Opportunistic 4D time-lapse using a regional non-repeated 4D monitor, an Ærfugl case study

Sokkeldirektorat Teknologidagen, 06.06.2024

R.Milne[1], A.Stav[1]
D. Lecerf[2], S. Marinets[2] , S. de Pierrepont[2], V. Zhelanov[2], A. Tantsereva[2]; J. Oukili[2]

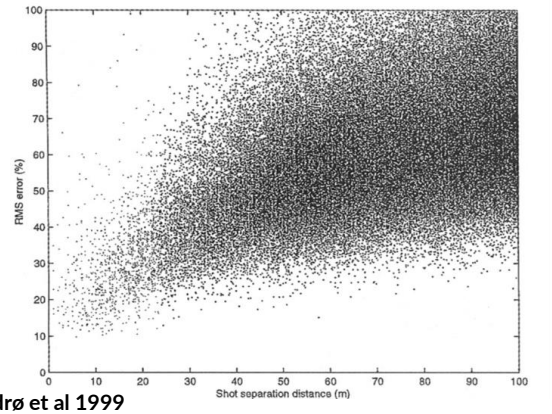
[1] Aker BP
[2] PGS

Agenda

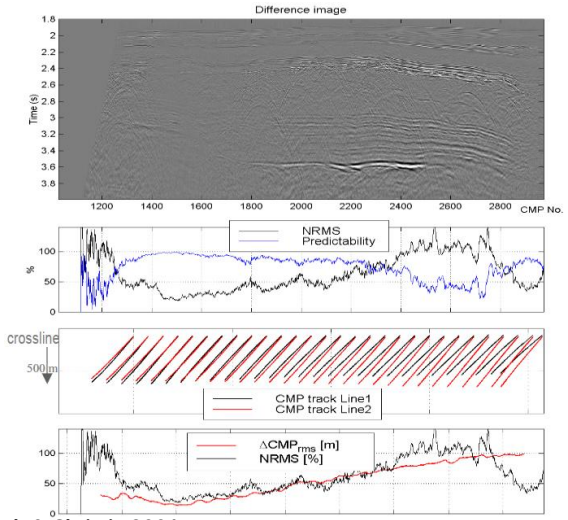
- 4D survey requirements
- Ærfugl field background
- 4D history and feasibility
- Opportunistic Multi-client 4D monitor
  - The decision
  - Acquisition and processing
- 4D results and analysis
- Summary / future work

4D survey requirements

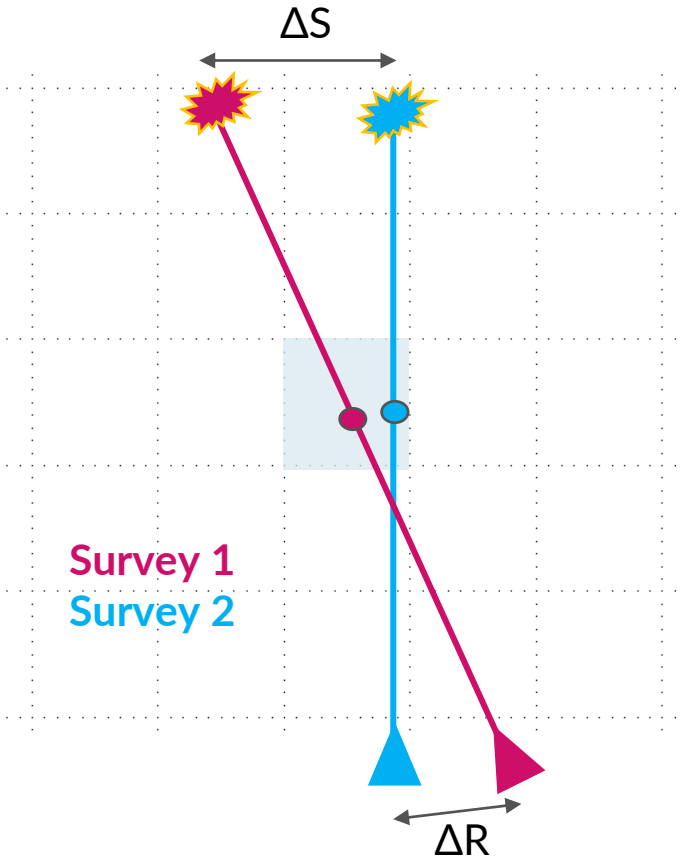
Geometric repeatability



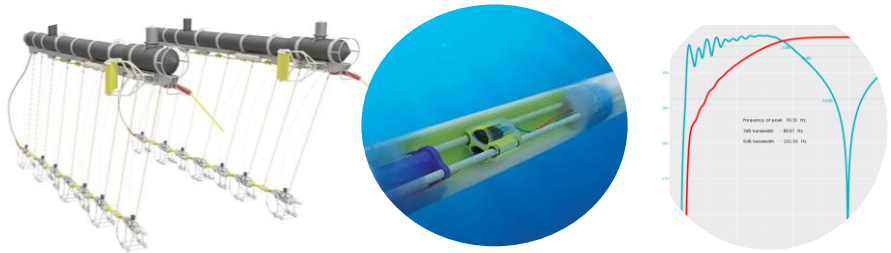
Landrø et al 1999



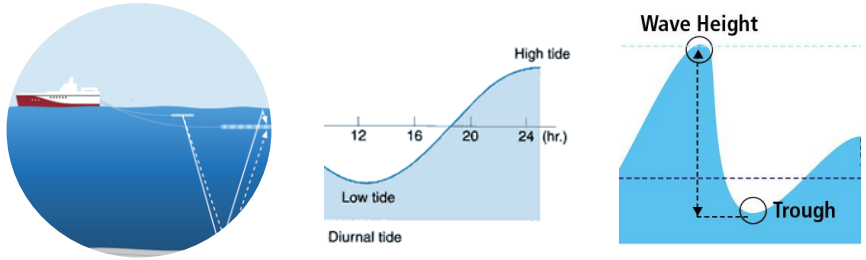
Kragh & Christie 2001



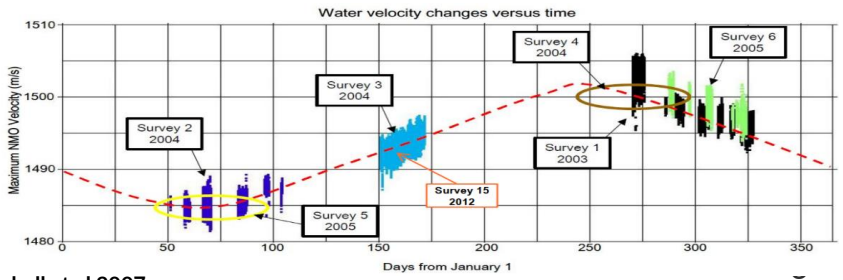
Source & Receivers



Statics and datum

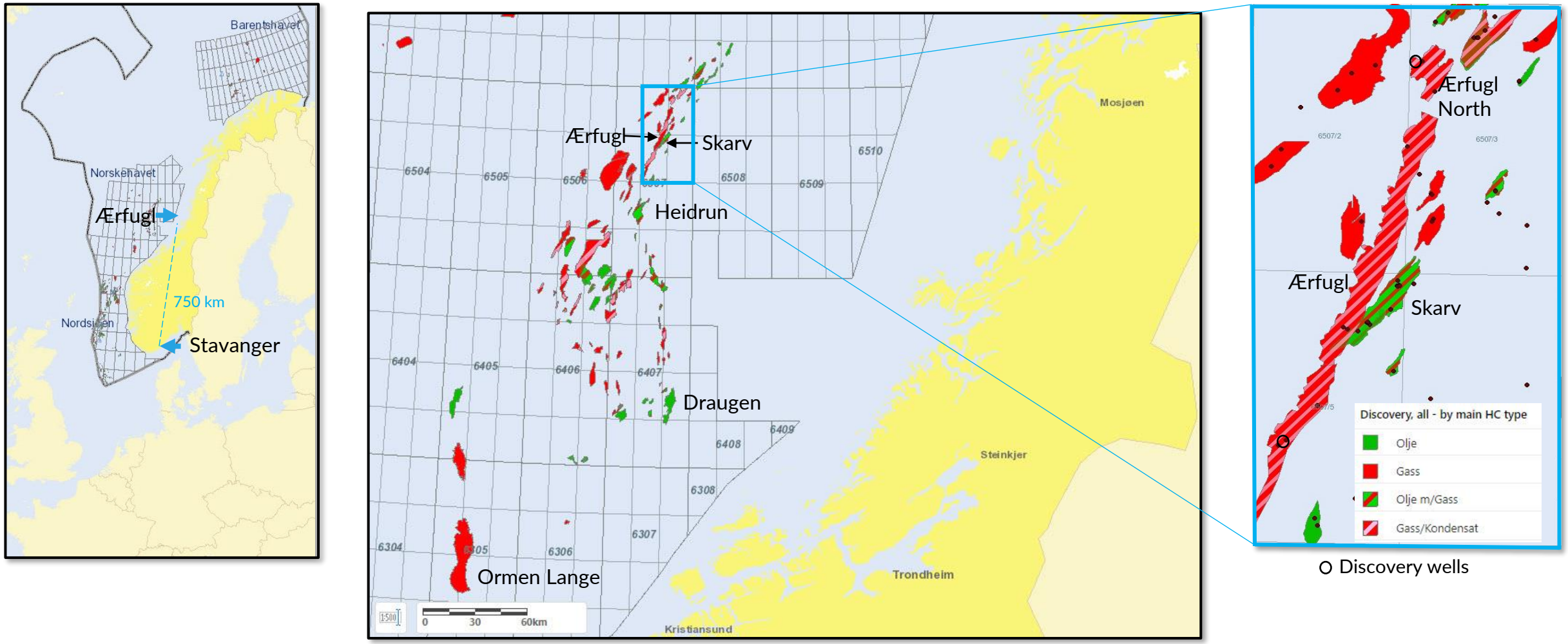


Seasonal changes



Hatchell et al 2007

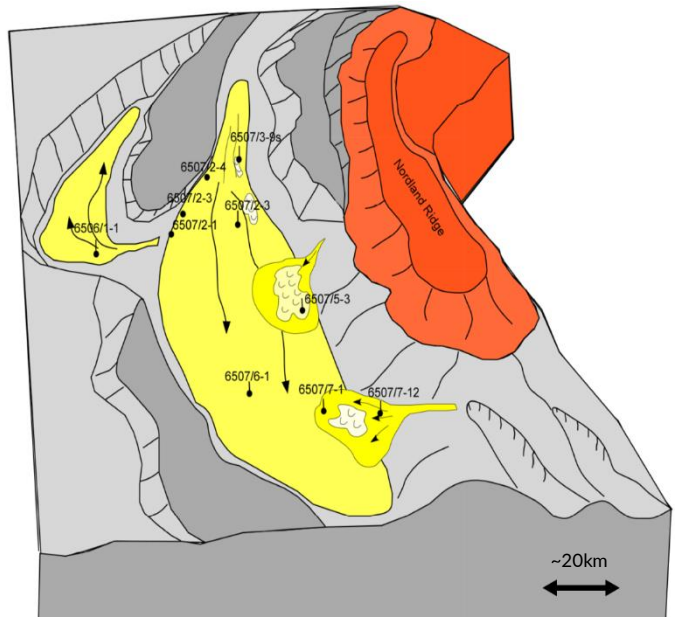
Ærfugl Field Introduction: location map

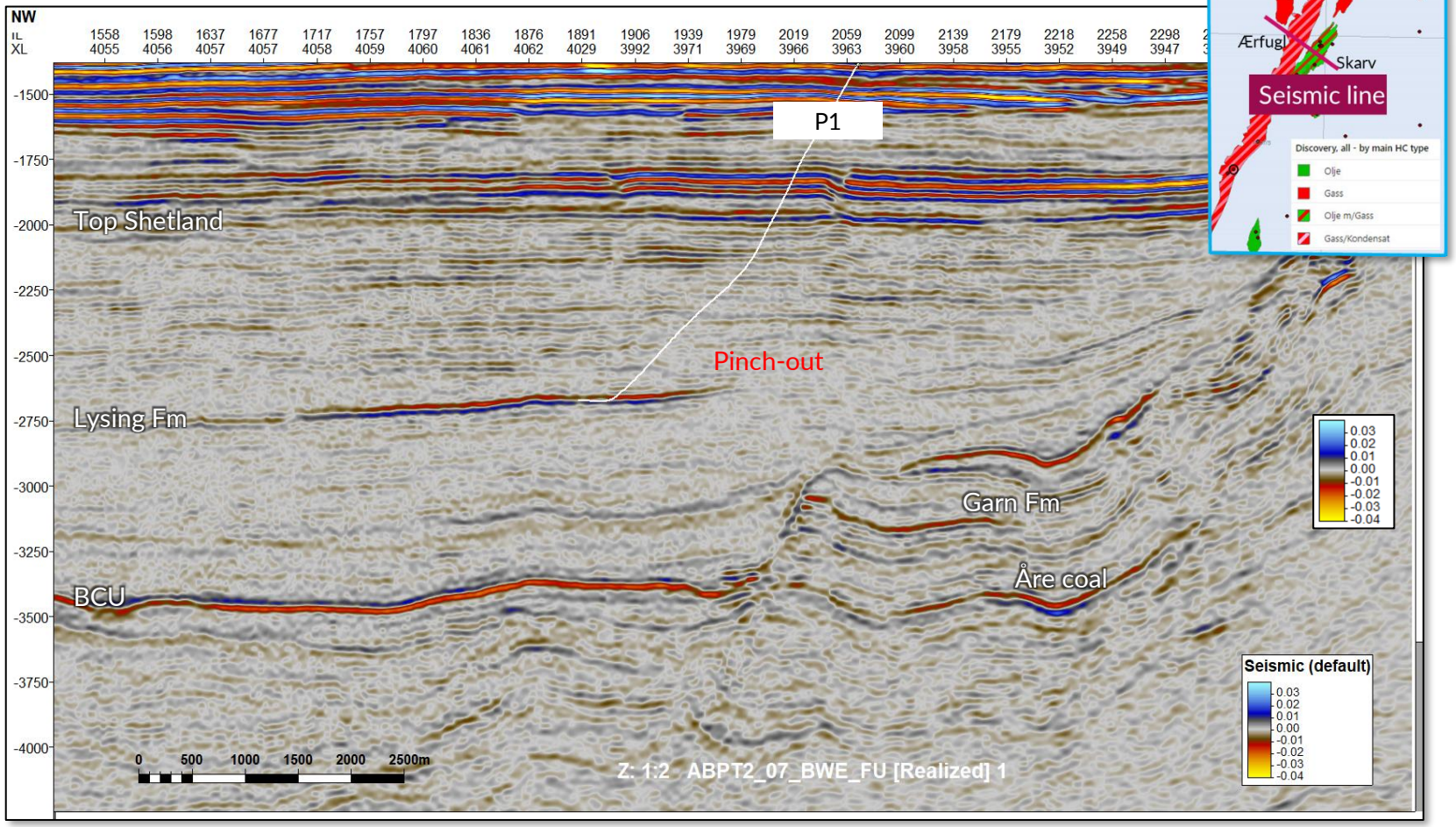


2 discoveries: Ærfugl discovered in 2000 and Ærfugl North discovered in 2012.
Field development: 2019-2021.

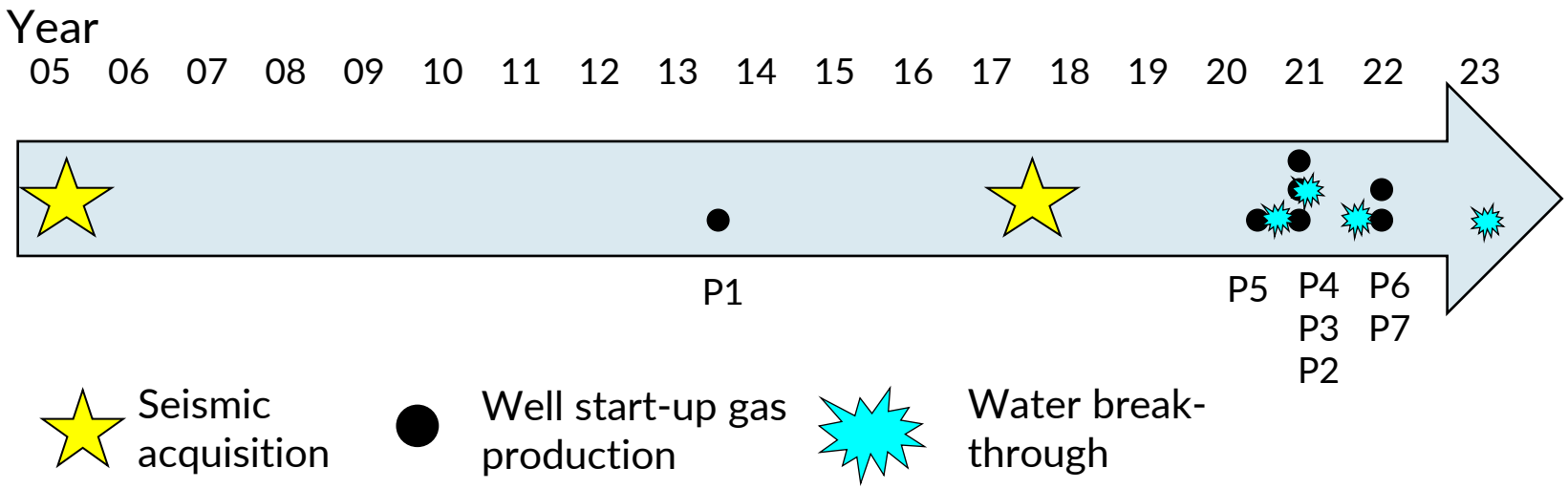
Ærfugl Field Introduction

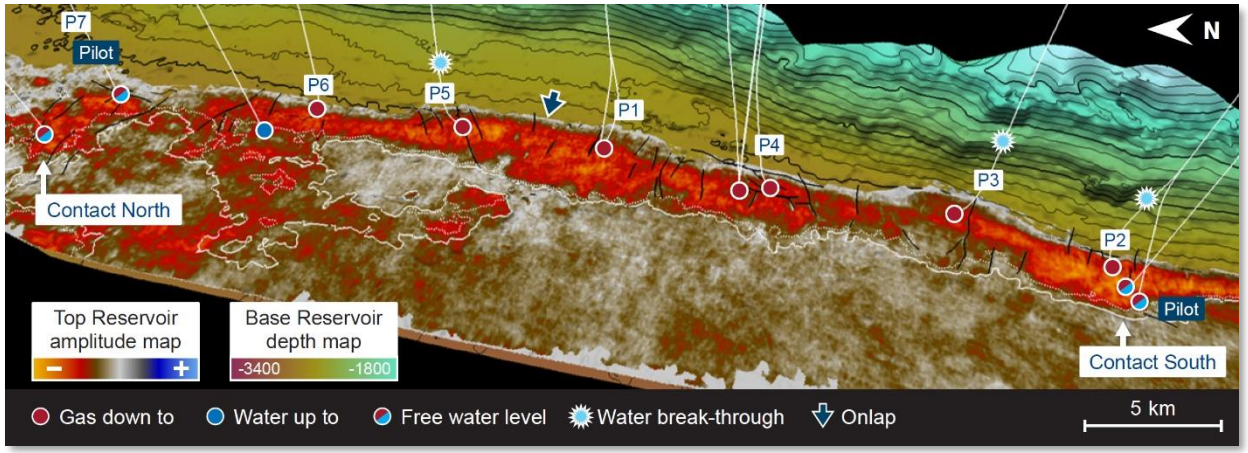
- Cretaceous Lysing Fm, Gas field
- Stratigraphic pinch-out to the east
- 60 x 3km
- Average 30m total thickness

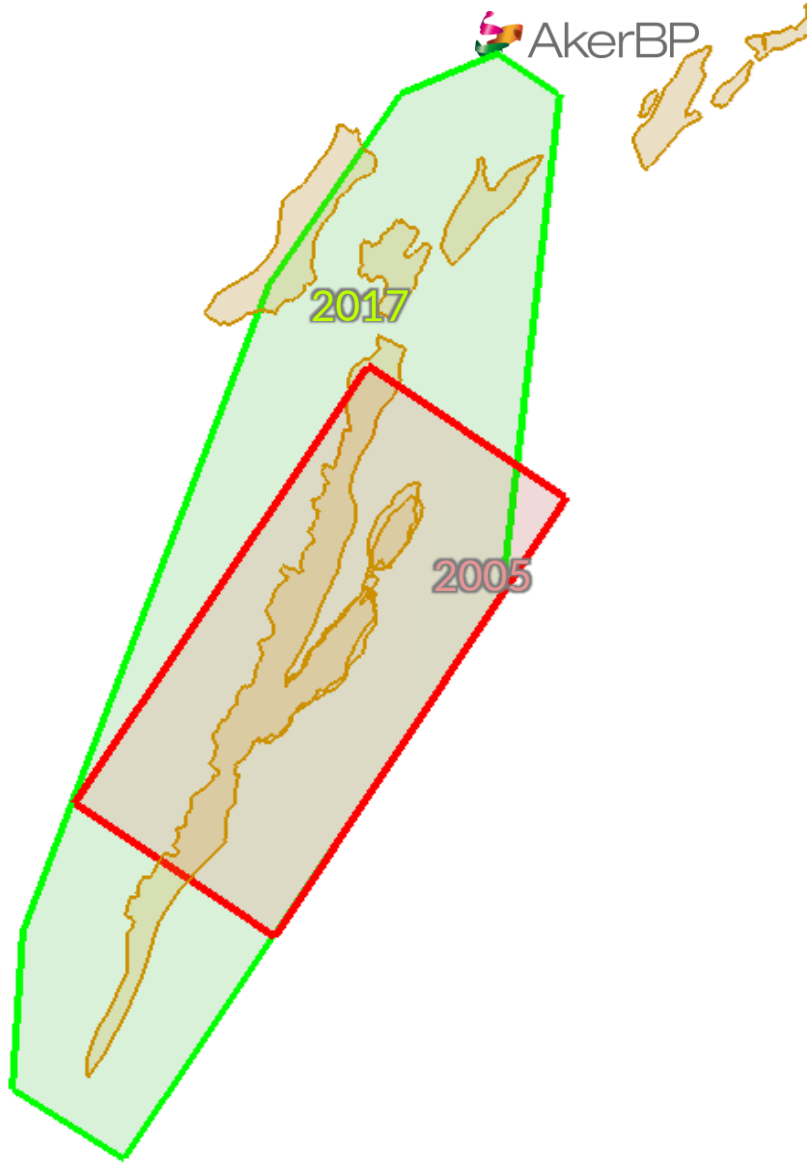




4D history at Ærfugl

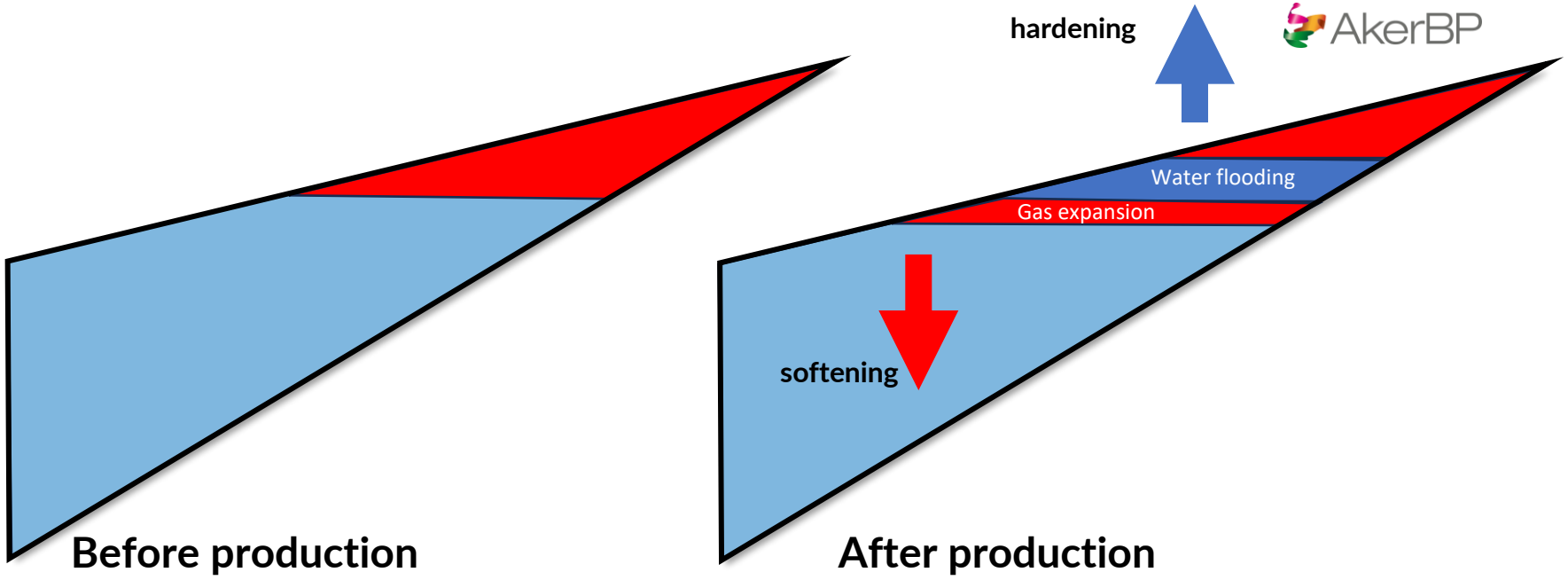


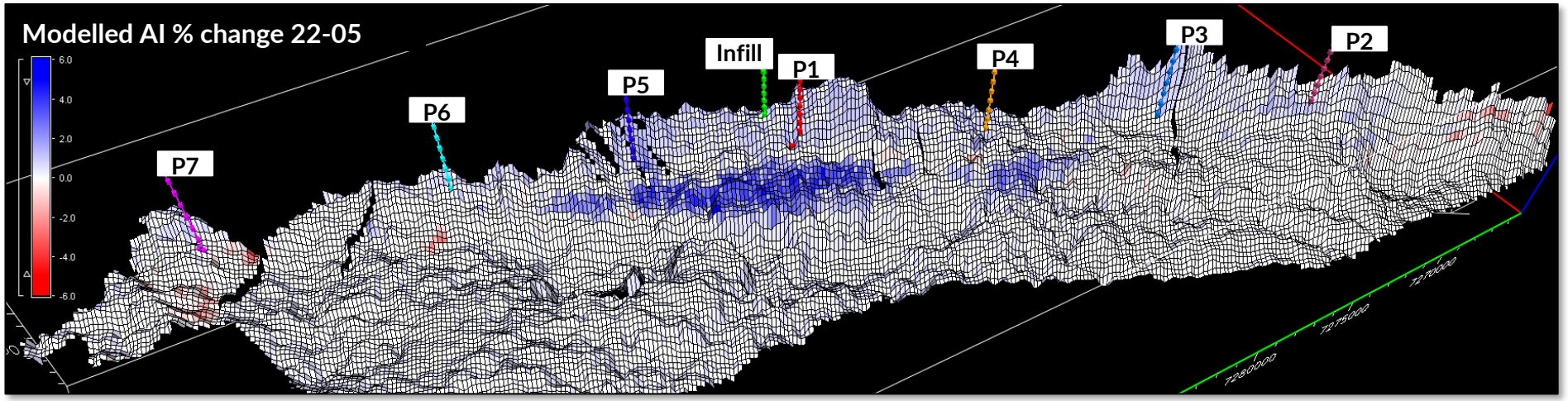


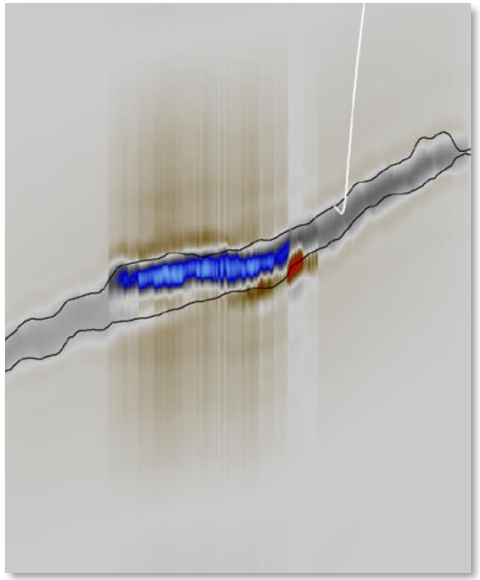


4D feasibility

- **Hardening**: water replacing gas and pressure depletion
- **Softening**: gas saturation increase (gas cap expansion or gas out of solution in the aquifer)

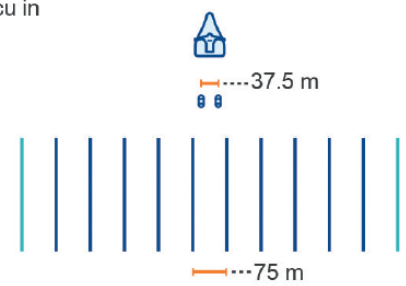




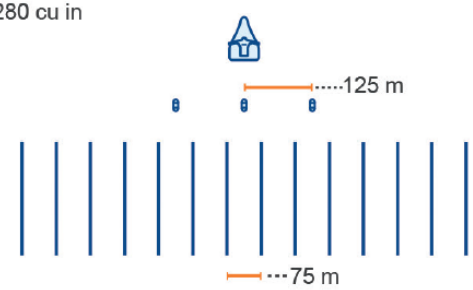


2022 Multi-client monitor?

Dual source
5 085 cu in

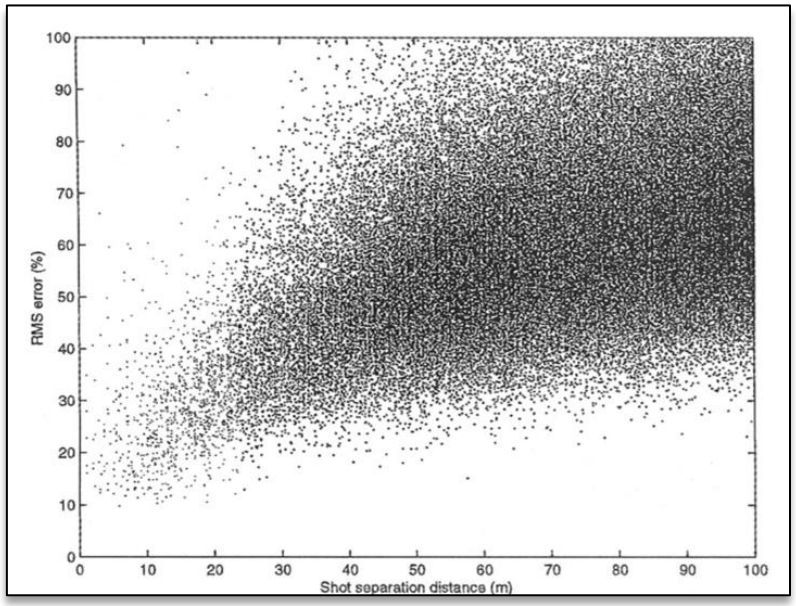


Triple source
3 280 cu in

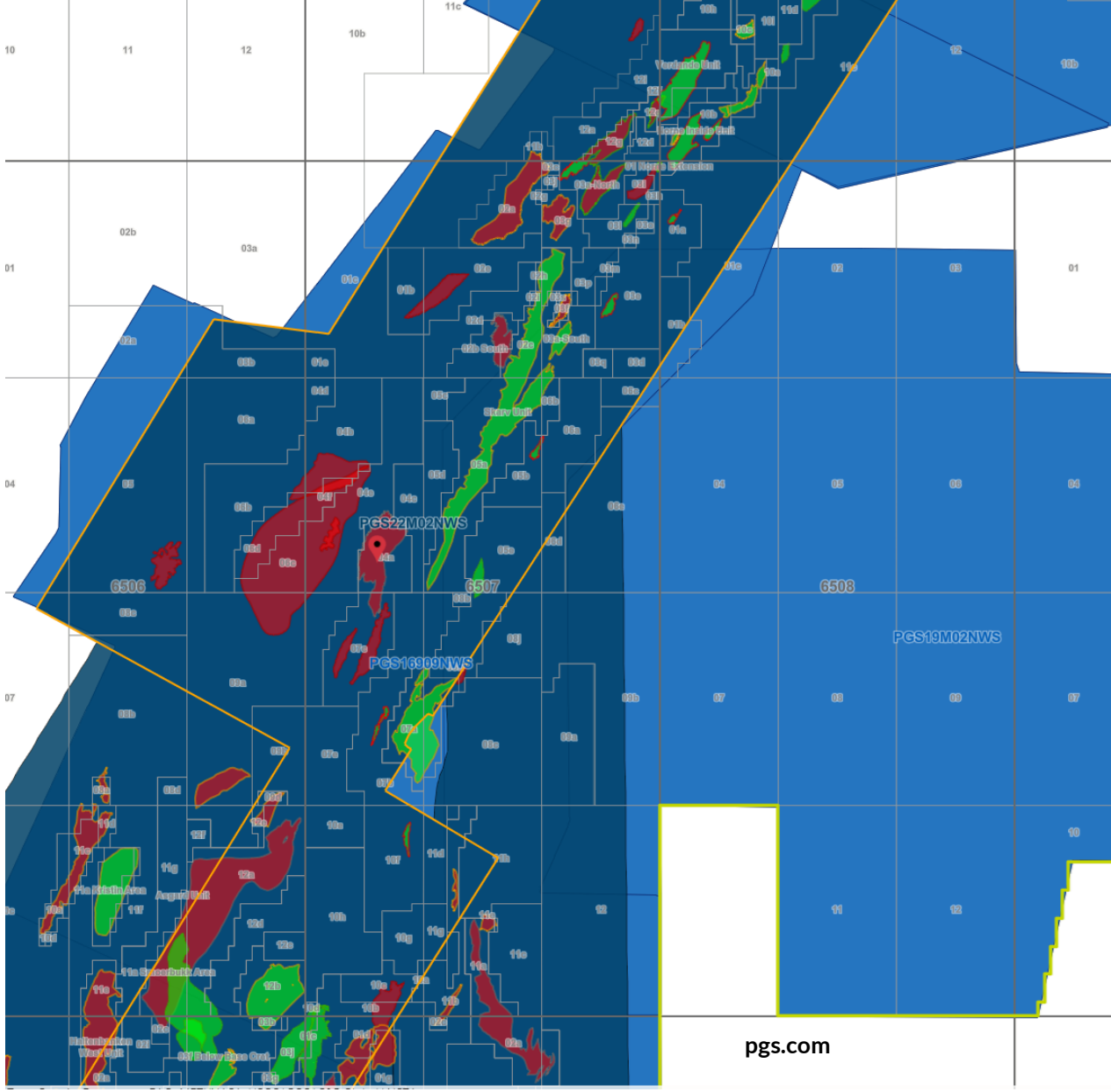


2005 Hydrophone, 10 cables, depth 7 m
2017 Multisensor, 12 cables, depth 18 m

2022 Multisensor, 14 cables, depth 25 m

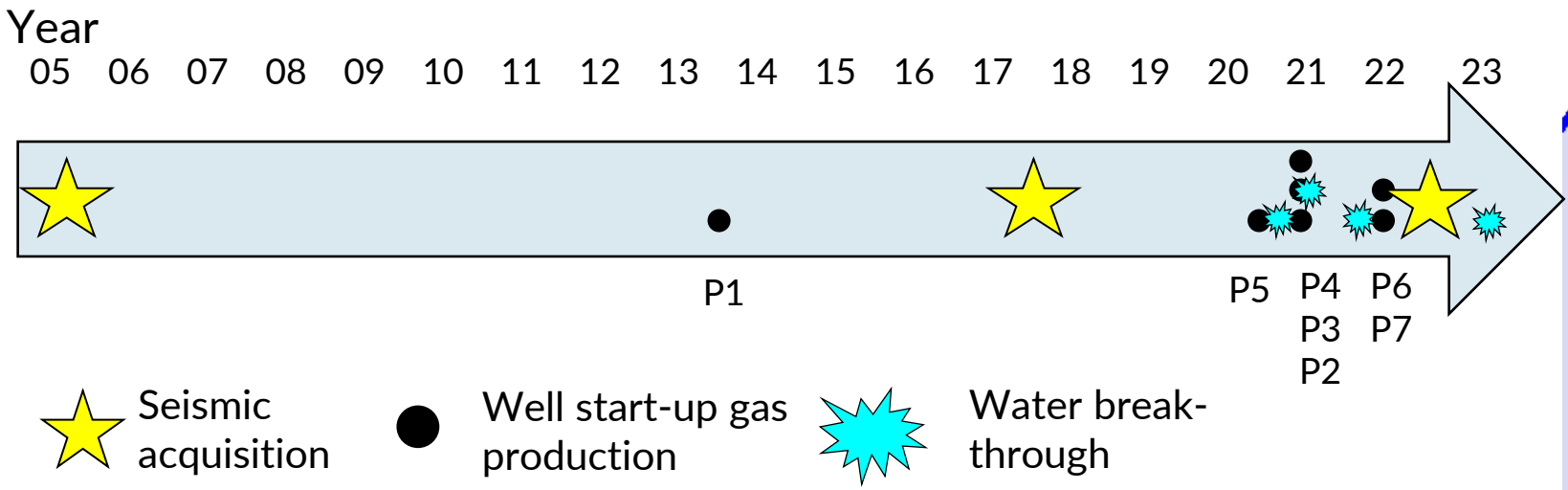


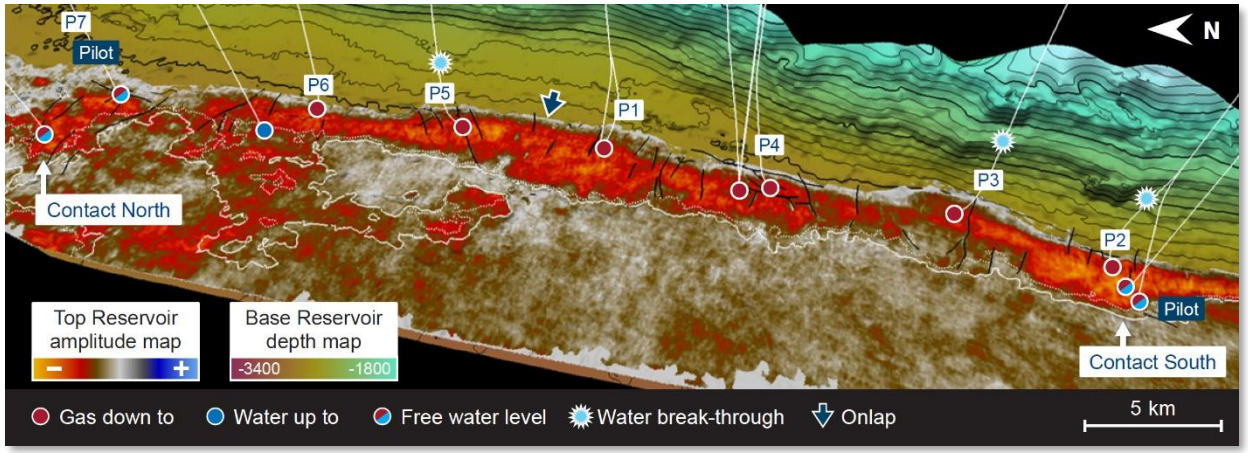
Landrø et al 1999

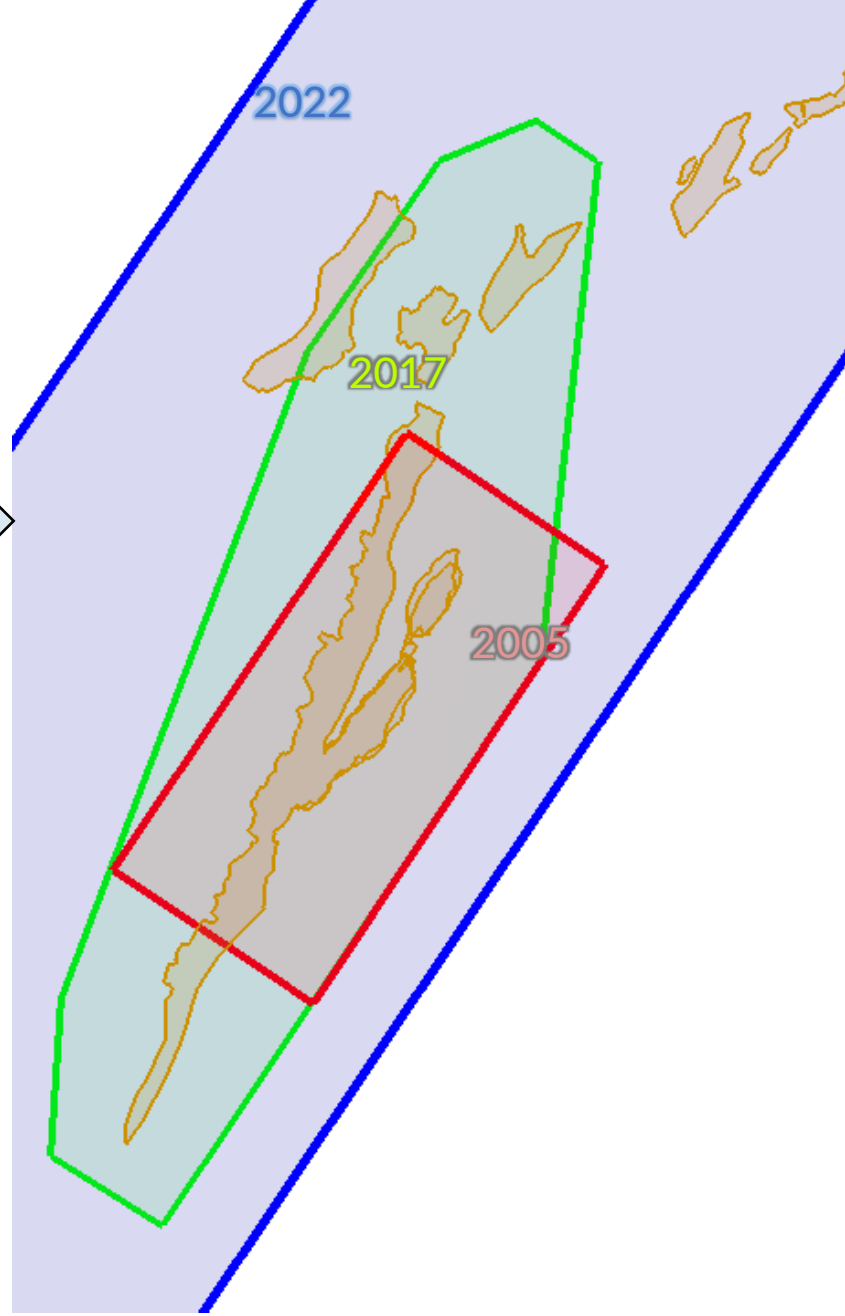


pgs.com

4D history at Ærfugl

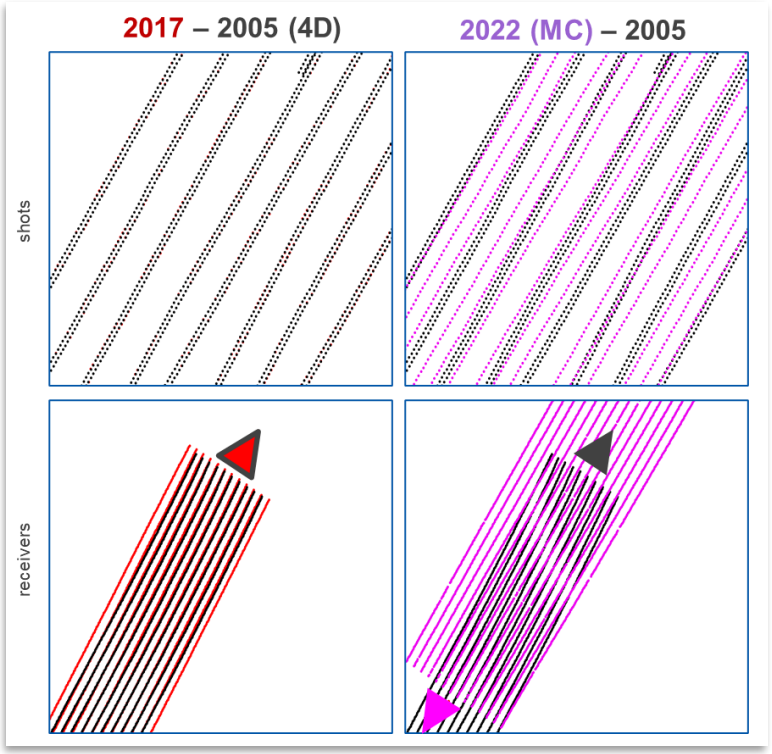


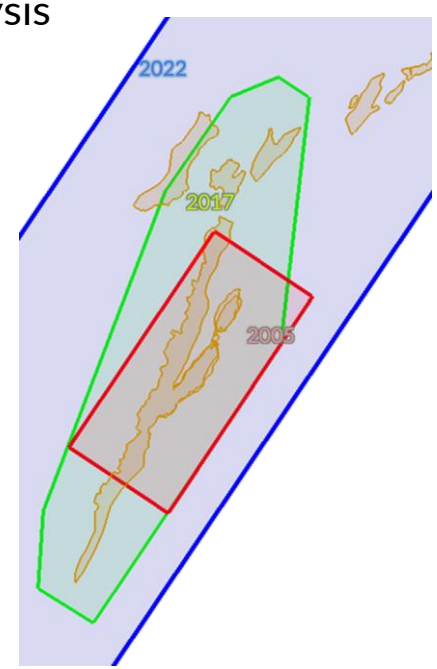


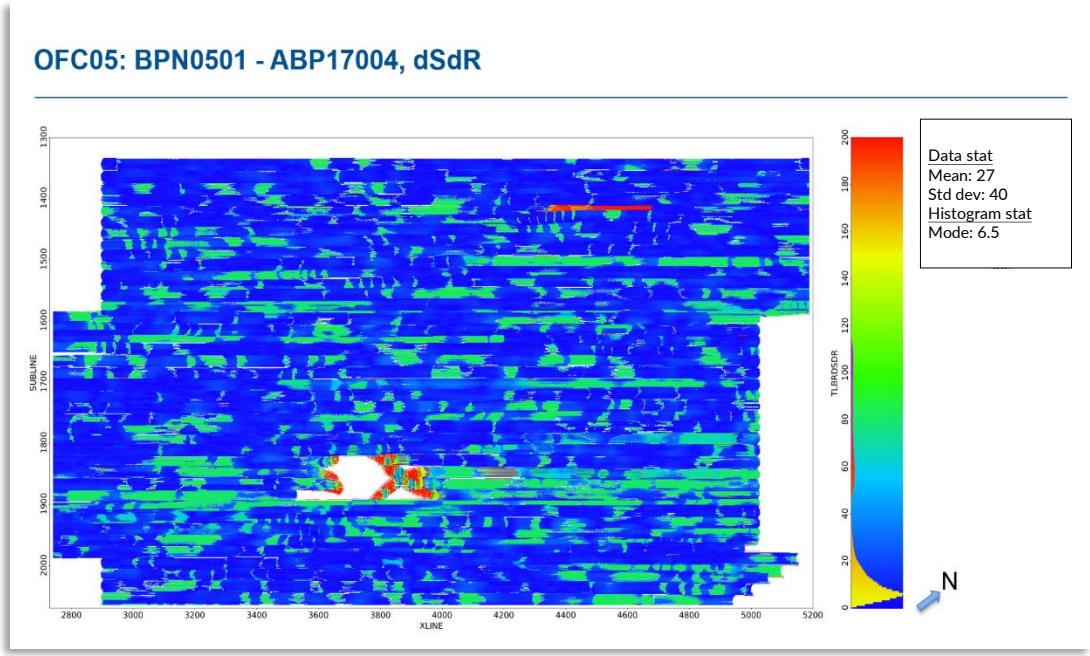


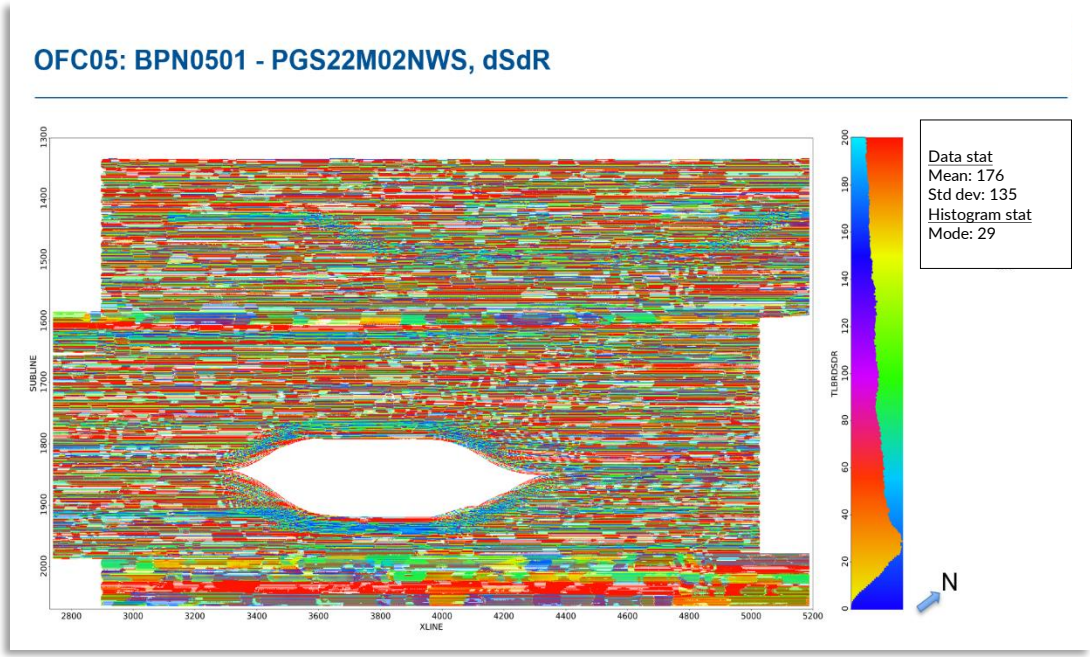
2022 repeatability

- 2022 Multi-client survey matched legacy azimuth by 6-degree deviation
- Phased 4D project
  - Phase 1: Geometric repeatability analysis
  - Phase 2: 2005 outline
  - Phase 2: Full 2017 outline





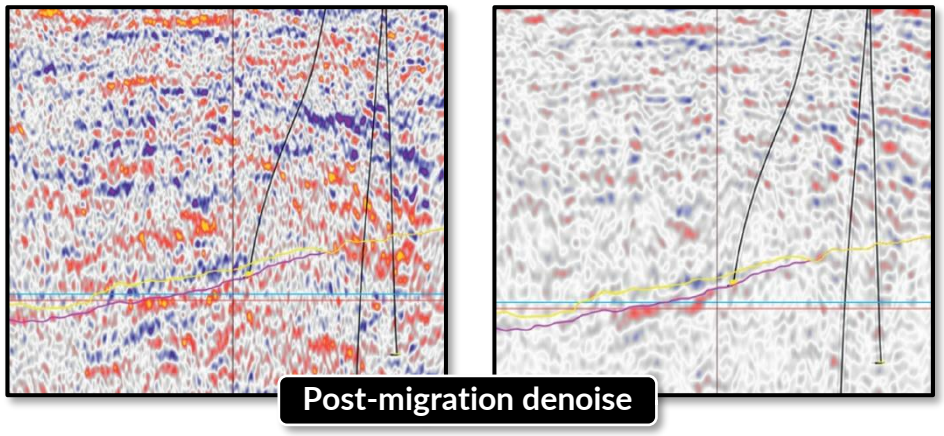


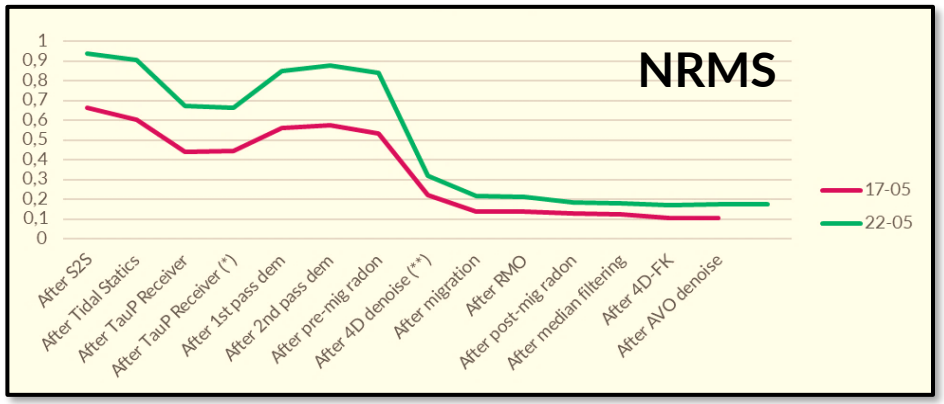


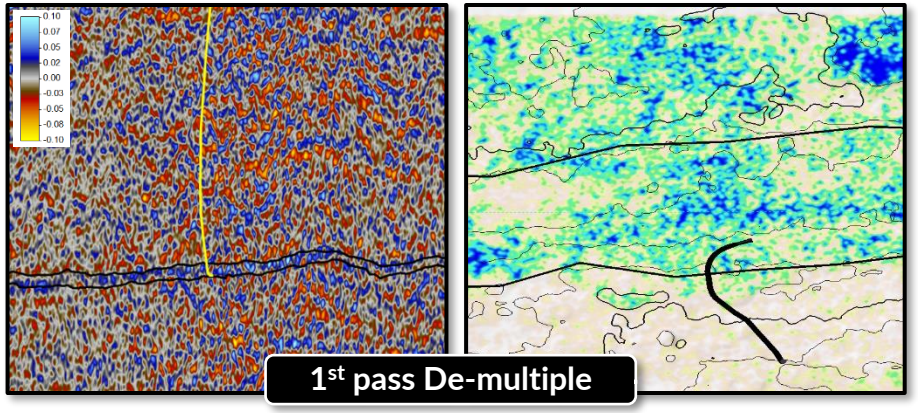
Seismic Processing

- Hard rugose seabed/multiples
- Weak underlying reflectivity
- Small expected 4D changes

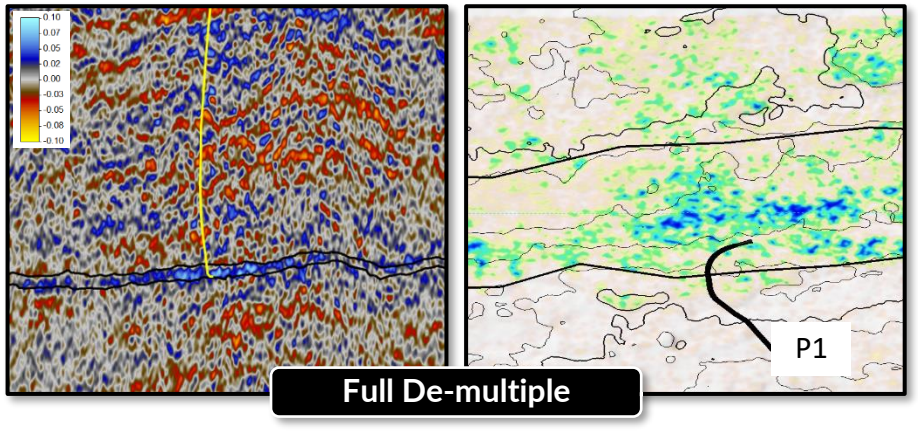
- Intermediate cubes
- 4D Co-denoise
- Good collaboration

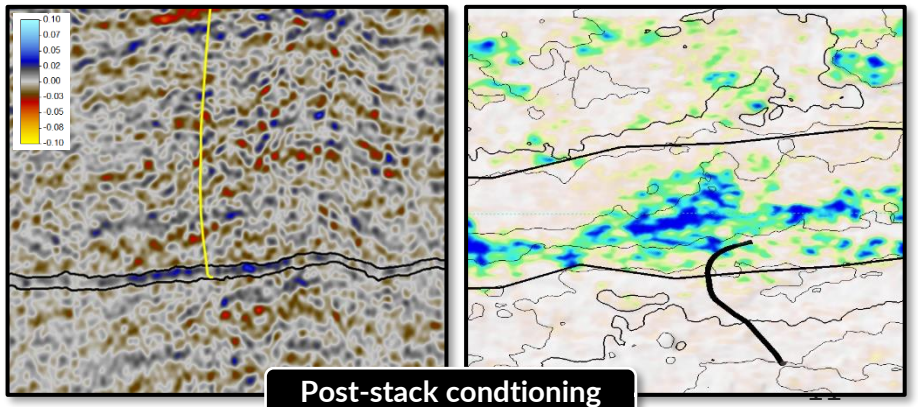




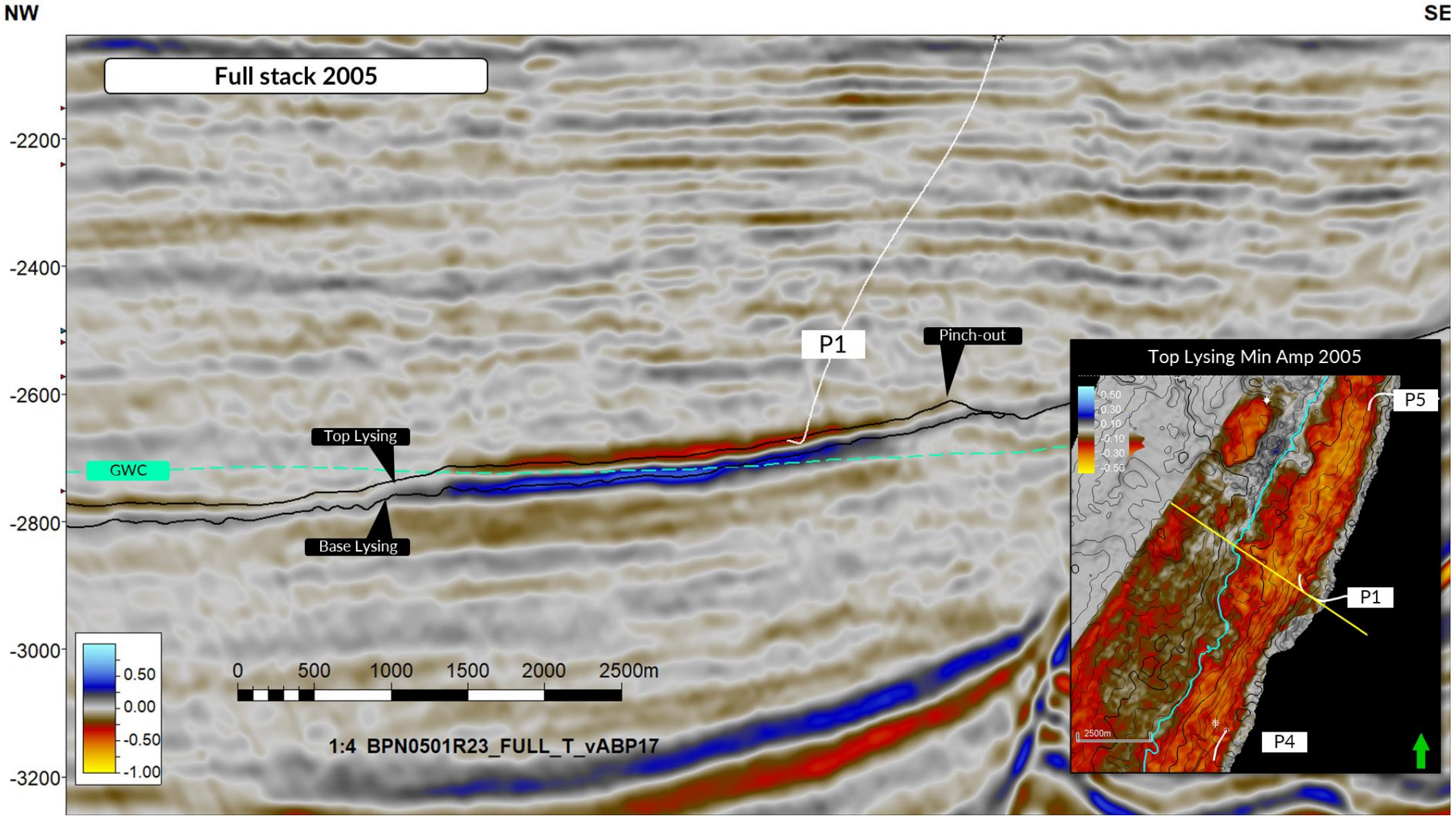


hardening

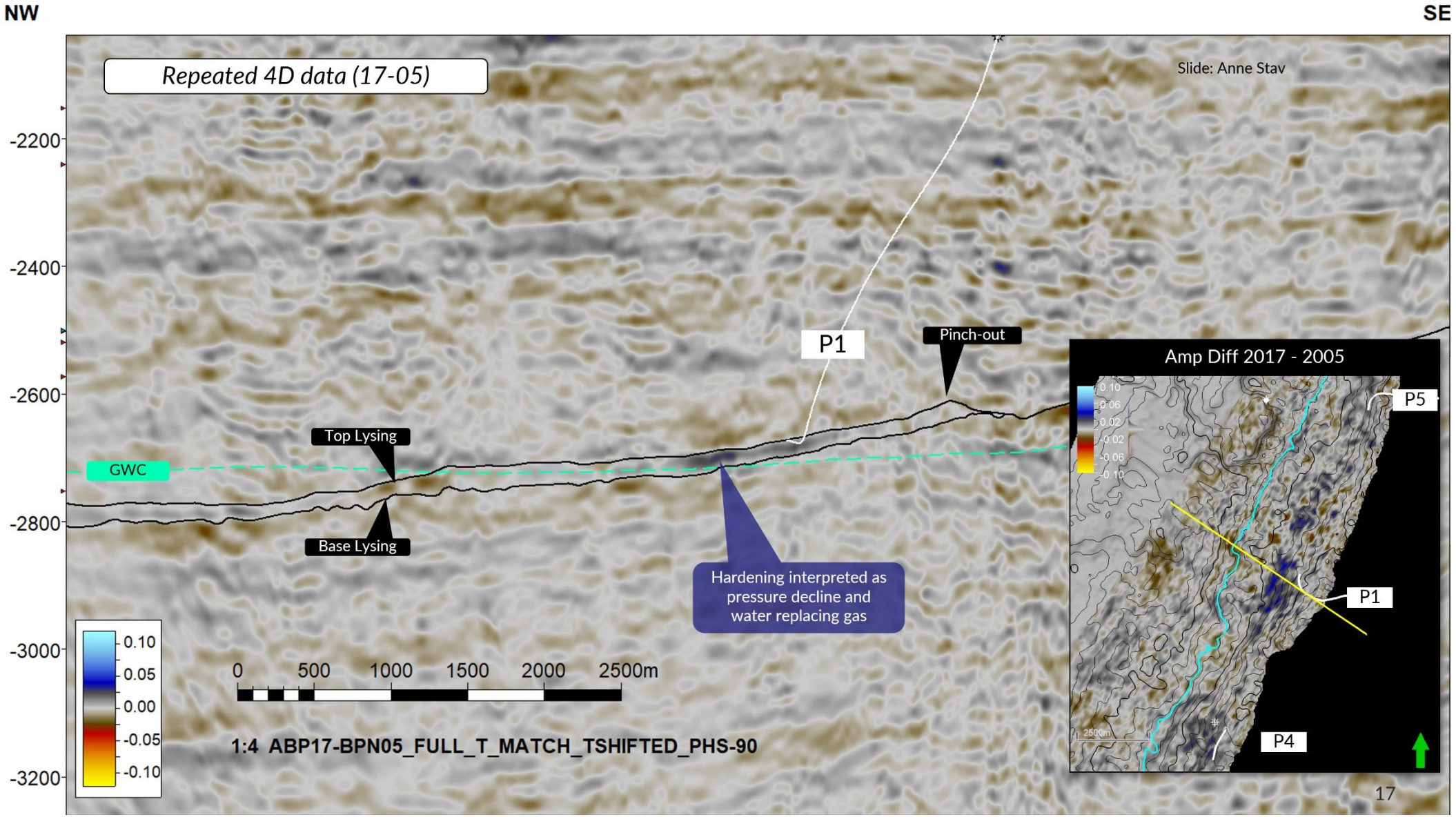


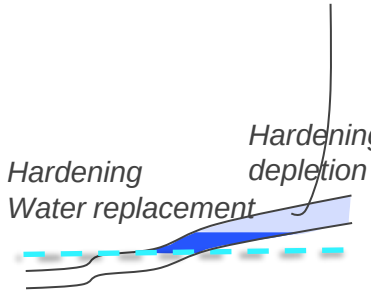


4D analysis: 2005 3D stack Crossline

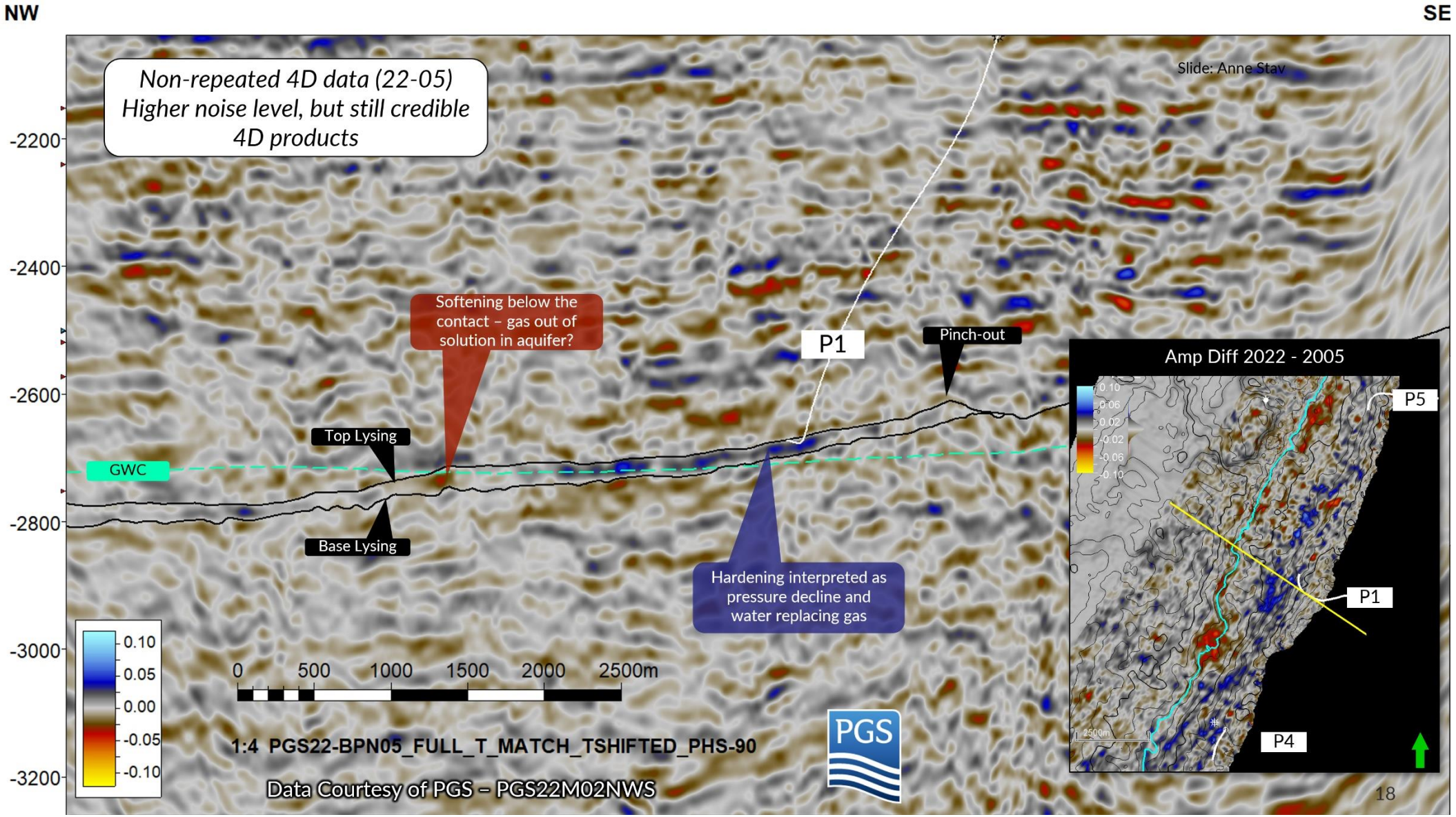


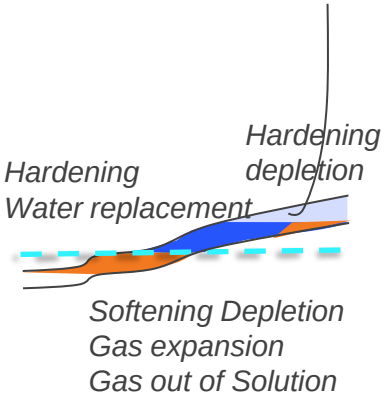
4D analysis: 2017 – 2005 Crossline





4D analysis: 2022 – 2005 Crossline





Summary

- Include 4D in value proposition of Multi-Client surveys
- Low-cost alternative to proprietary survey
- Future work: 4D with non-repeated azimuths

The 4D data results are important for reservoir characterization and infill well opportunities at Ærfugl

- Hardening: Mapping of the waterfront, potential flow units, segmentation
- Softening: depletion in the aquifer. Lack of softening may indicate compartmentalization

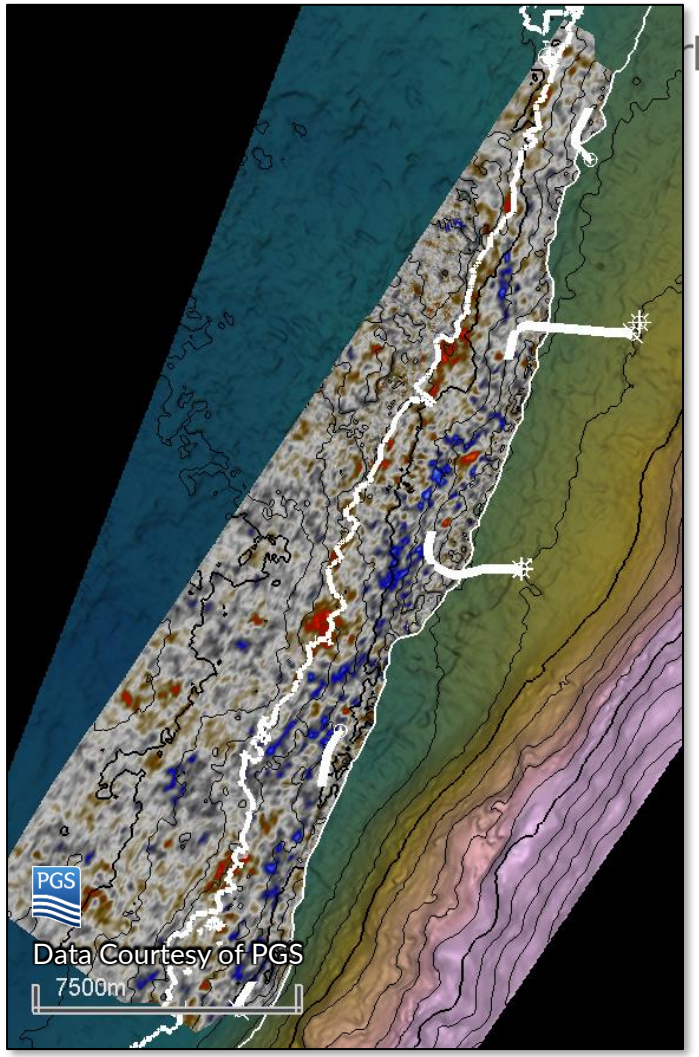


Figure: 4D amplitude difference 22-05

Acknowledgements

- Thanks to the Skarv unit field partners for permission to present this work

R.Milne[1], A.Stav[1]
D. Lecerf[2], S. Marinets[2] , S. de Pierrepont[2], V. Zhelanov[2], A. Tantsereva[2]; J. Oukili[2]

[1] Aker BP
[2] PGS

www.akerbp.com