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A Multiple Space and Time Scale Approach for the Characterization and Modeling of Deep Saline Formations for CO2 storage

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Abstract

MUSTANG (A MUltiple Space and Time scale Approach for the quaNtification of deep saline formations for CO2 storaGe) is a four year large-scale integrating project to span from 2009 to 2013 and to be funded by the **EU FP7**, under the coordination of the Uppsala University. The **MUSTANG** consortium comprises 19 institutions. It aims at developing guidelines, methods and tools for the characterization of deep saline aquifers for long term storage of CO2, based on a solid scientific understanding of the underlying critical processes. Field investigation technologies specifically suited to CO2 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 CO2 plumes in the reservoir and overburden during both the injection and containment phases. An improved understanding of the relevant processes of CO2 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). These focus is on processes relevant to the 1) seal integrity; 2) possible seepage via pre-existing or reactivated conductive fault zones; 3) effect of formation heterogeneities; 4) CO2 trapping mechanisms; and 5) effective simulation of the wide span of spatial and temporal scales of the coupled thermo-hydro-mechanical-chemical processes. Based on the improved process models, conceptual and numerical models will be developed for analyzing CO2 injection and storage and then applied at a number of test sites representing different geological settings and geographical locations in Europe and worldwide.

Introduction and Background

It is widely recognized that extensive efforts are required to mitigate the atmospheric releases of carbon dioxide. Storage in deep geological formations is considered a viable alternative for achieving this goal (e.g. IPCC, 2007). There are already operating facilities employing this technique. However, for the system to be built in more densely populated areas and in a large number of locations, confidence in system performance as well as public acceptance regarding its safety are needed. This requires (i) a thorough understanding of the relevant hydro-mechanical-chemical processes of the multiphase-multicomponent spreading processes in heterogeneous geological setting and (ii) good methods for the relevant geological site characterization and monitoring.

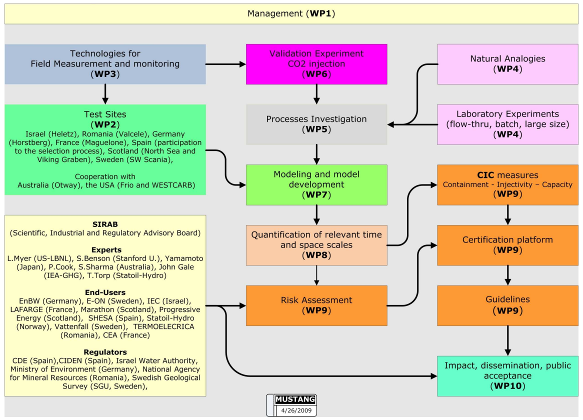

Figure 1: Structure of MUSTANG project

Methodology

The project structure is shown in Fig 1. and it is hierarchically structured as follows:

(1) Process understanding and description

Investigation of CO2 spreading phenomena includes extensive laboratory experiments (e.g. Figure 2); investigation of natural analogue sites in Great Britain and elsewhere with a particular focus on cap-rock integrity, theoretical process analysis and quantification, and based on the above, the development of improved process models and their implementation in computational models.

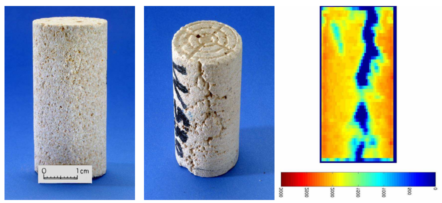

Figure 2: Core photos prior to and (left) and after (center) injecting a CO2 rich solution and tomographic image (right).

(2) Improved field characterization

Data from test sites in Germany, France, Sweden, the UK, Spain, Israel and Romania will be analyzed as well as new data collected (Figure 3). Through collaboration agreements, a link to sites outside Europe has been established as well, in particular to Otway in Australia and WESTCARB and Frio experiments in the US. Development of novel carbon dioxide specific field techniques involves in particular advanced tracer testing, seismic as well as electric monitoring.

(3) Improved interpretation and synthesis

Some of the existing best-performance computational models will be updated based on the findings above. Novel model development will be included for some critical sub-processes, in particular hydro-mechanical ones. Finally, the models are to be integrated into a risk assessment tool capable of providing insight on hydrologic, environmental and health risks related to the injection of CO2 at a specific site.

(4) CO_2 injection experiment for method validation

A CO2 injection experiment, will be carried out at the Heletz site (Israel). The reservoir is very well characterized by means of tens of deep oil exploration wells that mainly penetrated saline layers. The target layer is located at a depth of ~ 1600 m. It is ~25 m thick and possesses good hydraulic properties. Above it there a 40 m thick a sealing layer composed of shales. A existing exploration well will be reentered and a new well will be drilled in its closed vicinity. Sophisticated direct and indirect measurement and monitoring technologies will be installed. 1000 tons of CO2 is intended to be injected .

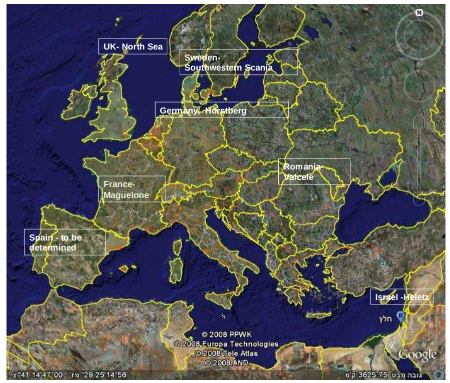

Figure 3 : The MUSTANG test sites.

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