

Responsible carbon storage

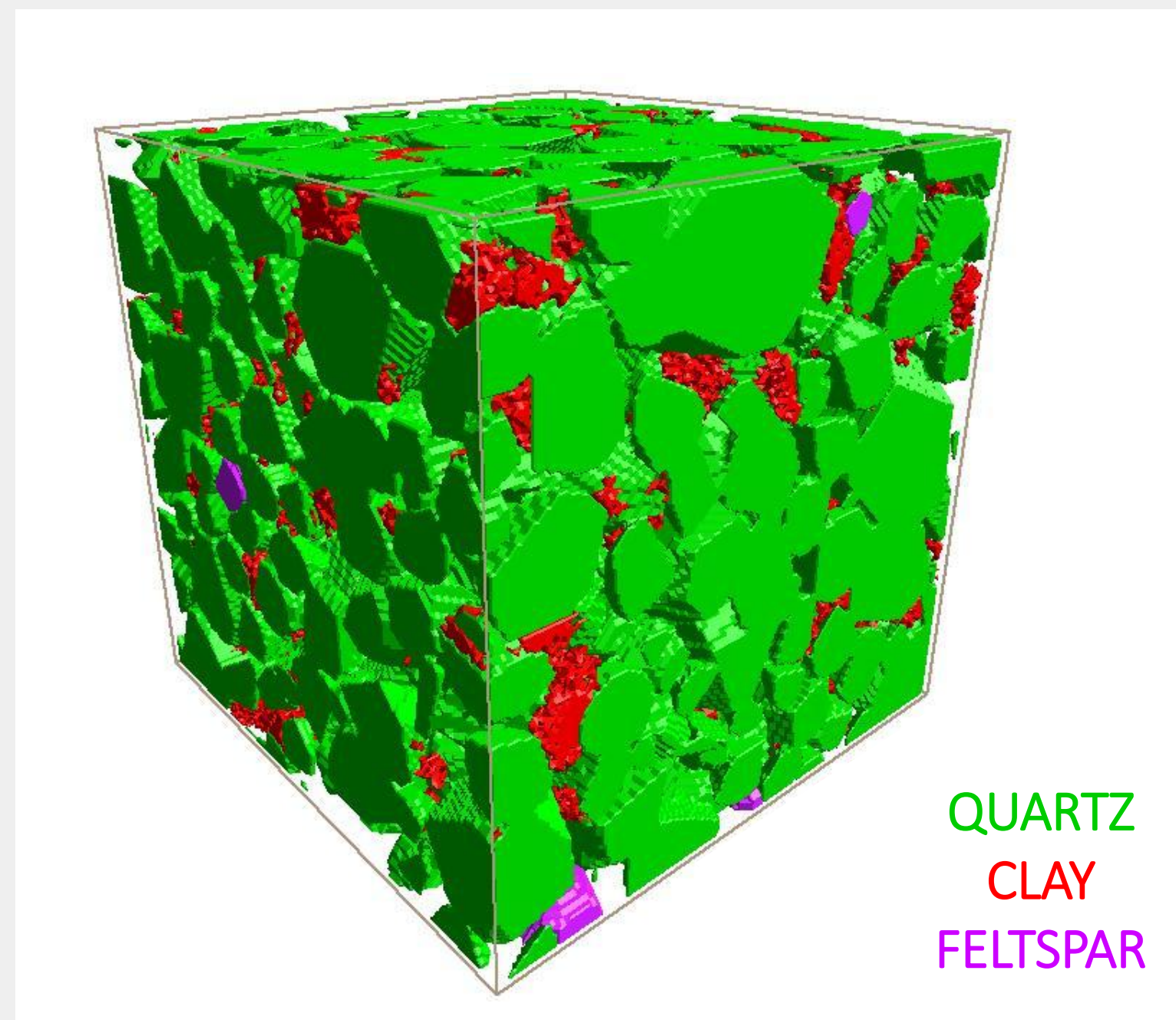
Cathrine Ringstad

Senior adviser CCS
The Bellona Foundation

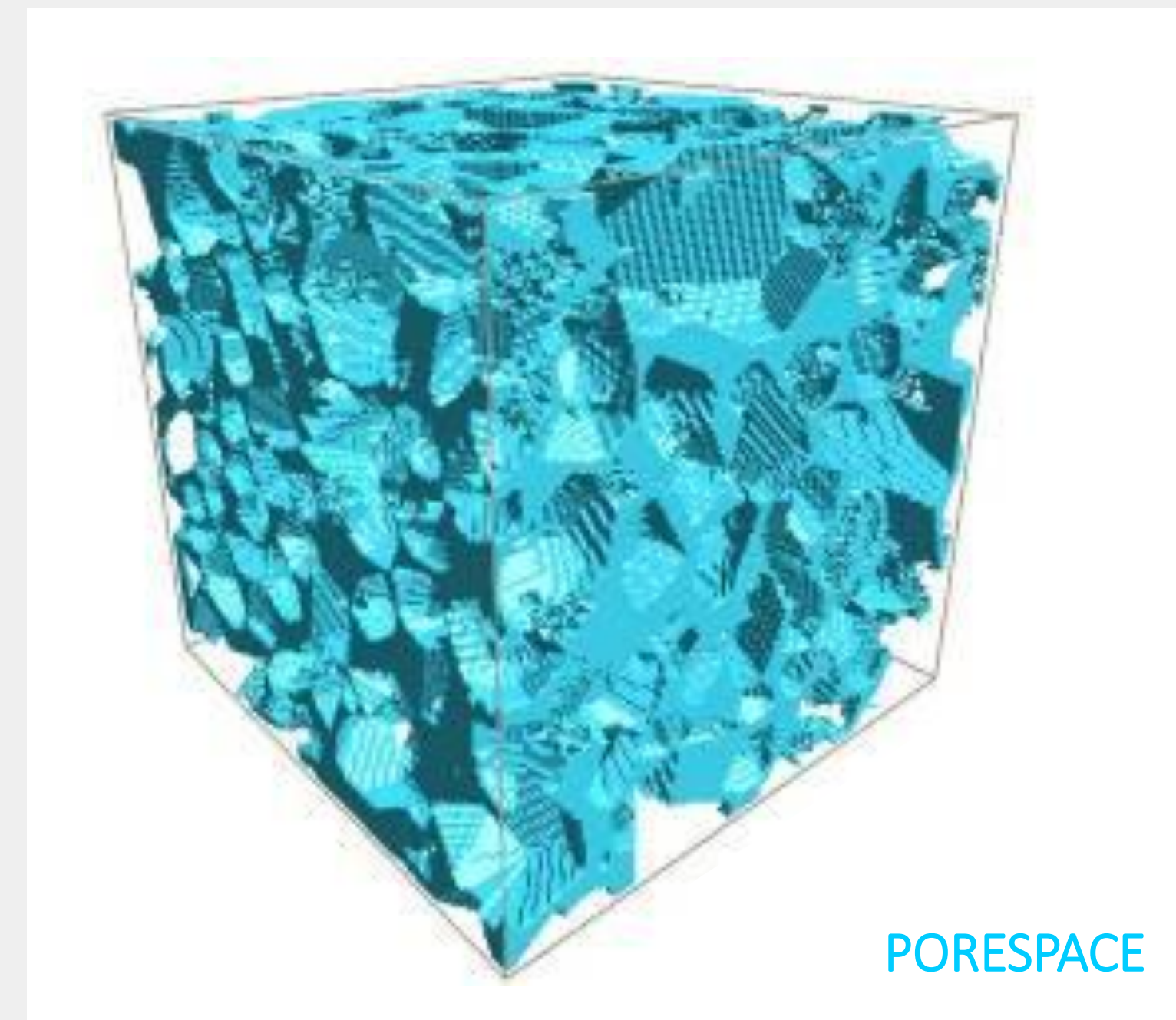
cathrine@bellona.no

A large, light grey abstract shape is located in the bottom right corner of the slide, partially overlapping the bottom edge of the contact information.

μ CT image of a sandstone



Size = 1 mm x 1 mm x 1 mm



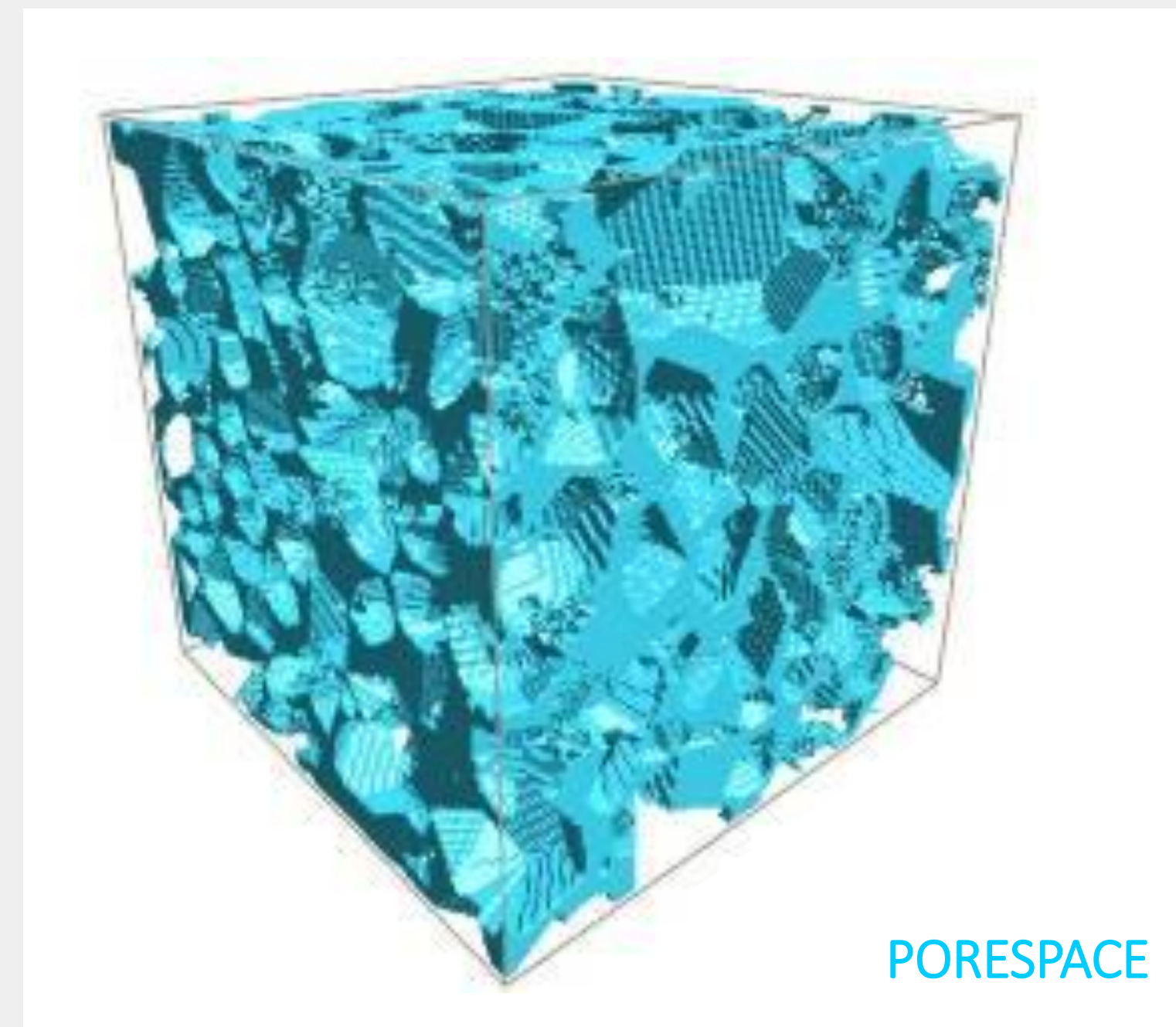
Main rock properties

Porosity

- Provides storage volume

Permeability

- Enables injection



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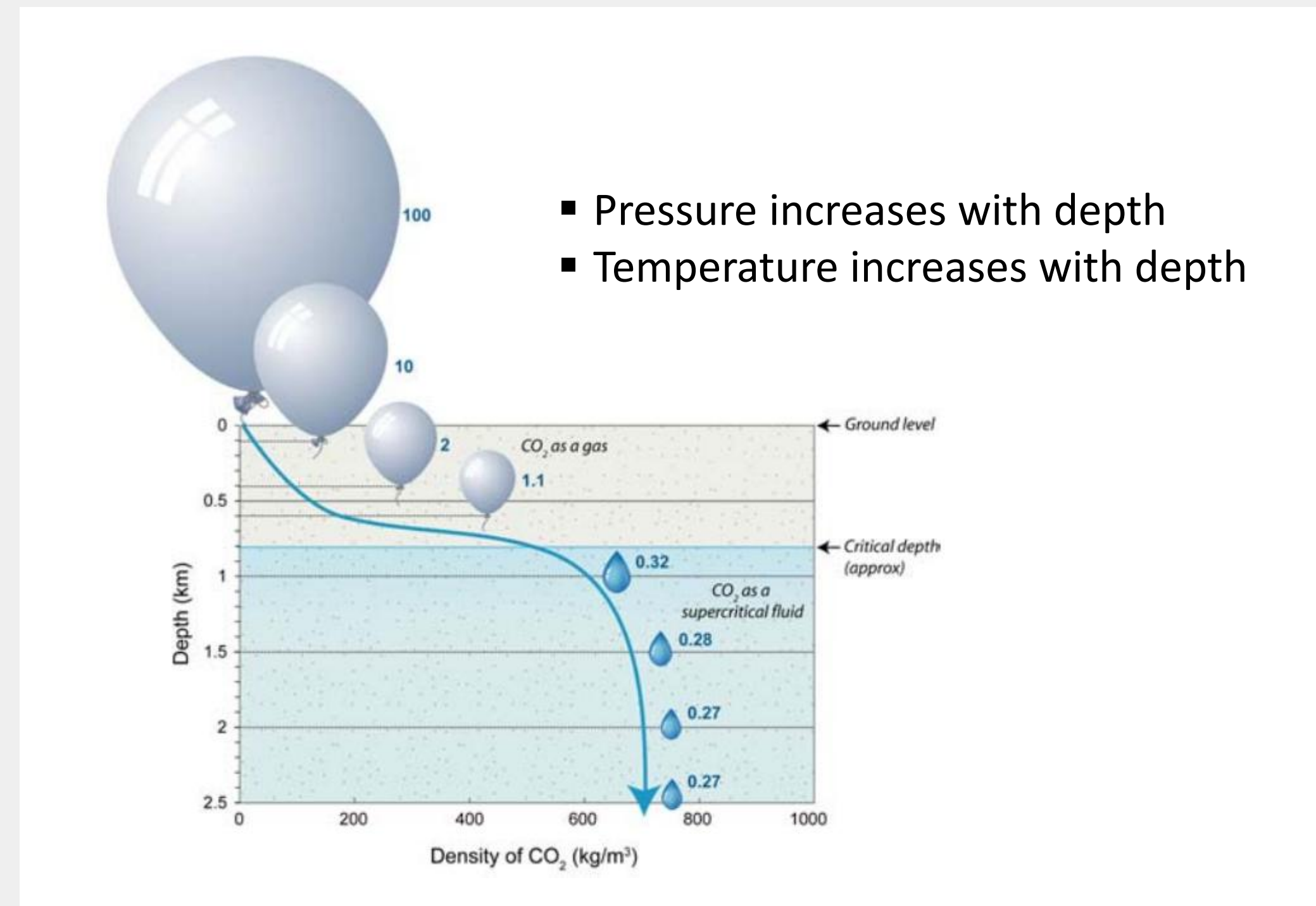
Permeability

- Enables injection

Subsurface conditions

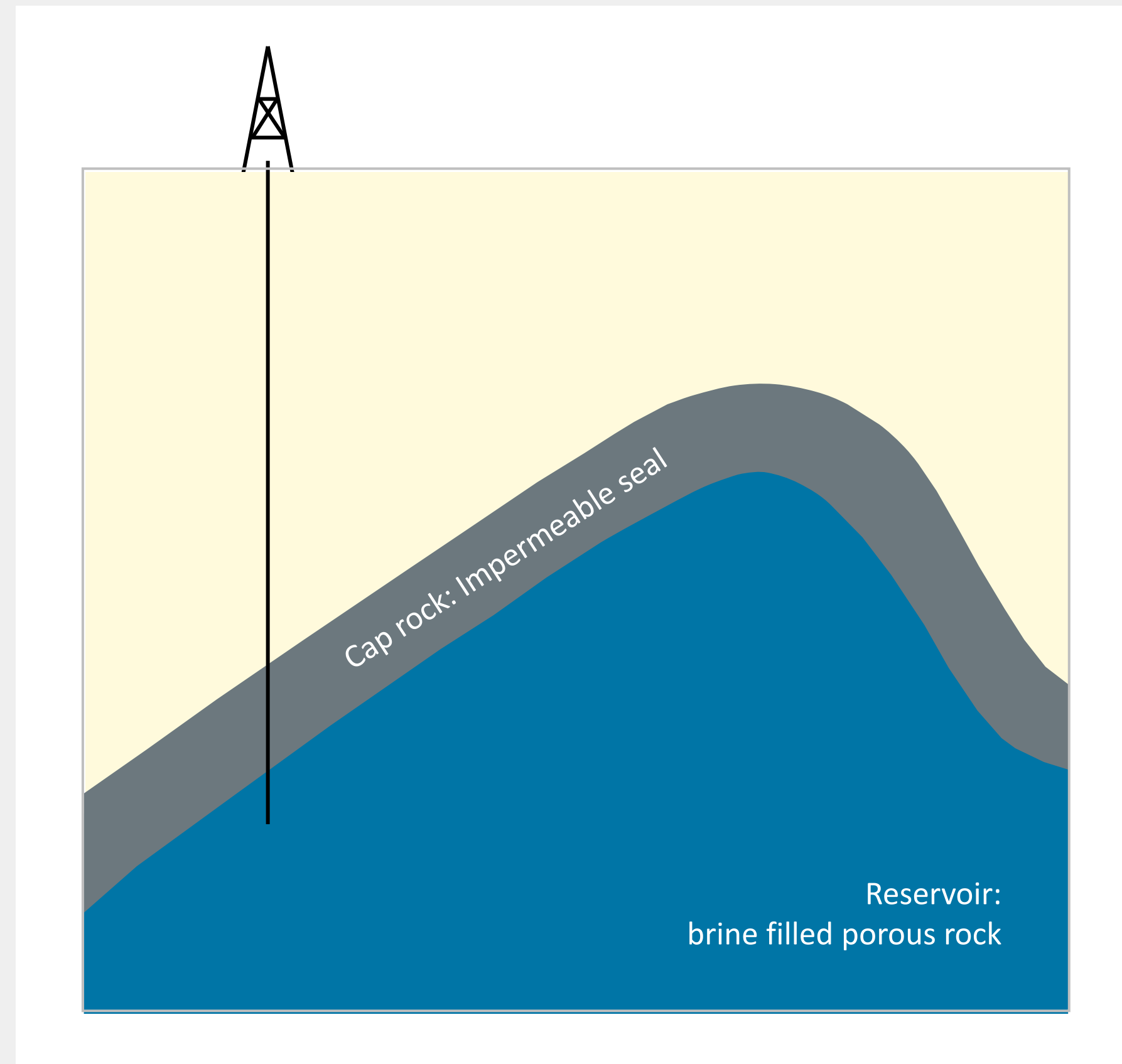
Pressure and temperature

- CO₂ in dense phase



The density of CO₂ is lower than the density of water

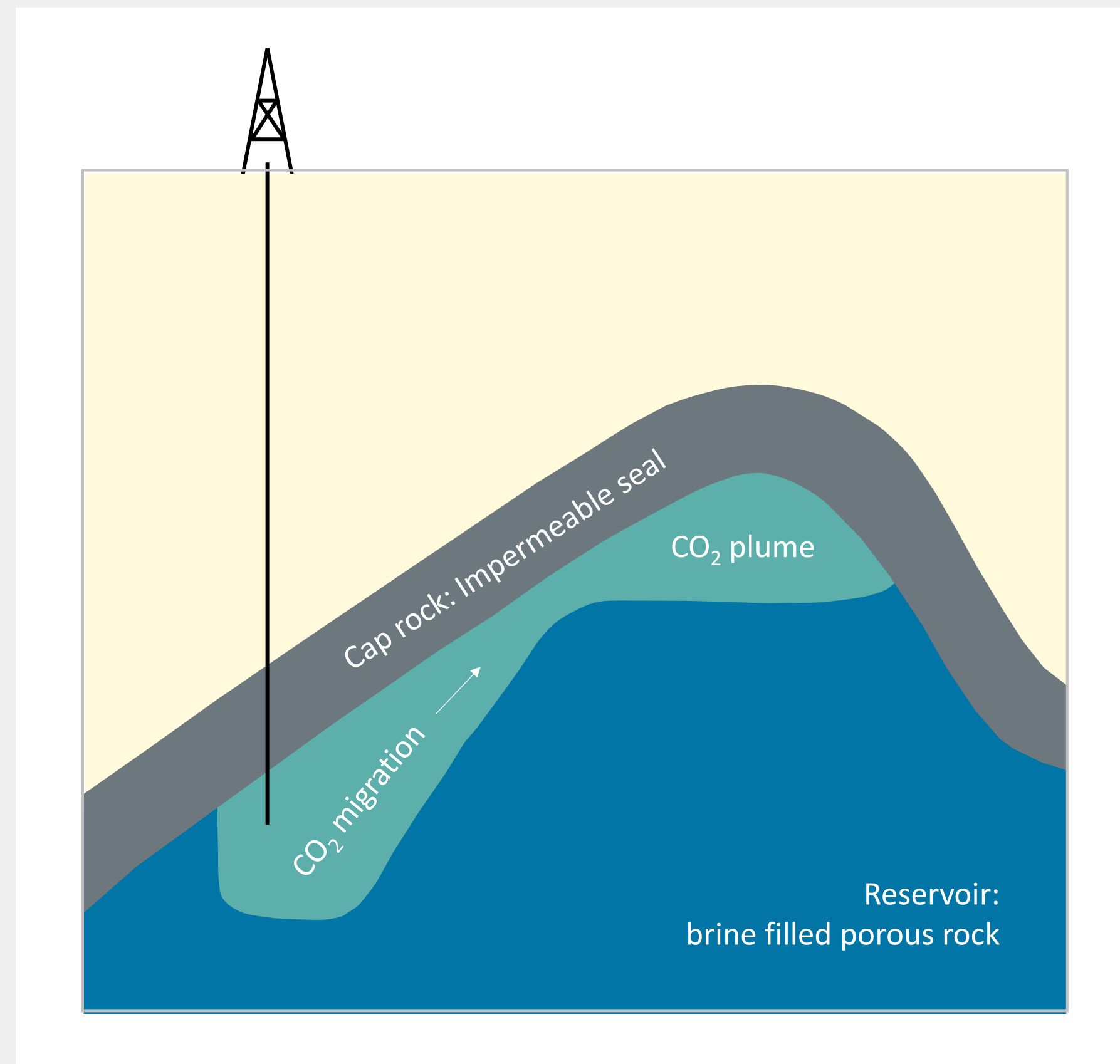
Trapping mechanisms



After Khandoozi et al. (2023)

Trapping mechanisms

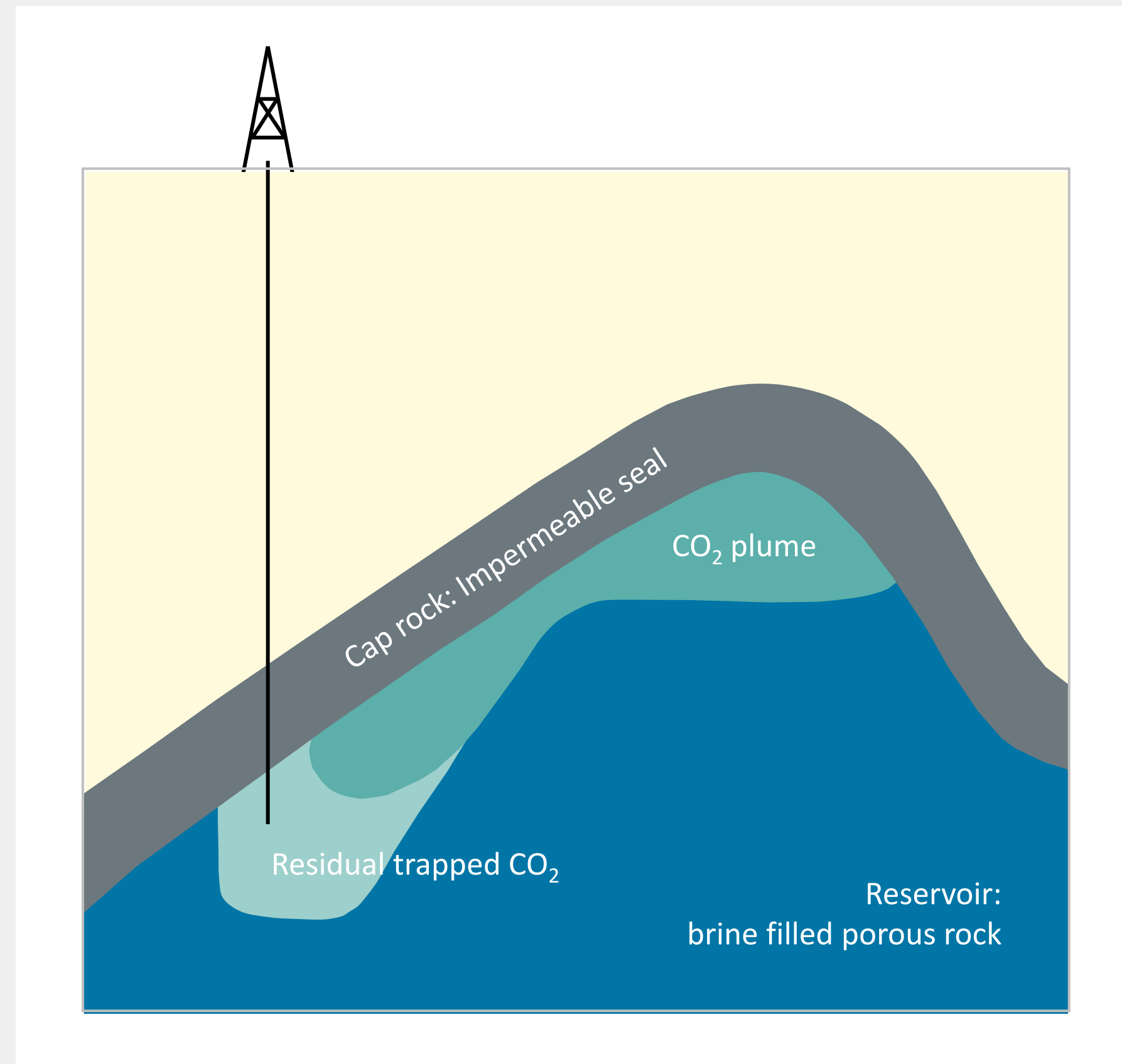
1) Structural or stratigraphic



After Khandoozi et al. (2023)

Trapping mechanisms

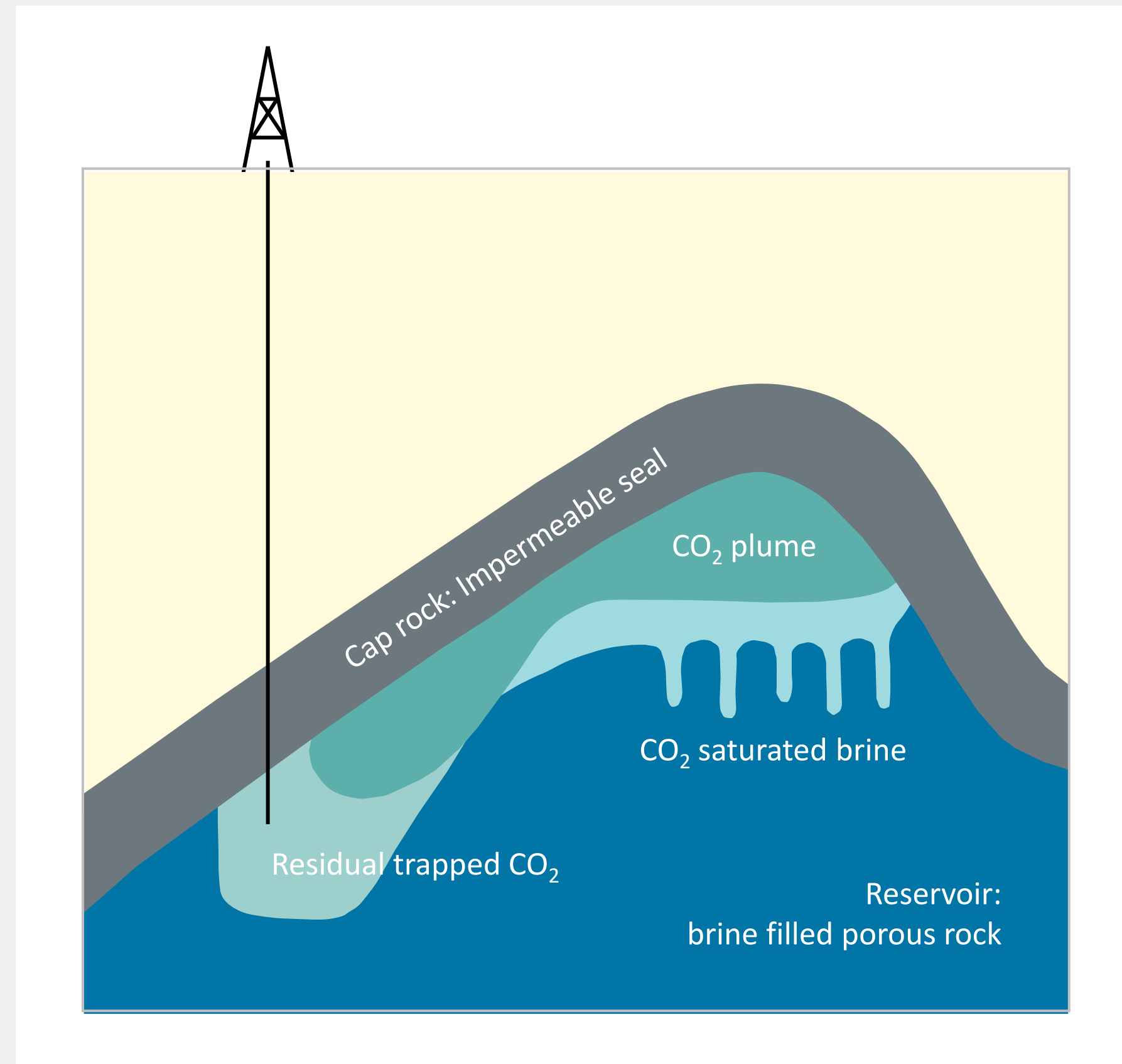
- 1) Structural or stratigraphic
- 2) Residual (capillary)



After Khandoozi et al. (2023)

Trapping mechanisms

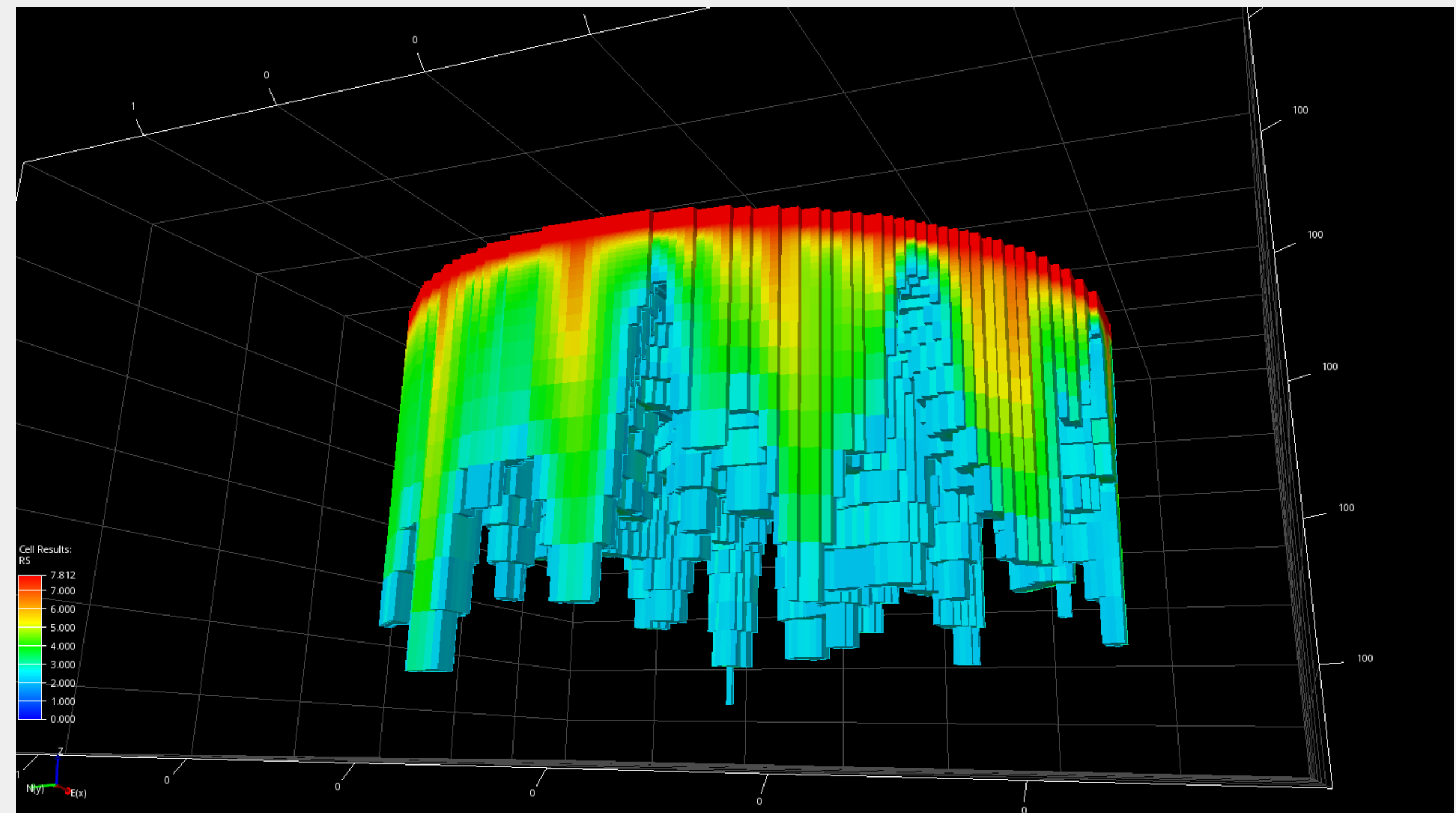
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- 3) Solubility (dissolution)



After Khandoozi et al. (2023)

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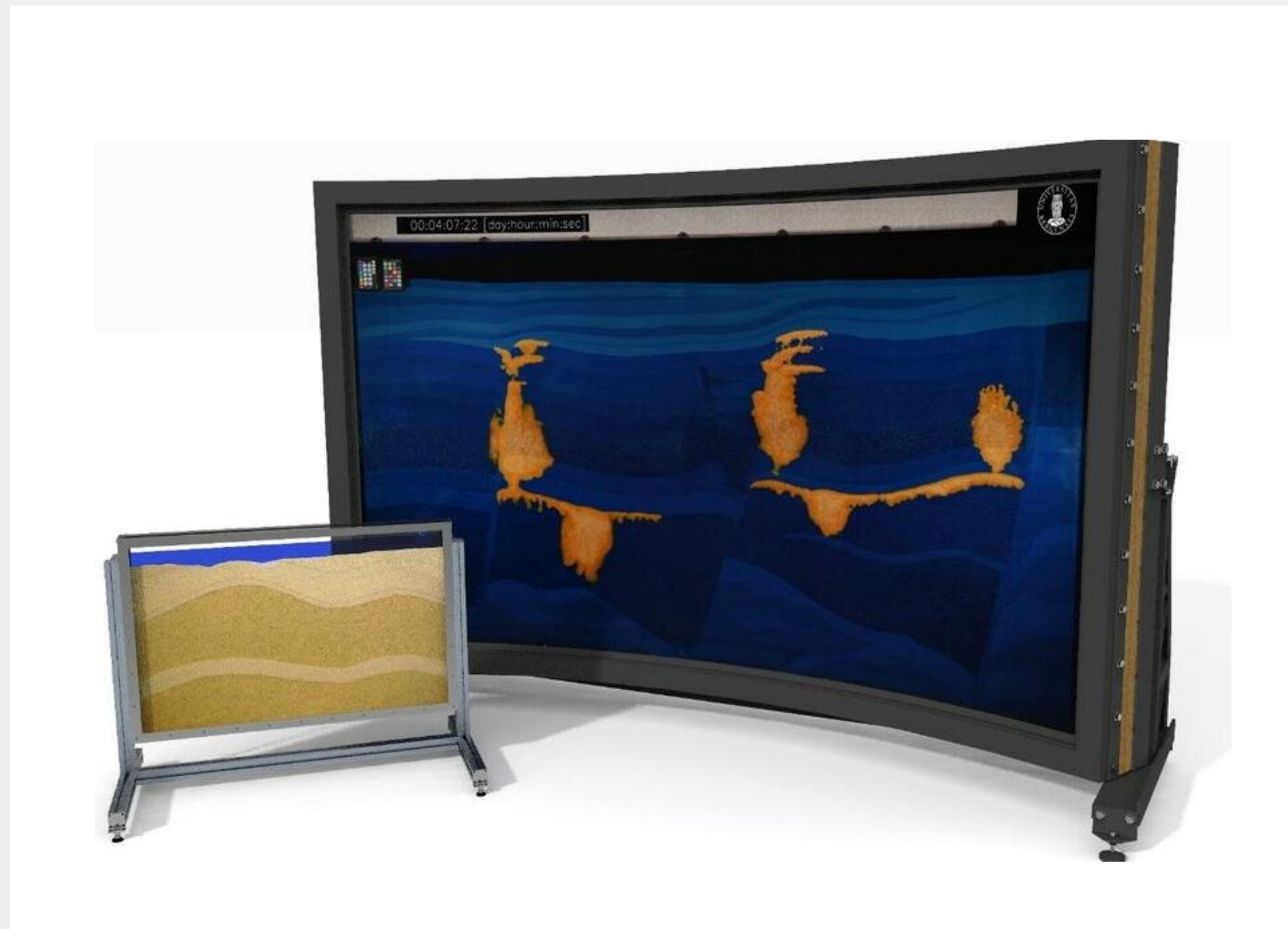
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Trapping mechanisms

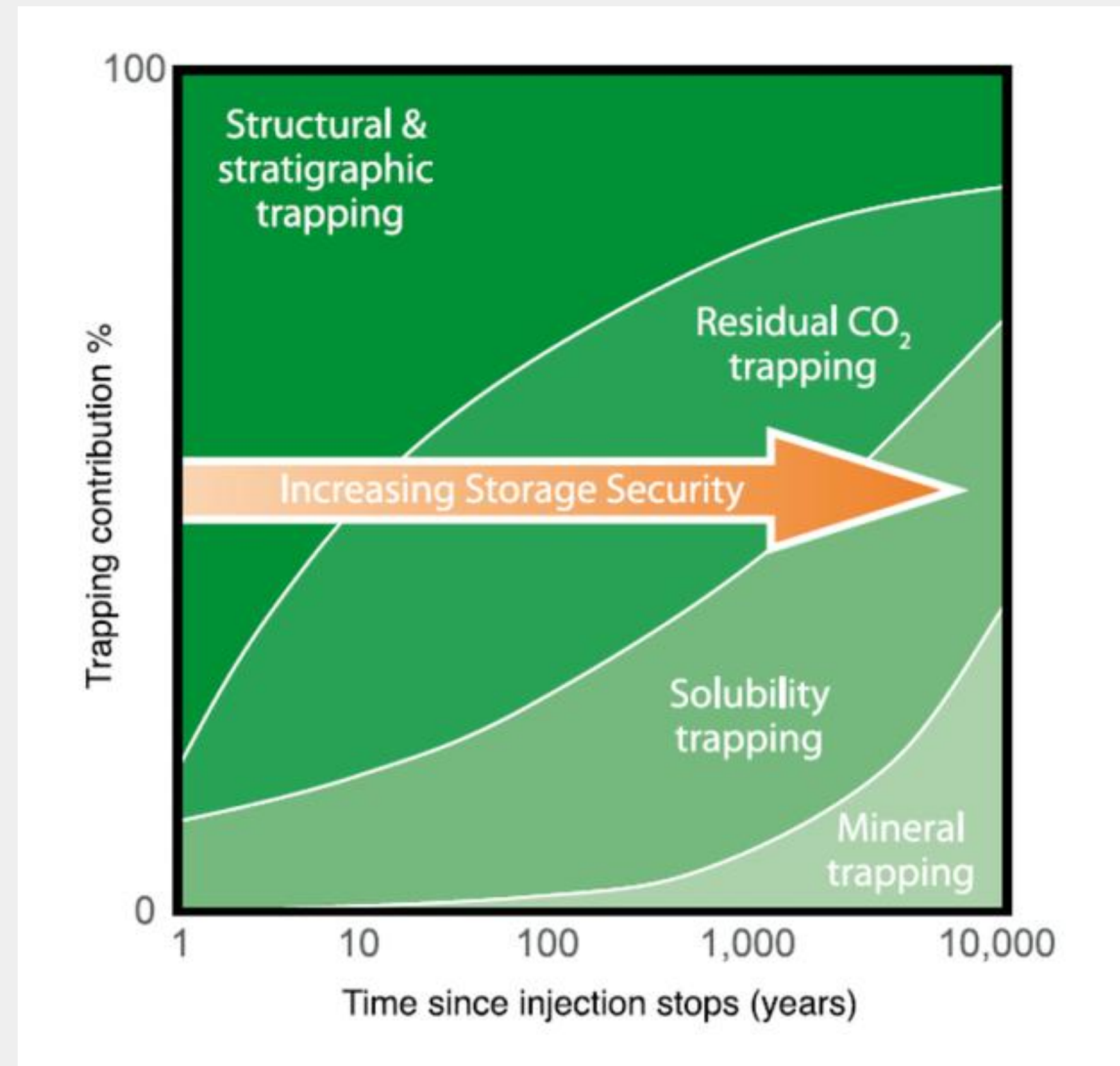
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The University of Bergen [FluidFlower concept for CCS](#)



Trapping mechanisms

- 1) Structural or stratigraphic
- 2) Residual (capillary)
- 3) Solubility (dissolution)
- 4) Mineralisation

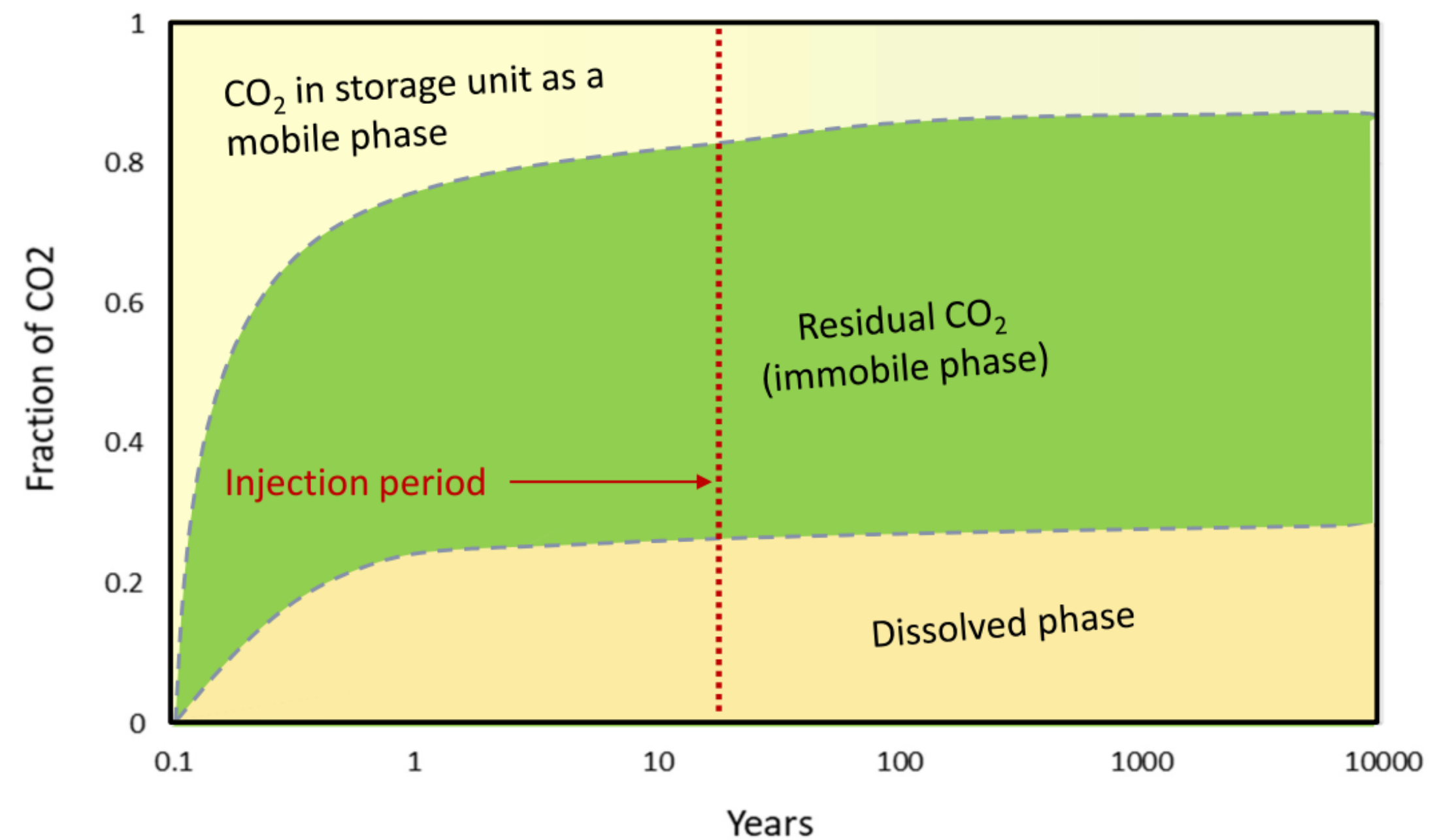


Hermanrud et al. (2009)

Trapping mechanisms

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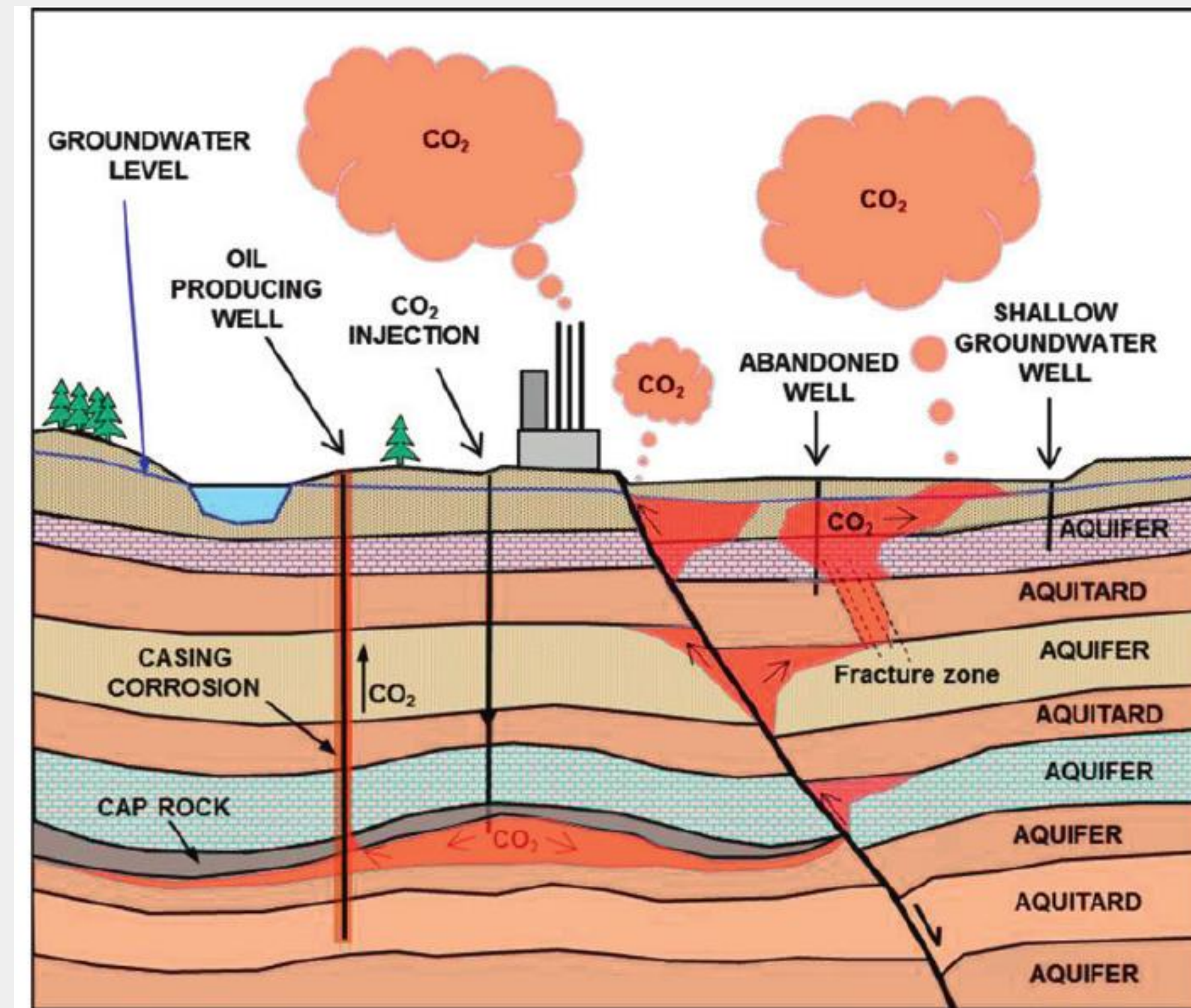
Storage trapping diagram for the Northern Lights project (Phase 1)



How safe is CO₂ storage?

Main leakage risks

- Fracturing of cap rock
- Leakage through faults
- Leakage through wells

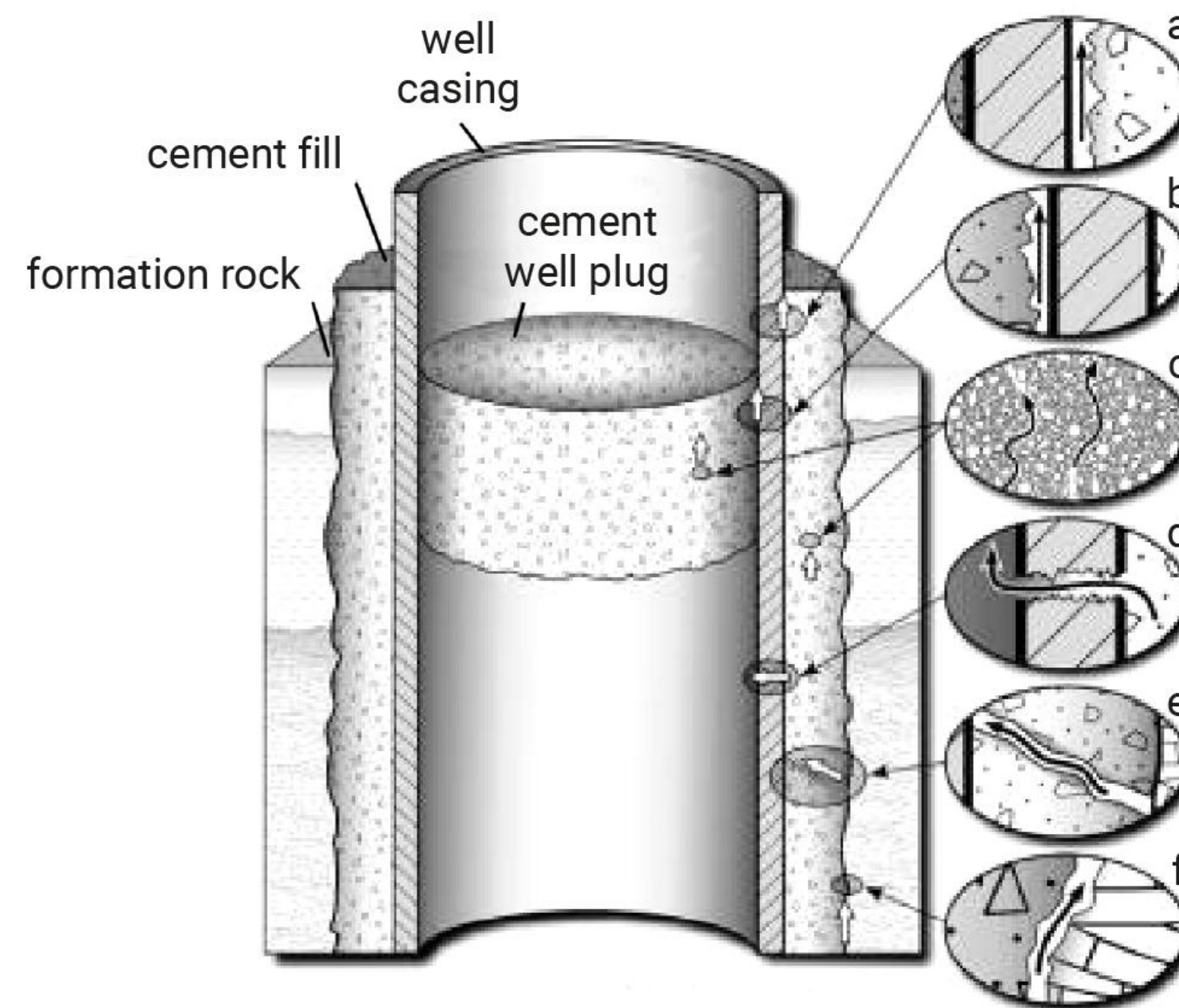


Brydie and Perkins (2014)

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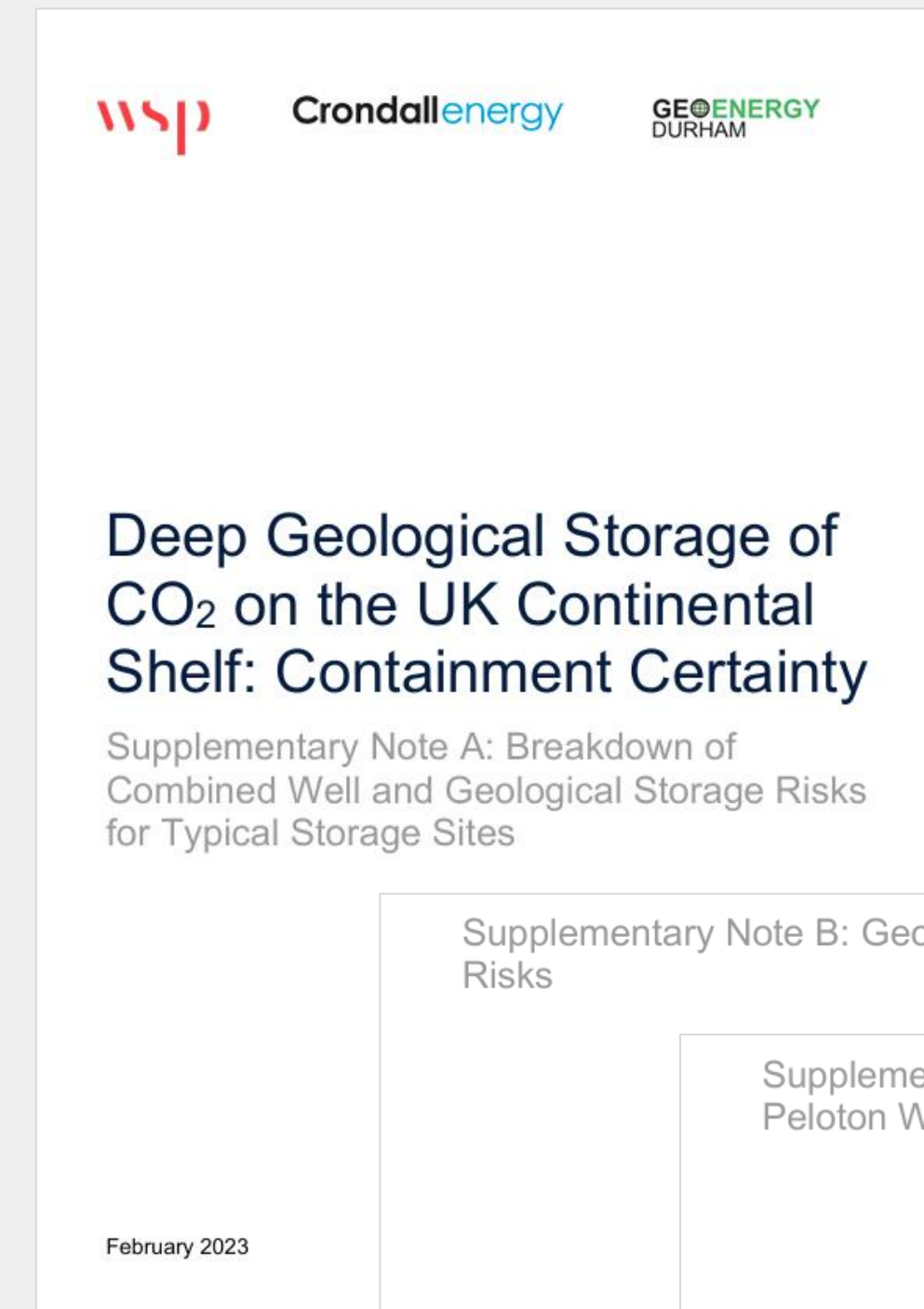
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GOV.UK



Supplementary Note B: Geological Leakage Risks

February 2023

Supplementary Note C: Well Analysis Using Peloton WellMaster Database

February 2023

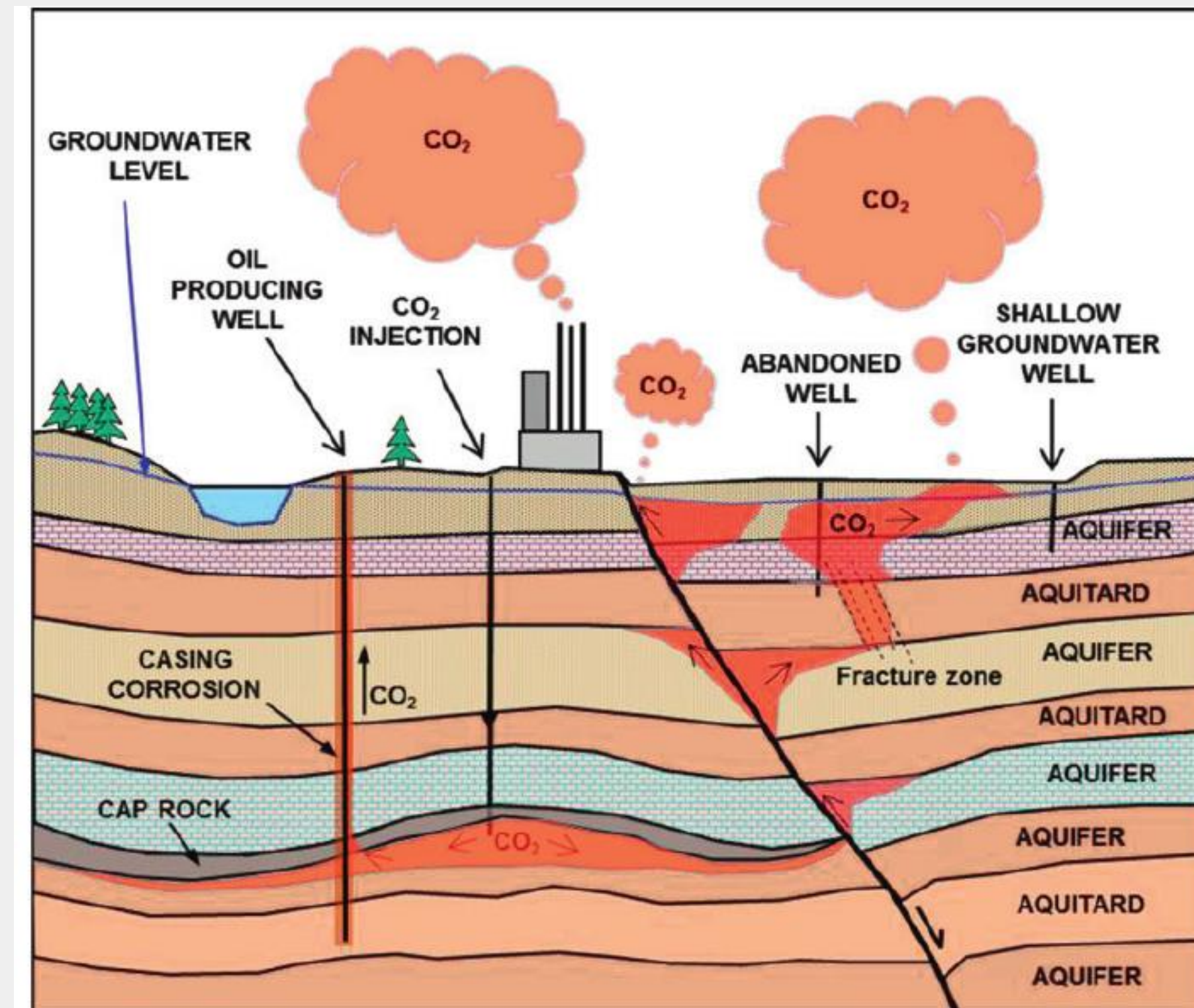
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Environmental risks

- Contamination of ground water
- Seismicity

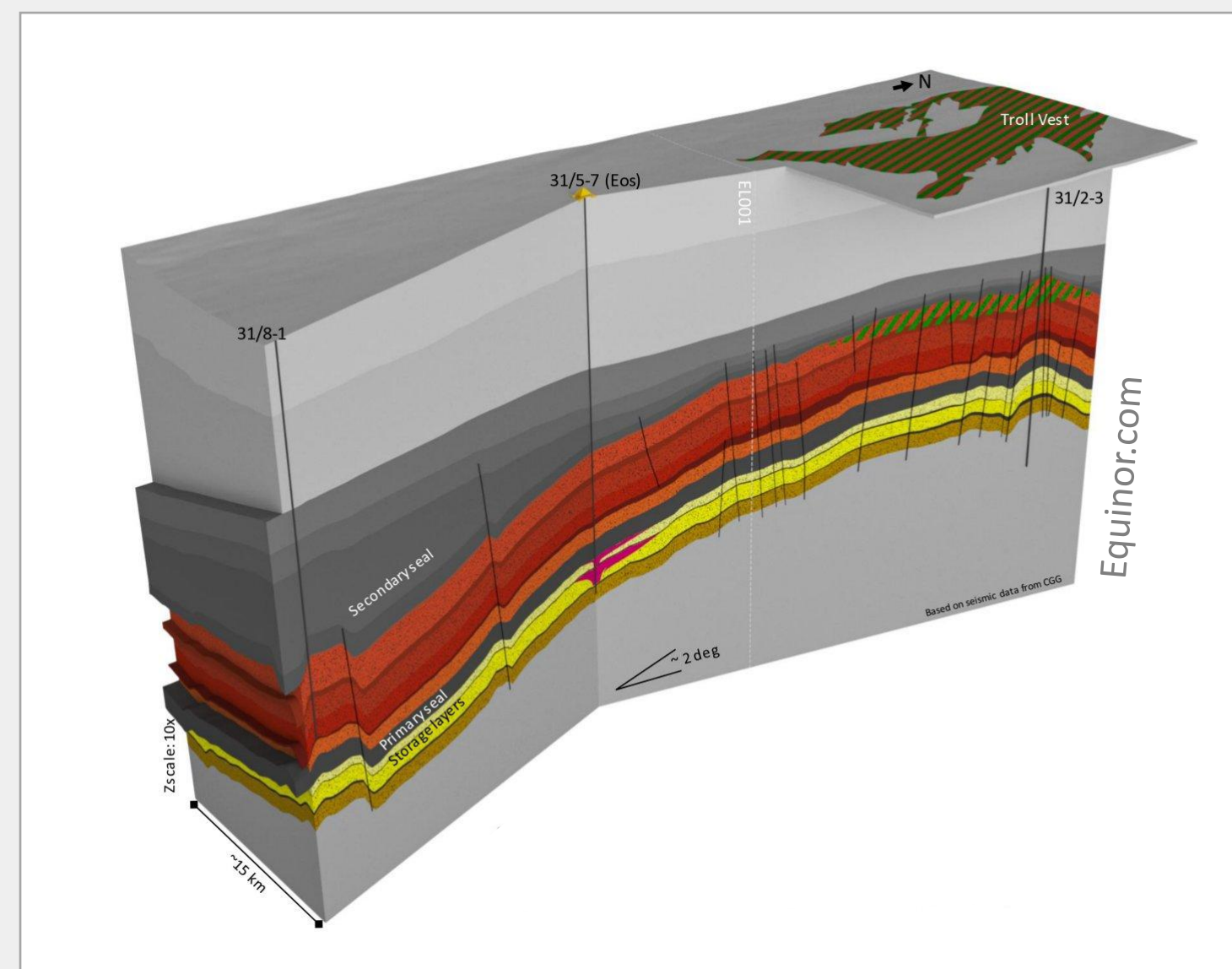
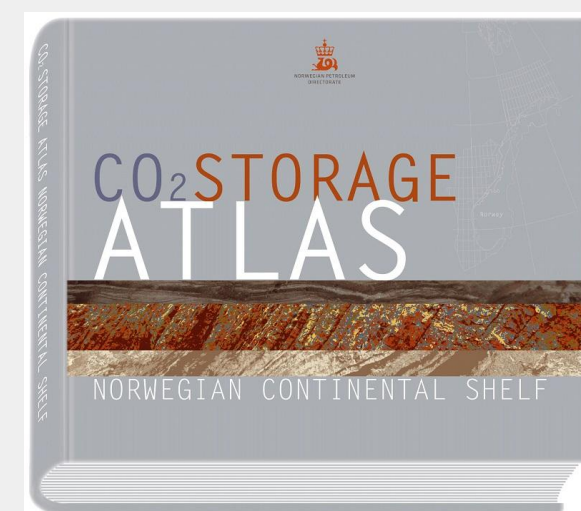
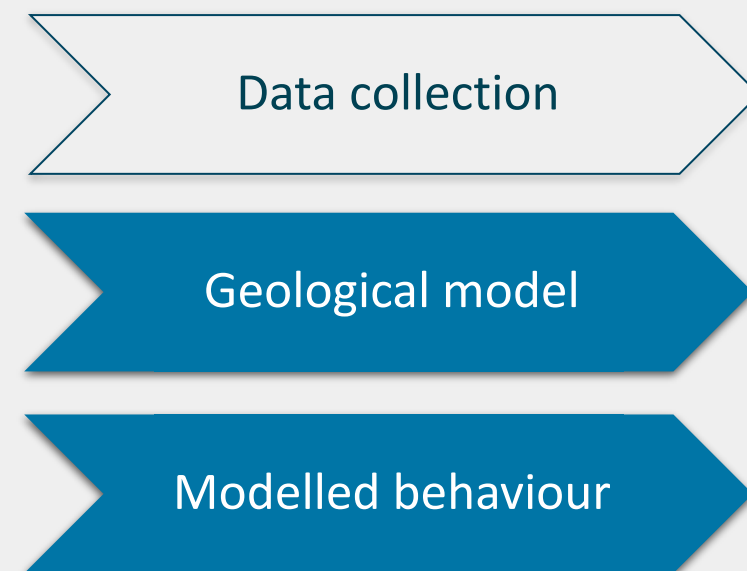


Brydie and Perkins (2014)

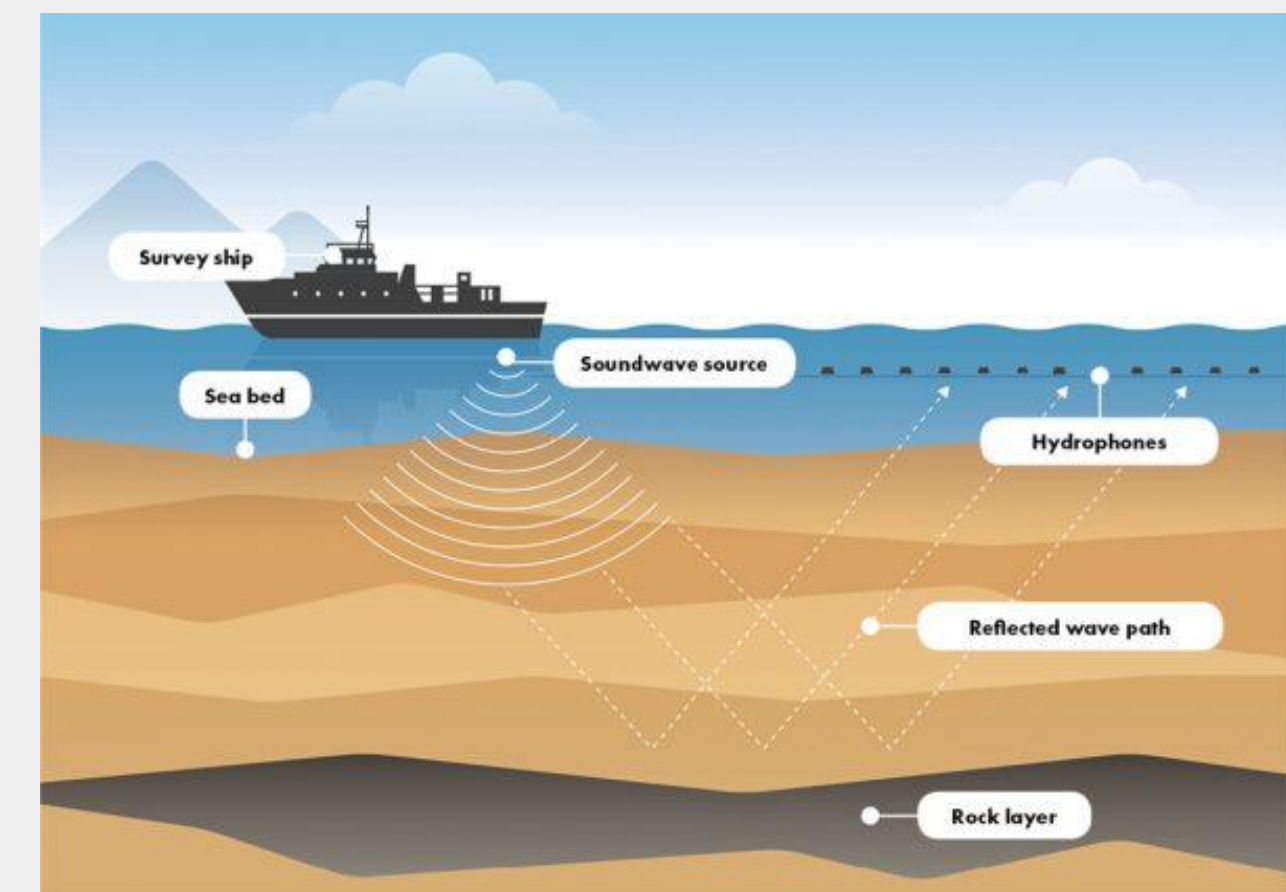
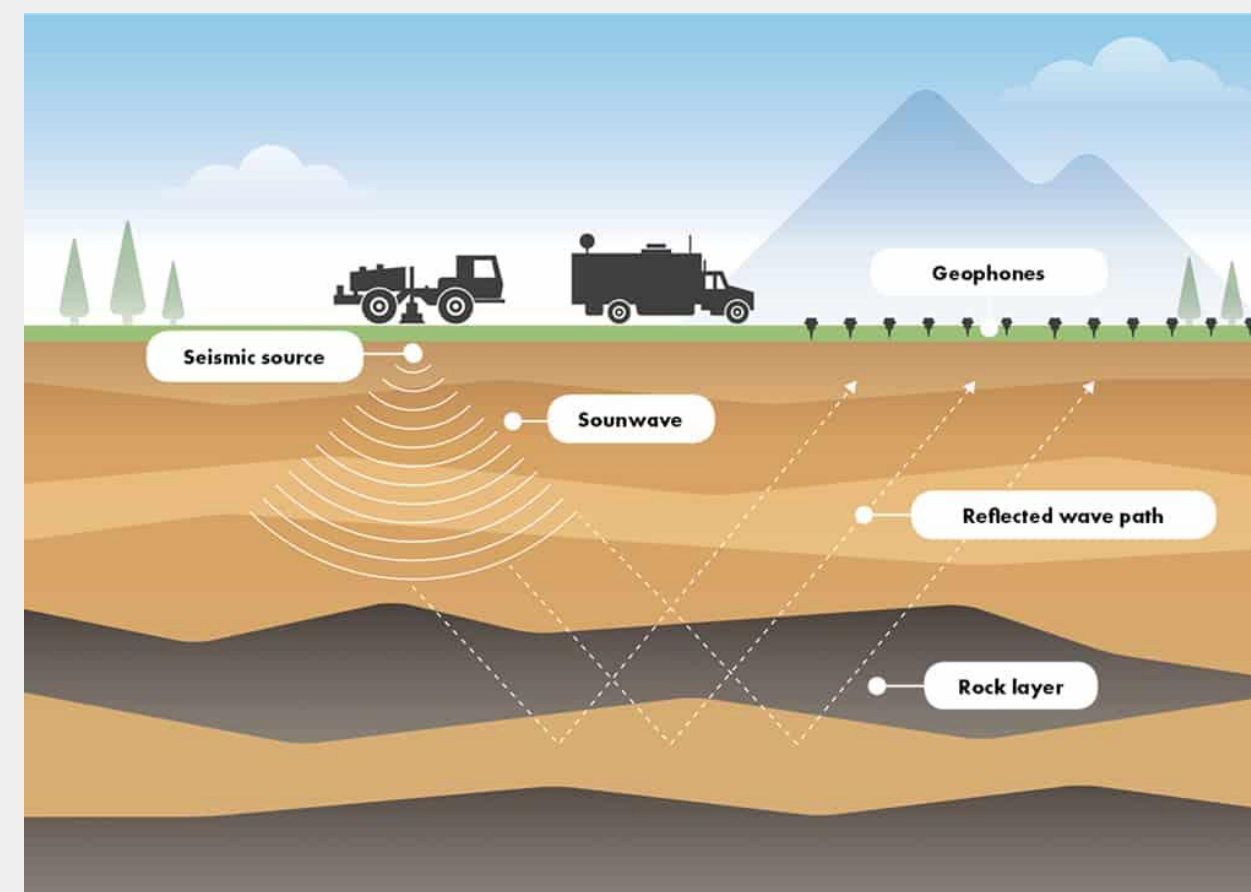
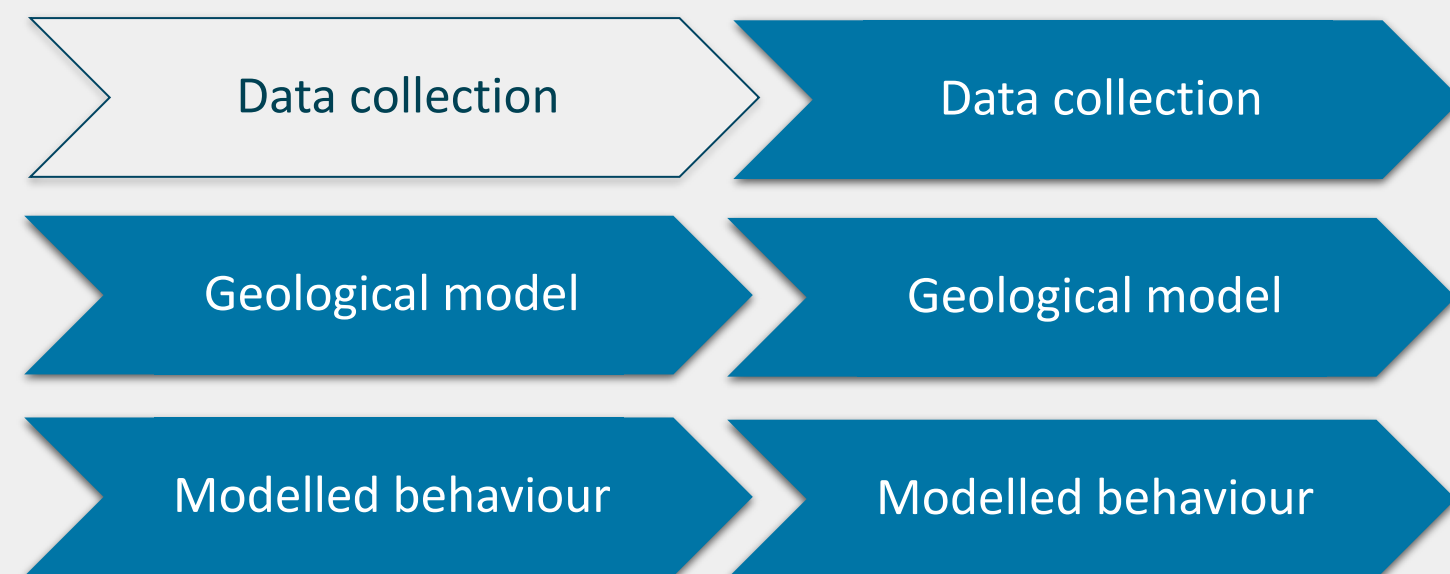
Life cycle of a geological CO₂ storage project



Life cycle of a geological CO₂ storage project

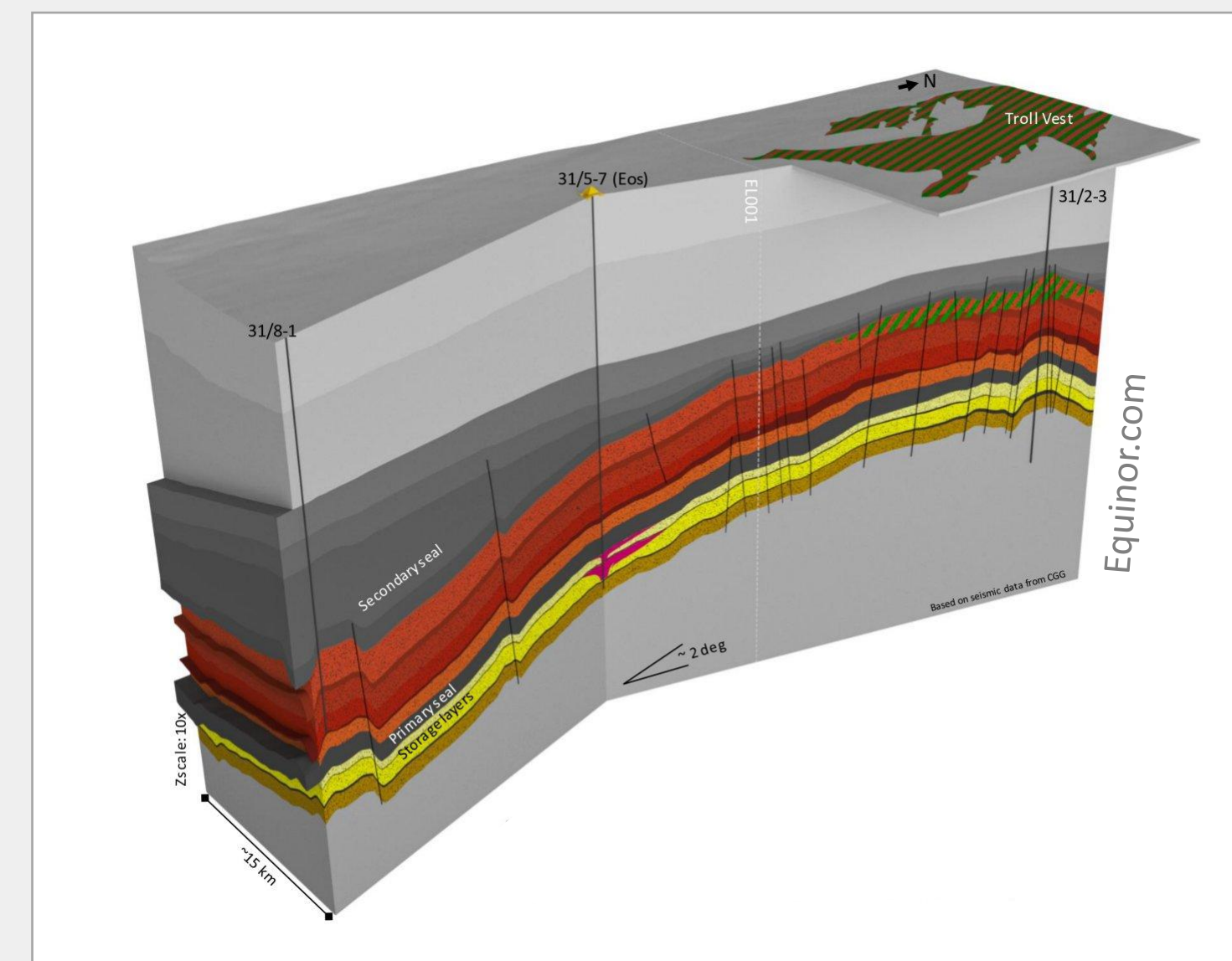
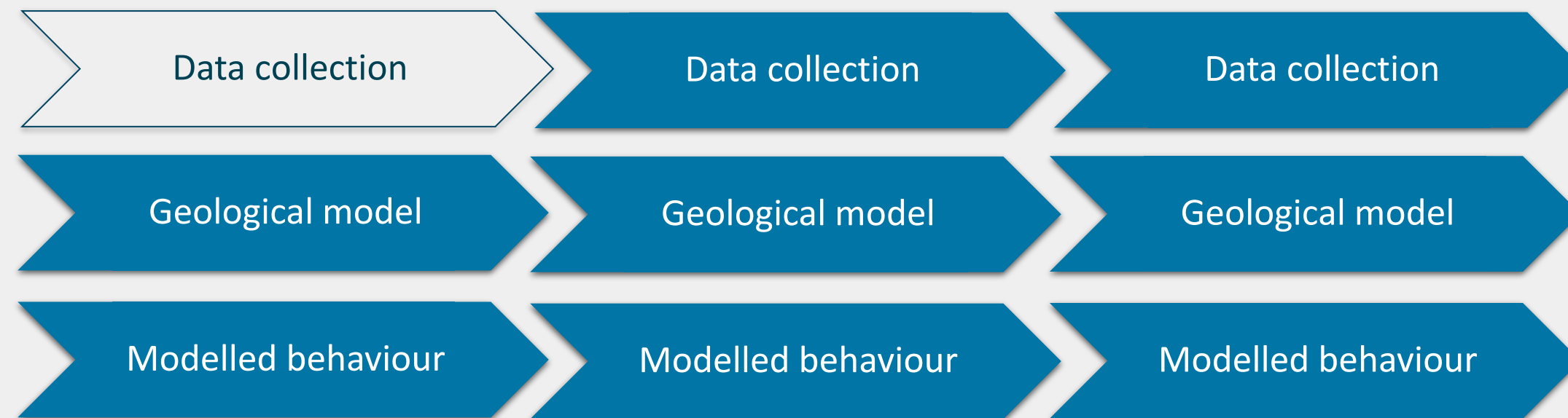


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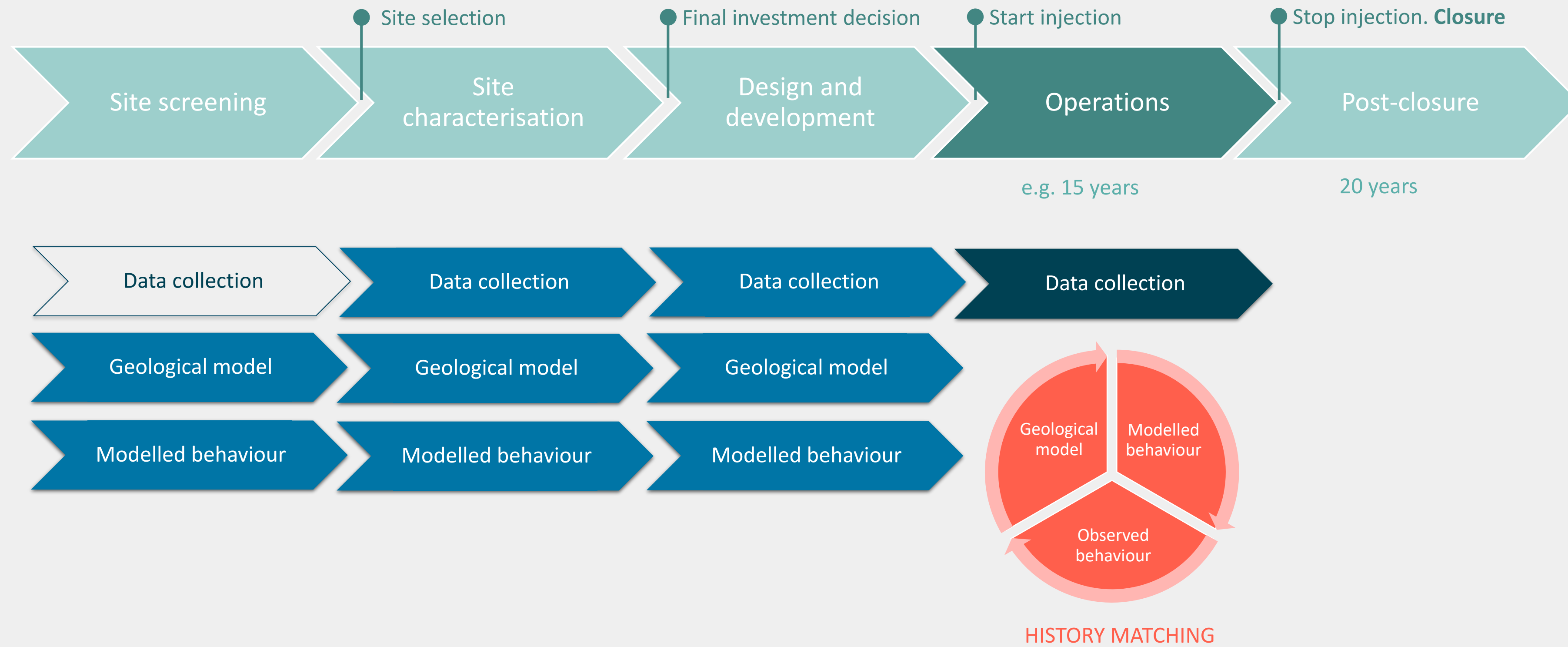


<https://energyinformationaustralia.com.au/>

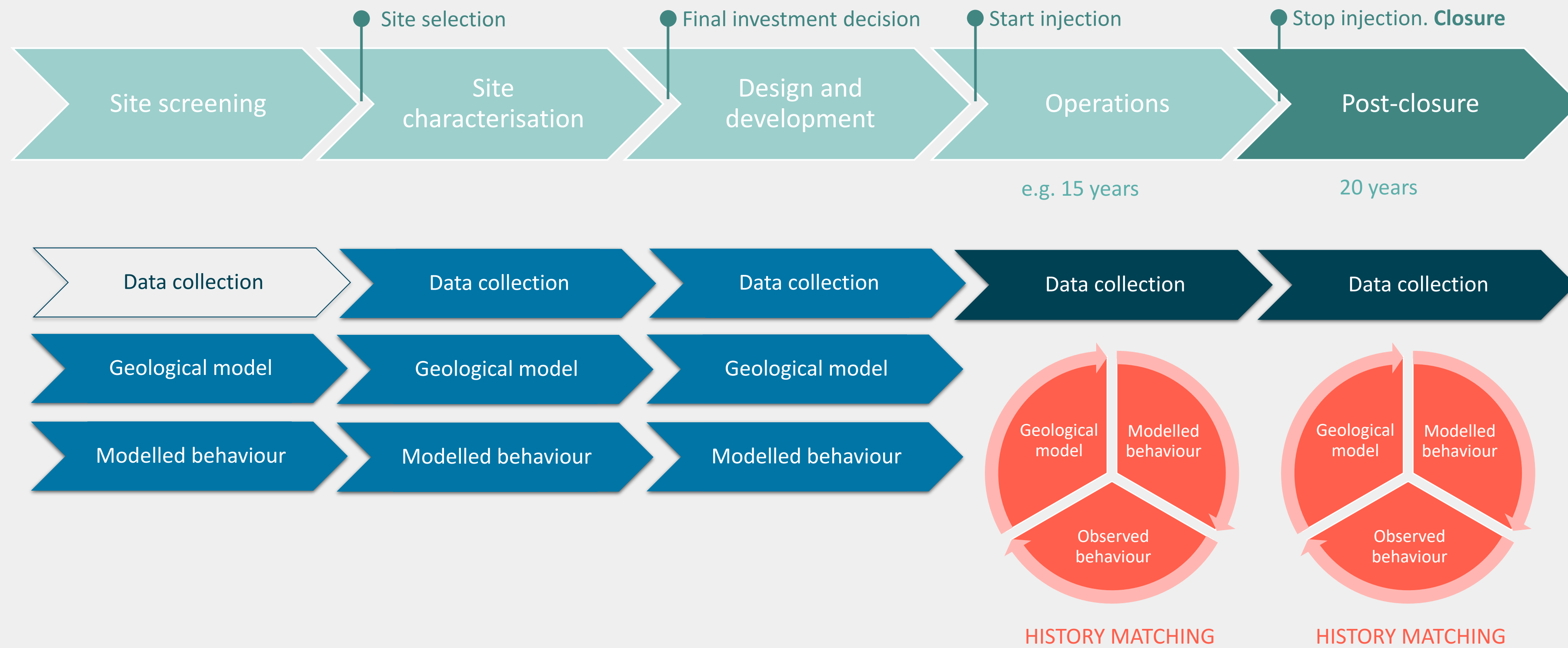
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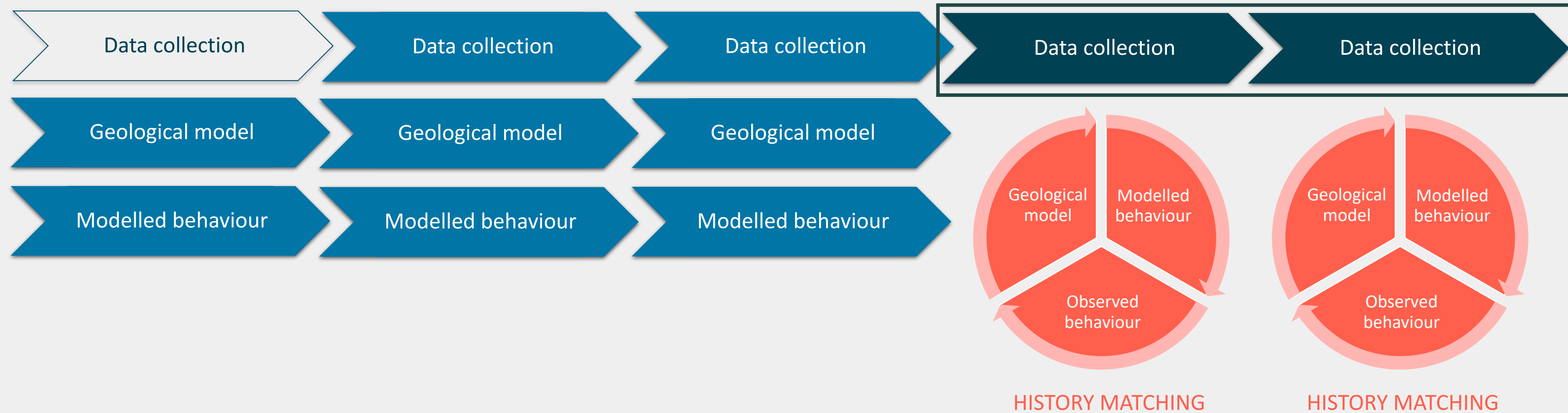
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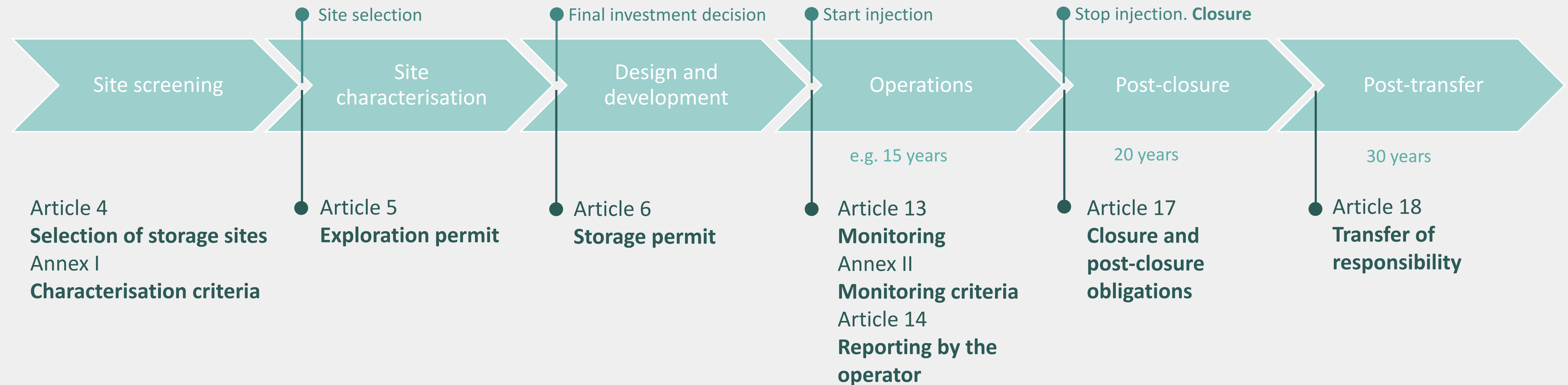


Life cycle of a geological CO₂ storage project

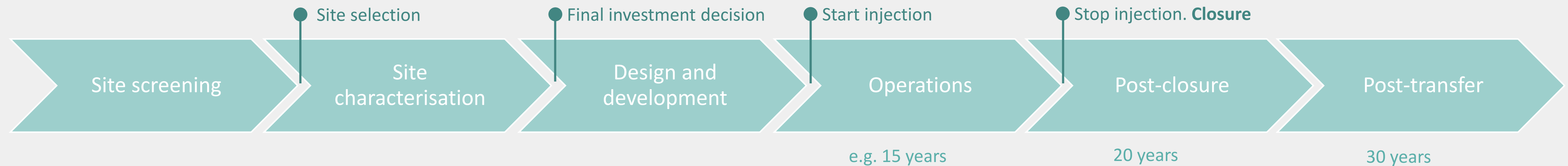


MONITORING
Conformance
 Agreement between simulations and observed behaviour
Containment
 Show that the CO₂ is securely stored

Life cycle of a geological CO₂ storage project **CCS directive** [DIRECTIVE 2009/31/EC](#)



Life cycle of a geological CO₂ storage project **CCS directive** [DIRECTIVE 2009/31/EC](#)



Environmental Impact Assessment Directive [DIRECTIVE 2011/92/EU](#)

Environmental Liability Directive [DIRECTIVE 2004/35/EC](#)

Water framework Directive [DIRECTIVE 2000/60/EC](#)

Groundwater Directive [DIRECTIVE 2006/118/EC](#)

ETS Directive [DIRECTIVE 2003/87/EU](#)

Monitoring and reporting of GHG emissions [REGULATION \(EU\) 2018/2066](#)

The diagram illustrates the process of CO2 capture, transport, and storage. It is divided into four main stages:

- LONGSHIP CO₂ capture:** Capture from industrial plants. Liquefaction and temporary storage.
- Transport:** Liquid CO₂ transported by ship.
- Receiving terminal:** Intermediate onshore storage. Pipeline transport to offshore storage location.
- Permanent storage:** CO₂ is injected into a saline aquifer.

The diagram shows a cross-section of the ocean and subsurface. A ship is shown transporting liquid CO₂ to a receiving terminal on the shore. A pipeline then transports the CO₂ to an offshore storage location, where it is injected into a saline aquifer at a depth of 2,600 meters. The distance from the receiving terminal to the storage location is 100 km.

Source from Northern Lights

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Approved by: Harald Anvik

Sign: _____

Managing expectations

Photo by Heidelberg Materials



Photo by Sweco

Conclusions

Europe has established a strict and comprehensive regulation framework for geological storage

→ **geological carbon storage is safe**

CCS will contribute to substantial emission cuts if deployed at scale, even though not perfect

Managing expectations through open and honest knowledge sharing

Yara's plant in Sluiskil, the Netherlands



Image: Yara