4D Exploration

SODIR Technology Day - 2025
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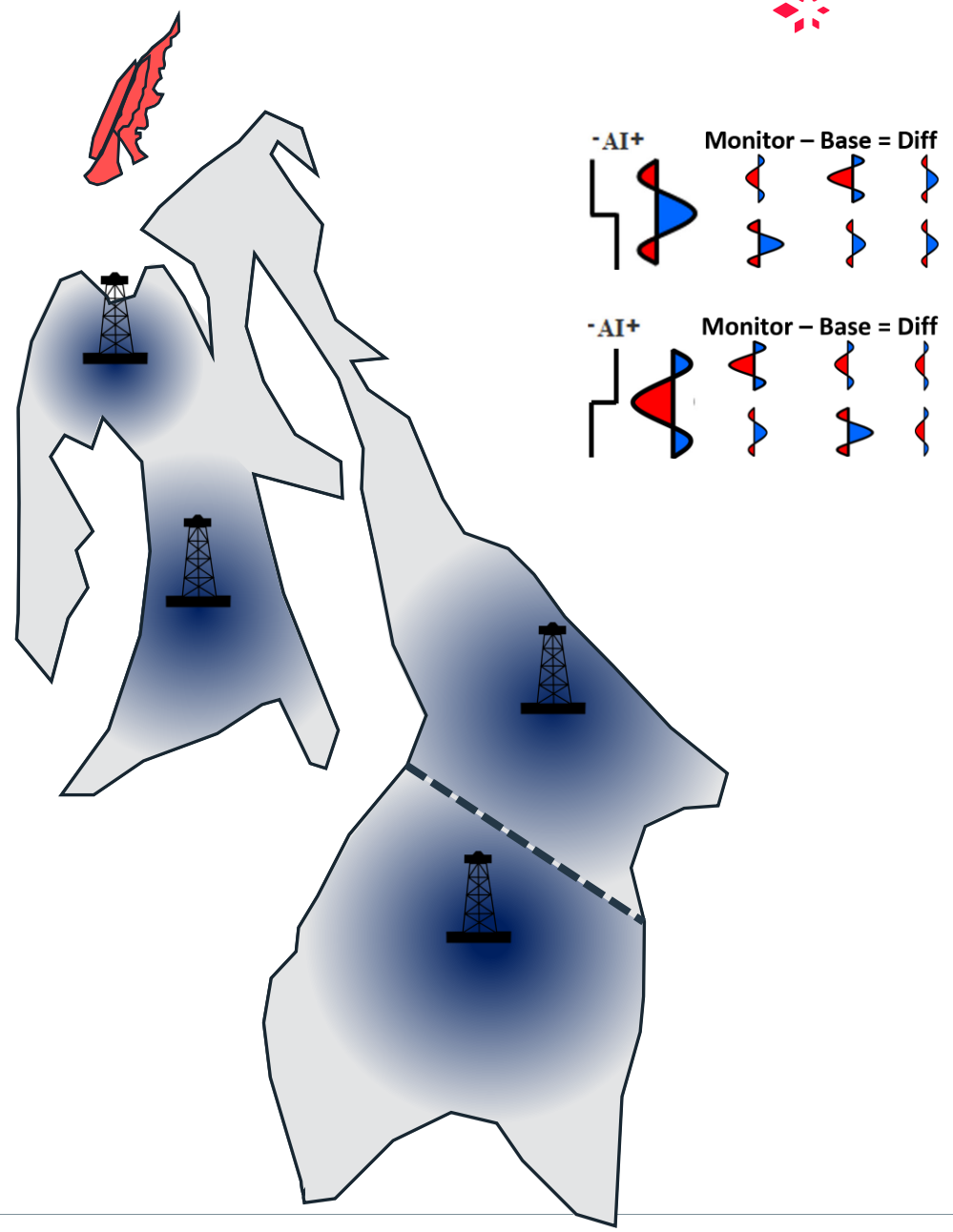
Outline

- 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

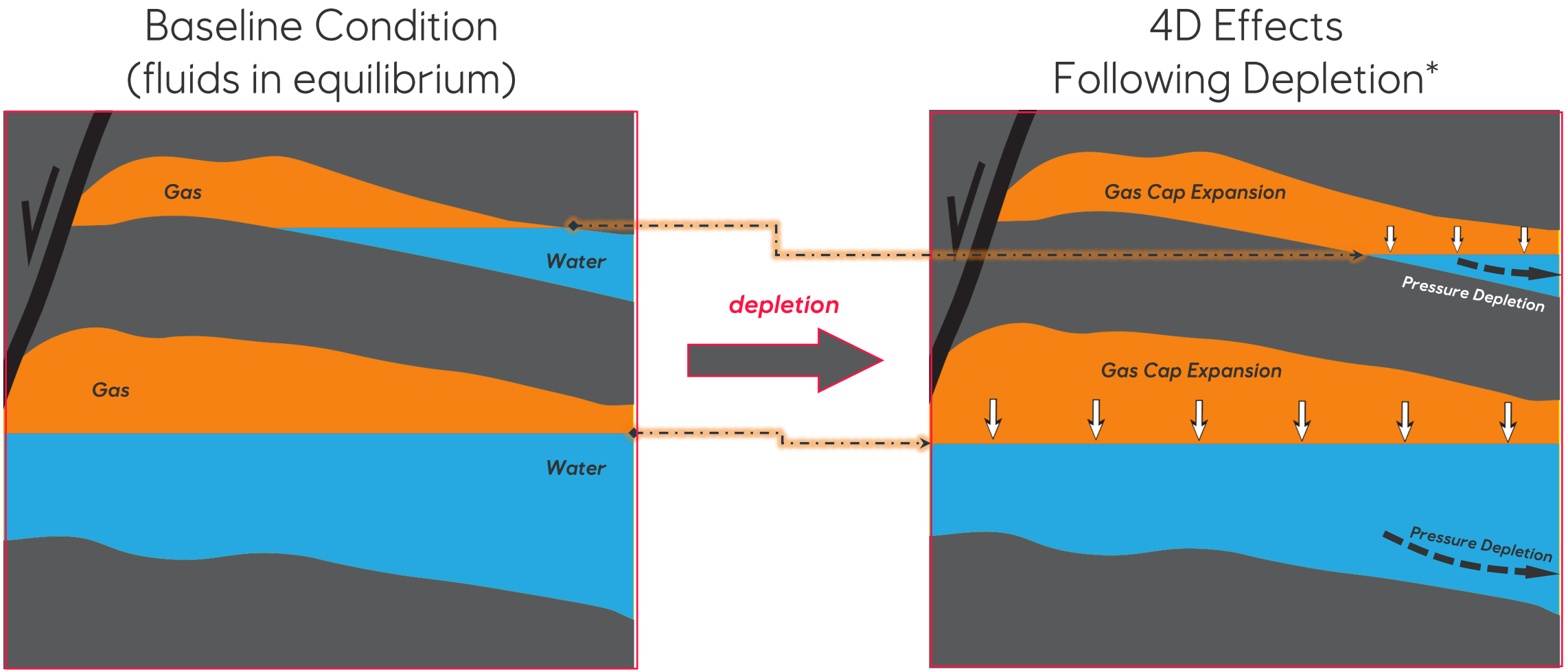
4D Seismic Data: Production versus Exploration

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



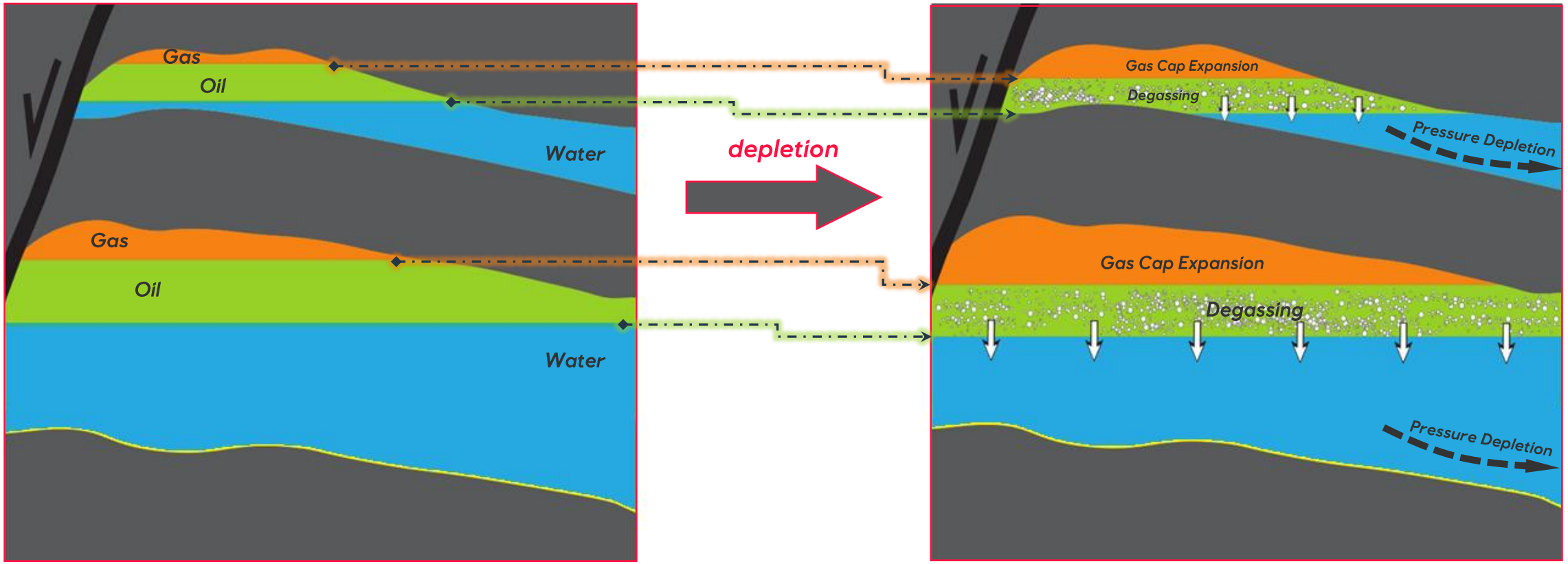
- Potentially large changes in reflectivity where gas has displaced water – otherwise subtle
- **Minor time shift changes depending on the change in GWC**

**contact depth change conceptual*

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

Baseline Condition (fluids in equilibrium)

4D Effects Following Depletion*

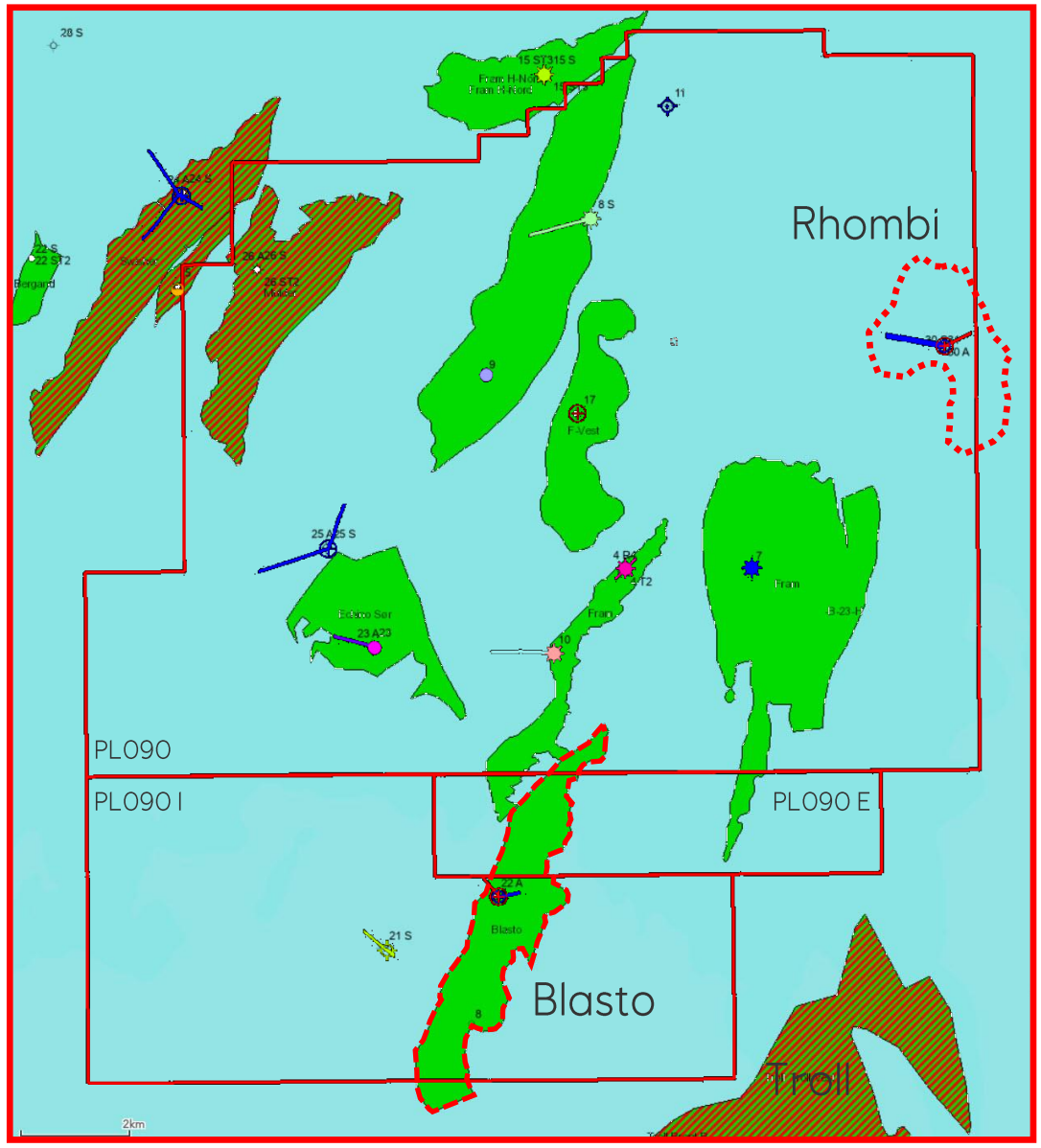


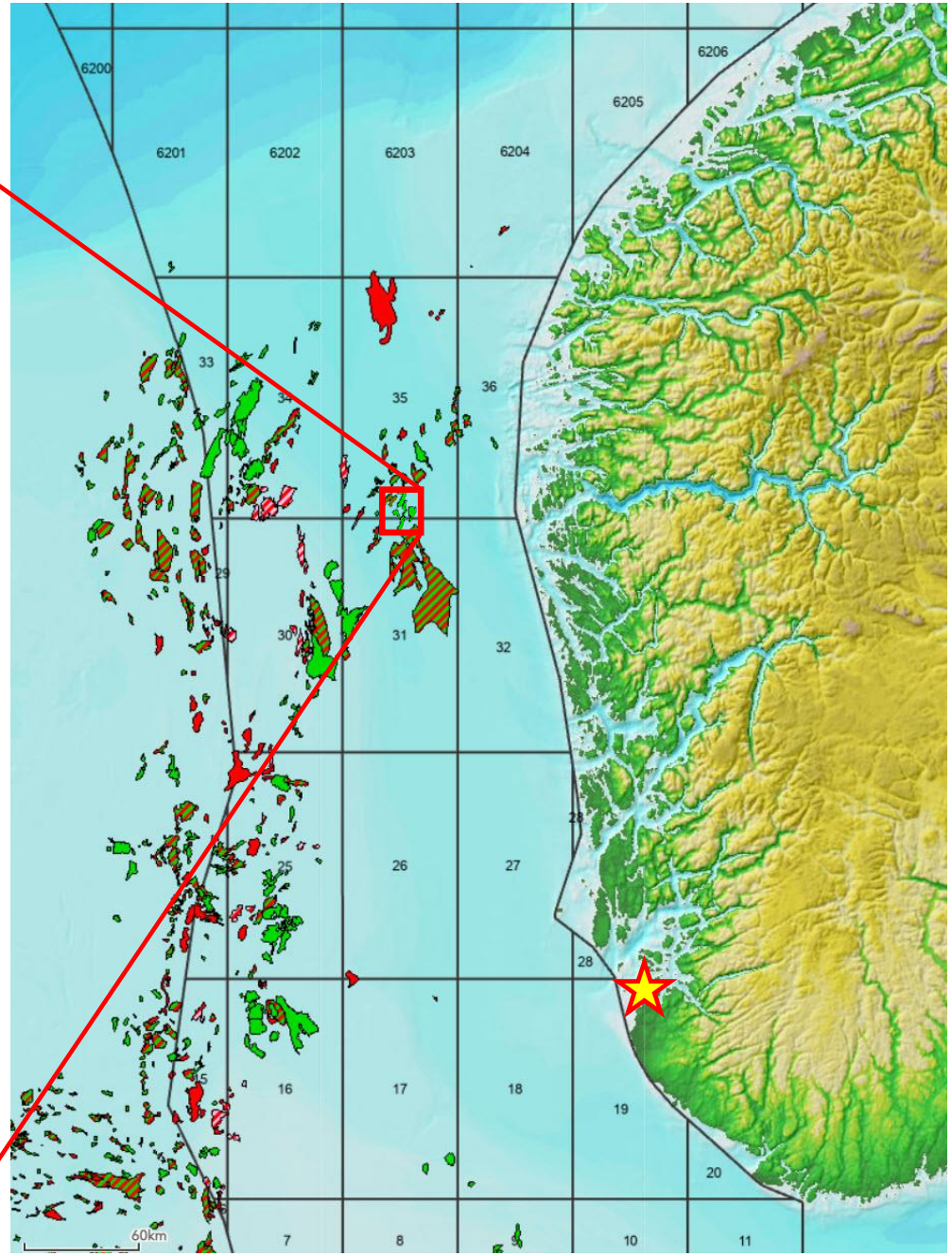
- Potentially large changes in reflectivity where gas/gas saturated oil has displaced oil/water
- **Large time shift changes from gas out of solution in oil**

**contact depth change conceptual*

4D Exploration in Practice – Fram Example

Location Map – Fram Area



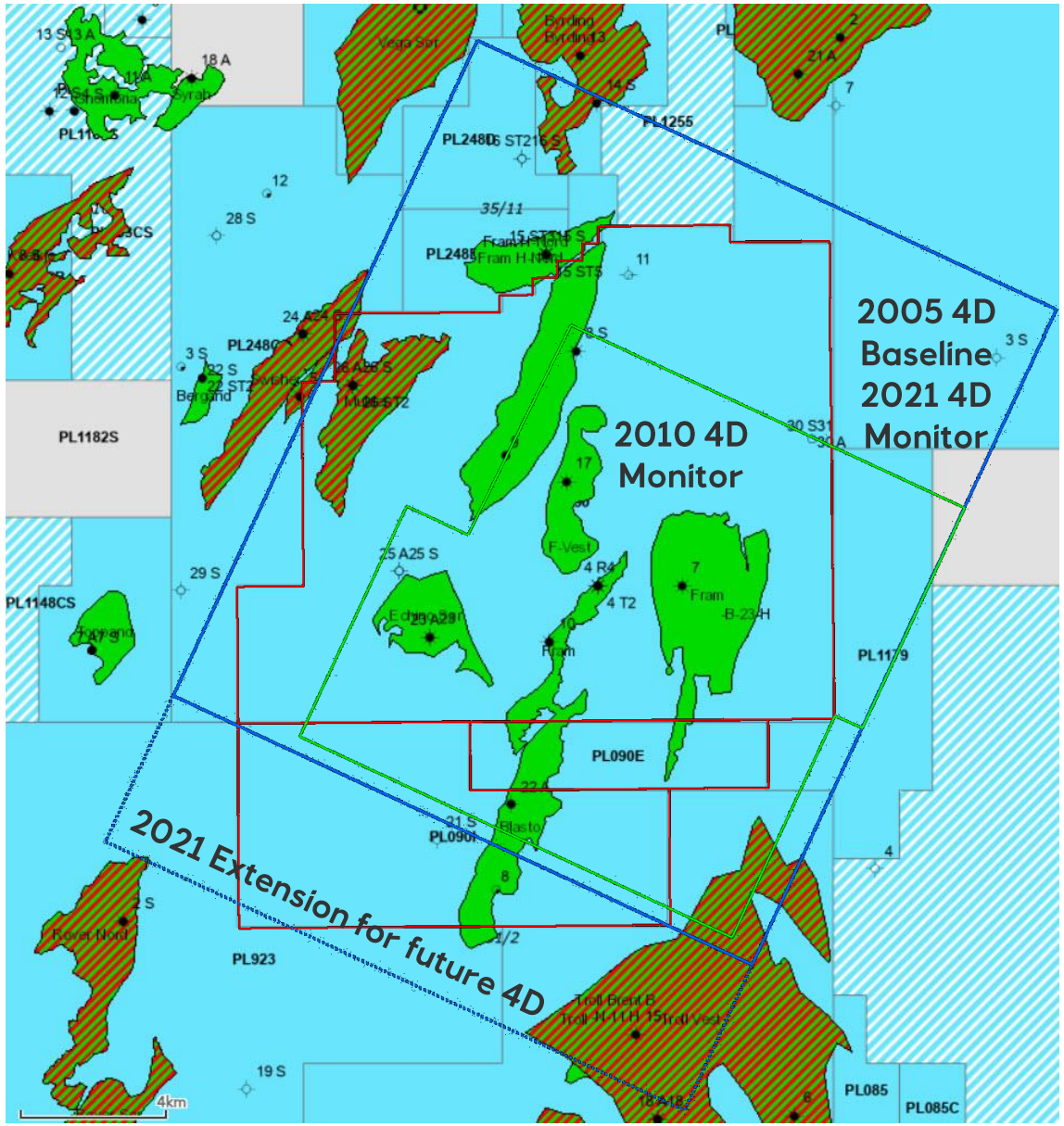


Fram 4D Surveys

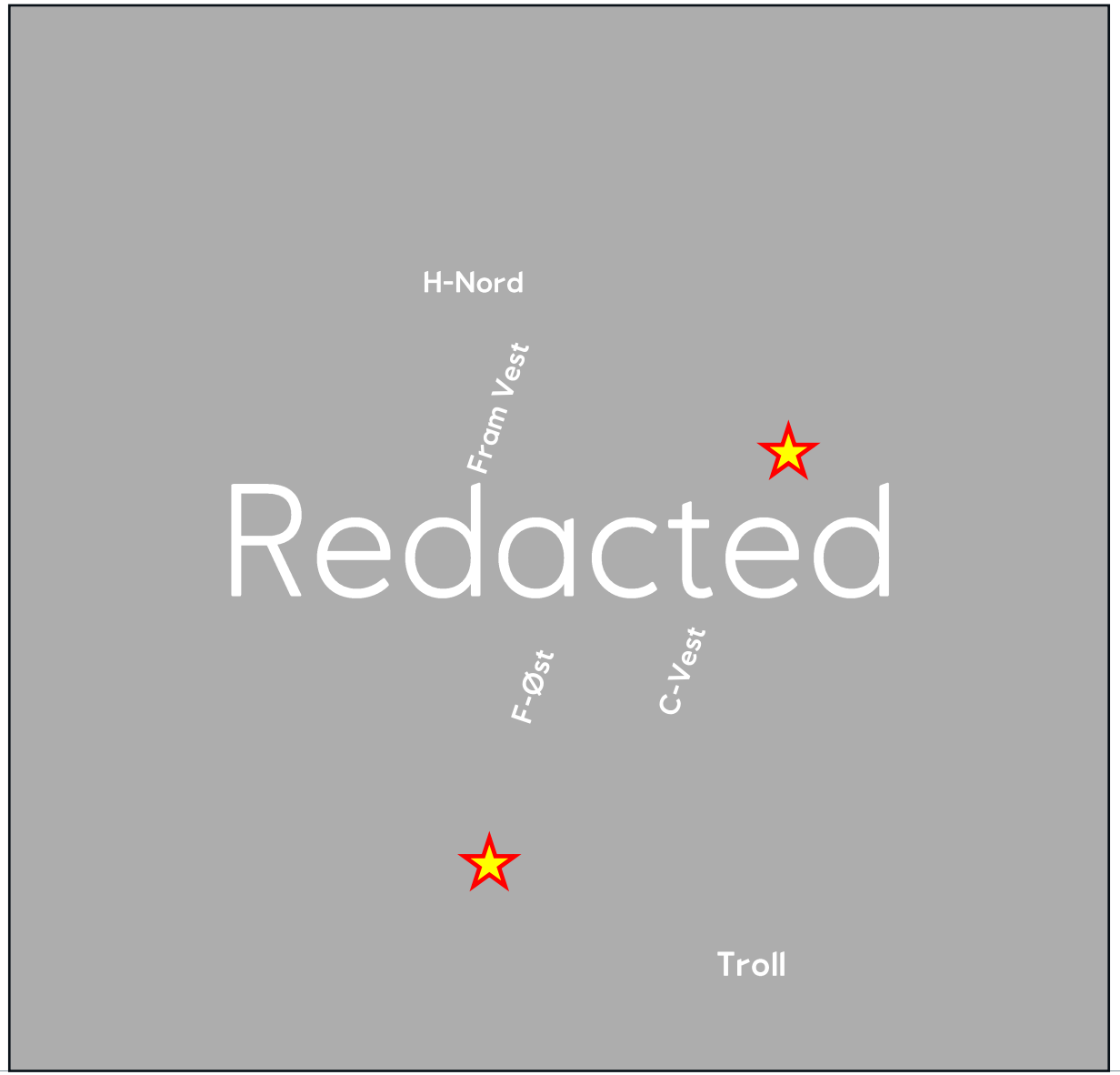
Baseline Survey
- 2005

Production Monitor
- 2010
- Used in Blasto Discovery

Exploration 4D
- 2021
- Rhombi Discovery

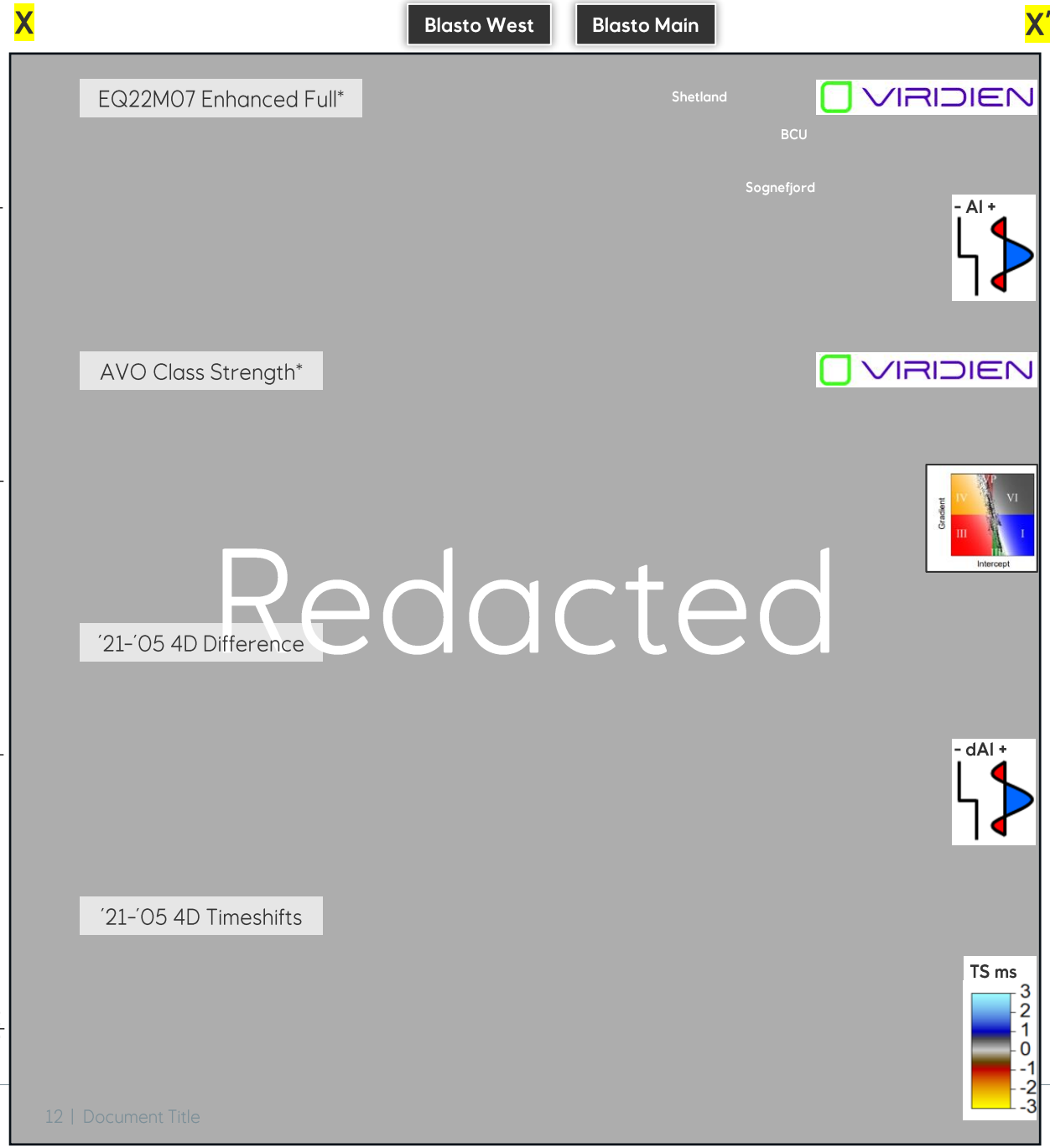


Fram 4D Difference 2005 vs 2021 – Sognefjord



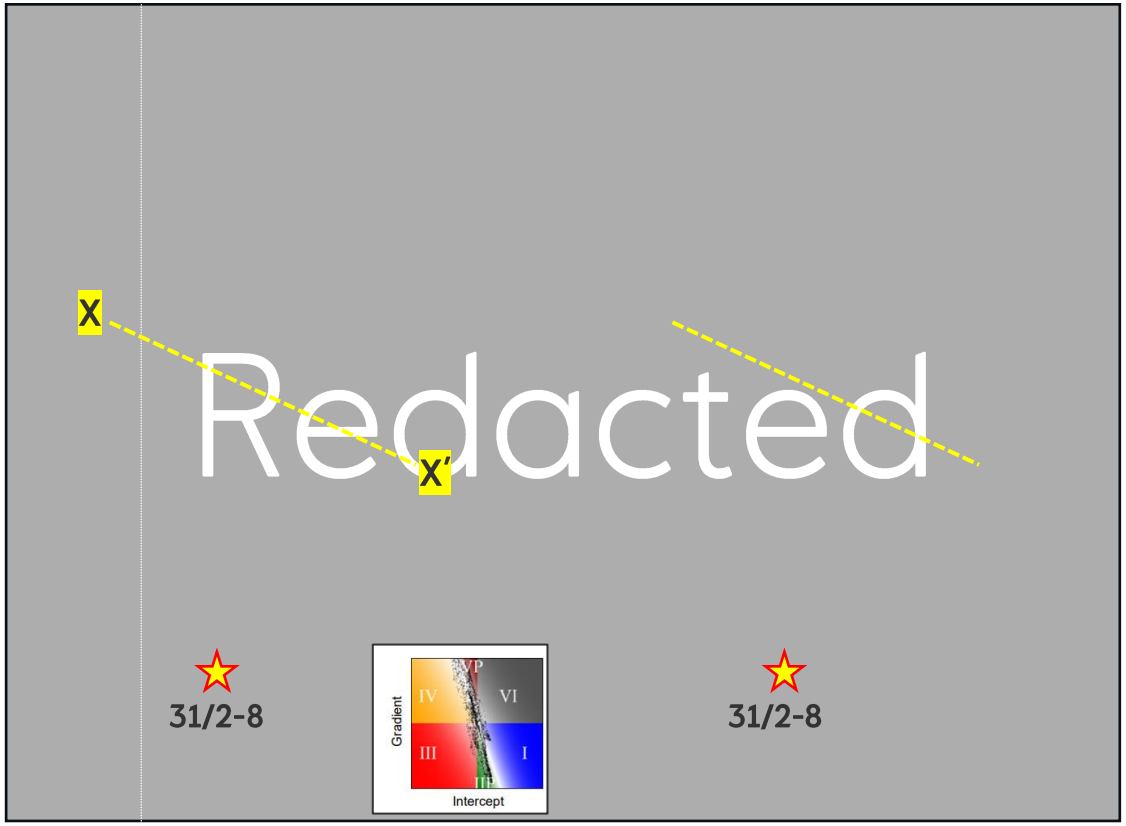
Successes – Blasto and Rhombi

Blasto - Sognefjord



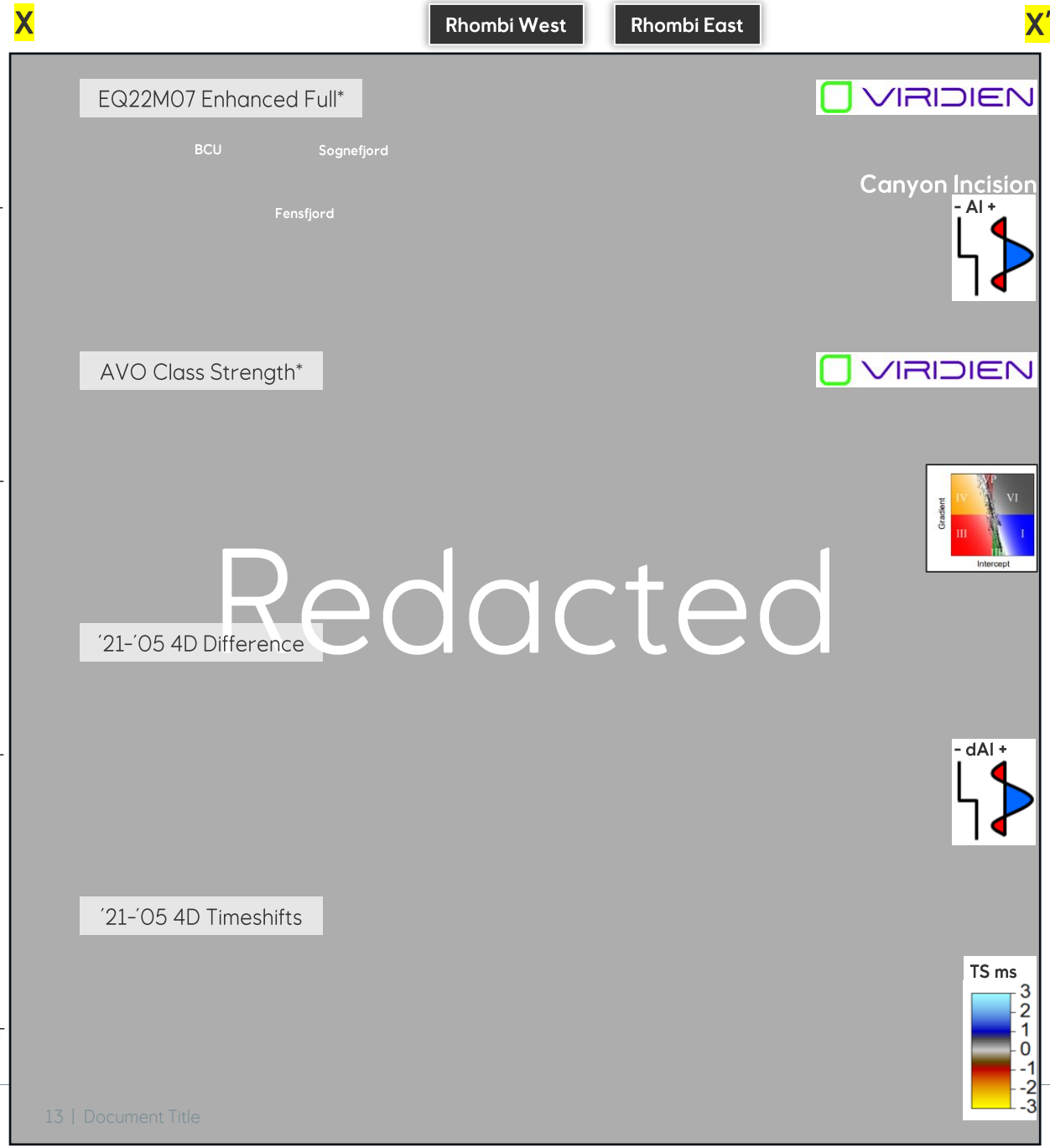
Top Blasto Depth
Sognefjord Unit 3

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



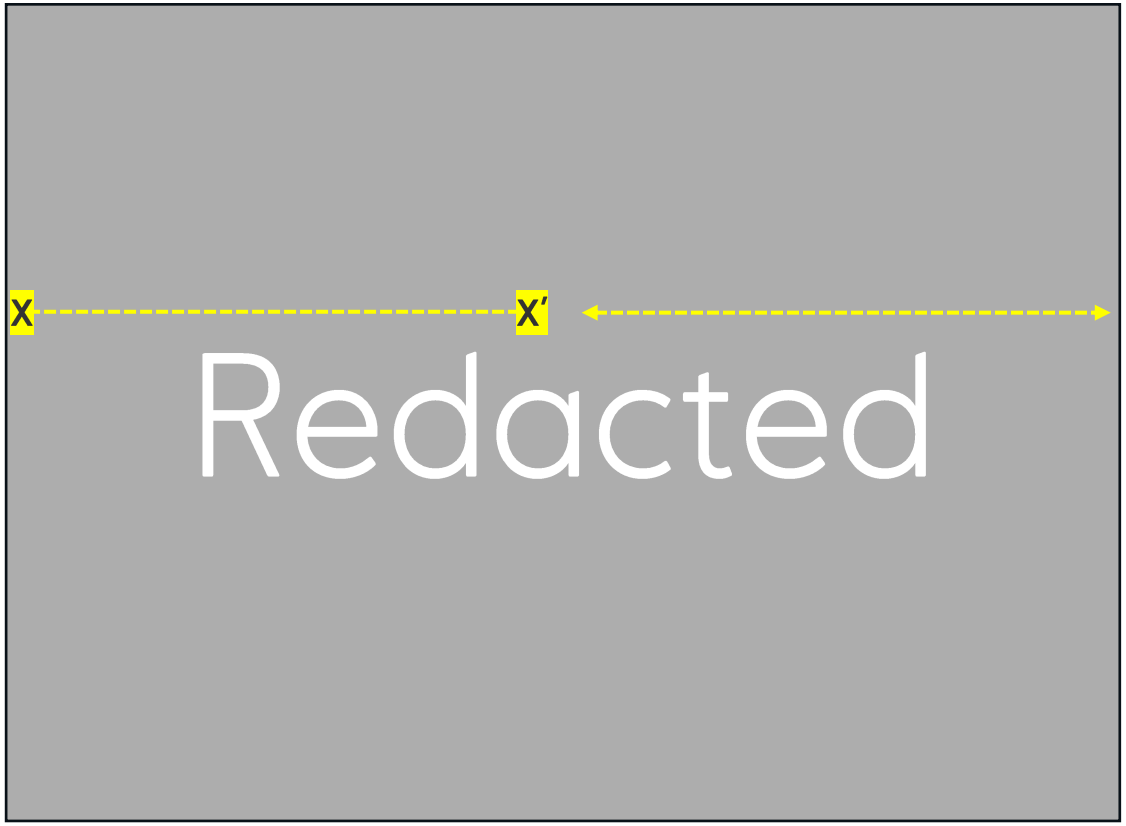
* Courtesy of Viridien

Rhombi – Sognefjord



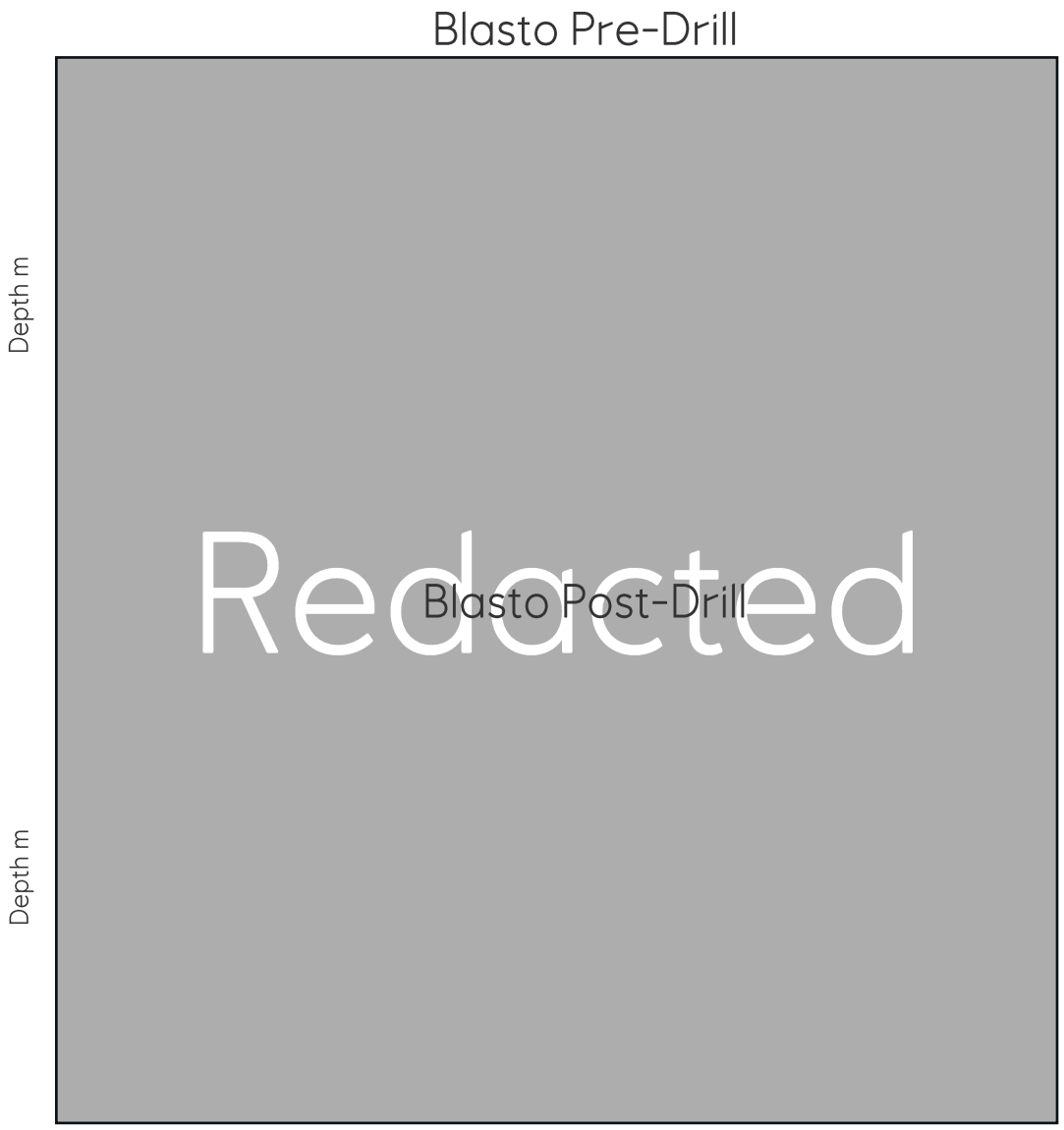
Top Rhombi Depth Sognefjord

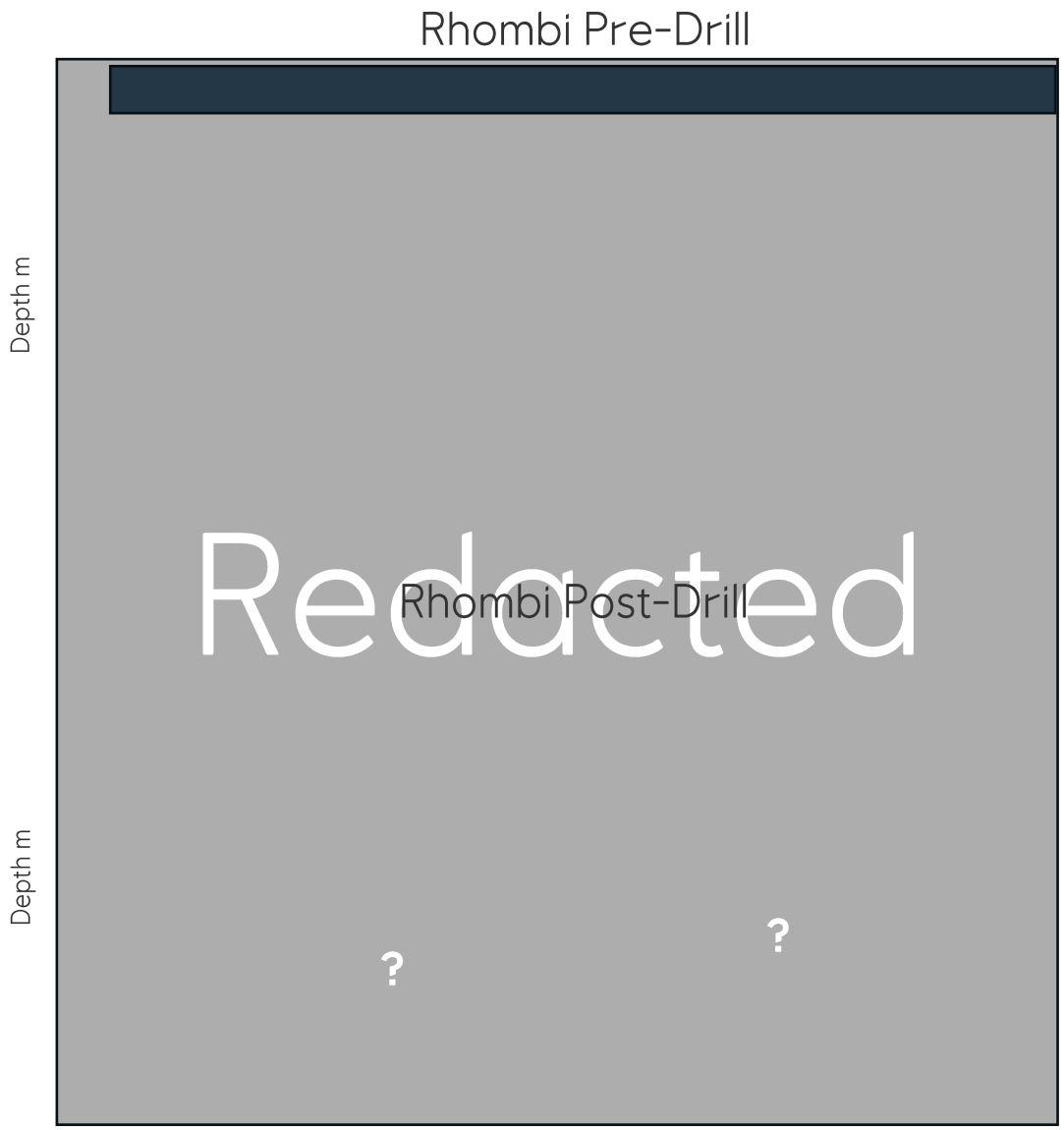
Top Rhombi Sognefjord '21-'05 4D Difference – RMS -15/50m



* Courtesy of Viridien

Blasto and Rhombi Drilling Results

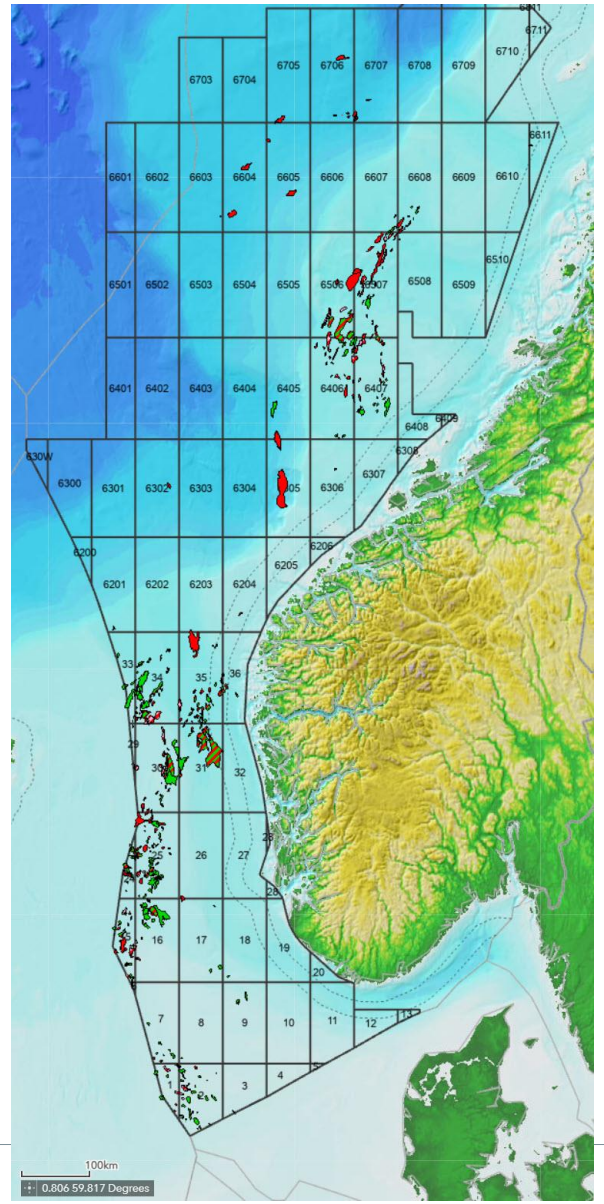




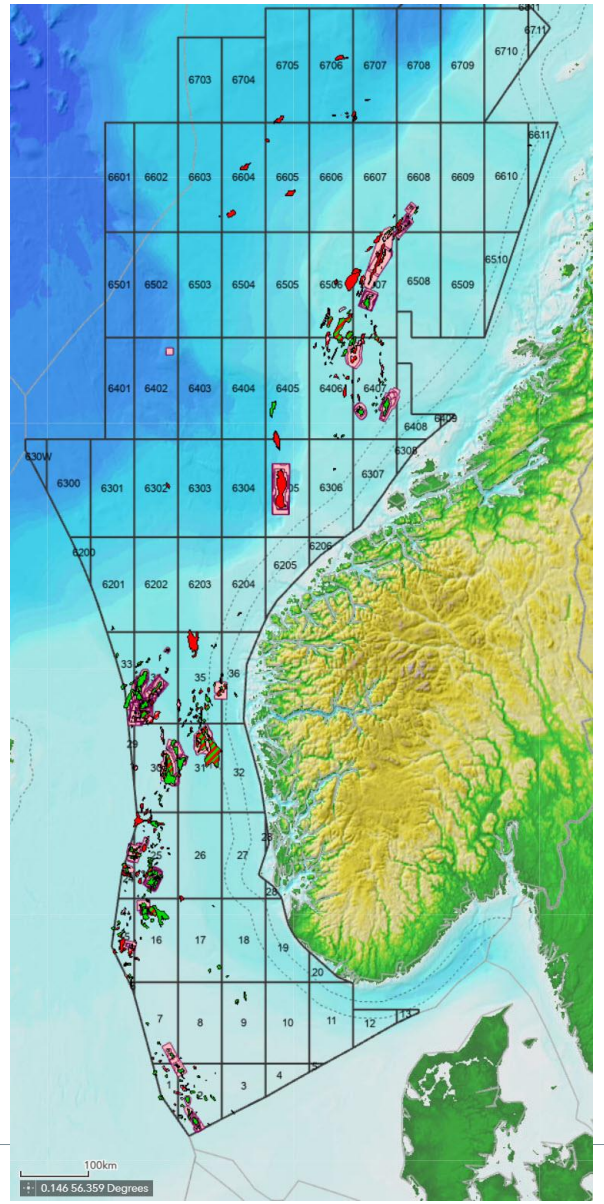
Into the Future – Ways Forward

4D Coverage Offshore Norway

Fields & Discoveries

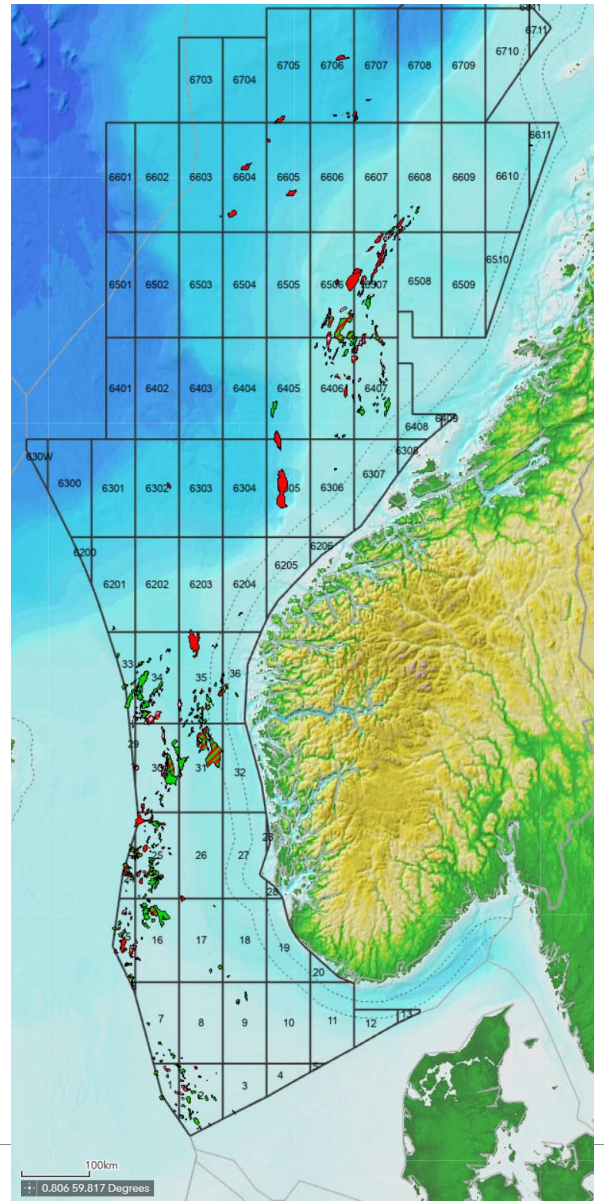


Fields & Discoveries & 4D

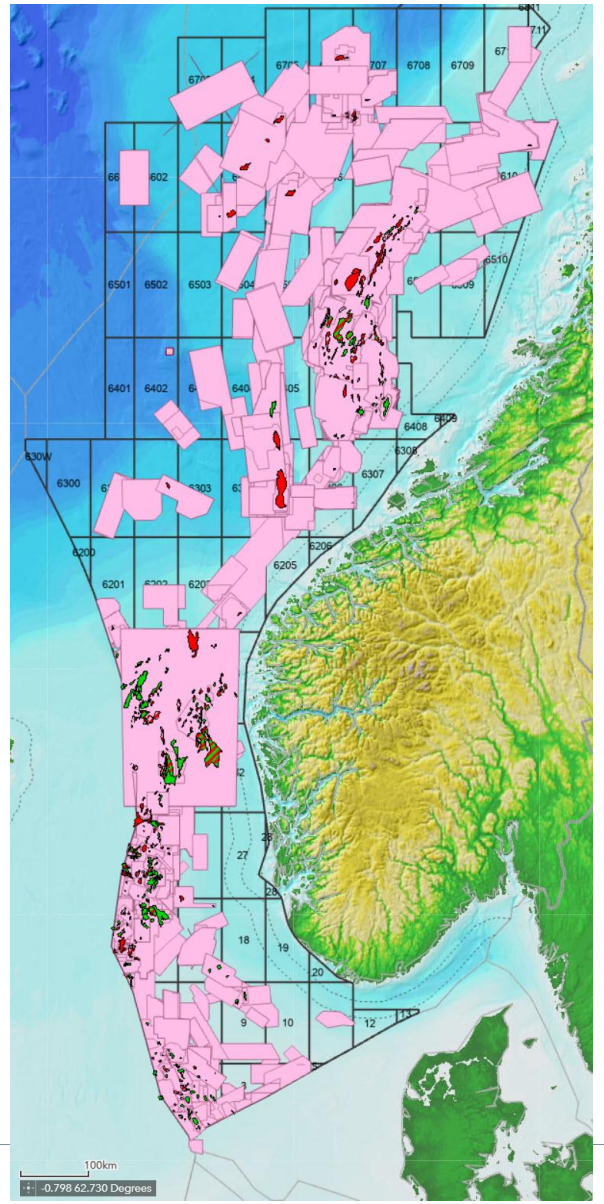


3D Coverage Offshore Norway

Fields & Discoveries

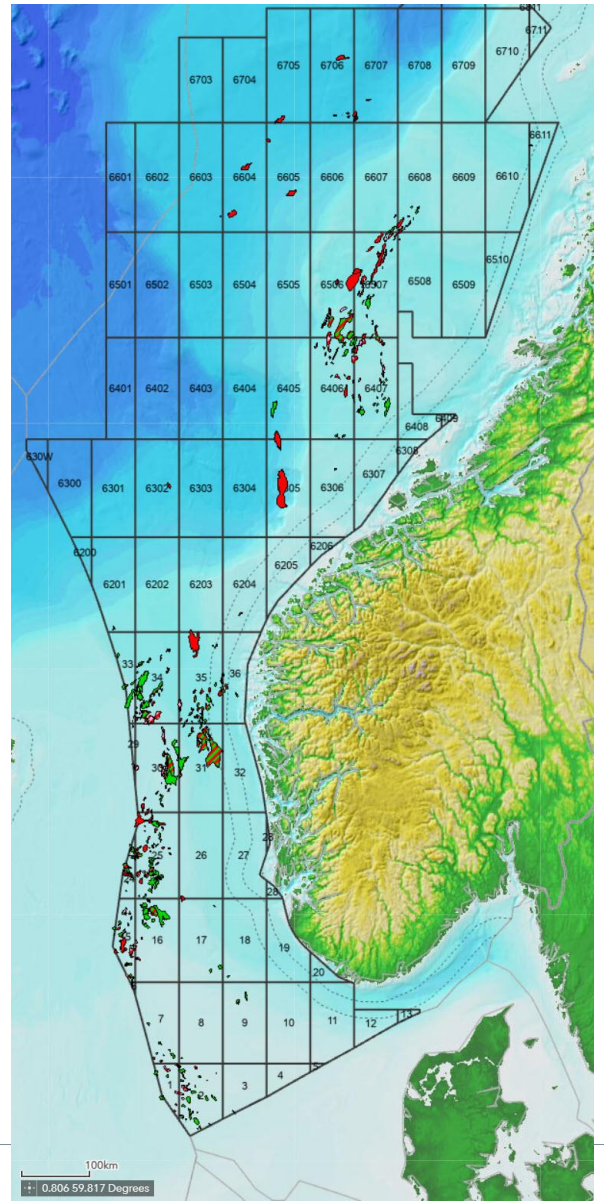


Fields & Discoveries & 3D

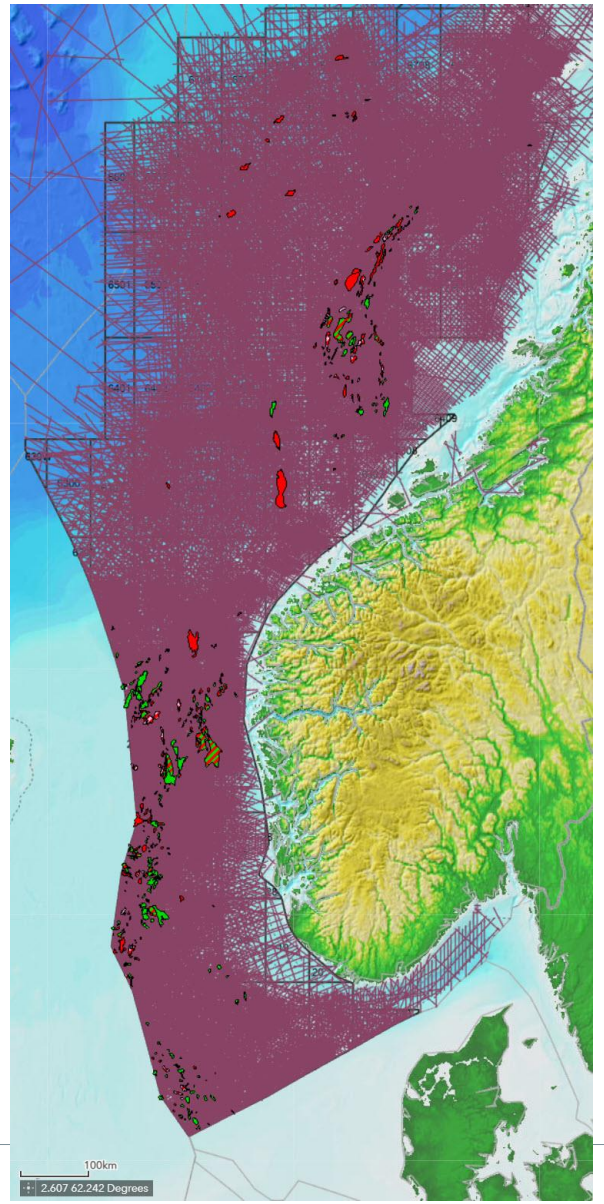


2D Coverage Offshore Norway

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

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- PL090 License Partners: Vår Energy & INPEX Idemitsu Norge

vår energi

INPEX
INPEX Idemitsu Norge

equinor

* Now with Aker BP

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