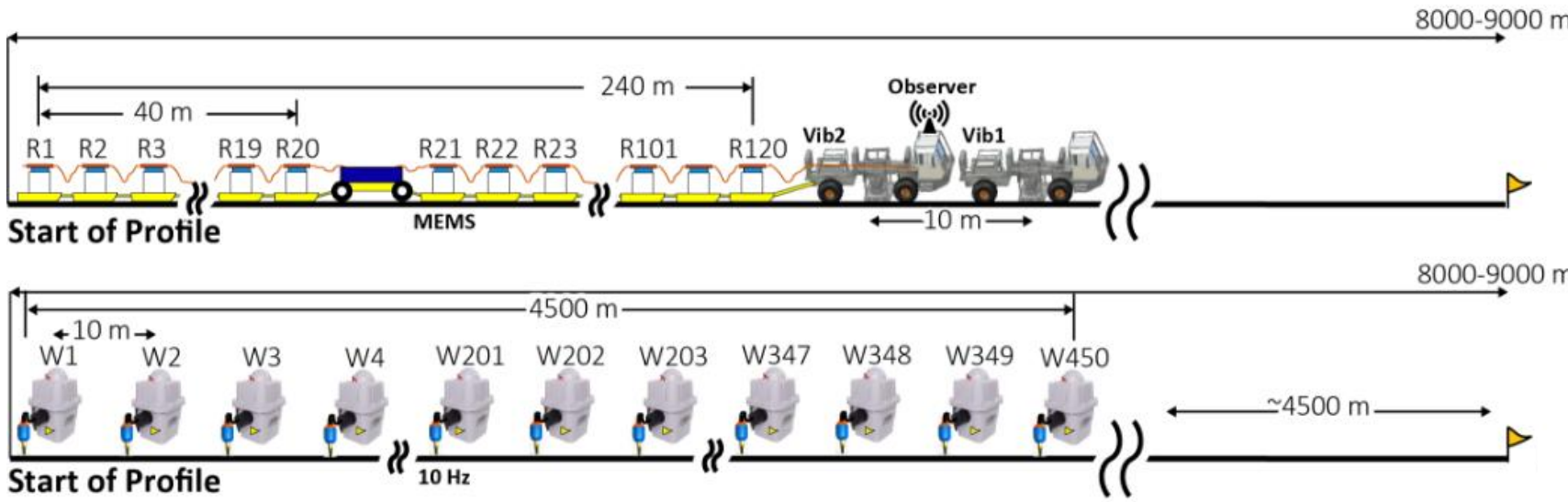
During 2022–2024, GEUS has worked on initial maturation of eight potential onshore and nearshore CO<sub>2</sub> storage sites towards licensing, including new acquisition of:

- \* 1450 km marine seismic data
- \* 600 km onshore seismic data



# Land seismic acquisitions

Illustration:  
A. Malehmir, Uppsala University



DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2023/38

**CCS2022-2024 WP1: The Havnsø structure**

Seismic data and interpretation to mature potential geological storage of CO<sub>2</sub>

Ulrik Gregersen, Henrik Vosgerau, Florian W.H. Smit, Bodil W. Lauridsen, Anders Mathiesen, Finn Mørk, Lars Henrik Nielsen, Rasmus Rasmussen, Karen Dybkjær, Emma Sheldon, Gunver K. Pedersen, Carsten Møller Nielsen, Kenneth Bredeesen, Shahjahan Laghari, Maiken L. Olsen & Lasse M. Rasmussen

G E O L O G I C A L S U R V E Y O F D E N M A R K A N D G R E E N L A N D  
DANISH MINISTRY OF CLIMATE, ENERGY AND UTILITIES

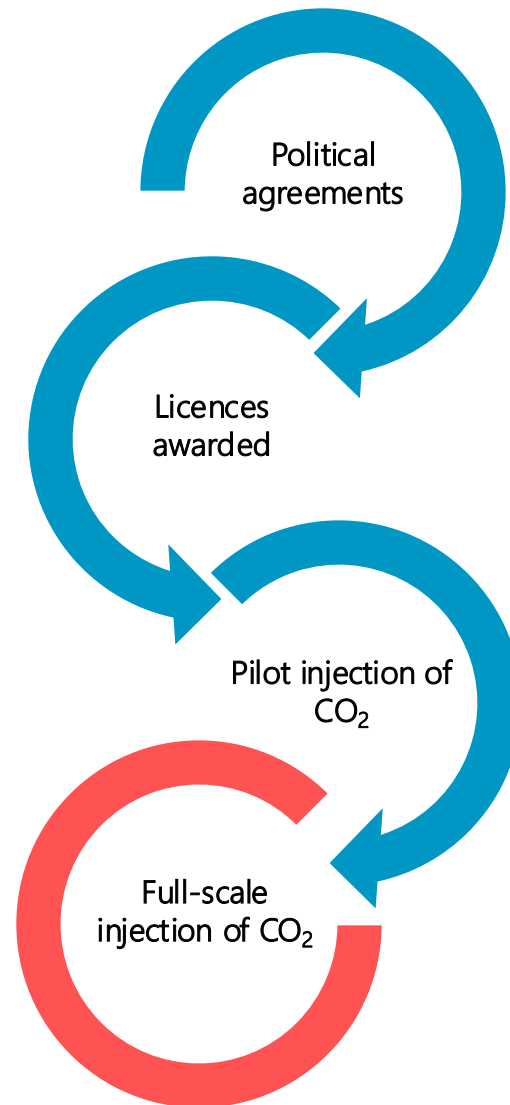
**G E U S**

# Developing CO<sub>2</sub>-storage in Denmark

Timeline from development of framework to actual injection

- **August 2022:** Opening of 1<sup>st</sup> Offshore storage licensing round
- **December 2022:** Permit granted for pilot injection Project Greensand
- **February 2023:** 1<sup>st</sup> offshore storage licences granted

- **December 2023:** Opening of 1<sup>st</sup> Onshore storage licensing round
- **June 2024:** three onshore licences awarded



- **June 2020:** 1<sup>st</sup> climate agreement for CCUS in Denmark
- **June 2021:** 1<sup>st</sup> Danish CCS strategy
- **June 2022:** Framework for CO<sub>2</sub> storage in Denmark

- **March 2023:** First ever injection of CO<sub>2</sub> in Denmark → Project Greensand pilot project permit

2020

Framework set

small-scale

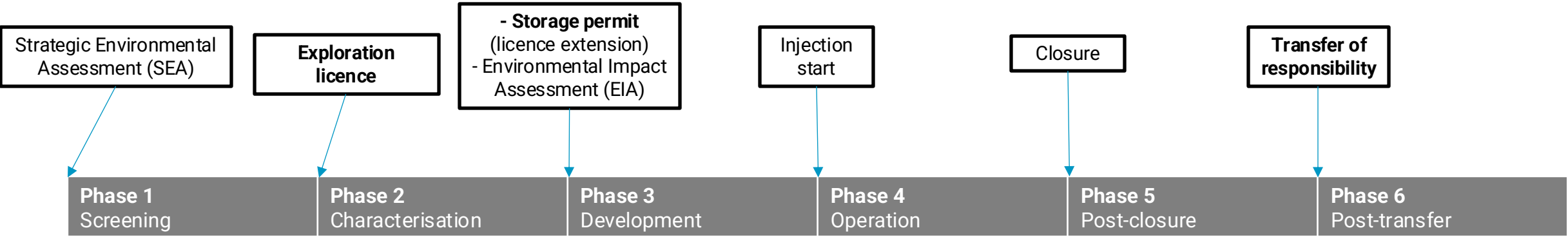
full-scale

2030

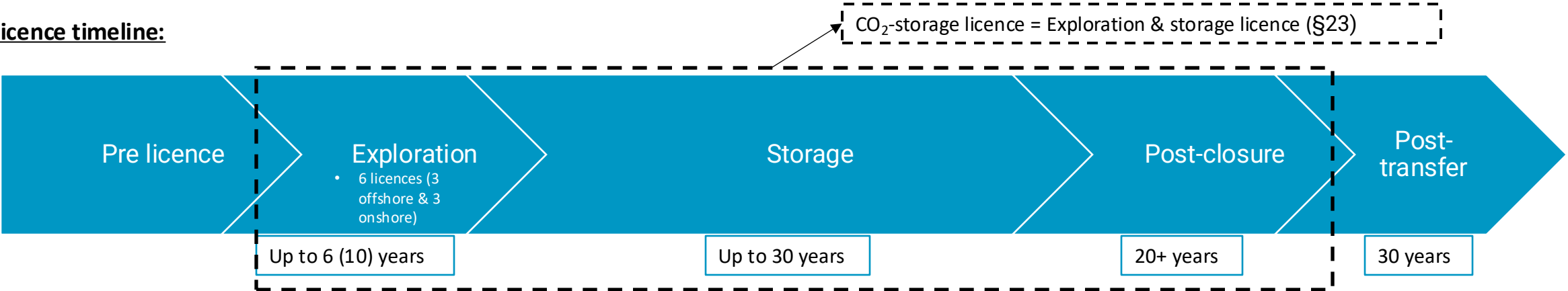
Danish Energy Agency

# CO<sub>2</sub>-storage licence roadmap & milestones

Milestones and CO<sub>2</sub>-storage project life-cycle phases (based on ISO 27914):



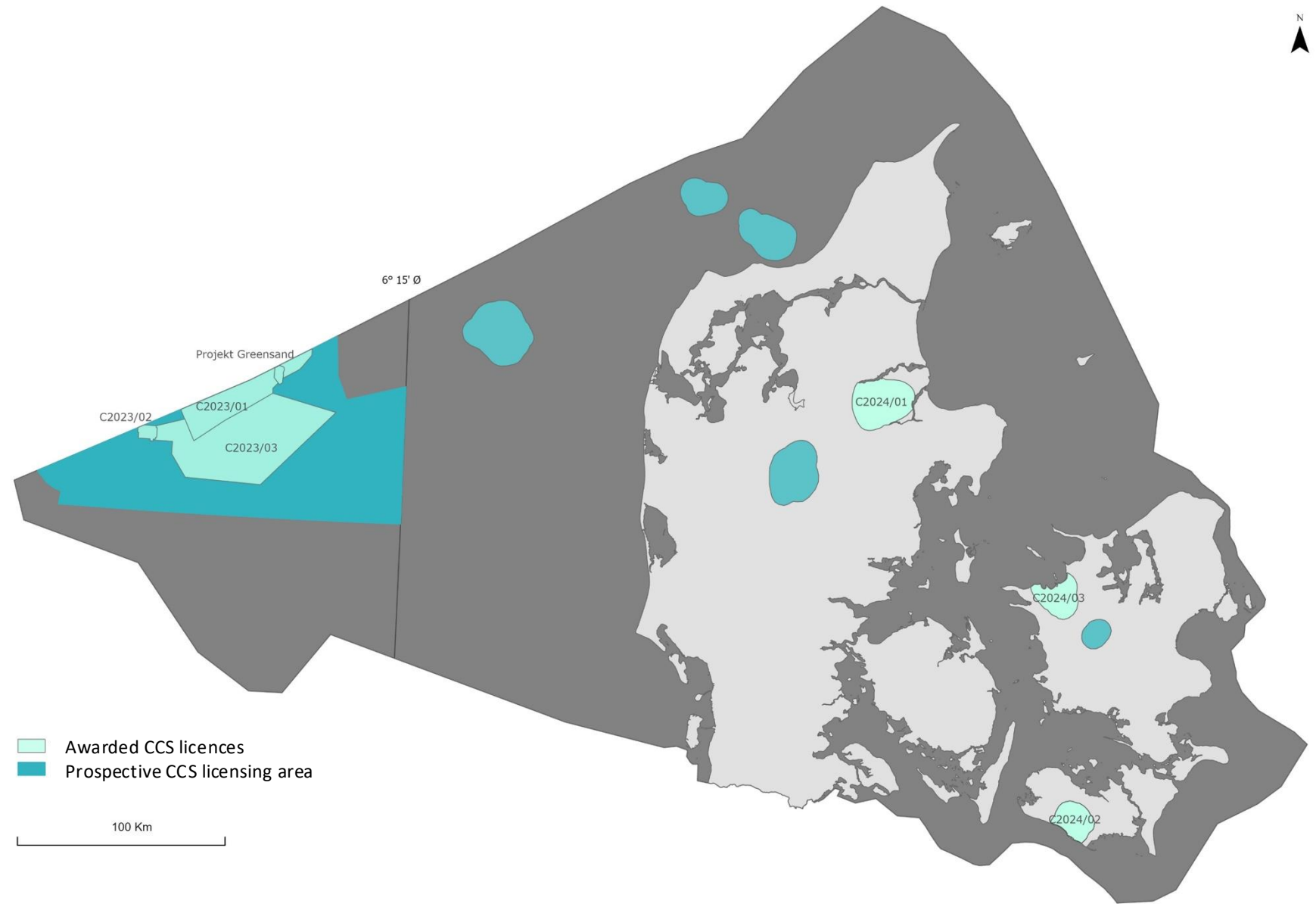
DEA licence timeline:



Danish Energy Agency

# Current licences and

- Offshore licences awarded in 2023
  - C2023/01 Ineos & Harbour Energy
  - C2023/02 & 03 TotalEnergies
- Onshore licences awarded in 2024
  - C2024/01 Harbour Energy & Ineos
  - C2024/02 Equinor & Ørsted
  - C2024/03 Carbon Cuts



Danish Energy Agency

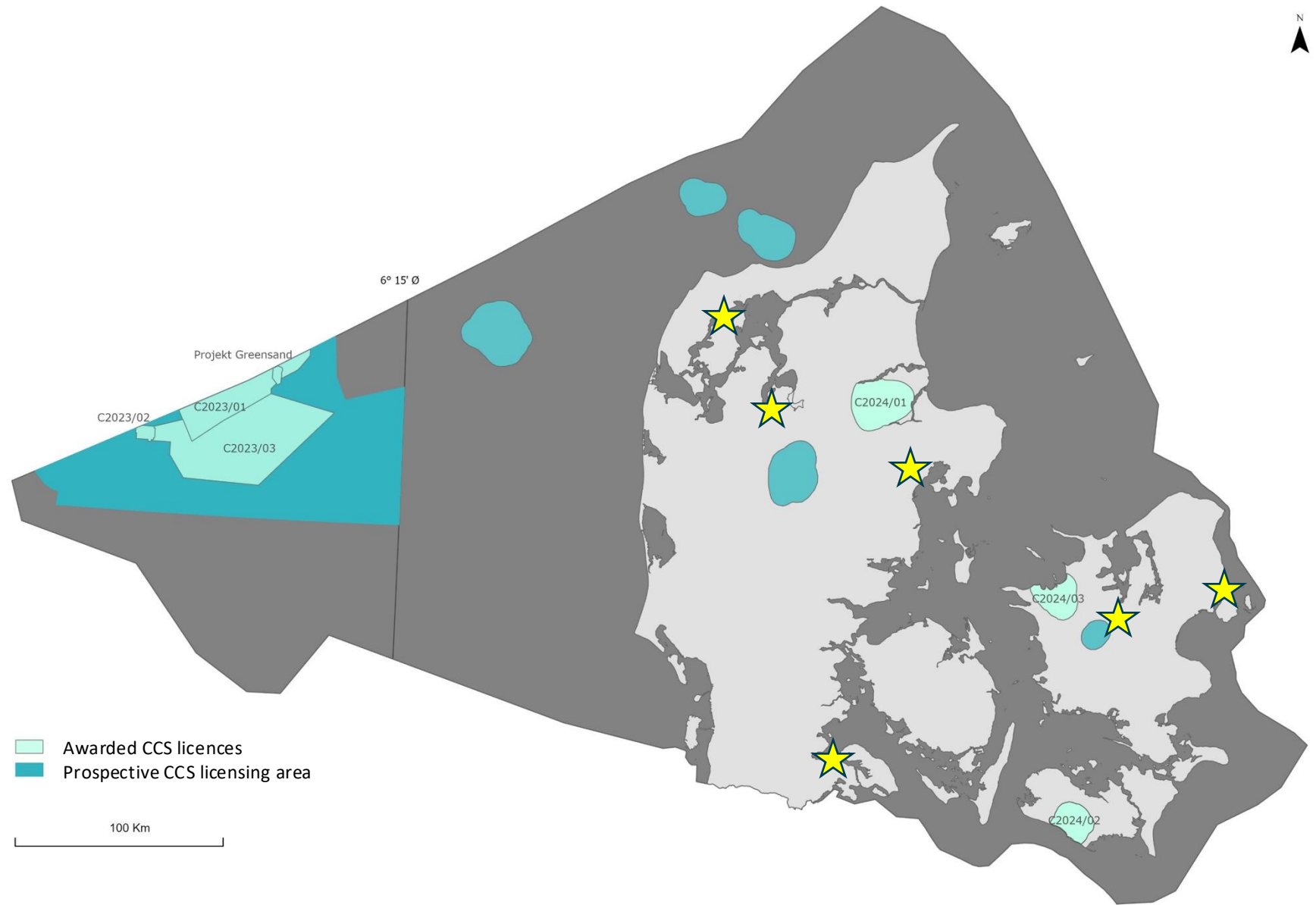


# Current licences and - and geothermal act

- Offshore licences awarded in 2023
  - C2023/01 Ineos & Harbour Energy
  - C2023/02 & 03 TotalEnergies
- Onshore licences awarded in 2024
  - C2024/01 Harbour Energy & Ineos
  - C2024/02 Equinor & Ørsted
  - C2024/03 Carbon Cuts

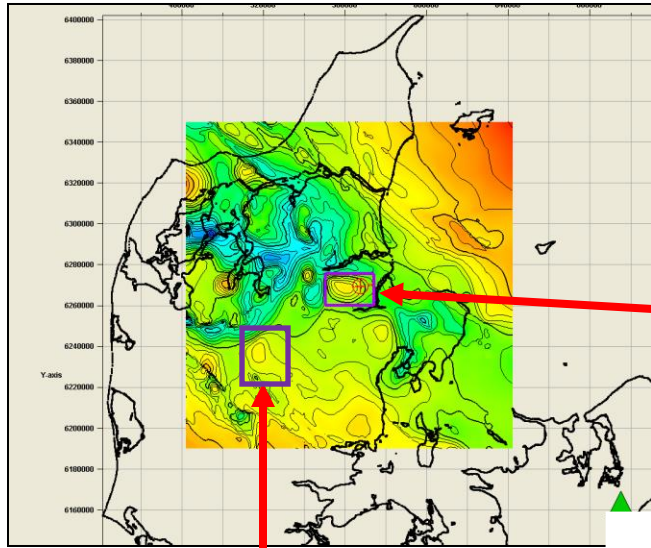
★ Geothermal activities/interests (same formations)

- Regulation of pressure interaction is high priority



Danish Energy Agency

# Regional pressure development - Gassum case

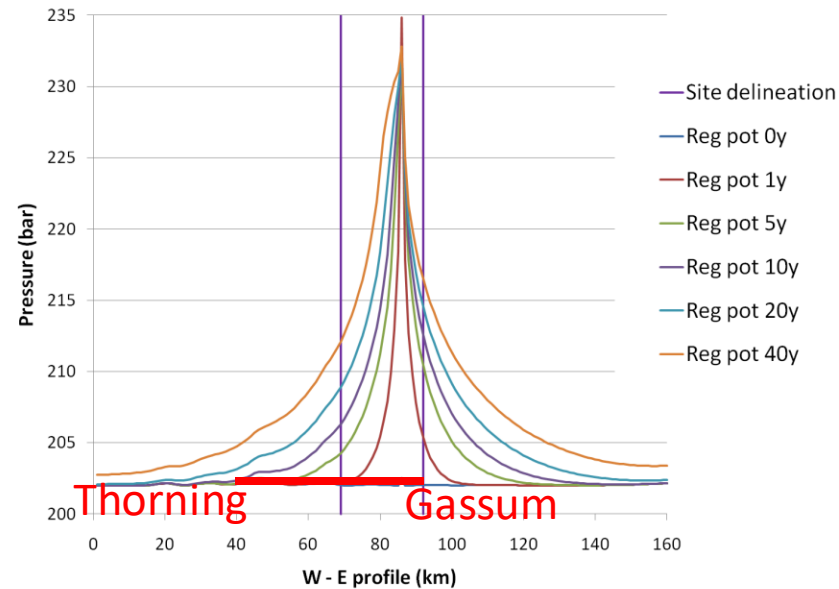


Regional model:  
160 km x 160 km

CO<sub>2</sub> injection:  
3 Mt/y for 40 years

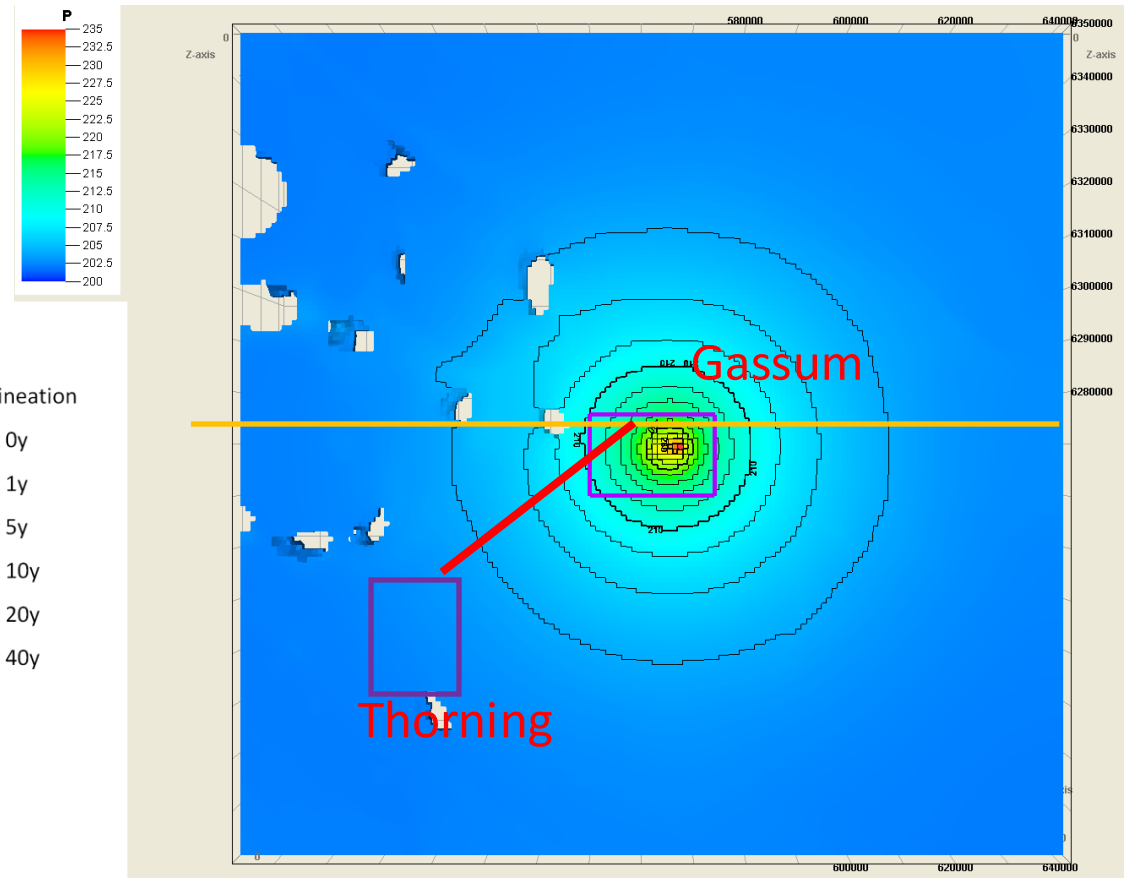
Gassum

Thorning  
Approx. 50 km to Gassum



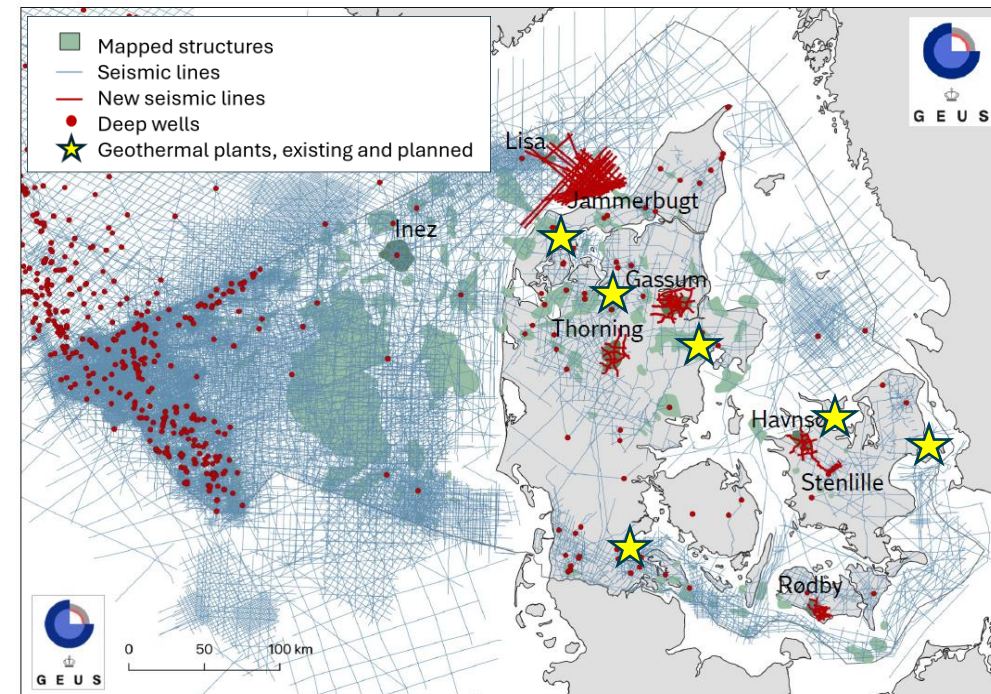
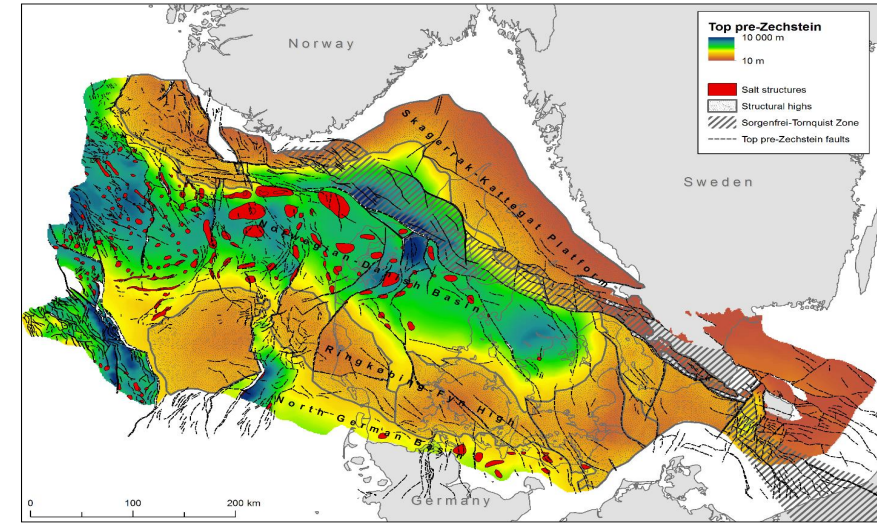
Simulated over-pressure (potential) after 40 years

- Pressure increase far beyond the site delineation
- Site model boundary conditions must mimic the regional pressure development



# DK plan forward – pressure interactions

- GEUS granted funds from DK state budget for regional pressure modelling (“Forskningsreserven”, start Q4 2024)
- Regional onshore subsurface modelling challenged by scares and uneven distributed data sets (deep wells, seismic), all data at GEUS
- Formation horizons mapped
- Structural closures mapped (GEUS 2020, GEUS 2022-2024)
- Major Fault zones (to some extent) mapped
- Regional/semi-regional geological modelling/understanding
- **Hydraulic unit(s) and boundary conditions** for flow/pressure modelling essential
- Cooperation with license owners; CCS, Geothermal and neighboring countries



# Public outreach

Citizen meetings prior to acquisition start (GEUS, DEA, COWI)

Citizen meetings on strategic environmental assessment (DEA, COWI)

Visitor's days

Survey web page

Information letters and flyers

Media interviews (many!)

Talks for schools and general public

Social media



## En 200 meter lang mikrofon lytter efter en klimaløsning under jorden



# What are people asking about?

- Why here?/Why us?/Why not in Copenhagen?
- What about the groundwater?
- What about our protected forest?
- What about the milking cows? (during seismic acquisition)
- How many trucks will pass us a day?
- Will a possibly CO<sub>2</sub> leak explode, poison us
- What about radon?
- Will our houses break?
- Why CO<sub>2</sub> from other countries?
- Why foreign companies?
- Why use such an unproven technique?
- What is CCS?
- What is CO<sub>2</sub>?
- What is a sandstone?
- What is seismic data?



# Take-home messages

- Public available subsurface data
- 1<sup>st</sup> screening for CCS possibilities funded by Government (seismic acquisition, geological interpretation/report)
- Licensing round(s), transparent dialog with authorities
- Active public acceptance strategy – GEUS, DEA, operator
- DK challenge – pressure interference between different subsurface activities