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|  | EUROPEAN COMMISSION RESEARCH AND INNOVATION DG | Final Report |
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Project No: 227286

Project Acronym: MUSTANG

Project Full Name: A multiple space and time scale approach for the quantification of deep saline formations for CO₂ storage

Final Report

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Project coordinator name:
Prof. Auli Niemi

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UPPSALA UNIVERSITET

Final Report

PROJECT FINAL REPORT

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Final Report

Please note that the contents of the Final Report can be found in the attachment.

4.1 Final publishable summary report

Executive Summary

MUSTANG has been a five-year, large-scale integrating project spanning from June 2009 to June 2014 (www.co2mustang.eu). The consortium comprises 19 institutions as project partners. Additionally, over twenty organizations, including overseas CO₂ experts, end-user industries and regulatory organizations are linked to the project via the Scientific, Industrial and Regulatory Advisory Board (SIRAB). The overall objective of the project has been to develop a comprehensive set of methodologies and tools for the assessment and characterization of deep saline aquifers for CO₂ geological storage, and for providing measures to determine the related performance and risks. The project can be roughly divided into four closely interlinked components as presented below.

1) The primarily field component, where (i) data from a number of example test sites with different geographic and geological settings has been analyzed to get an overview of possible conditions and circumstances that can occur in CO₂ geological storage, and based on these data 3D geological models of the sites have been constructed and parameter values to be used in dynamic simulation models been determined. (ii) improved field characterization techniques are being developed, in particular related to geophysical monitoring and tracer techniques to monitor the CO₂ plume and well instrumentation and (iii) full-scale CO₂ injection field experiments are carried out. The main injection experiment will take place in Heletz, Israel, with deep injection of supercritical CO₂ at a depth of 1600m. The objective of this experiment is to get an improved understanding of in-situ values of two important trapping mechanisms, the residual and dissolution trapping, to better understand the role of heterogeneity in this and to provide datasets for model and method validation. Additionally, a shallow CO₂ injection has been carried out at the Maquelone site, to cross-validate MMV technologies at shallow depth and to gain understanding of the transport and monitoring of gaseous CO₂.

2) The laboratory experiments and natural analogues component, has had an objective to provide information for modeling, concerning parameter upscaling, mass transfer mechanisms, and parameterization of the thermo-hydro-mechanical and chemical processes related to migration of CO₂. In particular, it has been of interest to observe the changes of rocks when in contact with CO₂. The focus is on (i) hydro-chemical alteration of cap-rocks due to CO₂; (ii) Thermo-Hydro-Mechanical-Chemical parameterization of rock dissolution due to injection; (iii) determination of parameters for numerical models; (iv) analysis of seal integrity, based on CO₂ analogues.

3) The modeling component, where (i) processes relevant to CO₂ spreading and trapping are formulated and expressed in the form of mathematical models; (ii) improved numerical models are being developed, by improving existing numerical tools and by developing new ones for certain processes, where the previous models are not so effective; and (iii) CO₂ injection and storage in the test sites is being modeled, to gain a broad understanding of the relevant conditions and to provide procedures and approaches to quantify sites for CO₂ injection; and (iv) methods and framework for treating the multiple space and time scales of CO₂ geological storage modeling is developed.

4) Performance assessment methodology component, where (i) procedure and methodology for CO₂ geological storage related risk assessment and (ii) web-based Decision Support System are being developed. In addition recommendations for storage site quantification procedure and methods are given.

Summary description of project context and objectives

MUSTANG is a five-year, large-scale integrating project spanning from June 2009 to June 2014 (www.co2mustang.eu). The consortium comprises 19 institutions as project partners. Additionally,

over twenty organizations, including overseas CO₂ experts, end-user industries and regulatory organizations are linked to the project via the Scientific, Industrial and Regulatory Advisory Board (SIRAB). The overall objective of the project has been to develop a comprehensive set of methodologies and tools for the assessment and characterization of deep saline aquifers for CO₂ geological storage, and for providing measures to determine the related performance and risks.

In alignment with the FP7 call for proposals on CO₂ storage: Development of a suitable methodology for the qualification of deep saline aquifers for CO₂ storage, the overall objectives of MUSTANG were defined as follows:

- Address the safety of geological CO₂ storage at all timescales and the liability issues.
- Give full confidence in geological CO₂ storage and form the basis for the legal and regulatory requirements allowing the deployment of large scale near zero emission power generation technology using underground CO₂ storage.
- Couple R&D and demonstration aspects.
- Develop a suitable methodology (seismic testing, exploratory drilling, etc) to assess the quality of a given site for geological storage.
- Develop a common generic methodology to address the various criteria put in place by the regulatory authorities with the ultimate view of satisfying the certification criteria that they will enforce.
- Compose a Collaborative Project (large-scale integrating project), with a predominant research component.
- Assist the regulatory process to be put in place regarding the storage of CO₂.
- Seek connection and cooperation with one or more of the specific sites for CO₂ storage emerging in Europe, where a deep saline aquifer could be used for the storage part.
- Seek cooperation with organizations from the member countries of the Carbon Sequestration Leadership Forum (CSFL).

The strategic objective of MUSTANG is therefore to develop and disseminate a comprehensive set of generic yet practical tools and methodologies for the identification, assessment, characterization and evaluation of deep saline aquifers for CO₂ storage. The most challenging issue is to demonstrate that containment will be effective, in the short and long term. This involves the following:

- Determining the spatial extent and geometry of the seal.
- Demonstrating that it is not compromised by faults, fractures or thinning over the entire potential footprint of the CO₂ plume.
- Characterizing the strength of the capillary seal.
- Demonstrating that CO₂ injection will not damage the seal – either by geo-mechanical effects associated with pressure build-up or by geochemical interactions. It is important to know the size of the injected plume of CO₂ – as this will determine the spatial extent over which the seal is needed.

In order to achieve the overall objective, and with a specific focus on the aforementioned technical issues, a number of secondary objectives has been delineated as follows:

- Develop tools for deriving improved CO₂ storage performance estimates such as CIC (Containment - Injectivity – Capacity), tools that enable the evaluation of the CO₂ injection discharges that can be applied to a specific site (Injectivity), of the total volume that can be stored (Capacity) and of the retention of the CO₂ over time (Containment).
- Provide the tools for identifying potential sites and for characterizing their suitability for CO₂ storage, i.e., determining the nature and spatial extent of the seal; identifying and quantifying the impact of possible faults and fractures and their capacity to convey CO₂ outside the reservoir.
- Conduct an extensive effort on process investigation both at the theoretical level and by means of innovative and challenging laboratory experiments, aimed at quantitatively understanding the major processes occurring during the injection and spreading of super-critical CO₂ (interaction with rock formation, impact on the sealing properties, dissolution, migration, instability effects, trapping and long term effects, etc.). Of particular interest are the characterization of the capillary seal, evaluation of the impact of the stored CO₂ on the properties of the medium in general and of the seal in particular (geo-mechanical effects resulting from pressure build-up and or geochemical reactions)
- Identify the needs for monitoring (in space and time), provide methods for the development of

cost-effective monitoring networks and technologies for the monitoring, by combining dedicated seismic techniques and drilling.

- Develop tools and methodologies for risk assessment to human health and the environment at large resulting from possible accidents (leakage through the cap-rock towards freshwater aquifers, leakage through faults and or abandoned wells) or due to uncertainties in the characterization of site settings.
- Demonstrate measurement and monitoring technologies and validate the computational models to be constructed by means of a dedicated validation experiment of CO₂ injection at field scale, under the real conditions of CO₂ storage.
- Address the relationships between risk and liabilities during the injection and post-injection phases and provide the information to the regulating authorities.
- Develop procedures for an efficient dissemination aimed at achieving maximum impact among the potential contractors, users and or stakeholders of CO₂ storage.

The objectives of the specific work packages are summarized below.

WP2 – Test Sites

Objectives are

- Gather all the available data and information that is relevant to the quantification of CO₂ storage. Supplement available data with the information to be collected within the framework of MUSTANG.
- Develop a conceptual model of each test site.
- Prepare all the necessary input for the computational models of each test sites to be used in WP's on modeling and impact evaluation. The field sites for which detailed conceptual models will be constructed, are the sites in South Scania (Sweden), Horstberg (Germany), Valcele (Romania), Heletz (Israel), Hontomín (Spain).

WP3 - Field Quantification Technologies

Objectives are

- Provide innovative, CCS-adapted, field measurement techniques to assess the suitability of a deep geologic saline formation for CO₂ storage.
- Provide technologies for monitoring the fate of CO₂ during the injection and migration phases in a saline aquifer.
- Recommend suitable and cost-effective technologies that could be applied for the MMV (Measurement Monitoring Verification) process.

WP4 - Laboratory Experiments and Natural Analogues

Objectives are

- Provide support to the theoretical improvement of reservoir-scale modeling, including parameter upscaling, by characterizing mass transfer mechanisms and identifying controlling parameters from core-sample scale to reservoir scale.
- Parameterize the thermo-hydro-mechanical & chemical - THMC - processes associated with the migration of supercritical and dissolved CO₂ in the aquifers and through the seal.
- Produce a comprehensive, self consistent, experiment and field observation data base for validating models.

WP5 - Processes

The overall objective of this WP is to provide a comprehensive framework, in the form of process models, for the description and investigation of the major processes occurring during the injection of CO₂ into a brine-containing formation and the interactions that will take place between the injected CO₂, the solid matrix and the indigenous liquid in the formation. This will enable the investigation of (i) the relative significance of the various processes under different conditions, and (ii) the behavior of the system as a whole, in response to various scenarios.

WP6 - Validation experiment

Objectives are

- Perform a CO₂ injection experiment at Heletz (Israel) site;
- Test novel monitoring and measurements technologies;
- Validate the process understanding and the resulting mathematical and numerical models;
- Demonstrate the MMV (Measurement Monitoring Verification) process;
- Recommend appropriate and cost-effective measurement and monitoring technologies.

- Achieve a high degree of integration of measurements and computational technologies and contribute to the preparation of best practices for the MMV process;
- Contribute to the development of best-practices regarding the MMV process.

WP7 - Modeling and model development

The overall objective is to provide a comprehensive modeling approach and associated numerical tools for the simulation of flow, transport, reactive transport, thermal and chemical processes occurring to the fluids and to the rock matrix during the injection and storage of CO₂, with special emphasis on the coupled effects, multiple scales and uncertainties due to heterogeneity. More specifically, the objectives are to:

- Adopt the best available THMC models for the simulation of the CO₂ flow and transport processes in deep saline formations; update them according to the findings of the Processes WP and incorporate a probabilistic approach for leakage pathway modeling into these models
- Apply these models to the validation experiment in Heletz and to the test sites, firstly, to validate the models and second, to get an understanding of the site performance, to be used as input in terms of ICE and risk assessment
- Update existing codes by incorporating innovative numerical schemes able to quantify the impacts on seal integrity resulting from the injection of CO₂.

WP8 - Scale effects

Objectives are

- Identify the time and space scales that are relevant for understanding and modeling of CO₂ spreading and for evaluation of performance and risk assessment.
- For each identified level of time – space scale, outline the significant flow and transport processes that need to be taken in account.
- For each process and time – space scale, define the upscaled formulation of the individual processes and of the comprehensive models that describe the injection and spreading in the brine saturated formation.

WP9 - Certification

Objectives are

- Develop a generic methodology for performance and risk assessment related to CO₂ storage in saline aquifers;
- Application of the methodology in one of the MUSTANG test sites;
- Develop measures for the performance evaluation of the CO₂ storage in a specific reservoir.
- Address the liability issue.
- Outline a set of practical guidelines for the quantification of a specific site for CO₂ storage.
- Develop a decision support system in order to assist the decision making process both at the scientific level and the decision making level.

WP10 – Impact

Objectives are

- Ensure efficient and reliable flow of information and knowledge within the consortium during the project lifetime;
- Disseminate results, findings and deliverables within the consortium and to the wide community of scientists, engineers and end users;
- Ensure adequate degree of communication and understanding at the level of the scientific community;
- Develop a knowledge management system to be implemented at the initial stage of the project to facilitate and support the internal and external transfer of knowledge;
- Maximize the impact of the project;
- Set-up of a network to other CO₂ storage related research projects, experimental sites and commercial companies for the effective employment of MUSTANG results as well as to integrate data and knowledge of a wide spectrum of potential sites.

Description of main S & T results/foregrounds

The description of the main S&T results/foreground are provided in a separate report that is attached.

Potential impact and main dissemination activities and exploitation results

Socio-economic impact and societal implications

MUSTANG has been addressing an issue of high relevance to society and its environmental and energy policy, namely geological carbon storage that is envisaged as a bridging technology in combating the negative climatic effects of carbon dioxide. More specifically, the project has provided new and improved methods and understanding for characterizing saline aquifers for this purpose; geological formations that are traditionally less understood, yet important due to their large volumetric capacity world-wide. The socio-economic impacts and wider societal implications of an individual project are difficult to identify, especially at the end of the project, as such effects can be expected to take a long time to manifest themselves. Nevertheless, we can expect MUSTANG to have contributed to better and/or possibly more cost-effective methodologies and understanding in this field, thereby providing (1) industry, regulators and other practitioners with methodologies and expertise to investigate geological storage of CO₂ in specific formations, and (2) the general public with an independent body of general knowledge that can help in confidence-building towards implementing this bridging technology.

Throughout the project duration some of the key components have been an extensive international cooperation and exposure (including an high-level advisory board, as well as overseas experts), affiliating a balanced pool of industrial partners, stakeholders and regulatory agencies to the project as well as contributing to the public outreach early on. The extensive dissemination activities to assure that the project results come to use are described below, as is the present and potential exploitation of the results. A special note should be given to the significant educational components of the project, including organization of training courses, producing educational material and involving students (PostDocs, PhD and MSc students) in the project work, thereby educating a 'new generation' of experts.

Dissemination overview

Dissemination activities have included production of the semi-annual newsletter, a continuously updated project website, semi-annual consortium meetings, training courses, presentations in meetings and conferences, organization of conference sessions as well as interviews and appearances in the general media. Below, more explanations of these activities are provided.

Semi-annual newsletters have been released since the start of the project. These newsletters have provided current information on the status of the project as well as of the various work packages and have been distributed to a network of potentially interested organizations. All newsletters are also found on the project webpage.

The MUSTANG web portal was established in October 2009. It was built and has been continuously maintained to provide information on the main activities and results of the project, but also to provide general information on Carbon Capture and storage (CCS) technology and activities for the public. The website can be accessed through <http://www.co2mustang.eu>. The Web site includes:

- General information on the project: objectives, members of the project consortium, work program.
- Results achieved during the project: submitted deliverables, journal publications, key presentations in the consortium meetings, other dissemination material (posters, lectures from MUSTANG partners in other related events)
- Related CCS information: general information regarding CCS, links to other related projects, and other events on CCS issues.
- Dissemination documents: the semi-annual newsletter, project flyer and the poster.
- A news section with the most relevant activities in the project.

The website contains both a public part and an intranet intended for internal information management between the project partners.

Training courses

Organizing formal Training courses has been a method to disseminate the project results and also to increase general knowledge of methodologies related to saline aquifer quantification for CO₂ storage.

- The first MUSTANG training course was organized by partner CSIC and Technical University of Catalonia (UPC) on 17-19th June 2010, in Barcelona. The focus was on Numerical Modeling of CO₂ storage, especially with the CODE_BRIGHT model.
- The second Training course was organized by University of Edinburgh, in connection to the Edinburgh consortium meeting (MUSTANG Training Course on Geological Storage of CO₂, Edinburgh, 22 – 24th June 2011). This course gave an overview of the current status of CCS operations and research, with the objective of providing a basic understanding of the scientific and technical issues that need to be addressed, in particular in terms of storage in saline aquifers. Keynote overview lectures were given by the SIRAB members from IEAGHG, LBNL, Statoil and Vattenfall and topical lectures by MUSTANG partners, on different technical aspects from laboratory and field experiments, to modeling. A field visit to a Natural Analogue in St Andrews was also included as was a visit to the Edinburgh laboratory facilities.
- An additional, informal training course was organized on the use of iTOUGH/TOUGH codes on 30th November 2012 at Uppsala University, Uppsala, Sweden. TOUGH2 code is one of the most widely used codes in CCS research, developed by LBNL. One of the key developers gave a short introduction to the code(s) and answered the users' questions.
- The third Training course was organized by University of Göttingen, in Göttingen, Germany (10-11th October, 2013). This third course had a general part with similar general content as the second Workshop, with project partners as lecturers and a second part on the specific use of the PFLOTRAN code, by the code developers from LLNL, USA. This third training course was jointly organized with two other EU projects TRUST and PANACEA.
- The fourth and final Training workshop was also the closing meeting of the MUSTANG project, held at Uppsala University, Uppsala on 26- 27th May 2014. This workshop was most widely advertised and summarized all the MUSTANG results. It also had a special part of Panel Discussions addressing the general issues of CCS in general and the research needs in particular, with high level expertise from SIRAB members from IEAGHG, Statoil, LBNL, Australia, as well as an independent CCS expert from Norway. When formulating the panel questions, regulator(s) were approached to bring up their point of view. The extensive proceedings consist of two parts: (1) part one containing the invited keynote talks and summarizing the outcome and conclusions of the panel discussions and (2) part two that has all the presentations of the MUSTANG work, thereby giving a good overview of the work done in the project. The presentation viewgraphs are available in full at the project website as well.

Proceedings of all training workshops are also to be found on project website, under Deliverables for Work Packages on 'Impact'. These proceeding also give an overview of the attendance and other parameters of the workshops. In general, the training courses have been well attended by participants from different countries and types of organizations, with a majority of participants being PhD students and other specialists working on or planning on working on CCS.

Other topic-specific scientific and educational dissemination

There has been a large number of topic-specific scientific presentations and publications by MUSTANG partners as described in the WP descriptions in the various progress reports (core reports about MUSTANG results, reported under WP1, Management on project website) and also listed in the Appendix of this final report.

A major scientific dissemination effort has been a MUSTANG presence at the European Geosciences Union General Assembly in Vienna, April 2011, 2012, 2013 and 2014. We proposed and have convened (the coordinator UU and the partners CSIC and UGOTT) a new session on 'Site Characterization/Field testing in CO₂ geological storage' which has been very well attended during 2011-2014. We have also convened/co-convened other CO₂ related sessions during the same period, especially sessions related to CO₂ modeling and seismic monitoring. Based on the outcome of year 2012 CO₂ sessions, a special issue is also in preparation to the highly recognized International Journal of Greenhouse Gas Control (Vol 19, Nov 2013), with the coordinator as one of the guest co-editors and a number of submissions from the MUSTANG project. Similarly, year 2013 CO₂ sessions resulted in a special issue of Energy Procedia (Vol 40, 2013).

Discussions are also underway with a positive response from International Journal of Greenhouse

Gas Control to have a dedicated special edition on the MUSTANG field injection site Heletz and the work that has been done there. This will be completed after the completion of the project.

Another high-level dissemination activity that we envisage to have a long-term impact, is the edited book (Niemi, Bear, Bensabat as editors and MUSTANG partners and certain SIRAB members and other key researchers as authors) around the themes of MUSTANG work (Geological Storage of CO₂ in Deep Saline Aquifers to be published by Springer) . The contract has been signed with Springer and the book is expected to be completed at the end of 2014. The book is expected to be used as educational material at universities and training courses, including the training courses of projects that can be seen as some type of continuation of MUSTANG (PANACEA, TRUST, CO₂QUEST).

General dissemination to the scientific/technical community, end-users and regulators

Main dissemination of project results to the scientific/technical community, end-users and regulators have been

- Presentations of the project, mainly by the project coordinator, in international meetings and conferences, often as invited speaker
- The fruitful and extensive interaction with the MUSTANG Scientific, Industrial and Regulatory Advisory Board (SIRAB).
- Participation to the EASAC (European Academies of Sciences Advisory Council) Working Group on CCS, work on the publication ‘CCS in Europe’
- Organizing a special openly advertised workshop, together with other EU-projects, on long-term effects of CO₂, in Trondheim

Examples of general presentations concerning the MUSTANG project include presentations (by the coordinator) in the following major international conferences and events (more detail given in the presentations summary in the appropriate Appendix of this final report):

- Conference on Carbon Capture & Sequestration 4th - 7th May 2009, Pittsburgh, Pennsylvania.
- EGU General Assembly 2009
- European Conference on CCS Research, Development and Demonstration. 19-22 April 2010, Rotterdam.
- CCS from cradle to grave: The technical and safety challenges’, IChemE Workshop, Birmingham, UK, 22-23 March 2012 (invited)
- Sixth Trondheim CCS Conference: CO₂ Capture, Transport and Storage 14-16 June 2011. Trondheim, Norway.
- CCS Research & Development to Implementation Conference. 24 - 26 May 2011, London, United Kingdom (invited)
- Seventh CO₂GeoNet Open Forum, Venice, 17-19 April 2012 (invited)
- Eight CO₂GeoNet Open Forum, Venice, 9-11th April 2013 (invited)
- CO₂ Capture and Storage in the Baltic Sea Countries Geological Survey of Finland (GTK), 23rd May 2013, Espoo (CO₂GeoNet meeting) (invited)
- Seventh Trondheim CCS Conference: CO₂ Capture, Transport and Storage 4-6 June 2013. Trondheim, Norway.
- 4th Annual Global Carbon Capture Utilization and Storage Summit 22-23 October, 2013, Beijing, China (invited)
- Leading the way in CCS implementation Workshop 14-15th April, 2014 UKCCS Research Centre, London, UK (invited)
- European Carbon Capture & Storage Research & Development Workshop (ECCSRD) 18th June 2014 Cranfield university, England (invited)

Examples of MUSTANG presence (interviews/general presentations) in general media/events to general public/non-specialists and policy makers include

- European Academies of Science Advisory Board (EASAC); working group on CCS. Report ‘Carbon capture and storage in Europe’; EASAC policy report 20, was completed and launched at Brussels, on 22 May 2013 (<http://www.easac.eu/>). MUSTANG coordinator (Niemi) was a member of the working group and responsible for answering the specific questions related to geological storage. While this work was obviously not financed by MUSTANG, it involves part of

the dissemination of project results to a wider audience.

- ‘Future wellbeing of mankind – Global threats and possibilities’ Seminar with international speakers at Uppsala University, 13 June 2012 (invited)
- Feature Article/ Profile in Pan European Networks – 8 Nov 2013 (European Science News). European level publication intended to policymakers, end-users and general public.

Appearances in mainly national level meetings for general public/non-specialists and policy makers include

- Energy09, Symposium at Uppsala University, Uppsala, 21-22 Oct 2009. (Invited)
- Sveriges Energiting, March 2010. (invited)
- GeoArena–Mötesplats Geologi (Meeting Place for Geology). Uppsala Kongress och Konsert, Uppsala, 16-17 October 2012 (invited)
- Svenska Kolinstitutet (Swedish Coal Institute) – Yearly meeting, Stockholm, 7 March 2013 (invited)
- SwedSTORECO2: towards a national test site for CO2 storage in Sweden - A seminar about carbon storage in Swedish bedrock, Uppsala, 5th March, 2013
- Hydrology days 24 March, 2014 Stockholm, Sweden (invited)
- Presentation to Russian Ambassador to Sweden 18 May 2011 Uppsala, Sweden
- Presentation to Danish Ambassador to Sweden 21 May 2014 Uppsala, Sweden

Interviews and other outreach in general media etc. to general public and policy makers, national and international

- interview for Uppsala Nya Tidning; summer 2009
- interview in Swedish TV news; July 2010
- interview for Sydsvenskan (Newspaper covering the issues of Southern Sweden)
- interview in Swedish Geological Survey Information Newspaper in the Today’s Industry, Spring 2010
- Interview for Swedish radio, Feb 2011
- IEA-GHG newsletters, summer 2010 and Aug 2012.
- Interview in ‘Research of the Future’ (Framtidens Forskning), June 2012, published as an attachment to a major Swedish newspaper (Svenska Dagbladet) and distributed e.g. at the important Swedish political/policy-making week at Almedalen, Gotland, summer 2012
- Interview ‘Promising prospects of CO2 geological storage in bedrock’ (Lovande möjligheter för lagring av koldioxid i berggrunden) in Swedish Geological Survey’s (SGU) attachment on geological research news to Dagens Industri (Industry of the Day)
- Appearance on Australian CO2CRC newsletter, June 2012
- Interview in ‘Forskarbladet- Tema Energi’ (Swedish newspaper intended to disseminate research results’ (March 2013)

Examples of presentations in international collaboration meetings by the coordinator include

- EU-Canada collaboration meeting in Ottawa, Canada May 4-6th, 2010.
- EU-Japan collaboration meeting in Amsterdam, September 21-22, 2010
- Meeting for Danish Research Council project “Environmental Technology for Geological Storage of Carbon Dioxide”, Copenhagen, Sep 13, 2010 as a member of the advisory board
- Thematic Workshop – Clean Coal Technologies, InnoEnergy. 25th May 2010, AGH-UST, Krakow, Poland

Organization of an International Workshop on long-term effects of CO2

On 3rd June 2013, ‘Brainstorming Day on the long-term fate of geologically stored CO2’ was organized in Trondheim, Norway, in collaboration with four other EU FP7 projects (PANACEA (main organizer), ULTIMATECO2, CO2CARE and CARBFIX). The event was hosted by Statoil and was organized in connection to the Trondheim CCS conference, in order to maximize the exposure to relevant interested parties. The Brainstorming Day gathered 49 attendees from universities, research institutes and industry. MUSTANG partners and MUSTANG SIRAB representatives had an active role in chairing several of the sessions. The meeting information can be found on <http://www.bsdt2013.org>.

Role of the Scientific, Industrial and Regulatory Advisory Board

A key component in the MUSTANG project has been the Scientific, Industrial and Regulatory Advisory Board (SIRAB) comprising leading experts in the field of CCS and other key participants. This advisory board has representation from 25 organizations, falling in mainly three categories 1) overseas and international scientific advisors (IEAGHG, LBNL (USA), Stanford University, CO2CRC (Australia) JOGMEG (Japan)); 2) key industries including Statoil, Vattenfall, EnBW, Petrobras, Schlumberger, EoN, to mention some and 3) regulators from the countries where there is a project field site. The full list of members is given on www.co2mustang.eu/MUSTANG_advisory.aspx. The role of the SIRAB has been two-fold: to give advice and feedback on the ongoing research and to disseminate the project results via them. Members of the SIRAB have been invited to attend the semi-annual consortium meetings, to deliver presentations and provide feedback and reviews on the project progress. Additionally, the coordinator and some WP leaders of MUSTANG have had meetings with certain members of the SIRAB on specific issues, upon demand. This has been especially the case for the planning of the Heletz CO₂ injection experiment, where the role of SIRAB has been very valuable. Most of the SIRAB members have attended at least one of the meetings. Detailed attendance can be seen in Consortium meeting agendas and/or summary progress reports, under Management (both to be found on project website)

Cooperation with other research programs dealing with CO₂ storage

MUSTANG has actively collaborated with several other research programs dealing with CO₂ storage. Specifically, through the collaboration structure of SIRAB, especially with CO₂CRC and Otway project (Australia); the extensive CO₂ research activities at Lawrence Berkeley National Laboratory, USA; Stanford University (Benson Lab, Stanford University); IEAGHG networks and many key industries.

Collaboration/exchange with other EU FP7 projects included both joint organization and/or participation meetings and interest/advisory boards; EU FP7 projects RISCS; CO₂PipeHaz; PANACEA, UlitimateCO₂; CO₂Care; TRUST. We have also given presentations in networking conferences organized by CO₂GeoNet and by CO₂NET. The Ketzin site was formally visited by the entire consortium.

At the institutional level, numerous MUSTANG beneficiaries have been and are actively involved in a number of CO₂ storage projects and related activities within their own organizations. Examples include Danish Research Council funded project “Environmental Technology for Geological Storage of Carbon Dioxide”; Norwegian SUCCESS project; SwedStoreCO₂ – a Swedish national project investigating the possibility for a pilot scale injection in Sweden; Bastor – a project looking at possibilities of injecting CO₂ in the Baltic Sea region; ADEME (French agency for environment and energy control); CO₂ storage program of the Spanish CIUDEN foundation; CO₂FIELDLAB, ANR COLINER, ANR CO₂FIX; VR-CO₂, Swedish Research Council strategic funds for CO₂ research; CASSEM - the UK’s first evaluation of saline formation storage; SCCS, a partnership with several industries and Scottish government and completing a detailed evaluation for storage of one selected saline formation in the North Sea; Compostilla EEP project, lead by CIUDEN; Characterization and selection of potential formations for deep geological storage in the frame of the project lead by the Spanish Geological Survey (beneficiary AMPHOS). These are only examples and not an exhaustive list, giving an idea of the contact surface between MUSTANG and many other key projects.

Exploitation of results

The products developed in the project include

- Expertise that could be offered by means of consulting/supervising at various levels of CO₂ projects (field experiments, laboratory experiments, design and planning of CO₂ injection, field characterization).
- Modeling software and modeling competence that could be deployed either commercially or non-commercially, for an improved analysis and modeling of CO₂ storage.
- Hardware in the field of seismic monitoring and tracer experiments; part of this hardware is mature and commercialized; part will be commercial in the near and mid-future.

One way to implement the technologies developed within MUSTANG is that involved partners offer services and products on an individual basis, in CO₂ related projects and beyond (oil and gas industry, environmental protection, water resources management). De facto this is already happening: UU is already using the knowledge and expertise gained in MUSTANG for the development of the emerging Swedish and Baltic CCS programs, VIBROMETRIC and UGOE are deploying the hardware they have developed, UEDIN and EWRE are already providing services based on the knowledge acquired in MUSTANG. A second implementation that is already happening resides in the fact that most of the partners are cooperating in CO₂ storage projects funded by the EU (PANACEA, TRUST, CO₂QUEST). These projects are helping in further developing the reported products and expertise and additional ones. Finally, it can be brought up that the EU CCS demonstration project including the Hontomin site, has in terms of the development of the test injections and the site characterization been developing very much parallel and in collaboration to the MUSTANG project and it can therefore be said, that MUSTANG work has even here already contributed to an emerging larger scale project.

Altogether, MUSTANG has contributed to the development of European expertise in the field of CO₂ storage; expertise that could be used by both the industrial and regulatory sectors. The wide geographical diversity of the partners and their structures does not allow for a common, rigid structure, capable of delivering integrated solutions in the field of CO₂ storage, which could be the ideal outcome of the project. However, we could envisage a flexible structure with ad hoc per cooperation between partners on a project basis, in order to suggest design and planning expertise as well as technologies (those developed in MUSTANG and the subsequent projects). MUSTANG has laid the groundwork for the formation of such a structure and the subsequent projects will provide the opportunity to materialize it.

One of the key questions is that the industrial deployment of CO₂ storage in Europe has not progressed as perhaps envisaged at the onset of MUSTANG. Part of the problem is believed to be the public opinion. In such an atmosphere, independent, largely university-based expert groups like MUSTANG can be valuable assets in confidence building and providing independent research both for the society at large, for the industry, and for the regulators.

Address of project public website and relevant contact details

Public website: www.co2mustang.eu

Contact details: Professor Auli Niemi, Department of Earth Sciences, Uppsala University, Villavägen 16, 75236 Uppsala, Sweden, auli.niemi@geo.uu.se

4.2 Use and dissemination of foreground

Section A (public)

Publications

| LIST OF SCIENTIFIC PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES | | | | | | | | | | |
|--|---|---|---|---------------------------|-----------|----------------------|---------------------|----------------|---|---------------|
| No. | Title / DOI | Main author | Title of the periodical or the series | Number, date or frequency | Publisher | Place of publication | Date of publication | Relevant pages | Is open access provided to this publication ? | Type |
| 1 | Design of a two-well field test to determine in situ residual and dissolution trapping of CO2 applied to the Heletz CO2 injection site 10.1016/j.ijggc.2013.01.036 | Fritjof Fagerlund, Auli Niemi, Jacob Bensabat, Vladimir Shtivelman | International Journal of Greenhouse Gas Control | Vol. 19 | Elsevier | Netherlands | 01/11/2013 | 642-651 | Yes | Peer reviewed |
| 2 | Coupled hydromechanical modeling of CO2 sequestration in deep saline aquifers 10.1016/j.ijggc.2010.06.006 | Victor Villarasa, Diogo Bolster, Sebastião Olivella, Jesus Carrera | International Journal of Greenhouse Gas Control | Vol. 4/Issue 6 | Elsevier | Netherlands | 01/12/2010 | 910-919 | Yes | Peer reviewed |
| 3 | Liquid CO2 injection for geological storage in deep saline aquifers 10.1016/j.ijggc.2013.01.015 | Víctor Villarasa, Orlando Silva, Jesús Carrera, Sebastião Olivella | International Journal of Greenhouse Gas Control | Vol. 14 | Elsevier | Netherlands | 01/05/2013 | 84-96 | Yes | Peer reviewed |
| 4 | Analysis of alternative push-pull-test designs for determining in situ residual trapping of carbon dioxide 10.1016/j.ijggc.2014.05.008 | K. Rasmussen, M. Rasmussen, F. Fagerlund, J. Bensabat, Y. Tsang, A. Niemi | International Journal of Greenhouse Gas Control | Vol. 27 | Elsevier | Netherlands | 01/08/2014 | 155-168 | Yes | Peer reviewed |

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| 5 | Upscaling of the constitutive relationships for CO2 migration in multimodal heterogeneous formations 10.1016/j.ijggc.2012.11.015 | Zhibing Yang , Liang Tian , Auli Niemi , Fritjof Fagerlund | International Journal of Greenhouse Gas Control | Vol. 19 | Elsevier | Netherlands | 01/11/2013 | 743-755 | Yes | Peer reviewed |
| 6 | Long term impacts of cold CO2 injection on the caprock integrity 10.1016/j.ijggc.2014.02.016 | Víctor Villarasa , Sebastià Olivella , Jesús Carrera , Jonny Rutqvist | International Journal of Greenhouse Gas Control | Vol. 24 | Elsevier | Netherlands | 01/05/2014 | 1-13 | Yes | Peer reviewed |
| 7 | A new generation of tracers for the characterization of interfacial areas during supercritical carbon dioxide injections into deep saline aquifers: Kinetic interface-sensitive tracers (KIS tracer) 10.1016/j.ijggc.2013.01.020 | Mario Schaffer , Friedrich Maier , Tobias Licha , Martin Sauter | International Journal of Greenhouse Gas Control | Vol. 14 | Elsevier | Netherlands | 01/05/2013 | 200-208 | Yes | Peer reviewed |
| 8 | Use of hydraulic tests to identify the residual CO2 saturation at a geological storage site 10.1016/j.ijggc.2013.01.043 | Lurdes Martinez-Landa , Tobias S. Rötting , Jesús Carrera , Anna Russian , Marco Dentz , Bruno Cubillo | International Journal of Greenhouse Gas Control | Vol. 19 | Elsevier | Netherlands | 01/11/2013 | 652-664 | | Peer reviewed |
| 9 | Hydromechanical characterization of CO2 injection sites 10.1016/j.ijggc.2012.11.014 | Víctor Villarasa , Jesús Carrera , Sebastià Olivella | International Journal of Greenhouse Gas Control | Vol. 19 | Elsevier | Netherlands | 01/11/2013 | 665-677 | Yes | Peer reviewed |
| 10 | CO2 storage is feasible and further demonstration projects are needed 10.1016/j.ijggc.2013.07.008 | Michael Kühn , Andreas Busch , Auli Niemi , Alexandra Amann-Hildebrand , Thomas Kempka , Stefan Lüth | International Journal of Greenhouse Gas Control | Vol. 19 | Elsevier | Netherlands | 01/11/2013 | 606-608 | Yes | Peer reviewed |
| 11 | Impact of CO2 injection through horizontal and vertical wells on the caprock mechanics | Víctor Villarasa | International Journal of Rock Mechanics and Mining Sciences | Vol. 66 | Elsevier BV | Netherlands | 01/02/2014 | 151-159 | Yes | Peer reviewed |

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| | al stability 10.1016/j.ijr mms.2014.01.001 | | | | | | | | | |
| 12 | A method for incorporating equilibrium chemical reactions into multiphase flow models for CO2 storage 10.1016/j.adv watres.2013.09.013 | Maarten W. Saaltink , Victor Vilarrasa , Francesca De Gaspari , Orlando Silva , Jesús Carrera , Tobias S. Röttling | Advances in Water Resources | Vol. 62 | Elsevier Limited | United Kingdom | 01/12/2013 | 431-441 | | Peer reviewed |
| 13 | Diffusion and trapping in heterogeneous media: An inhomogeneous continuous time random walk approach 10.1016/j.adv watres.2012.07.015 | Marco Dentz , Philippe Goetze , Anna Russian , Jalal Dweik , Frederick Delay | Advances in Water Resources | Vol. 49 | Elsevier Limited | United Kingdom | 01/12/2012 | 13-22 | Yes | Peer reviewed |
| 14 | Non-Fickian mixing: Temporal evolution of the scalar dissipation rate in heterogeneous porous media 10.1016/j.adv watres.2010.08.006 | Tanguy Le Borgne , Marco Dentz , Diogo Bolster , Jesus Carrera , Jean-Raymond de Dreuzy , Philippe Davy | Advances in Water Resources | Vol. 33/Issue 12 | Elsevier Limited | United Kingdom | 01/12/2010 | 1468-1475 | Yes | Peer reviewed |
| 15 | Modeling of pressure build-up and estimation of maximum injection rate for geological CO2 10.1002/ghg.1466 | Zhibing Yang , Auli Niemi , Liang Tian , Saba Joodaki , Mikael Erlström | Greenhouse Gases Science and Technology | N/A | John Wiley & Sons, Ltd | United Kingdom | 01/09/2014 | n/a-n/a | Yes | Peer reviewed |
| 16 | Integrated Onshore-Offshore Investigation of a Mediterranean Layered Coastal Aquifer 10.1111/j.1745-6584.2012.01011.x | Johanna Lof , Philippe Pezard , Frédéric Bouchette , Olivier Raynal , Pierre Sabatier , Natalya Denchik , Arnaud Levannier , Laurent Dezileau , Raphaël Certain | Ground Water | 51 | Blackwell Publishing | United Kingdom | 01/11/2012 | 550-561 | Yes | Peer reviewed |

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| 17 | A Numerical Model of Tracer Transport in a Non-isothermal Two-Phase Flow System for CO_2 Geological Storage Characterization 10.1007/s11242-013-0138-x | Fuguo Tong , Auli Niemi , Zhibing Yang , Fritjof Fagerlund , Tobias Licha , Martin Sauter | Transport in Porous Media | Vol. 98/Issue 1 | Springer Netherlands | Netherlands | 01/05/2013 | 173-192 | Yes | Peer reviewed |
| 18 | Semianalytical Solution for CO_2 Plume Shape and Pressure Evolution During CO_2 Injection in Deep Saline Formations 10.1007/s11242-012-0109-7 | V. Vilarrasa , J. Carrera , D. Bolster , M. Dentz | Transport in Porous Media | Vol. 97/Issue 1 | Springer Netherlands | Netherlands | 01/03/2013 | 43-65 | Yes | Peer reviewed |
| 19 | Front Tracking Using a Hybrid Analytical Finite Element Approach for Two-Phase Flow Applied to Supercritical CO_2 Replacing Brine in a Heterogeneous Reservoir and Caprock 10.1007/S11242-011-9799-5 | Christopher I. McDermott , Alexander E. Bond , Wenqing Wang , Olaf Kolditz | Transport in Porous Media | Vol. 90/Issue 2 | Springer Netherlands | Netherlands | 01/11/2011 | 545-573 | Yes | Peer reviewed |
| 20 | Capillary Pressure Curve for Liquid Menisci in a Cubic Assembly of Spherical Particles Below Irreducible Saturation 10.1007/s11242-011-9752-7 | Jacob Bear , Boris Rubinstein , Leonid Fel | Transport in Porous Media | Vol. 89/Issue 1 | Springer Netherlands | Netherlands | 01/08/2011 | 63-73 | Yes | Peer reviewed |
| 21 | Effects of CO_2 Compressibility on CO_2 Storage in Deep Saline Aquifers 10.1007/s11242-010-9582-z | Victor Vilarrasa , Diogo Bolster , Marco Dentz , Sebastian Olivella , Jesus Carrera | Transport in Porous Media | Vol. 85/Issue 2 | Springer Netherlands | Netherlands | 01/11/2010 | 619-639 | Yes | Peer reviewed |
| 22 | Dispersion and Dispersivity Tensors in Saturated Porous Media with Uniaxial Symmetry 10.1007/s11242-010-9558-z | Leonid Fel , Jacob Bear | Transport in Porous Media | Vol. 85/Issue 1 | Springer Netherlands | Netherlands | 01/10/2010 | 259-268 | | Peer reviewed |
| 23 | A Phenomenological Approach to Modeling Transport in Porous Media 10.1007/s11242-011-9926-3 | Jacob Bear , Leonid G. Fel | Transport in Porous Media | Vol. 92/Issue 3 | Springer Netherlands | Netherlands | 01/04/2012 | 649-665 | Yes | Peer reviewed |
| 24 | Experimental Characterization of Porosity Structure and Transport Property Changes in Limestone Undergoing Different Dissolution Regimes | L. Luquot , O. Rodriguez , P. Gouze | Transport in Porous Media | Vol. 101/Issue 3 | Springer Netherlands | Netherlands | 01/02/2014 | 507-532 | | Peer reviewed |

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| | 10.1007/s1124 2-013-0257-4 | | | | | | | | | |
| 25 | CO2 percolation experiment through chlorite/zeolite-rich sandstone (Pretty Hill Formation – Otway Basin–Australia) 10.1016/j.chemgeo.2011.11.018 | Linda Luquot , Muriel Andreani , Philippe Gouze , Pierre Camps | Chemical Geology | Vol. 294-295 | Elsevier | Netherlands | 01/02/2012 | 75-88 | Yes | Peer reviewed |
| 26 | Probability density functions for passive scalars dispersed in random velocity fields 10.1029/2010GL045748 | Marco Dentz , Daniel M. Tartakovsky | Geophysical Research Letters | Vol. 37/Issue 24 | American Geophysical Union | United States | 01/12/2010 | n/a-n/a | Yes | Peer reviewed |
| 27 | Some implications of cold CO2 10.1029/2010GL046412 | W. J. Raymond-Smith , Andrew W. Woods | Geophysical Research Letters | Vol. 38/Issue 6 | American Geophysical Union | United States | 01/03/2011 | n/a-n/a | | Peer reviewed |
| 28 | Permeability impairment of a limestone reservoir triggered by heterogeneous dissolution and particles migration during CO2 10.1002/grl.50595 | Papa O. Mangano , Philippe Gouze , Linda Luquot | Geophysical Research Letters | Vol. 40/Issue 17 | American Geophysical Union | United States | 16/09/2013 | 4614-4619 | | Peer reviewed |
| 29 | Distribution- Versus Correlation-Induced Anomalous Transport in Quenched Random Velocity Fields 10.1103/PhysRevLett.105.244301 | Marco Dentz , Diogo Bolster | Physical Review Letters | Vol. 105/Issue 24 | American Physical Society | United States | 01/12/2010 | 244301 | Yes | Peer reviewed |
| 30 | A general real-time formulation for multi-rate mass transfer problems | O. Silva, J. Carrera, M. Dentz, S. Kumar, A. Alcolea, M. Willmann | Hydrology and Earth System Sciences | 13 | European Geosciences Union | | 01/01/2009 | 1399-1411 | Yes | Peer reviewed |
| 31 | Anomalous mixing and reaction induced by superdiffusive nonlocal transport 10.1103/PhysRevE.82.021119 | Diogo Bolster , David A. Benson , Tanguy Le Borgne , Marco Dentz | Physical Review E - Statistical, Nonlinear, and Soft Matter Physics | Vol. 82/Issue 2 | American Physical Society | United States | 01/08/2010 | 347-361 | Yes | Peer reviewed |
| 32 | Random walk particle tracking simulations of non-Fickian transport in heterogeneous media 10.1016/j.jcp.2010.02.014 | G. Srinivasan , D.M. Tartakovsky , M. Dentz , H. Viswanathan , B. Berkowitz , B.A. Robinson | Journal of Computational Physics | Vol. 229/Issue 11 | Academic Press Inc. | United States | 01/06/2010 | 4304-4314 | Yes | Peer reviewed |

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| 33 | A scalable meshless formulation based on RBF Hermitian interpolation for 3D nonlinear heat conduction problems | Stevens, D. | CMES - Computer Modeling in Engineering and Sciences | 55/2 | Tech Science Press | | 01/01/2010 | 111-145 | No | Peer reviewed |
| 34 | Mixing in confined stratified aquifers | Diogo Bolster , Francisco J. Valdés-Pareda , Tanguy LeBorgne , Marco Dentz , Jesus Carrera | Journal of Contaminant Hydrology | Vol. 120-121 | Elsevier | Netherlands | 01/03/2011 | 198-212 | Yes | Peer reviewed |
| 35 | The impact of buoyancy on front spreading in heterogeneous porous media in two-phase immiscible flow 10.1029/2010WR009399 | Diogo Bolster , Insa Neuwiler , Marco Dentz , Jesus Carrera | Water Resources Research | Vol. 47/Issue 2 | American Geophysical Union | United States | 01/02/2011 | n/a-n/a | Yes | Peer reviewed |
| 36 | Risk assessment of MUSTANG project experimental site—Methodological development 10.1016/j.egypro.2011.02.354 | Stéphanie Dias , Yvi LeGuen , Olivier Poupard , Vladimir Shatvelman | Energy Procedia | Vol. 4 | Elsevier BV | Netherlands | 01/01/2011 | 4109-4116 | Yes | Peer reviewed |
| 37 | Effective non-local reaction kinetics for transport in physically and chemically heterogeneous media 10.1016/j.jcohyd.2010.06.002 | Marco Dentz , Philippe Goetze , Jesus Carrera | Journal of Contaminant Hydrology | Vol. 120-121 | Elsevier | Netherlands | 01/03/2011 | 222-236 | Yes | Peer reviewed |
| 38 | Mixing, spreading and reaction in heterogeneous media: A brief review 10.1016/j.jcohyd.2010.05.002 | Marco Dentz , Tanguy LeBorgne , Andreas Englert , Branko Bijeljic | Journal of Contaminant Hydrology | Vol. 120-121 | Elsevier | Netherlands | 01/03/2011 | 1-17 | Yes | Peer reviewed |
| 39 | X-ray microtomography characterization of porosity, permeability and reactive surface changes during dissolution 10.1016/j.jcohyd.2010.07.004 | Philippe Goetze , Linda Luquot | Journal of Contaminant Hydrology | Vol. 120-121 | Elsevier | Netherlands | 01/03/2011 | 45-55 | Yes | Peer reviewed |
| 40 | On the flow of buoyant fluid injected into a confined, inclined aquifer 10.1017/S0022112010005896 | IAIN GUNN , ANDREW W. WOODS | Journal of Fluid Mechanics | Vol. 672 | Cambridge University Press | United Kingdom | 01/04/2011 | 109-129 | | Peer reviewed |

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| 41 | On the propagation of non-isothermal gravity currents in an inclined porous layer 10.1017/jfm.2011.327 | W. J. Rayward-Smith, Andrew W. Woods | Journal of Fluid Mechanics | Vol. 686 | Cambridge University Press | United Kingdom | 01/11/2011 | 250-271 | | Peer reviewed |
| 42 | Dispersal of buoyancy-driven flow in porous media with inclined baffles 10.1017/jfm.2011.442 | W. J. Rayward-Smith, Andrew W. Woods | Journal of Fluid Mechanics | Vol. 689 | Cambridge University Press | United Kingdom | 01/12/2011 | 517-528 | | Peer reviewed |
| 43 | An experimental approach to the performance penalty of the use of classes in Fortran 95 10.1016/j.advengsoft.2011.05.011 | Luit J. Slooten, Francisco Batle, Jesus Carrera | Advances in Engineering Software | Vol. 42/Issue 10 | Elsevier Limited | United Kingdom | 01/10/2011 | 735-742 | | Peer reviewed |
| 44 | Geomechanical stability of the caprock during CO ₂ sequestration in deep saline aquifers 10.1016/j.egypro.2011.02.511 | Victor Villarasa, Sebastia Olivella, Jesus Carrera | Energy Procedia | Vol. 4 | Elsevier BV | Netherlands | 01/01/2011 | 5306-5313 | Yes | Peer reviewed |
| 45 | Time evolution of mixing in heterogeneous porous media 10.1029/2011WR011360 | J.-R. de Dreuzy, J. Carrera, M. Dentz, T. Le Borgne | Water Resources Research | Vol. 48/Issue 6 | American Geophysical Union | United States | 01/01/2012 | W06511 | No | Peer reviewed |
| 46 | Small-Scale CO ₂ Injection into a Deep Geological Formation at Heletz, Israel 10.1016/j.egypro.2012.06.048 | Auli Niemi, Jacob Bensabat, Fritjof Fagerlund, Martin Sauter, Julia Ghergut, Tobias Licha, Thomas Fierz, Gabriele Wiegand, Maria Rasmusson, Kristina Rasmusson, Vladimir Shvets, Michael Gendler | Energy Procedia | Vol. 23 | Elsevier BV | Netherlands | 01/01/2012 | 504-511 | Yes | Peer reviewed |
| 47 | A high-resolution local RBF collocation method for steady-state poroelasticity and hydromechanical damage analysis 10.1002/nag.2317 | D. Stevens, H. Power, J. Polanco, A. Cliffe | International Journal for Numerical and Analytical Methods in Geomechanics | NA | John Wiley and Sons Ltd | United Kingdom | 01/08/2014 | n/a-n/a | Yes | Peer reviewed |

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| 48 | The global approximate particular solution meshless method for two-dimensional linear elasticity problems 10.1080/00207160.2012.741227 | C. A. Bustamante, H. Power, W. F. Florez, C. Y. Hang | International Journal of Computer Mathematics | Vol. 90/Issue 5 | Taylor and Francis Ltd. | United Kingdom | 01/05/2013 | 978-993 | Yes | Peer reviewed |
| 49 | Experimental investigation into the sealing capability of naturally fractured shale cracks to supercritical carbon dioxide flow 10.1007/s12665-013-2407-y | K. Edlmann, S. Haszeldine, C. I. McDermott | Environmental Earth Sciences | Vol. 70/Issue 7 | Springer Verlag | Germany | 01/12/2013 | 3393-3409 | Yes | Peer reviewed |
| 50 | Predicting hydraulic tensile fracture spacing in strata-bound systems 10.1016/j.ijrmm.2013.06.004 | C.I. McDermott, K. Edlmann, R.S. Haszeldine | International Journal of Rock Mechanics and Mining Sciences | Vol. 63 | Elsevier BV | Netherlands | 01/10/2013 | 39-49 | Yes | Peer reviewed |
| 51 | A boundary element study of the effect of surface dissolution on the evolution of immiscible viscous fingering within a Hele-Shaw cell 10.1016/j.enganabound.2014.06.004 | H. Power, D. Stevens, K.A. Cliffe, A. Golin | Engineering Analysis with Boundary Elements | Vol. 37/Issue 10 | Elsevier Limited | United Kingdom | 01/10/2013 | 1318-1330 | | Peer reviewed |
| 52 | A solution to linear elasticity using locally supported RBF collocation in a generalised finite-difference mode 10.1016/j.enganabound.2012.08.005 | D. Stevens, H. Power, K.A. Cliffe | Engineering Analysis with Boundary Elements | Vol. 37/Issue 1 | Elsevier Limited | United Kingdom | 01/01/2013 | 32-41 | Yes | Peer reviewed |
| 53 | An alternative local collocation strategy for high-convergence meshless PDE solutions, using radial basis functions 10.1016/j.jcp.2013.07.026 | D. Stevens, H. Power, C.Y. Meng, D. Howard, K.A. Cliffe | Journal of Computational Physics | Vol. 254 | Academic Press Inc. | United States | 01/12/2013 | 52-75 | Yes | Peer reviewed |
| 54 | Two-phase flow in rough-walled fractures: Comparison of continuum and invasion-percolation models 10.1002/wrcr.20111 | Zhibing Yang, Auli Niemi, Fritjof Fageflund, Tissa Illangsekere | Water Resources Research | Vol. 49/Issue 2 | American Geophysical Union | United States | 01/02/2013 | 993-1002 | Yes | Peer reviewed |
| 55 | On the use of seismic data to monitor the injection of CO2 into a layered aquifer 10.1016/j.epsl.2013.02.035 | Peter Dudfield, Andrew W. Woods | Earth and Planetary Sciences Letters | Vol. 368 | Elsevier | Netherlands | 01/04/2013 | 132-143 | | Peer reviewed |
| 56 | A guideline for the identification of environmentally relevant, ionizable organic molecule species | Mario Schaffer, Tobias Licha | Chemosphere | Vol. 103 | Elsevier Limited | United Kingdom | 01/05/2014 | 12-25 | Yes | Peer reviewed |

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| | 10.1016/j.chemosphere.2013.12.009 | | | | | | | | | |
| 57 | Simulation of CO2 Injection into a Baltic Sea Saline Aquifer and Seismic Monitoring of the Plume 10.1016/j.egypro.2013.08.041 | Saba Joodaki , Auli Niemi , Christopher Juhlin , Daniel Sopher , Monika Ivandic , Mikael Erlström | Energy Procedia | Vol. 40 | Elsevier BV | Netherlands | 01/01/2013 | 355-364 | Yes | Peer reviewed |
| 58 | Modeling Gas Transport in the Shallow Subsurface in Maguelone Field Experiment 10.1016/j.egypro.2013.08.039 | Farzad Basirat , Auli Niemi , Hervé Perroud , Johanna Lofin , Nataliya Denchik , Gérard Lods , Philippe Pezard , Prabhakar Sharma , Fritjof Fagerlund | Energy Procedia | Vol. 40 | Elsevier BV | Netherlands | 01/01/2013 | 337-345 | Yes | Peer reviewed |
| 59 | Modelling of Far-field Pressure Plumes for Carbon Dioxide Sequestration 10.1016/j.egypro.2013.08.054 | Zhibing Yang , Auli Niemi , Liang Tian , Mikael Erlström | Energy Procedia | Vol. 40 | Elsevier BV | Netherlands | 01/01/2013 | 472-480 | Yes | Peer reviewed |
| 60 | Interwell Field Test to Determine in-situ CO2 Trapping in a Deep Saline Aquifer: Modelling Study of the Effects of Test Design and Geological Parameters 10.1016/j.egypro.2013.08.064 | Fritjof Fagerlund , Auli Niemi , Jacob Bensabat , Vladimir Shtivelman | Energy Procedia | Vol. 40 | Elsevier BV | Netherlands | 01/01/2013 | 554-563 | Yes | Peer reviewed |
| 61 | A meshless local RBF collocation method using integral operators for linear elasticity 10.1016/j.ijmecs.2014.05.018 | D. Stevens , H. Power , K.A. Cliffe | International Journal of Mechanical Sciences | unknown | Elsevier Limited | United Kingdom | 01/06/2014 | see journal | Yes | Peer reviewed |
| | Modelling of Kinetic Interface Sensitive Tracers for Two-Phase Systems | Tatomir, A., Maier, F., Schaffer, M., Licha, T., Sauter, M | Clean Energy Systems in the Subsurface: Production, Storage and Conversion | | Springer | Berlin Heidelberg | 01/01/2013 | 65-74 | No | Article |
| | Optimizing supercritical CO2 injection into deep saline aquifers using kinetic interface | Tatomir, A., Schaffer, M., | Models, Analysis, and Simulation of Flow and Reactive Transport in Porous Media | | | Stuttgart, Germany | 01/01/2014 | unknown | No | Article |

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| sensitive tracers: A numerical sensitivity study | Kissinger, A., Hommel, J., Maier, F., Licha, T., Nuske, P., Sauter, M., Helmig, R. | | | | | | | | |
| Entwicklung kinetischer Tracer zur Quantifizierung von Grenzflächen bei Injektionen von überkritischem CO ₂ in tiefe saline Aquifere | Schaffer, M., Maier, F., Licha, T., Sauter, M. | Publication series of the Deutsche Gesellschaft für Geowissenschaften | 78 | | | 01/01/2012 | 166 | No | Article |
| A Generalised RBF Finite Difference Approach to Solve Nonlinear Heat Conduction Problems on Unstructured Datasets 10.5772/21040 | D. Stevens , A. LaRocca , H. Power , V. LaRocc | Convection and Conduction Heat Transfer | | InTech | | 21/10/2011 | 281-296 | Yes | Article |
| EXTENSION OF CODE_BRIGHT TO SIMULATE NON-ISOTHERMAL CO ₂ INJECTION IN DEEP SALINE AQUIFERS | Victor Villarasa, Sebastia Olivella, Orlando Silva and Jesus Carreral, | 4th Codebright workshop | | CSIC | | 01/01/2014 | | | Conference |
| Tracer-based prediction of thermal reservoir lifetime: scope, limitations, and the role of thermosensitive tracers | Ghergut, I. | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2012 | 4038 | | Conference |
| Single-well tracer push-pull test sensitivity w. r. to fracture aperture and spacing | Ghergut, I. | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2012 | 4310 | | Conference |
| Single-well tracer test sensitivity w. r. to hydrofrac and matrix parameters (case study for the Horstberg site in the N-German Sedimentary Basin) | Ghergut, I. | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2012 | 6142 | | Conference |
| Single-well and inter-well dual-tracer test design for quantifying phase volumes and interface areas in subsurface flow and transport systems | Ghergut, I. | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2012 | 13549 | | Conference |
| Brine-phase spiking during CO ₂ injection at the Ketzin site, Germany | Sauter, M. | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2011 | 2823 | | Conference |
| A Method for Incorporating Chemical Reac | Saaltink, M. | Geophysical Research Abstracts | | European Geosci | | 01/01/2012 | | | Conference |

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| Tracer-based prediction of thermal lifetime: Scope, limitations, and the role of thermosensitive tracers. | Ghergut, I., Behrens, H., Licha, T., Sauter, M | Proceedings of the 38th Workshop on Geothermal Reservoir Engineering | | Stanford University | Stanford, California | 01/01/2013 | | | Conference |
| CCS site characterization by single-well and inter-well tracer tests. | Ghergut, I., Bensabat, J., Niemi, A., Licha, T., Ptak, T., Sauter, M | Proceedings of the 38th Workshop on Geothermal Reservoir Engineering | | Stanford University | | 01/01/2013 | | | Conference |
| Matching tracer selection to georeservoir typology - A note on geothermal reservoir classification | Ghergut, I., Behrens, H., Licha, T., Sauter, M | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2013 | EGU2013-3 852 | | Conference |
| Single-well and inter-well dual-tracer tests for CCS pilot site characterization at Hefetz (Israel): scope and limitations | Ghergut, I., Bensabat, J., Niemi, A., Licha, T., Lange, T., Tatomir, A., Sauter, M | Geophysical Research Abstracts | | European Geosciences Union | | 01/01/2013 | EGU2013-3 683-1 | | Conference |
| A numerical study of hydraulic tomography for monitoring a CO ₂ plume | Hu, L., Brauchler, R., Tatomir, A., Sauter, M., Bayer, P | Computational Methods in Water Resources, Stuttgart, Germany | | Conference organizers | | 01/01/2014 | | | Conference |
| Benchmark study on flow and solute transport in geological reservoirs | Karmakar, S., Tatomir, A., Oehlmann, S., Giese, M., Sauter, M | Computational Methods in Water Resources, Stuttgart, Germany | | Conference organizers | | 01/01/2014 | | | Conference |
| Characterization of geological reservoirs for storage of carbon dioxide using tracer tests | Tatomir, A., Lange, T., Sauter, M., | 5th International Conference on Applications of Porous Media, Cluj, Romania | | Conference organizers | | 01/01/2013 | | | Conference |
| MUSTANG - a multiple space and time scale approach for the quantification of deep saline formations for CO ₂ storage | Wiegand, G; Niemi, A., Goetze, P, Sauter, M | Am. Chem. Soc. 2010 spring meeting | | Washington, DC | | 01/01/2010 | Abstract 285 | | Conference |
| A Multiple Space and Time Scale App | Niemi, A. | Geophysical Research Abstracts | | European Geosci | | 01/04/2009 | EGU2009-1 2 | | Conference |

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| | Quantifying Mixing in Confined Stratified Aquifer Flows | Bolster, D., F. J. Valdés-Pareda, T. Le Borgne, M. Dentz and J. Carrera | Proceedings, American Geophysical Union Fall Meeting 2009 | | American Geophysical Union | | 01/01/2009 | | | Conference |
| | Exact Probability Density Function (PDF) of Concentration for Transport in a Random Velocity Field | Dentz, M. and D. M. Tartakovsky | Proceedings, American Geophysical Union Fall Meeting 2009 | | American Geophysical Union | | 01/01/2009 | | | Conference |
| | Simulations of CO2 injection at the Heletz field site – providing guidance for optimal design of a planned field injection experiment | Fagerlund, F., A. Niemi, J. Bensabat, Z. Yang, V. Shtivelman and I. Goldberg | Proceedings, American Geophysical Union Fall Meeting 2009 | | American Geophysical Union | | 14/12/2009 | | | Conference |
| | Scaling of mixing and spreading in heterogeneous porous media (Invited presentation) | Le Borgne, T., M. Dentz, D. Bolster, J. Carrera, J.-R. de Dreuzy, P. Davy | Proceedings, American Geophysical Union Fall Meeting 2009 | | American Geophysical Union | | 14/12/2009 | | | Conference |
| | Changes in seal capacity of fractured claystone caprocks induced by dissolved and gaseous CO2 seepage: evidences from experiments and molecular modelling | Andreani M., P. Guéze, L. Luquot, G. Pépère, J. Dweik, P. Jouanna | Proceedings, American Geophysical Union Fall Meeting 2010 | | American Geophysical Union | | 01/12/2010 | | | Conference |
| | Design and Analysis of Field Experiments for the Investigation of In-Situ CO2 Trapping. | Fagerlund, F., A. P. Niemi, J. Bensabat, M. Rasmussen, K. Rasmussen, L. Tian, V. Shtivelman, T. Licha | Proceedings, American Geophysical Union Fall Meeting 2010 | | American Geophysical Union | | 13/12/2010 | H13C-0981 | | Conference |
| | In Situ Carbon Dioxide Sequestration via Mineral Carbonation: New Insights from Lab-scale Flow-through Experiments (Invited oral presentation) | Guéze P., L. Luquot, M. Andreani, M. Godard, S. Peuble | Proceedings, American Geophysical Union Fall Meeting 2010 | | American Geophysical Union | | 13/12/2010 | | | Conference |

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| Percolation Experiment through Chlorite/Zeolite-Rich Sandstone (Pretty Hill Formation - Otway Basin - Australia) | Gouze P., L. Luquot, M. Andreani | Proceedings, American Geophysical Union Fall Meeting 2010 | | American Geophysical Union | | 13/12/2010 | | | Conference |
| Multi scale characterization of self-organized dissolution patterns during CO2 injection in limestones | Depraz, L., L. Luquot, P. Gouze | Proceedings, American Geophysical Union Fall Meeting 2010 | | American Geophysical Union | | 13/12/2010 | | | Conference |
| Spreading of Multiphase Flows in Heterogeneous Porous Media under the Influence of Buoyancy | Diogo Bolster, Marco Dentz, Insa Neuweiler, and Jesus Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/01/2010 | | | Conference |
| A mapping approach for the derivation of concentration PDFs in random velocity fields | Marco Dentz and Daniel M. Tartakovsky | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/01/2010 | | | Conference |
| Model simulations for guiding the design of the CO2 injection experiment at the Heletz site. | Fagerlund, F., A. Niemi, J. Bensabat, Z. Yang, V. Shtivelman, I. Goldberg and M. Gendler | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 02/05/2010 | | | Conference |
| Non-Fickian mixing in heterogeneous porous media | Tanguy Le Borgne, Marco Dentz, Diogo Bolster, Jesus Carrera, Jean-Raymond de Dreuzy, and Philippe Davy | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 02/05/2010 | | | Conference |
| Model for the dependence of conditions at the injection well head and the reservoir during CO2 injection. | Bensabat, J. Kitron Belinkov M., K. Rasmusson, M. Rasmusson, A. Niemi, and J. Bear | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-6101 | | Conference |
| Experimental program and technical implementation of CO2 injection experiment in a deep geological formation at Heletz, Israel | Bensabat J., A. Niemi, T. Fierz, M. Saut | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-6028 | | Conference |

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| | Characterization and Injection tests planned at the Hontomin CO2 injection site | Carrera, J., Orlando Silva, Andres Perez-Estua, Jose L Fuentes, Felix Mateos, Modesto Montoto | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-10490 | Conference |
| | Use of Gaussian Process Emulators for Quantifying Uncertainty in CO2 Spreading Predictions in Heterogeneous Geological Media. | Cliffe, A., Niemi, A., Power, H., Yang, Z., Liang, T., and Fagerlund, F. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-11898 | Conference |
| | Mass Transfer Limitations and Non-Localities for Large Scale Reactive Transport | Marco Dentz, Philippe Gouze, and Jesus Carrera, | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | | Conference |
| | Investigation of geochemical processes during CO2 injection using "push-pull" reactive tracer tests. | De Gaspari, F., J. Carrera, M.W. Sallink, O. Silva. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-7512 | Conference |
| | Experimental investigation of coupled processes affecting caprock seal integrity for CO2 sequestration. | Edlmann K., Christopher McDermott, and Stuart Haszeldine | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-4979 | Conference |
| | The MUSTANG site characterization programme | Erlström, M., Auli Niemi and Fritjof Fagerlund | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | | Conference |
| | Analysis of boundary conditions in numerical simulations of geological CO2 storage | Fagerlund, F., J. Ahlkrona, H. Holmgren, K. Nielsen, Z. Yang, A. Niemi, G. Kreiss | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | | Conference |
| | Modelling of novel tracers in a two-phase flow system for characterization of geologically stored CO2 in deep saline formations | Fagerlund, F., F. Tong, M. Rasmusson, | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | | Conference |

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| | Evaluation of design options for a field experiment of CO2 injection to a deep layered aquifer at the Heletz site using numerical modelling | Fagerlund, F., A. Niemi, J. Bensabat, V. Shtivelman | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | | Conference |
| | Model for the dependence of conditions at well head on reservoir properties during CO2 injection | Kitron-Belinkov, M., Rasmusson, K., Rasmusson, M., Niemi, A., Bensabat, J., Bear, J. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-6101 | Conference |
| | Investigation of thermosensitive tracers for the investigation of the thermal regime in CO2 sequestration reservoirs | Nottebohm, M., Licha, T. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-8754 | Conference |
| | SIMEX at Maquelone (Languedoc coastline, France): a shallow injection experimental site to test CO2 storage monitoring techniques from a multi-method approach | Pezard, P., Denchik, N, Lofi, J., Perroud, H., Jaafar, O., Neyens, D., Barry, S. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-9963 | Conference |
| | Subsurface characterization and modeling of a CO2 test site in south Scania, Sweden, with special emphasis on the treatment of hydrogeological heterogeneity | Rasmusson, K., Niemi, A., Erlström, M. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-9755 | Conference |
| | Modeling of single-well CO2 injection-withdrawal experiment to be carried out at the Heletz site | Rasmusson, M., Rasmusson, K., Fagerlund, F., Niemi, A., Bensabat, J., Shtivelman, V. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-6799 | Conference |
| | Hydrogeochemical characterization and monitoring at the Hontomin site (Spain) for geological storage of CO2 | Rotting, T., Jesus Carrera and Orlando Silva | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-4818 | Conference |

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| 3D parametric model of a potential trap for carbon dioxide storage. Case study: oil structure Valcele, Romania | Scradeanu , Daniel and Michaela Pagnejer | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-2 227 | | Conference |
| Flowing Fluid Electric Conductivity Logging method as a Tool to Characterize the Hydraulic Conductivity Structure of a Target Layer for CO2 Injection | Sharma, P., Niemi, A, Tsang, C-F, Bensabat , J. and Pezard, P. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-1 1814 | | Conference |
| 3D geological model of potential CO2 reservoir for the Heletz test site | Shtivelman V., Michael Gendler, and Igor Goldberg | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-1 307 | | Conference |
| Varying mathematical model formulations in space and time: a generalized approach | Slooten, L.J., M.W. Saaltink , A. Nardi, L.M. De Vries, J. Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011-4 842 | | Conference |
| Horstberg, NW Germany: a unique test site for CO2 sequestration in saline aquifers | Sperber, Christian and Manfred Wuttke | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011- 2422 | | Conference |
| Hydromechanical characterization test for CO2 sequestration in deep saline aquifers | Vilarrasa , V., S. Olivella , J. Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | EGU2011- 8103 | | Conference |
| Numerical Analysis of the coupling between dissolution at the interface and fingering evolution | H. Power, A. Golin, K.A. Cliffe, D. Stevens | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 03/04/2011 | | | Conference |
| Modeling wellbore and reservoir carbon dioxide flow for the Heletz experiment | M. Kitron-Belinkov, K. Rasmussen, M. Rasmusson, F. Fagerlund , A. Niemi, J. Bensabat , and J. Bear | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-7 823 | | Conference |
| Experimental and modeling study of the hydrogeochemical properties of the Hontom in main reservoir rock under CO2 subcritical conditions | Cama, J. , M. Garcia-Rios, J.M. Soler , G. Dávila | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | | | Conference |

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| “Push-pull” reactive tracer tests simulations with reactive multirate models to infer geochemical processes during CO2 injection | De Gaspari, F., J. Carrera, M. W. Saaltink, O. Silva, T. Rötting | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | | | Conference |
| Time-domain random walk modeling of heterogeneous diffusion and trapping in porous media | M. Dentz, P. Gouze, J. Dweik, A. Russian, and F. Delay. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | | | Conference |
| Evaluating and quantifying the potential for CO2 leakage through the caprock during carbon sequestration using a risk matrix | Edlmann K., Christopher Mc Dermott, and Stuart Haszeldine | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-4979 | | Conference |
| Facies distribution, heterogeneity study and numerical 3D modeling of a multilayered Rhaetian–Lower Cretaceous aquifer succession in the Höllviken Halfgraben, SW Skåne, Sweden – assessment of suitability for storage of CO2 | Erlström, M., Auli Niemi, Sofie Lindström, Niklas Gunnarsson | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-6244 | | Conference |
| Design of a two-well field test to determine in-situ residual and dissolution trapping of CO2 in a deep saline aquifer | Fagerlund, A. Niemi, J. Bensabat, and V. Shtivelman | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-7231 | | Conference |
| Hydraulic tests to identify the CO2 saturation at a geological site | Martínez, L., T. S. Roetting, J. Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | | | Conference |
| Modeling dolomite – brine interaction in the context of geological CO2 sequestration | Davila Ordóñez, M. G., M. García Ríos, J.M Soler, J. Cama | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-3090 | | Conference |
| SIMEx : a shallow integrated, multi-method hydrogeophysical monitoring experiment for CO2 storage conducted at Maguelone (Languedoc coastline, France) | Pezard, N. Denchik, J. Lofi, H. Perroud, and D. Neyens | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-10027 | | Conference |
| Identification of scale effects in dissolution trapping from the response of a push-pull experiment | Rasmusson, K., Niemi, A., Fagerlund, F., | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-7997 | | Conference |

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| | Analysis of alternative push-pull designs for determining in-situ trapping of CO2 | Rasmusson, M., Rasmusson, K., Fagerlund, F., Niemi, A., Bensabat, J., Shtivelman, V. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-8443 | Conference |
| | A Method for Incorporating Chemical Reactions into Multiphase Flow Models for CO2 Injection | Saaltink, M. W., Vilaras, F., De Gaspari, O., Silva, J., Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-5181 | Conference |
| | Modeling wellbore and reservoir carbon dioxide flow for the Heletz experiment | P. Sharma, C.F. Tsang, A. Niemi, and J. Bensabat | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-4640 | Conference |
| | Development of Kinetic Interface Sensitive Tracers (KIS-Tracer) for Supercritical Carbon Dioxide Injections into Deep Saline Aquifers | Schaffer, M., Maier, F., Licha, T., Sauter, M. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-2048 | Conference |
| | Upscaling of two-phase flow processes in CO2 geological storage | Silva, O., I. Neuweiler, M. Dentz, M. Saaltink, J. Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-6056 | Conference |
| | Effect of Permeability Heterogeneity on Storage Capacity Estimation in CO2 injection | Tian, L., Z. Yang, A. Niemi, A. Cliffe, and F. Fagerlund | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-4399 | Conference |
| | A solution scheme for simulating of tracer transport in a non-isothermal two-phase flow system | Tong, F., A. Niemi, Z. Yang, and F. Fagerlund | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-6743 | Conference |
| | Numerical Approaches to CO2-Sequestration in a Faulted and Low-Permeable Saline Aquifer in NW Germany | Wuttke, M. W., Sperber, C.M. | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | | Conference |

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| Macro-scale constitutive relationships for CO2 migration in heterogeneous geological formations | Yang, Z., A. Niemi, L. Tian, F. Fagerlund., T. H. Illangsekere | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 22/04/2012 | EGU2012-7723 | | Conference |
| Interwell field test to determine in-situ CO2 trapping in a deep saline aquifer: Modelling study of the effects of test design and geological parameters | Fagerlund, F., A. Niemi, J. Bensabat and V. Shtivelman | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/04/2013 | EGU2013-10183 | | Conference |
| Effect of permeability heterogeneity on CO2 sweep efficiency and implication for storage capacity | Tian, L, Z. Yang, A. Niemi, A. Cliffe, and F. Fagerlund | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/04/2013 | EGU2013-9076 | | Conference |
| Hydrogeological characterization and first CO2 injection experiment in the Heletz sands Reservoir, Heletz (Israel) | Jacob Bensabat, Auli Niemi, Chin-Fu Tsang, Prabhakar Sharma, Jesus Carrera, Martin Sauter, Alexandru Tatomir, Iulia Ghergut, Philippe Pezard, and Katriona Edlman | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/05/2014 | EGU2014-15042 | | Conference |
| Merging single-well and inter-well tracer tests into one forced-gradient dipole test, at the Heletz site within the MUSTANG project | Horst Behrens, Julia Ghergut, Jacob Bensabat, Auli Niemi, Tobias Licha, Thomas Ptak, and Martin Sauter | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/05/2014 | EGU2014-4434 | | Conference |
| CO2-rich brine injection through Heletz site sandstone samples: role of the flow rate injection on chemical and hydrodynamic properties | Linda Luquot, Philippe Goetze, and Jesus Carrera | Geophysical Research Abstracts, Proceedings EGU General Assembly | | European Geosciences Union | | 01/05/2014 | EGU2014-232 | | Conference |
| X-ray microtomography characterization | Depraz, L., L. | Proceedings from 2nd Conference on | | Conference organizer | | 01/01/2010 | | | Conference |

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| of pore rock structure changes induced by CO2 injection | Luquot, P. Gouze | 3D-Imaging of Materials and Systems | | s | | | | | |
| Effective non-local reaction kinetics for transport in physically and chemically heterogeneous media | Dentz. M., P. Gouze and J. Carrera | Proceedings from IAHR Groundwater Symposium 2010 (Valencia, Spain) | | Conference organizers | | | 01/01/2010 | | Conference |
| Caprock Hydromechanical Changes during CO2 Sequestration In Deep Saline Aquifers | Vilarrasa , V., S. Olivella , J. Carrera | Proceedings of XVIII International Conference on Computational Methods in Water Resources | | Conference organizers | | | 21/06/2010 | | Conference |
| Zeit-/temperaturabhängige Dualtracerbildung in-situ oder Sorption „überlisten“ die Push-Pull- Test-Insensitivität gegenüber Austauschprozessen im Gleichgewicht | Ghergut I, Behrens H, Nottebohm M, Licha T, Schaffer M, Maier F, Ptak T, Sauter M | Der Geothermiekongress 2011 (Bochum) | | GtV-BVG, Berlin | | | 01/01/2011 | | Conference |
| Sensitivität von Tracer-Push-Pull- Tests gegenüber Kluftöffnungen weiten und -dichten in Parallelkluft systemen | Ghergut I, Behrens H, Karmakar S, Maier F, Sauter M | Der Geothermiekongress 2011 (Bochum) | | GtV-BVG, Berlin | | | 01/01/2011 | | Conference |
| Coupled Hydromechanical Processes during CO2 sequestration in deep saline aquifers | Vilarrasa , V., S. Olivella , J. Carrera | Coupled Problems 2011, IV International Conference on Computational Methods for Coupled Problems in Science and Engineering | | Conference organizers | | | 20/06/2011 | | Conference |
| Small Scale injection experiment into deep geological formation, Heletz, Israel – Experiment plan, monitoring, predictive models and preliminary results of preparatory tests | Niemi, A. et al | 6th Trondheim CCS Conference TCCS-6 | | Sintef | Norway | | 14/06/2011 | | Conference |
| Generic evolution of mixing in heterogeneous media | Jean-Raymond De Dreuzy; Jesus Carrera; Marco Dentz; Tanguy Le Borgne | Proceedings, American Geophysical Union Fall Meeting 2011 | | American Geophysical Union | | | 01/12/2011 | | Conference |
| Concentration Uncertainty for Anomalous Transport in Fluctuating Media | Marco Dentz | Proceedings, American Geophysical Union Fall Meeting 2011 | | American Geophysical Union | | | 01/12/2011 | | Conference |
| An efficient injection concept for CO2 geological storage | Silva, O., Carrera, J., and Vi | 6th Trondheim CCS Conference TCCS-6 | | Sintef | Norway | | 01/12/2011 | | Conference |

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| Entwicklung kinetischer Grenzflächen tracer für Injektionen von überkritischem CO2 in tiefe saline Grundwasserleiter | Schaffer, M., Maier, F., Licha, T., Sauter, M. | Proceedings of Annual Meeting of the German Water Chemistry Society 2012 | | Conference organizers | | 01/01/2012 | | | Conference |
| MUSTANG – A multiple space and time scale approach for the qualification of deep saline formations for CO2 storage | Wiegand G., A. Niemi, J. Bensabat, P. Gouze, M. Sauter | Proceedings of the 10th International Symposium on Supercritical Fluids (ISSF 2012) | | Conference organizers | | 01/01/2012 | P-803 | | Conference |
| Mixing and Reaction in Heterogeneous Porous Media. | Marco Dentz | Proceedings of Computational Methods in Water Resources, CMWR meeting 2012 | | Conference organizers | | 01/01/2012 | | | Conference |
| Pre-injection characterization tests of Heletz (Israel) site in preparation of small-scale CO2 injection experiments | Niemi, A. et al | Proceedings of Seventh Trondheim CCS Conference: CO2 Capture, Transport and Storage | | Sintef | Norway | 04/06/2013 | | | Conference |
| Modelling of kinetic interface sensitive tracers for two-phase systems | Tatomir, A., Maier, F., Schaffer, M., Licha, T., Sauter, M. | Proceedings of the 3rd Sino-German Conference “Underground Storage of CO2 and Energy” | | Conference organizers | | 01/01/2013 | | | Conference |
| A High-Resolution Scalable Meshless Method for Coupled Poro-Elastic Analysis, based on Collocation with Radial Basis Functions | H. Power, D. Stevens and A. Cliffe | Proceedings of Fifth International Conference on Computational Methods for Coupled Problems in Science and Engineering | | Conference organizers | | 17/06/2013 | | | Conference |
| A detailed Boundary Element analysis of the flow field outside a growing immiscible viscous fingering within a Hele-Shaw cell | H. Power, D. Stevens and A. Cliffe | Proceedings of International Conference on Boundary Element and Meshless Techniques | | Conference organizers | | 16/07/2013 | | | Conference |
| The local Radial Basis Function Finite Collocation Method and a Generalized Finite Different Meshless Scheme for High-Convergence Solution of Boundary Value Problems (Keynote speaker) | H. Power, D. Stevens and K.A. Cliffe | Proceedings of ICCES 2013, Seattle, USA | | Conference organizers | | 01/01/2013 | | | Conference |
| High-Resolution Meshless Solutions using a Radial Basis Function Finite Collocation Approach (invited speaker) | H. Power and D. Stevens | Proceedings of ICCES 2014, Ho Chi Minh City, Viet Nam | | Conference organizers | | 01/01/2014 | | | Conference |
| Optimizing supercritical CO2 injection into deep saline aquifers using kinetic interface | Tatomir, A., Schaffer, M., | Proceedings of the 20th International Conference on Computational Methods in | | Conference organizers | | 01/01/2014 | | | Conference |

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| sensitive tracers: A numerical sensitivity study | Kissinger, A., Hommel, J., Maier, F., Licha, T., Nuske, P., Sauter, M., Helmig, R. | Water Resources 2014 | | | | | | | |
| Single-well and inter-well dual-tracer test design for measuring phase volumes and interface areas – Two ways overcoming SW insensitivity towards rapid-exchange processes. | Ghergut I, Behrens H, Licha T, Maier F, Nottebohm M, Schaffer M, Ptak T, Sauter M | Stanford Geothermal Program – Technical Reports | SGP-TR-19 4 | Stanford University | | 01/01/2012 | | No | Monogram |
| A note about 'heat exchange areas' as a target parameter for SWIW tracer tests. | Ghergut I, Behrens H, Maier F, Karmakar S, Sauter M | Stanford Geothermal Program – Technical Reports | SGP-TR-19 1 | Stanford University | | 01/01/2011 | | | Monogram |
| Basin analysis of the uppermost Triassic to LowerCretaceous, Danish Basin. Biostatigraphy and log correlation. | Lindström S., Mikael Erlström | Danmarks og Grönlands Geologiske Undersøgelse Rapport | 82 | Geological survey of Denmark and Greenland | | 01/01/2011 | | | Monogram |
| Carbon capture and storage in Europe | Niemi, A. and working group | EASAC policy report | 20 | EASAC | | 22/05/2013 | | Yes | Monogram |
| 3D modeling in Petrel of Geological CO2 site (MSc thesis) | Gunnarsson, N. | | | Uppsala University | | 01/01/2011 | | | Thesis |
| On the possibility of using organic molecules in the characterization of subsurface processes | Schaffer, M | | | Fakultät für Geowissenschaften und Geographie, Göttingen University | | 04/04/2013 | | Yes | Thesis |
| Thermo-Hydro- Mechanical Impacts of Carbon Dioxide (CO2) Injection in Deep Saline Aquifers | Vilarrasa V. | | | Universitat Politècnica de Catalunya. Escola Tècnica Superior d'Enginyers de Camins, Canals i Ports de Barcelona | Barcelona, Spain | 20/07/2012 | | | Thesis |
| Lithofacies analysis and heterogeneity study of the subsurface Rhaetian-Pliensbachian sequence in SW Skåne and Denmark (MSc) | Samer Bou Daher | | | Geological institute, Lund university | Lund, Sweden | 01/01/2012 | | | Thesis |

| LIST OF DISSEMINATION ACTIVITIES | | | | | | | | |
|----------------------------------|---|---|--|------------|-------------------------------|---|------------------|---|
| No. | Type of activities | Main Leader | Title | Date | Place | Type of audience | Size of audience | Countries addressed |
| 1 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | Conference on Carbon Capture & Sequestration | 04/05/2009 | Pittsburgh, Pennsylvania, USA | Scientific community (higher education, Research) | | Primarily USA, Canada, European nations |
| 2 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | "Carbon capture and Storage" Energy09, Symposium at Uppsala University | 21/10/2009 | Uppsala, Sweden | Scientific community (higher education, Research) | | Swedish and some other European countries |
| 3 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | American Geophysical Union Meeting | 14/12/2009 | San Francisco, USA | Scientific community (higher education, Research) | | Widely international |
| 4 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | American Geophysical Union Meeting | 14/12/2009 | San Francisco, USA | Scientific community (higher education, Research) | | Widely international |
| 5 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | Coloquio franco-español de CO2 | 01/01/2010 | Pau, France | Scientific community (higher education, Research) | | France, Spain |
| 6 | Oral presentation to a wider public | UPPSALA UNIVERSITET | Sveriges Energiting (Swedish National Energy Convention) | 16/03/2010 | Stockholm, Sweden | Industry - Civil society - Policy makers | | Sweden |
| 7 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | European Geosciences Union, General Assembly | 02/04/2010 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 8 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | European Geosciences Union, General Assembly | 02/04/2010 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 9 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | European Conference on CCS Research, Development and Demonstration | 19/04/2010 | Rotterdam, The Netherlands | Scientific community (higher education, Research) | | Widely international |

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| 10 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | "CCS Ready to go?" European conference on CCS research, development and demonstration | 19/04/2010 | Rotterdam, The Netherlands | Scientific community (higher education, Research) | | Widely international |
| 11 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | International Conference on Computational Methods in Water Resources | 21/06/2010 | Barcelona, Spain | Scientific community (higher education, Research) | | Widely international |
| 12 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | Gordon Research Conference on Flow and Transport in Permeable Media | 12/07/2010 | Lewiston ME, USA | Scientific community (higher education, Research) | | Widely international |
| 13 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | Gordon-Keenan Research Seminar | 10/07/2010 | Lewiston ME, USA | Scientific community (higher education, Research) | | Widely international |
| 14 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | Water-Rock Interactions meeting | 16/08/2010 | Guanajuato, Mexico | Scientific community (higher education, Research) | | Widely international |
| 15 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | SEG/EAGES Summer Research Workshop | 15/08/2010 | Snowbird, Utah | Scientific community (higher education, Research) | | Widely international |
| 16 | Oral presentation to a scientific event | IMAGEAU SAS | Conference on 3D-Imaging of Materials and Systems | 06/09/2010 | Hourtin, France | Scientific community (higher education, Research) | | France, mainly |
| 17 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | IAHR Groundwater Symposium | 19/09/2010 | Valencia, Spain | Scientific community (higher education, Research) | | Widely international |
| 18 | Oral presentation to a scientific event | OXAND SA | 10th International Conference of Greenhouse Gas Technologies | 19/09/2010 | Amsterdam, The Netherlands | Scientific community (higher education, Research) | | Widely international |
| 19 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | 10th International Conference of Greenhouse Gas Technologies | 19/09/2010 | Amsterdam, The Netherlands | Scientific community (higher education, Research) | | Widely international |

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| 20 | Oral presentation to a scientific event | TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY | American Geophysical Union Meeting | 13/12/2010 | San Francisco,USA | Scientific community (higher education, Research) | Widely international |
| 21 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | American Geophysical Union Meeting | 13/12/2010 | San Francisco,USA | Scientific community (higher education, Research) | Widely international |
| 22 | Oral presentation to a scientific event | CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE | American Geophysical Union Meeting | 13/12/2010 | San Francisco,USA | Scientific community (higher education, Research) | Widely international |
| 23 | Oral presentation to a scientific event | IMAGEAU SAS | American Geophysical Union Meeting | 13/12/2010 | San Francisco,USA | Scientific community (higher education, Research) | Widely international |
| 24 | Oral presentation to a scientific event | Karlsruher Institut fuer Technologie | American Geophysical Union Meeting | 13/12/2010 | San Francisco,USA | Scientific community (higher education, Research) | Widely international |
| 25 | Oral presentation to a scientific event | THE GEOPHYSICAL INSTITUTE OF ISRAEL | Annual Meeting of Israel Geological Society | 01/01/2011 | Israel | Scientific community (higher education, Research) | Israel |
| 26 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS | Der Geothermiekongress 2011 | 01/01/2011 | Bochum, Germany | Scientific community (higher education, Research) | Germany |
| 27 | Oral presentation to a scientific event | Karlsruher Institut fuer Technologie | Jahrestreffen des Fachausschusses Hochdruckverfahrenstechnik | 01/01/2011 | Maribor, Slowenien | Scientific community (higher education, Research) | Germany |
| 28 | Oral presentation to a scientific event | Environmental & Water Resources Engineering Ltd. | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 29 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 30 | Oral presentation to | THE UNIVERSITY | European Geosci | 03/04/2011 | Vienna, Austria | Scientific comm | Widely internat |

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| | a scientific event | OF NOTTINGHAM | ences Union meeting | | | unity (higher education, Research) | | ional |
| 31 | Oral presentation to a scientific event | THE UNIVERSITY OF EDINBURGH | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 32 | Oral presentation to a scientific event | SVERIGES GEOLOGISKA UNDERSOKNING | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 33 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 34 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 35 | Oral presentation to a scientific event | TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 36 | Oral presentation to a scientific event | CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 37 | Oral presentation to a scientific event | UNIVERSITATEA DIN BUCURESTI | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 38 | Oral presentation to a scientific event | THE GEOPHYSICAL INSTITUTE OF ISRAEL | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 39 | Oral presentation to a scientific event | LEIBNIZ-INSTITUT FUR ANGEWANDTE GEOPHYSIK | European Geosciences Union meeting | 03/04/2011 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 40 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN | The 6th Trondheim CCS Conference (TCCS-6) | 14/06/2011 | Trondheim, Norway | Scientific community (higher education, Research) | | Widely international |

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| 41 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | The 6th Trondheim CCS Conference (T CCS-6) | 14/06/2011 | Trondheim, Norway | Scientific community (higher education, Research) | | Widely international |
| 42 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | The 6th Trondheim CCS Conference (T CCS-6) | 14/06/2011 | Trondheim, Norway | Scientific community (higher education, Research) | | Widely international |
| 43 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | IV International Conference on Computational Methods for Coupled Problems in Science and Engineering | 20/06/2011 | Kos Island, Greece | Scientific community (higher education, Research) | | Widely international |
| 44 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | European Geosciences Union, General Assembly | 05/12/2011 | San Francisco, USA | Scientific community (higher education, Research) | | Widely international |
| 45 | Oral presentation to a scientific event | CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE | American Geophysical Union Meeting | 05/12/2011 | San Francisco, USA | Scientific community (higher education, Research) | | Widely international |
| 46 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS | Annual Meeting of the German Water Chemistry Society | 02/01/2012 | Germany | Scientific community (higher education, Research) | | Germany |
| 47 | Oral presentation to a scientific event | Karlsruher Institut fuer Technologie | 10th International Symposium on Supercritical Fluids | 02/01/2012 | San Francisco, USA | Scientific community (higher education, Research) | | Widely international |
| 48 | Oral presentation to a scientific event | AMPHOS 21 CONSULTING SL | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 49 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |

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| 50 | Oral presentation to a scientific event | THE UNIVERSITY OF EDINBURGH | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 51 | Oral presentation to a scientific event | SVERIGES GEOLOGISKA UNDERSOKNING | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 52 | Oral presentation to a scientific event | SVERIGES GEOLOGISKA UNDERSOKNING | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 53 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 54 | Oral presentation to a scientific event | TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 55 | Oral presentation to a scientific event | CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 56 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STUDIUM OEFFENTLICHEN RECHTS | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 57 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STUDIUM OEFFENTLICHEN RECHTS | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 58 | Oral presentation to a scientific event | LEIBNIZ-INSTITUT FUR ANGEWANDTE GEOLOGIE | European Geosciences Union meeting | 22/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | Widely international |
| 59 | Oral presentation to a scientific event | AGENCIA ESTADAL CONSEJO SUPERIOR DE | 4th International Conference on Porous Media (Purdue Un | 14/05/2012 | West Lafayette, USA | Scientific community (higher education, Research) | Widely international |

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| | | INVESTIGACIONES CIENTIFICAS | iversity) | | | | | |
| 60 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | International Conference on Boundary Elements and other Mesh Reduction Methods (BEM/ MRM) | 25/06/2012 | Split, Croatia | Scientific community (higher education, Research) | | Widely international |
| 61 | Oral presentation to a scientific event | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | International Conference on Computational Methods in Water Resources | 17/06/2012 | Urbana-Champaign, IL, USA | Scientific community (higher education, Research) | | Widely international |
| 62 | Oral presentation to a scientific event | Environmental & Water Resources Engineering Ltd. | International Conference on Greenhouse Gas Technologies GHGT-11 | 18/11/2012 | Kyoto, Japan | Scientific community (higher education, Research) | | Widely international |
| 63 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | European Geosciences Union meeting | 07/04/2013 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 64 | Oral presentation to a scientific event | Environmental & Water Resources Engineering Ltd. | European Geosciences Union meeting | 07/04/2013 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 65 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STUDIUM OEFFENTLICHEN RECHTS | European Geosciences Union meeting | 07/04/2013 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 66 | Oral presentation to a scientific event | THE UNIVERSITY OF NOTTINGHAM | International Conference on Computational & Experimental Engineering and Sciences | 24/05/2013 | Seattle, USA | Scientific community (higher education, Research) | | Widely international |
| 67 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STUDIUM OEFFENTLICHEN RECHTS | 3rd Sino-German Conference "Underground Storage of CO2 and Energy" | 21/05/2013 | Goslar, Germany | Scientific community (higher education, Research) | | China, Germany |

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| 68 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | The 7th Trondheim CCS Conference (T CCS-7) | 04/06/2013 | Trondheim, Norway | Scientific community (higher education, Research) | | Widely international |
| 69 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | The 7th Trondheim CCS Conference (T CCS-7) | 04/06/2013 | Trondheim, Norway | Scientific community (higher education, Research) | | Widely international |
| 70 | Oral presentation to a scientific event | THE UNIVERSITY OF NOTTINGHAM | International Conference on Computational Methods for Coupled Problems in Science and Engineering | 17/06/2013 | Ibiza, Spain | Scientific community (higher education, Research) | | Widely international |
| 71 | Oral presentation to a scientific event | THE UNIVERSITY OF NOTTINGHAM | International Conference on Boundary Element and Meshless Techniques | 16/07/2013 | Paris, France | Scientific community (higher education, Research) | | Widely international |
| 72 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | 2nd Workshop of CODE_BRIGHT Users | 06/05/2010 | Barcelona, Spain | Scientific community (higher education, Research) | | Primarily USA, Canada, European nations |
| 73 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | 3rd Workshop of CODE-BRIGHT Users | 02/06/2011 | Barcelona, Spain | Scientific community (higher education, Research) | | Primarily USA, Canada, European nations |
| 74 | Articles published in the popular press | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STUDIUM OEFFENTLICHEN RECHTS | Wünschelrute, Steine klopfen – und dann? – Ingenieurspiegel | 01/01/2011 | germany | Scientific community (higher education, Research) - Industry - Civil society - Policy makers | | Germany |
| 75 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STUDIUM OEFFENTLICHEN RECHTS | Deep Hydrogeology Workshop Uppsala University | 20/09/2011 | Uppsala, Sweden | Scientific community (higher education, Research) | | Sweden, Germany |

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| 76 | Oral presentation to a scientific event | Karlsruher Institut fuer Technologie | Invited lecture, SIN ASCO und MUSTANG: Vom NIR-inline-Monitoring für CO2-basierte Prozesse zur CO2-Tiefspeicherung | 01/01/2010 | Institute for Technical Chemistry, University of Oldenburg | Scientific community (higher education, Research) | | Germany |
| 77 | Oral presentation to a scientific event | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | 10th International Conference of Greenhouse Gas Technologies, GHGT-10 | 20/09/2010 | Amsterdam, Netherlands | Scientific community (higher education, Research) | | Widely international |
| 78 | Oral presentation to a scientific event | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS | Thirty-Eighth Workshop on Geothermal Reservoir Engineering | 01/01/2013 | Stanford, California | Scientific community (higher education, Research) | | Widely international |
| 79 | Organisation of Workshops | AGENCIA ES TATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | CODE_BRIGHT for CO2 Sequestration Modelling | 17/06/2010 | Technical University of Catalunya, Barcelona | Scientific community (higher education, Research) | | European countries, Israel |
| 80 | Organisation of Workshops | THE UNIVERSITY OF EDINBURGH | MUSTANG Training Course on Geological Storage of CO2 | 22/06/2011 | Edinburgh, Scotland | Scientific community (higher education, Research) | | European countries, Israel |
| 81 | Organisation of Workshops | UPPSALA UNIVERSITET | iTough2 Introductory Course | 30/11/2012 | Uppsala, Sweden | Scientific community (higher education, Research) | | European countries, Israel |
| 82 | Organisation of Workshops | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS | MUSTANG-TRUST-PANACEA Training Course on Geological Storage of CO2 | 10/10/2013 | Göttingen, Germany | Scientific community (higher education, Research) | | European countries, Israel |
| 83 | Organisation of Workshops | UPPSALA UNIVERSITET | Final workshop presenting the results of MUSTANG | 26/05/2014 | Uppsala, Sweden | Scientific community (higher education, Research) | | Primarily USA, Canada, European nations |
| 84 | Organisation of | UPPSALA UN | Session at European | 01/04/2011 | Vienna, Austria | Scientific comm | | Widely internat |

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| | Workshops | IVERSITET | Geosciences Union General Assembly (Site Characterization of CO2 geological storage sites) | | | unity (higher education, Research) | | ional |
| 85 | Organisation of Workshops | AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS | Session at European Geosciences Union General Assembly (ERE2.2 Site Characterization of CO2 geological storage sites) | 02/04/2012 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 86 | Organisation of Workshops | GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS | Session at European Geosciences Union General Assembly (ERE2.2 Field Methods and Analysis of field data for CO2 geological storage) | 01/04/2013 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 87 | Organisation of Workshops | UPPSALA UNIVERSITET | Session at European Geosciences Union General Assembly (ERE2.2 Field Methods and Analysis of field data for CO2 geological storage) | 01/04/2014 | Vienna, Austria | Scientific community (higher education, Research) | | Widely international |
| 88 | Organisation of Workshops | UPPSALA UNIVERSITET | Brainstorming Day on the long-term fate of geologically stored CO2 | 03/06/2013 | Trondheim, Norway | Scientific community (higher education, Research) | | Widely international |
| 89 | Posters | UPPSALA UNIVERSITET | Conference on Carbon Capture & Sequestration | 04/05/2009 | Pittsburgh, Pennsylvania, USA | Scientific community (higher education, Research) - Industry | | Widely international |
| 90 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | 7th CO2GeoNet Open Forum | 17/04/2012 | Venice, Italy | Scientific community (higher education, Research) - Industry | | Widely international |
| 91 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | IChemE Workshop (invited presentation) | 22/03/2012 | Birmingham, UK | Scientific community (higher education, Research) - Industry | | Widely international |

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| 92 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | CCS Research & Development to Implementation Conference (invited) | 24/05/2011 | London, UK | Scientific community (higher education, Research) - Industry | | Widely international |
| 93 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | 8th CO2GeoNet Open Forum (invited) | 09/04/2013 | Venice, Italy | Scientific community (higher education, Research) - Industry | | Widely international |
| 94 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | CO2 Capture and Storage in the Baltic Sea Countries | 23/05/2013 | Espoo, Finland | Scientific community (higher education, Research) - Industry | | Baltic countries |
| 95 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | GEUS | 11/10/2011 | Copenhagen, Denmark | Scientific community (higher education, Research) | | Widely international |
| 96 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | 4th Annual Global Carbon Capture Utilization and Storage Summit (invited) | 22/10/2013 | Beijing, China | Scientific community (higher education, Research) - Industry | | Widely international |
| 97 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | Leading the way in CCS implementation Workshop (invited) | 14/04/2014 | UKCCS research centre, London, UK | Scientific community (higher education, Research) | | European countries |
| 98 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | European Carbon Capture & Storage Research & Development Workshop (ECCSRD) (invited) | 18/06/2014 | Cranfield university, England | Scientific community (higher education, Research) | | European countries |
| 99 | Oral presentation to a scientific event | UPPSALA UNIVERSITET | Hydrology days | 24/03/2014 | Stockholm, Sweden | Scientific community (higher education, Research) | | Sweden |
| 100 | Interviews | UPPSALA UNIVERSITET | Digging Deep – Professor Auli Niemi discusses MUSTANG – a research project... Profile article in Pan European Networks publications | 01/01/2013 | Sweden | Scientific community (higher education, Research) - Industry - Civil society | | European countries |
| 101 | Interviews | UPPSALA UNIVERSITET | Interview for Uppsala Nya Tidning | 01/06/2009 | Uppsala, Sweden | Civil society - Policy makers - Medias | | Sweden |

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| 102 | Interviews | UPPSALA UN IVERSITET | Interview in Sw edish TV news (Finnish speaking main news) | 01/06/2010 | Uppsala, Sweden | Civil society - Poli cy makers - Medias | | Sweden, Finland |
| 103 | Interviews | UPPSALA UN IVERSITET | Interview for Sydsve nskan (Newspaper covering the issues of Southern Sweden) | 01/06/2010 | Sweden | Civil society - Poli cy makers - Medias | | Sweden |
| 104 | Interviews | UPPSALA UN IVERSITET | Interview in Sw edish Geological Sur vey Information Newspaper in the To day's Industry | 01/04/2010 | Uppsala, Sweden | Scientific comm unity (higher educat ion, Research) - Ind ustry - Civil society | | Sweden |
| 105 | Articles published in the popular press | UPPSALA UN IVERSITET | Newspaper article su bmitted to an Israeli newspaper | 03/01/2011 | Israel | Civil society - Poli cy makers - Medias | | Israel |
| 106 | Interviews | UPPSALA UN IVERSITET | Interview for Swedis h radio | 01/02/2011 | Sweden | Civil society | | Sweden |
| 107 | Oral presentation to a wider public | UPPSALA UN IVERSITET | 'Future wellbeing of mankind – Global th reats and possibilit ies' | 13/06/2013 | Uppsala, Sweden | Scientific comm unity (higher educat ion, Research) - Civ il society | | Sweden |
| 108 | Interviews | UPPSALA UN IVERSITET | Interview in 'Resear ch of the Future' (F ramtidens Forsk ning) | 01/06/2012 | Sweden | Civil society - Poli cy makers - Medias | | Sweden |
| 109 | Interviews | UPPSALA UN IVERSITET | Interview 'Prom ising prospects of C O2 geological storag e in bedrock' in Swe dish Geological Survey's (SGU) atta chment on geolo gical research news to Dagens Industri (Industry of the Day) magazine | 01/07/2011 | Sweden | Civil society - Poli cy makers | | Sweden |
| 110 | Oral presentation to a wider public | UPPSALA UN IVERSITET | GeoArena– Mötes plats Geologi (Meeti ng Place for Ge ology) (invited) | 16/10/2012 | Uppsala, Sweden | Scientific comm unity (higher educat ion, Research) - Civ il society - Policy | | Sweden |

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|-----|-------------------------------------|---------------------|--|------------|-------------------|--|--|---------|
| | | | | | | makers | | |
| 111 | Oral presentation to a wider public | UPPSALA UNIVERSITET | Carbon Capture and Storage possibilities in Sweden Svenska Kolinstitutet (Swedish Coal Institute) – Yearly meeting | 07/03/2013 | Stockholm, Sweden | Industry - Civil society | | Sweden |
| 112 | Oral presentation to a wider public | UPPSALA UNIVERSITET | SwedSTORECO2: towards a national test site for CO2 storage in Sweden | 05/03/2013 | Uppsala, Sweden | Scientific community (higher education, Research) - Industry - Civil society - Policy makers | | Sweden |
| 113 | Interviews | UPPSALA UNIVERSITET | Interview in 'Forskningstidningen' | 01/03/2013 | Sweden | Scientific community (higher education, Research) - Industry - Civil society | | Sweden |
| 114 | Interviews | UPPSALA UNIVERSITET | Presentation to Russian Ambassador to Sweden | 18/05/2011 | Uppsala, Sweden | Policy makers | | Russia |
| 115 | Interviews | UPPSALA UNIVERSITET | Presentation to Danish Ambassador to Sweden | 21/05/2014 | Uppsala, Sweden | Policy makers | | Denmark |

Section B (Confidential or public: confidential information marked clearly)

| LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, UTILITY MODELS, ETC. | | | | | |
|--|--------------|-------------------------------------|---|---------------------------------|---|
| Type of IP Rights | Confidential | Foreseen embargo date dd/mm/yyyy | Application reference(s) (e.g. EP123456) | Subject or title of application | Applicant(s) (as on the application) |

OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND

| Type of Exploitable Foreground | Description of Exploitable Foreground | Confidential | Foreseen embargo date dd/mm/yyyy | Exploitable product(s) or measure(s) | Sector(s) of application | Timetable for commercial use or any other use | Patents or other IPR exploitation (licences) | Owner and Other Beneficiary(s) involved |
|--|--|--------------|----------------------------------|--|--|---|--|---|
| General advancement of knowledge | Expertise from design and planning of the Heletz CO ₂ of injection experiments, the configuration of the well instrumentation and definition of the monitoring technologies deployed at Heletz. | No | | Expertise | CCS development programs | Immediately | None | UU |
| General advancement of knowledge | Design and planning of the field CO ₂ injection experiment and on modeling CO ₂ storage | No | | Expertise | CO ₂ injection and monitoring | Immediately | None | EWRE |
| Commercial exploitation of R&D results | Proprietary software platform for data analysis and visualization for more efficient processing of CO ₂ injection simulation models driven by the LANL PLFOT RAN simulator | No | | Computer software | CO ₂ injection and monitoring | Immediately | None | EWRE |
| Commercial exploitation of R&D results | JSWIWTT: Joint Single-Well Inter-Well Tracer Technology for quantifying fluid transport parameters, with improved on-site management of fluid supply/disposal, reducing hydraulic imbalance, fostering hydro-geomechanical | No | | Joint Single-Well Inter-Well Tracer Technology | CO ₂ injection and monitoring | 2020 | None | UGOE |

| | | | | | | | | |
|--|---|----|--|--------------------------------------|------------------------------|------------------------------------|------|-------------|
| | stability, and reducing the ambiguity of tracer signal inversion | | | | | | | |
| Commercial exploitation of R&D results | PISOT: Passive in-situ sampling technique for two organic tracer species, to avoid issues with tracer co-precipitation upon fluid depressurization and oxygen input | No | | Software and expertise | CO2 injection and monitoring | Immediately | None | UGOE |
| General advancement of knowledge | THM module (Thermal-Hydraulic-Mechanical) in PROOST software platform for the investigation of mechanical impacts subsequent to the injection of CO2 | No | | Software | CO2 injection and monitoring | Non-commercial use available today | None | CSIC |
| General advancement of knowledge | Development of a new approach to FE modelling implemented in Open GeoSys (www.OpenGeoSys.org). | No | | Software | CO2 injection and monitoring | Immediately | None | UEDIN |
| General advancement of knowledge | New approach for fracturing caprocks, and estimating the spacing of fractures developed by fluid overpressure | No | | Expertise | CO2 injection and monitoring | Immediately | None | UEDIN |
| Commercial exploitation of R&D results | 24-level, 4-component/level, deep borehole seismic receiver chain | No | | Deep borehole seismic receiver chain | CO2 injection and monitoring | 1-2 years | None | VIBROMETRIC |
| General advancement of knowledge | Low Frequency Seismic Source: A prototype low frequency surface seismic source has been built based on | No | | Low Frequency Seismic Source | CO2 injection and monitoring | Commercial use in 2015 | None | VIBROMETRIC |

| | | | | | | | |
|--|---------------------|--|--|--|--|--|--|
| | the VIBSIST concept | | | | | | |
|--|---------------------|--|--|--|--|--|--|

| ADDITIONAL TEMPLATE B2: OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND | |
|---|---|
| Description of Exploitable Foreground | Explain of the Exploitable Foreground |
| Expertise from design and planning of the Heletz CO2 of injection experiments, the configuration of the well instrumentation and definition of the monitoring technologies deployed at Heletz. | The Auli Niemi group within partner UU has worked, beyond coordination, on the design and planning of the Heletz CO2 of injection experiments the configuration (together with EWRE) of the wells instrumentation (tendering and procurement) and definition of the monitoring technologies deployed at Heletz. UU has used the gained expertise in the frame of the national and northern CCS development programs. |
| Design and planning of the field CO2 injection experiment and on modeling CO2 storage | In the frame of MUSTANG, EWRE team devoted most of the allocated effort to the design and planning of the field injection experiment and on modelling CO2 storage. The activities related to the field experiments including, site exploration and selection, well location, well design (drilling and completion), monitoring technologies, well stimulation, design of a CO2 injection system, site organization, logistics, tendering and procurement. Substantial expertise has been gathered and deployed in the field and this could be offered as service provider and/or consulting. Part of the experience gained at Heletz was transferred to the design and planning of the Hontomin site. |
| Proprietary software platform for data analysis and visualization for more efficient processing of CO2 injection simulation models driven by the LANL PLFOSTRAN simulator | EWRE extended its proprietary software platform for data analysis and visualization so it can pre and post-process more efficiently CO2 injection simulation models driven by the LANL PLFOSTRAN simulator. Additionally we have developed a simple yet effective code for the simulation of CO2 flow in the injection tube. We can qualify these developments as mature and ready for commercialization. |
| JSWIWTT: Joint Single-Well Inter-Well Tracer Technology for quantifying fluid transport parameters, with improved on-site management of fluid supply/disposal, reducing hydraulic imbalance, fostering hydro-geomechanical stability, and reducing the ambiguity of tracer signal inversion | JSWIWTT: Joint Single-Well Inter-Well Tracer Technology for quantifying fluid transport parameters, with improved on-site management of fluid supply/disposal, reducing hydraulic imbalance, fostering hydro-geomechanical stability, and reducing the ambiguity of tracer signal inversion. This is basically an expertise. The development of JSWIWTT is at the conceptual level. We plan to implement it at the Heletz site, evaluating the results, applying the concept at further sites within deep-georeservoir R&D projects. Commercially deployable expected by year 2020. |
| PISOT: Passive in-situ sampling technique for two organic tracer species, to avoid issues with tracer co-precipitation upon fluid depressurization and oxygen input | PISOT: Passive in-situ sampling technique for two organic tracer species, to avoid issues with tracer co-precipitation upon fluid depressurization and oxygen input. PISOT is a mix of expertise and hardware. PISOT is a product with full field maturity. The technique (hardware + expertise) will be deployed at the Heletz site and at further sites within deep-georeservoir R&D and/or commercial projects. Commercially deployable product as of today. |
| THM module (Thermal-Hydraulic-Mechanical) in PROOST software platform for the investigation of | CSIC has developed a THM module (Thermal-Hydraulic-Mechanical) in their PROOST software platform for the investigation of mechanical impacts subsequent to the injection of CO2. The software platform is still under development but has reached the level of fully developed product without field/market maturity. |

| | |
|--|---|
| mechanical impacts subsequent to the injection of CO2 | |
| Development of a new approach to FE modelling implemented in OpenGeoSys (www.OpenGeoSys.org). | UEDIN has been actively contributing to the development of a new approach to FE modelling implemented in OpenGeoSys (www.OpenGeoSys.org). This is a knowledge base increase, no specific commercial value. |
| New approach for fracturing caprocks, and estimating the spacing of fractures developed by fluid overpressure | New approach for fracturing caprocks, and estimating the spacing of fractures developed by fluid overpressure. Knowledge base increase, may have long term impact but no specific value at this stage. Development of Geomechanical Facies Concept allowing holistic comparison of different geological sites and settings with relevance to sub surface geo-engineering. This is a knowledge base, demonstrated for geothermal work, CO2 work and soon for fracking. Experimental investigation of fluid flow in low permeability fractured rock experimental expertise, already of interest to commercial parties. |
| 24-level, 4-component/level, deep borehole seismic receiver chain | 24-level, 4-component/level, deep borehole seismic receiver chain: Digital receivers, with 4-components/level were developed independently of the MUSTANG project. The tool has individually programmable amplifiers and 24-bit down-hole A/D conversion for up to 96-levels on a wireline cable. Its modules are interchangeable, with software-driven reconfiguration. The 4th component can be a hydrophone or a 1-Hz geophone, to provide a low-frequency solution. Although the development of the tool was funded independently of the Mustang Project, it has been integrated to the active and passive seismic monitoring at Heletz. This is a full product without field maturity. To acquire field maturity, the product is still to be fully proven at Heletz before and during injection. The low frequency capability is not yet commercially widely requested. However, in its standard band version the tool has been used in several mining-related 3D-VSP surveys.??? |
| Low Frequency Seismic Source: A prototype low frequency surface seismic source has been built based on the VIBSIST concept | Low Frequency Seismic Source: A prototype low frequency surface seismic source has been built based on the VIBSIST concept. The prototype is light and mobile, to serve the current needs of the project. However, the source emits a wide-band signal, extended to the lower part of the spectrum. The initial objective was to develop a near surface 'permanent' source. Later in the project it has been considered that placing a permanent prototype source at a predetermined fixed location would make problematic if not impossible the detection by seismics of such a small CO2 plume as derived through modelling. The same concept can however be used both for mobile and for permanent subsurface installations. This product is a prototype with proof of concept: The source has been used extensively in projects not related to CO2 capture and has proven its commercial worth. However, it has not yet been tested for this specific application and some technical variations are still expected to occur. A commercial version will start being offered in 2015. |

4.3 Report on societal implications

B. Ethics

| | |
|--|----|
| 1. Did your project undergo an Ethics Review (and/or Screening)? | No |
| If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final reports? | |
| 2. Please indicate whether your project involved any of the following issues : | |
| RESEARCH ON HUMANS | |
| Did the project involve children? | No |
| Did the project involve patients? | No |
| Did the project involve persons not able to consent? | No |
| Did the project involve adult healthy volunteers? | No |
| Did the project involve Human genetic material? | No |
| Did the project involve Human biological samples? | No |
| Did the project involve Human data collection? | No |
| RESEARCH ON HUMAN EMBRYO/FOETUS | |
| Did the project involve Human Embryos? | No |
| Did the project involve Human Foetal Tissue / Cells? | No |
| Did the project involve Human Embryonic Stem Cells (hESCs)? | No |
| Did the project on human Embryonic Stem Cells involve cells in culture? | No |
| Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos? | No |
| PRIVACY | |
| Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)? | No |
| Did the project involve tracking the location or observation of people? | No |
| RESEARCH ON ANIMALS | |

| | |
|--|----|
| Did the project involve research on animals? | No |
| Were those animals transgenic small laboratory animals? | No |
| Were those animals transgenic farm animals? | No |
| Were those animals cloned farm animals? | No |
| Were those animals non-human primates? | No |
| RESEARCH INVOLVING DEVELOPING COUNTRIES | |
| Did the project involve the use of local resources (genetic, animal, plant etc)? | No |
| Was the project of benefit to local community (capacity building, access to healthcare, education etc)? | No |
| DUAL USE | |
| Research having direct military use | No |
| Research having potential for terrorist abuse | No |

C. Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

| Type of Position | Number of Women | Number of Men |
|--|-----------------|---------------|
| Scientific Coordinator | 1 | 0 |
| Work package leaders | 4 | 13 |
| Experienced researchers (i.e. PhD holders) | 14 | 39 |
| PhD student | 7 | 8 |
| Other | 9 | 29 |

| | |
|---|---|
| 4. How many additional researchers (in companies and universities) were recruited specifically for this project? | 7 |
| Of which, indicate the number of men: | 4 |

D. Gender Aspects

| | |
|---|----------------|
| 5. Did you carry out specific Gender Equality Actions under the project ? | No |
| 6. Which of the following actions did you carry out and how effective were they? | |
| Design and implement an equal opportunity policy | Not Applicable |
| Set targets to achieve a gender balance in the workforce | Not Applicable |
| Organise conferences and workshops on gender | Not Applicable |
| Actions to improve work-life balance | Not Applicable |
| Other: | |
| 7. Was there a gender dimension associated with the research content - i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed? | No |
| If yes, please specify: | |

E. Synergies with Science Education

| | |
|---|--|
| 8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)? | Yes |
| If yes, please specify: | Formal training courses at graduate level; involvement of masters and PhD students in research |
| 9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)? | Yes |

F. Interdisciplinarity

| | |
|---|---|
| 10. Which disciplines (see list below) are involved in your project? | |
| Main discipline: | 1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences) |
| Associated discipline: | |
| Associated discipline: | 1.1 Mathematics and computer sciences [mathematics and other allied fields: computer |

sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

G. Engaging with Civil society and policy makers

| | |
|--|---|
| 11a. Did your project engage with societal actors beyond the research community? (if 'No', go to Question 14) | Yes |
| 11b. If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)? | No |
| 11c. In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)? | |
| 12. Did you engage with government / public bodies or policy makers (including international organisations) | Yes, in communicating /disseminating / using the results of the project |
| 13a. Will the project generate outputs (expertise or scientific advice) which could be used by policy makers? | Yes - as a secondary objective (please indicate areas below - multiple answer possible) |
| 13b. If Yes, in which fields? | |
| Agriculture | No |
| Audiovisual and Media | No |
| Budget | No |
| Competition | No |
| Consumers | No |
| Culture | No |
| Customs | No |
| Development Economic and Monetary Affairs | No |
| Education, Training, Youth | Yes |
| Employment and Social Affairs | No |
| Energy | Yes |
| Enlargement | No |
| Enterprise | No |
| Environment | Yes |
| External Relations | No |
| External Trade | No |
| Fisheries and Maritime Affairs | No |
| Food Safety | No |

| | |
|--------------------------------------|---------------------|
| Foreign and Security Policy | No |
| Fraud | No |
| Humanitarian aid | No |
| Human rightsd | No |
| Information Society | No |
| Institutional affairs | No |
| Internal Market | No |
| Justice, freedom and security | No |
| Public Health | No |
| Regional Policy | No |
| Research and Innovation | Yes |
| Space | No |
| Taxation | No |
| Transport | No |
| 13c. If Yes, at which level? | International level |

H. Use and dissemination

| | |
|---|-----|
| 14. How many Articles were published/accepted for publication in peer-reviewed journals? | 171 |
| To how many of these is open access provided? | 50 |
| How many of these are published in open access journals? | 7 |
| How many of these are published in open repositories? | 40 |
| To how many of these is open access not provided? | 6 |
| Please check all applicable reasons for not providing open access: | |
| publisher's licensing agreement would not permit publishing in a repository | Yes |
| no suitable repository available | No |
| no suitable open access journal available | No |
| no funds available to publish in an open access journal | No |
| lack of time and resources | No |
| lack of information on open access | No |
| If other - please specify | |
| 15. How many new patent applications ('priority filings') have been made? | 0 |

("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).

| | |
|-------------------|---|
| Trademark | 0 |
| Registered design | 0 |
| Other | 0 |

17. How many spin-off companies were created / are planned as a direct result of the project?

0

Indicate the approximate number of additional jobs in these companies:

0

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

Difficult to estimate / not possible to quantify, None of the above / not relevant to the project

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (FTE = one person working fulltime for a year) jobs:

0

I. Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

Yes

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

No

22. Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

| | |
|--|-----|
| Press Release | Yes |
| Media briefing | Yes |
| TV coverage / report | Yes |
| Radio coverage / report | Yes |
| Brochures /posters / flyers | Yes |
| DVD /Film /Multimedia | No |
| Coverage in specialist press | Yes |
| Coverage in general (non-specialist) press | Yes |

| | |
|--|-----|
| Coverage in national press | Yes |
| Coverage in international press | Yes |
| Website for the general public / internet | Yes |
| Event targeting general public (festival, conference, exhibition, science café) | Yes |

23. In which languages are the information products for the general public produced?

| | |
|------------------------------------|-----|
| Language of the coordinator | No |
| Other language(s) | No |
| English | Yes |

| | |
|---|---|
| Attachments | Final report Mustang.pdf |
| Grant Agreement number: | 227286 |
| Project acronym: | MUSTANG |
| Project title: | A multiple space and time scale approach for the quantification of deep saline formations for CO2 storage |
| Funding Scheme: | FP7-CP |
| Project starting date: | 01/06/2009 |
| Project end date: | 31/05/2014 |
| Name of the scientific representative of the project's coordinator and organisation: | Prof. Auli Niemi UPPSALA UNIVERSITET |
| Name | |
| Date | 03/10/2014 |

This declaration was visaed electronically by Auli NIEMI (ECAS user name nniemiau) on 03/10/2014