Smeaheia baseline geophysical models

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In spring 2016, Gassnova presented a feasibility report on full-scale CCS deployment in Norway [Gassnova, 2016] for which Statoil had conducted the storage part study. After the selection of three possible locations for injection, the Smeaheia site in the North Sea was chosen as the most viable location [Furre et al., 2017]. The containment structure of the Smeaheia site is a fault block located east of the Troll gas field, north-west of Bergen. The same reservoir formations are present in Smeaheia and in the gas producing formation at Troll, i.e. the Sognefjord, Krossfjord, and Fensfjord formations [Halland et al., 2013]. The CO_2 injection was recommended to be at 1200 to 1500 m depth in the alpha structure located west of the faulted segment. Eastern beta structure is also considered in the project. This reservoir is estimated to be suitable for containment of in excess of 100 million tons of CO_2. In June 2017, Gassnova awarded Statoil the contract for concept and FEED studies for CO_2 storage at Smeaheia. Later, Shell and Total have joined as equal partners in the Statoil-led project. SINTEF and partners will, through the NCCS Centre and other projects, support the developments at Smeaheia on the research side for various aspects including characterisation and monitoring.

The Measurement, Monitoring, and Verification (MMV) program at Smeaheia must conform to Norwegian regulations established in 2014 that will ensure conformance (understanding of CO_2 behaviour), containment (ensuring the CO_2 migration is controlled) and contingency (detecting and addressing significant anomalies and leakages). A mix of several monitoring methods will be proposed to address these objectives including seismic techniques. Reliable baseline models are prerequisites for better site characterization, better assessment of storage risks, efficient injection strategy and cost-efficient monitoring. In addition, quantitative images of the reservoir obtained from baseline models might be helpful for storage planning. For example, quantitative mapping of porosity can be helpful for reservoir characterisation.

Available data (before CO_2 injection) at Smeaheia include numerous 2D seismic surveys, 3D seismic cubes, as well as well logs data (Figure 1). We select one seismic 2D line crossing the area of interest (the alpha and beta structures where the CO_2 injection are possible) and we perform the following steps:

- Pre-processing of raw data, building of starting velocity model used for Amplitude-Versus-Offset (AVO) and Full Waveform Inversion (FWI) techniques.
- Development of rock physics models based on log data that will be used in AVO analysis and rock physics inversion.
- Calculation of seismic attributes and AVO analysis using optAVO tool [Causse et al., 2007] [Ravasi et al., 2017].

- Acoustic FWI [Virieux and Operto, 2009] [Romdhane and Querendez, 2014] to derive high-resolution velocity model with uncertainty quantification in a second step [Eliasson and Romdhane, 2017].
- Rock physics inversion using FWI (and potentially seismic attributes) results [Dupuy et al., 2016] [Dupuy et al., 2017].

This workflow has also been successfully applied to the Sleipner dataset [Dupuy et al., 2017].
The main aim is to obtain relevant and accurate seismic baseline models for selected 2D lines before applying the methodology to 3D cubes in the area of interest. Synthetic seismic models as well as resistivity and density models could be built from the derived baseline models. In addition, the baseline models will be used as background and reference case to define the monitoring strategies. Quantifying expected influence of CO_2 saturation and pressure changes over the full storage time (including post-closure) is part of the MMV plan. These expected changes will be derived from baseline models. Additionally, quantitative imaging (FWI and rock physics inversion) will provide strong insight for better reservoir characterisation and will help planning storage options.

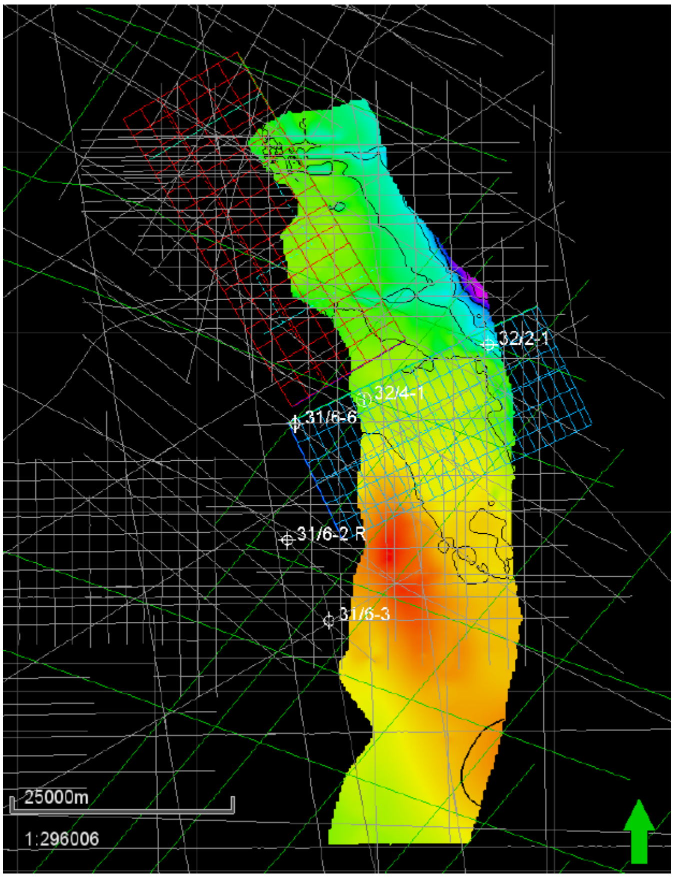

Figure 1: seismic and wells at Smeaheia. Blue and red grids give the location of respectively GN1101 and TNE01 3D cubes. The five wells are indicated by white crosses and the 19 2D seismic surveys in the area are also indicated.

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