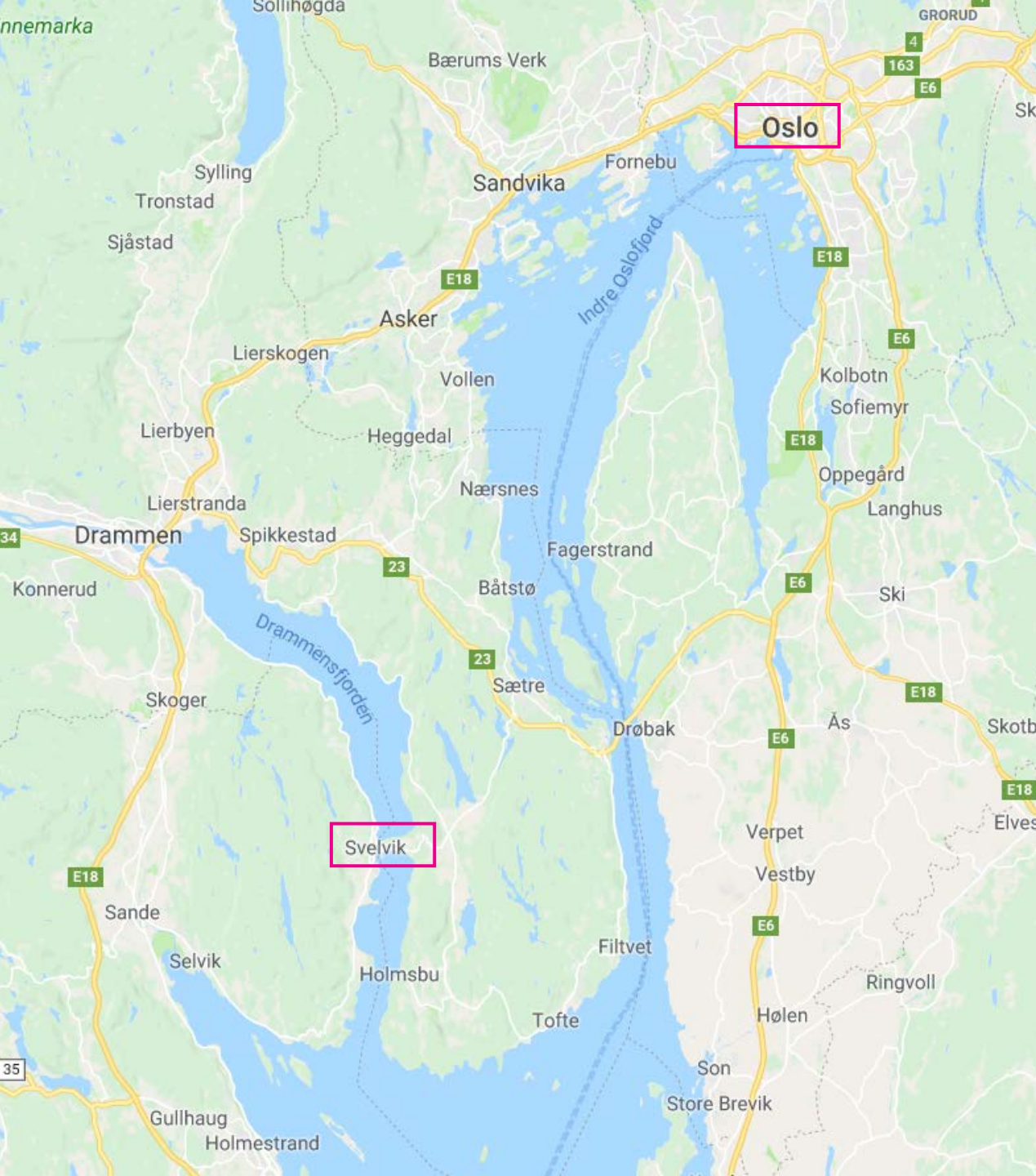




## A CO<sub>2</sub> MONITORING EXPERIMENT FOR PRESSURE-SATURATION DISCRIMINATION AT THE NEW SVELVIK CO<sub>2</sub> FIELD LAB

Eliasson, P., Jordan, M., Ringstad, C., Røphaug, M. and Hagby, K.  
SINTEF Industry









## A SMALL SCALE MONITORING LABORATORY

For rapid and cost efficient development and testing of technologies required for large-scale CCS applications







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CORE SAMPLE



cm scale

FULL-SCALE



km scale







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FIELD LAB



m scale

FULL-SCALE



km scale







## A SMALL SCALE MONITORING LABORATORY

For rapid and cost efficient development and testing of technologies required for large-scale CCS applications

### CORE SAMPLE



cm scale

### FIELD LAB



m scale

### FULL-SCALE



km scale





## A SMALL SCALE MONITORING LABORATORY

### INJECTION WELL (#2)

- Injection of water and/or CO<sub>2</sub>
- Injection depth @ 64 – 65 m

### MONITORING WELLS (M1 – M4)

- 100 m deep
- Instrumented behind casing
  - in-situ measurements
  - cross-well monitoring



Drone photo: ICO<sub>2</sub>P (UiO)

## GEOLOGICAL MODEL

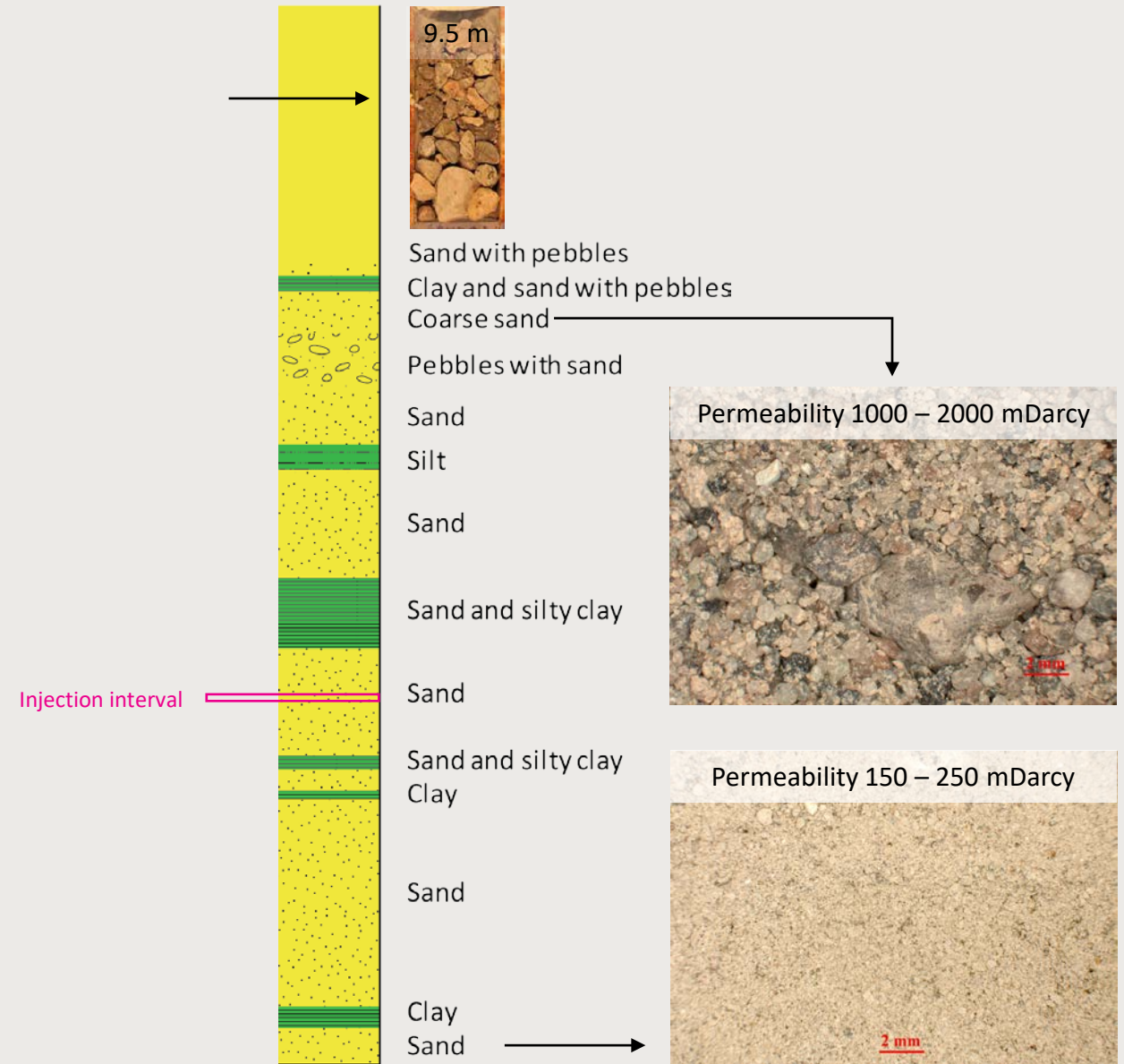
### Down to ~35 m

Sand and gravel deposits close to the glacier front

### Below ~35 m

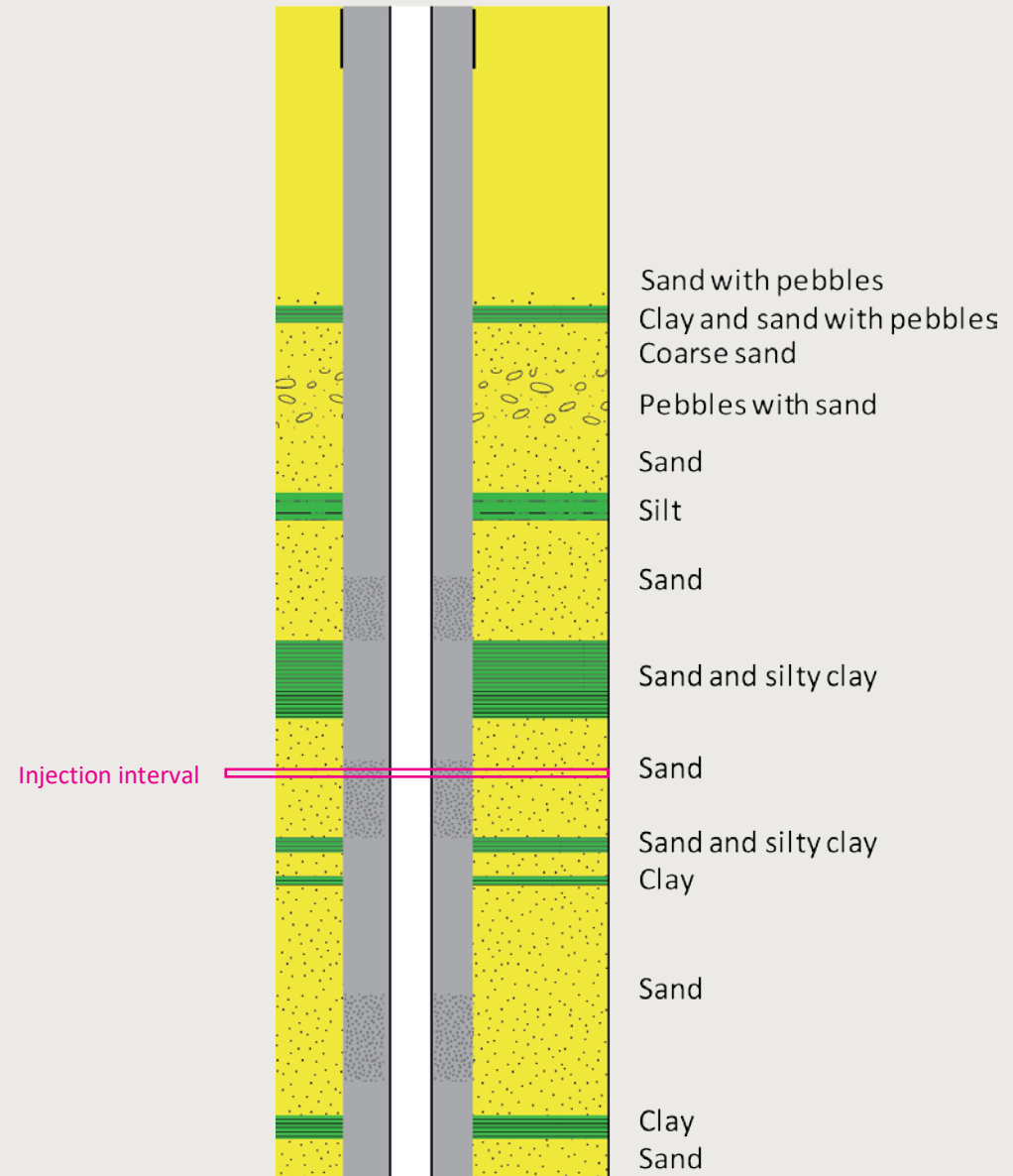
Alternating layers of sand, silt and clay deposition further away from the glacier front

Injection interval = 64 – 65 m





## MONITORING WELLS INSTRUMENTATION BEHIND CASING



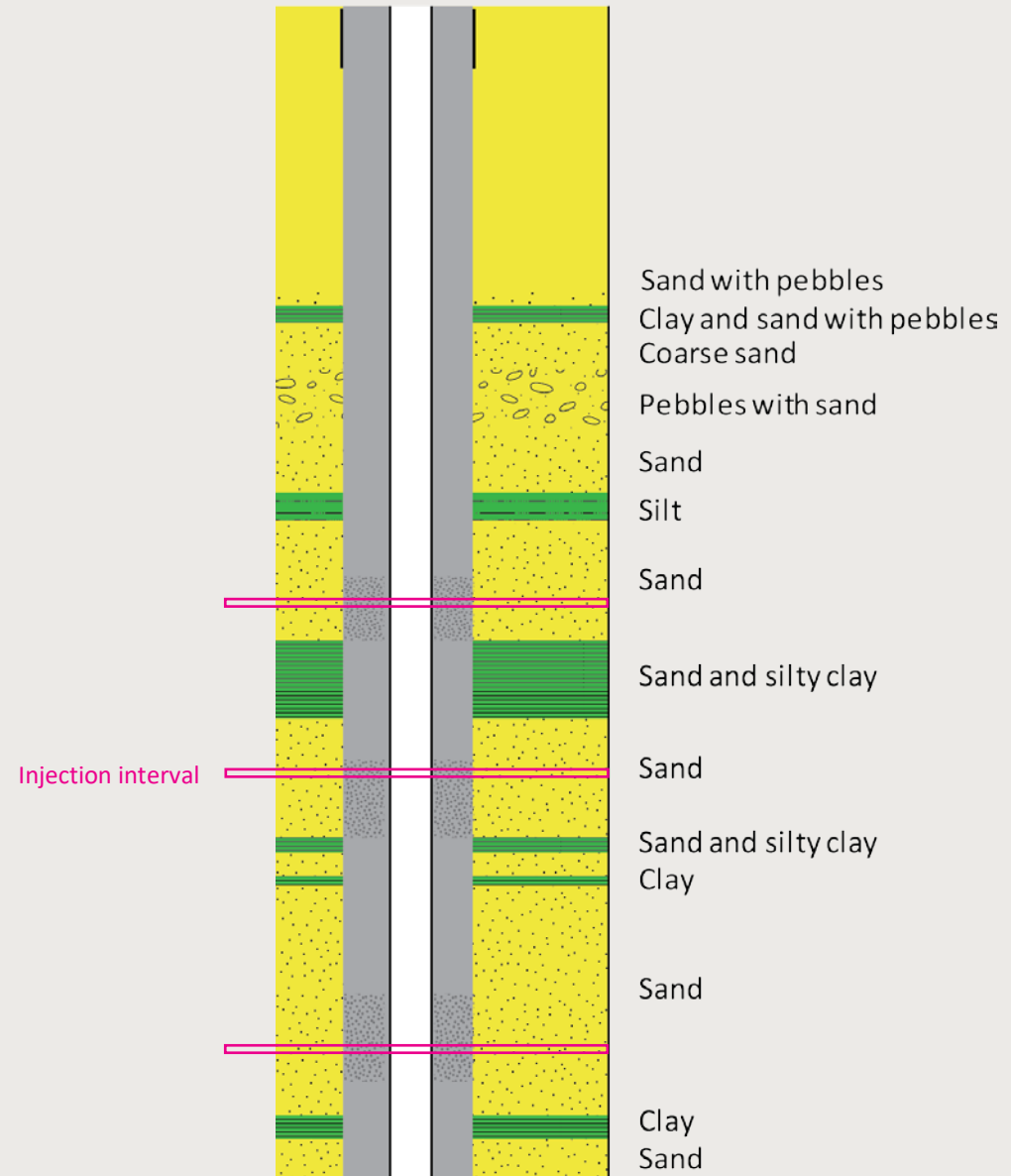


## MONITORING WELLS

### INSTRUMENTATION BEHIND CASING

#### IN-SITU MEASUREMENTS

- Pore pressure (at three depths)
- Temperature (injection layer)
- Fluid sampling (injection layer)





## MONITORING WELLS

### INSTRUMENTATION BEHIND CASING

#### IN-SITU MEASUREMENTS

- Pore pressure (at three depths)
- Temperature (injection layer)
- Fluid sampling (injection layer)
- Electrical resistivity tomography (ERT)

## Electrical resistivity tomography (ERT)





## MONITORING WELLS

### INSTRUMENTATION BEHIND CASING

#### IN-SITU MEASUREMENTS

- Pore pressure (at three depths)
- Temperature (injection layer)
- Fluid sampling (injection layer)
- Electrical resistivity tomography (ERT)

#### FIBREOPTIC CABLES

- Distributed acoustic sensing (DAS)
- Distributed temperature sensing (DTS)
- Distributed strain sensing (DSS)

## FIBREOPTIC CABLES



Loop installation with no splicing



## MONITORING WELLS

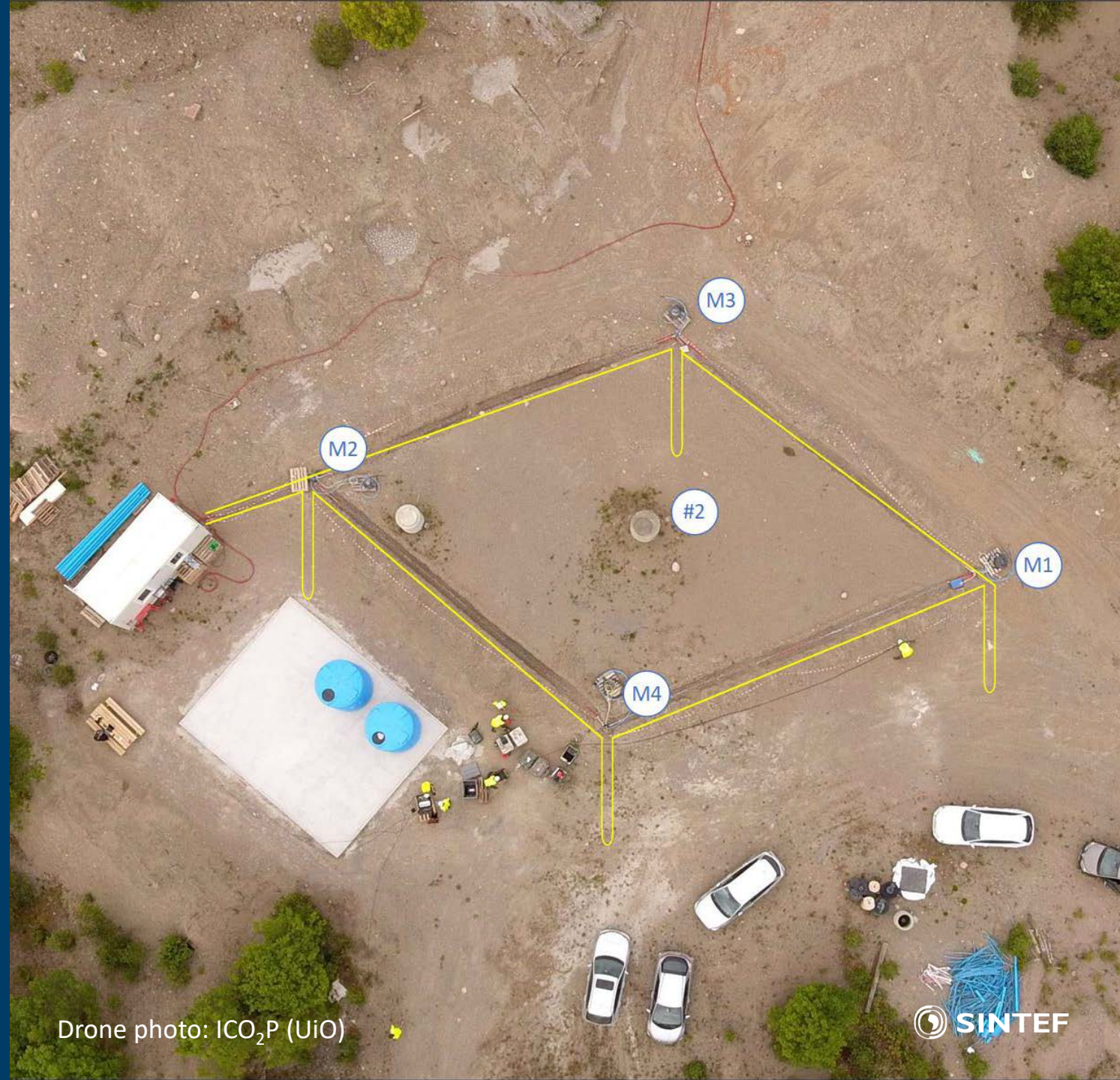
### INSTRUMENTATION BEHIND CASING

## IN-SITU MEASUREMENTS

- Pore pressure (at three depths)
- Temperature (injection layer)
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- Electrical resistivity tomography (ERT)

## FIBREOPTIC CABLES

- Distributed acoustic sensing (DAS)
- Distributed temperature sensing (DTS)
- Distributed strain sensing (DSS)



Drone photo: ICO<sub>2</sub>P (UiO)



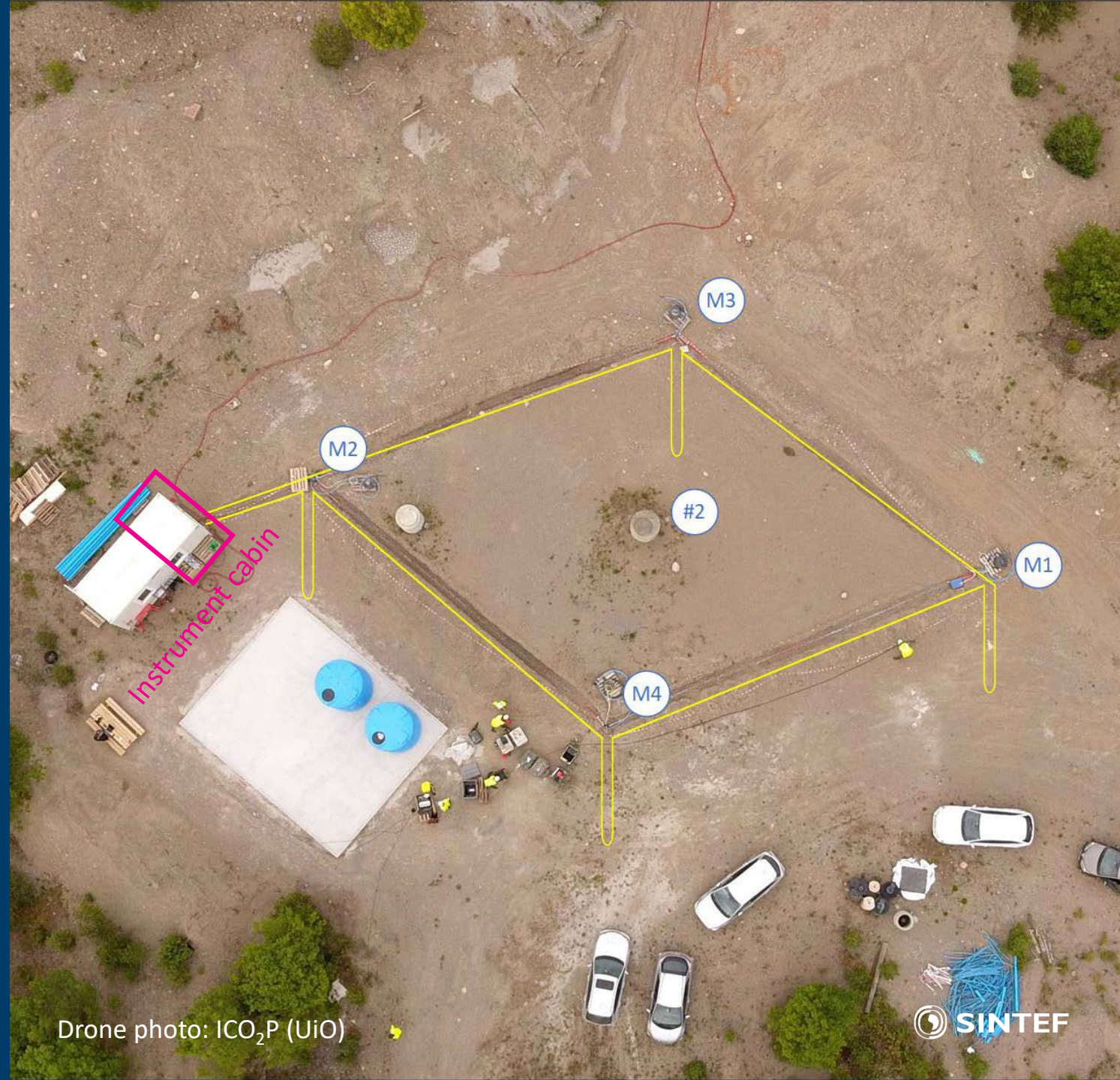
MONITORING WELLS  
INSTRUMENTATION BEHIND CASING

IN-SITU MEASUREMENTS

- Pore pressure (at three depths)
- Temperature (injection layer)
- Fluid sampling (injection layer)
- Electrical resistivity tomography (ERT)

FIBROPTIC CABLES

- Distributed acoustic sensing (DAS)
- Distributed temperature sensing (DTS)
- Distributed strain sensing (DSS)



Drone photo: ICO<sub>2</sub>P (UiO)



## MONITORING WELLS

### INSTRUMENTATION BEHIND CASING

#### IN-SITU MEASUREMENTS

- Pore pressure (at three depths)
- Temperature (injection layer)
- Fluid sampling (injection layer)
- Electrical resistivity tomography (ERT)

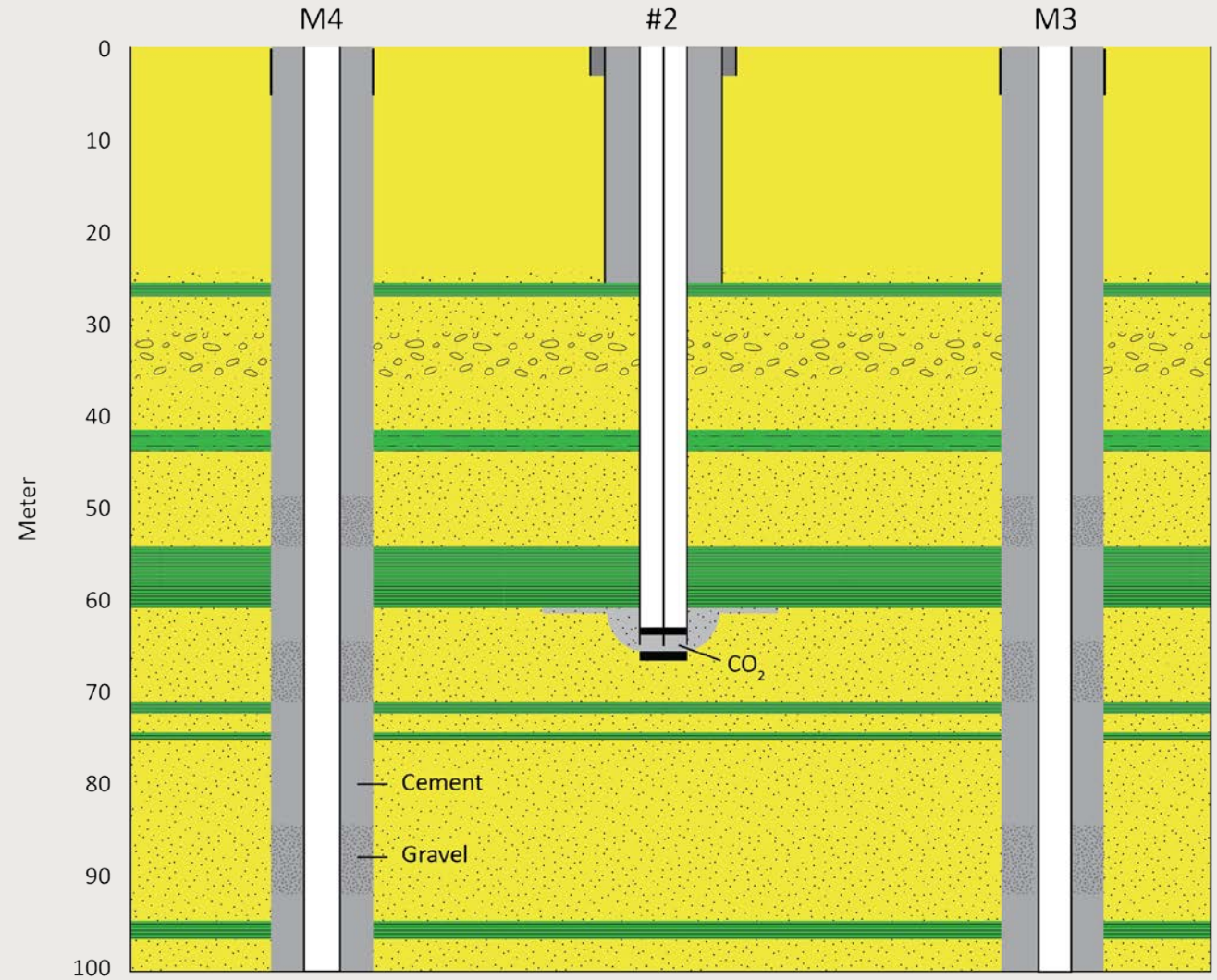
#### FIBROPTIC CABLES

- Distributed acoustic sensing (DAS)
- Distributed temperature sensing (DTS)
- Distributed strain sensing (DSS)
- LBNL straight DAS and DSS
- LBNL helical DAS and DSS





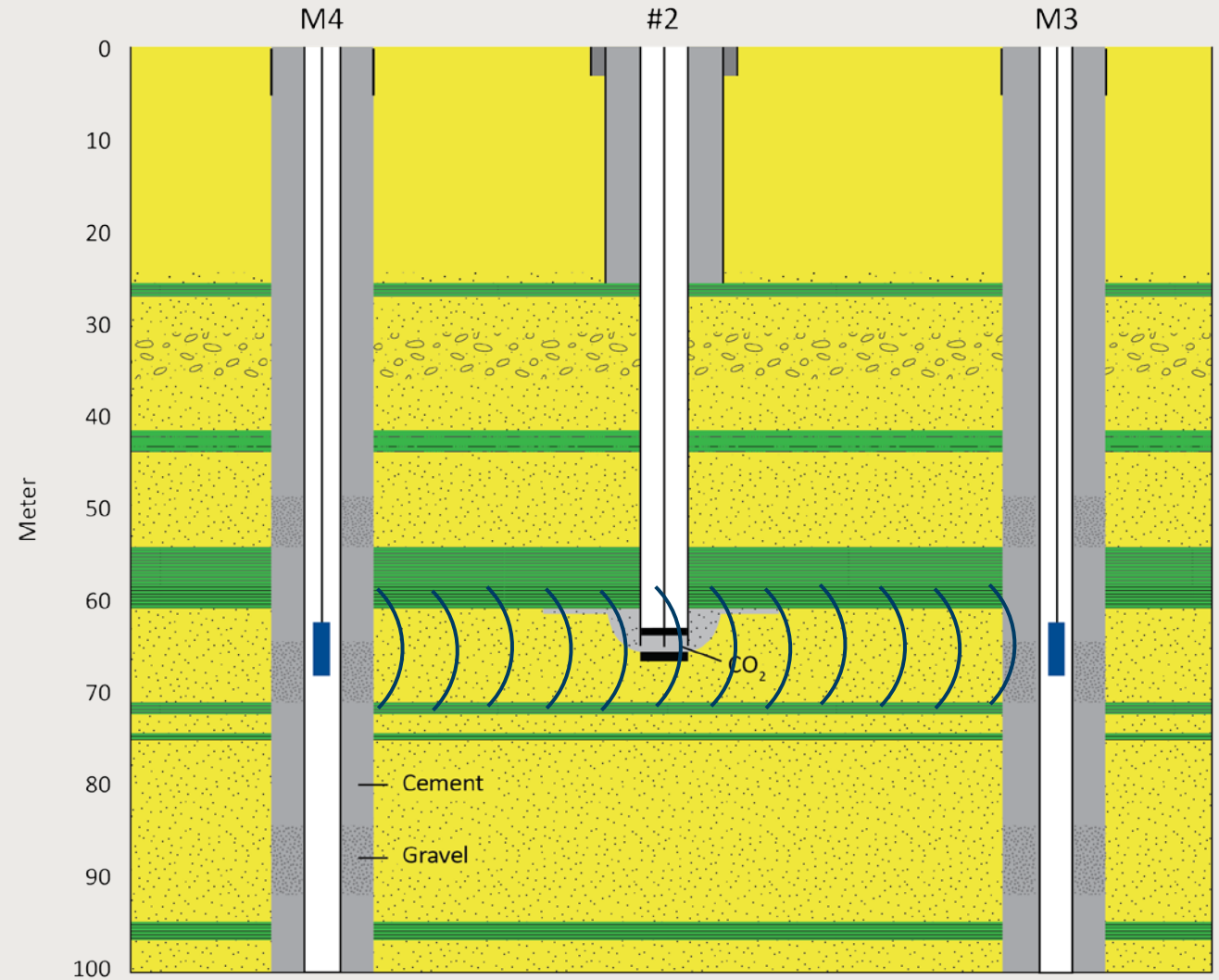
MONITORING WELLS  
INSTRUMENTATION BEHIND CASING





MONITORING WELLS  
INSTRUMENTATION BEHIND CASING

DOWNHOLE TOOLS  
CONVENTIONAL MEASUREMENTS









## INFRASTRUCTURE FOR BRINE AND CO<sub>2</sub> INJECTION



INJECTION WELL



BASELINE MEASUREMENTS  
HYDROGEOLOGICAL MEASUREMENTS

SHALLOW AQUIFER

WATER WELLS W1, W2 and W5

DEEP AQUIFER

INJECTION WELL #2

1) TIDAL EFFECTS

NGWM20 P-5.2

Revheim et al.: Tidal effect on pressure in upper and lower aquifer of the Svelvik Ridge

2) AQUIFER COMMUNICATION

Water extraction from shallow aquifer  
Well BR3







## PRE-ACT PROJECT



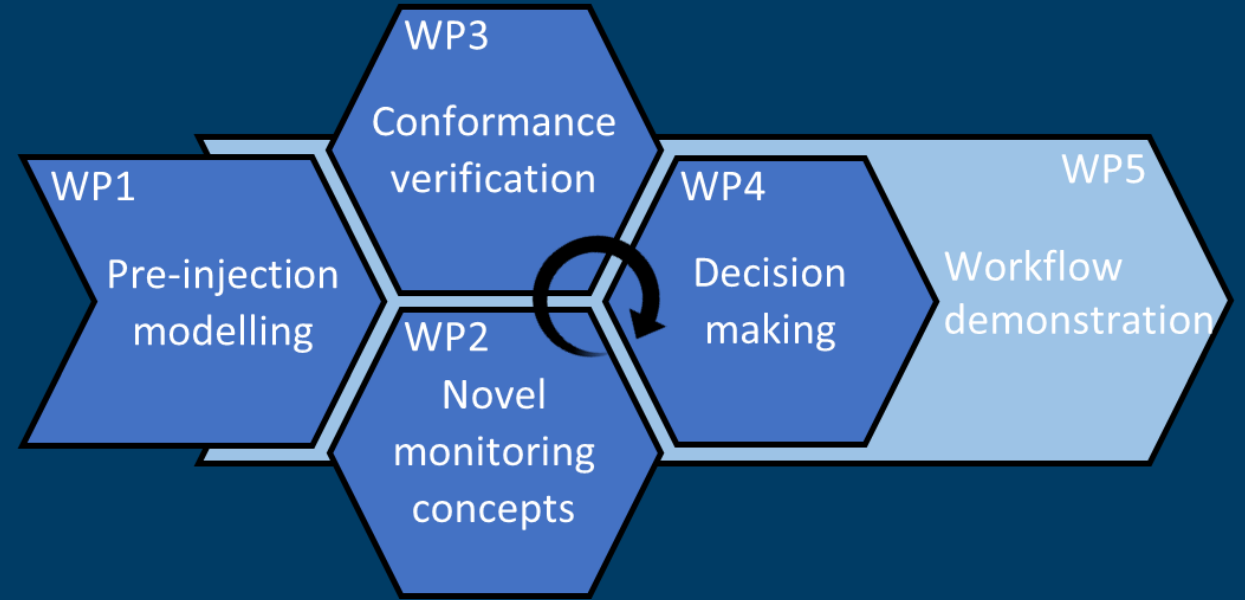
Pressure control and conformance management for safe and efficient CO<sub>2</sub> storage - Accelerating CCS Technologies

**BUDGET** ~ 5.2 MNOK

**DURATION** 1/9 2017 – 31/8 2020

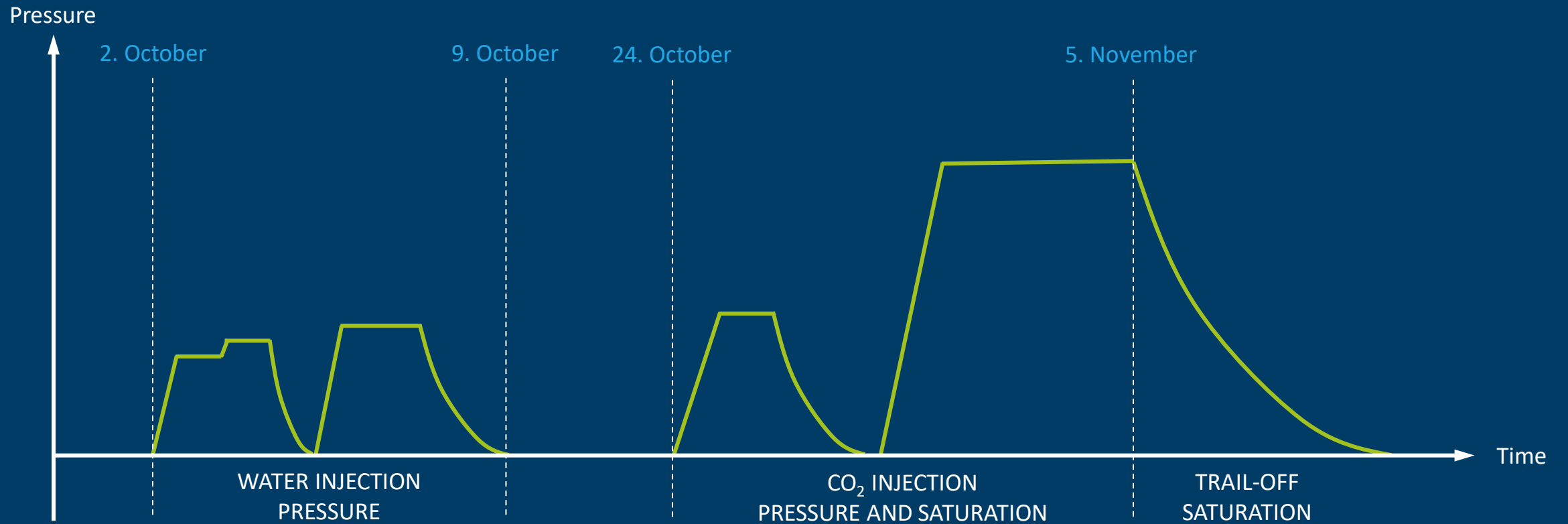
## SVELVIK CAMPAIGN

Pressure-saturation quantification/discrimination central theme in Pre-ACT – supported by experimental campaign

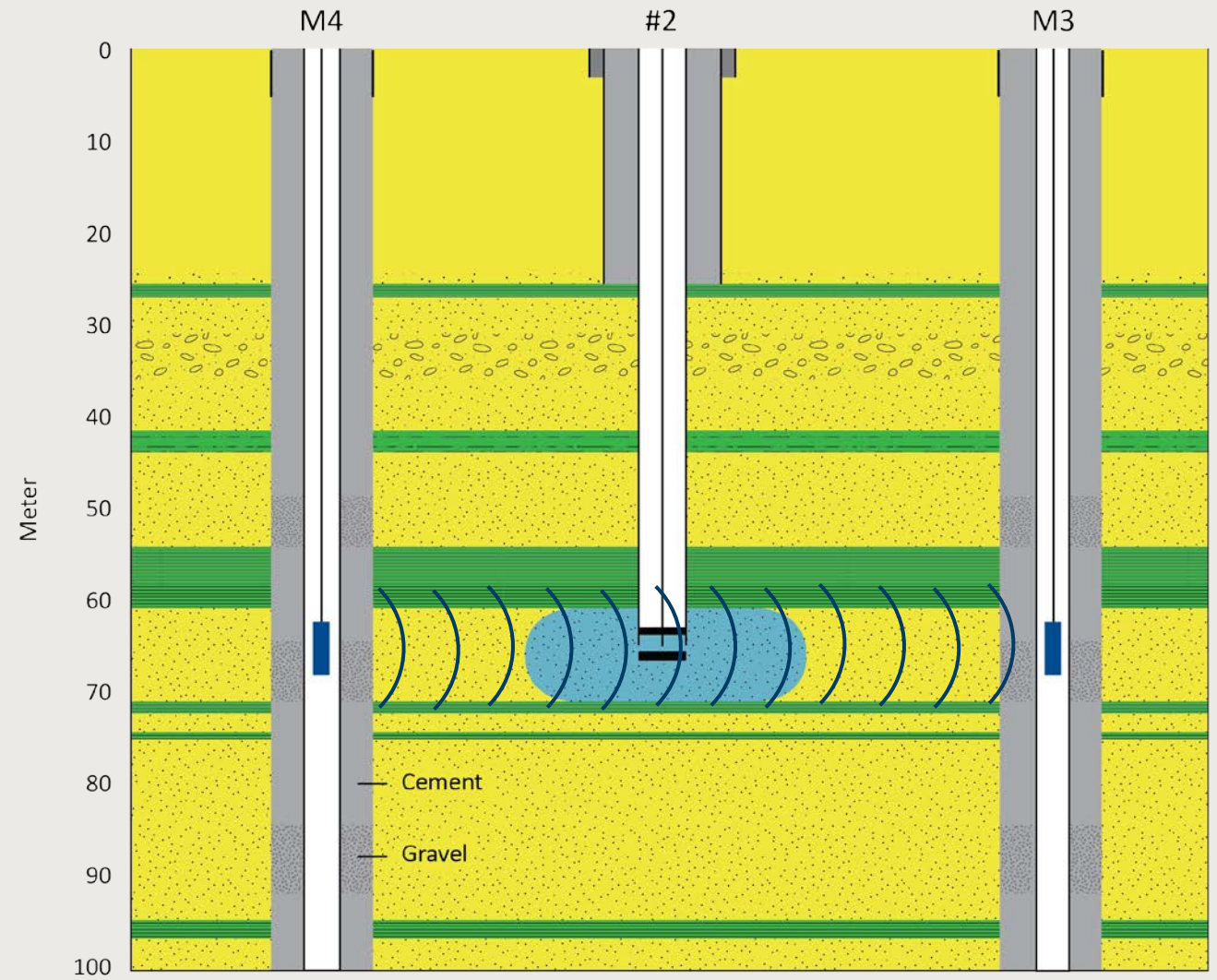




## PRE-ACT EXPERIMENTAL CAMPAIGN



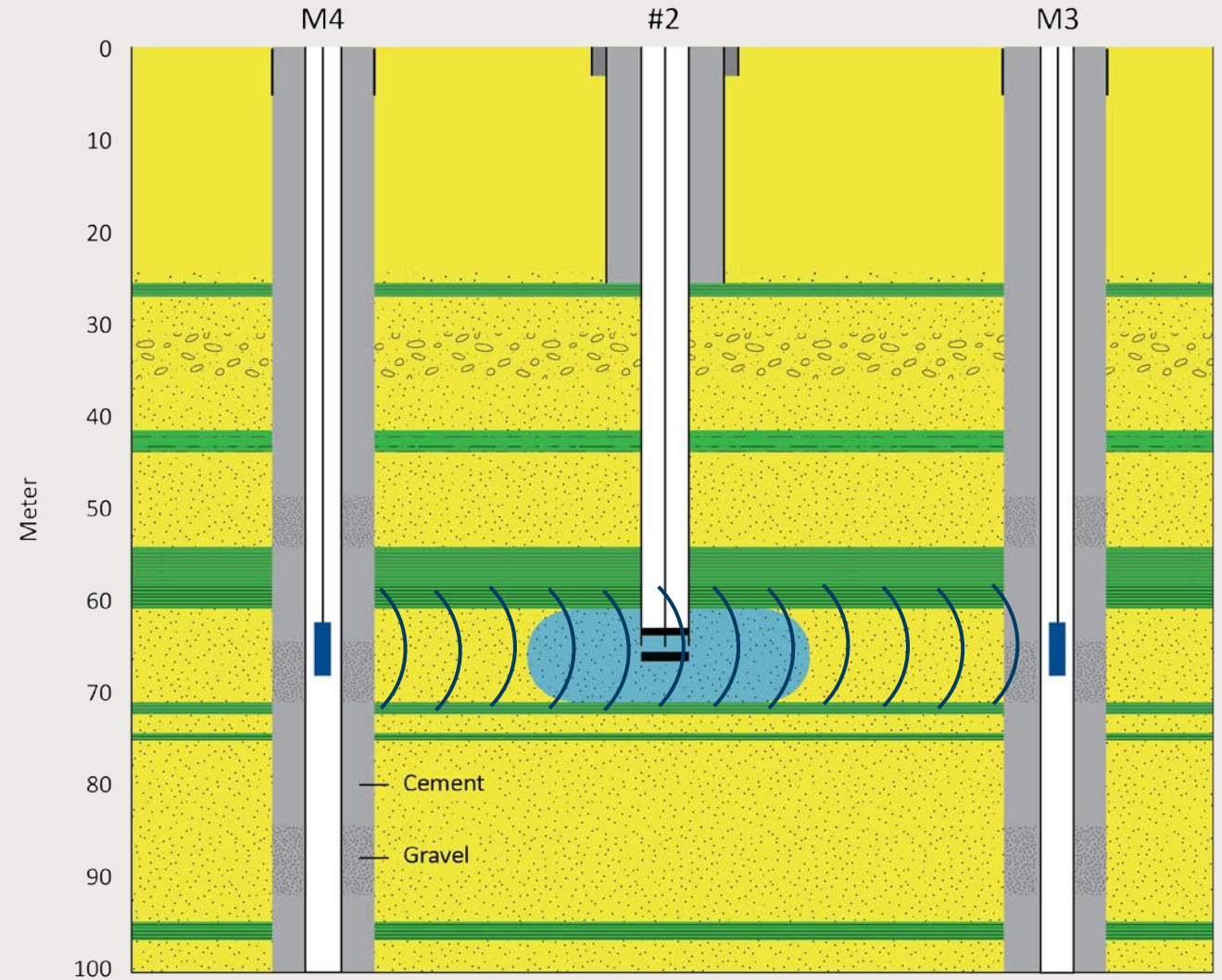
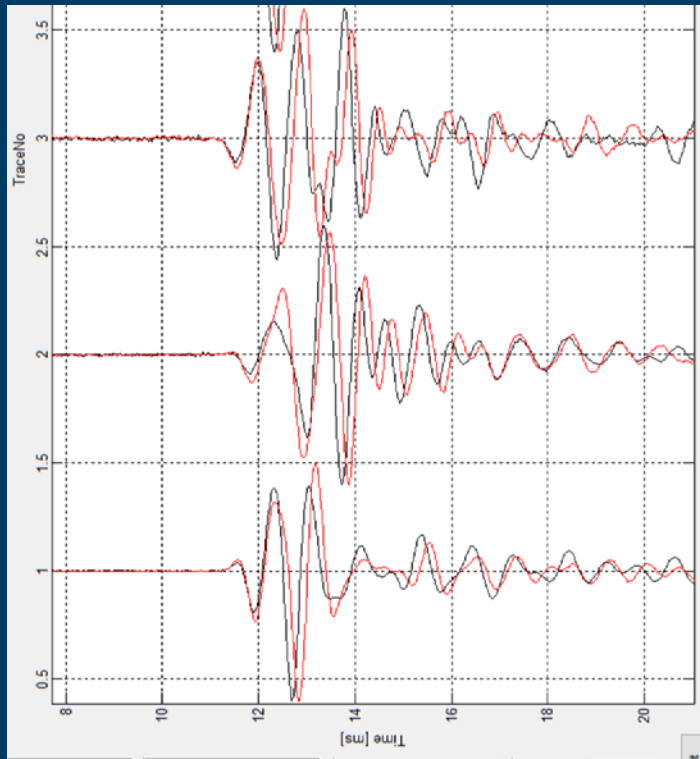






## PRE-ACT EXPERIMENTAL CAMPAGIN

### Cross-well seismic measurements





ICO<sub>2</sub>P

A CLIMIT KPN PROJECT @ UiO

Application of noble gas signatures in monitoring schemes for offshore CO<sub>2</sub> storage

Differentiate injected CO<sub>2</sub> from natural methanogenic/biogenic CO<sub>2</sub> rich gases

NGWM20 P-5.7

Weber et al.:

Gas composition of the Svelvik Ridge aquifers used to design noble gas tracers for a CO<sub>2</sub> injection experiment





## FIBEROPTIC MEASUREMENTS

A GASSNOVA DEMO PROJECT @ SINTEF

### BASELINE (BEFORE INJECTIONS)

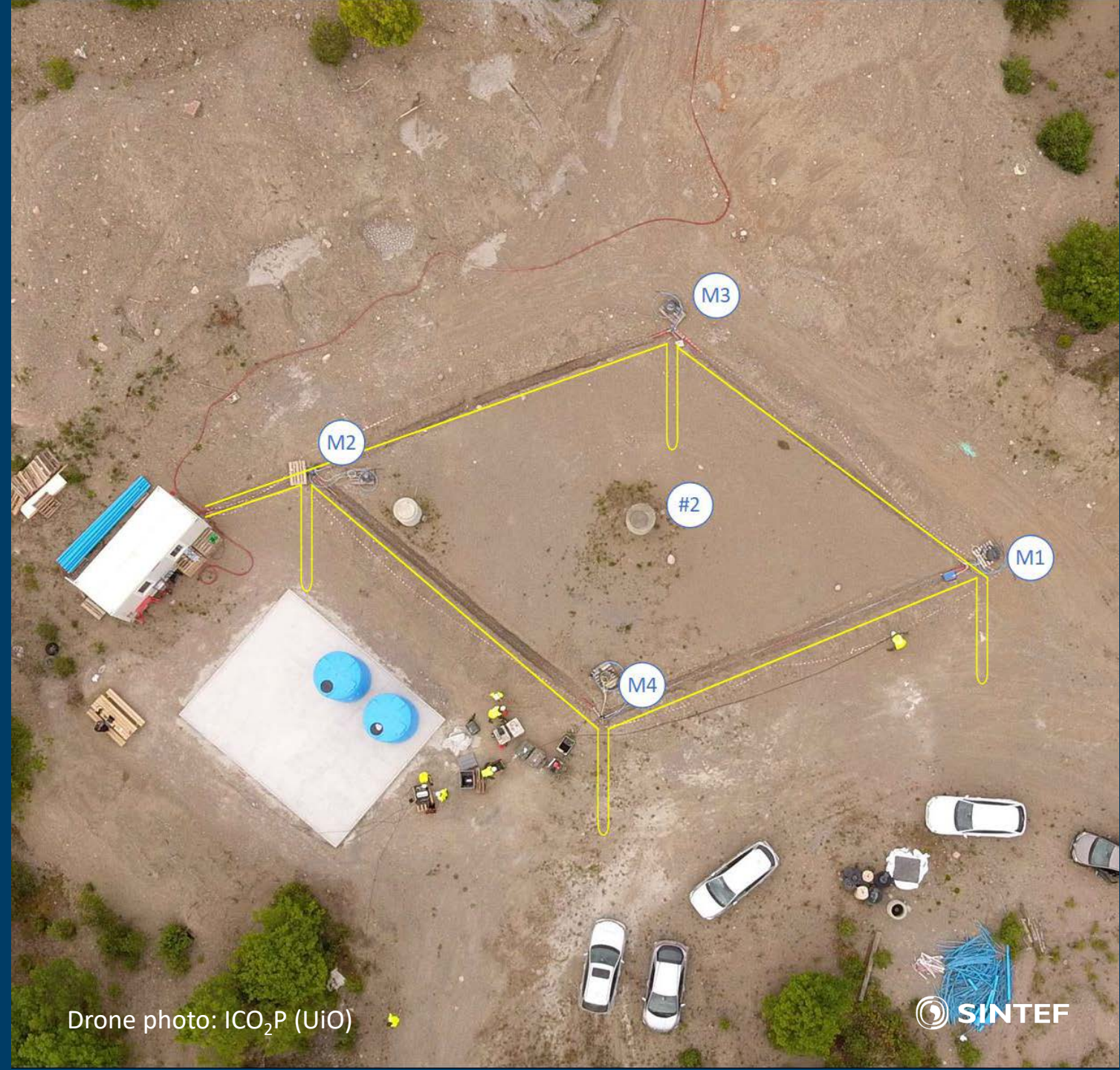
- Temperature (NTNU, Silixia)

### DURING WATER INJECTION

- Temperature (NTNU, Silixia)

### DURING CO<sub>2</sub> INJECTION

- Acoustic (FEBUS)
- Temperature (NTNU, Silixia)



Drone photo: ICO<sub>2</sub>P (UiO)



## ACKNOWLEDGEMENT

### SCIENTIFIC CONTRIBUTORS



UiO : University of Oslo

**NORSAR**



### FUNDING



### AUTHORITIES

