# Emerging geophysical monitoring technologies for safe and cost-efficient $CO_2$ storage

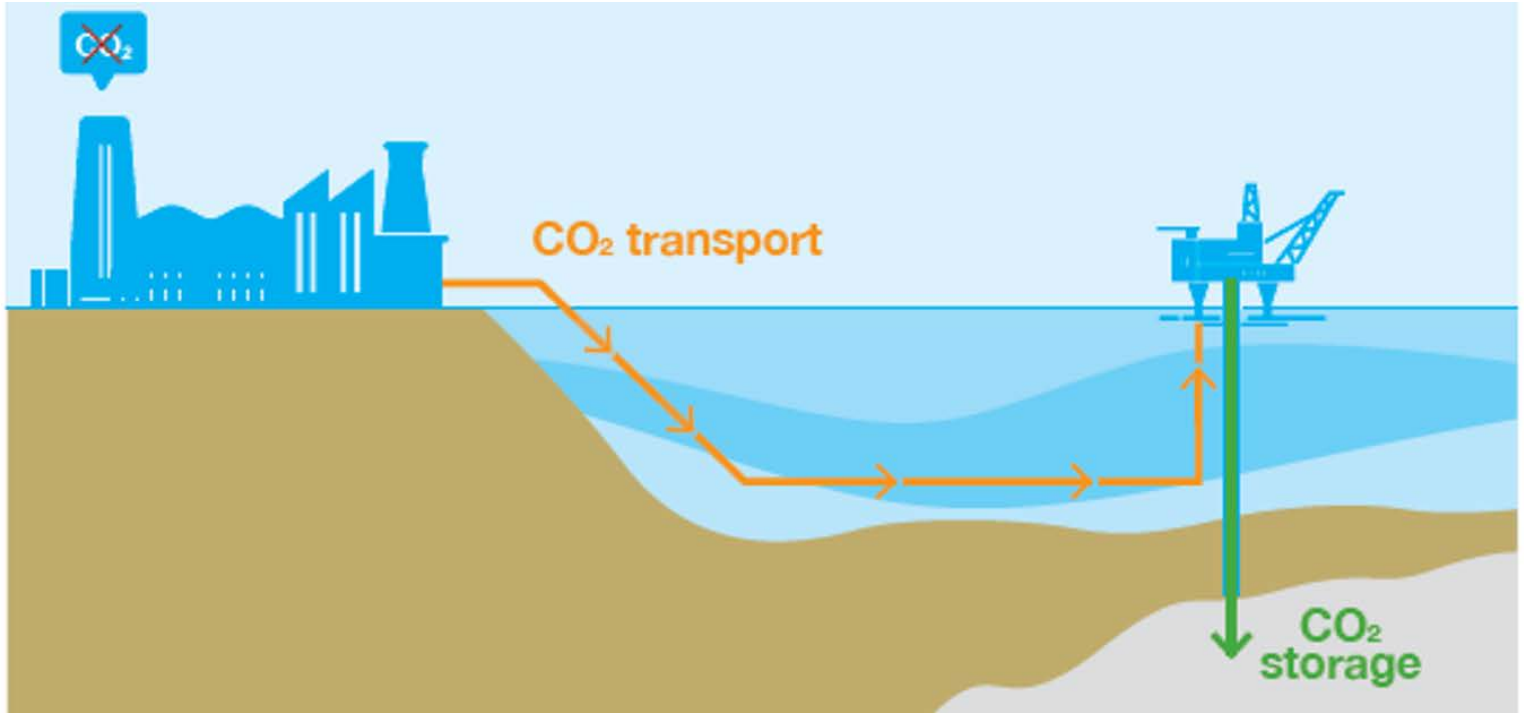
Cathrine Ringstad, SINTEF

18 May 2022

Courtesy PGS

# *Safe and cost efficient $CO_2$ storage*
## *Emerging geophysical monitoring technologies*

$CO_2$ CAPTURE → UTILISATION → TRANSPORT → STORAGE




Oil and gas authority, UK

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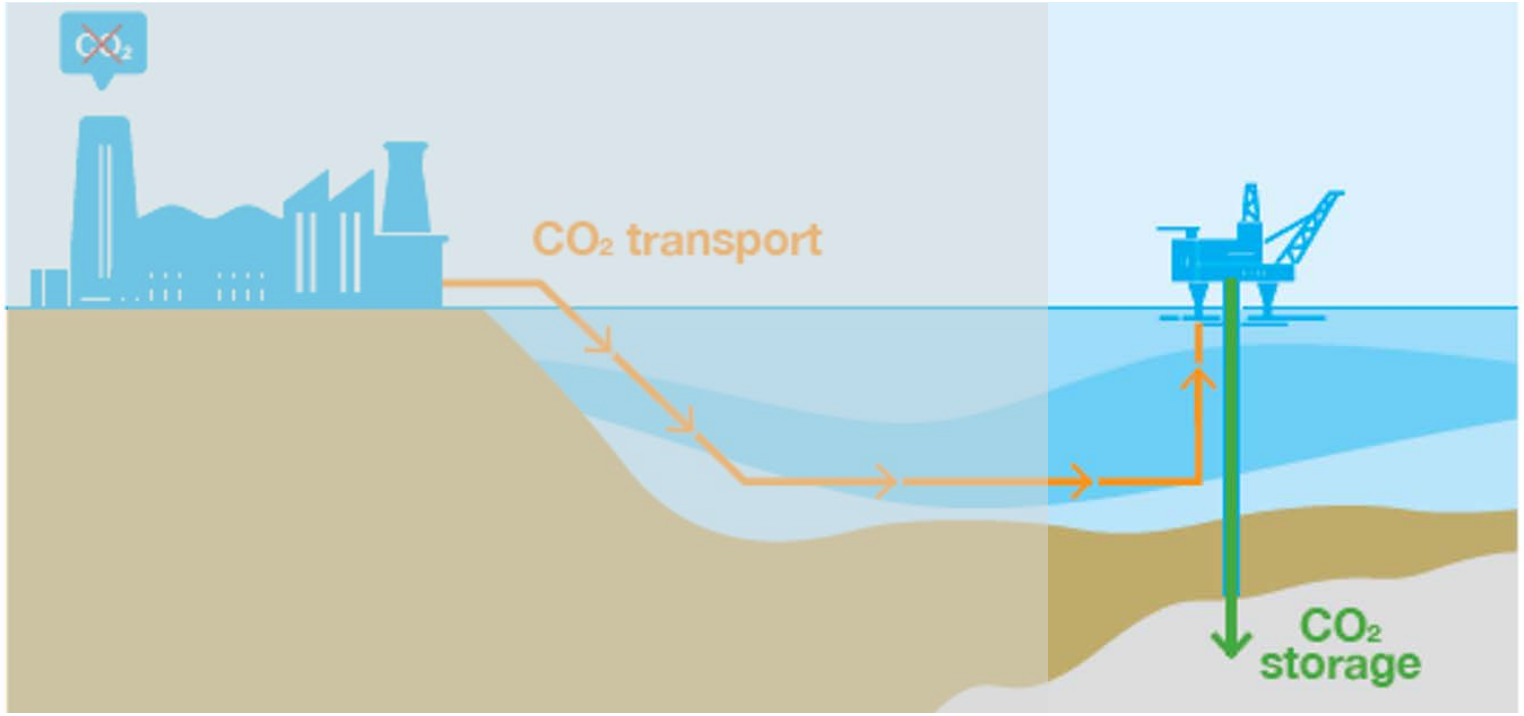


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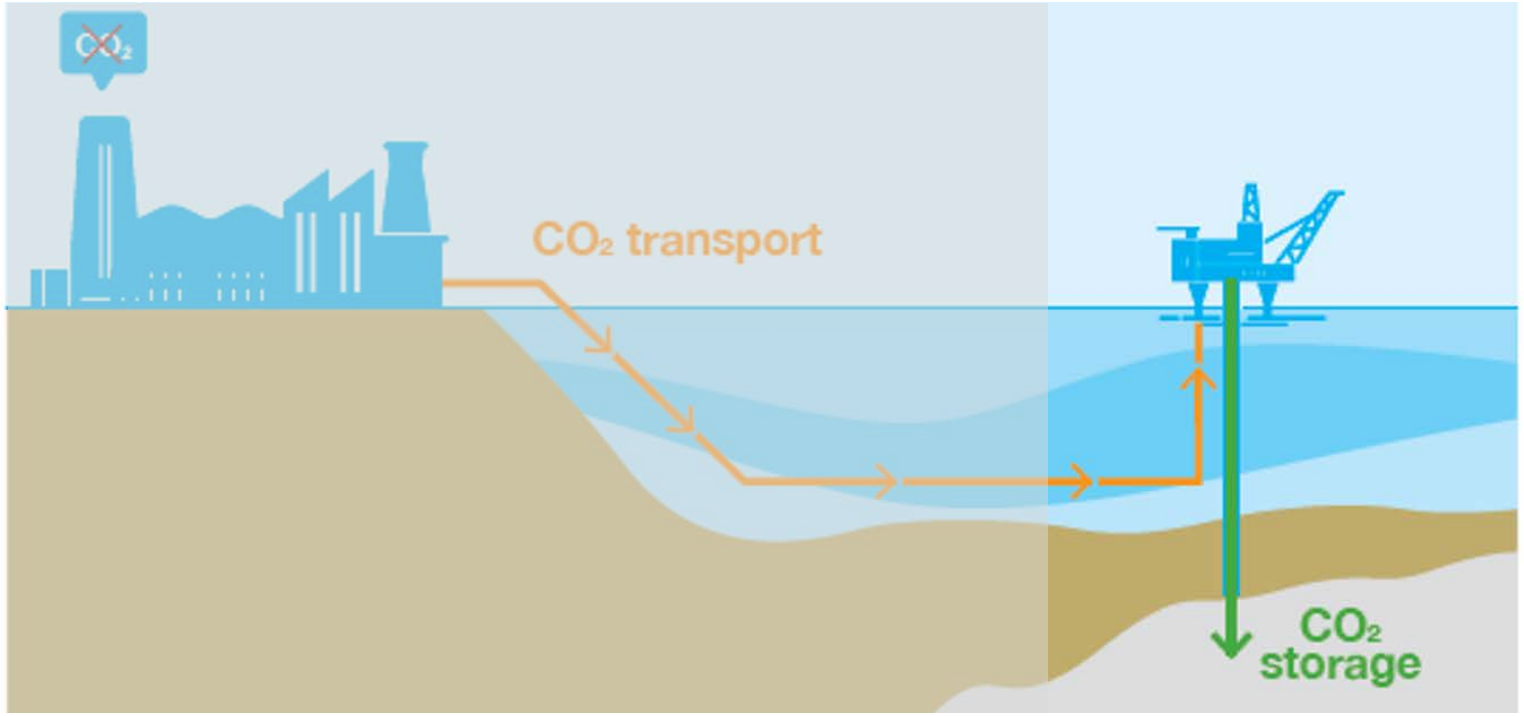



Oil and gas authority, UK

Core samples from the Statfjord field

Norwegian petroleum museum

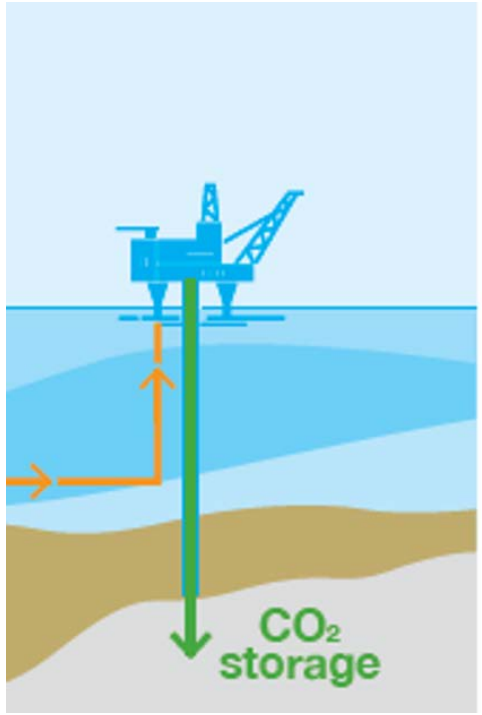
# *Safe and cost efficient $CO_2$ storage*
## *Emerging geophysical monitoring technologies*

GEOLOGICAL STORAGE OPTIONS

- Saline formations
- Depleted oil and natural gas reservoirs
- Coal seams
- Basalt formations

- On-shore
- Off-shore

STORAGE

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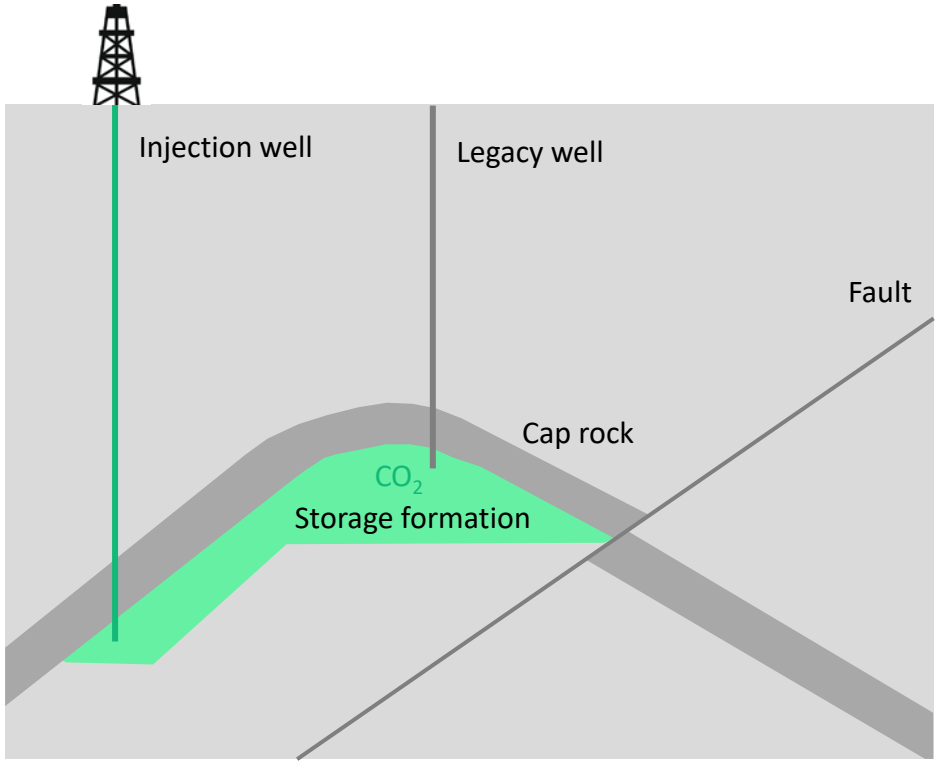

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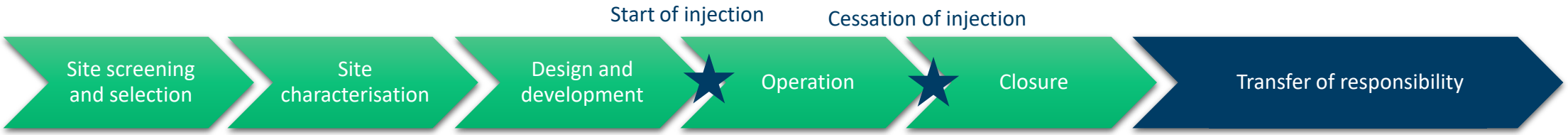
LIFE CYCLE OF A GEOLOGICAL $CO_2$ STORAGE PROJECT



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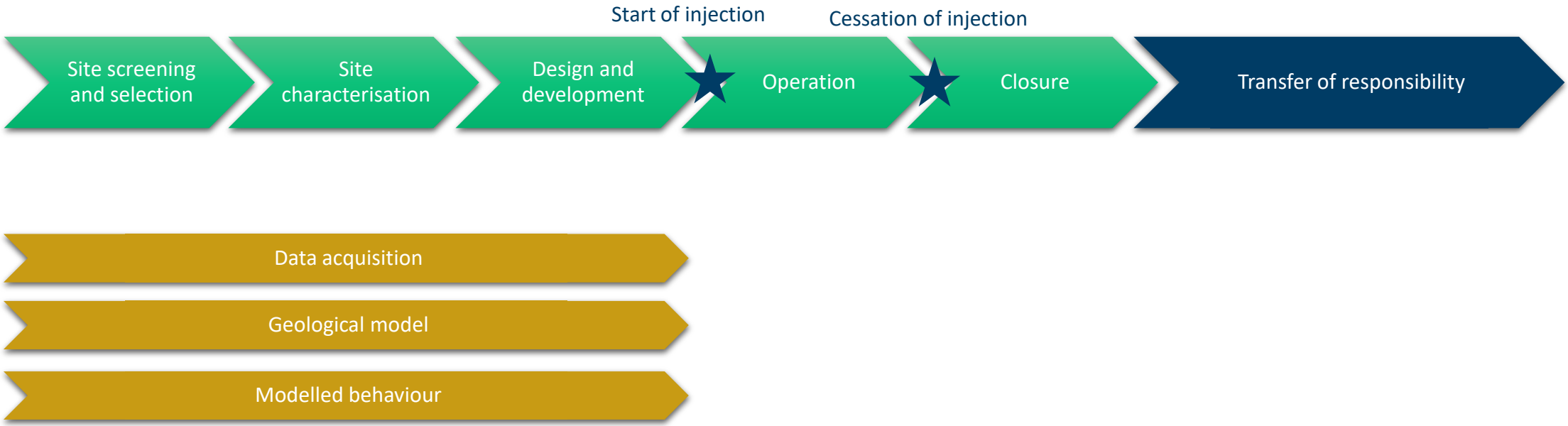
LIFE CYCLE OF A GEOLOGICAL $CO_2$ STORAGE PROJECT



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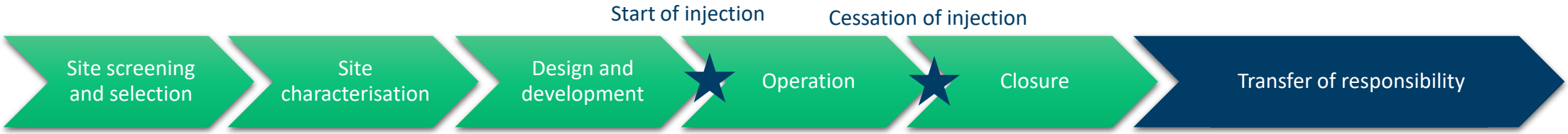


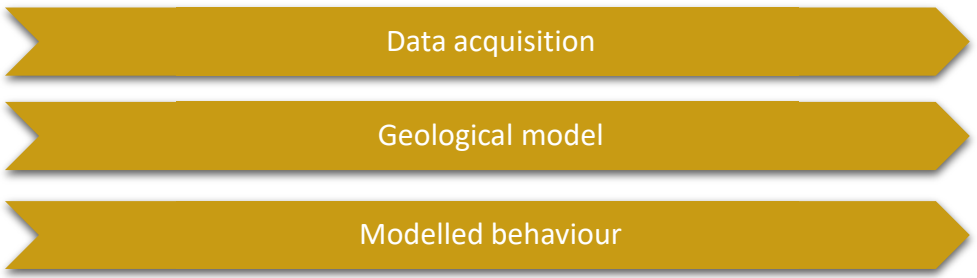


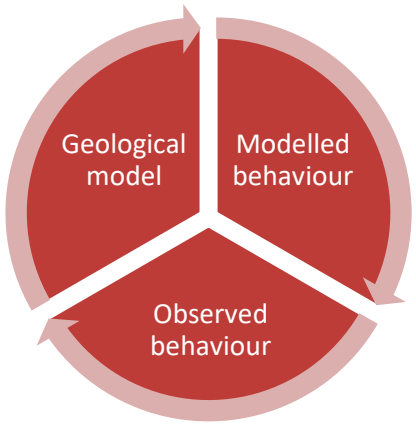


HISTORY MATCHING

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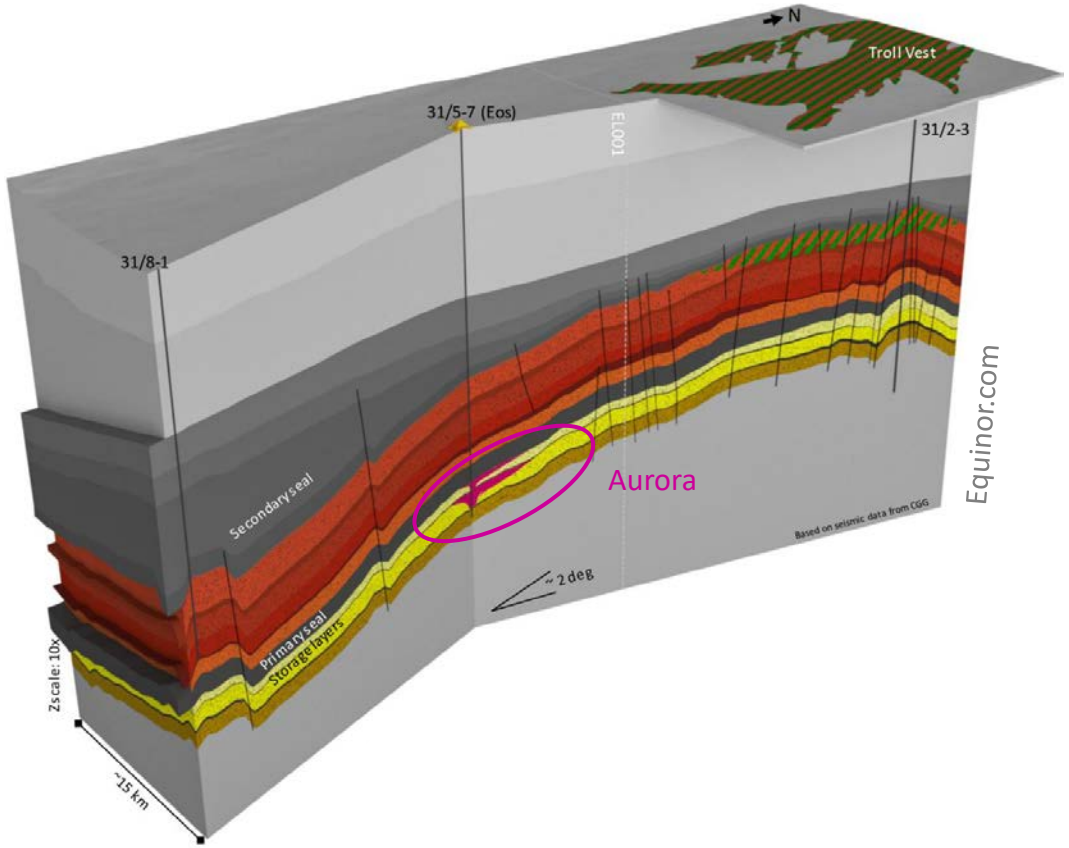
MONITORING OBJECTIVES

**Conformance**
Agreement between simulations and observed behaviour

**Containment**
Show that the $CO_2$ is securely stored



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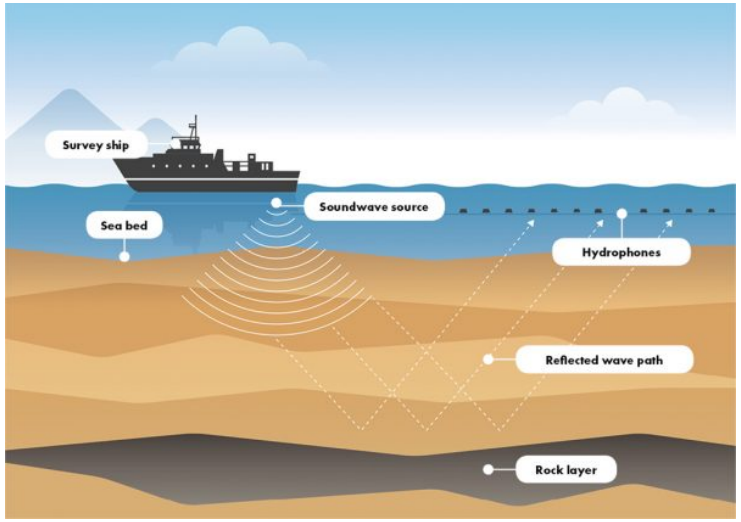
### EXISTING TECHNOLOGIES

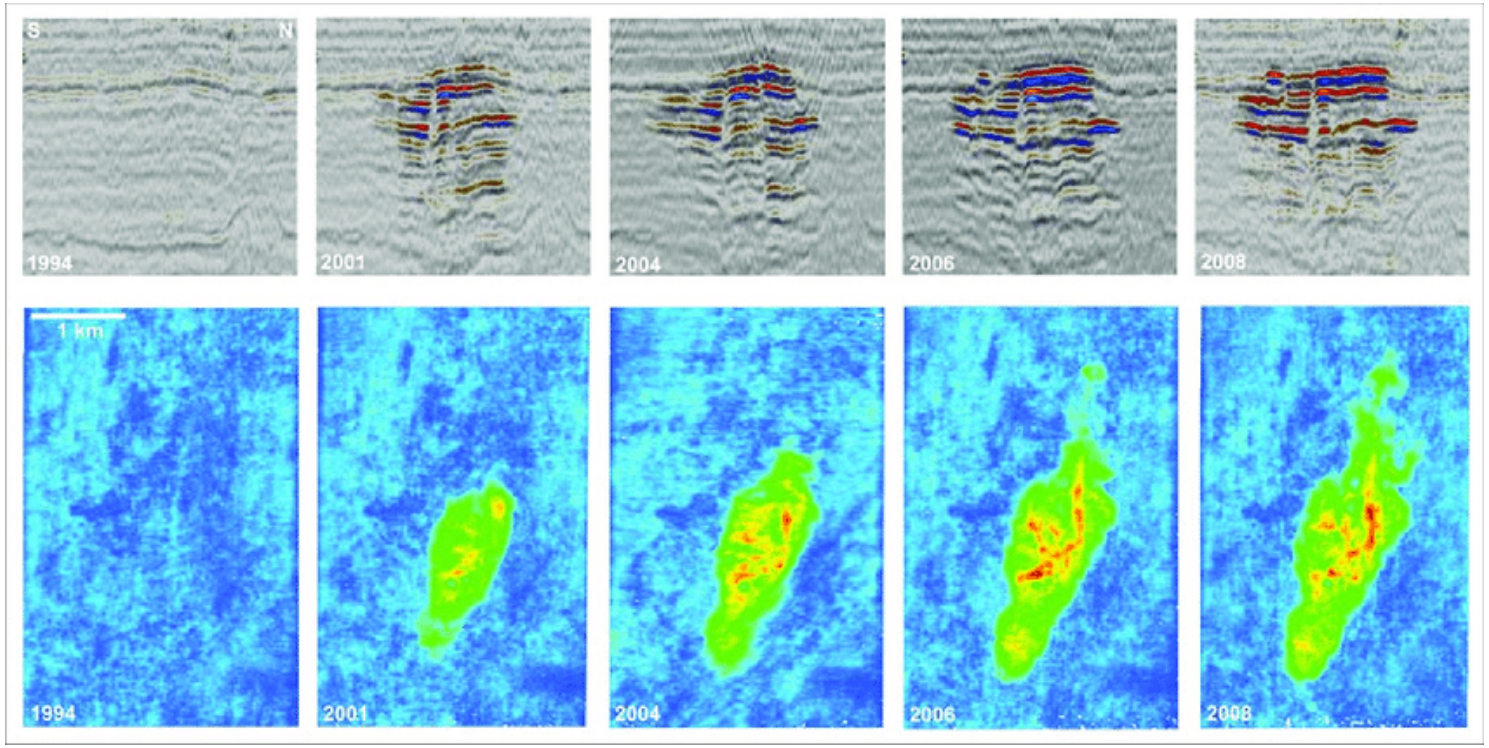
#### SEISMIC ACQUISITION




https://energyinformationaustralia.com.au/

### EXAMPLE

#### SLEIPNER (NORWAY) OFF-SHORE $CO_2$ AQUIFER STORAGE




Chadwick *et al.* (2010)

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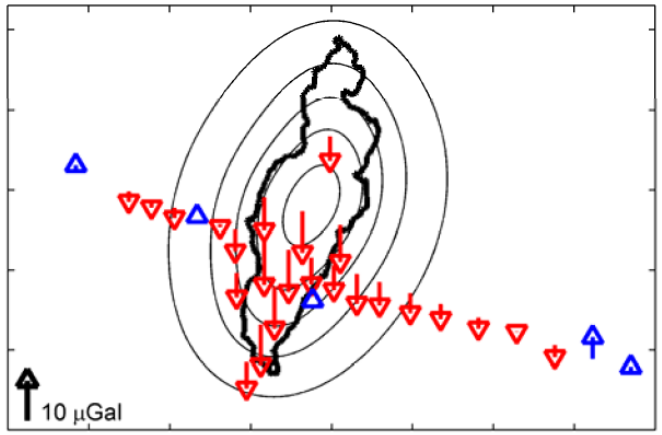
EXISTING TECHNOLOGIES

SEISMIC ACQUISITION

GRAVITY




Alnes *et al.* (2011)

EXAMPLE

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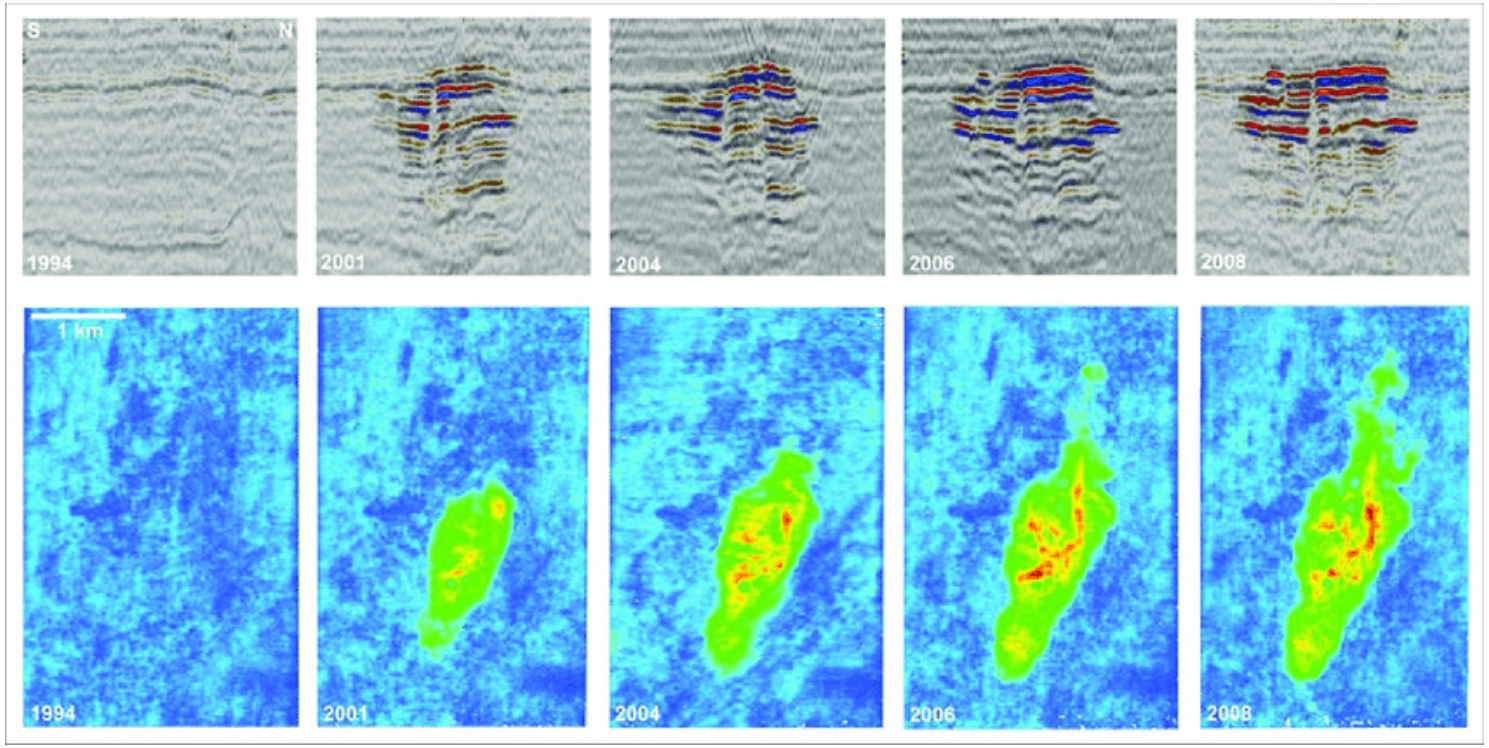


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EXISTING TECHNOLOGIES

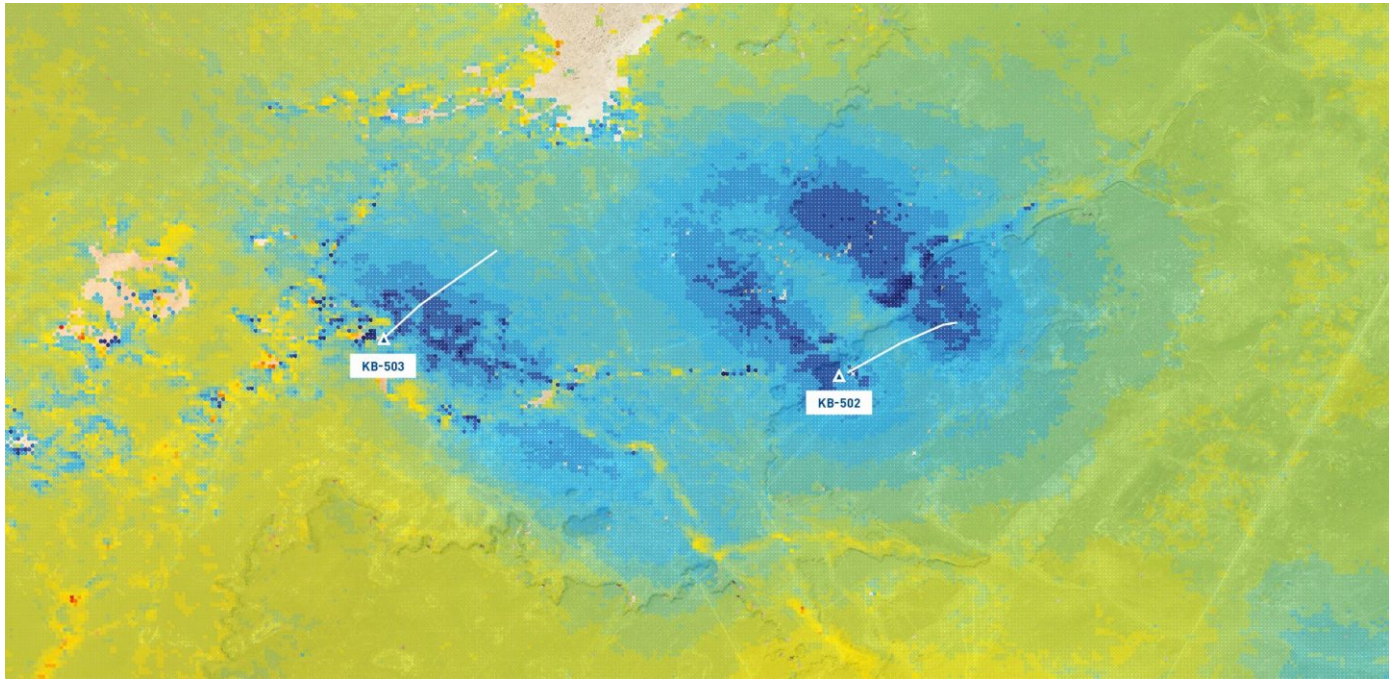
SEISMIC ACQUISITION

GRAVITY

SATELLITE (InSAR)

EXAMPLE

IN-SALAH (ALGERIE) ON-SHORE $CO_2$ AQUIFER STORAGE




Surface deformation

https://site.tre-altamira.com/

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EXISTING TECHNOLOGIES

SEISMIC ACQUISITION

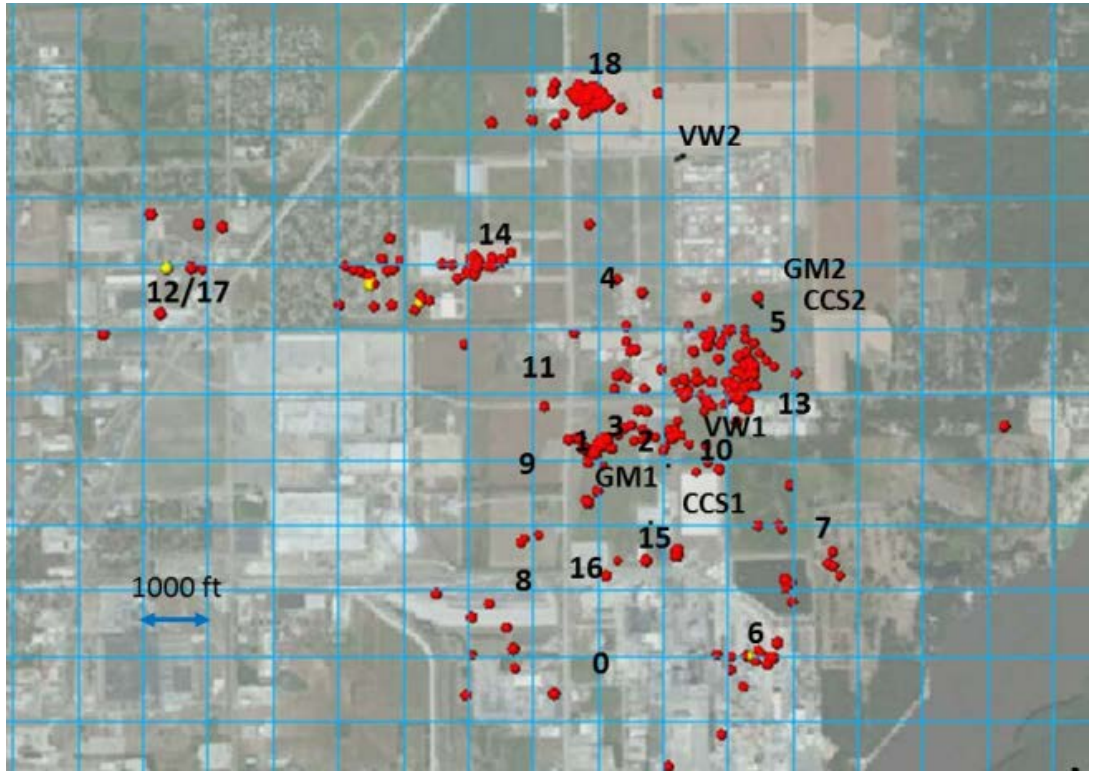
GRAVITY

SATELLITE (InSAR)

MICRO-SEISMICS

EXAMPLE

DECATUR (USA) ON-SHORE $CO_2$ AQUIFER STORAGE




Greenberg (2016)

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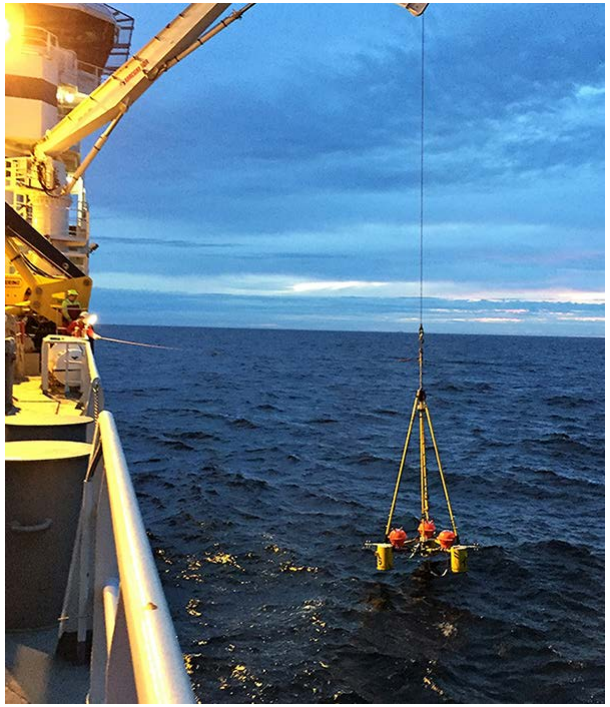
EMERGING TECHNOLOGIES

NEW DATA TYPES

- Controlled source electromagnetic (CSEM) methods



www.allton.com

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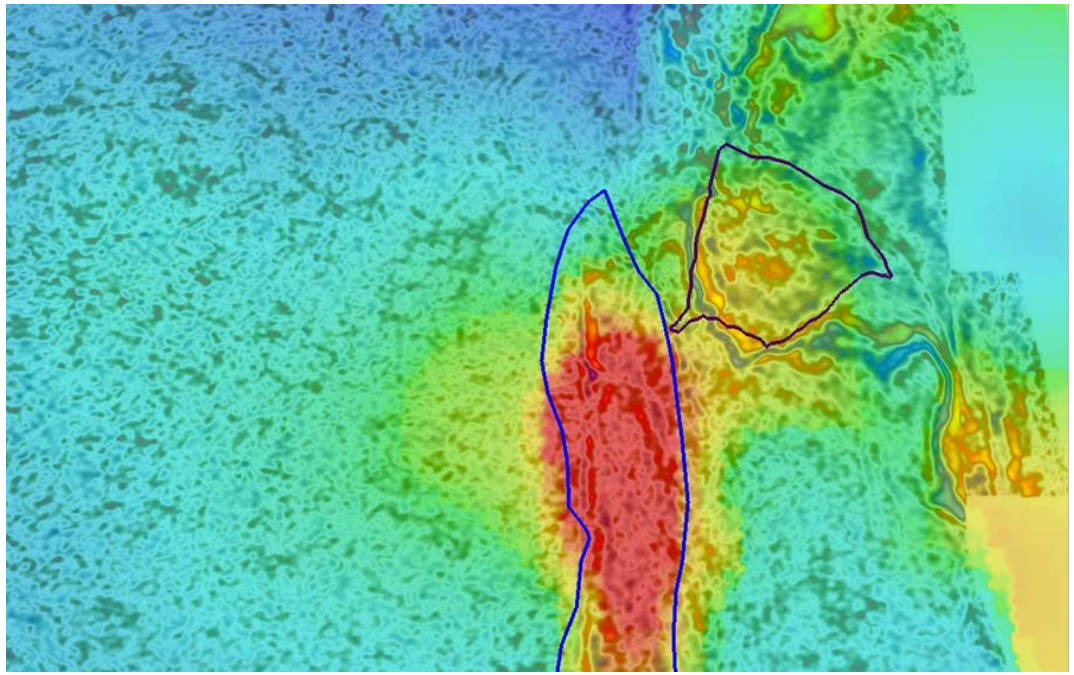

Resistivity map @ 2432 m

Allton CSEM survey

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EMERGING TECHNOLOGIES

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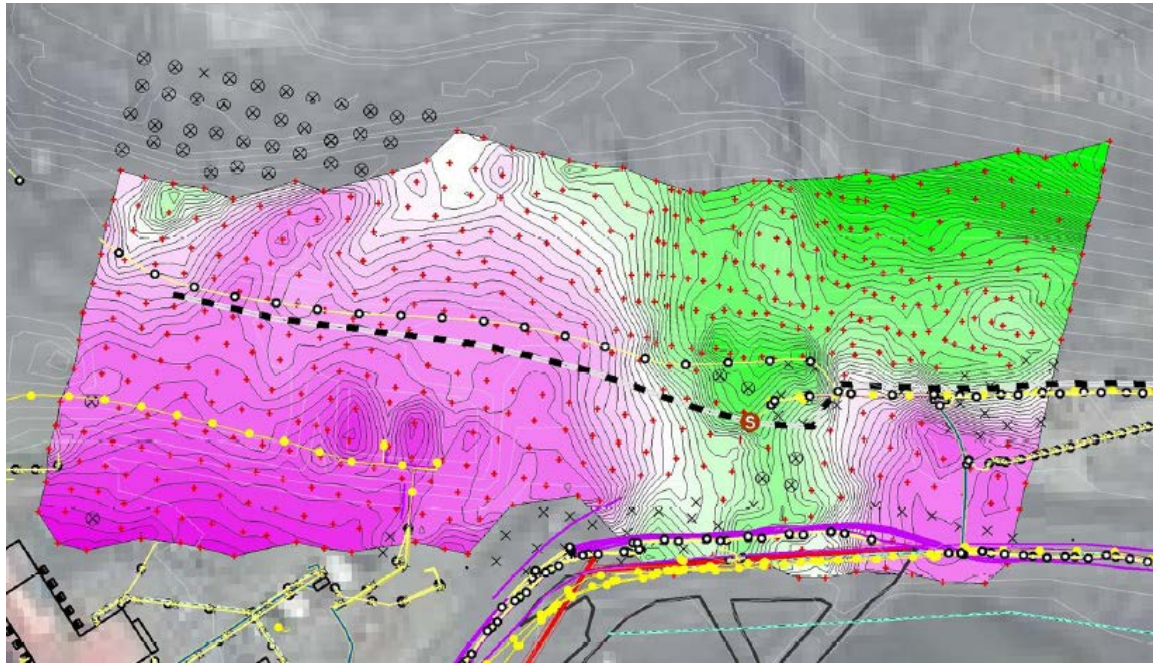
- Controlled source electromagnetic (CSEM) methods
- Magnetometric resistivity (MMR)



Magnetic field intensity

Jessop *et al.* (2018)

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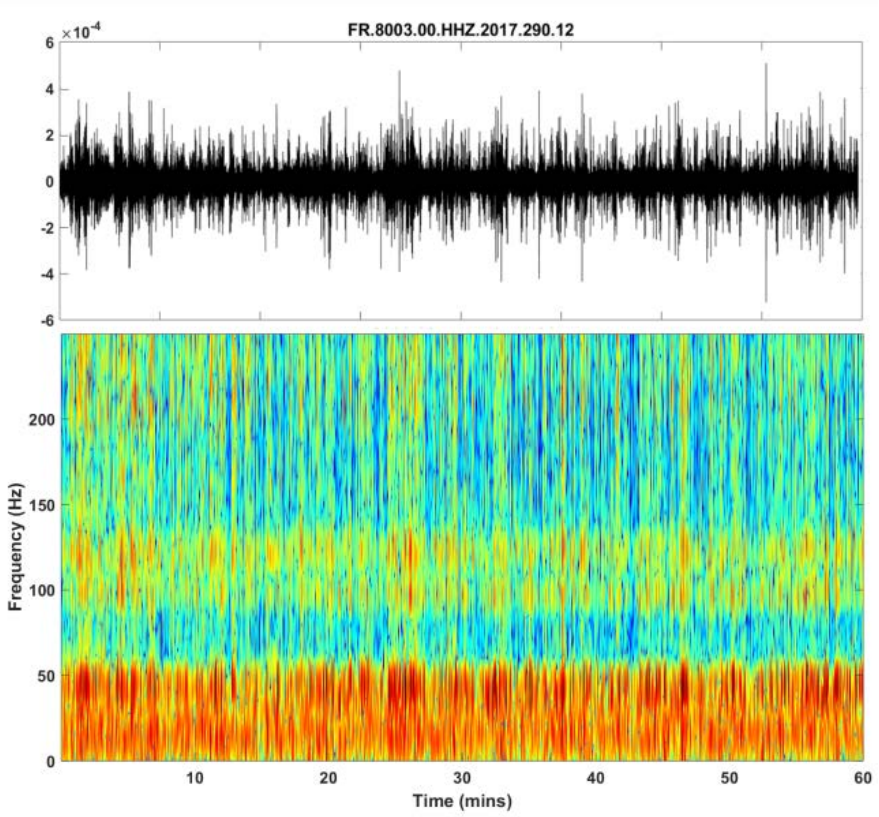
NEW DATA TYPES

- Controlled source electromagnetic (CSEM) methods
- Magnetometric resistivity (MMR)
- Ambient seismic noise




Macquet and Lawton (2018)

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### EMERGING TECHNOLOGIES

#### NEW DATA TYPES

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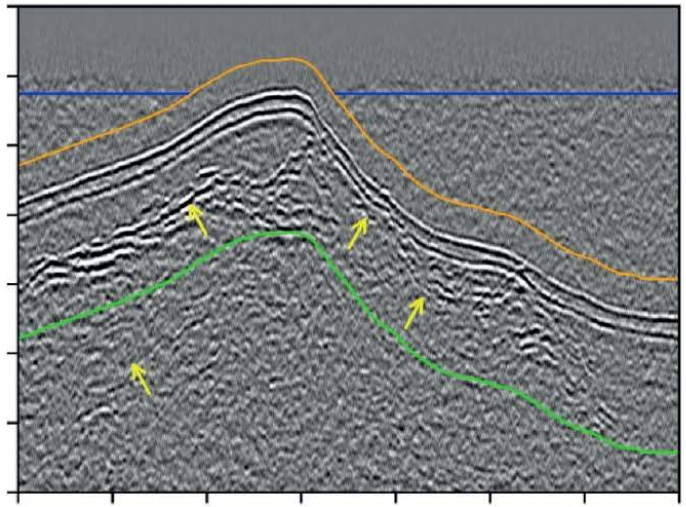
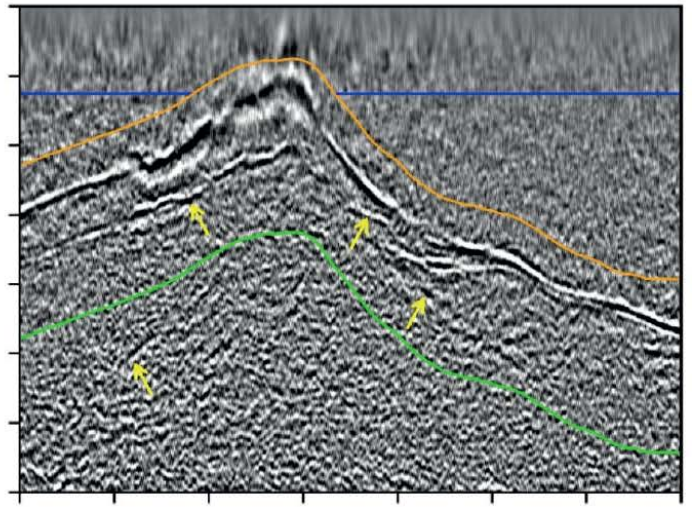
- Distributed acoustic sensing (DAS)



Conventional seismic



Distributed acoustic sensing (DAS)

Ringrose *et al.* (2021)

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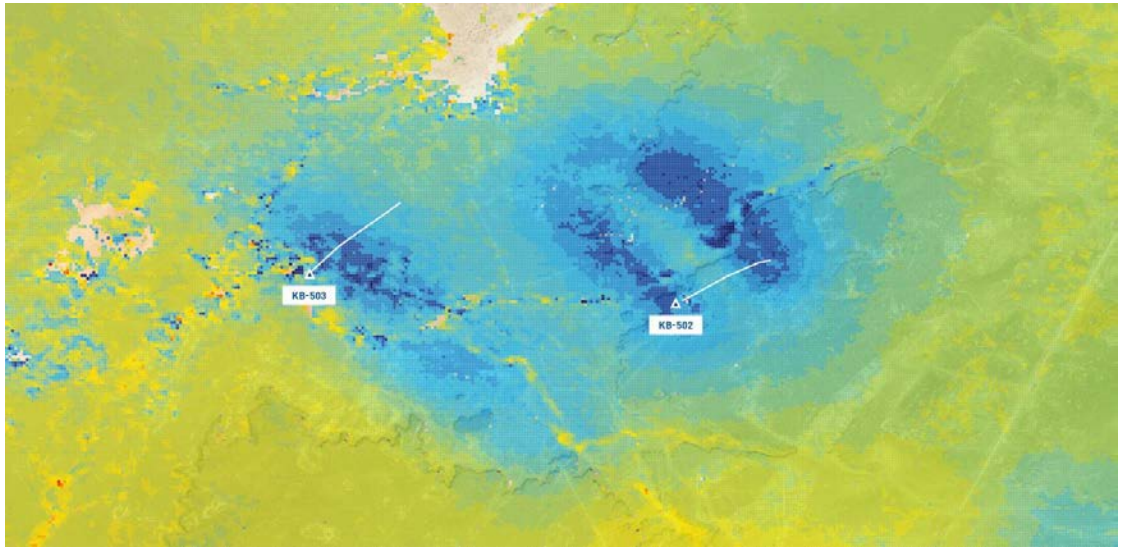
- Distributed strain sensing (DSS)

IN-SALAH ON-SHORE $CO_2$ AQUIFER STORAGE




Satellite InSAR surface deformation for on-shore applications

https://site.tre-altamira.com/

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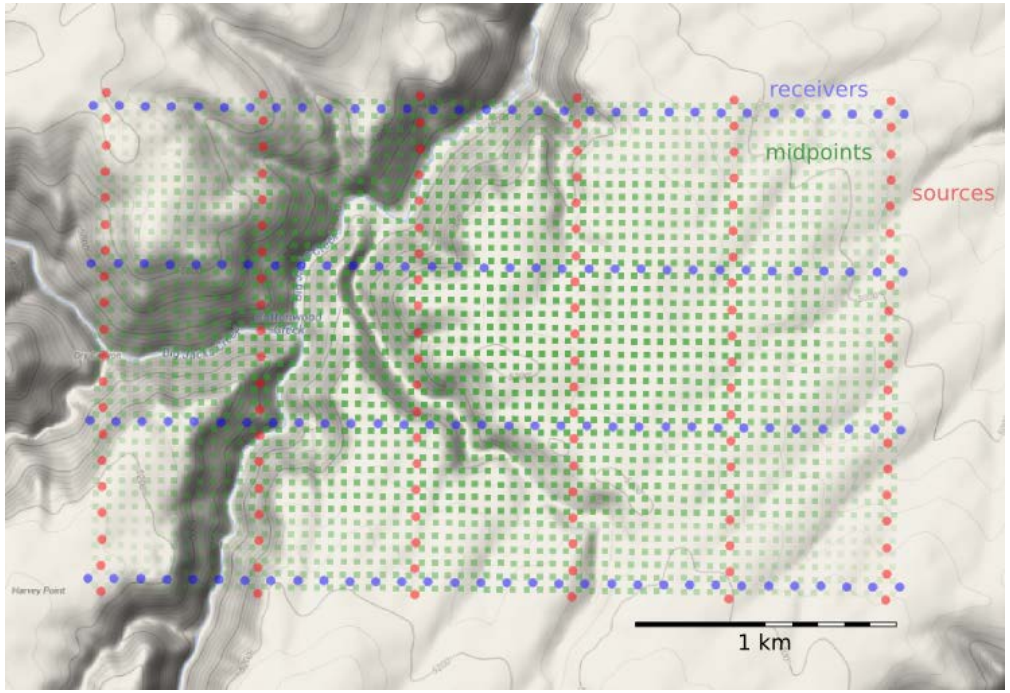
#### SMART AND IMPROVED MONITORING

- Sparse grid




https://agilescientific.com/blog/

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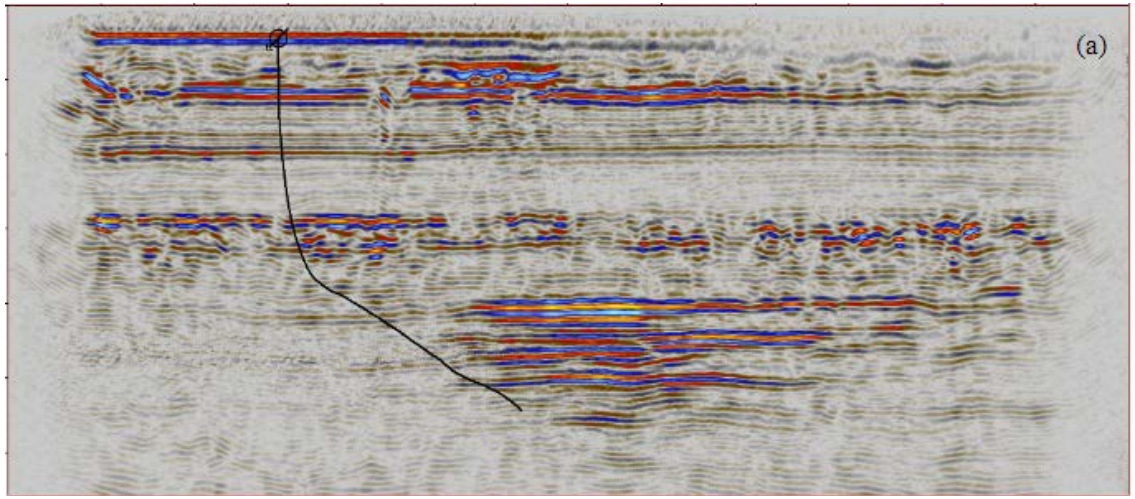
#### SMART AND IMPROVED MONITROING
- Sparse grid

#### ANALYSES
- Improved utilisation of existing data types
- Integration of different data types
- Survey optimisation
- Uncertainty quantification (UQ)
- Value of information (VOI)

SLEIPNER OFF-SHORE $CO_2$ AQUIFER STORAGE




Romdhane and Querendez (2014)

Improved utilisation of existing data types

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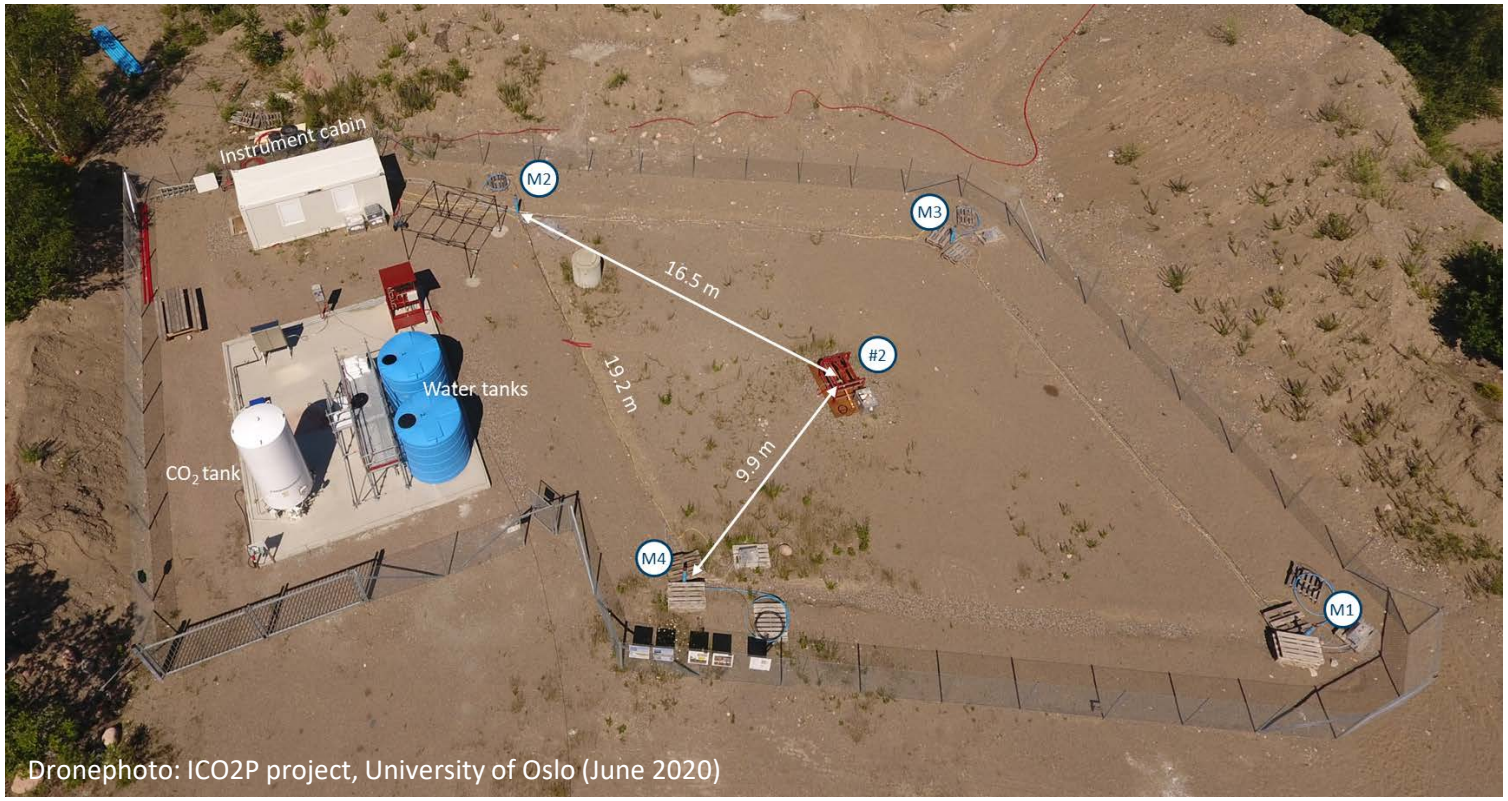
### COST EFFICIENT FIELD TESTING
### ECCSEL SVELVIK $CO_2$ FIELD LAB, NORWAY



Dronephoto: ICO2P project, University of Oslo (June 2020)

Seismic source

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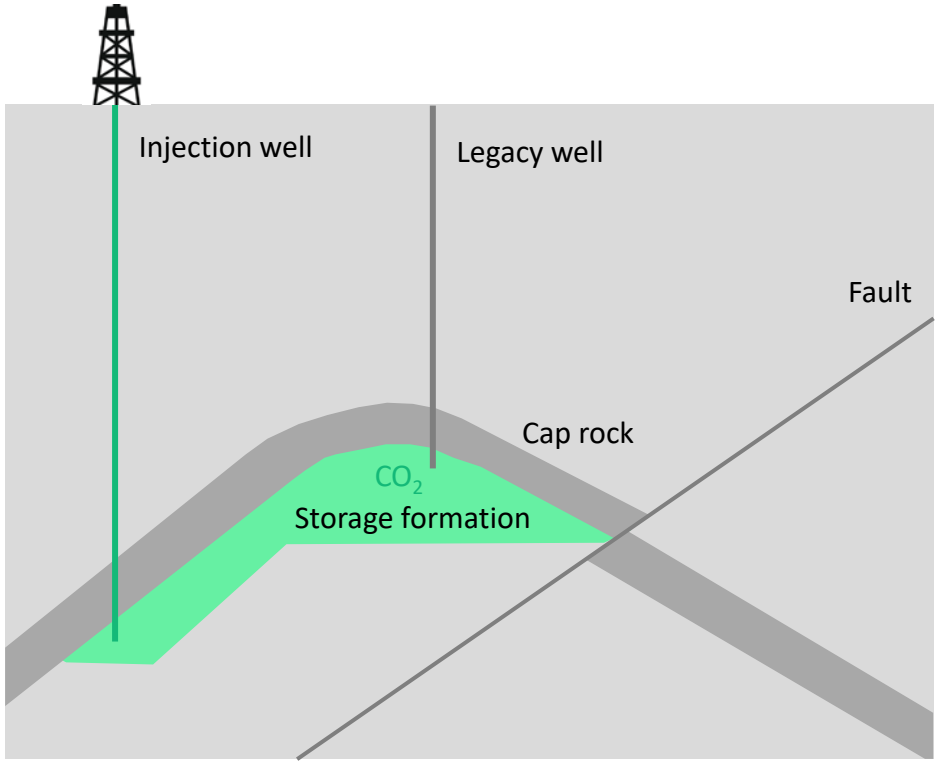
EMERGING TECHNOLOGIES

WELL INTEGRITY

- Seismic methods
- Electromagnetic methods
- Fibreoptic sensors



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ACKNOWLEDGEMENT

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# Thank you for your attention