Assessment of CO\textsubscript{2} storage prospectivity in the northwestern German North Sea

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In this study, we present the results of the assessment of the CO\textsubscript{2} storage prospectivity in the Entenschnabel area, the northwestern edge of the German exclusive economic zone in the North Sea. The work was carried out within the scope of the project “Subsurface Potentials for Storage and Economic Use in the North German Basin” (German acronym TUNB, www.bgr.bund.de).

Our investigation closes the regional gap remaining from previous studies assessing the prospectivity of CO\textsubscript{2} geological storage in Germany. For the German main land BGR and the German state GSOs have cooperated in mapping reservoir- and barrier rock units forming prospective areas for CO\textsubscript{2} storage (Storage Catalogue of Germany (Müller et al. 2011)). Storage potentials in the central German North Sea sector were assessed in the project “Geoscientific Potential of the German North Sea” (German acronym GPDN, www.GPDN.de, Jähne-Klingberg et al. 2014, Bense et al. 2017).

Any assessment of storage potentials in regional saline aquifers requires inter alia a detailed knowledge on the distribution of appropriate reservoir rocks (rocks with high porosity and permeability; i.e. sandstones) and barrier rocks (rocks with low porosity and/or permeability, providing a barrier to the migration of fluids out of the reservoir rock; i.e. clay and salt rocks). To gain such knowledge, we collected, (re)evaluated and compiled all available geological data on spatial distribution, depth, thickness, lithology and facies of such rock units of the deeper subsurface of the study area. Generally, our assessment procedure consists of three consecutive steps. In the first step we identified sections in the stratigraphic record of the study area which comprises appropriate reservoir or barrier rock lithologies (i.e. sand, clay, salt). This was done based on lithological, stratigraphical and geophysical data from deep boreholes. Identified sections were grouped to stratigraphically defined reservoir and barrier rock units. In a second step, the spatial distribution, depth and thicknesses of the reservoir and barrier rock units were mapped based on seismic sections and data from deep boreholes. Mapping was complemented by the evaluation of existing geological cross-sections, maps and structural models of the study area. In a third step, a 3D geological model of the study area was queried by specific thickness and depth criteria, identifying prospective areas of reservoir and barrier rock units. The categorization of prospective areas was based on the criteria depth (minimum depth of 800 m below sea level) and thickness (minimum thickness for barrier rocks 20 m and for reservoir rocks a minimum net thickness of 10 m).
A major challenge within the area investigated is given by its geological complexity caused by multiphase extension during Triassic to Late Jurassic times, halokinetic movements with formation of rim-synclines as well as Late Cretaceous structural inversion, resulting in strong local variations of the sedimentary record.

As the distribution and quality of relevant and available geological data is heterogeneous, the characterizations of the reservoir-barrier-rock units are partly based on extrapolations from adjacent states. Nevertheless, for most parts of the study area the high quality and quantity of available data (e.g. 3D seismic data and detailed 3D models) allowed not only to assess the storage potentials in the same level of detail as presented in previous studies, but also to focus exemplarily on individual horizons, e. g. for a more detailed differentiation of the stratigraphic record into potential reservoir and barrier-rock horizons, each of which comply with the criteria for a reservoir- or barrier-rock unit. An example for this is provided by Lower and Middle Jurassic subgroups, considered as a whole in previous studies as a barrier or reservoir rock unit, respectively.

Results of our assessment have been compiled in maps with information on depth, thickness and spatial distribution of prospective reservoir and barrier rock units, complemented by additional reservoir geologic information (e.g. lithological parameters) and discussed in a regional geological context. By intersecting the prospective areas of reservoir rock units with the prospective areas of the corresponding barrier rock units (‘reservoir-seal-pairs’) prospective areas of reservoir-barrier rock units (Schulz et al. 2013) are defined, which are considered as prospective areas for CO2 geological storage.

The results of our study have paved the way for a regional aquifer based assessment of storage capacity in the Entenschnabel area, comparable to assessments contained in the central German North Sea and the German main land (e.g. Knopf et al. 2010, Knopf & May 2017).

References
S. Knopf, F. May, Comparing Methods for the Estimation of CO2 Storage Capacity in Saline Aquifers in Germany: Regional Aquifer Based vs. Structural Trap Based Assessments. Energy Procedia 114, 4710-4721-