

# Improvements in seismic imaging and prediction of thin sand injectites

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# Agenda

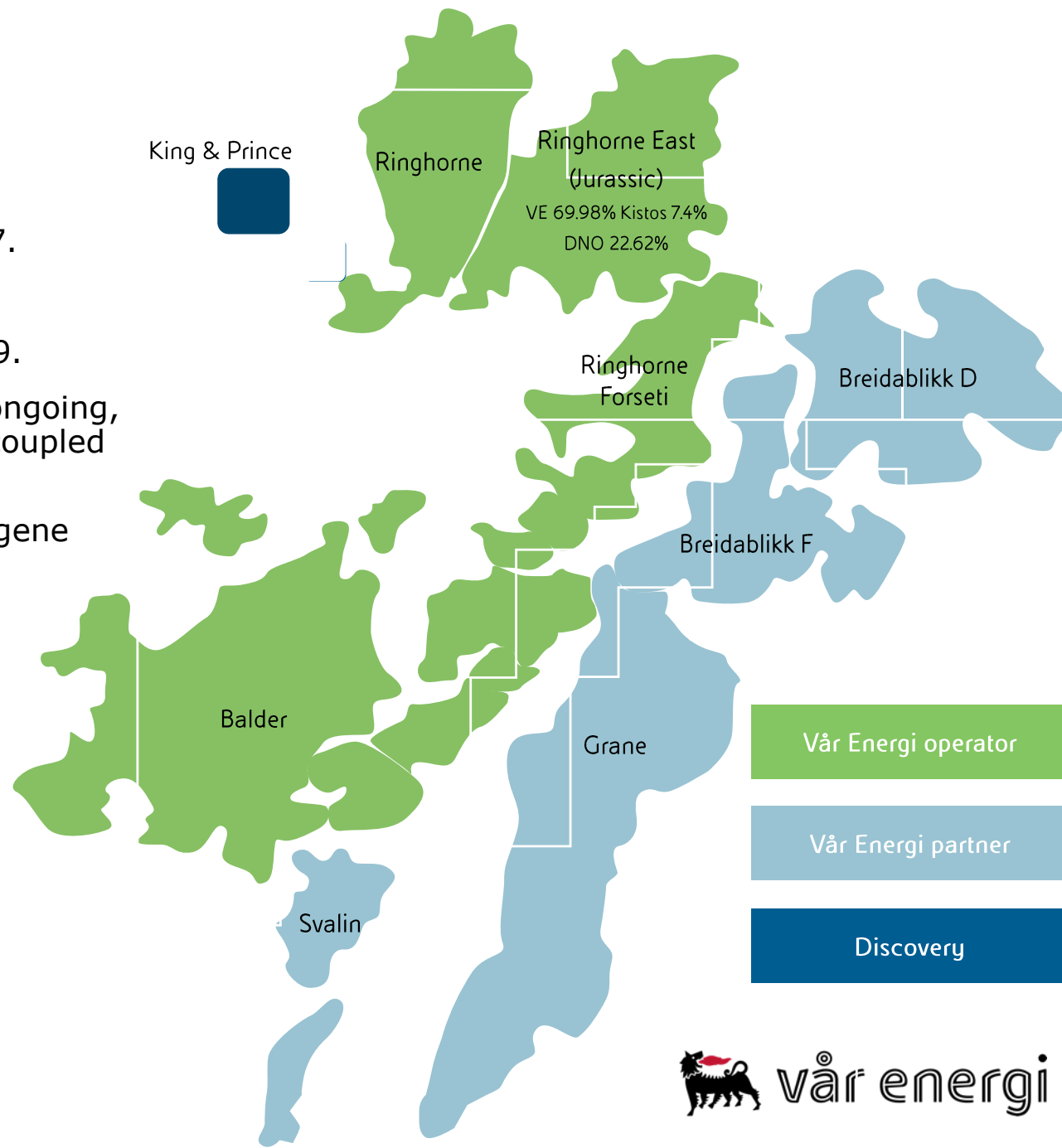
- Introduction to the Balder field
- Balder drilling target maturation
- New technologies
- Conclusions



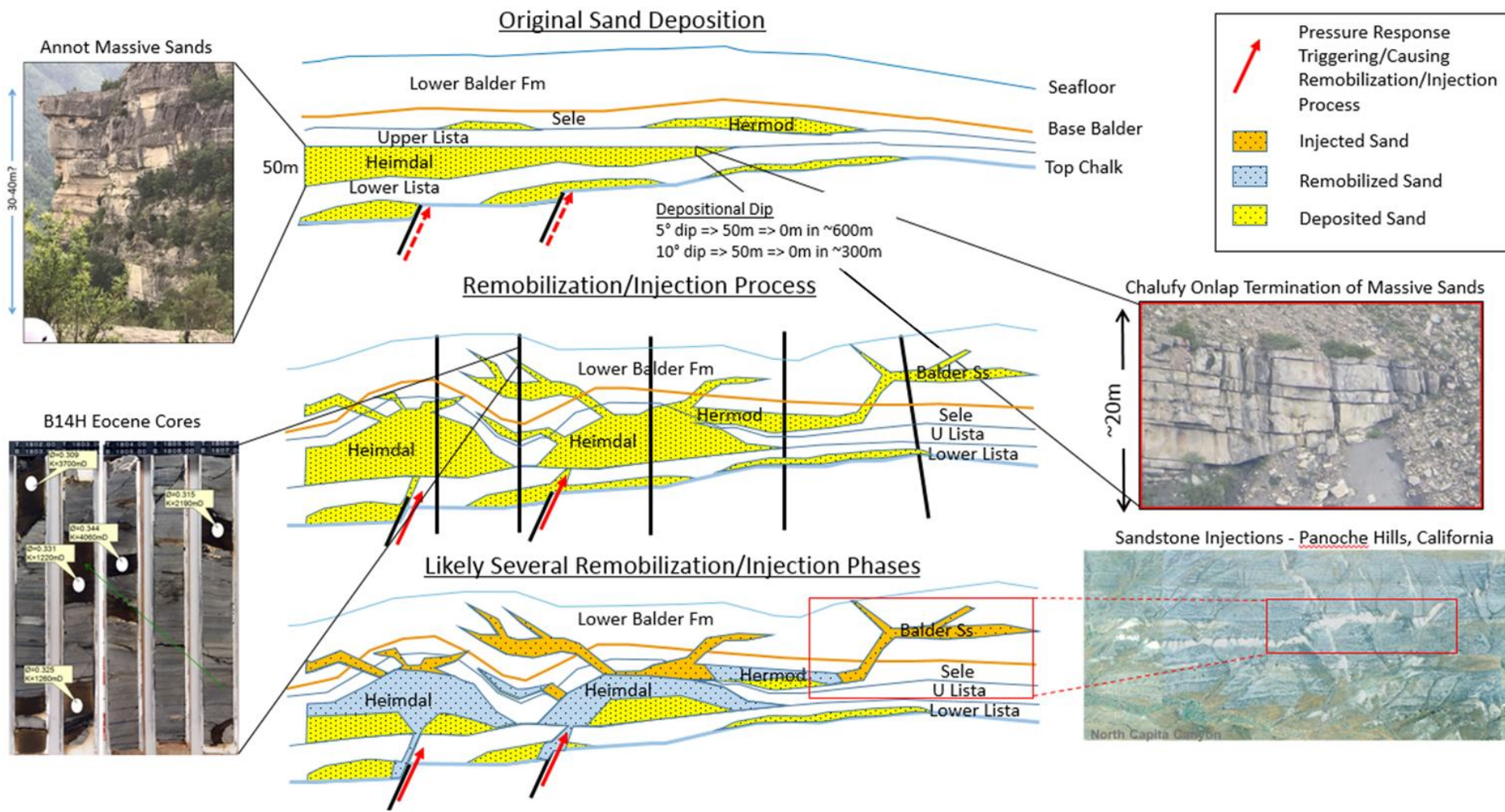
# Balder and Ringhorne Area

Vår Energi 90%, Kistos Energy (Norway) 10%

- First License (PL001) awarded on the shelf in 1965.
- First discovery on Norwegian Continental Shelf in 1967.
- Balder production started in 1999, Ringhorne in 2003.
- ~1.7 Bbbl oil in place, ~450 mbbl produced since 1999.
- Balder and Ringhorne Area Future area development ongoing, including 26 development wells to be drilled by 2025 coupled with exploration program.
- Main target reservoirs: remobilized and injected Paleogene deep water systems.

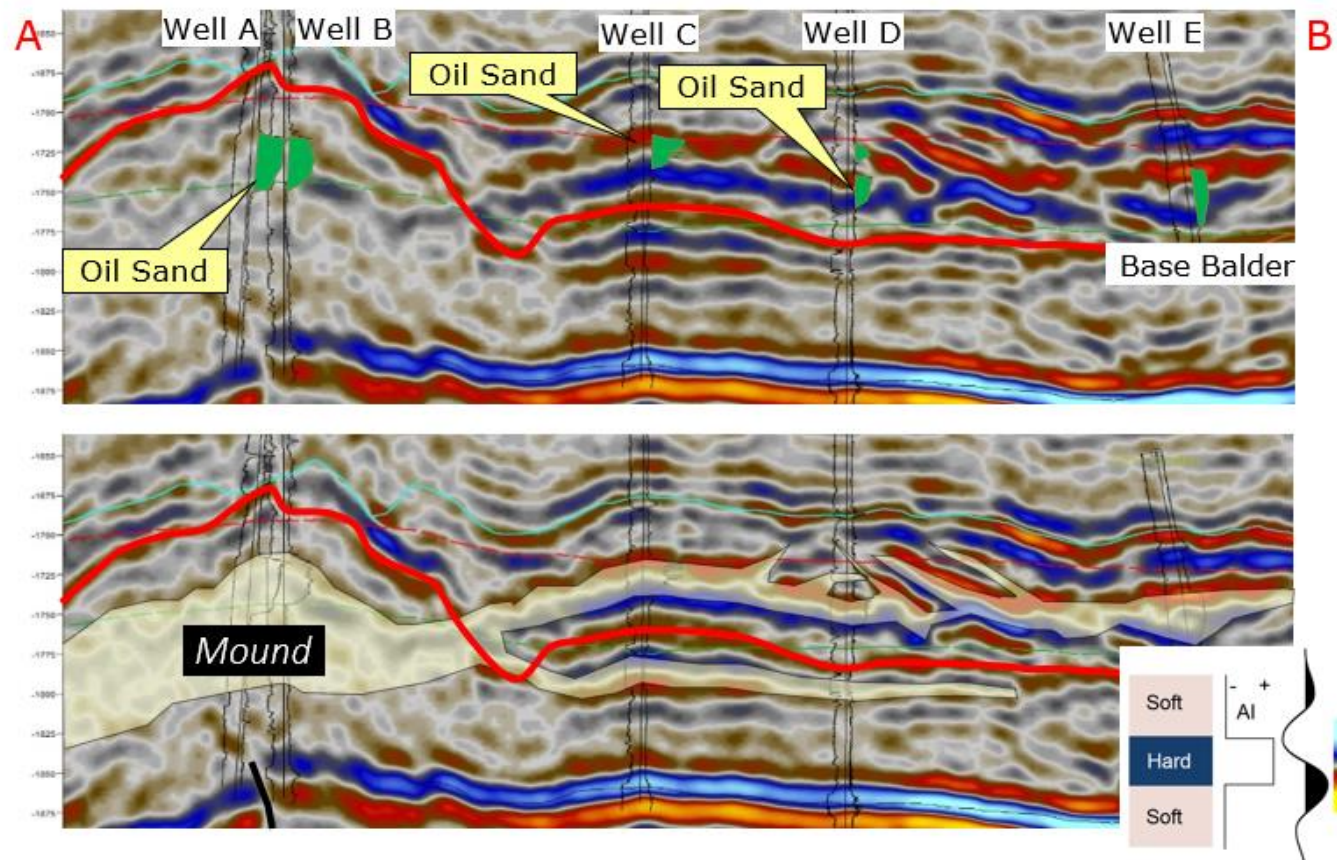


# Deposition and remobilization process

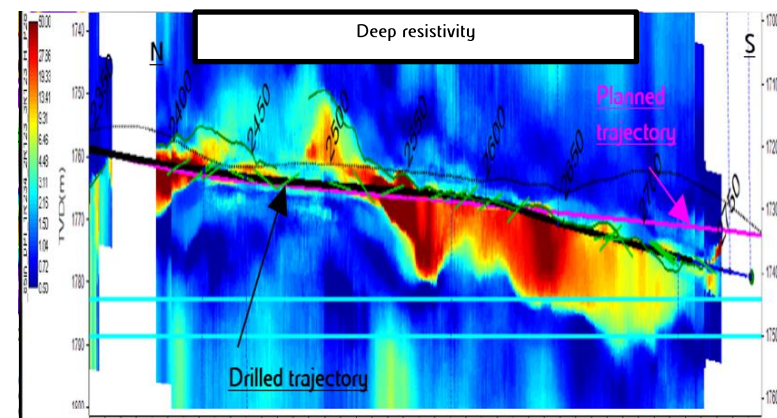
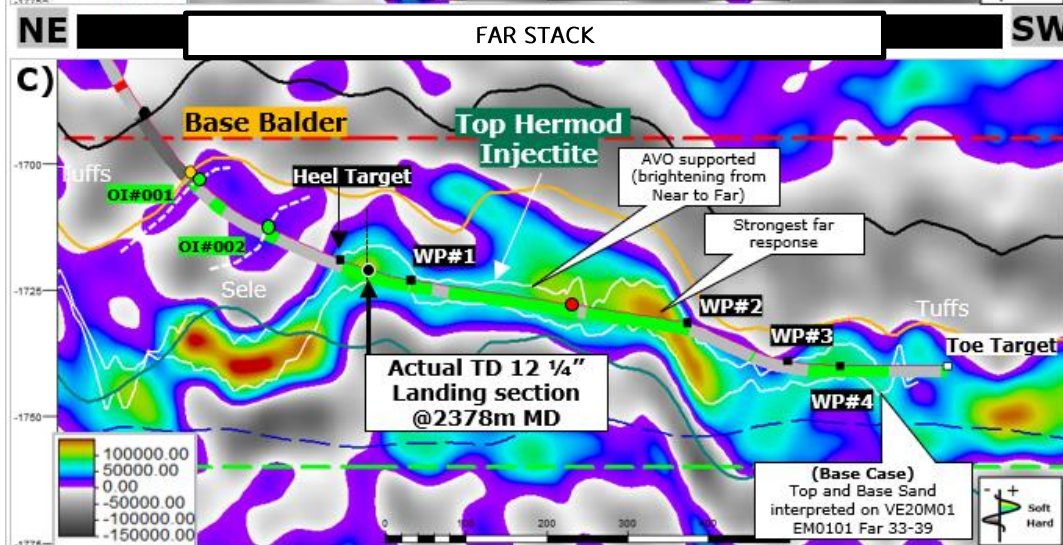
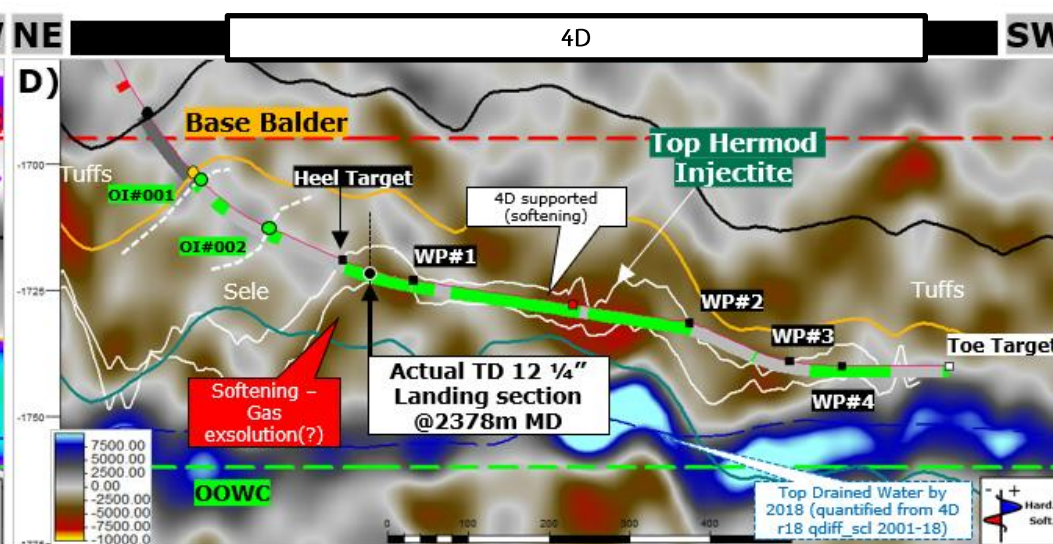
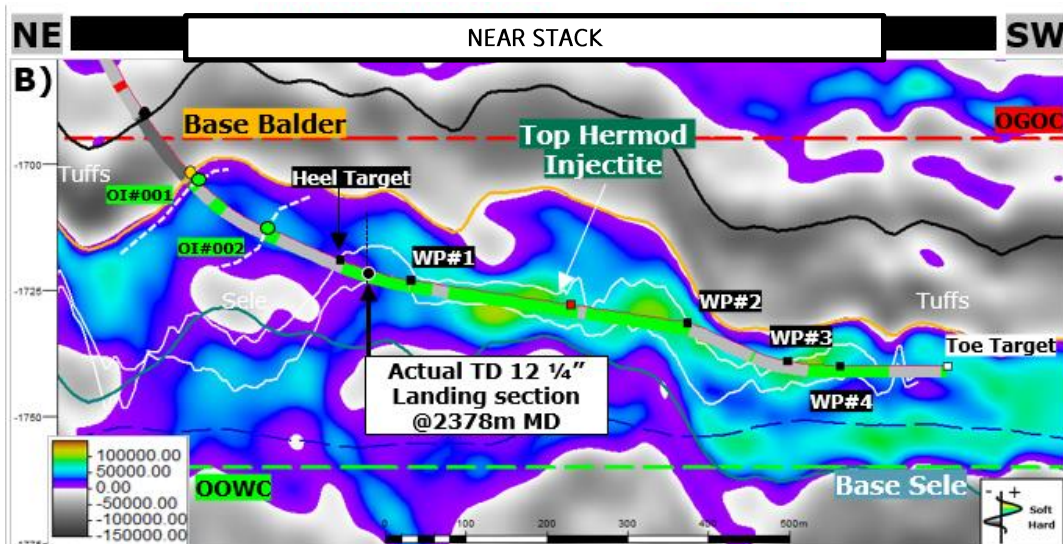


- Initial onlap and overstepping of Utsira High topography.
- Complex reservoir architecture and resultant imaging challenges due to remobilization and polyphase injection.

# Deposition and remobilization process

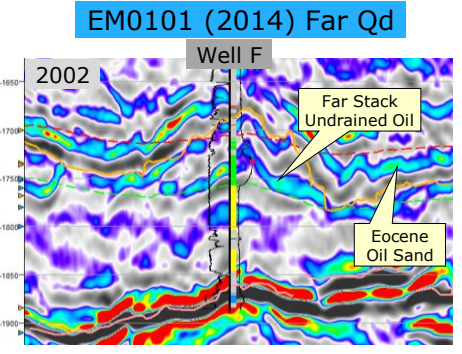
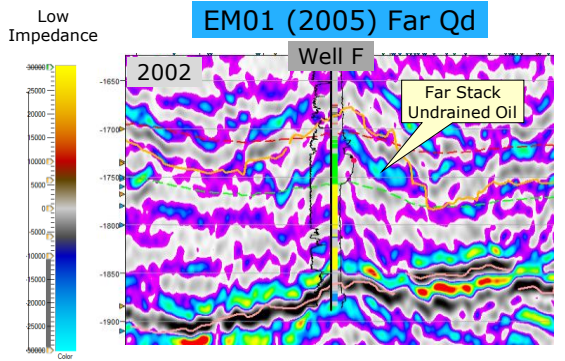
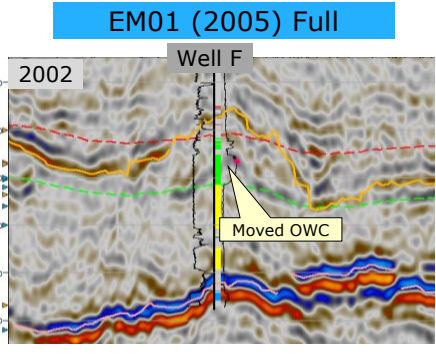
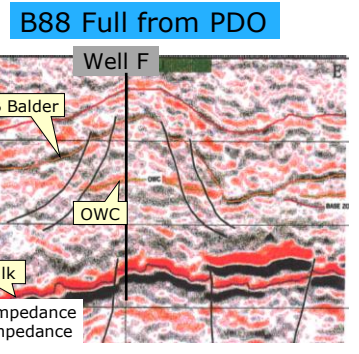
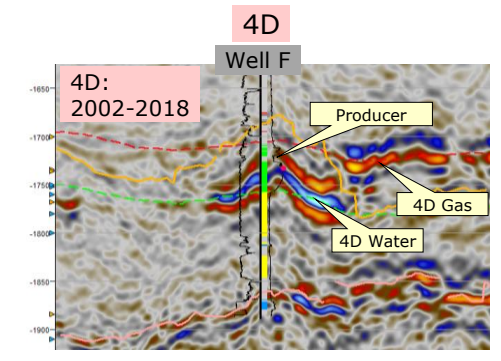
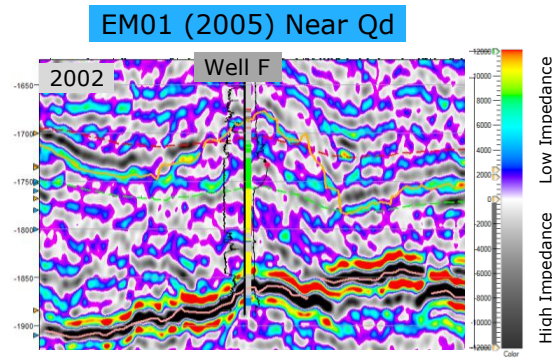
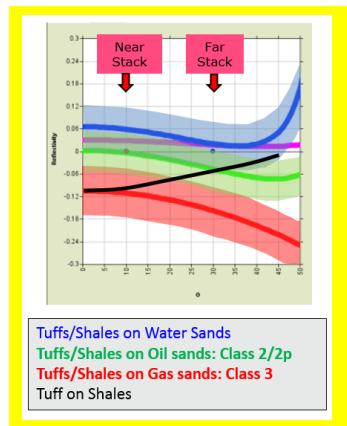


# Maturation of Balder targets – strongly seismically driven



# Continuous seismic data quality improvement

	1988	2002	2019	2023
<b>Main Surveys</b>	<b>B88</b>	<b>EM01</b>	<b>MAZ</b>	<b>OBN</b>
<b>Migration</b>	PoSTM	PSTM -> PSDM (2011)	PSDM	PSDM
<b>Imaging</b>	Imaging main reflectors. Main sand <b>not</b> imaged	2001: Slight data quality improvement 2008-2012: AVO, depth migration, imaging HC sands, derived cubes 2014: Improved velocity model	Broadband Improved imaging	Improve imaging + velocity model
All surveys:	1988	2002	2009 2012 2018	2021 2023



# Complex reservoirs & complex wells

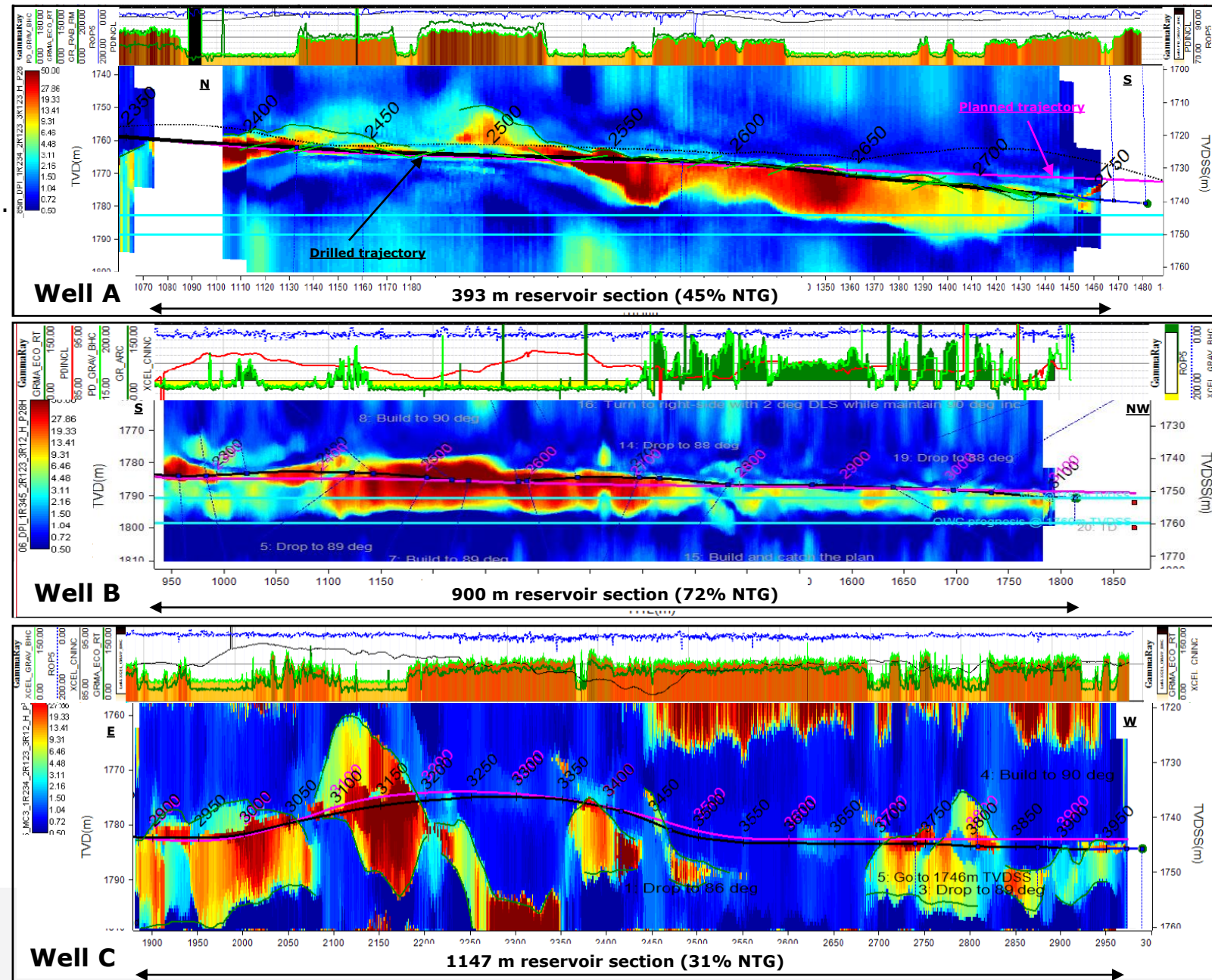
- Complex Geometry
  - Varying stand off (ranging from 10-25 m).
  - Different target oil sand thickness (10-35 m).
  - Connection to water.

- Well A:
  - 393 m reservoir section (45% NTG).

- Well B:
  - 900 m reservoir section (72% NTG).

- Well C:
  - 1147 m reservoir section (31% NTG).
  - First MLT in the Balder field and longest section completed so far.

## Deep resistivity section along wellbore

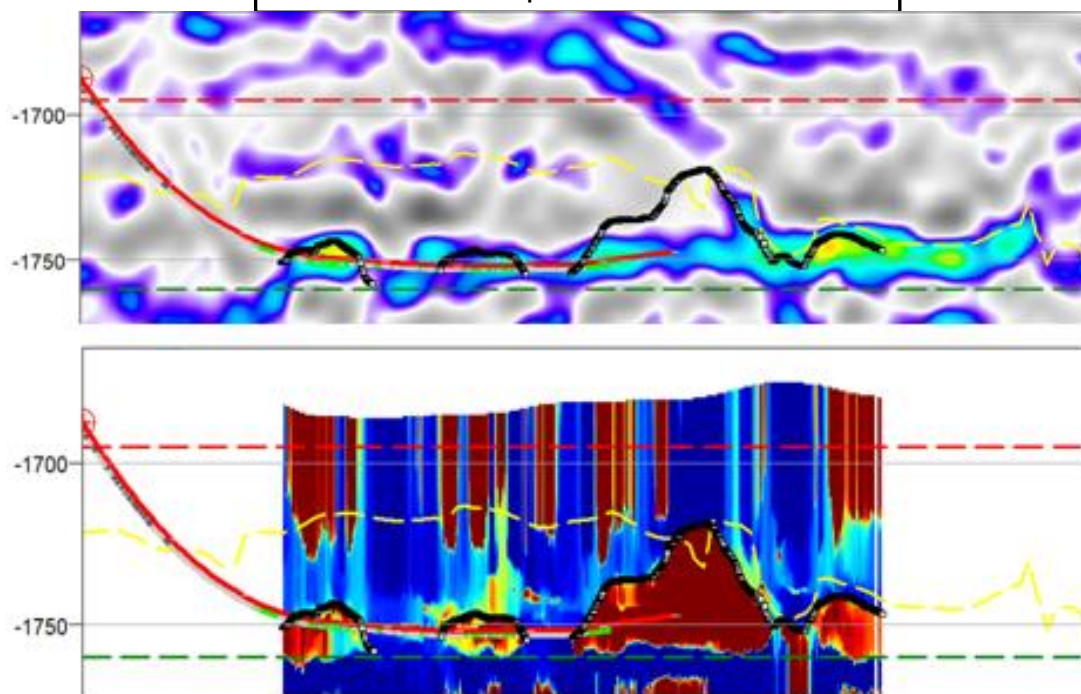




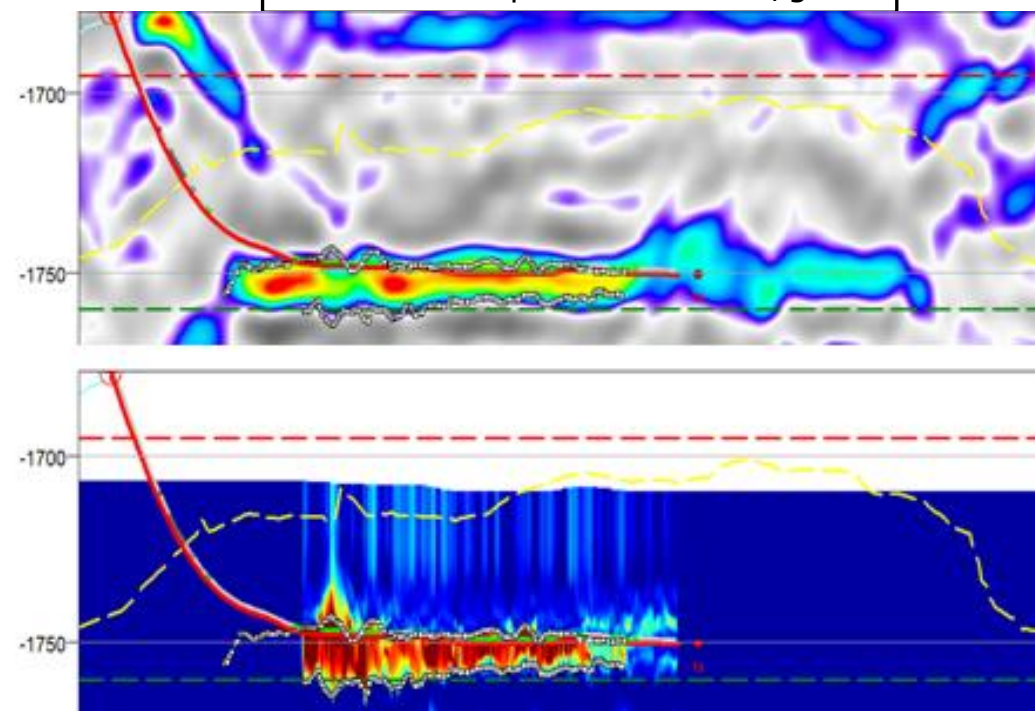
# Can new technology assist us?

- Future of Balder development:
  - Increasingly more complex targets.
- Main challenges:
  - Sometimes surprising well results (+/- !) - are we harnessing all the data we can? Potential to improve **Prediction**?
  - Manual and complex workflows → long well target maturation time: Potential for increase in **Efficiency**?

Well A – under prediction of net sand



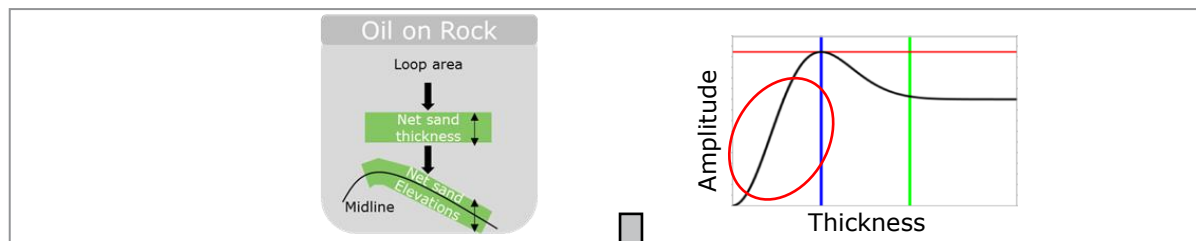
Well B – over prediction of net/gross



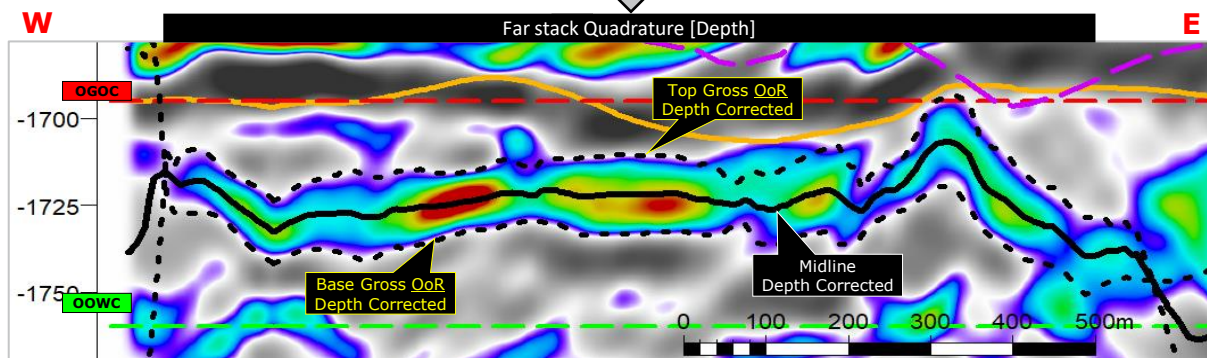
# Predicting sub-seismic sand thickness and sand probability

## Thickness estimation

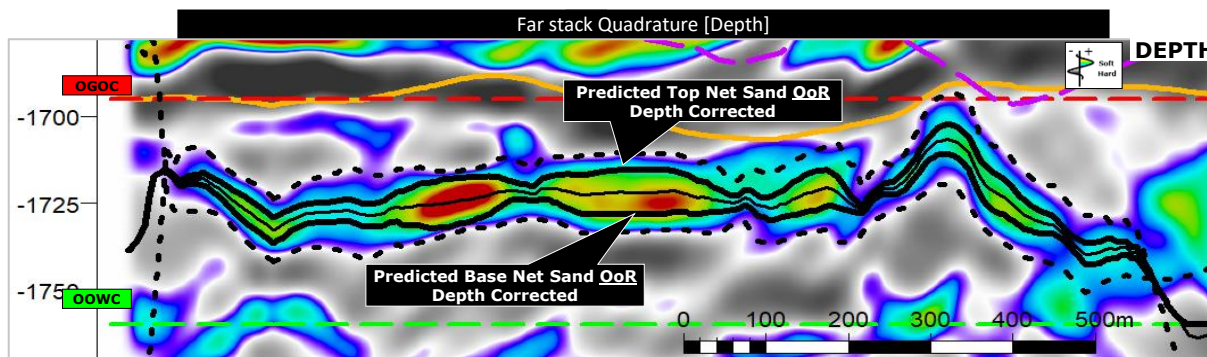
Workflow



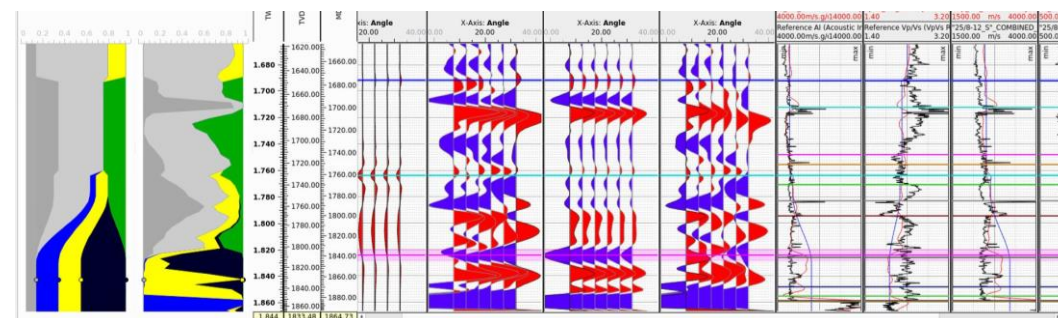
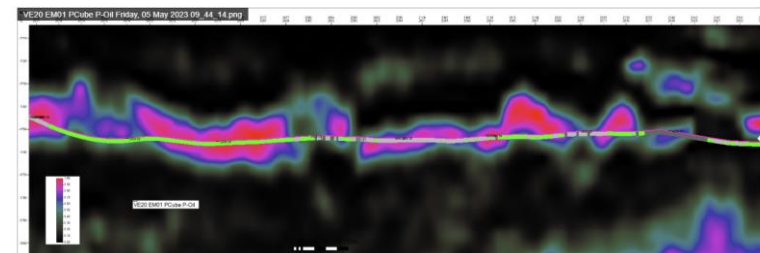
Apparent thickness



Predicted thickness

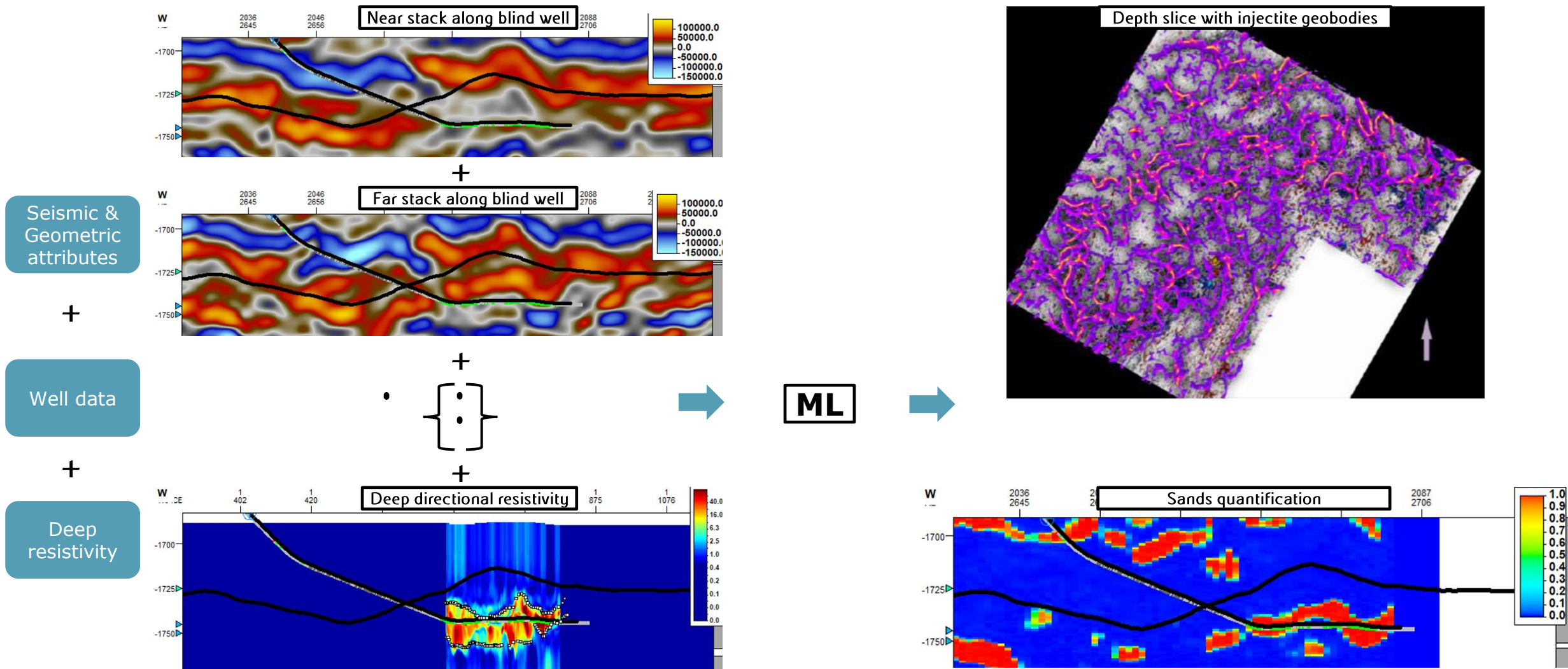


## Oil sand probability (Pcube+)



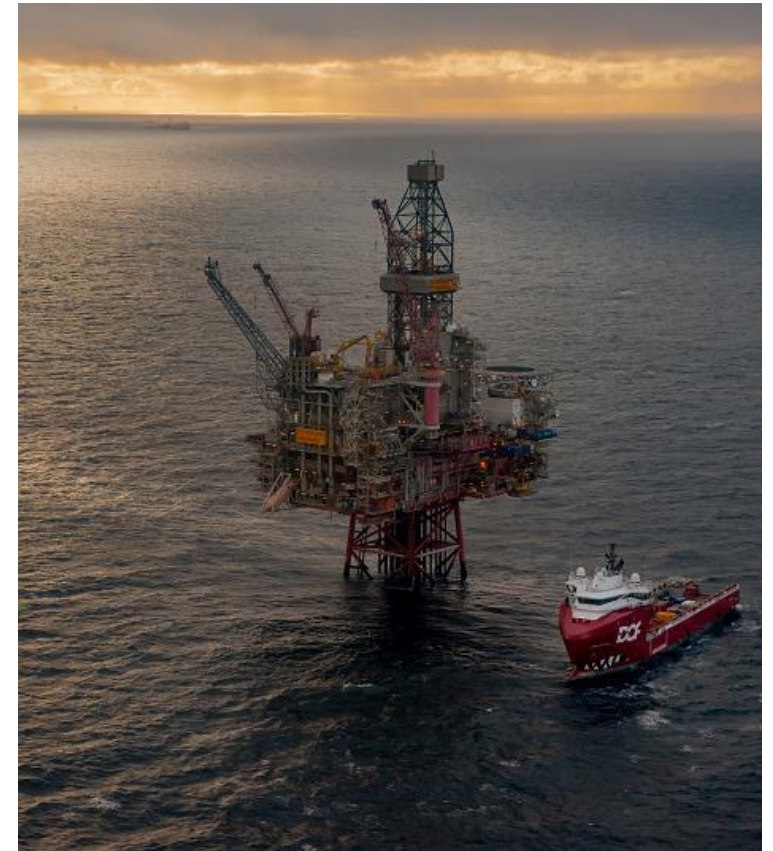
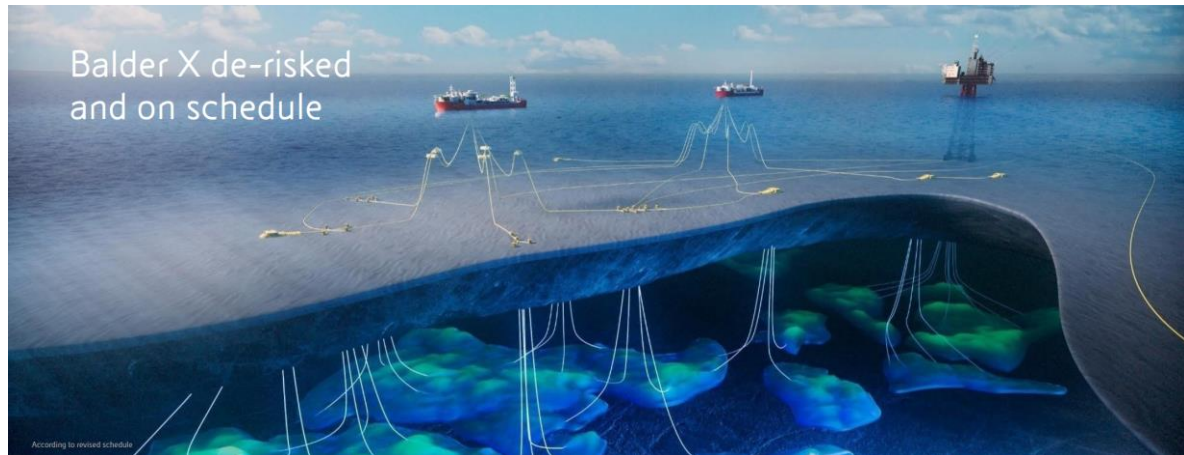
Rock physics and Bayesian inversion

# Sand prediction with Machine Learning – Promising pilot project



# Conclusions

- The Greater Balder area is a complex subsurface puzzle.
- Continuous exploration of cutting-edge technologies and workflows is central for improving subsurface understanding and securing future area development.



## Acknowledgement:

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vår energi