NORSAR
Exploring the Earth

NORSAR – Research Institute in Seismology and Applied Geophysics

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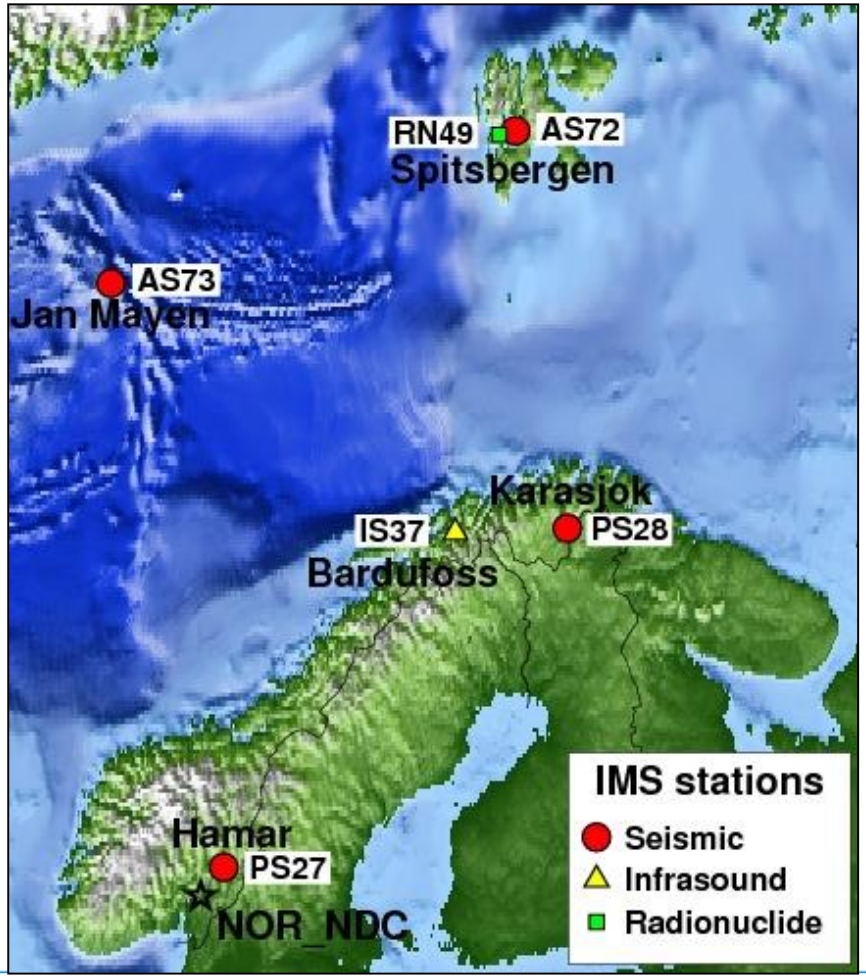
NORSAR (NORwegian Seismic ARray)



- NORSAR is a scientific not-for-profit research institute:
  - Established in 1968
  - Connected to internet in 1973 as the first institution outside the US
- Operating stations within the International Monitoring System (IMS)
  - Monitoring Nuclear Test Ban
  - Including the original NORSAR array near Hamar
- R&D within many fields of seismology and applied geophysics:
  - Seismic modelling
  - Microseismic monitoring
  - Seismic hazard and risk
  - Nuclear test monitoring
  - Seismological arrays

NORSAR Contributes to Solve Society Challenges

Safe and effective oil and gas

Optimize seismic data collection

Monitor Production

…

Safer society

Nuclear testing

Rockslides

Subsidence

Cracking

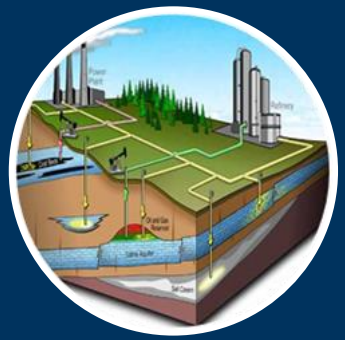
Tunnels

Weather systems and climate

Large weather systems

Ice sheet movements

…



New energy

CCS – CO_2storage

Geothermal energy

…

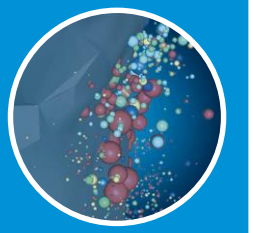
Norway's National Competence Centre for wave propagation in the earth and atmosphere

NORSAR Activities and Products

CONSULTANCY SERVICES

Seismology and Test Ban Monitoring

Earthquake Hazard and Risk



Microseismic Monitoring

Seismic Modelling

SOFTWARE PACKAGES

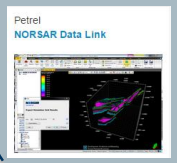
NORSAR-2D

NORSAR-3D

SeisRoX

Add-ons

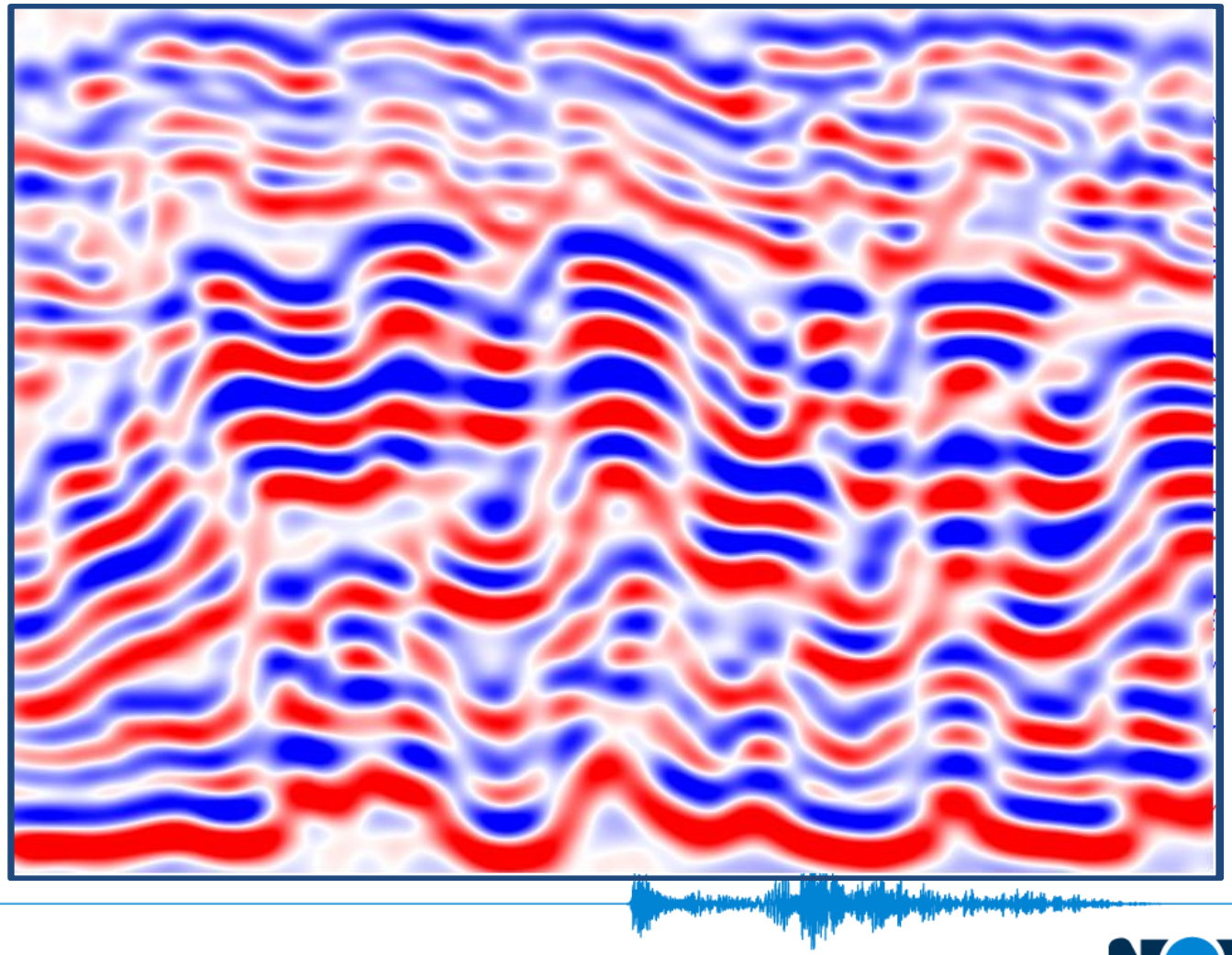
VelRock



Petrel plugins

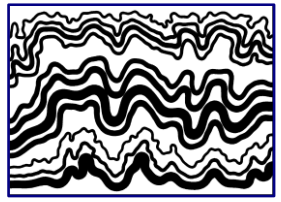
NORSAR Business and Cooperation

From Geology to Seismics



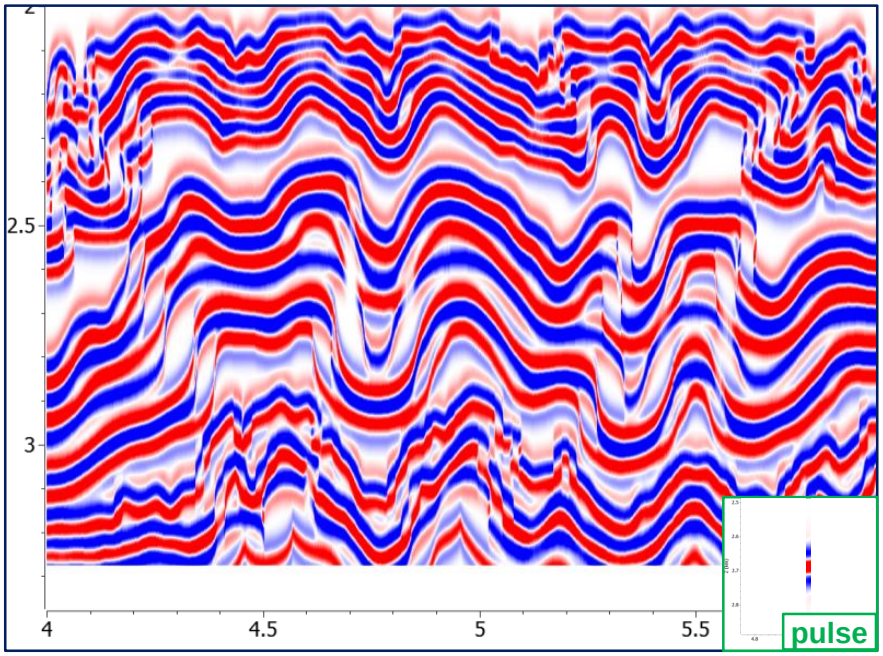
Figures by I. Lecomte, NORSAR

From Geology to Seismics

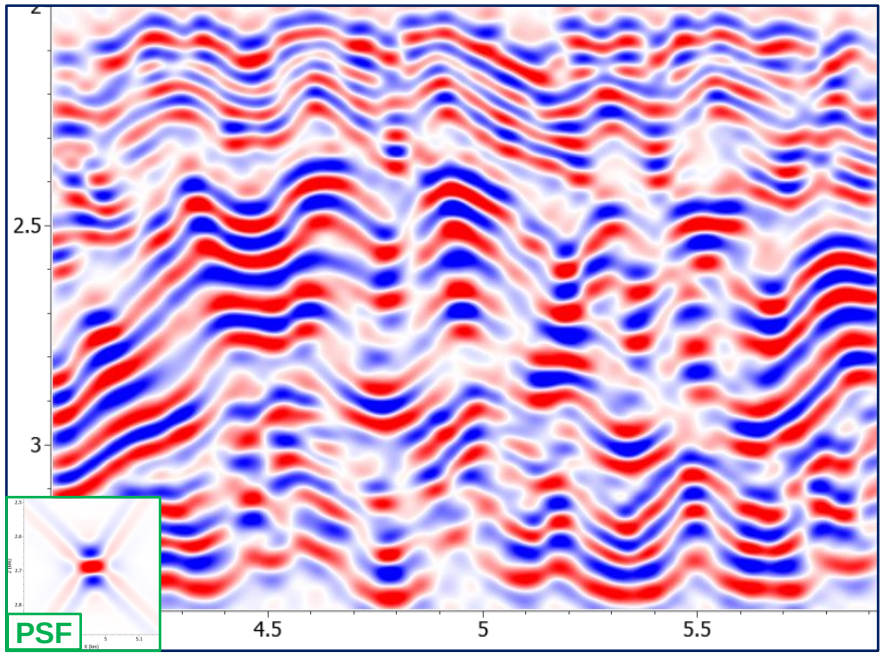


Courtesy of D. W. Schmid

1D wavelet convolution



3D PSF convolution by NORSAR



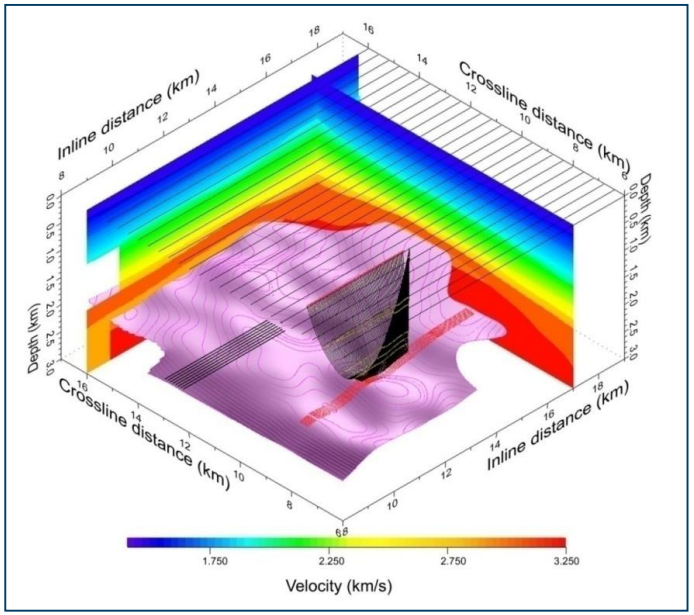
What you see and what you don't see in a seismic image is not only dependent on the **target reflectivity**, but also on the **seismic survey** geometry, the **overburden** structures and properties, and the **target topography**.

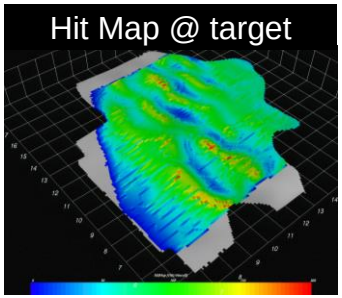
Figures by I. Lecomte, NORSAR

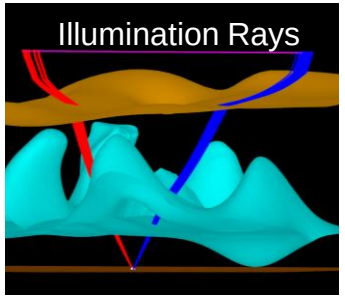
Integrated Modelling Tools

NORSAR-3D:

- Full featured Model Builder
  - Open models / Complex structures
- Accurate and robust Wavefront propagation
  - 3D heterogeneous and anisotropic models
  - Direct waves, converted waves, multiples, peg-legs, …
- Flexible survey geometries
  - Full survey geometry from navigation data
  - Analytic surveys
- Target oriented results
  - Illumination Maps: Amplitude, Fold, Aperture, etc.
  - Interactive Illumination Rays, Flower Plots
  - Seismic gathers



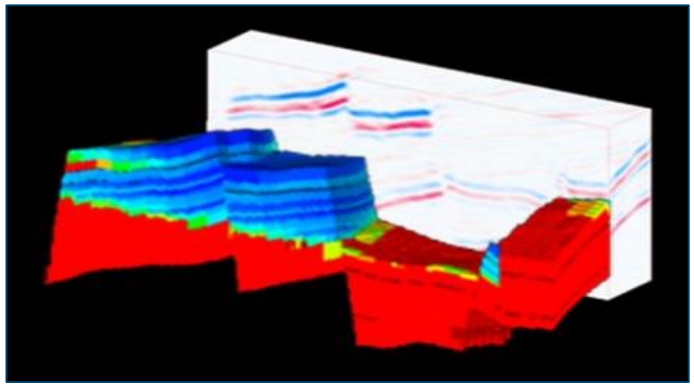




Integrated Modelling Tools

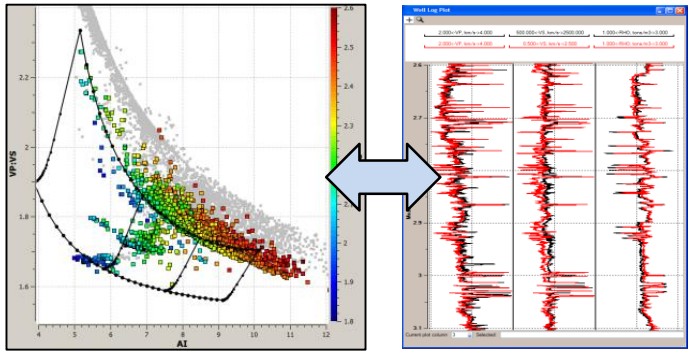
SeisRoX:

- Detailed reservoir models
  - Geological and fluid simulation models
- Rapid simulation of seismic reservoir response
- Full and partial stack seismic volumes
- Geologic and elastic volumes

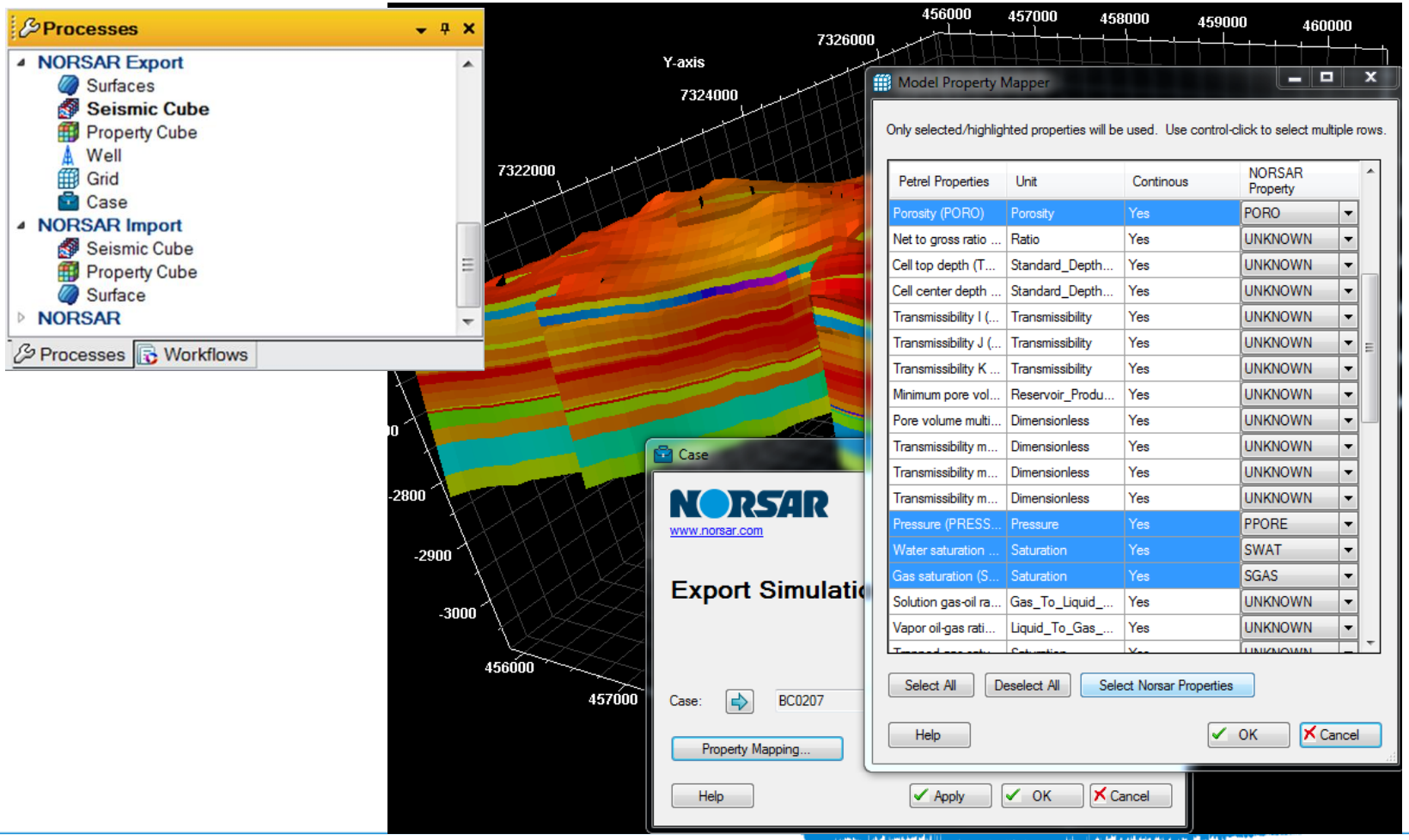


VelRock:

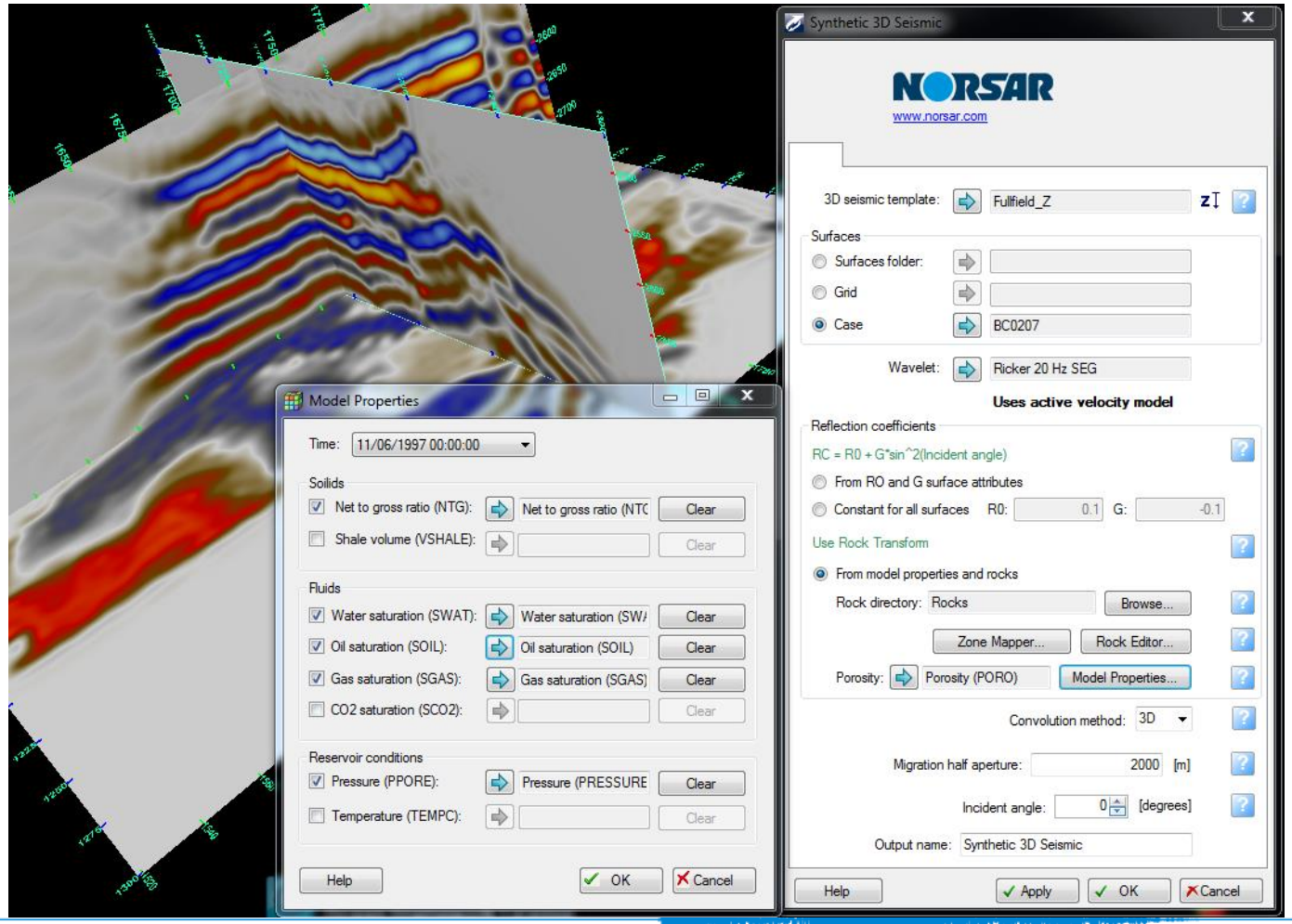
- Rock physics modelling and analysis
- Well log data and reservoir models



Petrel Datalink – Fluid Simulation Case



Petrel Plugin: Synthetic 3D Seismic



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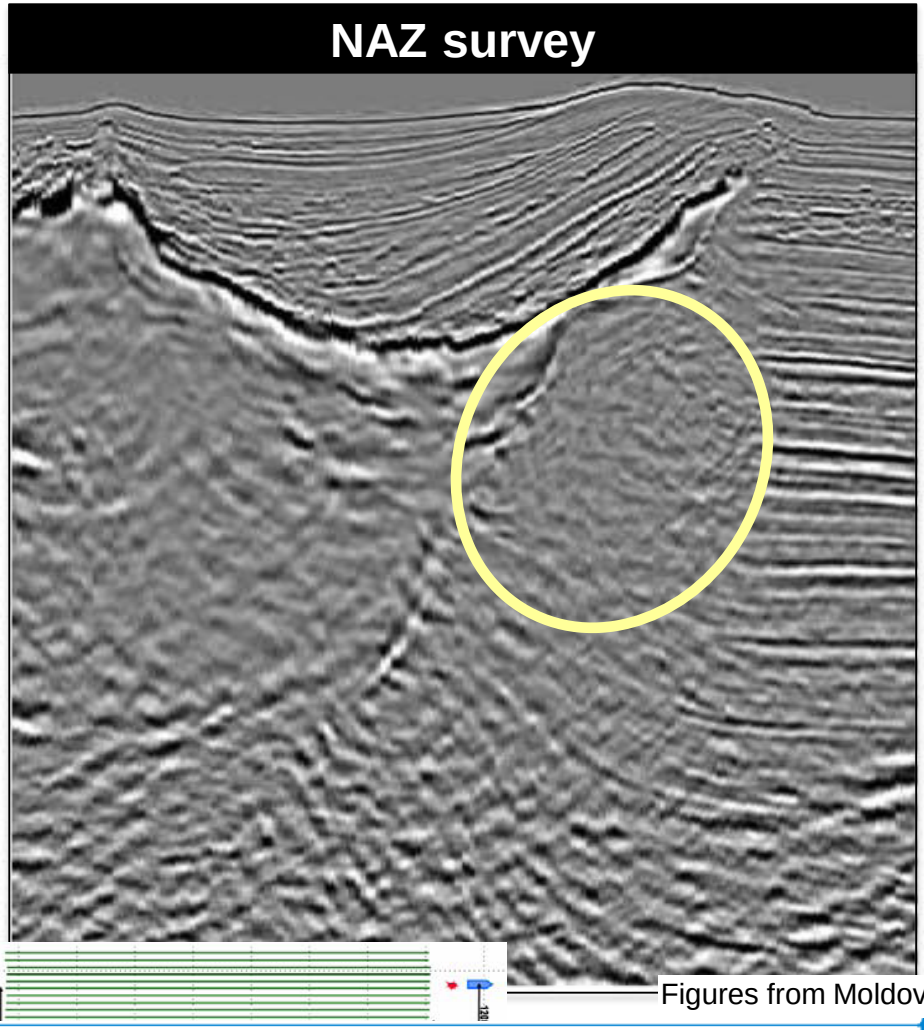
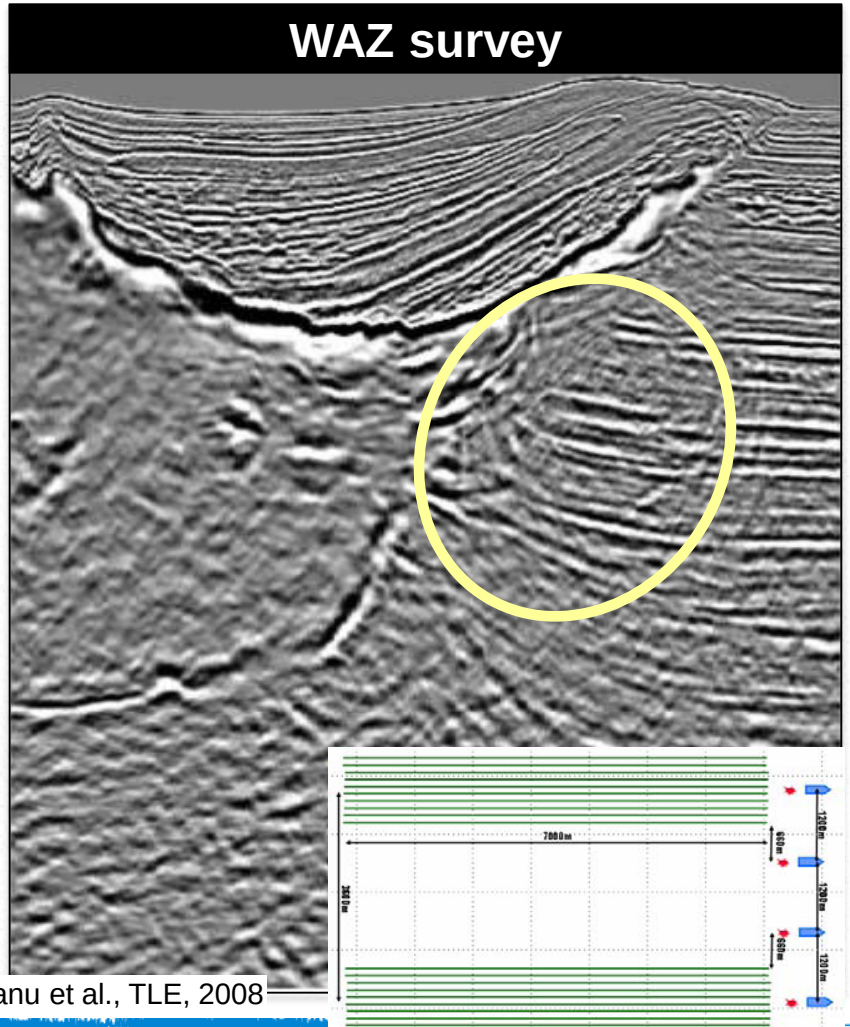
Ongoing R&D Activities

Seismic Data Quality

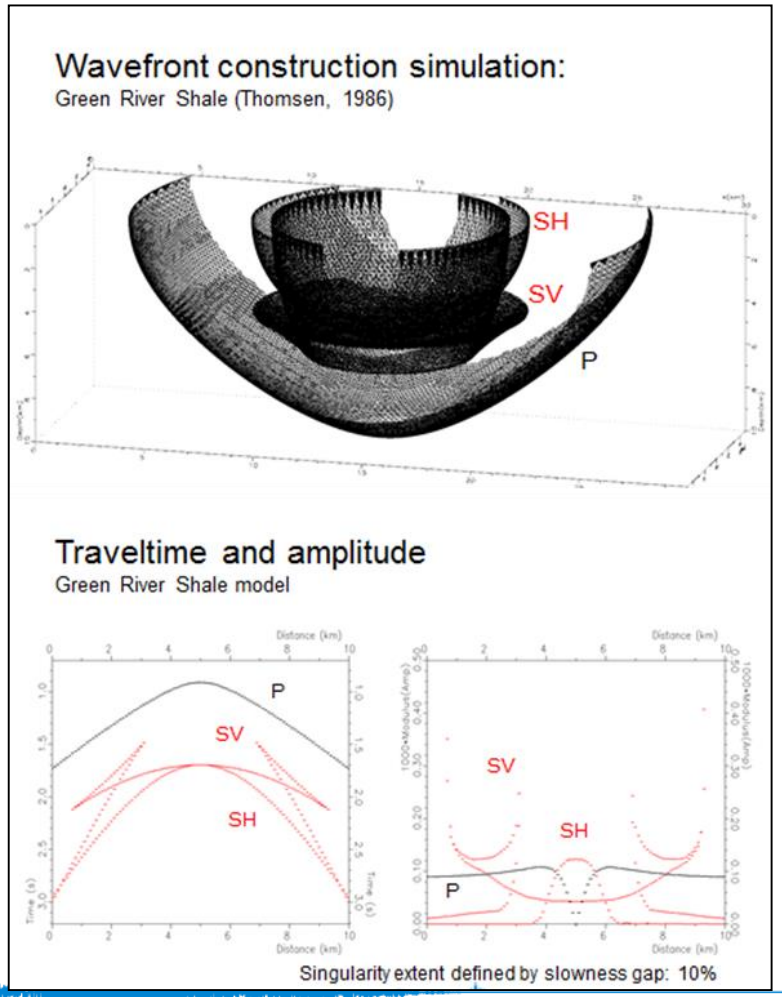




Figures from Moldoveanu et al., TLE, 2008

Seismic Wave Propagation in Complex Media

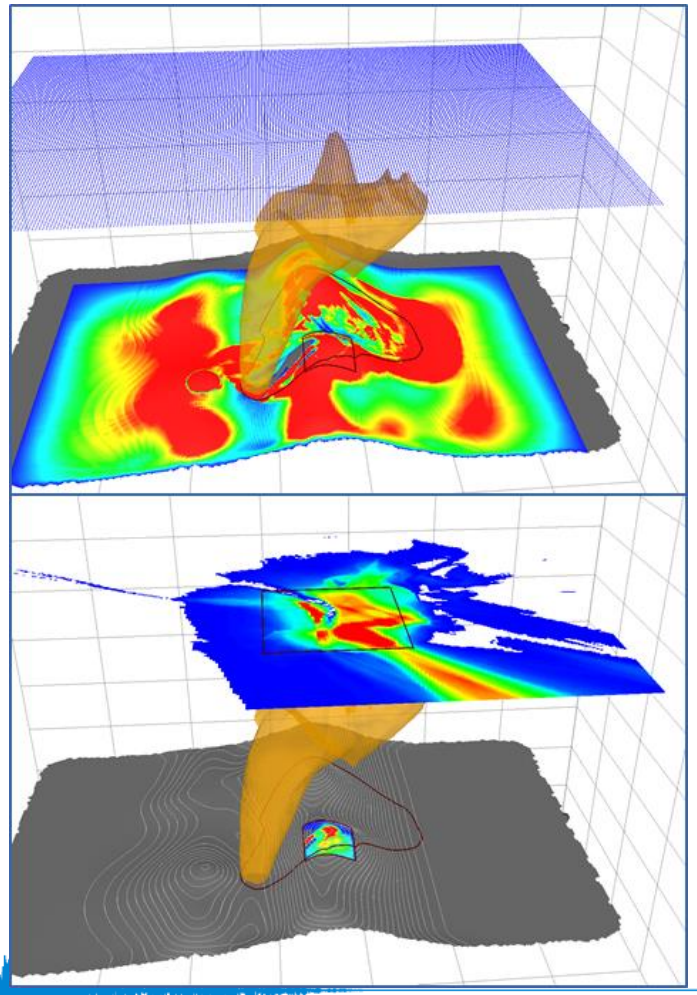
- S-wave anisotropy
- Optimization of 3D velocity models
- Applications using Greens Functions
  - Kirchhoff modelling
- Multi-component seismic gathers in different domains
- …



Simulation of Modern Seismic Surveys

- Full-azimuth surveys
- Multi-vessel acquisitions
- Permanent and retrievable ocean bottom seismometers
  - Cables and nodes
- Offset-vector tile analysis
- Broadband seismics
- …

- **Quantification of illumination and resolution properties at target**



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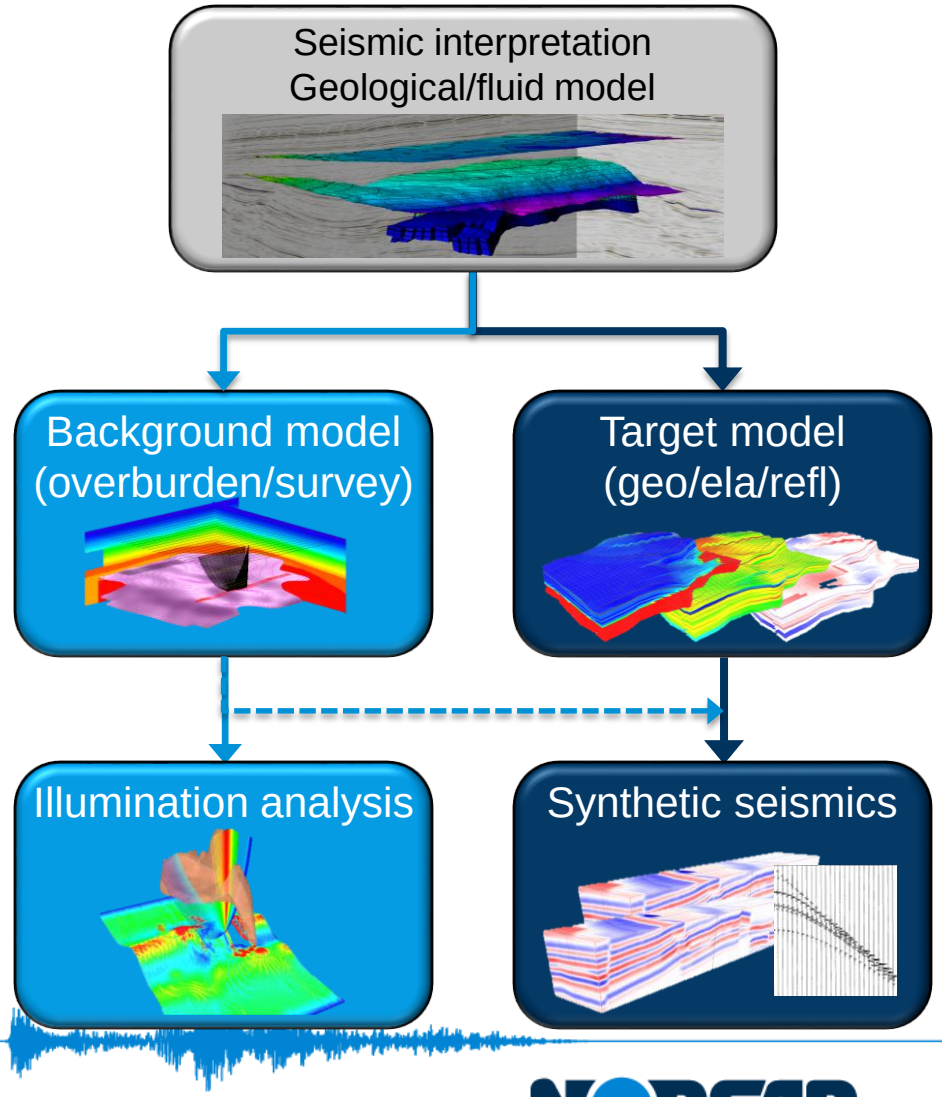
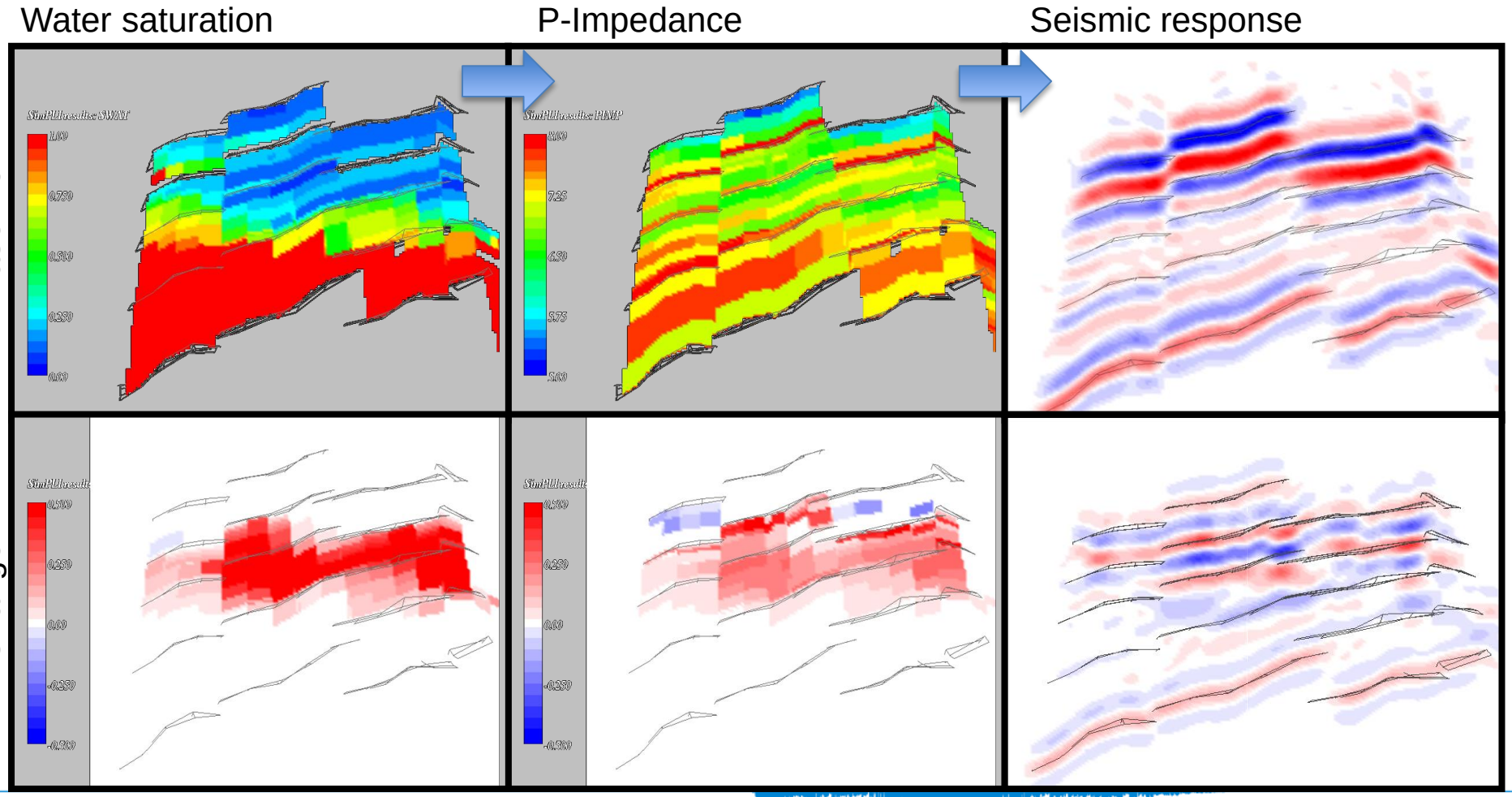
Reservoir-to-Seismic Modelling by NORSAR

- Purpose(s):
  - To link key reservoir properties to seismic response
  - To guide seismic mapping of reservoir properties
  - To quantify seismic response changes due to production
- NORSAR approach:
  - Integrated rock physics and 3D seismic modelling
  - Illumination compliant
    - includes illumination and resolution constraints from overburden and survey
    - use offset-angle relationship from 3D overburden model
  - Sensitivity and uncertainty analysis

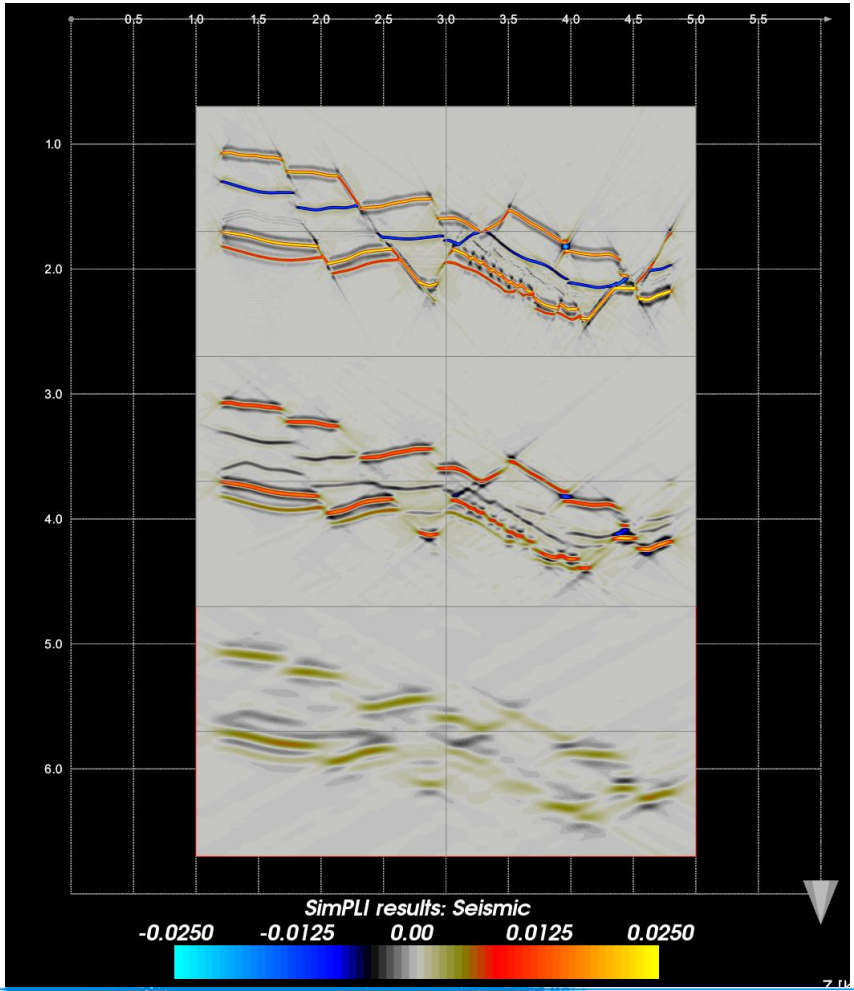


Simulator-to-Seismic Modelling

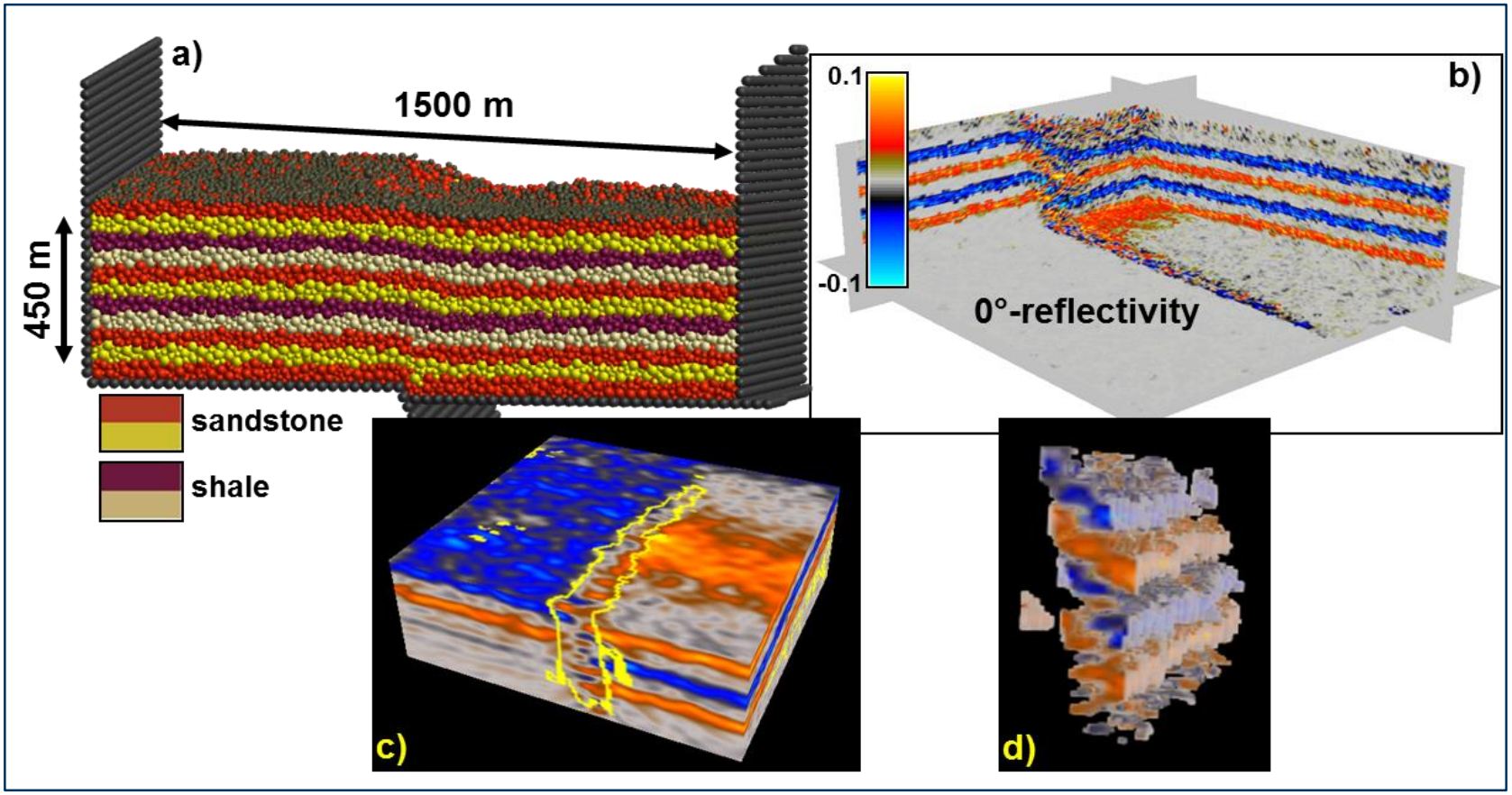


Modelling-Assisted Analysis of Seismic Data

- Imaging feasibility
  - Illumination and resolution
- AVO/AVA feasibility
  - Offset-angle relationship
  - Target dips
  - Parameter estimation
- …



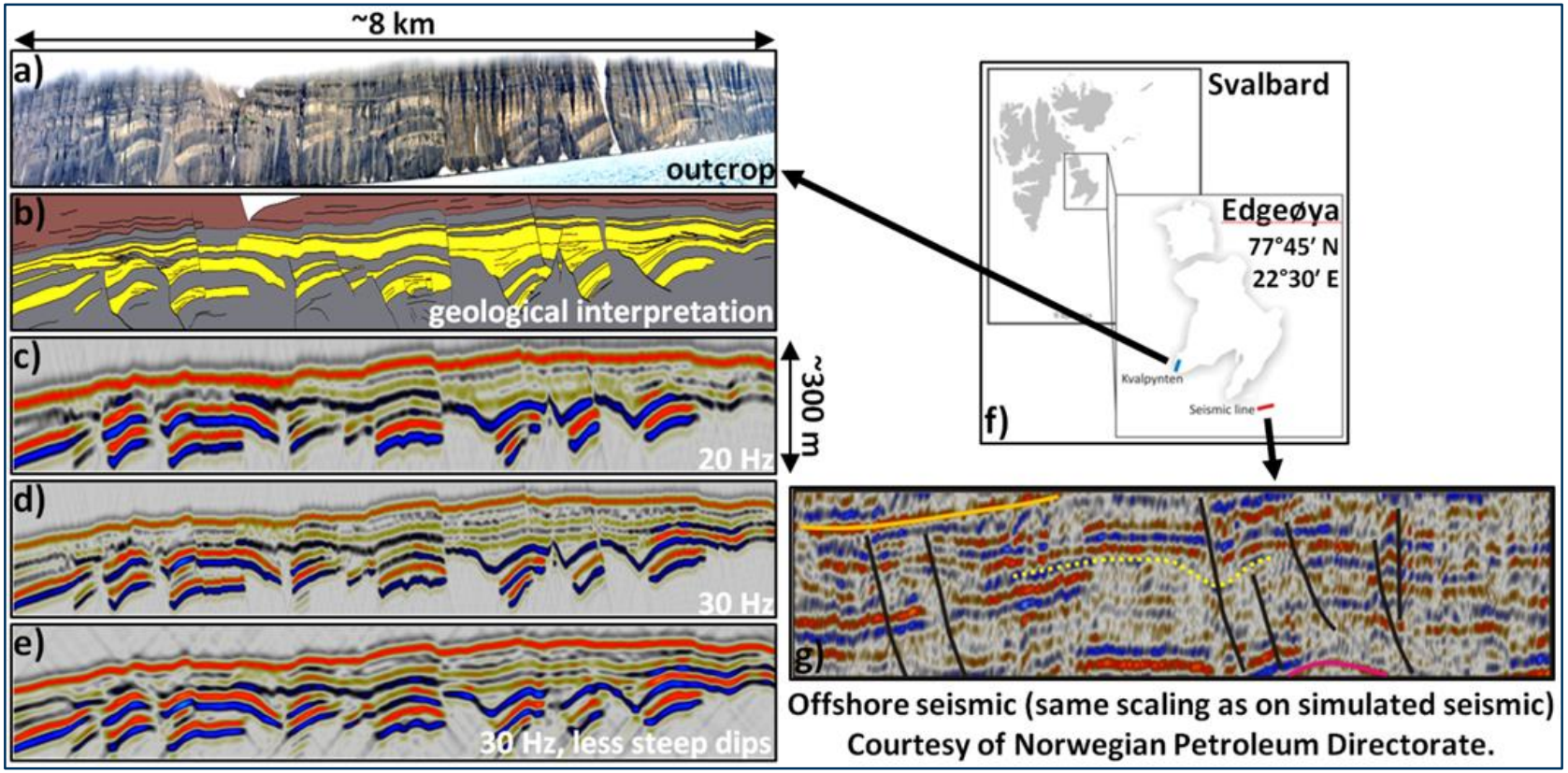
Seismic Imaging of Fault Zones



On-going work with PhD candidate C. Botter, UiS, with RCN funding, grant #210425, "Seismic imaging of fault zones"

Project leader @ NORSAR: Isabelle Lecomte

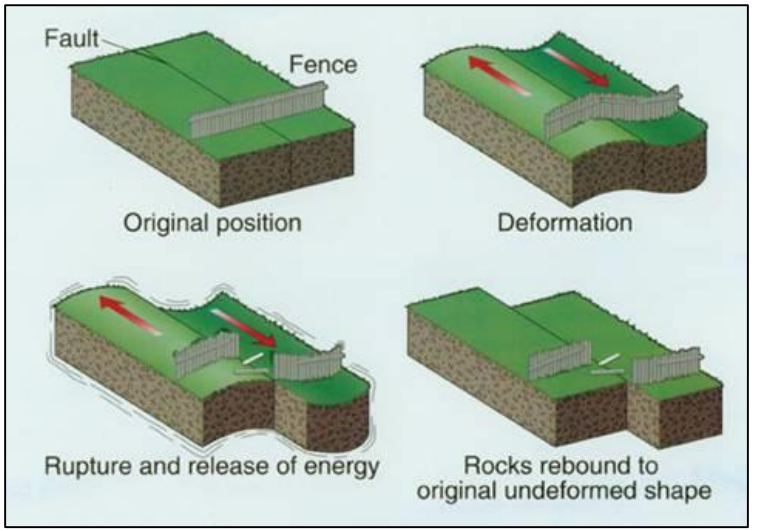
Seismic Imaging of Outcrops



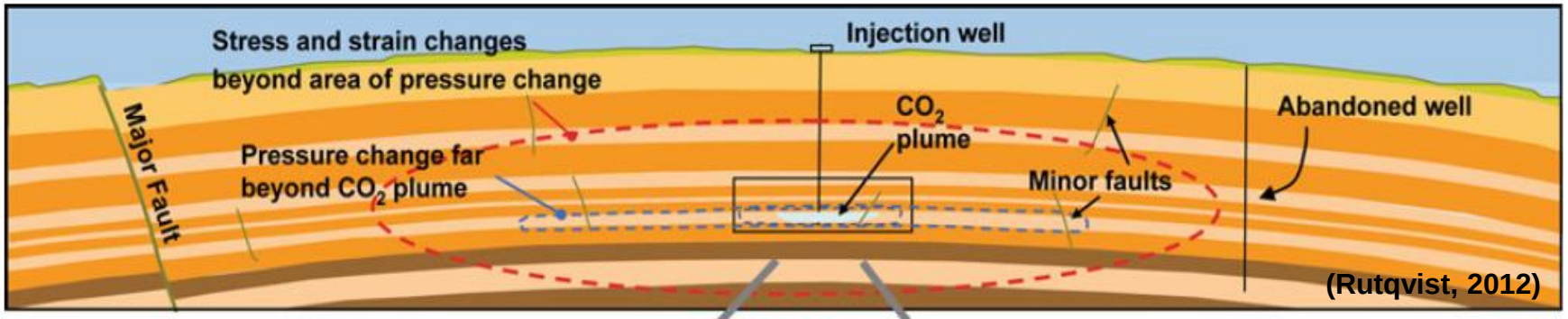
On-going work for UiO RCN-Petromaks project "Trias North", grant #234152, with funding from Tullow Oil Norge, Lundin Norway, Statoil Petroleum, Edison Norge and RWE Dea Norge.

Project leader @ NORSAR: Isabelle Lecomte

Microseismicity

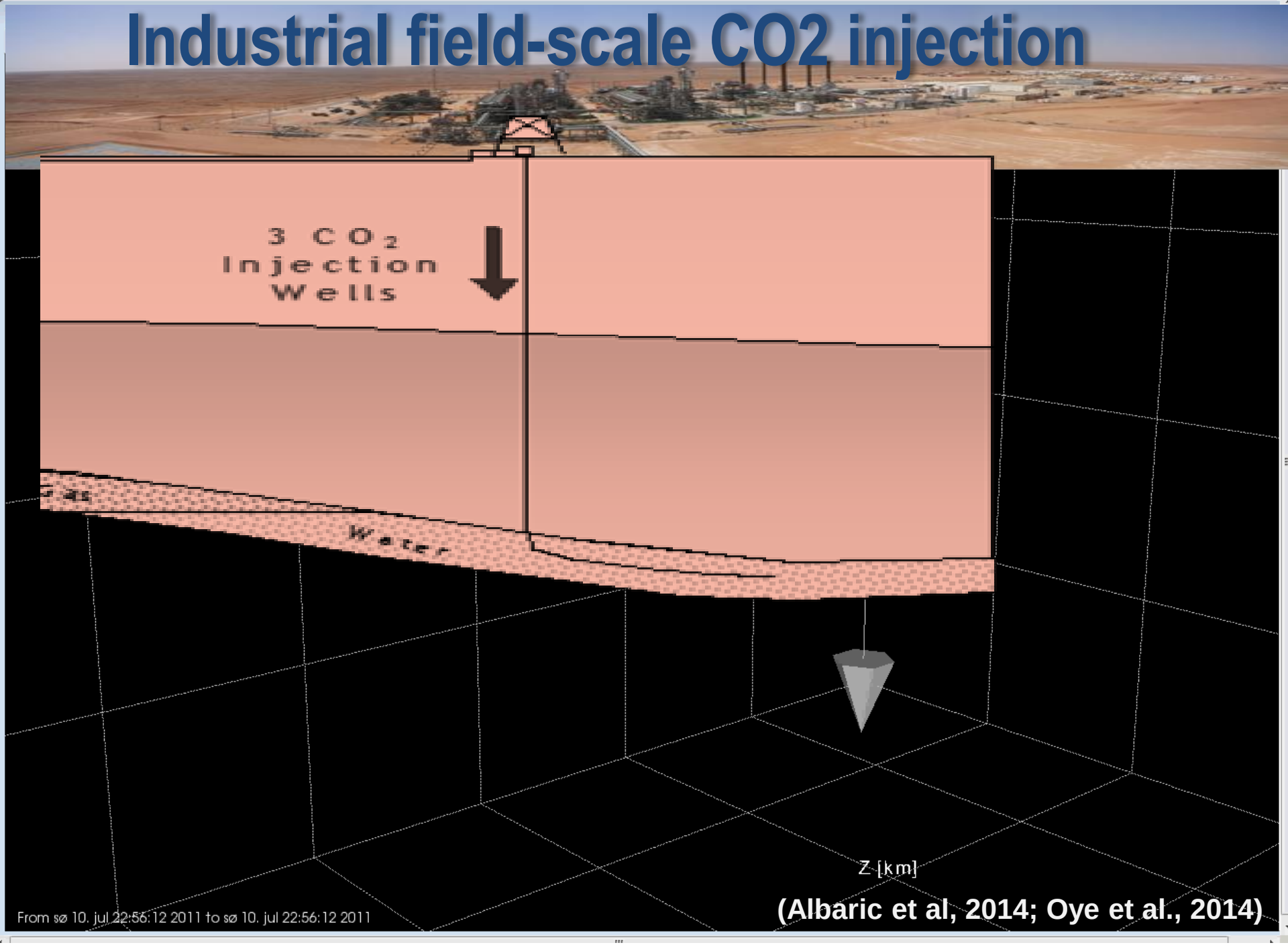


- Continuous seismic monitoring to establish the **natural**, background seismicity (related to tectonic stresses).
- Fluid production/injection changes the relative pressure-field and hence the state of stress. These stress changes can **trigger** shear failure on existing faults and **induce** new fractures/faults.

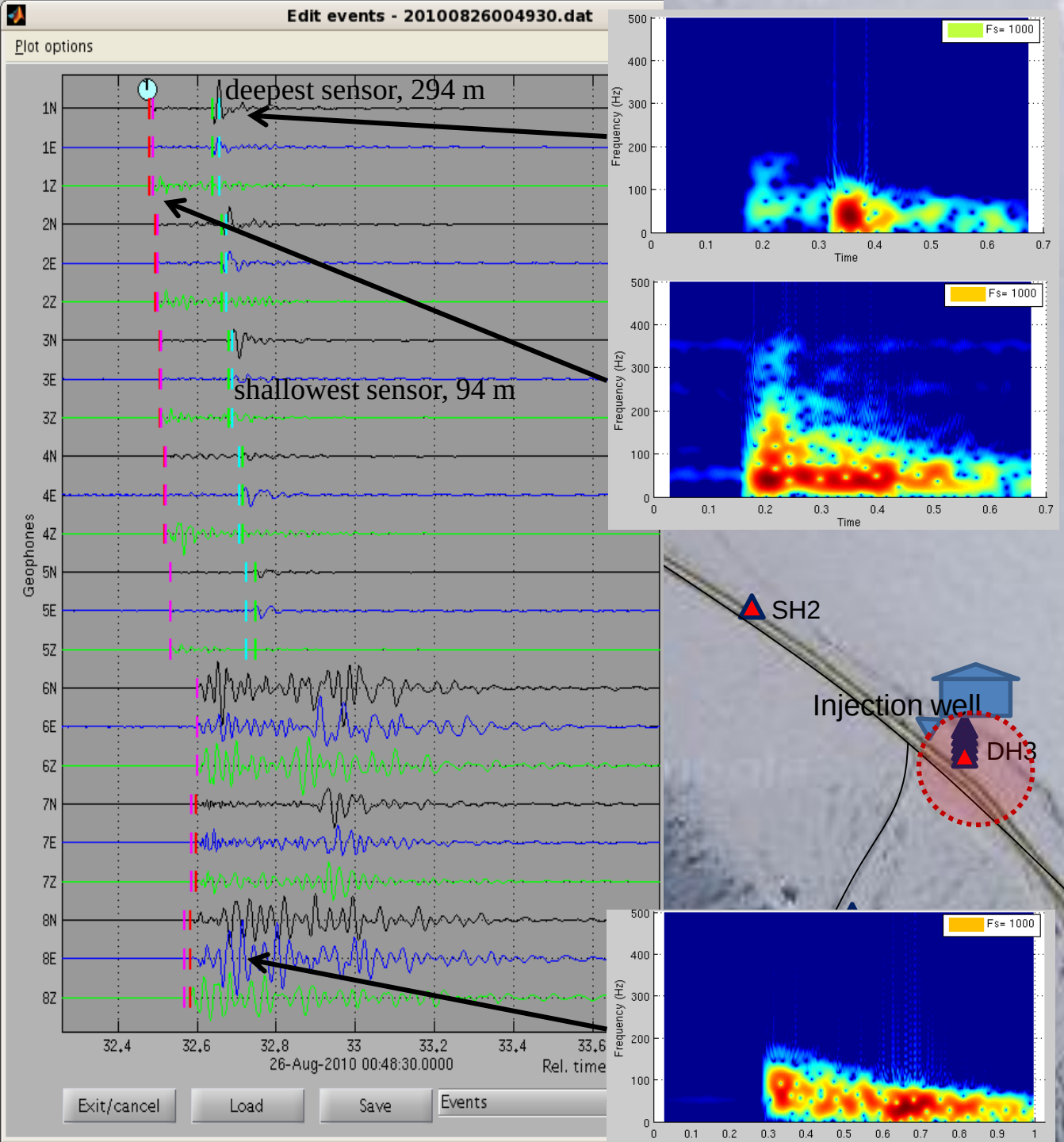


Head of department: Volker Oye

Industrial field-scale CO2 injection



(Albaric et al, 2014; Oye et al., 2014)



Event on 26th August 2010 at 00:49 GMT (7 hours after 5-day water injection test)

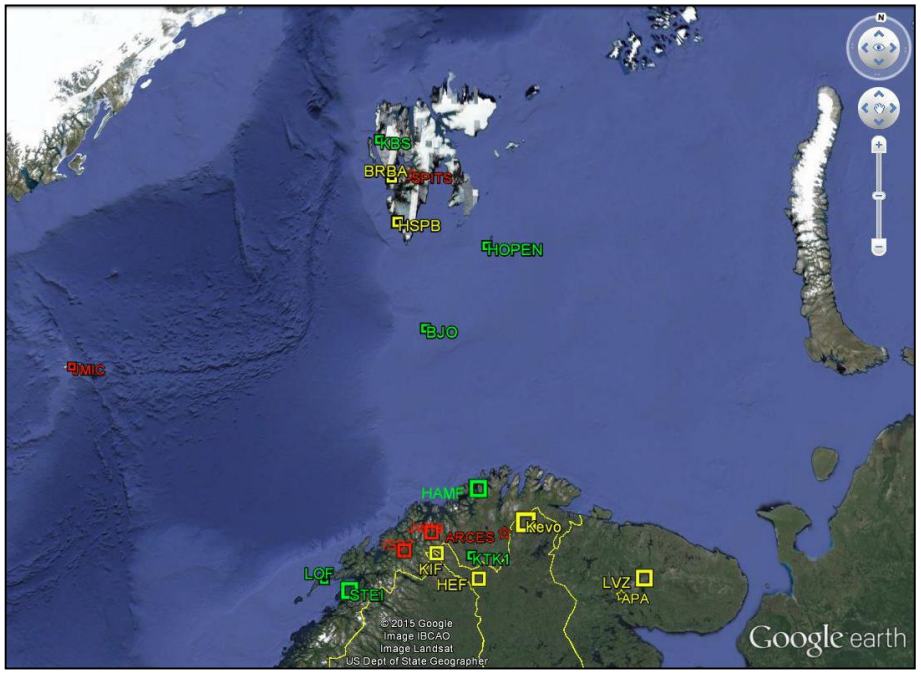
Clearly improved Signal-to-Noise conditions at deep borehole sensors as compared to shallow borehole sensor (12 m depth)

Event was also clearly seen at SPITS

Seismic Monitoring of Barents Sea

- Seismicity in the Barents Sea:
  - Background seismicity
  - Intraplate seismicity along unknown faults
  - Seismic risk due to oil & gas production
- Cryosphere Dynamics:
  - Mobility of glaciers
  - Modelling of climate change effects

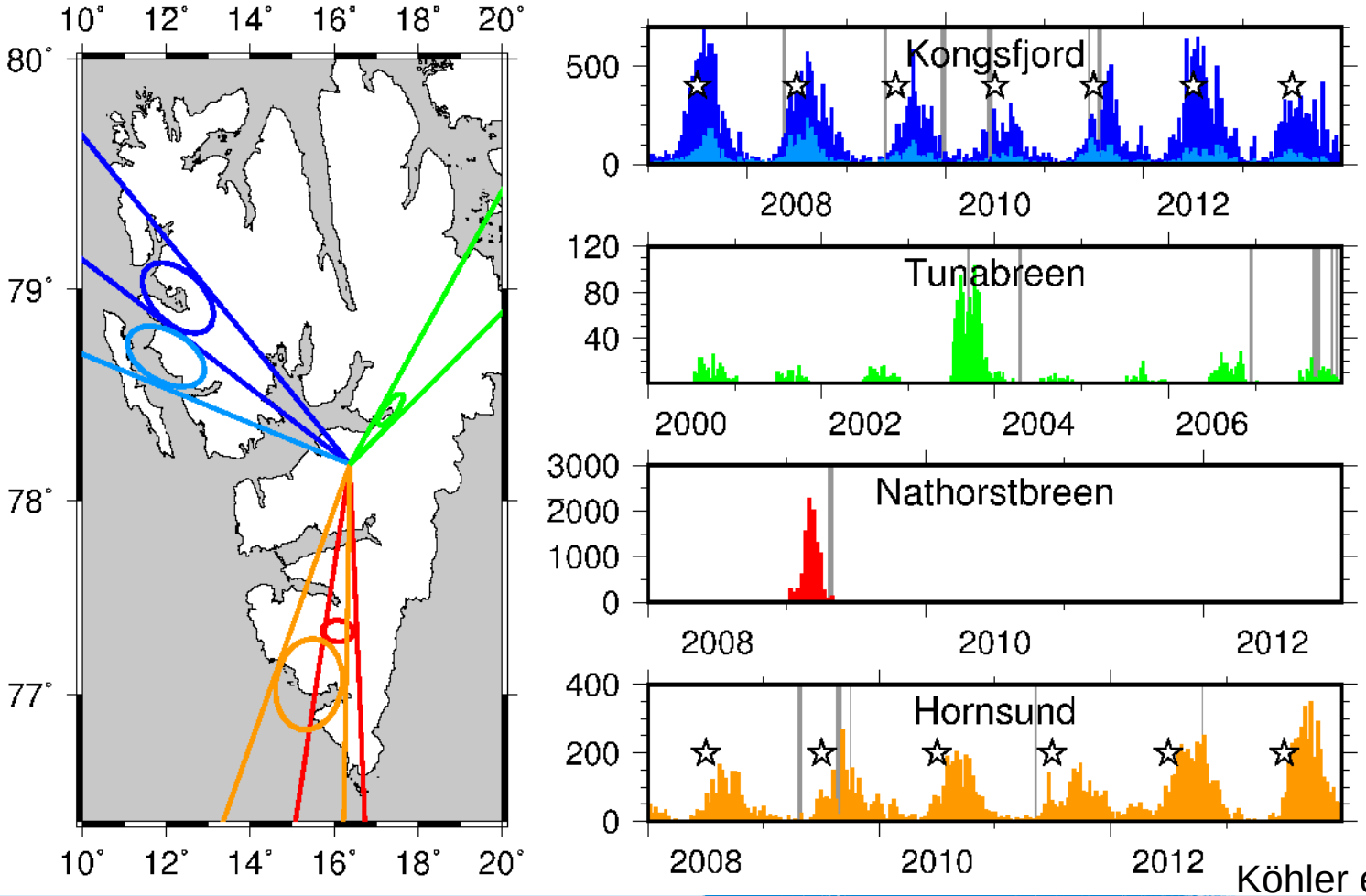
- Extensive archive of digital data from the Arctic (oldest data from 1971):
  - Seismic array data
  - Radionuclide station data
  - Infrasound array data
- New array (BJOA) at Bjørnøya 2017
  - Installation funding by NFR/EPOS



Pilot project with “Det norske”:
Collect and analyse data that can monitor geophysical processes in the European Arctic

Project leader: Johannes Schweitzer

Spitsbergen – Icequakes



Köhler et al., 2015

Thank you!

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