
Petroleum and geophysics, NTNU

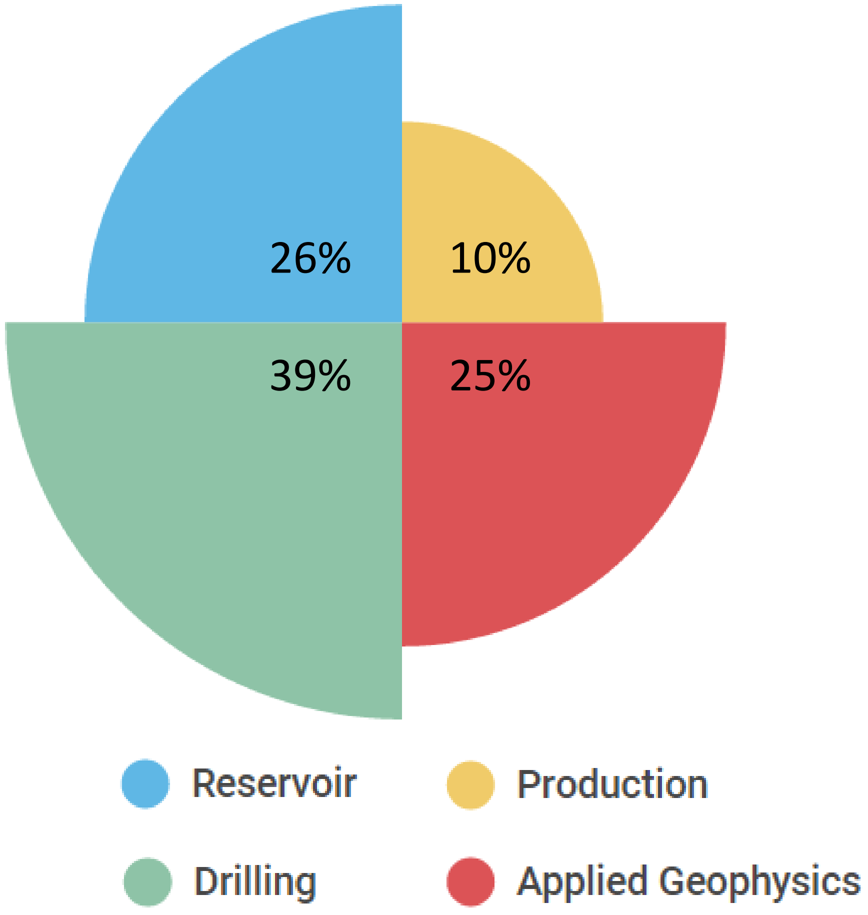
Study programs

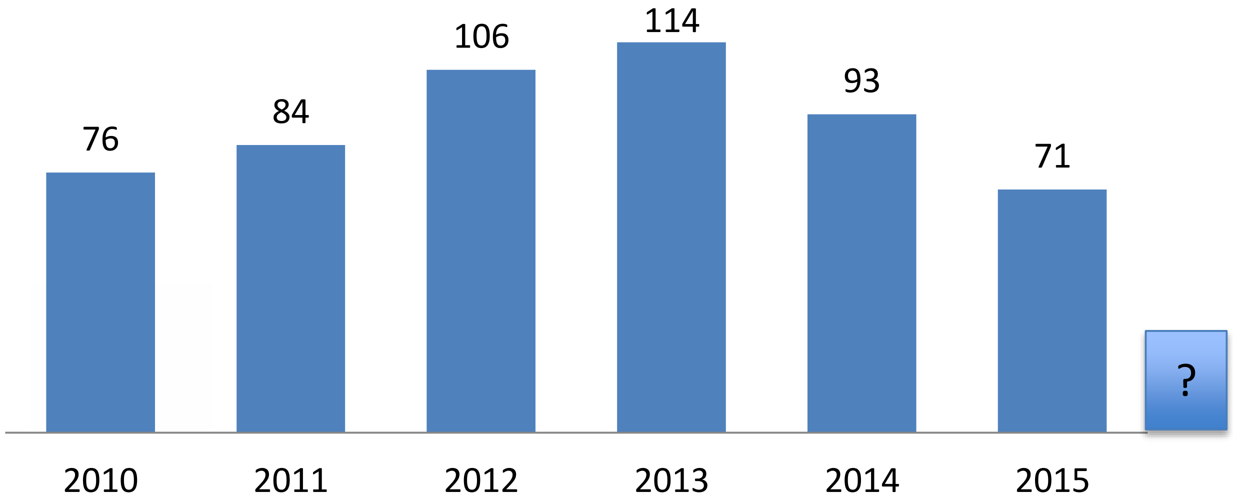
- International Master's (MSc)
  - Petroleum Engineering (2 yrs)
  - Petroleum Geosciences (2 yrs)

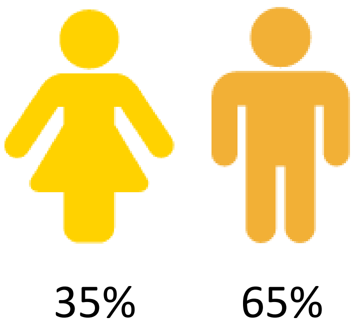
- Integrated Master's
  - Petroleum Geosciences and Engineering (5 yrs)
  - Petroleum Geosciences and Engineering (2 yrs)
  - Engineering Science and ICT (5 yrs)

- Other related programmes:
  - Geotechnology (5 yrs)

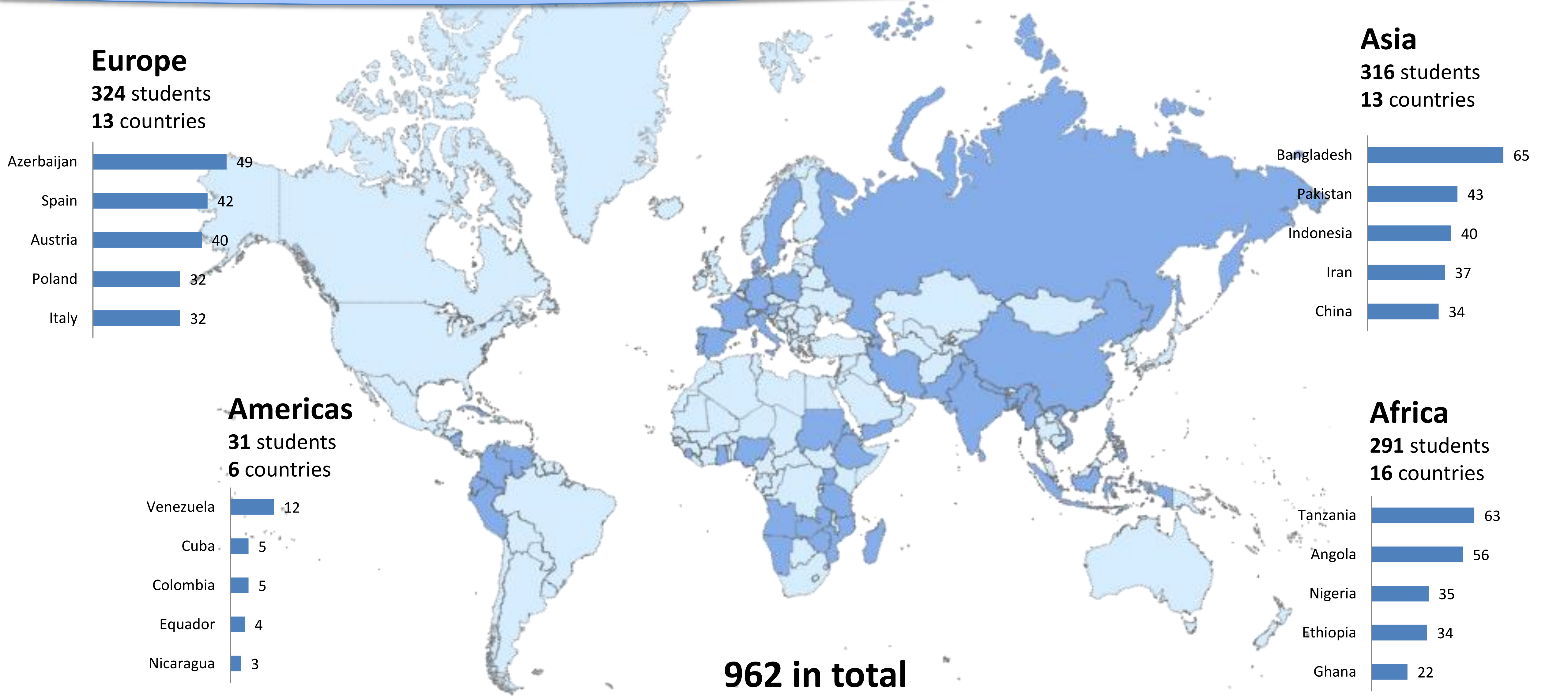
Master students 2010-2015





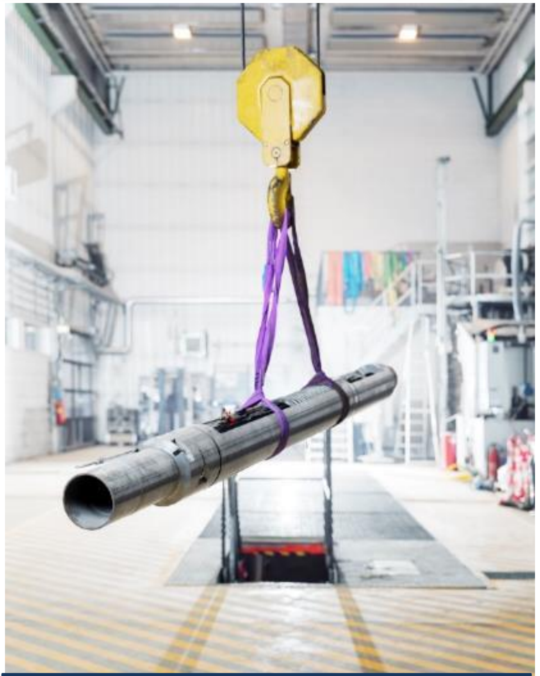


Non-Norwegian students attending the M.Sc. programs in Petroleum Engineering/Geoscience 1993-2014/15



Laboratory and workshop facilities

Mechanical workshop



Test hall for drilling and production experiments

CT

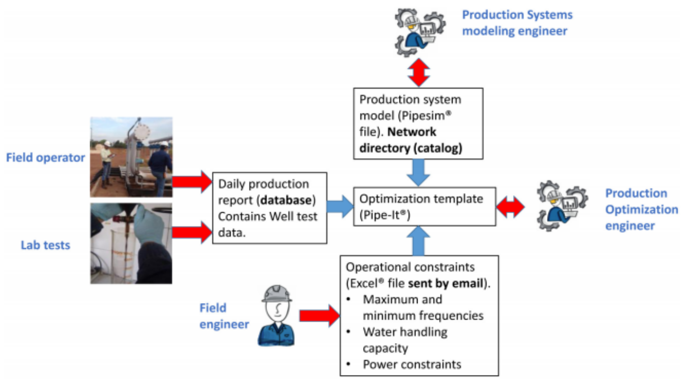
Mechatronics workshop

Schlumberger Geo-computing

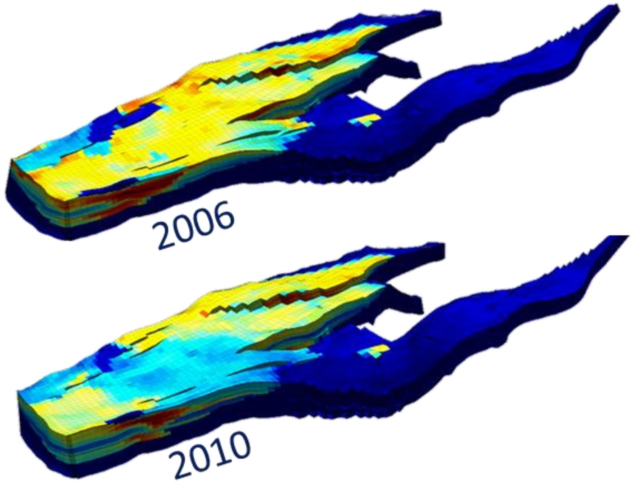
Core Analysis Lab

Groups, faculty and staff

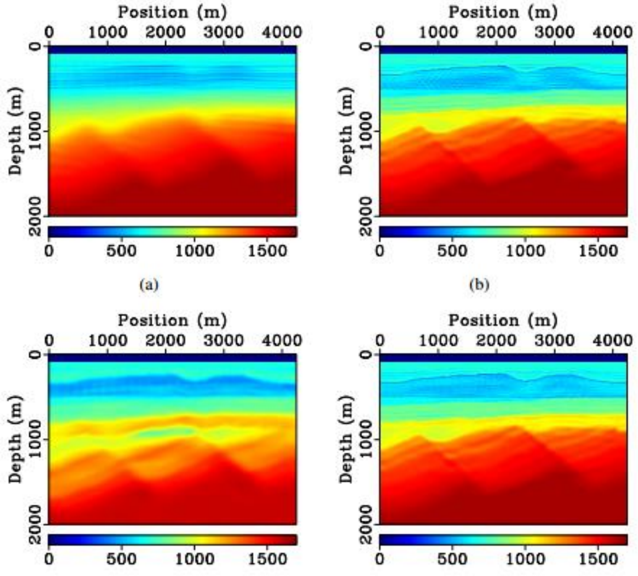
Well Completion and Production Systems



Reservoir Engineering



Applied Geophysics



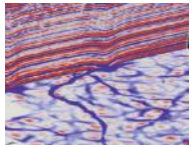
11 Professors
20 Adjunct Professors
5 Associate Professors
3 Assistant Professors

60 PhDs and Post doctoral candidates
15 technical and administrative staff

Research projects - Geophysics

ROSE - Rock Seismic research project
Consortium sponsored by NFR and
20 companies, Host

WAVES
EU-ITN Marie Curie, Partner



CASE – Applied geophysics
Consortium, Host

Research Centre for Arctic Petroleum Exploration
NCE, Partner

BigCCS – Centre for Carbon Capture and Sequestration
FME, Partner

Deep Sea Mining

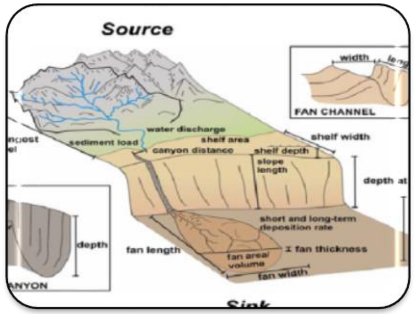
IGD Interpretation of Geophysical Data

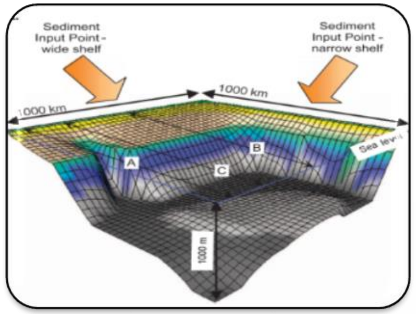
For project details see (www.igdgeo.com)

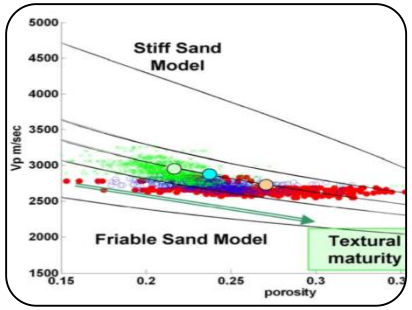
Stratigraphic Forward Modelling (SFM)

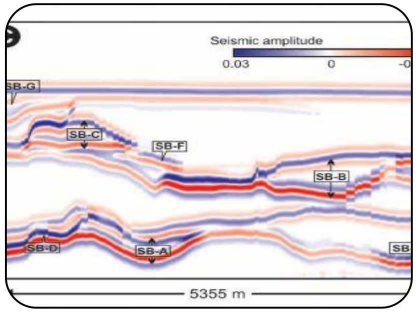
Carlos Aizprua (PhD Candidate – NTNU-IPT-IGD)

Research Objective: couple process-based geological models with rock physics









Research Paths

- **Analysis of source to sink systems**
- **Geological modelling**
- **Rock Physics**
- **Seismic forward modelling**
- Quantitative Sedimentology
- Coastal hazards, etc.

Industrial Applications

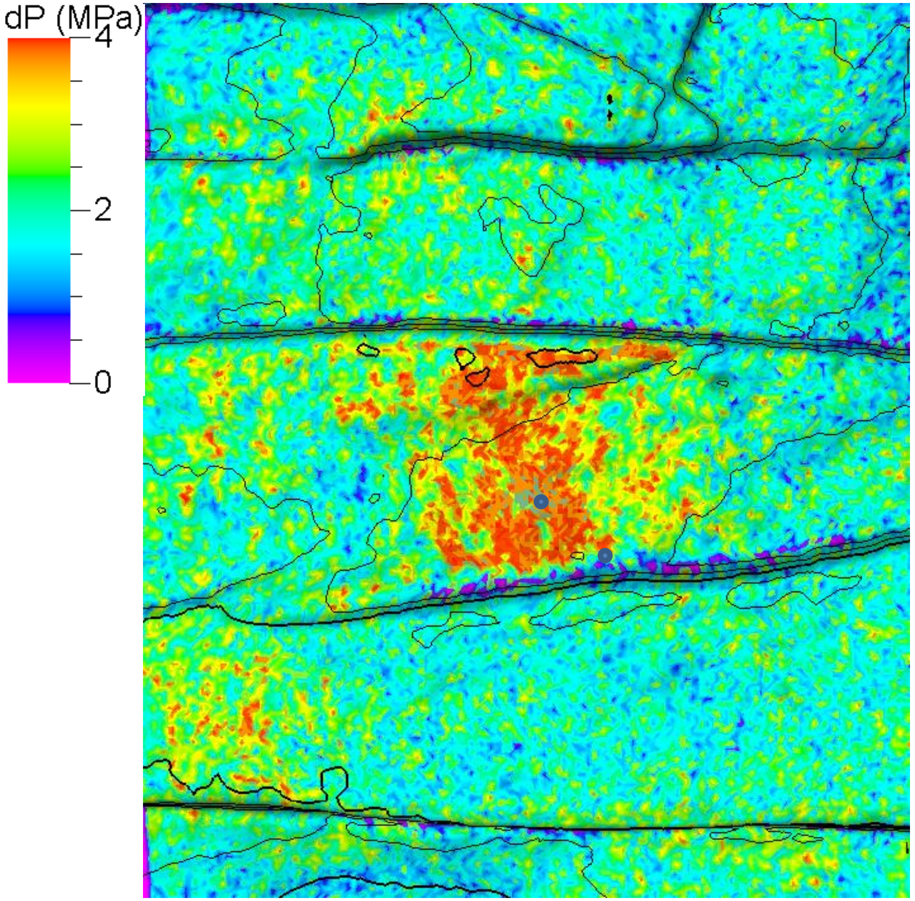
- Test conceptual models
- **Porosity prediction**
- **Risk reservoir presence**
- **Insights into seismic amplitude**
- Basin modelling input
- Discipline integration tool

Grude et al., SEG 2012

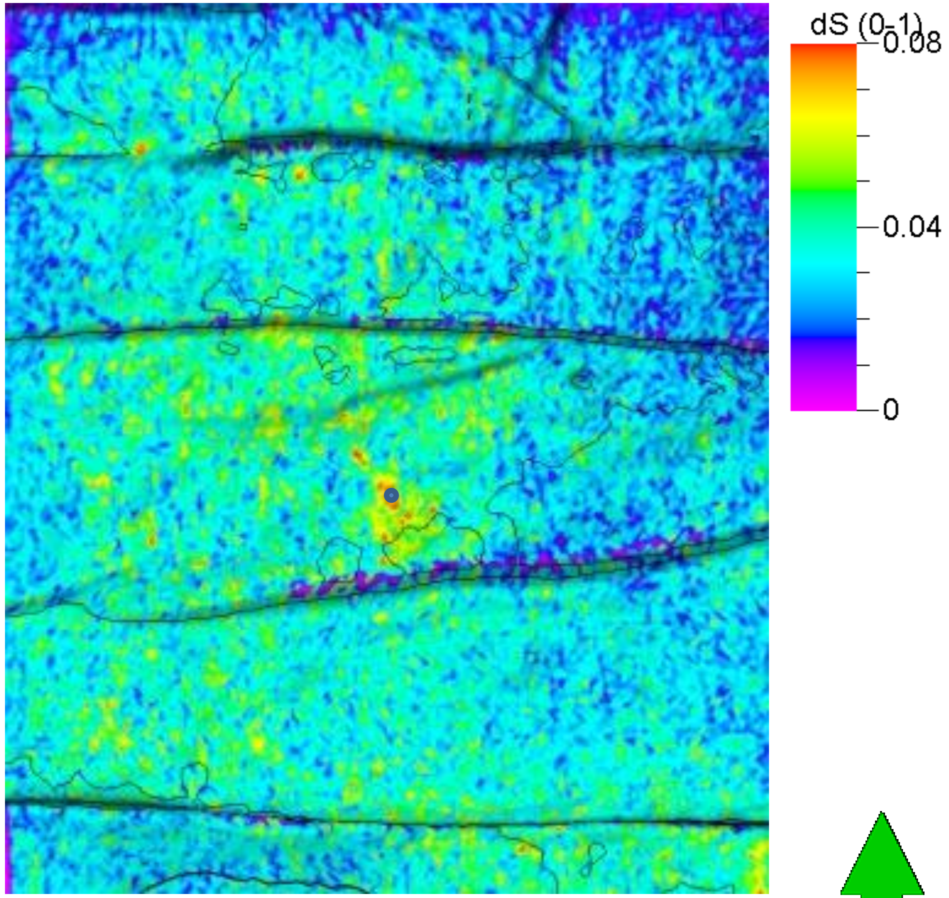
Inverted changes in saturation and pressure

Using near and far stacks

ΔP

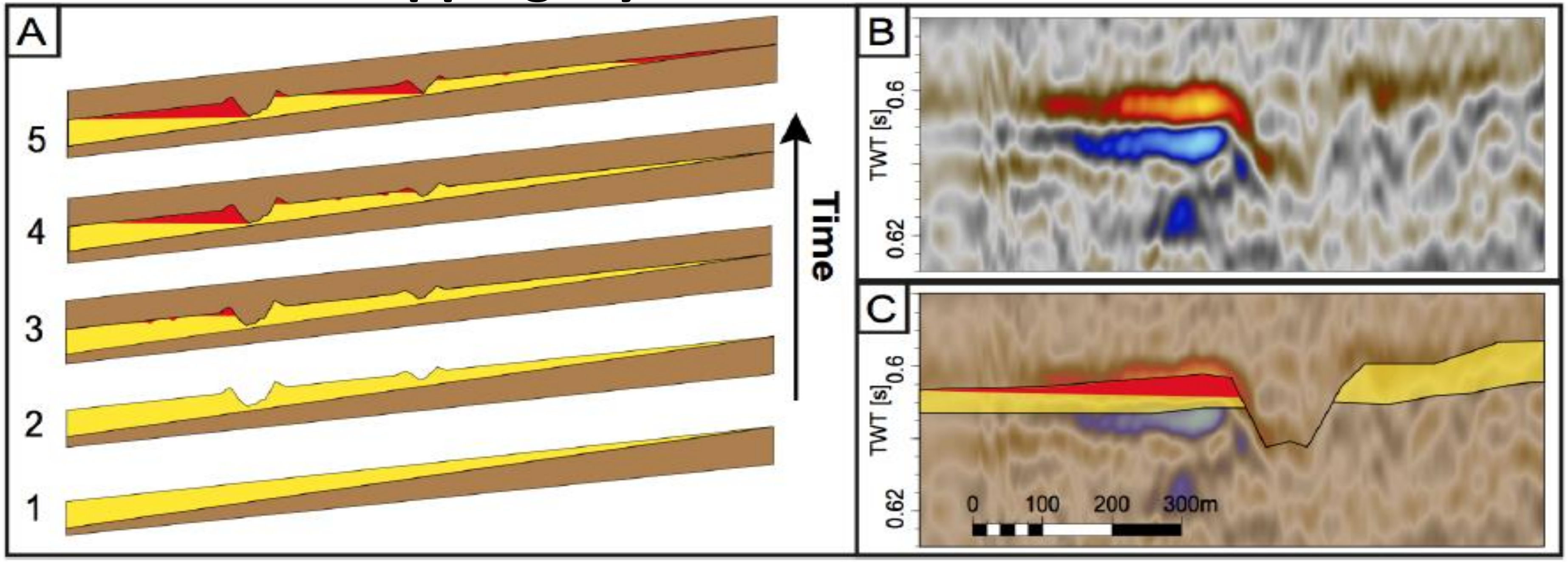


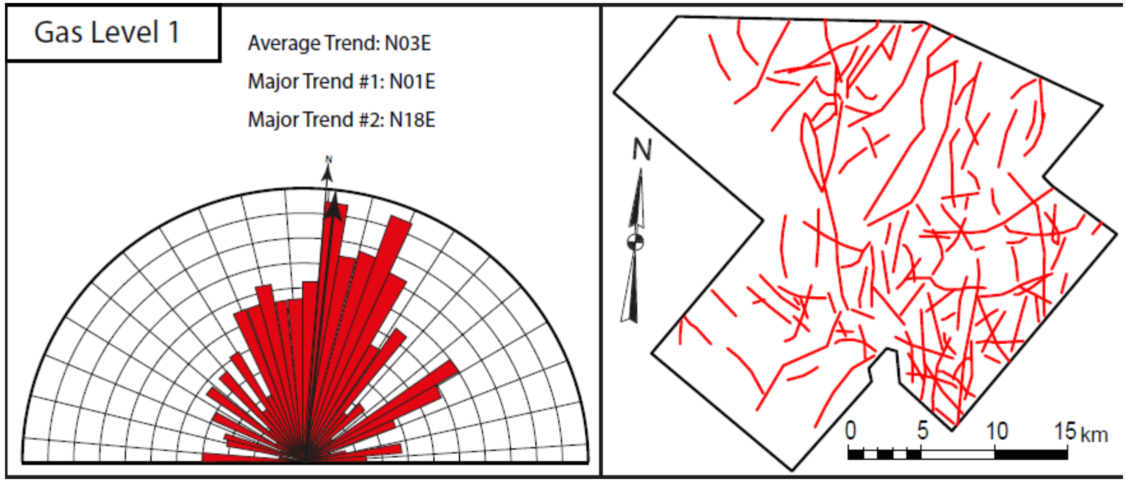
ΔS



Brie e=3

Overburden monitoring: Ice scours create traps when the intersect dipping layers

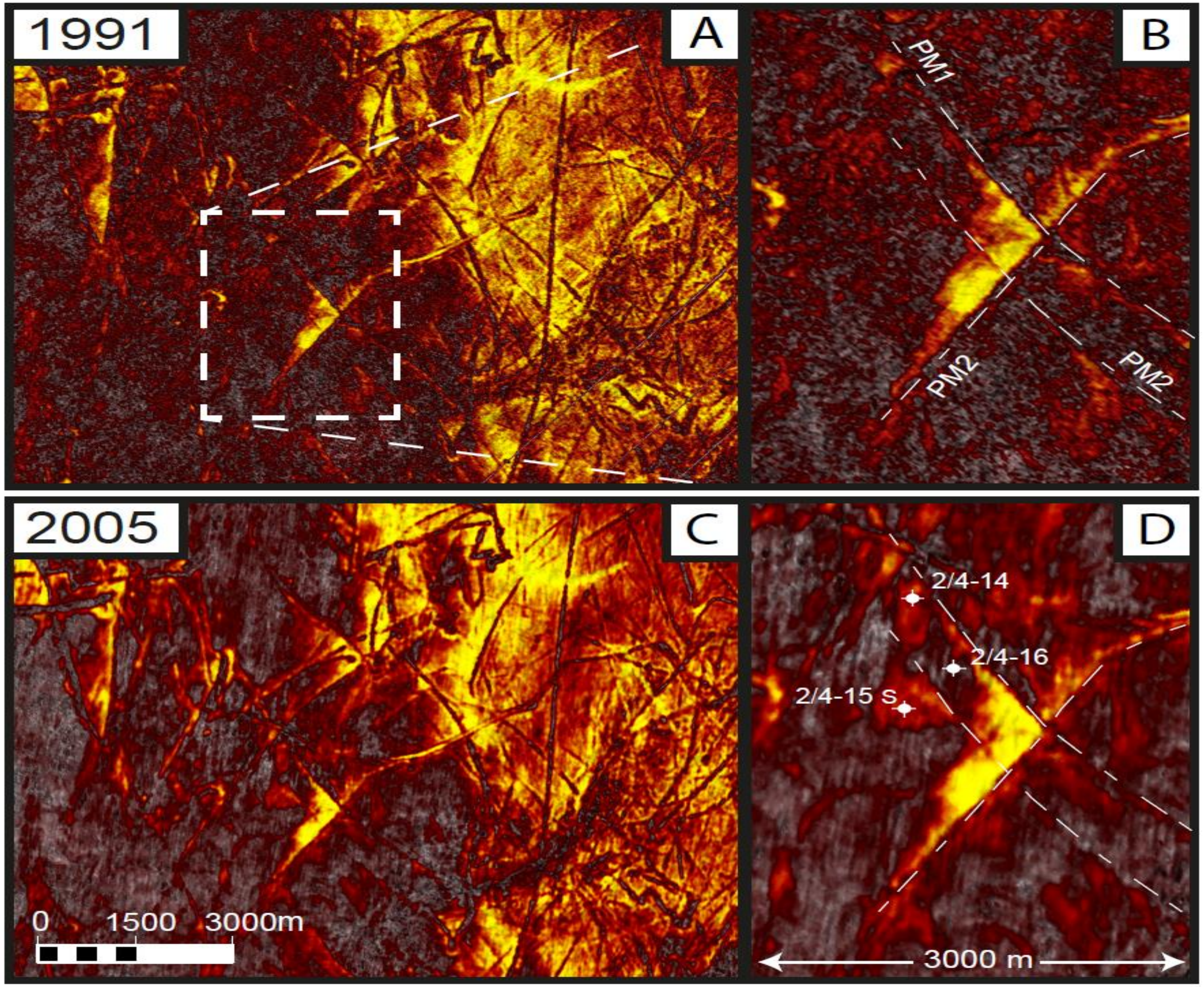




Ice scours orientation to North, sand layer dipping to West => perpendicular directions

Haavik and Landrø, 2014

4D effects: gas movements in overburden

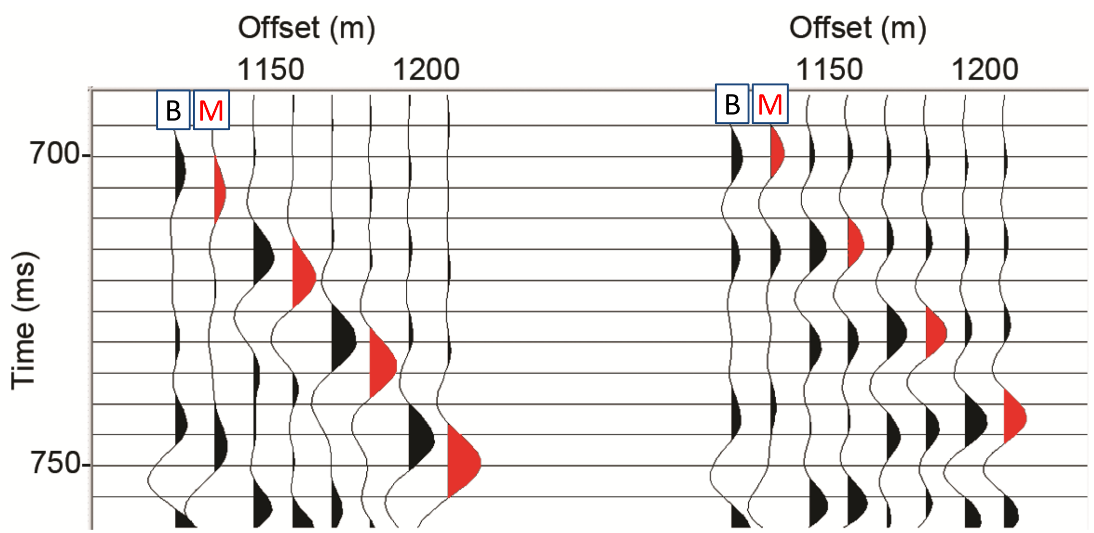


Haavik and Landrø, 2014

4D refraction timeshift analysis

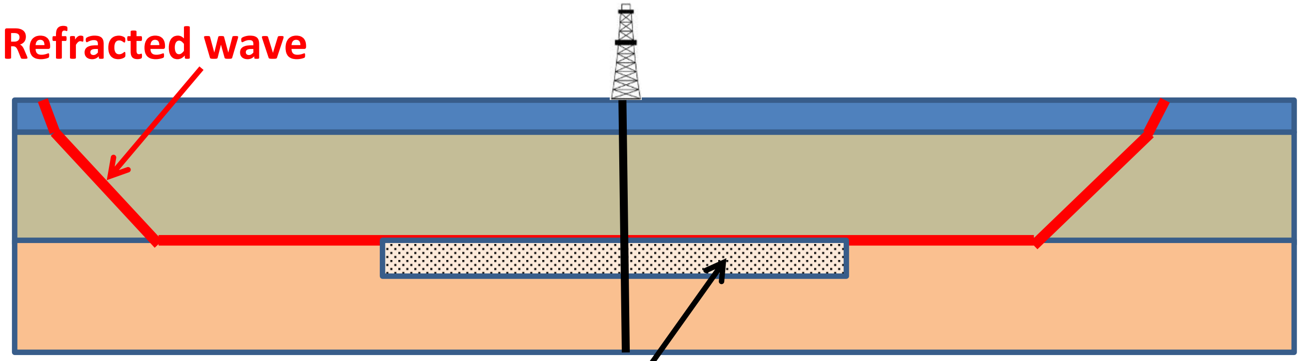
Close to well

Away from well



Field data

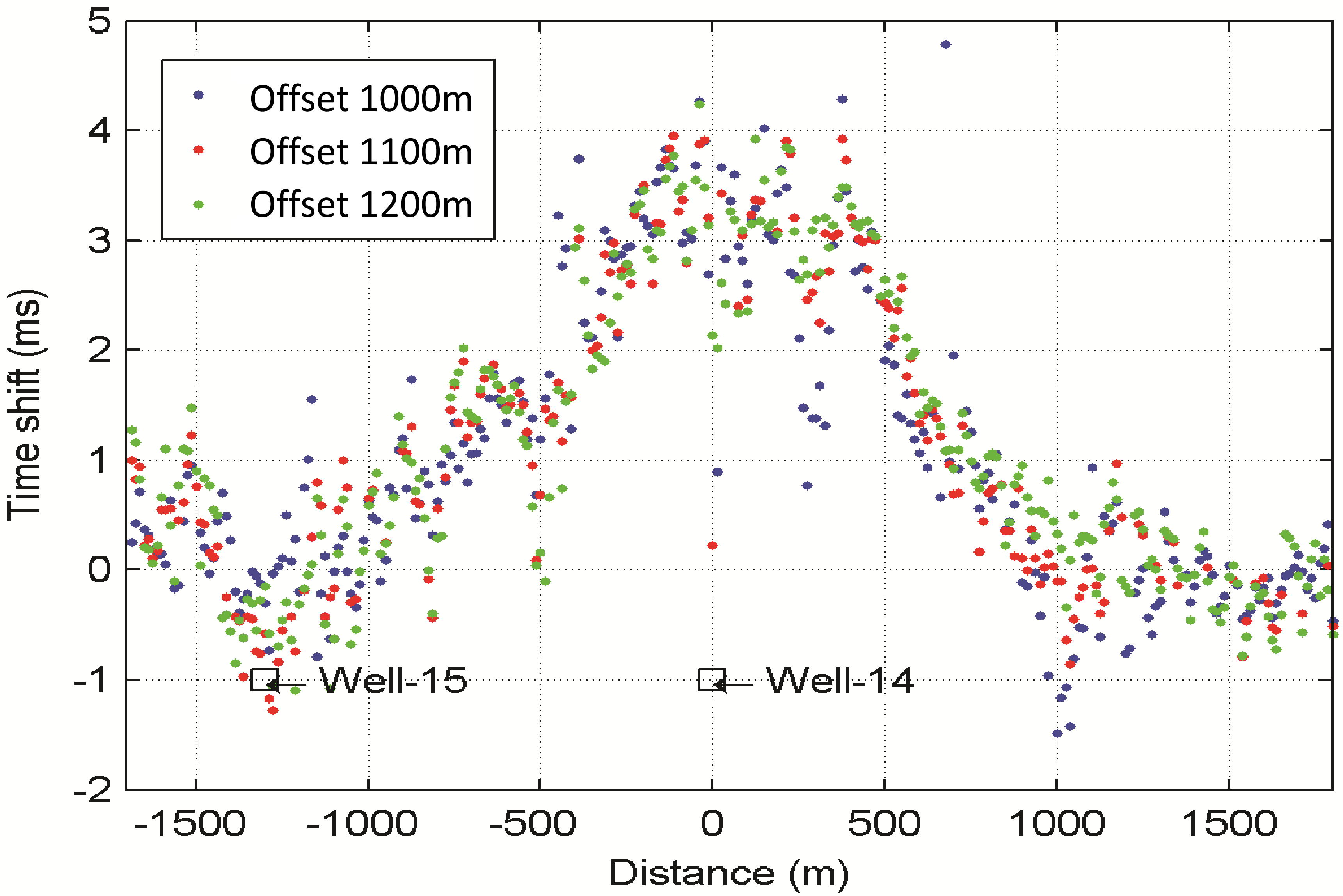
(SAGA well 2/4-14)



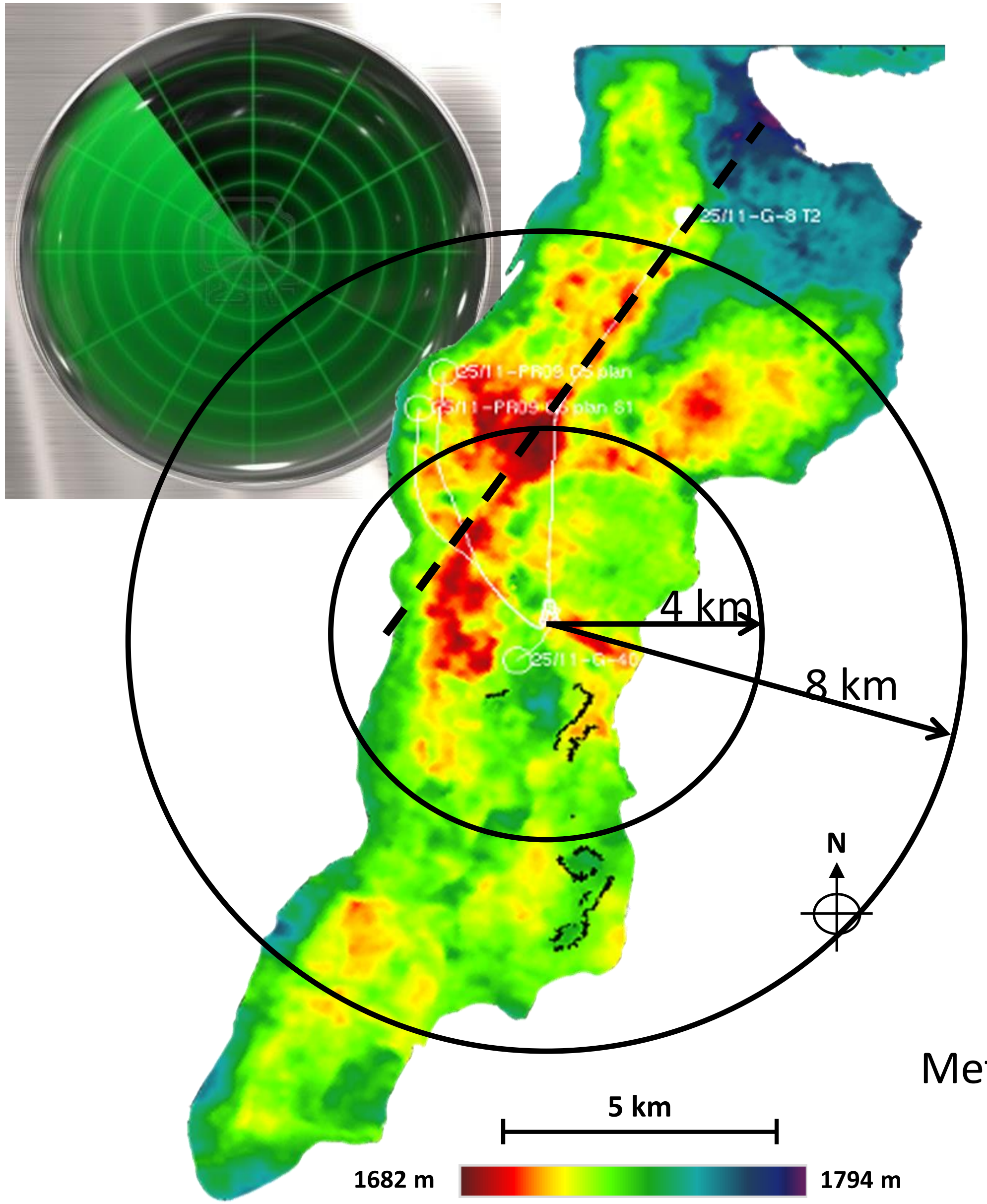
Gas accumulation caused by blow out

Zadeh and Landrø, 2012

4D refraction timeshift analysis



Time lapse refraction radar – Permanent receivers



Reservoir monitoring:

- **Refractions from top/base reservoir**
- **Rig source fired every day**
- **Measure 4D time shifts and amplitudes**
- **Multiazimuthal analysis**

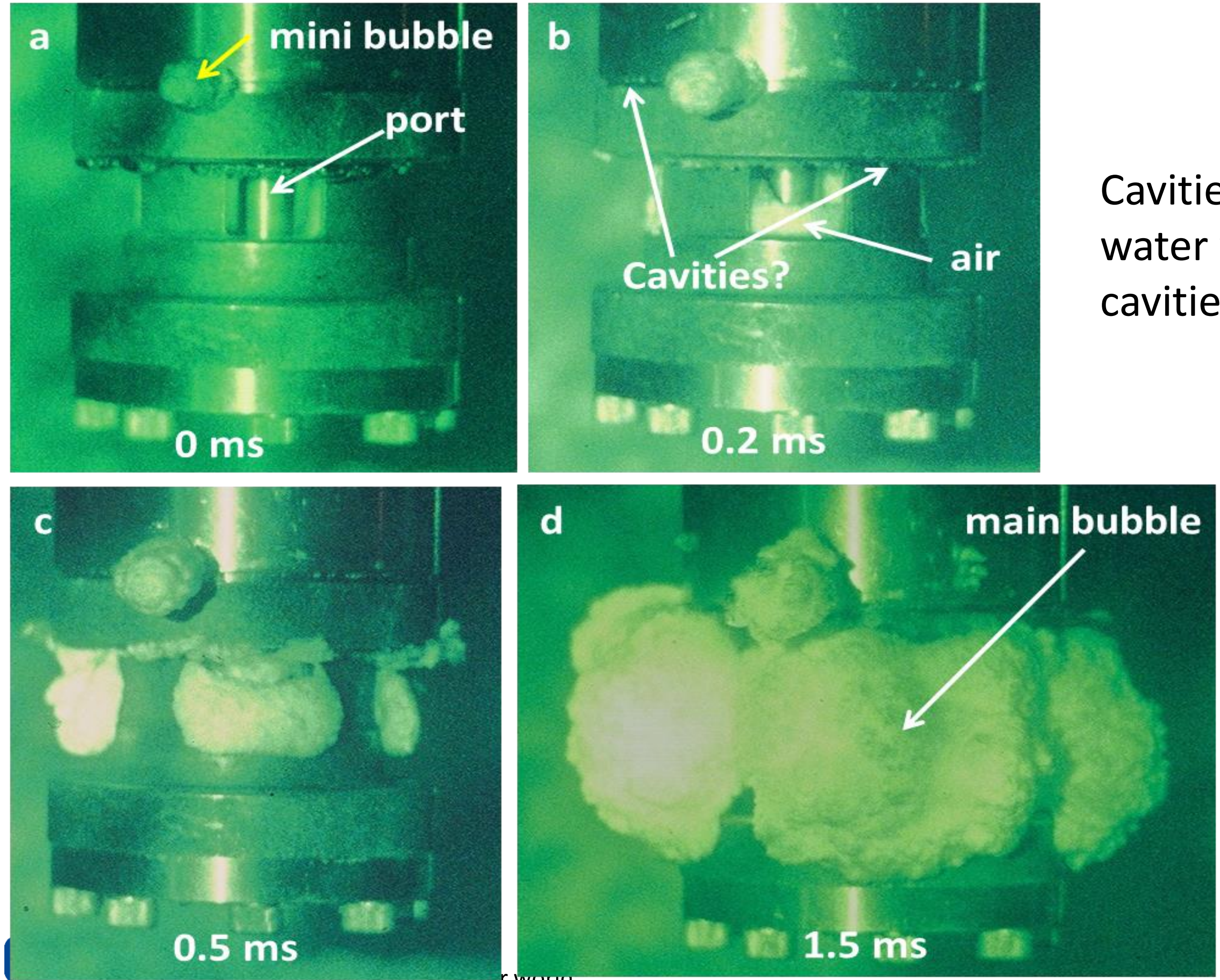
Overburden monitoring:

- **Leakage detection**
- **Pressure build ups**
- **Stress/strain changes**
- **Disposal wells (waste injection)**

Method is sensitive to ***velocity*** variations

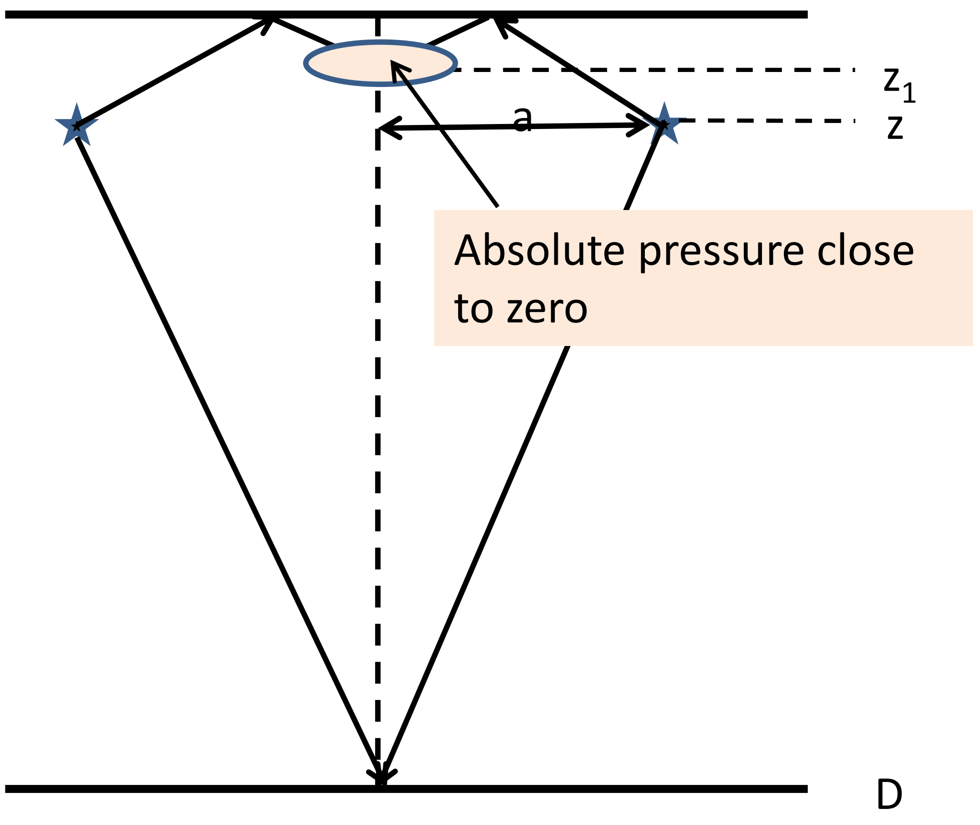
Seismic Acquisition

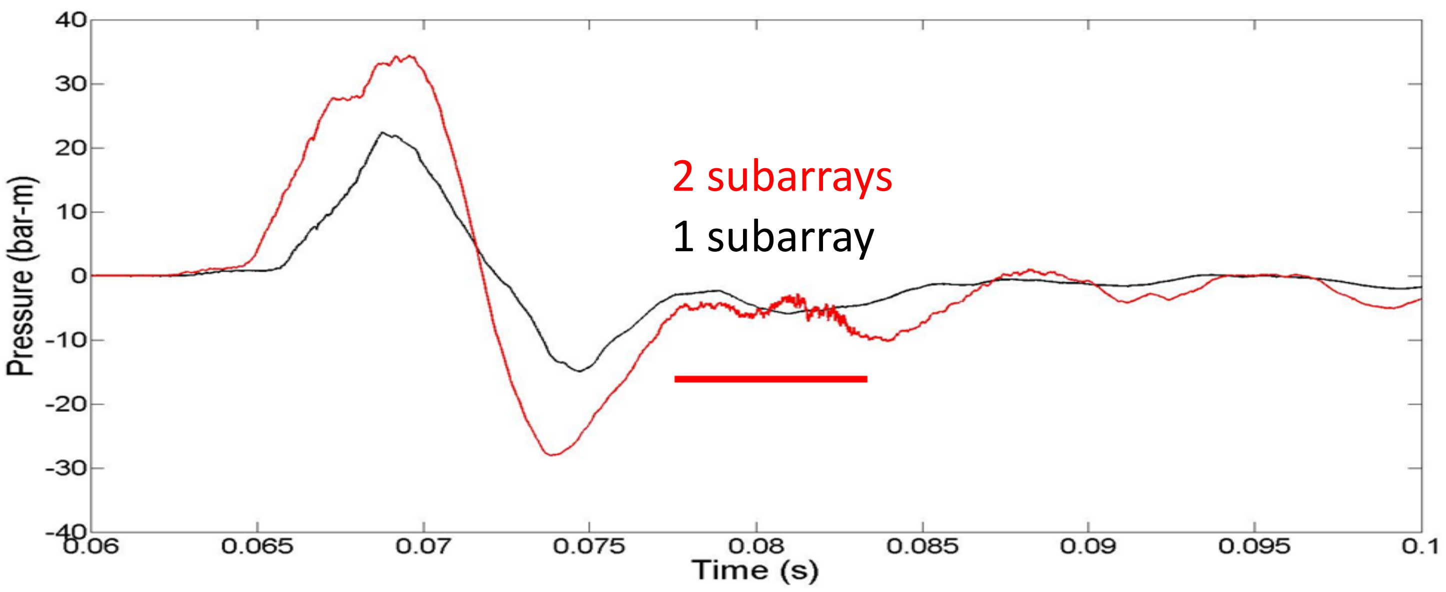
Cavitation from single air guns is small – weak acoustic signals

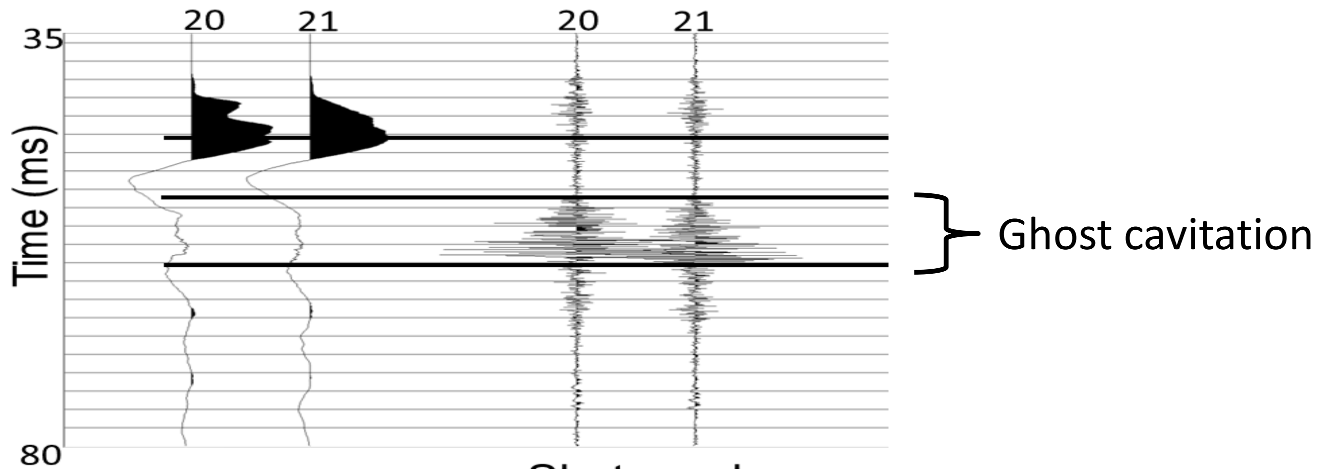


Cavities form close to edges and are caused by high water velocity, similar to propeller cavities – these cavities are small and create weak acoustic signals

High frequency sound from air gun arrays: ghost cavitation



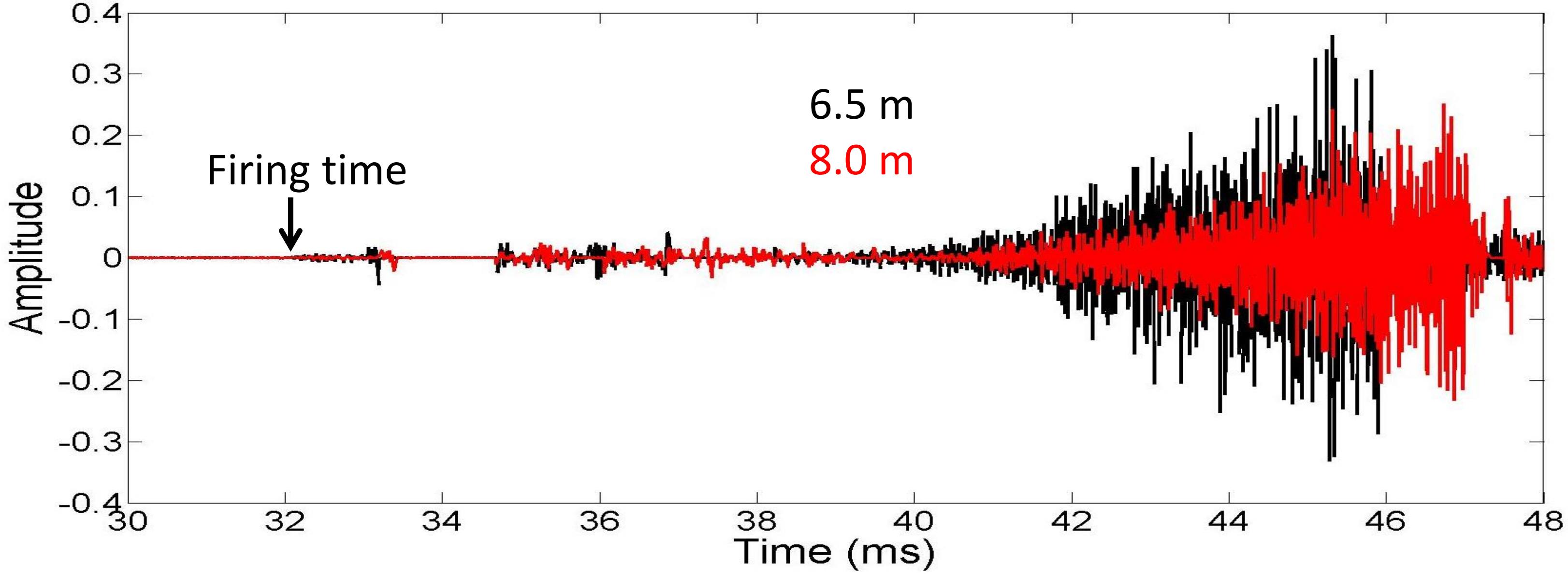


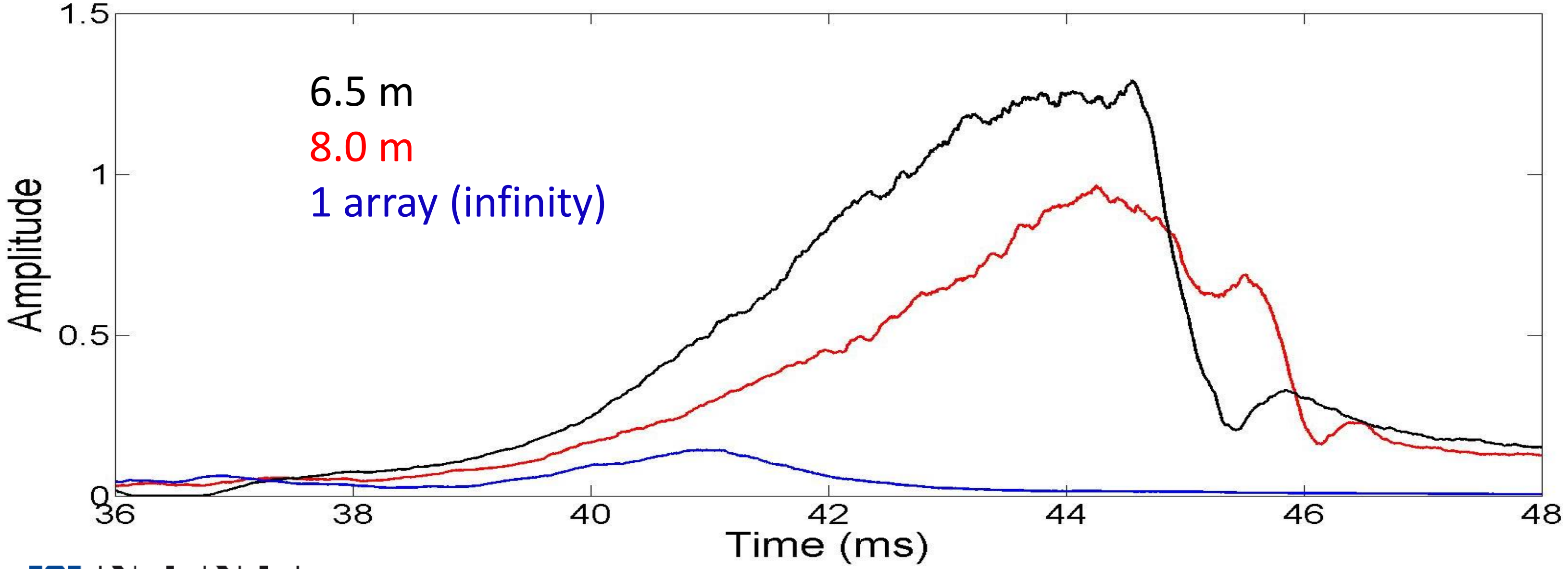


No filter

10-20 kHz and scaled

After 10 kHz high pass filter





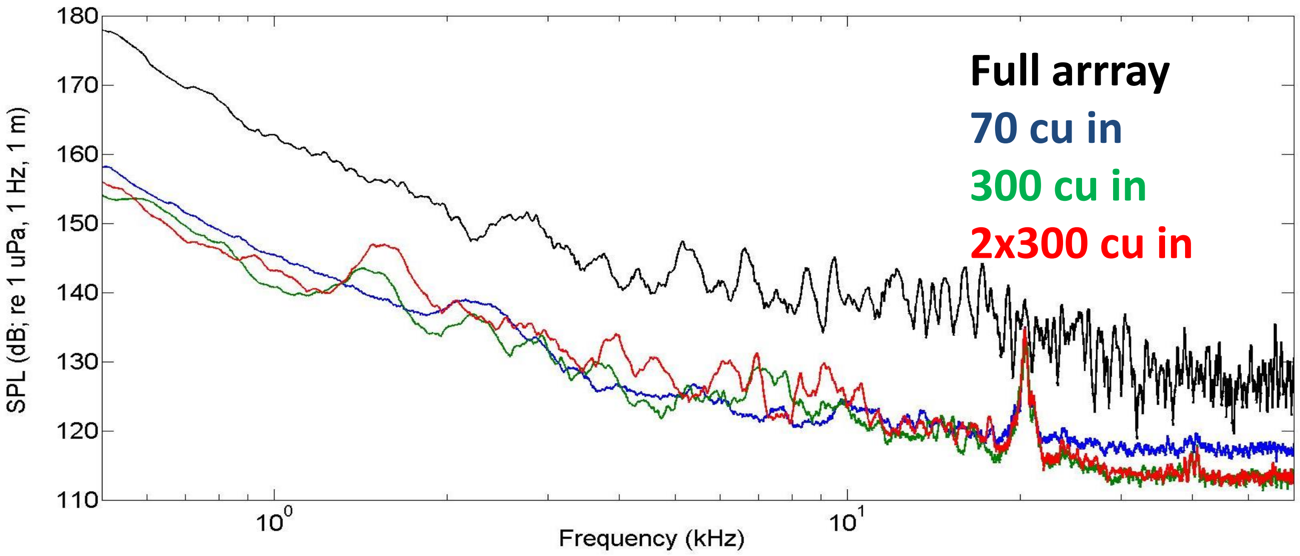
Amplitude of ghost cavitation signal decreases as subarray distance increases

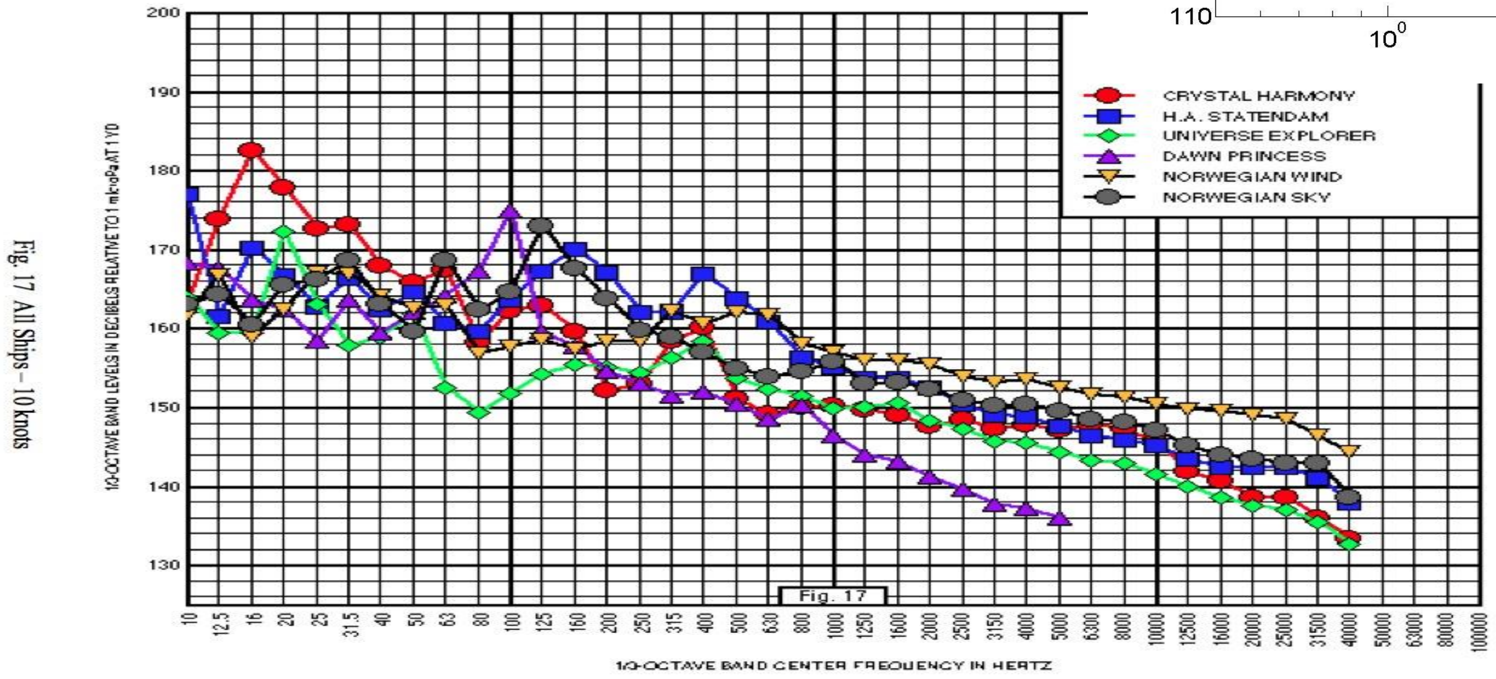
The signal is delayed somewhat (1 ms, as expected from modeling)

Single array is MUCH weaker and arrives earlier in time

Signal strength of the ghost cavitation is similar to large cruise ships

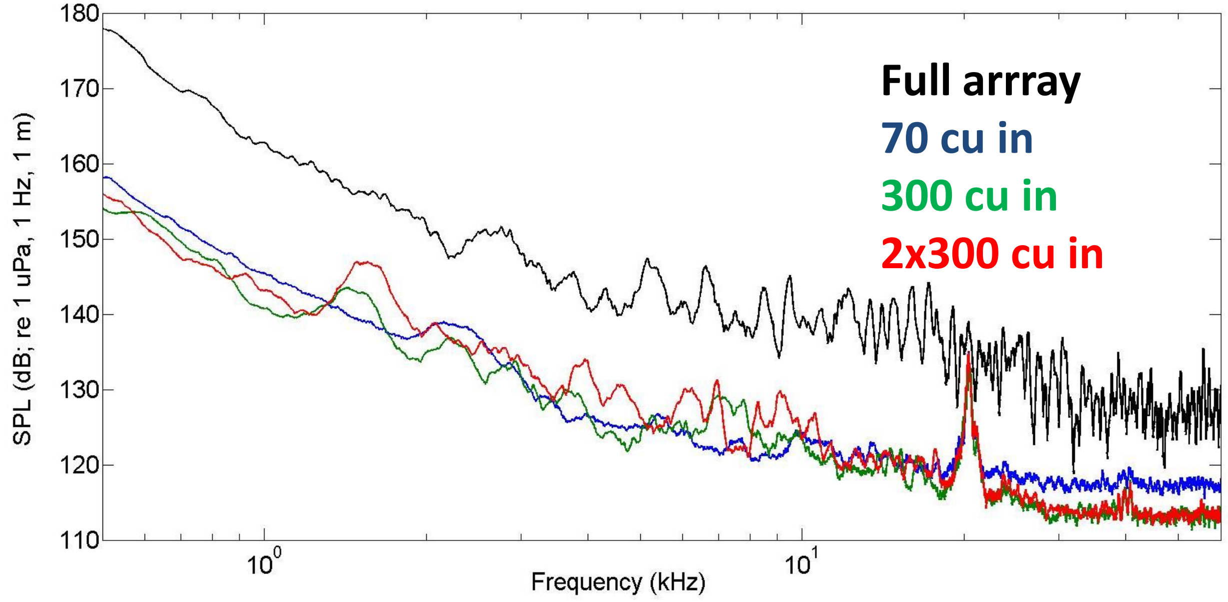
	Seismic	Ship
0.5 kHz	180 dB	165 dB
1 kHz	162 dB	158 dB
10 kHz	142 dB	150 dB

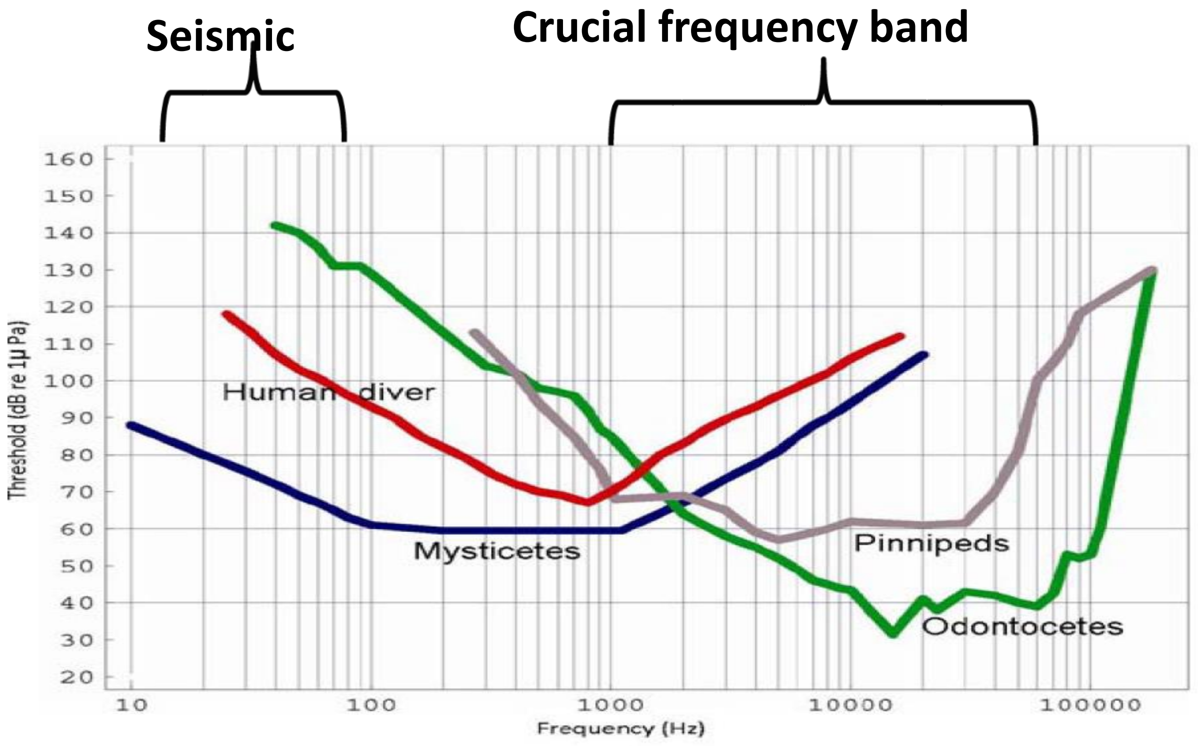




Ghost cavitation noise decays faster with frequency

Comparing seismic signals and hearing curves of marine life





Odontocetes = toothed whales
Mysticetes = whales without teeth
Pinnipeds = fin-footed mammals

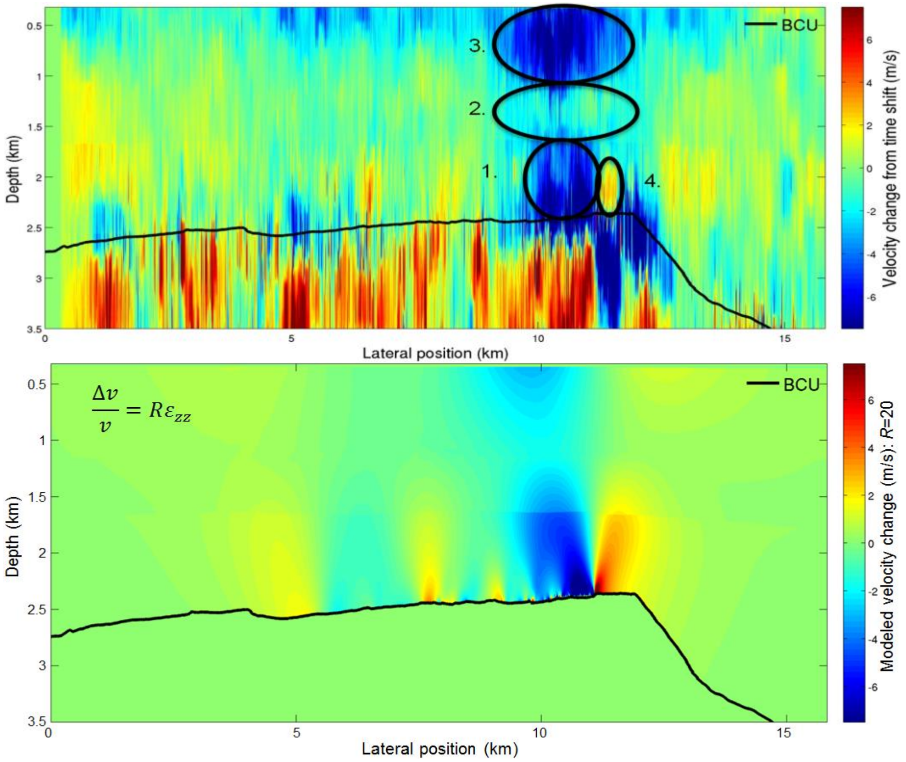
The dilation factor – relating geomechanics to 4D seismic

layer, we will assume that the two changes are proportional to each other (Røste et al., 2005):

$$\frac{\Delta v(x_0)}{v(x_0)} \approx \alpha \frac{\Delta z(x_0)}{z(x_0)}, \qquad (2)$$

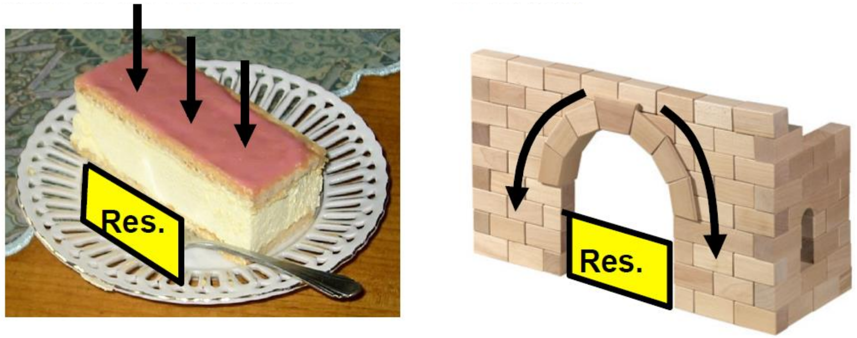
where the dilation factor α is a parameter dependent on the rock properties of the layer. This is a crucial parameter, because it deter-

Røste et al., and Hatchell et al. suggested the same parameter at the EAGE-meeting in 2005



From Røste TLE, 2015

Stress arching:



From Schutjens et al., 2010

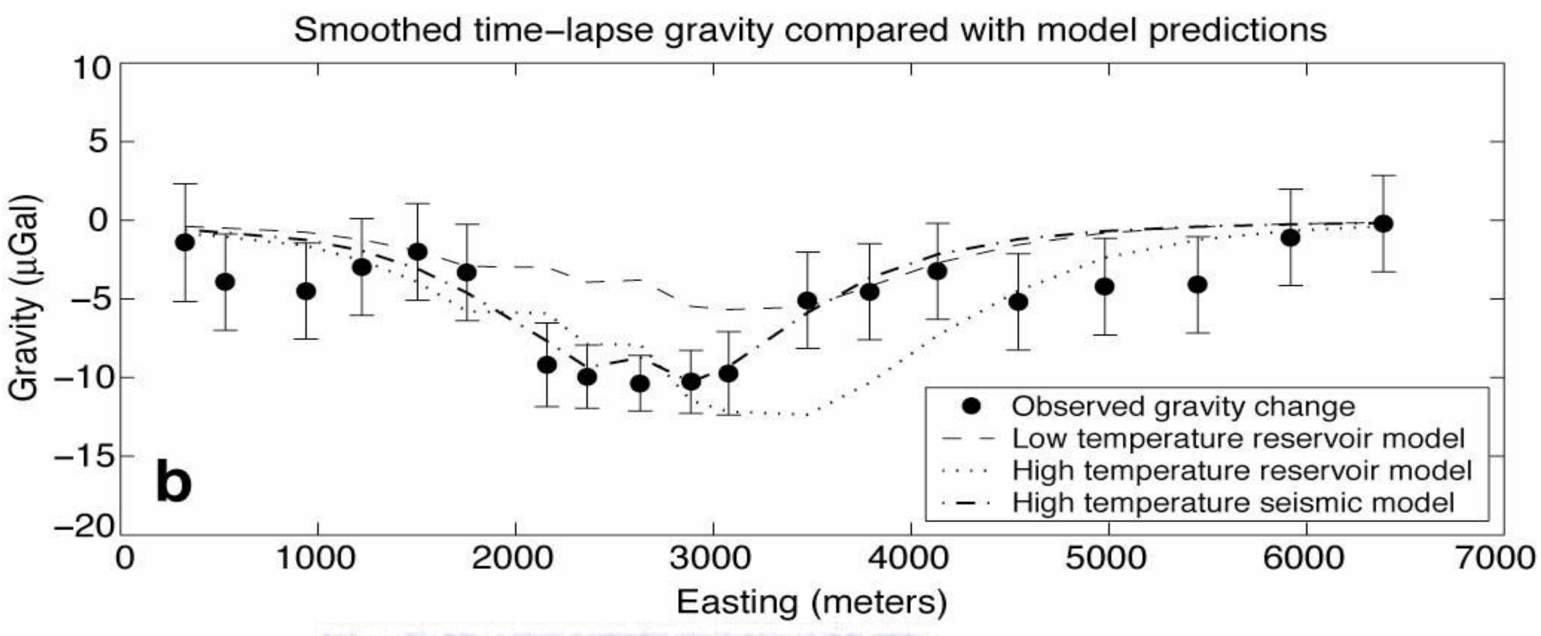
Summary – Geophysics Research, NTNU

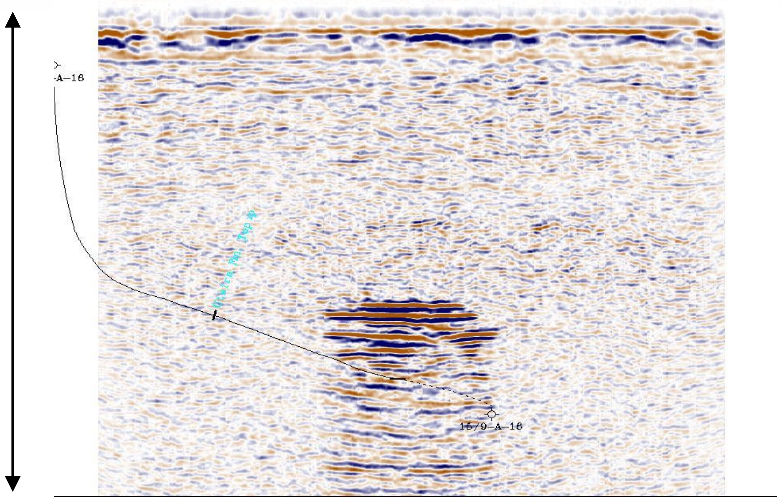
- Seismic interpretation
- 4D seismic
- Reservoir seismic
- Seismic acquisition
- Seismic imaging and inversion
- Rock physics and geomechanics

Thank you!

Trondheim, Norway, 21st December 2014 @ noon

Time lapse gravity – Sleipner CO_2 plume





Work by H. Alnes, O. Eiken, S. Nooner, G. Sasagawa, T. Stenvold and M. Zumberge

NTNU
Knowledge for a better world