MUSTANG

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

Project Number:227286

Work-Package: *WP10*

WP Title
Impact

Deliverable *D10.14*
Proceedings of the third annual workshop

March 2013

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CO	Confidential (only the consortium and the EU officers)	

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Executive summary

This training course presented an overview of the current status of CCS operations and research, with the objective of providing the participants with a basic understanding of the scientific and technical issues that need to be address for the successful injection of CO_2 into saline formations. The course focused on the technical and scientific considerations for CO_2 injection, the exploration of critical process in laboratory studies and by field techniques, as well as the related numerical modeling. The training course was intended for students and professionals that wish to gain a greater understanding of current research findings in the CCS field. Days 1 and 2 focus on general topics, while Days 3 and 4 provides a short introductory training course to parallel CO2 simulation capabilities of the PFLOTRAN software.

The course was jointly organized by three ongoing EU FP7 Research and Development projects working on the topic (MUSTANG, PANACEA and CO_2TRUST).

Keywords	Training course, PFLOTRAN, CCS operations

Course description

Carbon capture and storage (CCS) is a rapidly developing field with scientific and technical challenges that are being addressed globally. This training course presented an overview of the current status of CCS operations and research, with the objective of providing the participants with a basic understanding of the scientific and technical issues that need to be address for the successful injection of CO_2 into saline formations. The course focused on the technical and scientific considerations for CO_2 injection, the exploration of critical process in laboratory studies and by field techniques, as well as the related numerical modeling. The training course was intended for students and professionals that wish to gain a greater understanding of current research findings in the CCS field. Days 1 and 2 focus on general topics, while Days 3 and 4 provides a short introductory training course to parallel CO_2 simulation capabilities of the PFLOTRAN software.

The course was jointly organized by three ongoing EU FP7 Research and Development projects working on the topic (MUSTANG, PANACEA and CO_2TRUST).

Lectures during the first two days of the training course covered the following topics:

- Overviews of the current status of CCS projects and the main challenges
- Information needed and data assembly for characterization of storage sites
- Field techniques for site characterization
- Field techniques for monitoring
- Laboratory experiments of critical properties and processes
- Processes taking place during CO_2 injection and storage, their conceptual and numerical modeling

The last two days were devoted to training on the use of the PFLOTRAN software. The training will be delivered by the developers of this software.

PFLOTRAN is an open source parallel, multiphase, multicomponent and multiscale code for the modelling of subsurface processes. It has the capabilities to model CO_2 storage problems, including thermal, chemical and mechanical effects.

The main goal of this course was to give you the essential understanding and tools to start applying the software to your models. Participants were guided from the software installation to the first simulation cases on a number of hands-on problems.

The course was held over two days, and will be given by the software developers. Participants were required to bring their own laptops.

1.1.Teaching Staff and organisers

The tutors of the course are directly or indirectly involved in the MUSTANG, PANACEA or CO_2 TRUST projects and have an excellent scientific and technical knowledge of the subject. The lThe list of teaching staff and organisations involved in the training course is shown in the table below.

Table 1. Teaching staff

Jacob Bear (co-chair)	Technion Israel Institute of Technology	Israel
Auli Niemi(co-chair)	Uppsala University	Sweden
Jacob Bensabat	EWRE Ltd	Israel
Jésus Carrera	CSIC	Spain
Calin Cosma	Vibrometric	Finland
Marco Dentz	CSIC	Spain
Katriona Edlman	University of Edinburgh	Scotland
Mikael Erlström	Swedish Geological Survey	Sweden
Philippe Gouze	CNRS	France
Stuart Hazeldine	University of Edinburgh	Scotland
Monika Ivandic	Uppsala University	Sweden
Christopher Juhlin	Uppsala University	Sweden
Satish Karra	LANL	USA
Peter Lichtner	LANL	USA
Chris McDermott	University of Edinburgh	Scotland
Johannes Miocic	University of Edinburgh	Scotland
Philippe Pezard	CNRS	France
Henry Power	University of Nottingham	England
Martin Sauter (co-chair)	Georg-August-Universität Göttingen	Germany
Richard Tran Mills	Oakridge National Laboratory	USA

1.2. Programme

The course was programmed as a 3 day course. It was organised as theoretical presentations and following practical exercises with the delivered tutorials.

Presentations and contents of the short course are annexed and organised per each day course (Annex 1).

Table 2 Course programme

Training Course Program Outline
Wednesday 9th October *08:30 - 9:00 Registration* 9:00 - 9:15 Introduction to the course and practicalities (Auli Niemi, Martin Sauter, Alexandru Tatomir) **Part I – General Background** Background to CO_2 geological storage, Experiences from field injection projects, Experiences from natural analogues, Capacity estimates of CO_2 geological storage sites. 9:15- 9:45 Introduction to geological storage of CO_2 and examples of field projects (Auli Niemi) 09:45-10:30 Experiences from natural analogues (Johannes Miocic)

10:30-10:45 Coffee break

10:45-11:30 Capacity estimates of CO_2 geological storage sites (Johannes Miocic)

Part II– Processes and modeling

Overview of the processes and their relevance to different key questions in geosequestration, Mathematical models for CO_2 spreading and related processes, Numerical Modeling of CO2 geological storage.

11:30-12:30 Mathematical models for CO_2 spreading and related processes (part 1; two-phase flow) (Jacob Bear)

12:30 – 13:30 Lunch

13:30-15:30 Mathematical models for CO_2 spreading and related processes (part 2, non-isothermal transport, deformable porous media) (Jacob Bear)

15:30 -15:45 Coffee

15:45-16:45 Hydro-mechanical processes (Henry Power)

Part III - Experimental Characterization and Monitoring

Numerical Modeling of CO_2 geological storage continued, Scale effects and upscaling

16:45-17:45 Laboratory experiments for CO_2 geological characterization (Katriona Edlmann)

17:45-18:00 Closing of Day 1

Thursday 10th of October

Part III - Experimental Characterization and Monitoring (cont.)

9:00-9:45 Characterization and monitoring of an injection experiment – Example Heletz, Israel (Jacob Bensabat)

9:45-10:30 Characterization and monitoring of an injection experiment – Example Hontomin, Spain (Jesus Carrera)

10:30-10:45 Coffee break

10:45-11:45 Geophysical monitoring of CO_2 geological storage sites, case study Ketzin (Monika Ivandic)

Part IV– Risk Assessment

Field Characterization of CO_2 storage sites, Monitoring of CO_2 storage sites, Laboratory experiments for characterizing injection sites and for evaluating the influence of CO_2 on rock and fluids

11:45-12:30 Risk assessment in geological storage of CO2 (Katriona Edlmann)

12:30-13:30 Lunch

Part V - Numerical modeling of geological storage of CO_2

13:30-14:15 Numerical Modeling of Geological Storage – part 1; Methodologies (Jesus Carrera)

14:15 – 15:15 Numerical Modeling of Geological Storage – part 2; Results and examples (Jesus Carrera)

15:15 – 15:30 Coffee

15:30 – 16:30 Scale effects and upscaling (Marco Dentz)

16:30 – 17:00 Approaches to deal with large scale problems (Auli Niemi)

17:00-17:15 Closing of day one and introduction to days 3 and 4

Friday 11th

Training course on the use of PFLOTRAN model.

PFLOTRAN (http://ees.lanl.gov/pflotran/) is a massively parallel code capable of simulating flow, reactive transport, heat transport and mechanical effects in geological reservoirs. The course will be devoted on training on construction and setting of applications relevant to the storage of CO_2 in geological formations.

9:00 Introduction to PFLOTRAN (Peter Lichtner)

10:00 Installing PETSc & PFLOTRAN on Windows, Macs and Linux machines (Richard Mills)

10:30 Setting up the input file (Lichtner/Karra/Mills)

- Reactive Transport
- Supercritical CO2

12:00 Lunch

13:30 Example problems

14:00 Multiple continuum model (Satish Karra/Peter Lichtner)

14:30 Modelling mechanical deformation (Satish Karra)

15:00 Hands-on problems / examples

Saturday 12th of October

Training course on the use of PFLOTRAN model.

9:00 Parallel performance (Richard Mills)

9:30 Hands-on problems/Examples [continued]

Links to the contents of the course

Part I – General Background

Introduction to geological storage of CO_2 and examples of field projects (Auli Niemi)

Experiences from natural analogues (Johannes Miocic)

Capacity estimates of CO_2 geological storage sites (Johannes Miocic)

Part II– Processes and their mathematical modelling

Mathematical models for CO_2 spreading and related processes (Jacob Bear)

Hydro-mechanical processes

(Henry Power)

Part III– Experimental Characterization and Monitoring

Laboratory experiments for CO_2 geological characterization (Katriona Edlmann)

Characterization and monitoring of an injection experiment – Example Heletz, Israel (Jacob Bensabat)

Characterization and monitoring of an injection experiment – Example Hontomin, Spain (Jesus Carrera)

Geophysical monitoring of CO_2 geological storage sites, case study Ketzin (Monika Ivandic)

Part IV– Risk Assessment

Risk assessment in geological storage of CO_2 (Katriona Edlmann)

Part IV– Numerical modelling of Geological storage of CO_2

Numerical Modeling of Geological Storage – part 1; Methodologies (Jesus Carrera)

Numerical Modeling of Geological Storage – part 2; Results and examples (Jesus Carrera)

Approaches to deal with large scale problems (Auli Niemi)