MUSTANG News

December 2010

3rd NEWSLETTER

In this issue:

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ABOUT MUSTANG

http://www.co2mustang.eu

A multiple space and time scale approach for the quantification deep saline formations for CO_2 storage

This 3rd newsletter gives a brief overview of the progress and news during the period June 2010-December 2010.

MUSTANG started June 2009. It is mainly funded by the EU FP7, and is coordinated by Uppsala University. The MUSTANG consortium is comprised of 19 institutions (universities, research institutes and SMEs). In addition, a number of organizations are affiliated through the Sceintific, Industrial and regulatory Advisory Board (SIRAB).

MUSTANG aims at developing guidelines, methods and tools for the characterization of deep saline aquifers for long term storage of CO_2, based on a solid scientific understanding of the underlying critical processes. Field investigation technologies specifically suited to CO_2 storage will be improved and developed. These are destined to improve the determination of the relevant physical and chemical properties of the site, and enabling short response times in the detection and monitoring of CO_2 plumes in the reservoir and overburden during both the injection and containment phases. An improved understanding of the relevant processes of CO_2 spreading is aimed at by means of theoretical investigations, laboratory experiments, natural analogue studies as well as a dedicated field scale injection test, to take place at the Heletz site (Israel).

Newsletter submitting organization:

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Project support

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SUMMARY OF ACTIVITIES

Key activities and progress during the previous six months are summarized as follows:

Mustang consortium visit to Maguelone site (France) during the 3rd Consortium meeting

- Scientific and technical work in the project work-packages is progressing according to the schedule, and presented in detail below. Important activities included: (i) data compilation for the five MUSTANG test sites and the establishment of a common modelling framework for them, (ii) production of a report summarizing and describing the processes relevant to the behaviour and modeling of CO_2 in saline formations during the injection, spreading and containment stages, (iii) work progress on the Heletz and Maguelone field experiments, and iv) initiation of failure mode analysis (FMA) model.
- Progress of the project was presented during the 3rd Consortium Meeting held in Montpellier (France) in June 2010, along with visit to the Maquelone site.
- A training course on CO_2 sequestration modelling was organised and held on 17-19 June 2010 at the Technical University of Catalunya, Barcelona, Spain.
- First reporting period to EU is presently ongoing.

3th CONSORTIUM MEETING IN MONTPELLIER

Last Consortium meeting took place in Montpellier In June 2010 and was organised by Geosciences Montpellier (UNIVERSITE MONTPELLIER 2).

The meeting was divided into sessions over 3 days. During the first day invited speakers from European Commission, followed by CIUDEN, Lawrence Berkeley National Laboratory, IEAGHG, and Petrobras, presented their related CCS programmes and gave inputs to the project as external advisors.

During the second day, the WP leaders presented the work progress and next steps in their respective work packages. A visit to the SIMEX ("**S**hallow **I**njection **M**onitoring **Ex**periment") site in Maguelone was also held.

Within the last day, workshops on specific work packages were organised:

- Workshop 1 was focused on Processes, Modeling and Scale Effects
- Workshop 2 on Risk assessment was performed in the frame of WP9
- Workshop 3 was focused on the validation experiment at the Heletz site.

JACOB BEAR HORTON MEDAL !

MUSTANG partner Prof Jacob Bear is the 2010 recipient of the highly recognized Horton medal. The prize is awarded by American Geophysical Union (AGU) to no more than one person annually for 'outstanding contributions in hydrology'.

RESEARCH Progress by Work Packages

The scientific work program is structured along 8 Research Technological Development Work Packages (WP 2-10). Below is a brief progress of the work in them.

Test sites (WP2)

The compilation of data from the MUSTANG test sites in South Scania (Sweden), Horstberg (Germany), Valcele (Romania), Heletz (Israel) and Hontomín (Spain) has been achieved.

A report on 3D structures of test sites has been delivered. It includes a set of geological models of the different sites. The models are intended to be used for both the visualisation and as input for site specific modelling of CO_2 injection and storage at the different sites. The 3D structural modelling work is an ongoing process throughout the Mustang project. The site models will therefore consequently be updated and refined during the whole characterisation process. Deliverable DO22 is, thus, intended to give a general outline of the major structural elements and surfaces that are essential to the numerical CO_2 modelling to be performed at the different sites.

WP leader: Swedish Geological Survey (SGU)

For more information: Dr. Mikael Erlström

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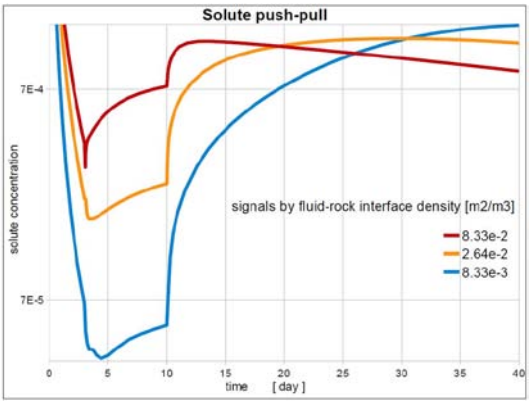
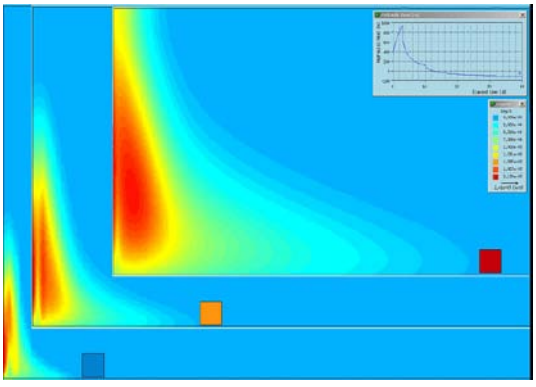


Field quantification techniques (WP3)

This WP develops CCS adapted field measurement techniques for assessing the suitability of a deep geologic saline formation for CO_2 storage. The following progress was achieved:

- Laboratory investigations for the examination of suitability of CO_2-brine interfacial tracers: identification of analogue fluids for experiments at ambient temperatures.
- Preliminary design for hydraulic and tracer experiments at the Heletz experimental site: Numerical studies on the interpretability of solute tracer signals from single-well push-pull tests with limited duration of the 'pull', i.e. fluid withdrawal phase (which is often unavoidable because of cost, time and operational restrictions). To a certain extent it appears to be possible to estimate fluid-rock interface densities from incipient tracer 'pull' signals, when tracer withdrawal tailings are not available (cf. attached picture).
- Examination of available data from Horstberg as to the suitability of the assessment of the sandstone reservoir: ongoing.
- Valcele test site characterisation: Interpretation of 8 production tests in 3 oil boreholes; injection tests in Badenian complex II; chemical compatibility tests for injection water and water reservoir for Badenian complex are in progress
- Development of geophysical monitoring techniques: Investigation objectives, technical aspects and field activities for the Heletz site were planned. Seismic modelling studies show that sources and receivers can be spaced at about 100m separation for imaging a CO_2 plume if frequencies as low as 5Hz can be generated.



Tracer concentration signals from single-well push-pull tests in parallel-fracture systems with different fracture densities. Fracture aperture: 2e-4 m ; matrix porosity: 20% ; solute diffusion coefficient: 3e-8 m^2/s ; fluid injection: 1000 m^3 /d for 3 days ; fluid withdrawal: 100 m^3/d for 30 days

The tailing of solute withdrawal signals is rarely available from field tests, and the fracture area parameter has to be determined from incipient tracer signals only.

WP leader: University of Götttingen (UGOE)

For more information: Prof. Dr. Martin Sauter

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Laboratory experiments and natural analogues (WP4)

This WP aims at producing a comprehensive, self consistent experimental and field observation database for validating models. Tasks achieved are:

- Experiments: Preliminary experiment using reservoir and caprock cores, provided by the Geological Survey of Israel, is performed by CNRS and UEDIN. Cores from several other sites have been sampled for batch-reactor and flow-through experiments. New equipment for performing batch-reactor and flow-through experiments reproducing in-situ conditions have been set up and are now coming into operation. A set of flow-through experiments through fractured cement samples has been performed for validating the experimental protocols.
- Brine properties: The construction of the equipment for measuring the $scCO_2$-brine mixture properties is in its final stage.
- Tracers: Tests for evaluating the measurement accuracy of organic tracer in $scCO_2$/brine mixture using in-line Raman spectrometry are in progress. Dependencies on pH and temperature of reaction kinetics of organic tracers in brine are established.
- Analogues: The study of analogues for assessing the critical combination of processes that could lead to the failure of the caprock integrity is in progress.
- Modelling: A new FE numerical method has been developed for modelling heterogeneity to enable coupled process modelling of critical combinations of processes that could lead to caprock failure.

High p-T autoclave for measuring CO_2-brine mixture properties up to 200°C and 50 MPa

WP leader: Centre National de la Recherche Scientifique (CNRS)

For more information: Dr. Philippe Gouze

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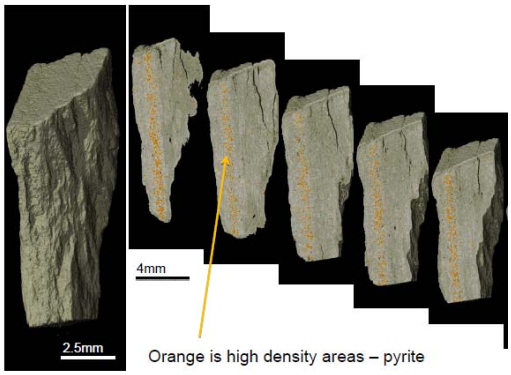

X- ray CT image and slice through cap-rock sample exposed to brine and CO_2 at 90ºC for 120 days (Edinburgh University, UEDIN)

Processes (WP5)

The 1st consortium meeting, last June 2009, marked the beginning of work focused on modeling the injection, spreading and storage of CO_2 in deep brine-containing geological formations.

Within the first period, the various teams involved in WP5 have been conducting research on the processes that occur in the formation---flow, dispersion, diffusion, chemical reaction, storage due to compressibility of fluids and solid matrix, heat transport, etc. This phase was reported in the first deliverable of the WP.

During the meeting in Montpelier (3rd consortium meeting), a workshop was held on the content of a second deliverable (named *A comprehensive description of all processes involved*). As a consequence, the various teams have been conducting research on developing mathematical models, incorporating the processes discussed earlier.

Research results are now being assembled in the second deliverable which is currently under preparation. This report will contain the mathematical models of relevant to CO_2 geological storage.

WP leader: Israel Institute of Technology

For more information: Prof. Jacob Bear

cvrbear@techunix.technion.ac.il

Validation (WP6)

This WP comprises two field experiments: 1) testing of monitoring technologies at shallow depths (Maguelone, France); 2) CO_2 injection experiments at ca. 1500 m depth (Heletz, Israel).

- The Maguelone experimental site has been substantially developed over the past 6 months with the start of the SIMEx project (including the drilling of 5 new holes to a minimum of 20m depth, two of them cored through the 3m thick reservoir located at 15m depth). Downhole logging was conducted in each of the new holes, with surface geophysics (electrical and seismic) deployed along orthogonal lines, the design of a dedicated injection hole and the establishment of 3 downhole observatories. These observatories include a Schlumberger (SWS) WestBay completion for fluid sampling and downhole pressure monitoring, and two electrical resistivity arrays designed, constructed and installed by ImaGeau. For the latter, a double-cask was designed and constructed in the context of MUSTANG, with a capacity for CO_2 injection in a central tube and possible deployment down to 1500 m depth.
- Substantial work was completed during the last six months at the Heletz injection test site

  1) Concerning work on the technicalities of the injection site, the following has been achieved: the final design of the instrumentation for the injection and monitoring well H18; the consolidation of the simulations of the push-pull and the dipole experiment; the beginning of the injection well re-entry process; and the configuration of the ground facilities (i.e. storage tanks, pipes and compressor/pump).

  2) Concerning the extensive borehole installations on the site, a tender for the procurement of the down-hole instrumentation was issued by the University of Uppsala and the system by SOLEXPERTS from Switzerland was selected for the instrumentation of the injection and monitoring wells. A service company for the cementation and cleaning of H18 and purchase of additional consumables has also been contracted and CO_2 suppliers have been identified.

WP leader: Environmental & Water Resources Engineering Ltd. (EWRE)

For more information: Dr. Jacob Bensabat

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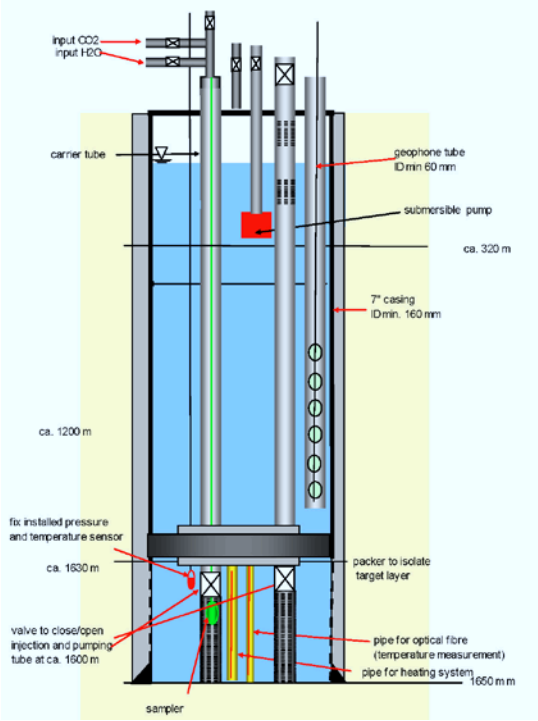

Injection well at Heletz site

Numerical model development and modelling (WP7)

During these months, the modelling scenarios for the site models have been defined. Models will be built for the five MUSTANG sites, South Scania (Sweden), Horstberg (Germany), Valcele (Romania), Hontomín (Spain) and Heletz (Israel). The modelling work will extend most of the duration of the MUSTANG project and the procedure and modelling scenarios outlined in these last 6 months will be continuously updated and developed as the work proceeds, and more data and methods become available.

WP leader: Nottingham University (UNOTT)

For more information: Prof. Henry Power

Henry.Power@nottingham.ac.uk

SIMEX ("Shallow Injection Monitoring Experiment") experimental site Maguelone

Scale effects (WP8)

Relevant processes for the large scale modelling of CO_2 storage in heterogeneous reservoirs have been studied. We identified and studied the salient processes related to heterogeneity in the physical and chemical medium properties and their interaction with the local scale flow, reaction and transport laws. These processes lead to the scale effects observed for large scale flow, reaction and transport and need to be quantified in a realistic large scale modelling exercise. The main findings to date include: (i) development of non-local effective transport formalisms and their application to reactive transport in heterogeneous media with fast reactions; (ii) application of the above formalism to reactive transport with kinetic reactions and derivation of an upscaled equation. The result explains observed scale effects of kinetic reaction rates and illustrates that both chemistry and transport affect upscaling; (iii) advances in the understanding of spreading and mixing, including the proposal of a new mixing scale, that provides a basis for the formulation of general transport equations; (iv) formulation of a perturbation-based upscaling of multiphase flow parameters under stable flow conditions.

WP leader: National Research Council of Spain (CSIC)

For more information: Prof. Jesús Carrera

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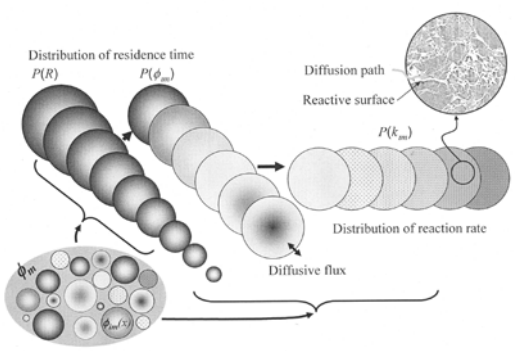

Conceptual models of matrix diffusion and reaction. The two directions indicated in the figure stand for chemical ($P(k_{im})$, distribution of kinetic rate coefficient) and physical heterogeneity ($P(R)$ and $P(\phi_{im})$, the distributions of inclusion sizes and porosity). The CT scan of the rock illustrates the non-resolved subscale. The different sphere sizes stand for the different types of heterogeneity that are unified in the medium, as indicated by the ellipse in the lower left corner.

Certification (WP9)

Acquisition of data from the Heletz site enabled the initiation a FMEA analysis (Failure Modes and Effect Analysis). The objectives of a FMEA approach are to identify all potential failure modes of a system and of its sub-systems, to analyze the consequences, in order to take the appropriate measures for the situations that would be unacceptable. The FMEA is currently applied to 3 sub-systems of the Heletz site: (i) the caprock and the (ii) sealing fault(s) which have a major function of confining the injected CO_2, and (iii) the reservoir which has a major function of enabling CO_2 injection, and to have the capacity to contain all the CO_2.

In parallel, the development of the DSS (Decision Support System) continues. The DSS is a J2EE application including different modules (GIS, visualization, database and analysis) to support site criteria regarding Capacity, Injectivity and Containment.

WP leader: Oxand

For more information: Dr. Yvi LE GUEN

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Impact (WP10)

Dissemination activities are always being developed in parallel with the technical activities of the project. The tasks undertaken include production of the newsletter and updates to the project website and to the knowledge management system of the project. The work also include participation to and evaluation of the training workshops, first one being held in Barcelona (June 2010).

WP leader: Amphos 21

For more information: Beatriz Medina

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Visit to Maguelone site (France) during the 3rd Consortium Meeting in Montpellier

RESULTS FROM FIRST TRAINING COURSE

The course (17-19 June 2010, Barcelona) provided contextual training on the use of CODE_BRIGHT to model and to simulate some phenomena related to CO_2 geological storage. It targeted both partners currently involved in the research areas of MUSTANG as well as new members of the CCS community.

The objectives of this short course were:

- Showing the capabilities and the numerical approach of CODE_BRIGHT.
- Developing simple tutorial examples in the context of CO_2 geological storage.
- Discussing the feasibility of extending some functionalities of CODE_BRIGHT to describe supercritical CO_2 storage.

The course was attended by 15 participants from different countries and types of organisations. The participants were members of universities (75%), consultancies (19%), and research institutes (6%). According to the participants, the course was generally well balanced and highly informative. Overall, the training course was very positively evaluated and fulfilled the participant expectations. The Institute of Environmental Assessment and Water Research (IDAEA-CSIC) and the Department of Geotechnical Engineering and Geosciences of the Technical University of Catalonia (UPC) were the organisers of this training course.

A WORD FROM THE COORDINATOR

After 18 months in operation, Mustang project is now in the stage where the first solid results start to emerge. This can be seen e.g. in the extensive amount of MUSTANG contributions submitted to the coming EGU conference in Vienna, April 2011.

Now it is a good time to address our most sincere thanks to all the members of the SIRAB that have provided their advice and support and helped us to progress. Besides the SIRAB contributions in our meetings that we all have had the possibility to follow, I would especially like to bring to your attention our visits to CO2CRC and Otway site in Australia (hosted by P.Cook and S. Sharma) and to Lawrence Berkeley National Laboratory, USA, where the LBNL colleagues, in particular L.Myer and B.Freifeld, have organized advisory group meetings to discuss the experimental design of our injection experiment. In addition, the contributions and advice by many others, by S.Benson from Stanford, T.Torp from Statoil, C.Bernstone from Vattenfall, to mention some, have been extremely helpful.

During the year that passed, I also had the great opportunity to participate to two important collaboration meetings organized by the EU, as the representative of the MUSTANG project. One, held in Weyburn and in Ottawa, Canada (coordinated by J. Schuppers) discussed the initiation of a formal EU-Canada collaboration, while the other one held in Amsterdam (coordinated by P. Petrov) discussed the collaboration between EU and Japan. It was interesting to me to learn from the Canadian and Japanese CCS experience, including the experiences from the pioneering Weyburn site, as well as have the possibility to present the MUSTANG project to them.

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NEXT EVENTS

Below are given key events of MUSTANG project that are open to external participation:

4th Consortium Meeting

17 - 20 January 2011, Haifa (Israel)

5th Consortium Meeting

20 - 22 June 2011, Edinburgh (UK)

JANUARY 2011

Mo	Tu	We	Th	Fr	Sa	Su
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31						

4th Consortium meeting

JUNE 2011

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5th Consortium meeting

MUSTANG PARTNERS

MUSTANG ADVISORY BOARD- SIRAB

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- **International scientific advisors**

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