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A MUltiple Space and Time scale Approach for the quaNtification of deep saline formations for CO_2 storaGe

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CO_2 storage is feasible and further demonstration projects are needed

CO_2 storage at the EGU general assembly 2012

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Preface

The General Assembly of the European Geosciences Union (EGU) is the largest conference in Europe dedicated to geosciences. Approximately 11,000 participants were registered in 2012, with the conference being hosted for the 8th time in Vienna, Austria, from 22 to 27 April. Within the EGU the Division Energy, Resources & the Environment (ERE) was hosting four sessions dedicated to the geological storage of CO_2. From more than 118 papers presented at the conference, 15 were selected for publication in this special issue of the International Journal of Greenhouse Gas Control. All articles are fully peer-reviewed and cover various important aspects of CO_2 storage, demonstrating the diversity of disciplines required for the planning of safe and feasible long-term underground storage of CO_2.

We recognize that research has come a long way in addressing the reliability of long-term CO_2 storage and the feasibility has been proven in several demonstration and large-scale field operations. Research should therefore focus on site selection and pore space capacity in the future. This is concluded for example by Jenkins et al. (2012): *"The Otway Project has provided verification of the underlying science of CO_2 storage in a depleted gas field […] and quantitative verification of long-term storage has been demonstrated. A direct measurement of storage efficiency has been made, confirming that CO_2 storage in depleted gas fields can be safe and effective, and that these structures could store globally significant amounts of CO_2."* Comparable to this study are the results from the second largest but now depleted European onshore gas field in the Altmark, Germany. Kühn et al. (2012) came to the final result that *"… the research project provides the technological, logistic and conceptual prerequisites for implementing a CO_2-based EGR project in the Altmark"*. Martens et al. (2012) gives similar arguments for aquifer storage: *"The Ketzin project successfully demonstrates CO_2 storage in a saline aquifer on a research scale."* Consequently, the next step would be towards a new generation of field tests. Oldenburg (2011) postulates that an *"Improved understanding of geologic CO_2 storage processes requires risk-driven field experiments […] aimed at understanding the circumstances under which things can go wrong [… because] the central challenge of carbon dioxide capture and storage (CCS) lies in its vast scale."* The importance of field tests covering various geological and technological settings to take CCS forward is emphasized also in the recent report of the European Academies Science Advisory Council for Europe (EASAC 2013).

Despite all the encouraging results from these field tests showing the general feasibility of safe CO_2 storage we do have knowledge gaps to fill. This we tried to do within the ERE programme including the following sessions:

Long-term storage of CO_2 in geological systems: results from laboratory studies

Subsurface flow of CO_2 through saline and hydrocarbon reservoirs exhibits distinct phase behaviour, chemical reactivity and petrophysical flow properties relative to other systems that have been extensively studied in the fields of petroleum engineering, groundwater hydrology and contaminant transport. Experimental investigations are critical for the development of accurate simulations of CO_2 flow and trapping in the subsurface. This session focused on investigations of the most pressing timely issues in the geologic storage of CO_2 that are either conducted as a pure experimental or as a combined experimental/modelling studies. From this session two studies are included in this special issue: Hangx et al. (2013) studied the effect of CO_2 on the mechanical properties of the Captain D sandstone acting as the primary storage reservoir in the Goldeneye field, offshore Scotland. Amann-Hildenbrand et al. (2013) investigated the sealing capacity of generic, worldwide clay-rich caprocks.

Site characterization for CO_2 geological storage sites

Site characterization of geological formations for storage of CO_2 is a principal task. Several conference contributions highlighted and demonstrated advances in process understanding and the development of related measurement techniques. Furthermore, the role of modelling in assessing the physical and chemical evolution of the storage site and the effect of spatial variability of geological properties with regard to reservoir capacity and risk assessment were discussed. Within this context Fagerlund et al. (2013) studied the design of a two-well field test to determine the in-situ residual and dissolution trapping of CO_2, which was applied to the Heletz CO_2 injection site (Niemi et al. 2012). Martinez-Landa et al. (2013) suggest the application of hydraulic tests in order to identify the residual CO_2 saturation at a geological storage site. Vilarassa et al. (2013) focused on the hydromechanical characterization of CO_2 injection sites. Cahill et al. (2013) present in detail and discuss a small field scale experiment to study the hydro-geochemical impact of CO_2 leakage on shallow potable aquifers.

Modelling and up-scaling of CO_2 storage sites

Static geological modelling and dynamic flow modelling of CO_2 storage sites is of utmost importance for an efficient and safe site operation. Numerical modelling allows for understanding site-specific processes and risks and consequently for the prediction of short- to long-term site behaviour. Commercial and scientific modelling tools available are able to capture the major processes involved in CO_2 storage. However, unified modelling approaches related to data integration into static models and parameter up-scaling from point data to reservoir- or regional-scale models have to be developed in order to ensure reliability, reproducibility and comparability of modelling results Nevertheless, new modelling approaches were presented at the EGU General Assembly, e.g. the utilization of virtual elements to represent brine migration via discrete faults at regional-scale and related salinization of shallow aquifers (Tillner et al. 2013). Furthermore, Ashraf et al. (2013) introduced a new tool to assess the feasibility and efficiency of global sensitivity analysis and risk assessment using the arbitrary polynomial chaos. Klein et al. (2013) evaluate the long-term mineral trapping at the Ketzin pilot site using an integrative approach coupling geochemical modelling and reservoir simulations. Afanasyev (2013) implemented a new simulation tool for multiphase compositional flow modelling and demonstrate its applicability in CO_2 injection at subcritical conditions to understand the impact of dissolution and phase transitions between liquid and gaseous

CO_2 at in situ conditions. Yang et al. (2013) present an approach to upscale two-phase flow characteristics, including the capillary pressure and relative permeability functions for multi-model heterogeneous systems and analyse the effect the rock material composition has on these. Basis for every dynamic model is the static model. Within this respect Norden and Frykman (2013) discuss the implementation of the Ketzin pilot site reservoir model.

Geophysical imaging of CO_2 geological storage sites

Geophysical methods play a key role for the non-invasive investigation and the spatial and temporal characterization of underground CO_2 storage sites. Estimates of storage capacity and the detection of potential leakage paths before the injection as well as time-lapse monitoring of the CO_2 plume in the subsurface during and after injection are mandatory key tasks to be performed. An example is given by Ivanova et al. (2013) with the discussion about the impact of temperature on CO_2 storage at the Ketzin site based on fluid flow simulations and seismic data. Alcalde et al. (2013) describe active seismic characterization experiments of the Hontomín research facility. Hagrey et al. (2013) introduce the combination of seismic and geoelectric modelling studies of parameters controlling CO_2 storage in saline formations.

The collection of manuscripts presented in this special issue give a flavour of the scientific width and depth of the disciplines needed to assess if CO_2 storage becomes an available option to mitigate climate change and present a brief overview of the state of the science.

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We as guest editors of this special issue and convener of the CO_2 sessions at the General Assembly 2012 of the European Geosciences Union (EGU) owe many thanks in general to all presenters who contributed with talks and posters to the conference programme of the division Energy, Resources & the Environment (ERE) of the EGU and in particular to the authors of this special issue.

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