Exploration _Advanced geophysical methods

* Research Challenges

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29% of the remaining hydrocarbon resources at the NCS are located in the Norwegian part of the Barents Sea.

25% of the world remaining undiscovered conventional hydrocarbon resources are located in the Arctic.

Additional interest in the area is triggered by the high oil price and unstable political conditions.
Exploration and Reservoir Characterization

Research Challenges

⇒ environmental issues
⇒ challenging environment
⇒ deep water
⇒ decreased data availability

increase reserve replacement
decrease exploration risk
Outlines

- Advanced geophysical methods
- Integrated approach
- What about CO$_2$ storage?
Advanced geophysical and seismic methods for enhanced data interpretation and improved imaging

Ocean Bottom Seismic OBS

→ Imaging in difficult areas (e.g. complex geology, salt, gas clouds, ...)
→ Improved prediction of lithology and fluids

SINTEF’s semi-automatic workflow
• Vector fidelity
• Multiple attenuation
• Velocity model construction
• Depth migration in angle domain
Advanced geophysical and seismic methods
for
enhanced data interpretation and improved imaging

Tiger (seismic finite difference 3D modelling)

→ to plan acquisition survey
  (including OBS, Node and 4C)

→ to assist difficult interpretation
  (e.g. in complex geol. structures, salt, etc.)

→ to simulate changes in reservoirs
  (e.g. after gas injection in reservoir...)

Extremely robust and realistic
New clusters allow a quicker realisation
Multi proxy approach and integration of various information sources

**EM technology coupling to seismic**

- EM is fast, gives information on lithology but the resolution is poor
- Seismic data are more difficult to process but resolution is higher

**Our idea at SINTEF**

- Obtain better constrained models by joining EM and seismic
- Reduce uncertainty of rock physics models by using both electric conductivity and seismic parameters
- Reduce prospect uncertainty further by adding results from EM/seismic and rock physics modelling in basin models, and vice versa
Multi proxy approach and integration of various information sources

**IntCSEM** → Controlled-source electromagnetic methods (fluid content)
→ seismic data (geol. structures)
→ basin modelling data (hc volumes phases, uncertainties)
→ rock physics (lithology, hc volumes phases, uncertainties)
Multi proxy approach and integration of various information sources

Top seal integrity and leakage

1. Fracturing of cap rock due to depressurisation
2. Changed migration paths due to tilting
3. Gas exsolution from oil due to depressurisation
4. Reduced maturation and generation due to reduced burial depth – traps are not filled to spill point
Multi proxy approach and integration of various information sources

Top seal integrity and leakage

Cap rock properties:
Porosity, permeability, entry pressure, mech. strength as function of
• Facies
• Compaction and diagenesis
• Databases / literature

Leakage and remigration:
• Hydraulic leakage
  • Pressure and stress interactions
  • Erosion and uplift effects
• Trap simulator
• Seismic detection of fractures / leakage

Applying leakage/seal models – case study:
• Constraining burial and temperature history
• Modelling pressure and stress history
• Modelling leakage processes
• Integration seismic / EM / Bas Mod
• Calibration to well observations
Two Field Laboratories, where CO₂ can be injected in permeable rocks in a well-controlled and well-characterised geological environment, will be established.

CO₂ will be injected to obtain underground CO₂ distributions that resemble leakages. Various monitoring technologies will be studied with respect to their performance to detect known amounts of CO₂.
The focus will be on the sensitivity to detect CO₂ leakage out of the storage containment.

Requirements will be determined for monitoring systems to be sufficiently sensitive to allow early remediation.

Project duration 2008 - 2011