CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

successful news

SUbsurface CO2 storage- Critical Elements and Superior Strategy

Newsletter from the SUCCESS centre – April 2013 – no. 9

SSC RAMORE summarizes:

The sealing is tight

– CO_2 mixed with formation water does not geochemically alter the seals to such an extent that they leak, professor of geology Per Aagaard summarizes. He adds:

– Although these results of the SSC Ramore project are promising, we still need more knowledge of the process involved in the sealing caprock above the CO_2 reservoir to be certain that the sealing is tight and that CO_2 stays in place. Now our research focus has somewhat shifted towards how the geomechanical properties change with diagenetic processes (cementation) and structural deformation processes.

7–8 years ago, when the planning of the SSC RAMORE project started, the IPCC pointed out important knowledge gaps prior to deployment of carbon capture and storage (CCS) to reduce the CO_2 emissions to the atmosphere. To evaluate potential CO_2 leakage from subsurface storage of CO_2, SSC RAMORE focused on the geochemical interaction of CO_2 in formation water with caprocks and with engineered materials in wells, as well as with the corresponding changes in geomechanical properties.

Furthermore, the project carried out simulations of injected CO_2 in reservoir models to improve monitoring of CO_2 reservoirs, and developed a methodology for risk assessments of CO_2 storage in the subsurface.

Per Aagaard led the project at University of Oslo, establishing good cooperation between the research partners (UiB, IFE, NGI) and making a fundament for FME SUCCESS, where he is now scientifical leader for the Oslo group.

SSC RAMORE, one of the many projects associated with SUCCESS, is now ending with its last PhD-dissertations. A final report summarizes the main results of the project. You may download it from *http://www.mn.uio.no/geo/english/research/groups/success/*.

Have you updated your calendar?

SUCCESS fall seminar

October 22nd and 23rd

While the SUCCESS winter seminar mainly focuses on work within the project, our annual fall seminar also brings in speakers and hopefully inspiration from the outside world. The program will be ready before summer catches us, but please note the dates now.

SUCCESS Annual Report

A fully operational centre

2012 was the first year that SUCCESS was fully operational: All PhDs employed, full financing, scientific advisory committee (SAC) running – and results coming. Here you can read SAC member Nick Rileys introduction chapter in our Annual Report 2012. Download the full report and read more about our research and the people behind it: **http://fme-success.no/index.cfm?id=398162.**

The FME SUCCESS Centre is unique amongst European national research programmes on Carbon Capture & Storage (CCS) relating to fossil fuel use in that it is entirely dedicated to the downstream part of the CCS chain, namely (geological) storage.

CCS is the only technology that could mitigate, directly, fossil fuel emissions from combustion on the scale required to meet the atmospheric stabilisation targets of CO_2. Such targets are needed in order to address the potential climate change & ocean acidification risks posed by rising levels of atmospheric & oceanic CO_2. For CCS to be effective it is the CO_2 storage aspect that is the most difficult part of the CCS chain to gain confidence in. Hence FME SUCCESS' relevance to Norway, which is a maritime country, in the Holarctic/Arctic region (the Arctic is currently warming faster than anywhere else on the planet) with an economy heavily dependent on fossil fuels.

Geological CO_2 storage aims to isolate the captured CO_2 from the atmosphere for timescales of thousands of years. Like a carpenter has to work with the grain of the wood, so we have to work with the natural characteristics of the rocks in order to ensure a safe result for CO_2 storage over the long term.

The FME SUCCESS Centre is researching into how to harness natural processes & features within the rocks to see if the vast geological potential (identified by oil and gas operations) that Norway has for storing CO_2 can be realized, particularly offshore at great depth beneath the seabed, and onshore in the Arctic. This requires the scientists and engineers who can develop and deploy methods for predicting how CO_2 can be effectively trapped underground over long timescales, either by forming new minerals or by dissolving in deep brines held within pores in the rocks.

We need to be able to calculate how much CO_2 can be stored and where. Can we assess at what rate it can be injected & when? If the CO_2 did move out of the intended storage depth what would happen? Could we intervene to stop it leaking out to the seabed or ground surface? What would be the effects of leakage on marine or Arctic life? Can we monitor the CO_2 so that we can be sure it is behaving as predicted? How would we do this?

These are some of the big challenges that the FME SUCCESS Centre research is addressing, bringing together a well integrated and critical mass of key Norwegian institutes and expertise in the geo- and biological sciences, mathematical modeling, physics, social sciences and engineering. The Centre has also attracted high quality post-graduate researchers from around the world, providing a focus for capacity building and training that will impact far into the future, not only for Norway, but globally.

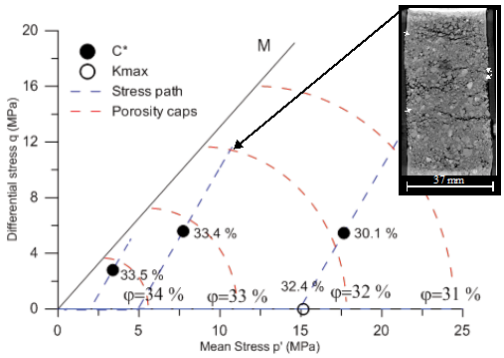
Research highlight

Deformation mechanisms in sandstone reservoirs

Shallow saline aquifers are suggested as promising reservoirs for geological storage of CO_2, and in order to fulfill safe storage criteria, knowledge about deformation mechanisms in sand and poorly lithified sandstone in this kind of reservoirs is essential. The internal composition of reservoirs – and the properties, geometry and distribution of deformation structures related to faults – play a major role for the fluid distribution and for understanding how a reservoir will deform during changes in stress conditions. The microfabric produced during deformation is controlled by the deformation mechanisms, which again is governed by external conditions such as state of stress and burial depth, as well as internal lithological and petrophysical properties.

A series of triaxial experiments investigating the mechanical properties of uncemented sandstone from Provence, France is carried out in the laboratory at NGI. Variation in consolidation stress has been used to simulate deformation at various burial depths. Different methods and procedures and visualization techniques have been used to visualize deformation in the tested samples.

The experimental results are compared with the modified cam-cap model, a model describing the elastic-plastic yield during shear enhanced compaction. Plotting the experimental results together with the modified cam-cap model contour lines for various porosities demonstrates porosity loss at differential stresses lower than what is need to reach the failure line and for mean stress lower than wheat is needed for the same porosity loss during hydrostatic loading. The work aims at combining insight from experimental investigation of deformation and strain localization in porous sandstones with field observations of deformation bands to better understand the parameters controlling the initiation and localization of deformation bands observed in sandstone reservoirs.



Porosity reduction predicted from hydrostatic loading using an end-cap model and measured porosity reduction for the onset of shear-enhanced compaction, C, during axial loading. Inserted is a micro CT scan showing sample deformation at the end of the 5 MPa confining pressure test on uncemented sandstone.*

Elin Skurtveit is a PhD student at the IMPACT project and affiliated to CIPR/UiB and NGI.

Nordic CCS Summer School August 18–23 (Trondheim / Mongstad)

The Summer School is a one-week intensive course in CO_2 capture, transport and storage. The course has a distinct industrial focus that will be ensured by involving lecturers from industry as well as a one-day excursion to the CO_2 capture plant at Technology Centre Mongstad (TCM). By covering the complete CCS value chain and addressing framework issues such as life cycle analysis, financing, HSE, public acceptance, political and legal issues and innovation, the students will develop knowledge on how CCS works in "real life". An important goal with the course is to develop a Nordic CCS network between the participants. The course is primarily intended for PhD/Post.doc students and industry researchers with CCS competence. However, students at the Master level can also apply.

Read more: *http://www.sintef.no/Projectweb/NORDICCS/CCS_SummerSchool/*

IMPACT in Grenoble

Reza Alikarami, a member of our collaborating project IMPACT, has recently visited Laboratoire 3SR in Grenoble, France to perform experiments for his PhD. These experiments have as a primary objective to explore the micro-scale behaviour of granular materials in a range of mean stress. During the stay ten *in-situ* triaxial compression tests with x-ray scanning were performed. These tests were run on Ottawa 50/70 sand and Hostun NH31 sand (which have different angularity) from the end of 2012 until end of March 2013.

The X-ray scanner in Laboratoire 3SR allows the entire sample to be imaged in full-field 3D in various configurations, while it is deformed in triaxial compression. The acquired 3D images allow macroscopic measurements (such as sample volume) to be made in each imaged configuration. Since individual grains can be seen in these 3D images, meso- and micro-scale measurements can also be made.

Meso-scale measurements assess variables (such as porosity) on a representative elementary volume, whereas micro-scale measurements take the discrete nature of the medium into account and can measure grain sizes and coordination number when grains are identified in the 3D images. Furthermore, some specially-developed tools will be used to follow the material's deformation between imaged configurations, allowing kinematics, and thus strain to be measured.

EGU: Spring in Vienna

The yearly general assembly of the European Geosciences Union (EGU) gathers a broad audience from the scientific community. CCS was allocated a separate, two-day program block with oral and poster presentations this year (extended abstracts available at EGU.eu), including several contributions from SUCCESS delegates. The standard of presentations was high and Vienna offered a taste of spring, setting a perfect scene for intersting discussions and networking.

SUCCESS related presentations included among others these titles:

- Modeling CO_2 distribution in a heterogeneous sandstone reservoir: the Johansen Formation, northern North Sea
- Upscaled modeling of CO_2 injection with coupled thermal processes
- Fluid focusing and breaching of low permeability layers in reacting and visco-elasto-plastically deforming reservoir rocks

CCS directive into effect

The EU directive on CCS is now approved by all partners in the EEA and will go into effect on June 1st, 2013. The directive establishes a legal framework for the environmentally safe geological storage of CO_2 and sets licencing regulations for all geological storage sites, except those with a total intended storage below 100 kilotonnes, undertaken for research, development or testing of new products and processes.

- *Read the directive here*
- *Blogpost by Catherine Banet* (specialist in EU/EEA energy and environmental law)

SUCCESS in Geologiskt forum

Geologiskt forum is Sweden's largest popular science magazine on geology. In its March issue SUCCESS and UNIS postdoc Ingrid Annell presented the Svalbard dream of a carbon-neutral society over several glossy pages. Well done!

SUCCESS (Subsurface CO_2 Storage – Critical Elements and Superior Strategy) is one of several Norwegian centres for environment-friendly energy research, funded by the Norwegian Research Council and industry partners. For more info and contact address: *www.fme-success.no*.

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