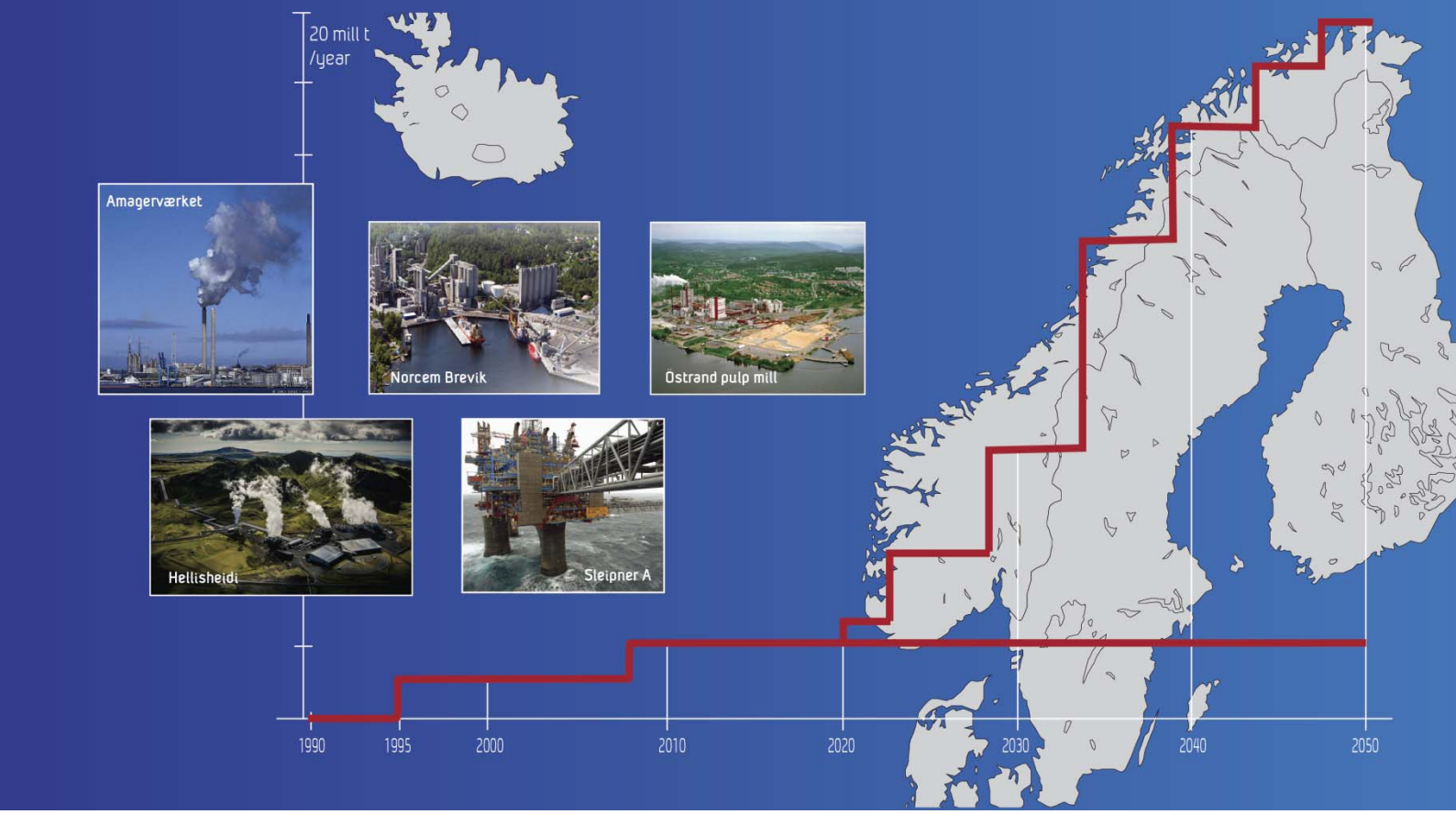

The Nordic CO_2 storage atlas and the process of making it

Karen Lyng Anthonsen

NORDICCS Conference contribution D 6.1.1407 (3)

August 2014

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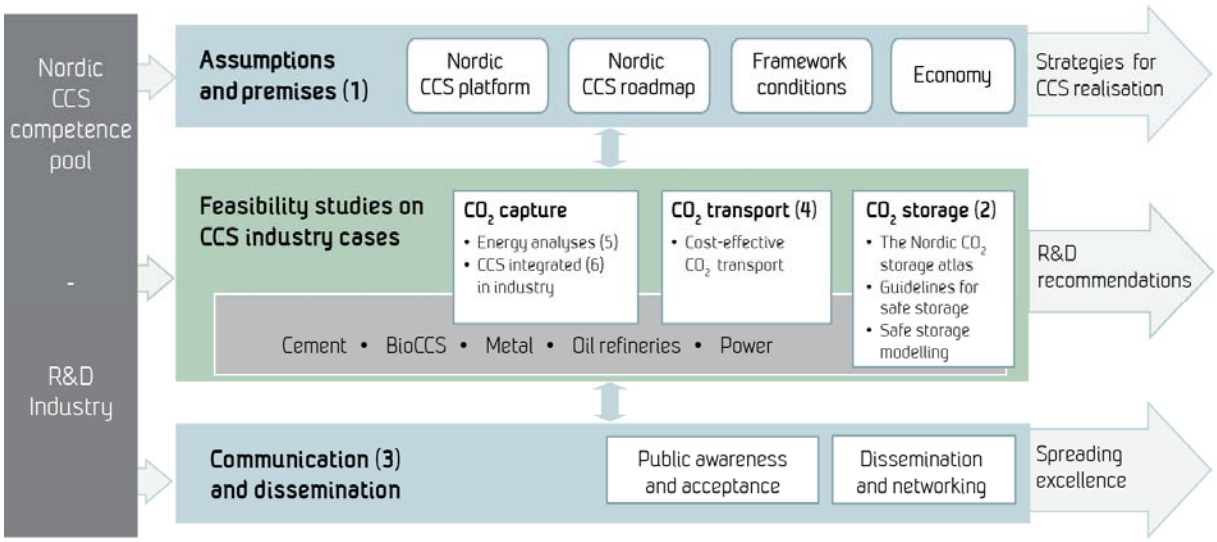

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Contact: Centre Director Nils A. Røkke • + 47 951 56 181 • Nils.A.Rokke@sintef.no
www.sintef.no/NORDICCS

Summary

A description of the process and methodology of making the Nordic CO_2 storage atlas. Including available data, the difference storage options in the Nordic countries and how to evaluate the storage capacities.

Contribution to the International Carbon Conference, Reykjavik, Iceland, August 2014.

Keywords Storage capacity, CO_2 storage atlas, Nordic countries, sedimentary basins, basalts

Authors Karen Lyng Anthonsen, GEUS – Geological Survey of Denmark and Greenland, Denmark, kla@geus.dk

Date August 2014

About NORDICCS

Nordic CCS Competence Centre, NORDICCS, is a networking platform for increased CCS deployment in the Nordic countries. NORDICCS has 10 research partners and six industry partners, is led by SINTEF Energy Research, and is supported by Nordic Innovation through the Top-level Research Initiative.

For more information regarding NORDICCS and available reports, please visit http://www.sintef.no/NORDICCS.

The Nordic CO_2 storage atlas and the process of making it

Karen L. Anthonsen

Geological Survey of Denmark and Greenland – GEUS

Øster Voldgade 10, DK-1350 Copenhagen K, Denmark, e-mail: kla@geus.dk

One of the final outcomes of NORCICCS – the Nordic Competence Centre is a web-based CO_2 storage atlas, which will be public released in autumn 2015. The atlas will show the location of sites potentially qualified for CO_2 storage. The mapped storage sites will be ranked with respect to their suitability for CO_2 storage, based on geological properties and the state of knowledge, in order to point out the most prospective areas at present time.

The primary tools to map subsurface storage sites are wells and seismic surveys. The wells can give information about the existence of a porous reservoir rocks and overlaying tight cap rocks. The seismic survey gives the possibility to map the reservoir and cap rock between the wells.

In order to judge if a mapped storage site will be able to contain the required amount of CO_2 from one or several emission sources it is important to estimate the storage capacity. The first approach is a static calculation, calculating the pore volume and multiplying it with a storage efficiency factor. If a potential storage site gives promising results, a dynamic modelling and injection simulation can give more detailed capacity estimations. In NORDICCS seven sites have been selected for modelling.

In the Nordic region four CO_2 storage options have been included in the mapping. It is potentially possible to store CO_2 in the pore space of sedimentary formations (aquifers), in depleted hydrocarbon fields or in porous basaltic lava. The last opportunity is ultramafic rocks were the CO_2 can react with the rock and form carbonate minerals (carbonisation).

The different geological setting in each of Nordic country yield different storage opportunities. In Finland the crystalline basement rocks only allow a minor potential for CO_2 storage by carbonisation of ultramafic rocks [1]. Sweden has the possibility to store in sedimentary formations in the south-eastern part of the Baltic Sea and South-West of Scania [2]. In Denmark and Norway the existences of extensive sedimentary basins offers the opportunity to exploit large pore volumes in aquifers for CO_2 storage [2] [3]. In Iceland the research project CarbFix investigate the potential for CO_2 storage by injection of CO_2 saturated water into porous basalts [2] [4].

[1] Aatos et al. (2006), *Report No. M10.1/2006/3*. Geological Survey of Finland (GSF)
[2] Anthonsen et al. (2013), *Energy Procedia* **37**, 5080-5092
[3] Halland et al. (2014), *CO_2 storage atlas - the Norwegian Continental Shelf*. The Norwegian Petroleum Directorate.
[4] Gislason et al. (2010), *International Journal of Greenhouse Gas Control* **4**, 537-545.

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Karen L. Anthonsen

Geological Survey of Denmark and Greenland - GEUS
Øster Voldgade 10, DK-1350 Copenhagen K, Denmark, e-mail: kla@geus.dk

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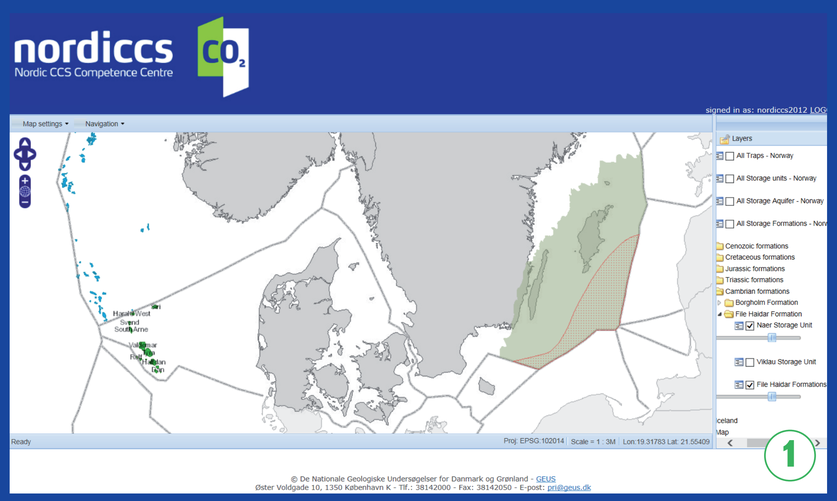
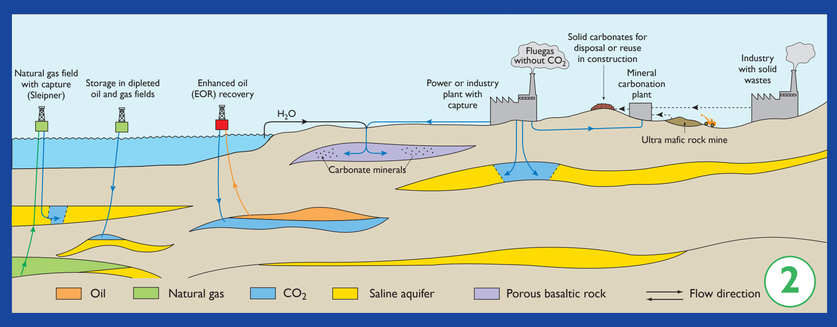
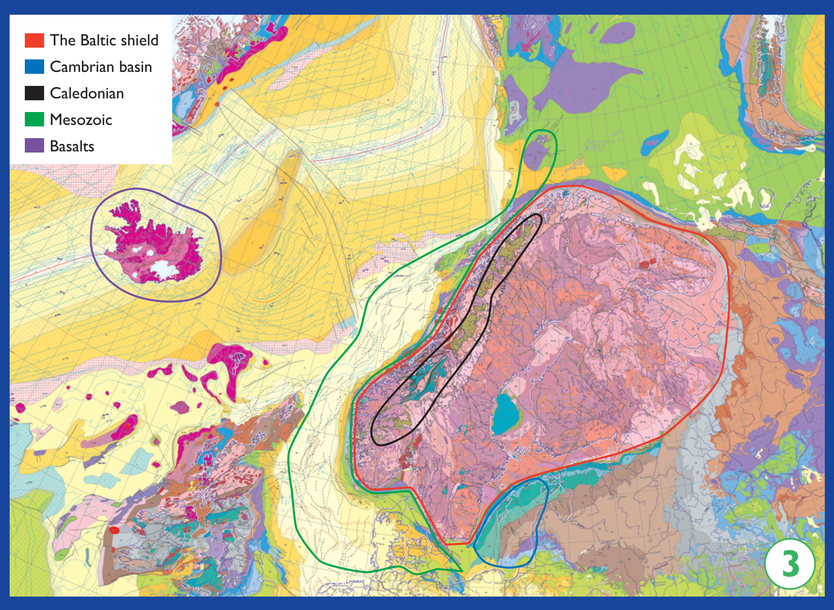


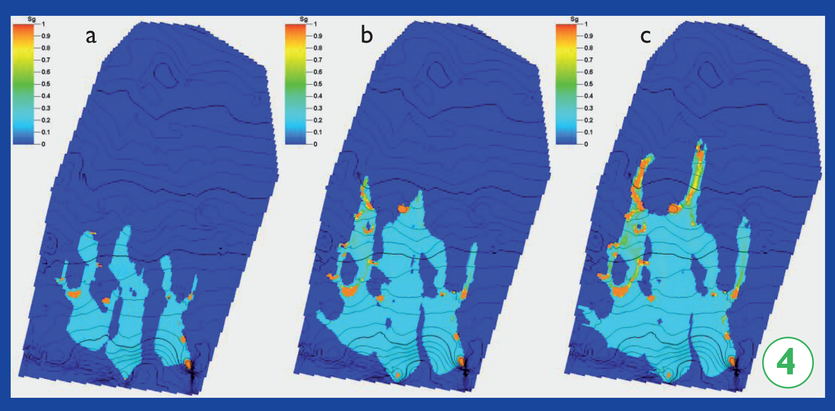
Prototype of the NORDICCS CO_2 storage atlas webGIS.



Geological CO_2 storage options in the Nordic region.



European geological map with outlines of the geological framework of the Nordic region.



Example of a CO_2 injection model. This example shows the CO_2 distribution after 4000 years injection in the Gassum Formation, off-shore between Norway and Denmark. The base case model with uniform layer thickness of 5 m in the whole model (a) and for refined layer thickness below the top equal to 2 m (b) and 1 m (c). From Bergmo et al. 2013 [5].

References

[1] Aatos et al. (2006), Report No. M10.1/2006/3. Geological Survey of Finland (GSF)
[2] Anthonsen et al. (2013), Energy Procedia 37, 5080-5092
[3] Halland et al. (2014), CO2 storage atlas - the Norwegian Continental Shelf. The Norwegian Petroleum Directorate.
[4] Gislason et al. (2010), International Journal of Greenhouse Gas Control 4, 537-545.
[5] Bergmo et al. (2013), Energy Procedia 37, 4863-4871.

1 One of the final outcomes from NORCICCS – the Nordic Competence Centre is a web-based **Nordic CO_2 storage atlas**, which will be public released in autumn 2015. The atlas will show the location of sites potentially qualified for CO_2 storage. The mapped storage sites will be ranked with respect to their suitability for CO_2 storage, based on geological properties and the state of knowledge, in order to point out the most prospective areas at present.

2 In the Nordic region four **CO_2 storage options** have been included in the mapping. It is potentially possible to store CO_2 in the pore space of **sedimentary formations (aquifers)**, in **depleted hydrocarbon fields** or in **porous basaltic lava**. The last opportunity is CO_2 reactions with mined ultramafic rocks or waste material from industry forming **carbonate minerals** (carbonisation).

3 The different **geological setting** in each of Nordic country yield different storage opportunities. In Finland the crystalline basement rocks only allow a minor potential for CO_2 storage by carbonisation of ultramafic rocks [1]. Sweden has the possibility to store in sedimentary formations in the south-eastern part of the Baltic Sea and South-West of Scania [2]. In Denmark and Norway the existences of extensive sedimentary basins offers the opportunity to exploit large pore volumes in aquifers for CO_2 storage [2] [3]. In Iceland the research project CarbFix investigate the potential for storage by injection of CO_2 saturated water into porous basalts [2] [4].

4 **Storage capacity** estimations is important in order to judge if a mapped storage site will be able to contain the required amount of CO_2 from one or several emission sources. **Static calculation** is a first approach to capacity estimates and is done by calculating the pore volume of the reservoir and multiplying it with a storage efficiency factor. If a potential storage site gives promising results, a **dynamic modelling** and injection simulation can give more detailed capacity estimations. In NORDICCS seven sites have been selected for modelling.

5 The **primary tools** to map subsurface storage sites are wells and seismic surveys. The **wells** can give information about the existence of porous reservoir rocks and overlaying tight cap rocks. Analysis of well logs and cores can give information on porosity, permeability and deposition environment (facies). The **seismic survey** makes it possible to map the reservoir, cap rock and the faults between the wells, and to understand the geometry of the formations.

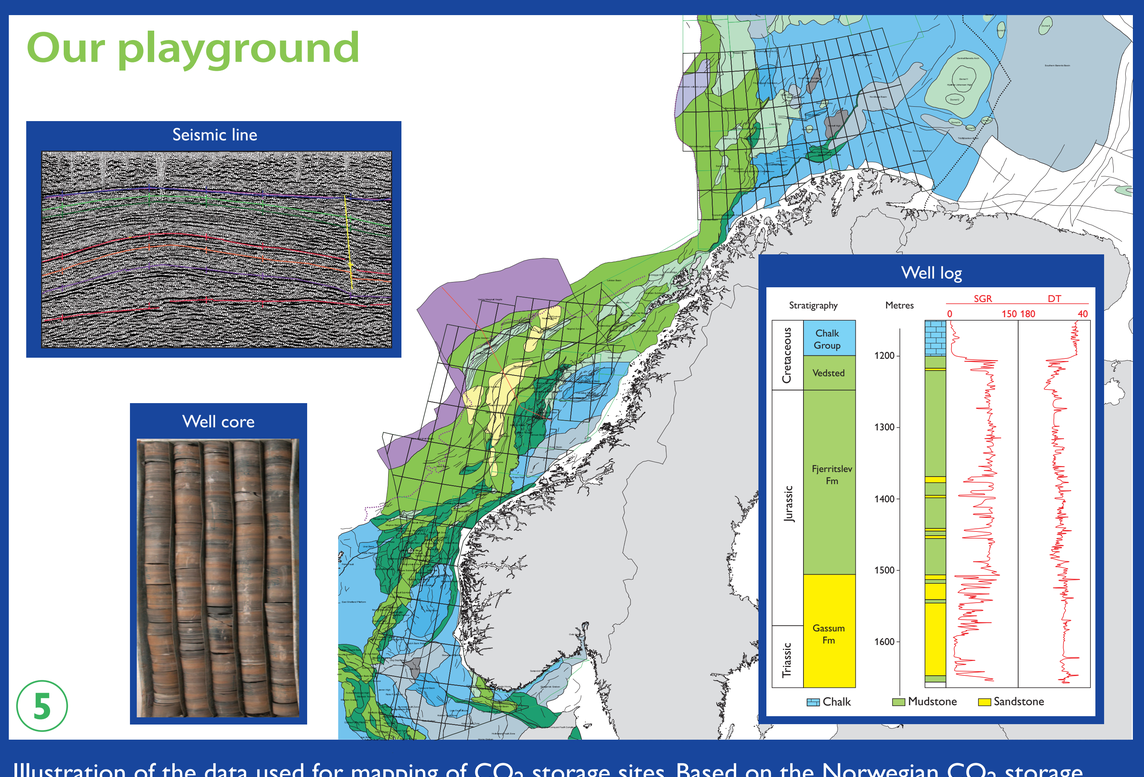


Illustration of the data used for mapping of CO_2 storage sites. Based on the Norwegian CO_2 storage atlas by the Norwegian Petroleum Directorate.

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