Dry-run licence application
Sparse data and Risk Assessment
The onshore Vedsted structure, NW Denmark

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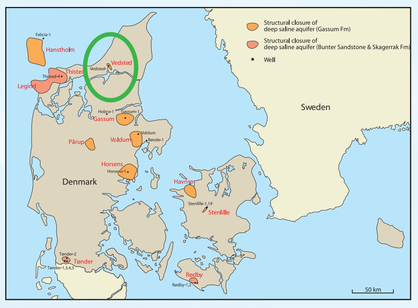
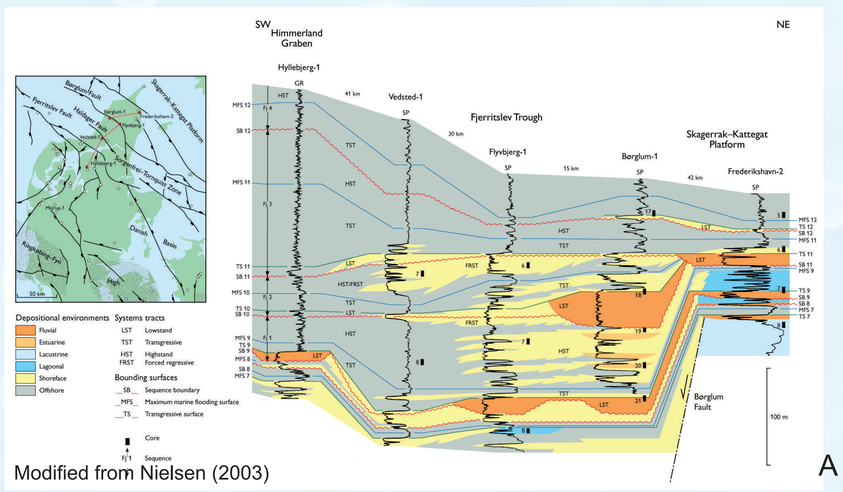
Introduction

In this early stage of site evaluation, the regional geological model and the sequence stratigraphic interpretation are important contributors to the construction of a realistic geo-model. Flow simulation is applied to investigate the interplay between geological heterogeneity at different scales, the filling geometry, and ultimately the contribution from the different trapping mechanisms.

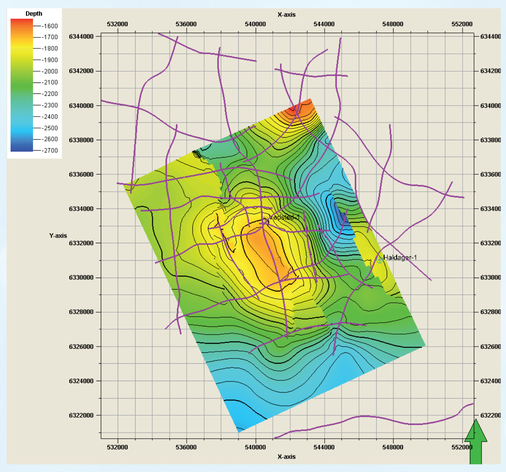


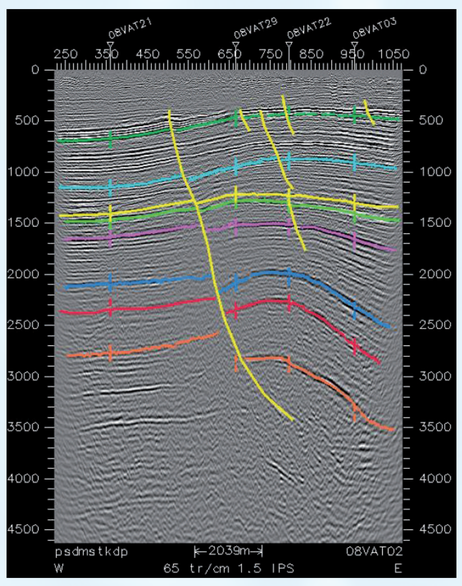
The Vedsted structure is situated in northern Jutland close to the city of Ålborg. The main reservoir is mapped in the Upper Triassic – Lower Jurassic Gassum Formation.
The Vedsted structure is a domal structure situated in a small graben related to northwest-southeast trending faults. The graben structure is part of a Triassic rift system forming the deep Fjerritslev Trough. The structure has been explored with the Vedsted-1 well drilled in 1958.

Geological input



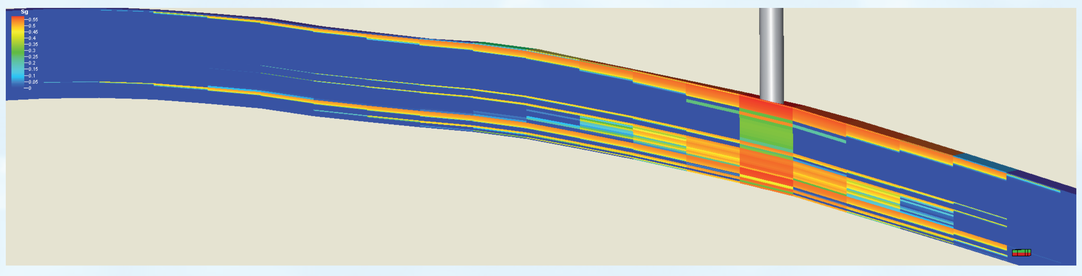
A: SW-NE well-log panel across the Danish Basin, the Sorgenfrei-Tornquist Zone and the Skagerrak-Kattegat Platform showing part of the Gassum Reservoir.The shallow water sands of shoreface and estuarine facies clearly extend from the Scandinavian terrestrial terrains in the NE and into the Danish Basin terminating into offshore mudstone facies. The shoreline fluctuations cause interfingering of these different facies types and give rise to pronounced vertical variability and intraformational sealing layers.
B: Porosity profile in the Gassum Formation showing the lower transgressive sequence developing into the offshore claystones, and an overlying regressive unit with shoreface facies.





C: The new 2008 2D lines.
Outline of site model V.1 area
D: Section 08VAT02 across northern part of Vedsted Structure. Note: Growth fault affecting all interpreted levels soling out in the Triassic section.
Colour code: - Dark green: Base Chalk Group; -Light blue: Top Frederikshavn Formation, -Yellow: Top Haldager Sand Formation, -Light green: Base Haldager Sand Formation (MCU), -Purple: Intra Fjerritslev F-III Member. -Blue: Near Top Gassum Formation, -Red: Near Top Skagerrak Formation, -Orange: Intra Triassic marker. Note: minor extensional faults cut Base Chalk, but sole out in Lower Cretaceous.

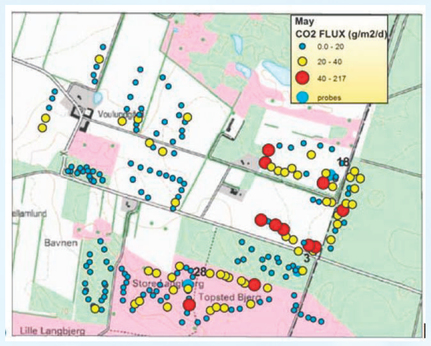
Geo-model and flow simulation

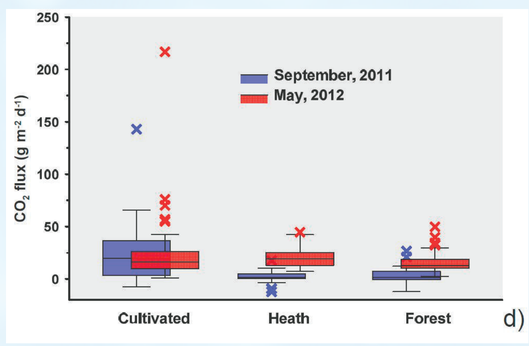


Vertical section through injection well. CO_2 gas phase saturation after 10 years injection. Section 4 km long, 300 m height.
After some years constant injection, the CO_2 distribution clearly shows the subdivision of the migrating CO_2, mainly due to the low permeability intraformational sealing layers but having also higher capillary entry pressures. The layering in the geo-model has maximum continuity, which probably overestimates the segregation to be found in real cases, but any intra-reservoir sealing layers will have this effect on the distribution.

Monitoring

The present work details near-surface gas geochemistry research conducted at the Voulund Agricultural research site (central Denmark), which was used as a natural analogue to the Vedsted area. Soil gas and gas flux was measured in the area to define the range of natural baseline values for these parameters and to better understand the influence of such factors as land-use, climate, and seasonality on their temporal and spatial variability.

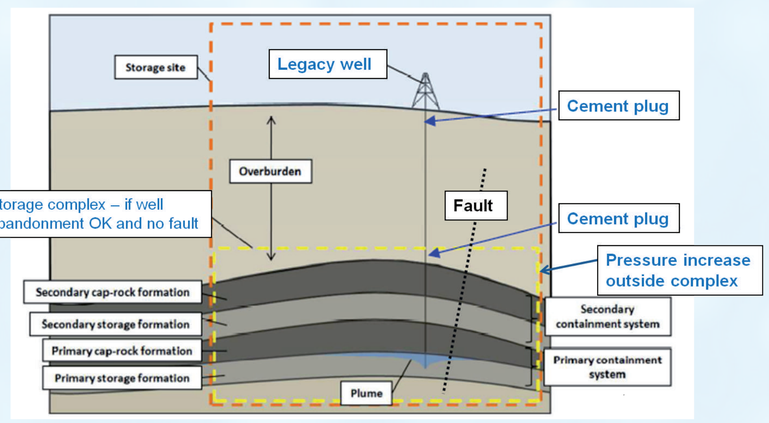




Classed post maps of CO_2 flux from the May, 2012 campaigns.
Box and whisker plot showing the statistical distribution of CO_2 flux, divided for land-use type and campaign.

Storage complex

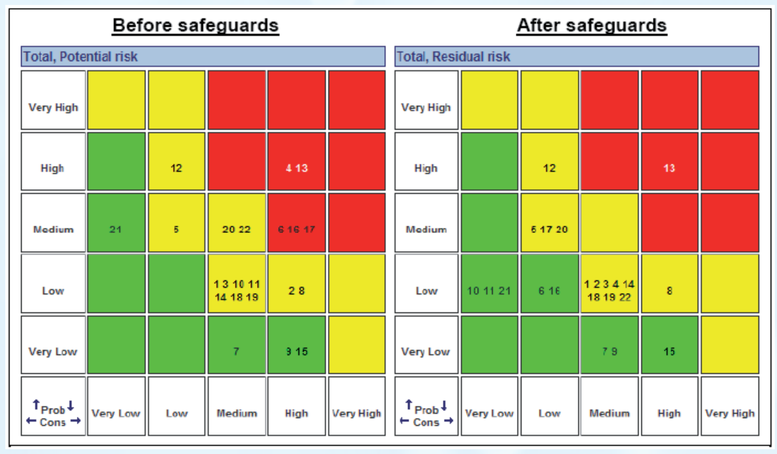
For defining the storage complex for the Vedsted site and the surroundings, the Guidance Document 2 to the EC directive was consulted.
It is obviously that the storage complex must delineate the anticlinal structural closure together with the potential leaking faults. At this stage faults can be identified on the seismic interpretations, but the state of the faults is unknown, i.e. open or non-open and the termination points are to some degree uncertain.



The figure shows a principal sketch for the Vedsted site defining the storage complex and the different site specific conditions that were considered. There seems to exist some confusion in the definition of storage site and storage complex; in the definition of the storage site the surface facilities are included, but the complex may be defined without including the surface if wells penetrating through the overburden are properly sealed off.

Risk register

Input from the risk assessment workshop was condensed into 22 discrete hazards. Safeguards and action that can reduce the probability and/or reduce the consequence form the individual risk is described (DNV 2010). A risk matrix for the 22 hazards visualize how each will plot before and after a safeguard is put to action



Summary

• A number of studies were accomplished in the past five years covering a range of issues to take the project to a level of sound decision for further project development. The objective for the present interim dry-run licence application is to evaluate the completeness of both the work achieved and ongoing for a permit to develop an onshore site for safe geological storage of CO_2.
An important objective for the SiteChar project is also to set up a methodology or workflow for maturing a project through to the development phase and secure readiness for an application for a storage permit to be issued to the competent authorities

• The sparse data for most saline aquifers raise the demand for using the geological framework to supplement the sometimes few local observations. From this can be derived the probable architecture for the heterogeneity, and thereby the influence on injectivity, connectivity and filling efficiency.

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