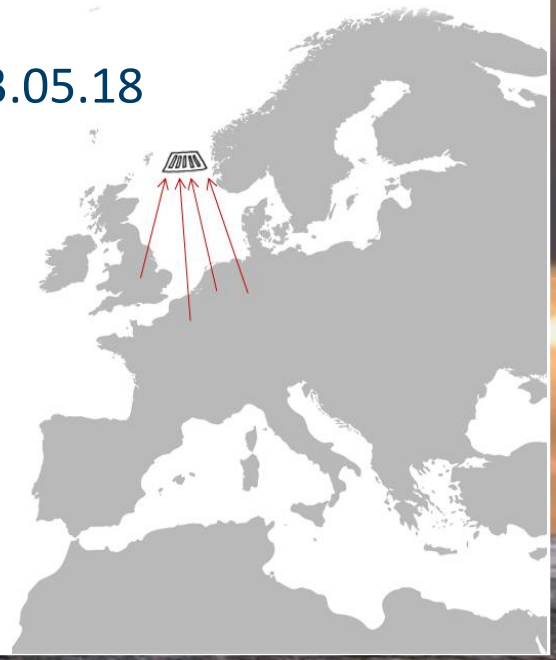
3rd Int. Workshop on Offshore Geologic CO_2 Storage, 03.05.18

NEW TECHNOLOGY FOR HANDLING LEGACY WELL INTEGRITY ISSUES



Malin Torsæter
SINTEF Industry, Dpt. Petroleum

6242 wells in Norway

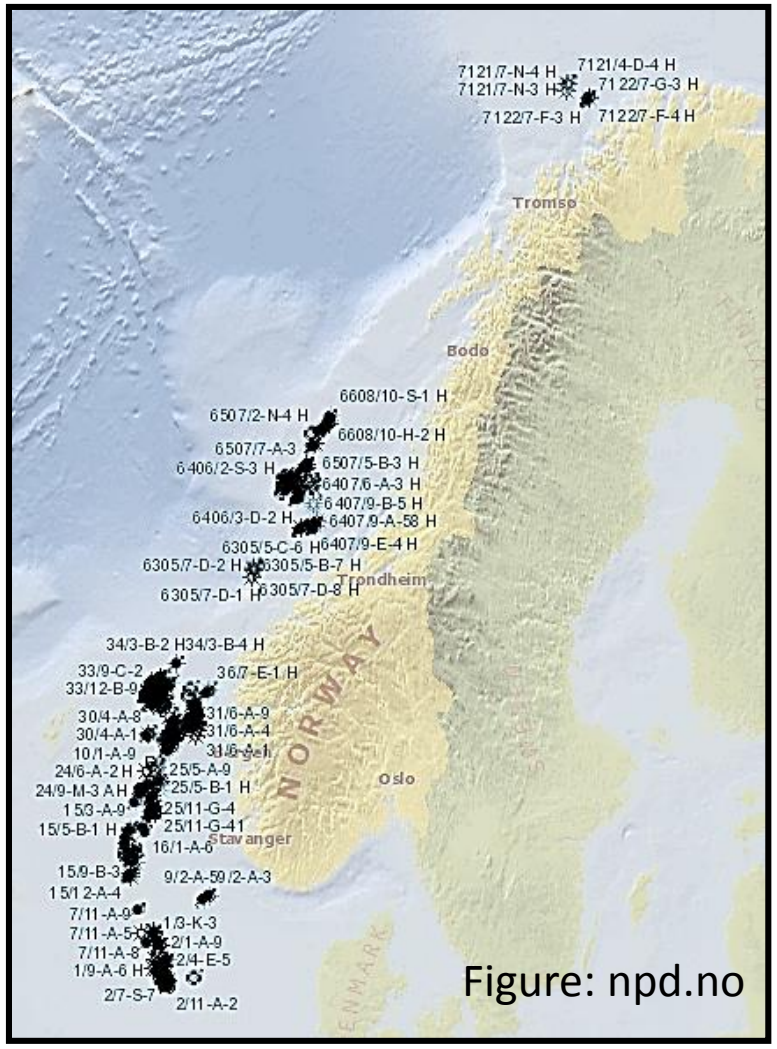


Figure: npd.no

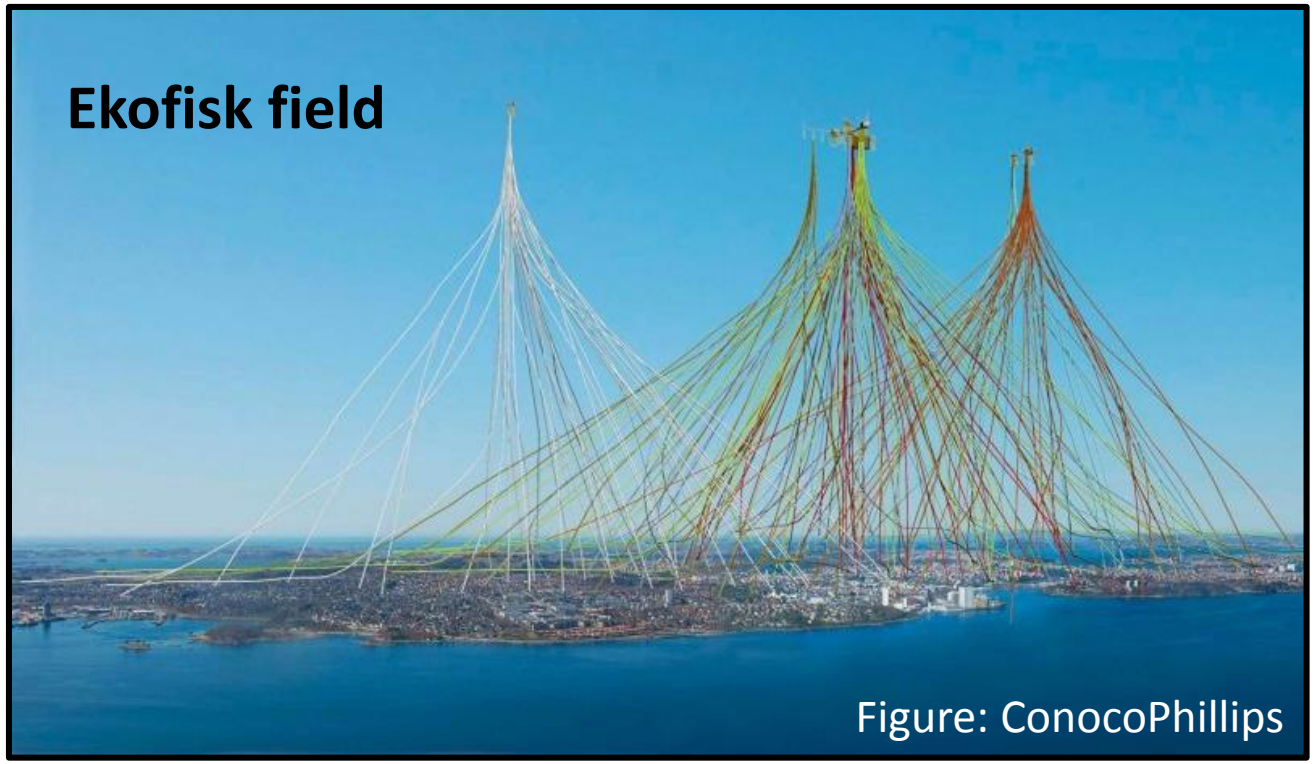


Figure: ConocoPhillips

Often hundreds of wells at each field

… and they can never be removed!

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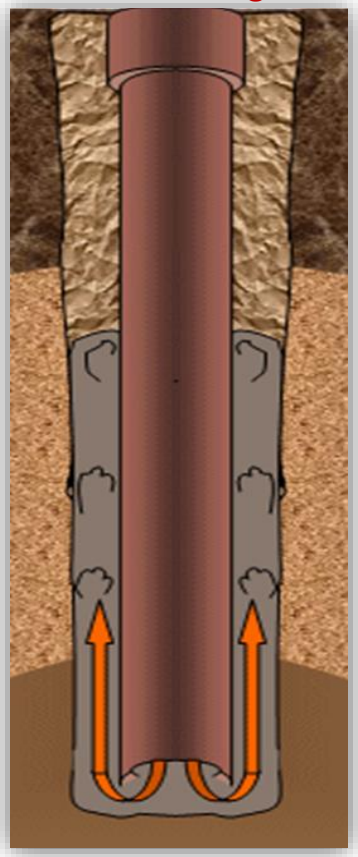
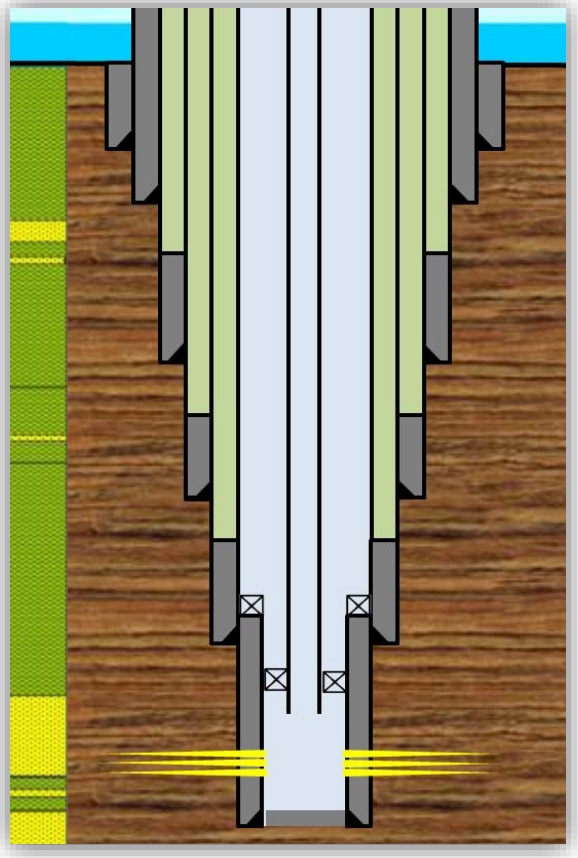
Engineered structures of steel and cement

Drilling

Cementing

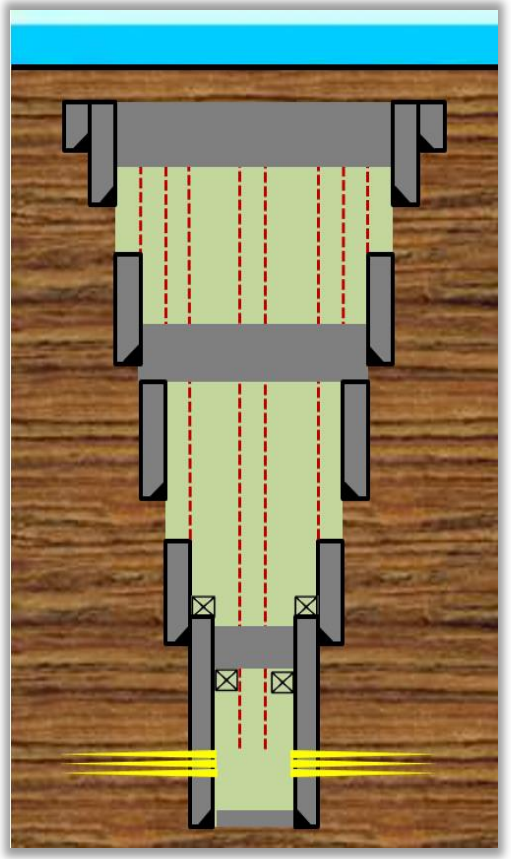


Operational



WI issues can be remediated

Plugged



Re-entry & repair difficult/impossible

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State-of-the-art when it comes to handling legacy wells in a CCS context

…is to avoid them…

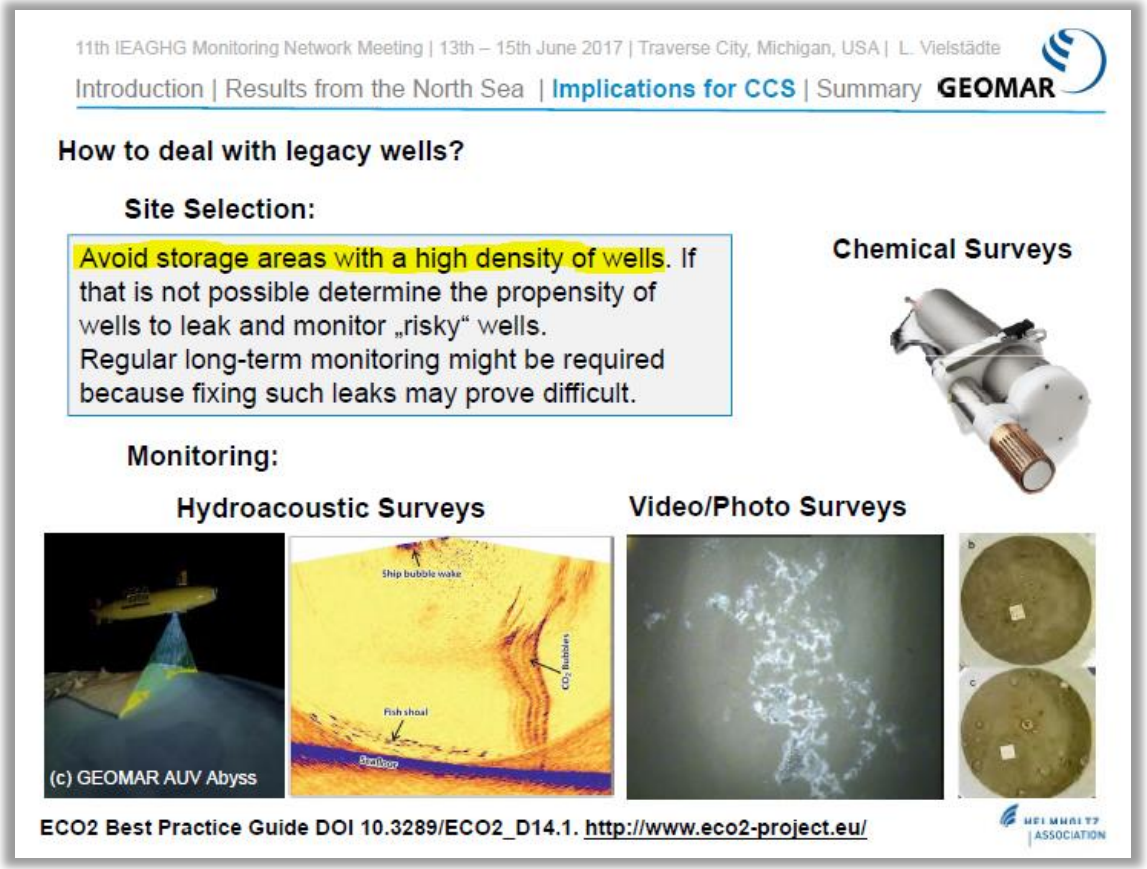
Candidates: Norwegian full-scale project

- Utsira formation southeast of Sleipner
- Viking Group at Smeaheia
- Heimdal Formation at Heimdal

Favored due to good geological reservoir setting, large available capacity and the scarcity of legacy wells in the area

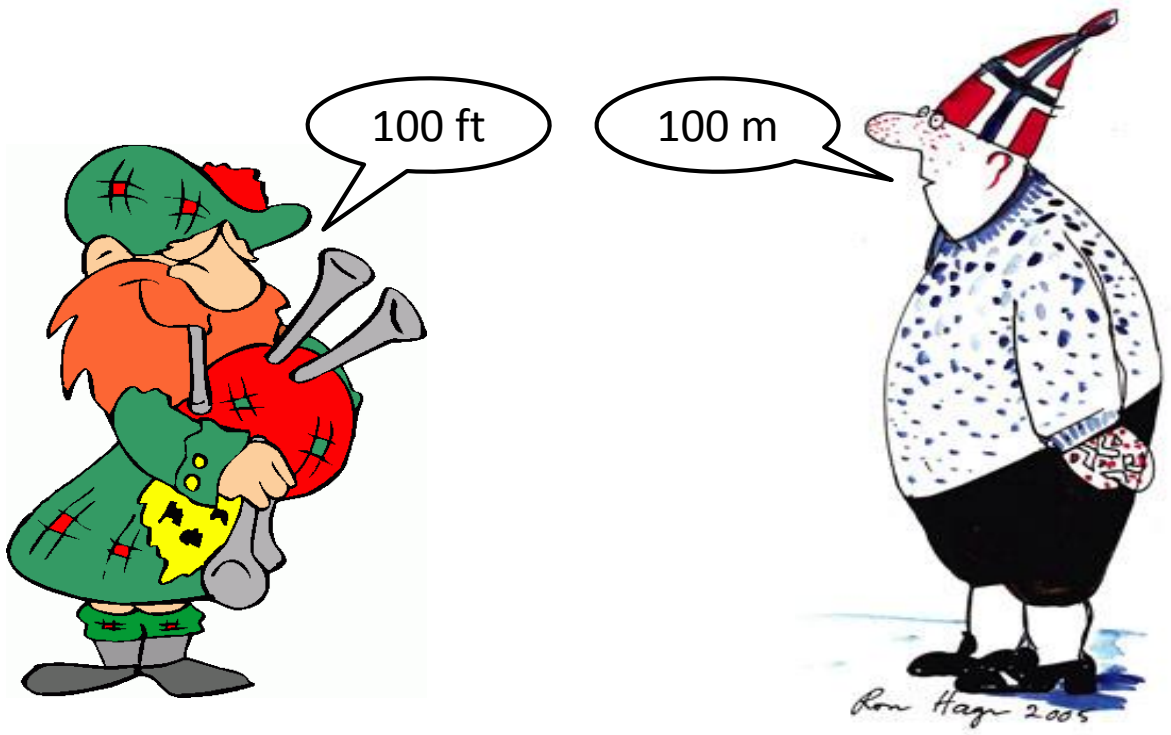
How can we reach Gt storage volumes while avoiding wells?

Are we OK with not utilizing the best characterized reservoirs?



How can we ensure safety of legacy wells?

What do you mean by safe?



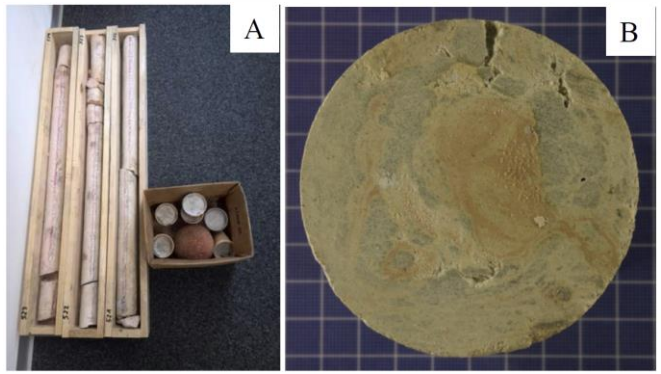
Each country has its own specifications of "safe plug lengths" for wells. Where do the different numbers come from?

Kuip et al, *Energy Procedia* **4** (2011) 5320–5326

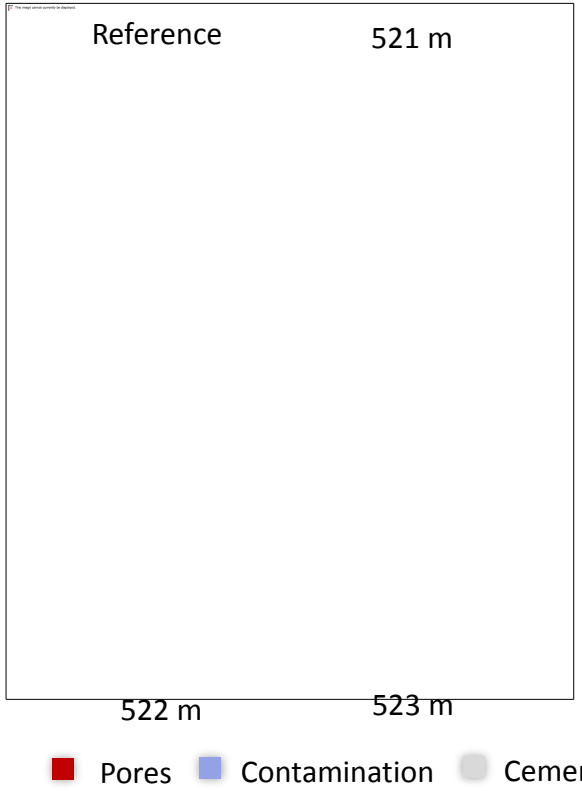
Country	Min. plug length (m)
Denmark	100 (or 50 + mech plug)
Norway	100 (or 50 + mech plug)
Netherlands	100 (or 50 + mech plug)
United Kingdom	30
Australia	60
Canada	15
China	30
Japan	30
USA - API	30
USA - Alaska	60
USA - California	30 (60 offshore)
USA - Texas	30

Not only plug lengths: *materials matter*

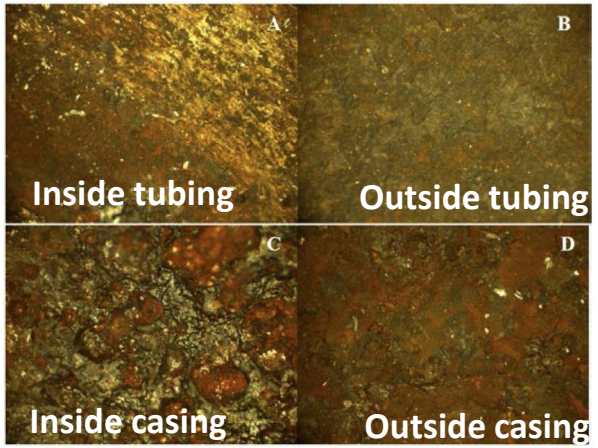
CO_2 injection in the period 2009-2013

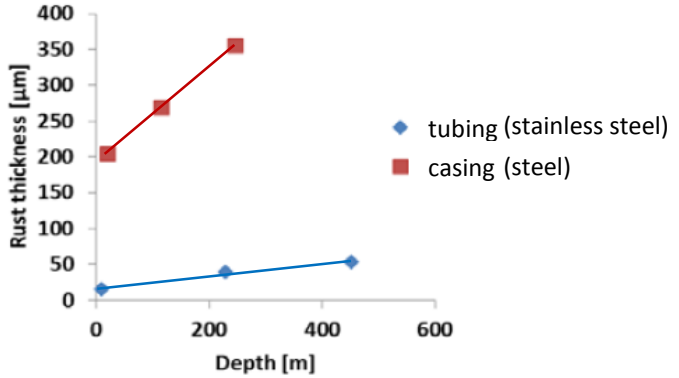


Cement from well plug placed 2013, drilled out 2015



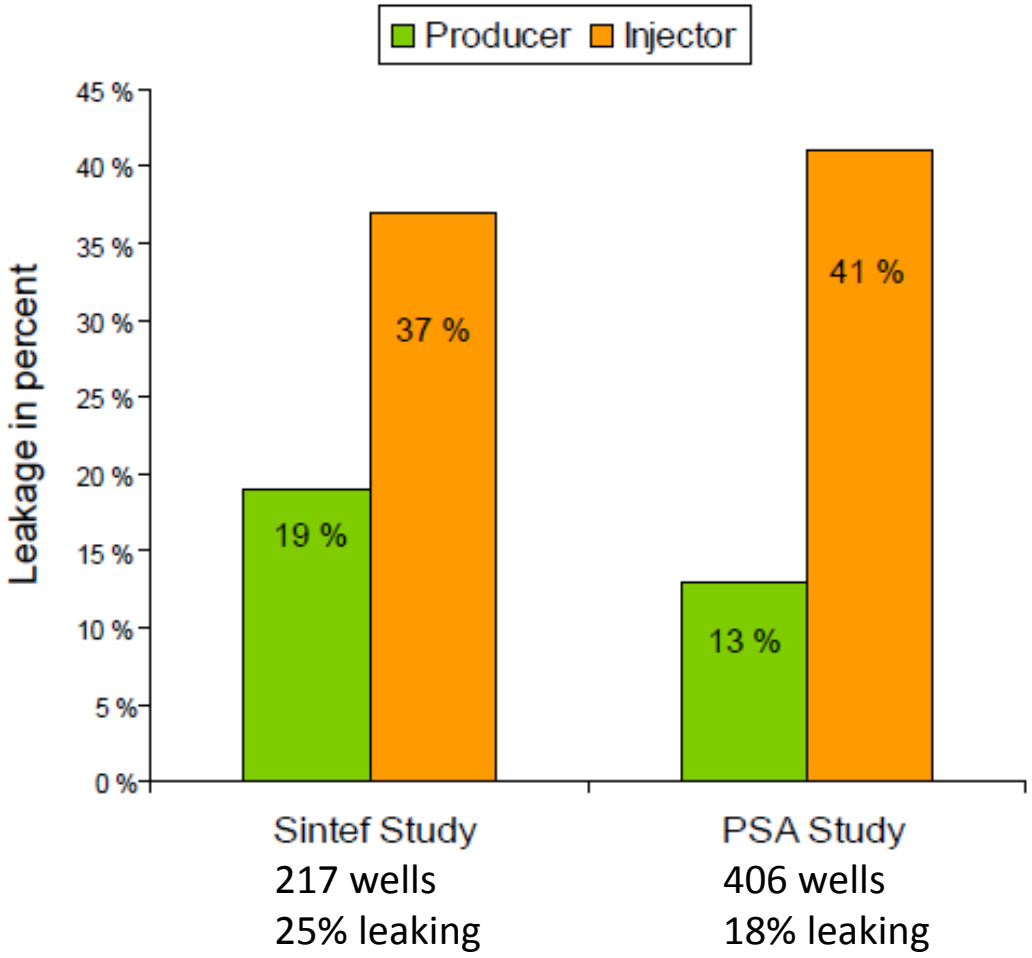
Microscopy study of pipes

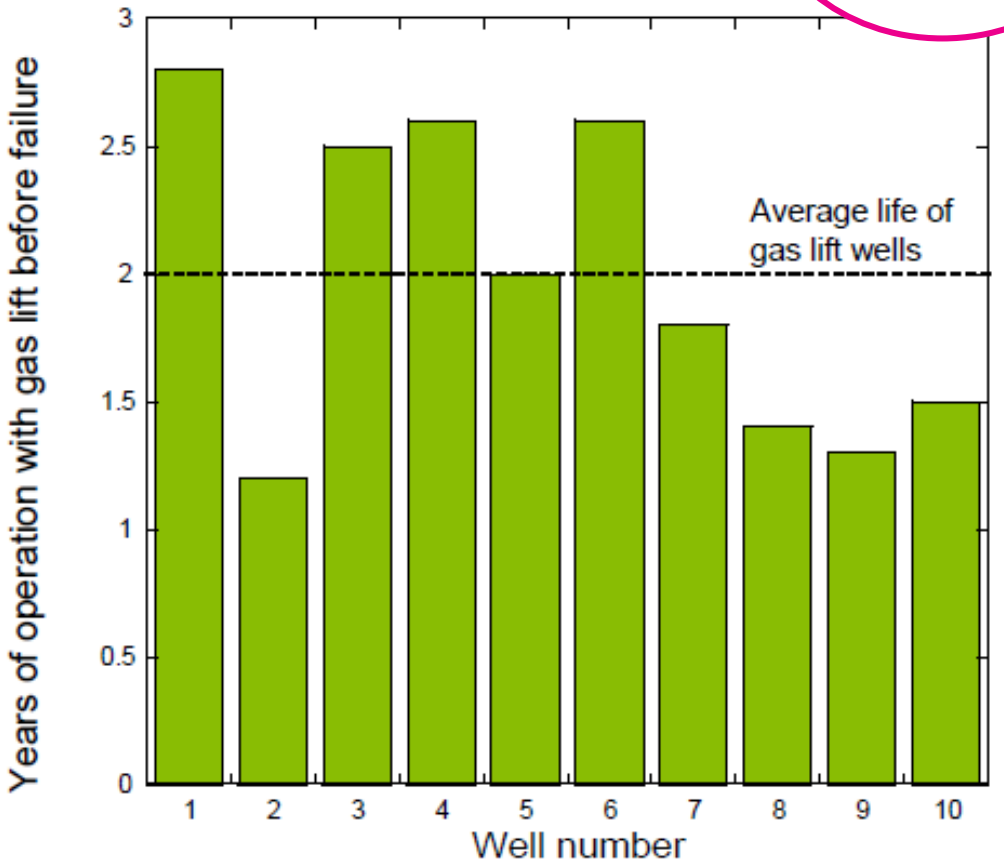




Operations: *Impact on well integrity*

Loads:
- Thermal
- Chemical
- Mechanical

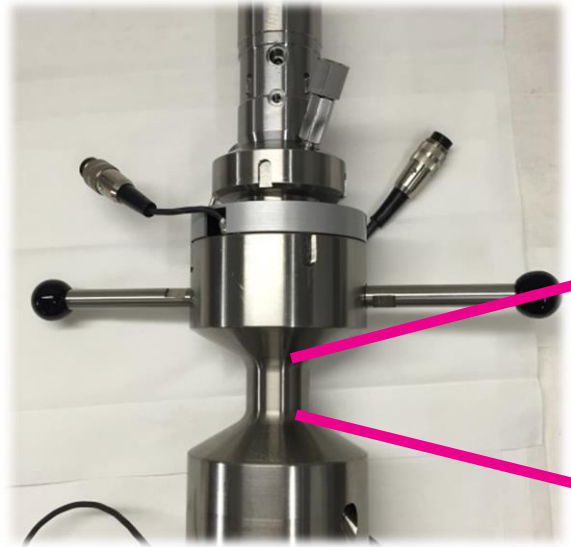


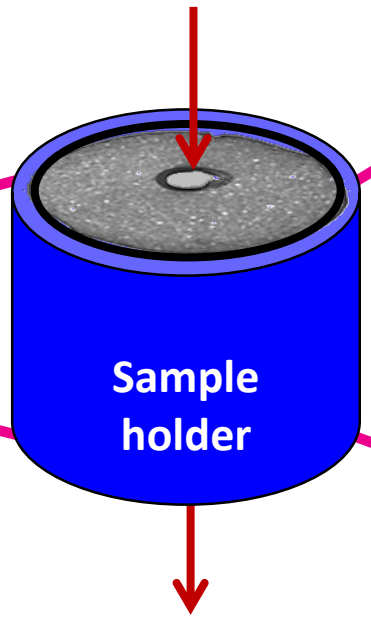


Randhol & Carlsen (2007), Assessment of Sustained Well Integrity on the NCS, SINTEF study: http://www.ieaghg.org/docs/wellbore/Wellbore%20Presentations/4th%20Mtg/01.pdf

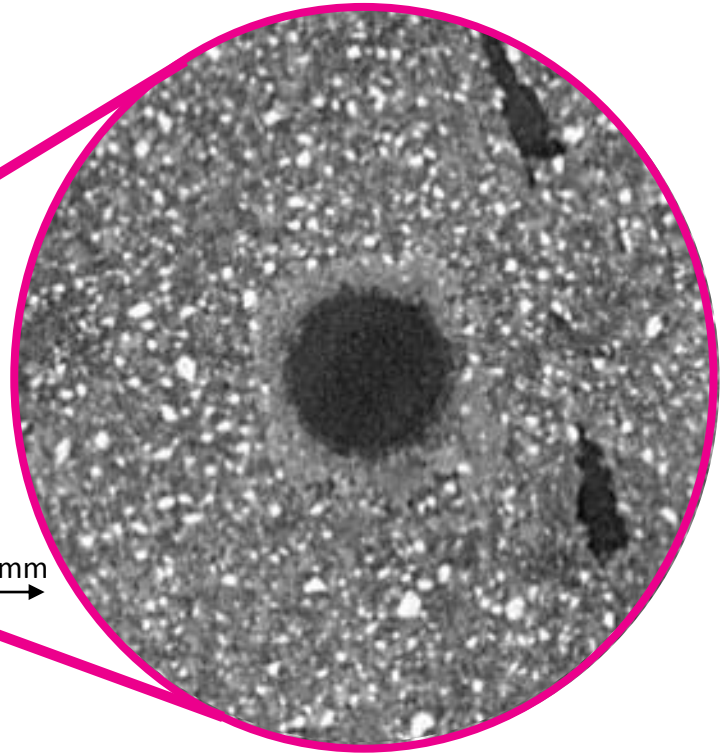
NCCS: *Understanding CCS well conditions*

- Unique realistic experiments with high potential





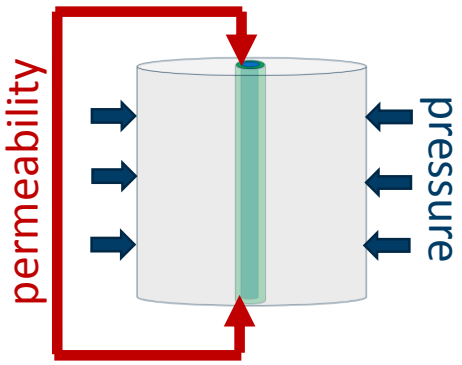
Images recorded in-situ at 280 bars and 80°C

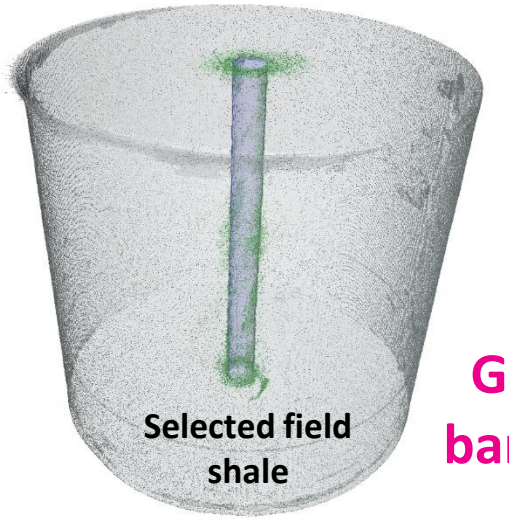


Work with nature: *shale/salt*

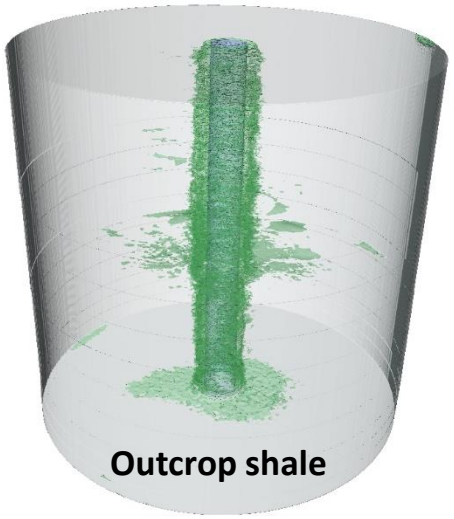
- How can we plan to use formations as barriers?
- How can we activate such barriers?

Cylindrical shale sample creeping towards pipe





Good barrier!



Poor barrier!

E. Fjær et al. (2016), How creeping shale may form a sealing barrier around a well, *Am. Rock Mech. Assoc.*, **ARMA 16-482**.

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Evaluating wells:
logging and "tophole"

- Physics: material/fluid impact on signals
- Eliminate human log interpretation

  → machine learning

- **New consortium:** "tophole" (non-invasive) continuous well integrity monitoring

SINTEF AkerSolutions

NCCS NORWEGIAN CCS RESEARCH CENTRE

Take home messages

- We should not be happy with avoiding legacy wells, but should learn to deal with them. More research needed:
  - (Locating), evaluating & remediating wells
  - Establishing & forecasting well integrity

MISSION INNOVATION
Accelerating the Clean Energy Revolution

- Interesting new technology is on the rise
  - Better understanding of CCS well conditions
  - From engineering materials to formations as barriers
  - Improved barrier verification methods

Thank you for your attention!