Classification and characterization of CO\textsubscript{2} storage sites on the Norwegian Continental Shelf

Eva Halland, Fridtjof Riis

\textsuperscript{1,2}Norwegian Petroleum Directorate

Abstract

Depending on their specific geological properties, several types of geological formations can be used to store CO\textsubscript{2}. In the North Sea Basin, the greatest potential capacity for CO\textsubscript{2} storage will be in deep saline-water saturated formations or in depleted oil and gas fields.

The results presented in the CO\textsubscript{2} Storage Atlas are based on studies of all relevant geological formations and hydrocarbon fields on the Norwegian Continental Shelf (NCS). Norwegian Petroleum Directorate (NPD) has access to all data collected from the petroleum industry and has a national responsibility for these data. More than 50 years of petroleum activity has generated a large quantity of data. These data and analyses together with many years of dedicated work to establish geological play models, have given us a good basis for the classification and characterization of potential CO\textsubscript{2} storage sites. The newly established Norwegian full-scale CCS project has chosen Smølaheia area as a storage site for the captured CO\textsubscript{2}. This area was selected out of three possible storage sites, based on the screening and evaluation done in this work.

The first step in site selection is the screening of potentially suitable formations and structures using specific criteria. In the site selection process it should be demonstrated that the potential sites have sufficient capacity to store the expected CO\textsubscript{2} volume and sufficient injectivity for the expected rate of CO\textsubscript{2} capture and supply. The integrity of the site must be assessed for the period required by the regulatory authority and requirements in the regulations, so as avoid any unacceptable risks to the environment, human health or other uses of the subsurface.

The aquifers were evaluated regarding reservoir quality and presence of relevant sealing formations. Those aquifers that may have a relevant storage potential in terms of depth, capacity and injectivity have been considered. The most attractive aquifers and structures were investigated by geomodelling and reservoir simulation.

In all models, it is assumed that there will be no water production. The volumes of injected CO\textsubscript{2} are constrained by the fracturing pressure. Our estimates of fracturing pressures are based on a large data base of leak-off tests and pore pressures in exploration wells. The regional fracture pressure trends are quite similar in North Sea and Norwegian Sea shelf, and somewhat lower in deeply eroded areas in the Barents Sea.

Aquifers and structures have been characterized in terms of capacity, injectivity and safe storage of CO\textsubscript{2}. To complete the characterization, the aquifers are also evaluated according to the data coverage and their technical maturity. Guidelines and check lists were developed to facilitate characterization. Parameters used in the characterization process are based on data and experience.
from the petroleum activity on the NCS and the fact that CO$_2$ should be stored in the supercritical phase to obtain the most efficient and safest storage. For evaluation of regional aquifers in CO$_2$ storage studies, the mineralogical composition and the petrophysical properties of the cap rocks are rarely well known. To characterize the sealing capacity in this study, we have mainly relied on regional pore pressure distributions and data from leak-off tests combined with observations of natural gas seeps. In exploration wells on the Norwegian shelf, pressure differences across faults and between reservoir formations and reservoir segments are commonly observed. Such pressure differences give indications of the sealing properties of cap rocks and faults. Based on such observations in the hydrocarbon provinces, combined with a general geological understanding, one can use the sealing properties in explored areas to predict the properties in less explored or undrilled areas.

The scores for capacity, injectivity and seal quality are based on evaluation of each aquifer/structure. The checklist for reservoir properties gives a more detailed overview of the important parameters regarding the quality of the reservoir. The most important parameters evaluated for demonstrating an acceptable storage site are listed below:

**Containment** – Seal distribution and effectiveness, trap, fault risk/sand to sand, geochemistry, plume migration control
**Injectivity** - Permeability, thickness, heterogeneities, geochemistry
**Capacity** - porosity, initial pressure, communication in the complex, communication beyond the complex
**Leakage risk to surface** - environmental consequences, “hazard for life”
**Monitorability** - depth, base line definition, feasibility, monitoring potential
**Commercial aspects** - maturation cost, development cost, potential use of CO$_2$, opening for future developments, conflicting commercial activity, cost/ton CO$_2$
**Maturation** - feasibility, data availability, maturity, maturity potential

These parameters are set into different checklists for detailed grading. The scores for capacity, injectivity and seal were determined from the individual parameters established in the guidelines. Each parameter was given a score, and the scores were combined to give the final score for the aquifer. Some parameters were weighted, as will be presented in the different check lists.