

# 4D Exploration

SODIR Technology Day - 2025  
Mark Van Schaack & Fabian Tillmans  
5 June 2025



# Outline

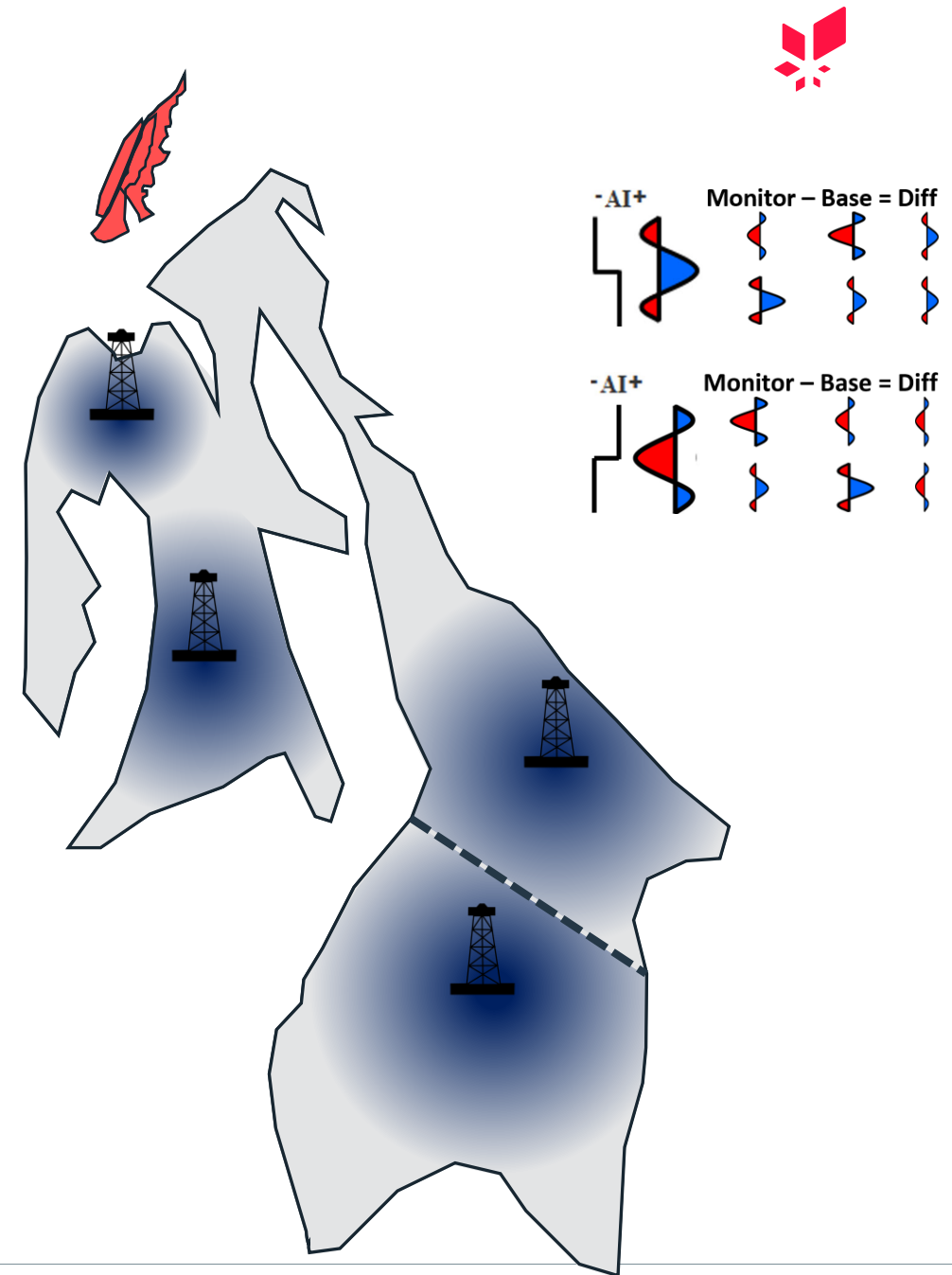
- Utilizing 4D Seismic Data in Exploration
  - 4D Production Monitoring vs Exploration
  - Potential 4D Signal Characteristics in Exploration
- 4D Exploration in Practice - Fram Example
  - Identifying Prospects
  - Fram Successes
    - Blasto
    - Rhombi
- Into the Future – Ways Forward
- Summary



## 4D Seismic Data: Production versus Exploration

# 4D Seismic Applied to Reservoir Monitoring, Development, and Exploration

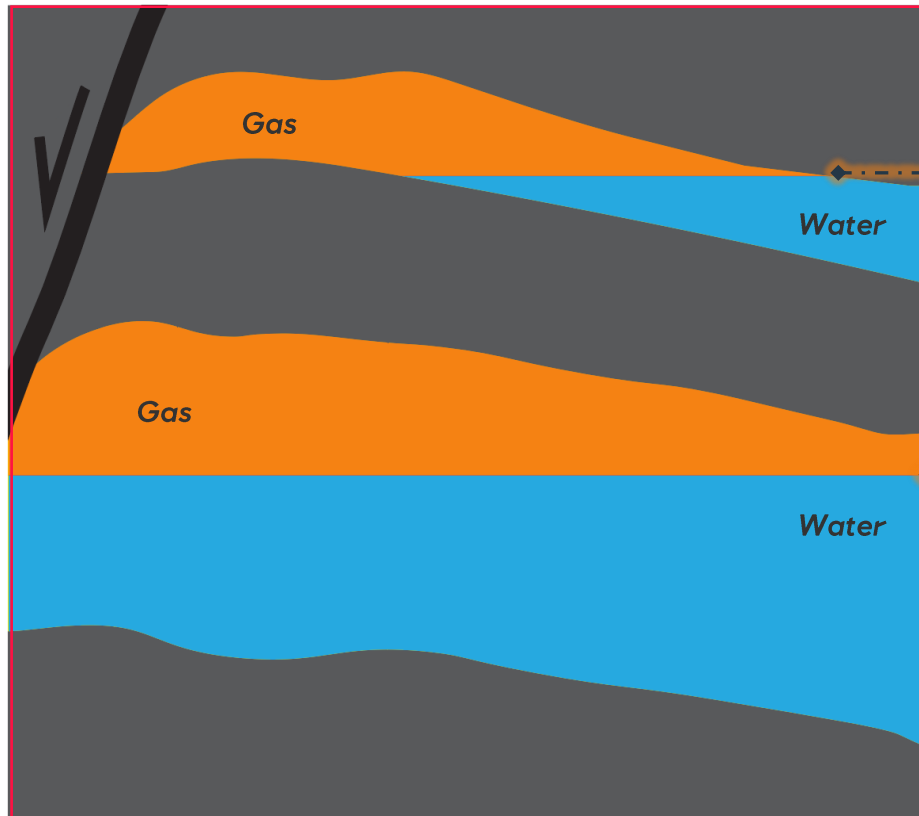
- 4D seismic observes changes in impedance (~rock hardness) over time
- Replacing softer fluids with harder fluids generally makes the rock harder
- Decreasing pore pressure of the rock generally makes the rock harder



# Potential 4D Depletion Effects in a Single-Phase Gas Field



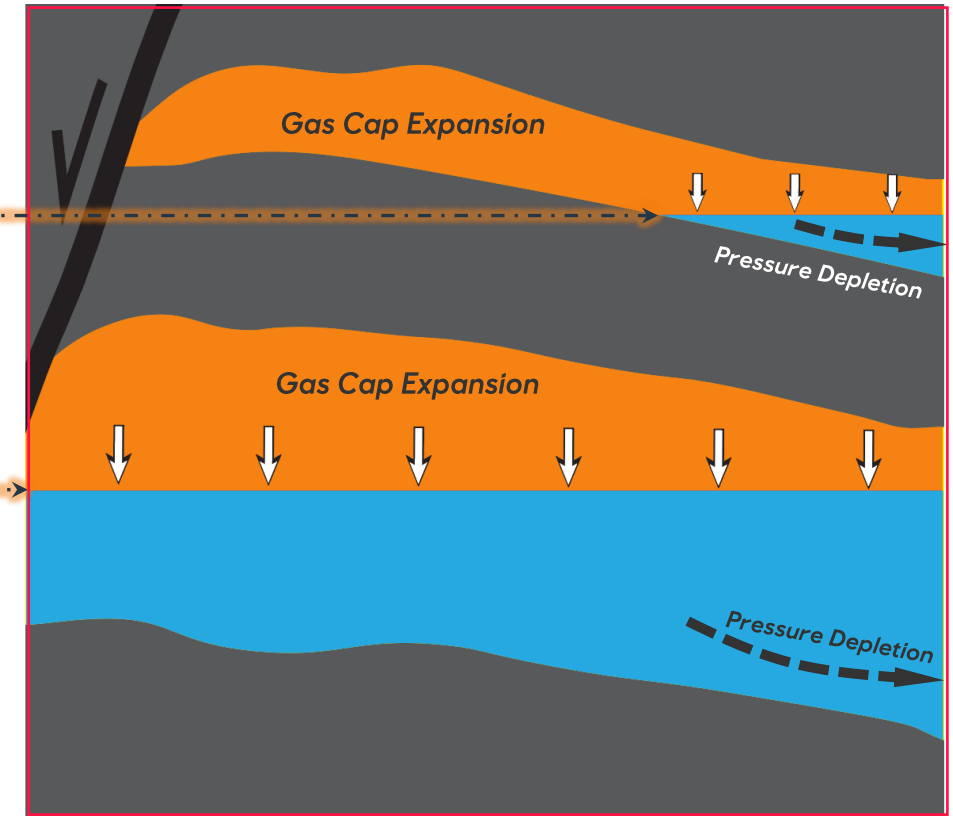
Baseline Condition  
(fluids in equilibrium)



depletion



4D Effects  
Following Depletion\*



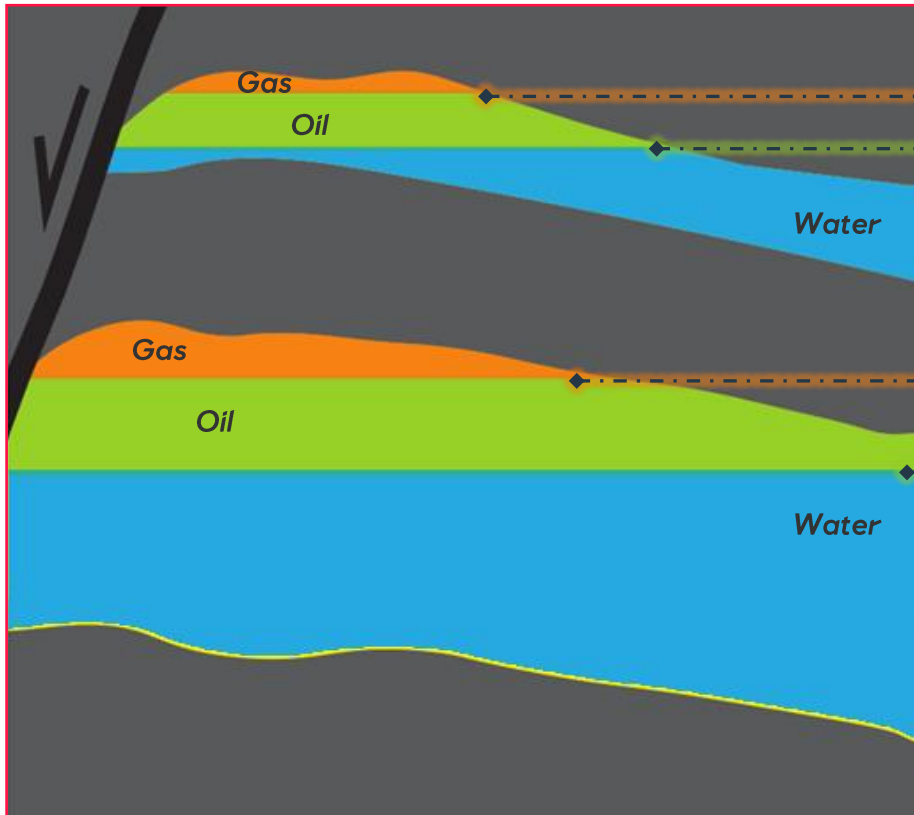
- Potentially large changes in reflectivity where gas has displaced water – otherwise subtle
- **Minor time shift changes depending on the change in GWC**

\*contact depth change conceptual

# Potential 4D Depletion Effects in a Two-Phase Oil Field



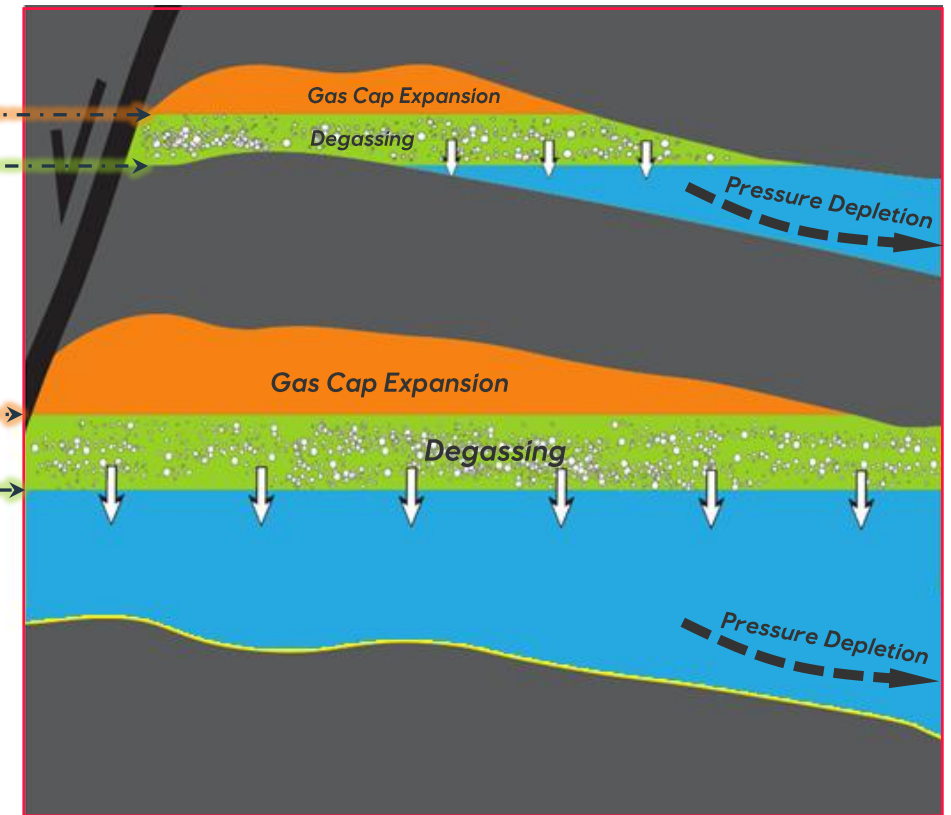
Baseline Condition  
(fluids in equilibrium)



depletion



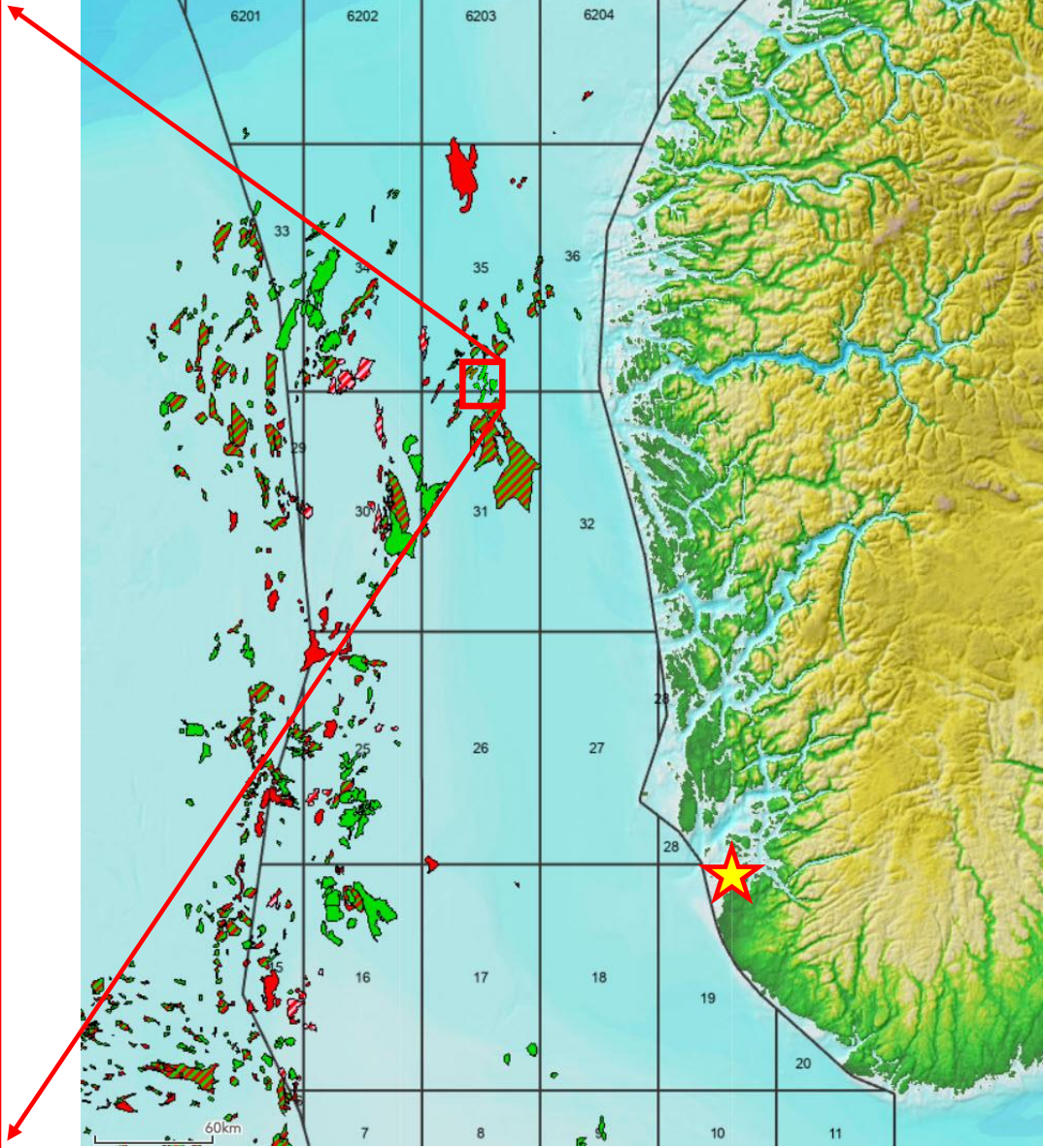
4D Effects  
Following Depletion\*

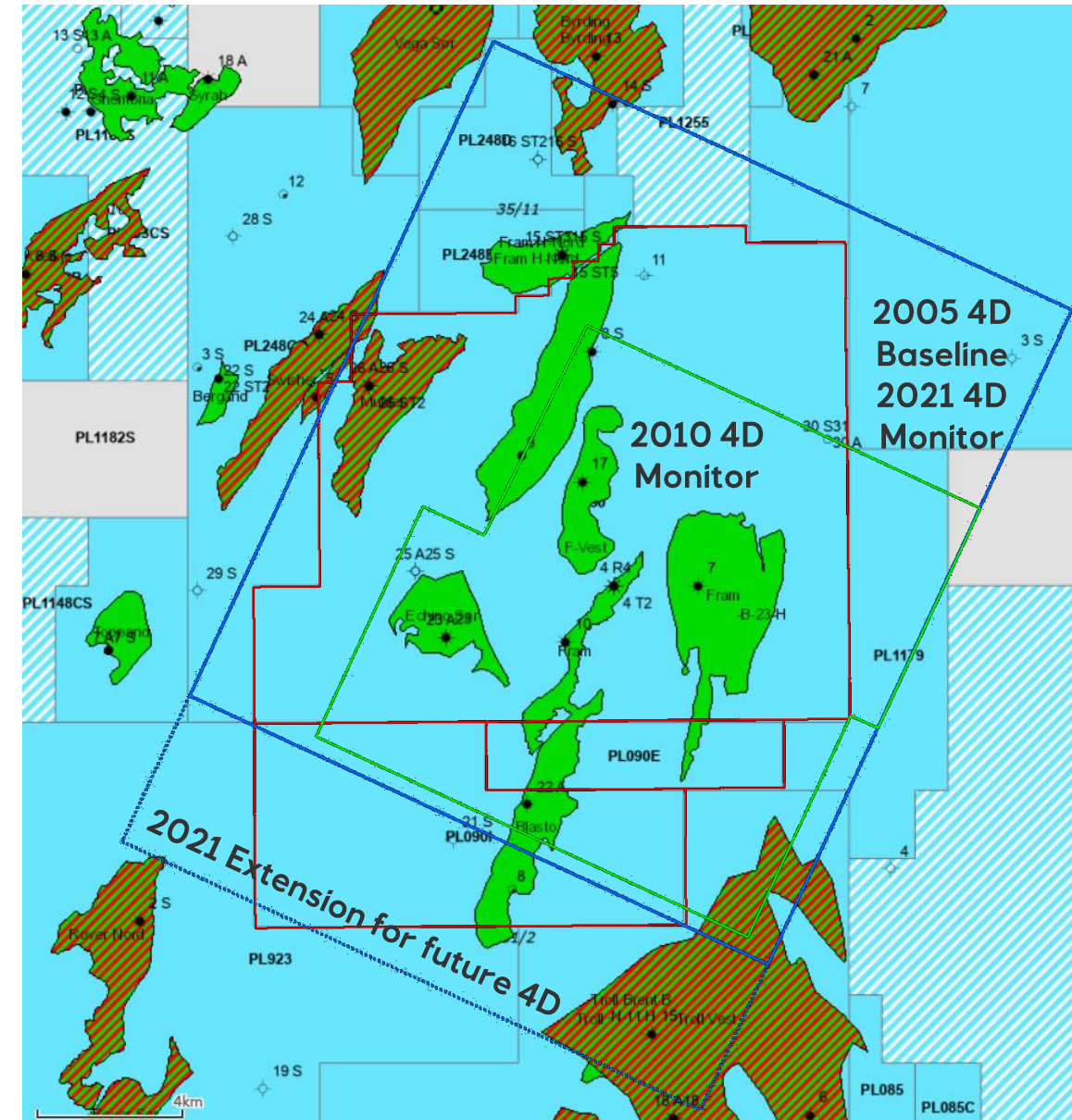


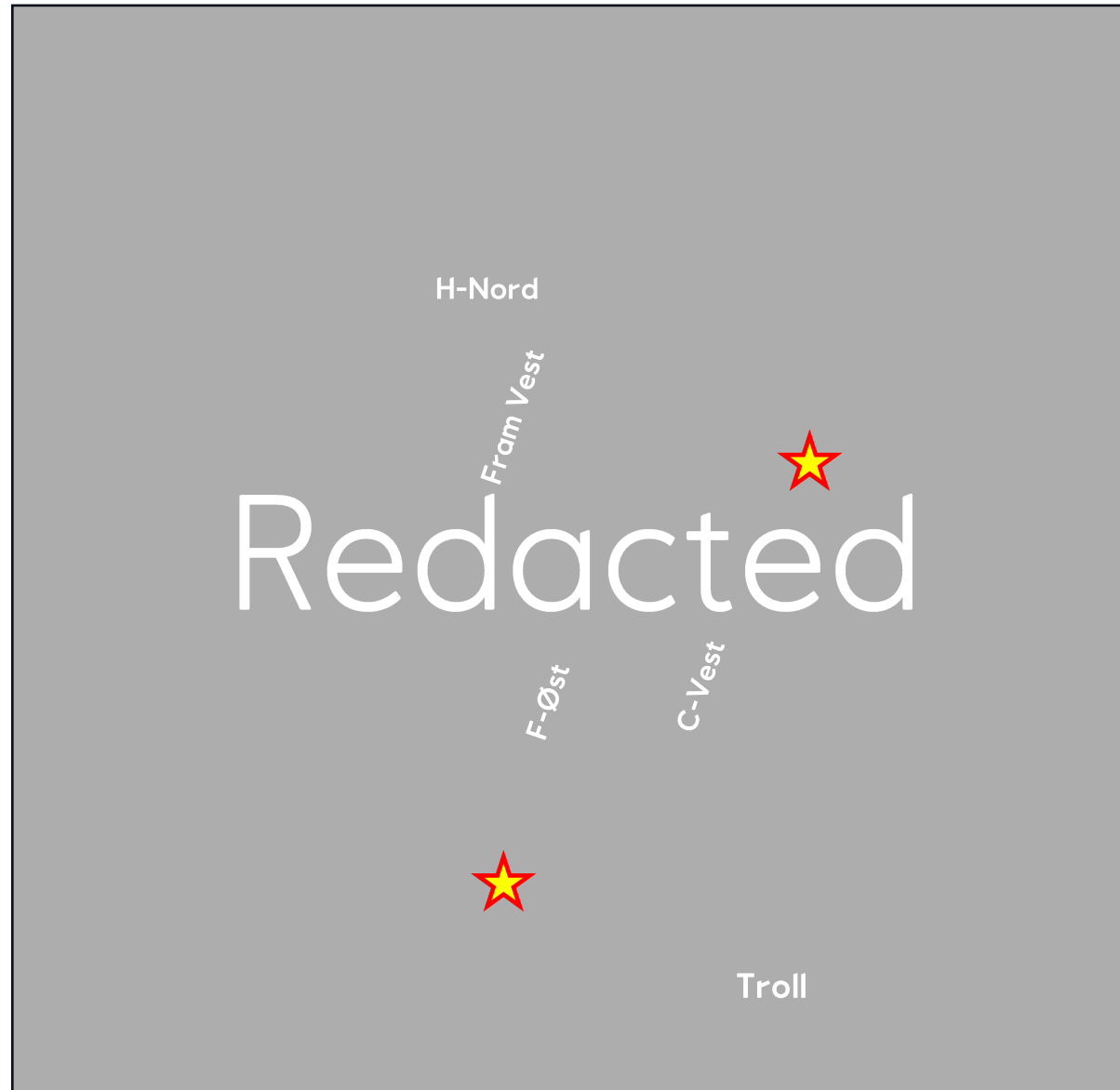
- Potentially large changes in reflectivity where gas/gas saturated oil has displaced oil/water
- **Large time shift changes from gas out of solution in oil**



## 4D Exploration in Practice – Fram Example









## Successes – Blasto and Rhombi



Blasto West

Blasto Main



# Blasto - Sognefjord



Depth m

EQ22M07 Enhanced Full\*

Shetland

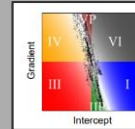
BCU

Sognefjord



Depth m

AVO Class Strength\*



Depth m

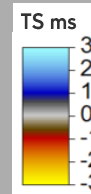
'21-'05 4D Difference

Redacted



Depth m

'21-'05 4D Timeshifts



Top Blasto Depth  
Sognefjord Unit 3

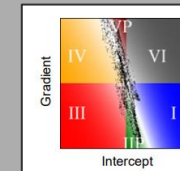
Top Sognefjord  
'21-'05 4D Difference - RMS 0-100ms



Redacted



★  
31/2-8



★  
31/2-8

X

Rhombi West

Rhombi East

X'

# Rhombi - Sognefjord



Depth m

EQ22M07 Enhanced Full\*

BCU Sognefjord

Fensfjord

VIRIDIEN

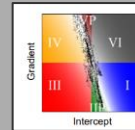
Canyon Incision



Depth m

AVO Class Strength\*

VIRIDIEN



Redacted

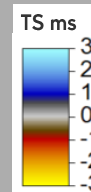
'21-'05 4D Difference

Depth m



Depth m

'21-'05 4D Timeshifts



Top Rhombi Depth  
Sognefjord

Top Rhombi Sognefjord  
'21-'05 4D Difference - RMS -15/50m

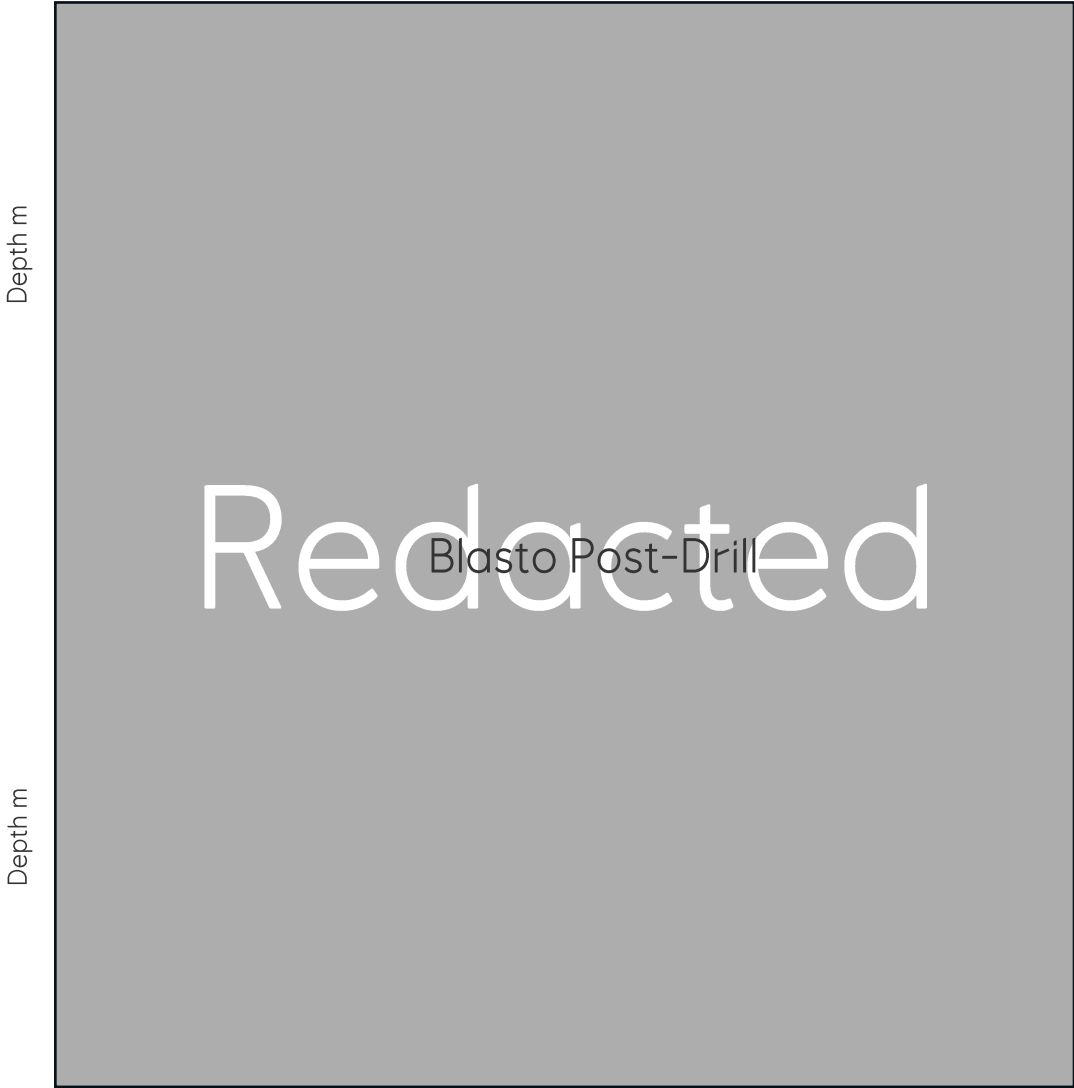
X

X'

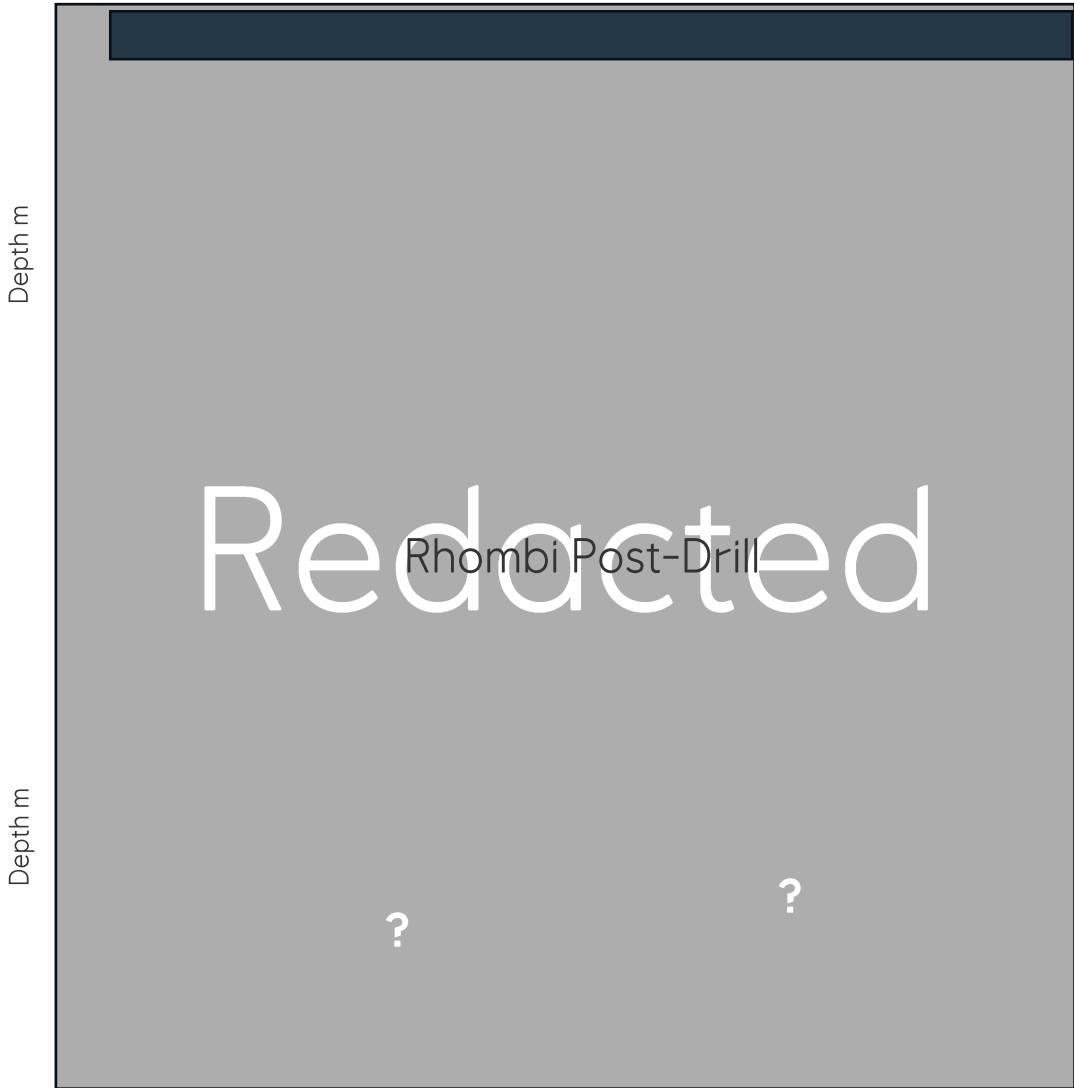
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Blasto Pre-Drill



Rhombi Pre-Drill



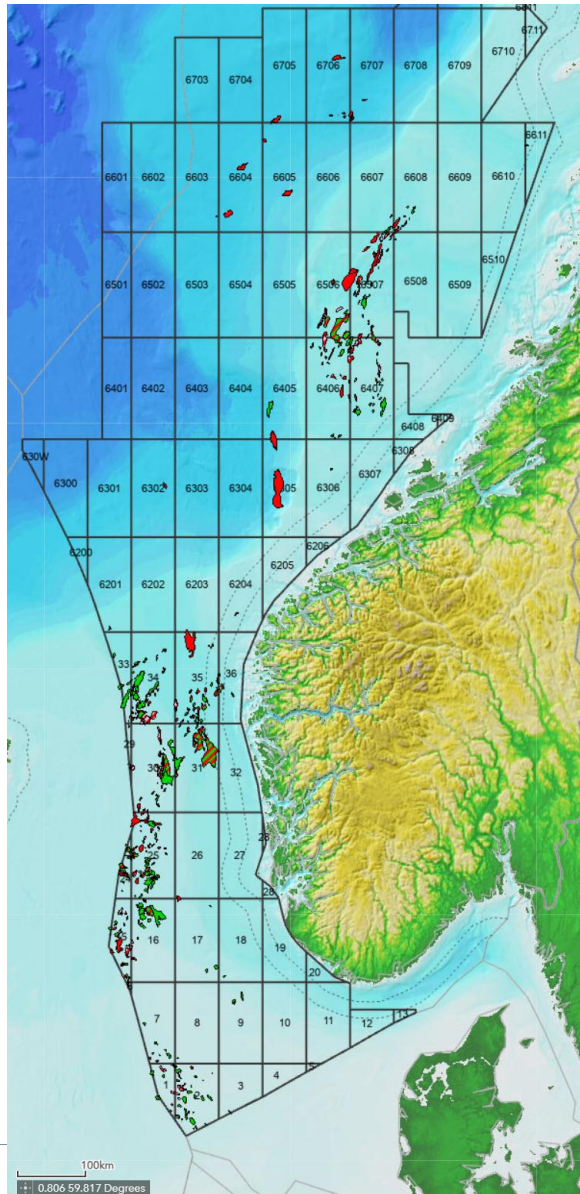


# Into the Future – Ways Forward

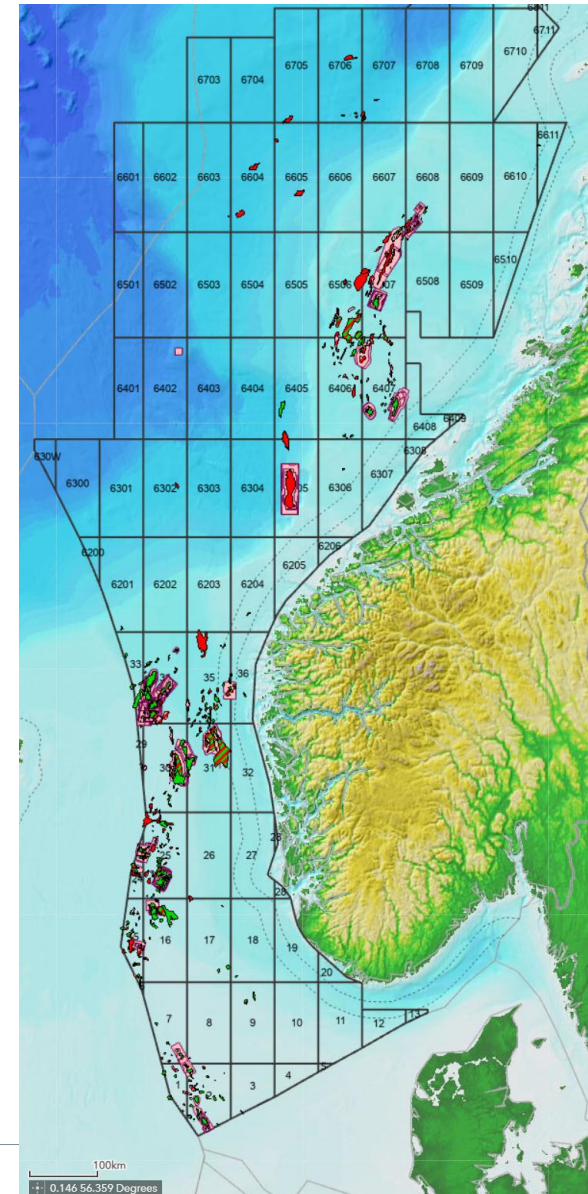
# 4D Coverage Offshore Norway



## Fields & Discoveries



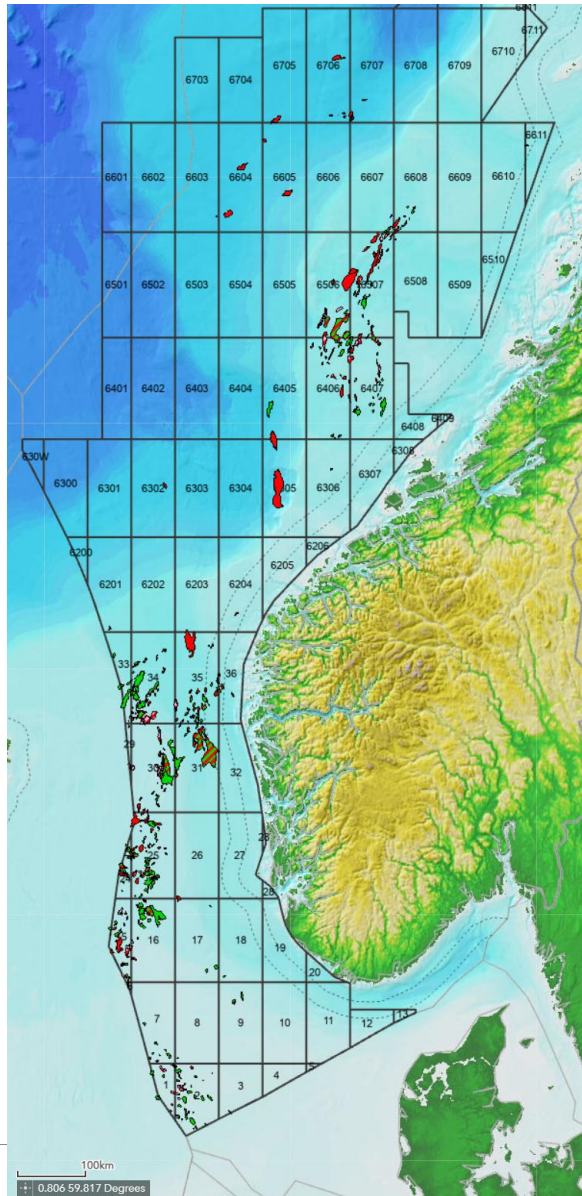
## Fields & Discoveries & 4D



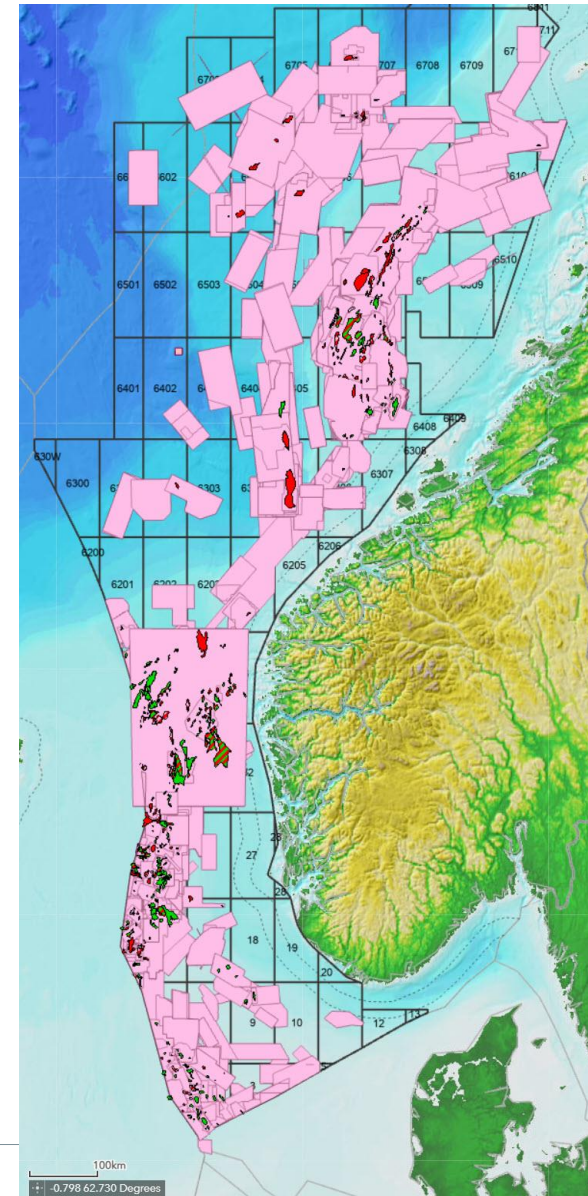
# 3D Coverage Offshore Norway



Fields & Discoveries



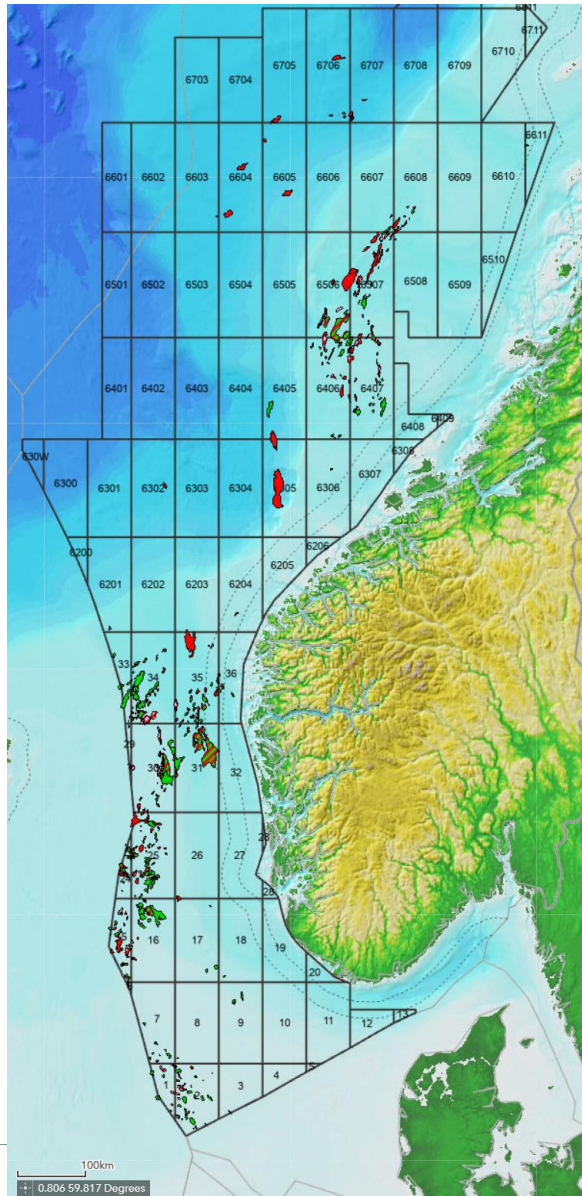
Fields & Discoveries & 3D



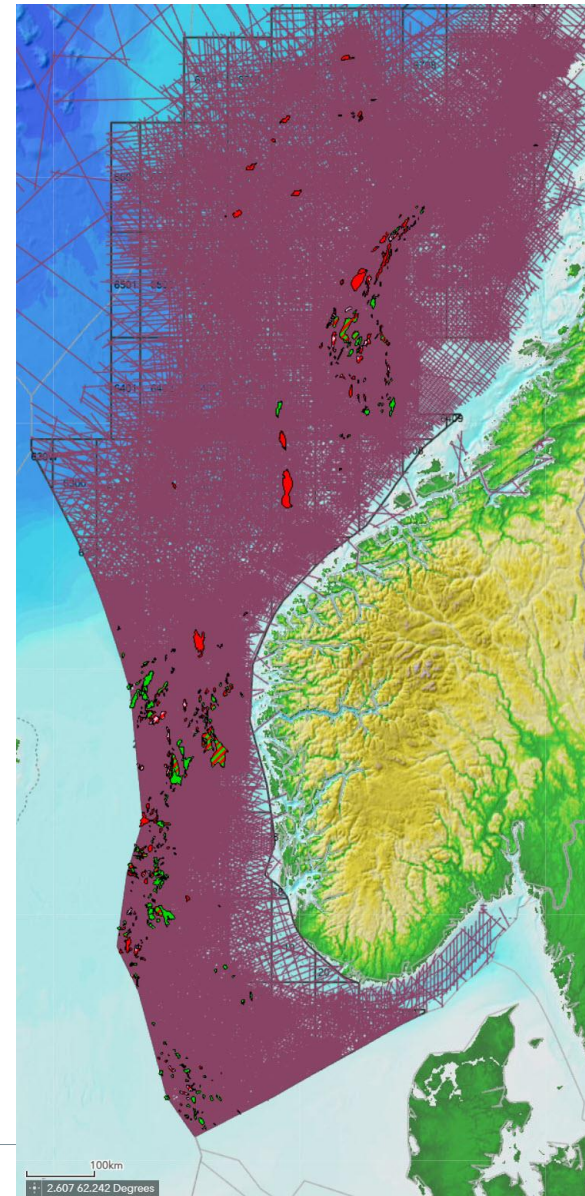
# 2D Coverage Offshore Norway



## Fields & Discoveries



## Fields & Discoveries & 2D





## Summary

- “4D for Exploration” is a natural extension of the 4D seismic time-lapse reservoir monitoring technique and is used to identify new hydrocarbon volumes – which will typically be found near infrastructure
- The long term prognosis for the NCS is increasing levels of pressure depletion creating more opportunities for exploration using this technique
- A primary limiting factor of “4D for Exploration” is the availability of long-term time-lapse surveys of large extent
  - Can we make use of “non-standard” seismic data to extend our coverage?



## Acknowledgements

- Equinor Exploration: Åshild Danielsen Kvamme, Per Walter Ulvedal, Åshild Winsnes and many others...
- Equinor Research and Technology: Svend Østmo, Vegard Berg, Sondre Torset and Thomas Røste\*
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- Fram Field Development: Shicun Ren, Laust Jørgensen
- PL090 License Partners: Vår Energy & INPEX Idemitsu Norge



## 4D Exploration

Mark Van Schaack and Fabian Tillmans

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