Th CO2 05

Assessing Potential Influence Of Nearby Hydrocarbon Production On CO2 Storage At Smeaheia

H. Lauritsen[1]*, S. Kassold[1], R. Meneguolo[1], A. Furre[1]
[1]Equinor

Summary

In 2016, a study identified the Smeaheia area located 30km off the western coast of Norway, as a suitable storage site for CO2. A concept selection study requested by the Gassnova public enterprise was subsequently performed by the Northern Lights subsurface team, a group comprised of personnel from Equinor and partners. The study revealed challenges with the various geological structures planned for CO2 storage, as well as the importance of understanding the pressure connectivity with the neighbouring hydrocarbon producing Troll field. Due to these challenges Smeaheia was not found mature enough for concept selection at this stage

Introduction

As a contribution to the Paris Agreement's goals, the world's first project for offshore storage of CO_2 from several onshore industrial sources was initiated by the Norwegian Government. The Northern Lights Project is a demonstration project with full-scale CCS value chain, including capture, ship transport and permanent geological storage. Equinor ASA, formerly known as Statoil, was awarded the contract for concept selection and FEED (Front-End Engineering Design) for the storage solution in June 2017. Norske Shell and Total E&P Norge entered as equal partners, in October 2017.

A 2016 feasibility study identified the Smeaheia area located 30km off the western coast of Norway, as the preferred storage site. A concept selection study requested by the Gassnova public enterprise was subsequently performed by the Northern Lights subsurface team, a group comprised of personnel from Equinor and partners. The study revealed challenges with the various geological structures planned for CO_2 storage, as well as the importance of understanding the pressure connectivity with the neighbouring hydrocarbon producing Troll field. Due to these challenges Smeaheia was not found mature enough for concept selection at this stage.

Frame conditions

The Smeaheia area is the easternmost fault block on the Horda platform, bounded to the West by the Vette Fault towards the giant Troll field (Figure 1). Two structures, named Alpha and Beta, have been identified as interesting for CO_2 storage within Smeaheia. Both Alpha and Beta have been penetrated by exploration wells, 32/4-1 T2 (1996) and 32/2-1 (2008), respectively. The wells showed no hydrocarbons and were reported with hydrostatic pressure.

CO_2 injection is planned for the Sognefjord and Fensfjord Formations, of the Upper Jurassic Viking Group, which define the Primary Storage Unit. These formations offer good reservoir properties and connectivity which will facilitate adequate CO_2 distribution in the area.

Viking Gp. is as well the main reservoirs in the Troll field which produced 39.1 GSm^3 of gas and 7.4 MSm^3 of oil alone in 2017 (source: npd.no [1]). Troll began production in 1995 and in July 2018 it was announced that Troll phase III will prolong the lifetime of the field until 2060 (npd.no [2]). The drainage strategy for Troll Phase III is pressure depletion. An assessment has been performed to identify possible communication pathways between the Smeaheia fault block and the Troll East fault block. In total, 6 paths have been observed that are related to ramp structures along the Vette Fault. In addition, the southernmost tip of the Vette Fault is also regarded as a potential pathway for pressure communication given the reservoirs within the Primary Storage Unit are still present. Given these potential pathways, communication with Troll is deemed more likely than not, and the Smeaheia area is expected to be strongly influenced by production induced depletion.

Alpha defines the primary structure for storage on Smeaheia. It is a gently dipping 3-way closure, fault-bounded to the west by the Vette Fault with a top depth of the storage unit at 1200 m TVD. The Beta structure is situated on the eastern side of the Smeaheia block in the hangingwall of the Øygarden Fault Zone with a top depth of the storage unit at 900 m TVD.

Beta is a 3-way closure juxtaposed against the basement along the Øygarden Fault Zone. On the footwall side, complex fault systems have been observed in the sediments overlying the basement indicating the basement is also fractured and faulted, thus posing an increased risk of CO_2 leakage. Beta has therefore been disqualified as a suitable storage structure. This development has led to limitations on the overall storage capacity of Smeaheia by introducing restrictions to where CO_2 migration is acceptable.

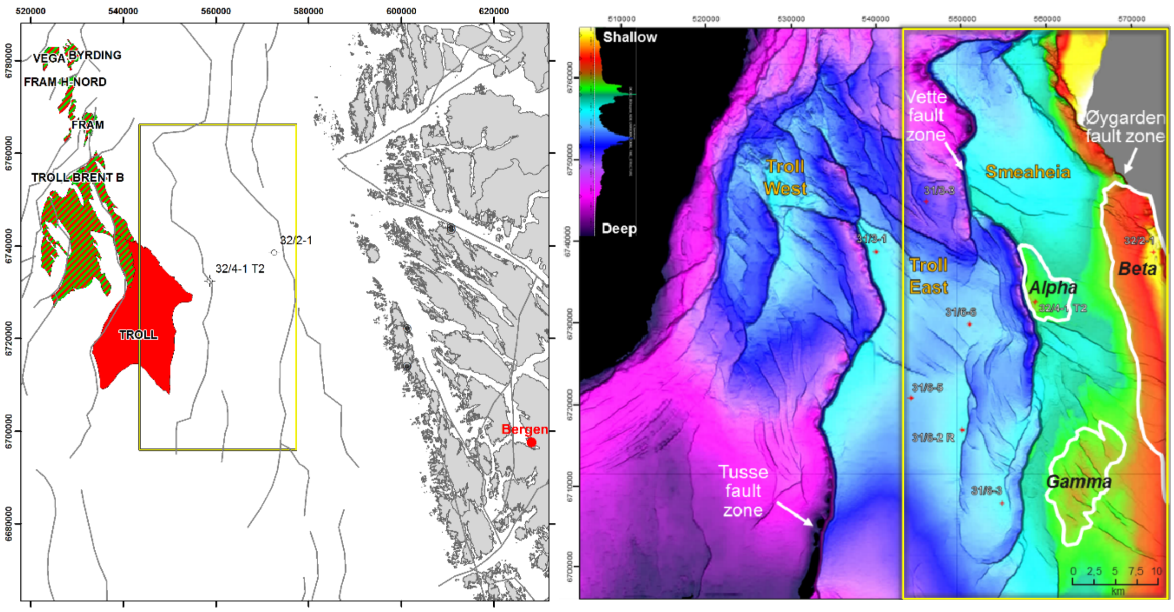

Figure 1 *Left: Area map with main structural elements and the Smeaheia area in magenta; Right: Figure from Meneguolo, R. 2018, Map showing the Smeaheia area with the main structures evaluated for CO_2 storage.*

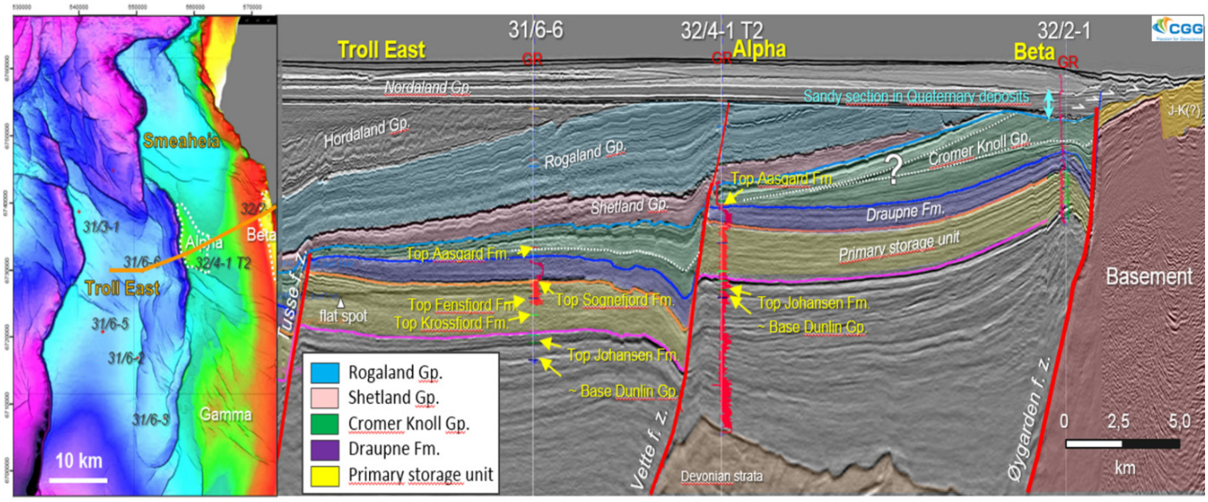

Figure 2 *Seismic cross section including the main structural elements and stratigraphy (modified from Meneguolo, R. 2018). Seismic sections shown with courtesy of CGG.*

Reservoir technology

The reservoir simulations performed for Smeaheia mainly focused on identifying the key parameters influencing the theoretical storage capacity and estimating their relative importance by testing them dynamically in an Eclipse 300 (E300) simulation model. With the exclusion of Beta as a suitable storage structure, the storage capacity estimate is predominantly governed by the pressure depletion from nearby producing Troll fields that is assumed to carry on long after the planned CO_2 injection period. This depletion has great impact on the CO_2 density and hence the volume it will occupy in the pore space.

The project team successfully constructed a geological and dynamic model to be utilized in testing the most important parameters to CO_2 injection and storage (Figure 3). The model covers an area permitting the direct modelling of the two governing frame conditions: pressure influence from Troll production and monitoring of CO_2 migration towards the Beta structure. The model allows for testing of the main CO_2 trapping mechanisms of structural, residual, and dissolution trapping.

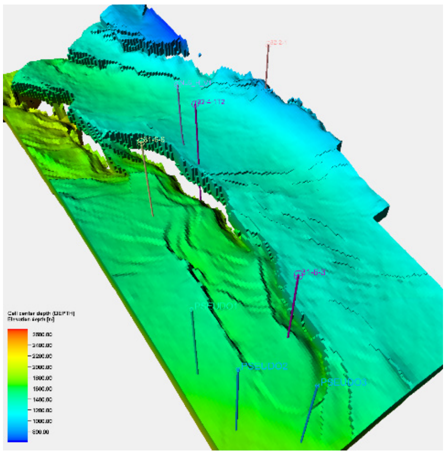

***Figure 3** Outline of the E300 dynamic model.*

The simulation work mainly focused on a scenario where 40 MT CO2 is injected in one well located in the Viking Gp and assuming strong pressure influence from nearby fields. The injection point was placed deep in Viking to allow for residual trapping of CO2 as it migrates to the shallowest point and structural trapping in Alpha. The simulation work performed showed that 5-20% of the injected CO_2 would elude trapping on Alpha and flow to the Beta structure where it could potentially escape through the Øygarden fault zone (Figure 4).

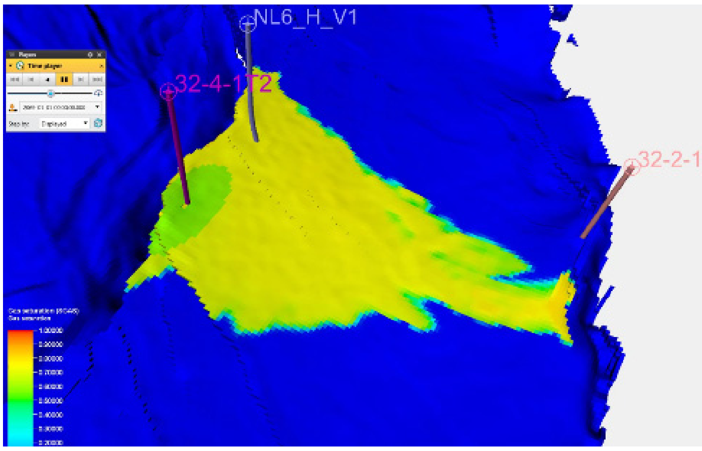

***Figure 4** Bird view on CO2 plume as it spills from Alpha to Beta.*

Conclusions

The project has acquired a good understanding of controlling elements and resulting scenarios for CO_2 storage capacity. Based on the modelling described above the storage capacity estimates are currently too low for full-scale development. A potential increase in capacity would require a larger development and higher investments than what is currently being evaluated. Methods or tools for confidently estimating aquifer recharge would help increasing storage capacity.

Acknowledgements

We thank Equinor ASA for allowing us to publish these results. Special thanks are given to the Northern Lights Subsurface Team, which forms the basis for this abstract. Furthermore, Anne-Kari Furre and Andrew McCann provided valuable discussion and input. CGG is gratefully acknowledged for their permission to display relevant seismic lines.

References

[1] http://factpages.npd.no/factpages/Default.aspx?culture=no/ 16.07.2018 15:13

[2] http://www.npd.no/en/news/News/2018/Developing-Troll-phase-three/ 16.07.2018 15:57
R. Meneguolo [2018] The Northern Lights project: towards the implementation of full-scale CCS in the North Sea. CO2 GeoNet Post-Open Forum workshop, Venice, 26th April 2018.