UKCCSC Poster Abstracts

Mineral Carbonation in Oman

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Carbon Capture and Storage (CCS) is a vital technology in which atmospheric anthropogenic CO_2 is injected and stored in subsurface reservoirs and therefore mitigates global warming due to the increased levels of this greenhouse gas.
A different approach to CO_2 storage in reservoirs is the fixation of CO_2 by means of specifically enhanced chemical reactions. CO_2 may react with some minerals, such as Mg silicates (Maroto-Valer et al., 2005).
The geology of Oman provides many suitable locations for the carbonation of minerals. There is a widespread presence of mafic and ultramafic rocks as components of the Semail Ophiolite. These rocks represent the main source for Mg-silicates to be used in the CO_2 mineralisation process (Kelemen and Matter, 2008). The setting of the ophiolite and the environmental conditions allow a very good outcrop of the rocks (Lippard and al., 1986).
Several sources of high volume CO_2 emissions produced by power plants (mainly fired by gas turbines), are suitable for CCS in Oman. The power-plants are close to the main outcrop of the ophiolite thus reducing the associated cost for transport of the carbon dioxide to the mineralisation plant. The average concentration of CO_2 in the exhaust fumes is around 4 – 5 %. Currently, available mineralisation methods request capture techniques suited to concentrate the CO_2 from this level to much higher values before the carbonation process could be performed.
The resulting products of the CO_2 carbonation are large volumes of rocks. Depending on the process and on the typology of available minerals the requested weight of rock for the sequestration of 1 metric tonne of carbon dioxide ranges from 3 to 6 metric tons (Zevenoven and Kohlmann, 2001). Due to the local conditions in Oman (large availability of free surfaces) the storage of these by-products should not present a problem. There is also the possibility, to be fully explored yet, that these products could be used as building materials, i.e. for road constructions, reducing the costs of the whole process.

The aim of this work is to consider the various methods that could be applied in CO_2 mineralisation in Oman.

Impact of medium-term exposure to CO_2 enriched seawater on the physiology of the velvet swimming crab, *Necora puber*

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Ocean acidification (OA) is predicted to play a major role in shaping marine biodiversity over the next century. Along with this, potential leaks from Carbon Capture and Storage (CCS) pipes pose a threat to marine biota. We investigated the effect of 30 d exposure to OA and CCS leakage scenarios (pH 8.00, 7.30 and 6.70) on the survival, physiological functions, and immune response of an economically and ecologically important crustacean, the velvet swimming crab *Necora puber* - a species known to possess good extracellular buffering ability during short-term exposure to hypercapnic conditions. A suite of physiological proxies (O_2 uptake, haemolymph acid-base balance and ionic regulation, exoskeleton mineralisation, heat tolerance, lipid peroxidation) were measured after 30 d exposure to elevated pCO_2 conditions. *Necora puber* was able to buffer extracellular pH over 30 d exposure to hypercapnic sea water, with no evidence of net shell dissolution, thus demonstrating that HCO_3^- is actively taken up from the surrounding water. In addition, tolerance to heat, carapace mineralization, and immune response were not affected by hypercapnic conditions. In contrast, whole-animal O_2 uptake significantly decreased with increasing pCO_2, whilst significant increases in haemolymph [Ca^{2+}] and [Mg^{2+}] and chelae [Mg^{2+}] were observed with increasing pCO_2. No effect of pCO_2 was found on survival. In conclusion, we confirm that most physiological functions in *N. puber* are resilient to predicted OA scenarios but based on a longer period of exposure than previously investigated. However, under CCS scenarios metabolic rates, haemolymph chemistry and chelae mineralization were severely compromised.

Numerical study of compressed CO2 pipeline decompression characteristics using CFD-DECOM

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There is growing world-wide interest for carbon capture and storage (CCS). The critical link between capture and storage is the transportation of the captured CO2 over long distances. The most economical means is through pipelines either as dense phase fluid or as a gas.
CO2 pipelines are susceptible to long running ductile fractures. The Battelle two curve model (TCM) is often used to determine the toughness required to arrest a running ductile fracture in a pipeline. The key input to the TCM is the gas decompression curve, a relationship between the pressure and velocity of the pressure wave, which is dependent on the thermodynamic properties of the fluid; its initial pressure and temperature. For a lean gas, the decompression curve is essentially a smooth curve. However, for rich gases and CO2, it contains a plateau due to discontinuity caused by the phase transition. The existence of the plateau in the decompression curve means that a higher toughness is required to arrest a running fracture.
A CFD based pipeline blowdown model has been developed and validated against experimental data for rich gas and dense phase carbon dioxide. The multi-component fully compressible two-phase solver is coupled with the homogeneous equilibrium model which assumes that the two phases share identical velocity, temperature and pressure. Real gas behavior is considered by two equations of state. The liquid-vapor phase equilibrium of a multi-component rich gas is determined by flash calculations. A conjugate heat transfer problem is solved simultaneously for the pipe flow and wall heat transfer. The conserved transport equations are solved using an Arbitrary Lagrangian-Eulearian method. Predictions carried out for some published shock tube tests are found to be in reasonably good agreement with the experimental data.

Scrutinizing CO2 sequestration: A case study coupling InSAR and geomechanical modelling to monitor spatial and temporal characteristics of CO2 injection at In Salah, Algeria.

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Options for monitoring CO2 storage are varied and range from discrete chemical well sampling programs to full field time-lapse seismic surveys. Crucial for any monitoring program is that it be as cost effective as possible yet yielding sufficiently accurate measurement. Time-lapse seismics has generally proven to be a sufficiently accurate means of monitoring CO2 in the subsurface. However, there is debate as to whether seismics is the most cost effective approach in the quantitative measurement of CO2 flow and containment. The cost of monitoring is compounded potentially further by the various international regulations related to CO2 sequestration, where, for example, it can be argued that CO2 storage monitoring requirements are much stricter than those for natural gas storage.
For on-shore sequestration, there has been a significant drive to integrate satellite interferometric synthetic aperture radar (InSAR) with geomechanical modeling to link surface deformation with the movement and storage of injected CO2. At the In Salah CO2 storage project, export gas specifications require the removal of CO2 from the produced natural gas with strict long term monitoring requirements to ensure that CO2 is contained indefinitely. Thus there has been significant research into linking geomechanical modeling with InSAR observations (e.g., Rutqvist et al., 2010; Vasco et al., 2010).

We analyze the surface deformation resulting from CO2 storage at In Salah in order to provide constraints on the temporal and spatial evolution of CO2 within the reservoir. Specifically, we process InSAR from the pre-injection period 1992-2004 and the injection period 2004-2009 and combine the InSAR observations with geomechanical modeling of reservoir deformation to determine the volume of CO2 stored. The results using a simple yet fast geomechanical model (Geertsma, 1973) indicate that, between 2004 and 2008, 97 ± 9 % of the 1157 x 106 m3 of CO2 injected into the reservoir has been stored. This value is close to the stringent 99 % target for CO2 storage permanence set by the Intergovernmental Panel on Climate Change. Our study provides the first practical assessment of CO2 storage and demonstrates that it is possible to develop independent, fast and cost-effective assessments of future schemes in the absence of ground-based surveys. The strength of this approach is that very little field data is needed to provide a sufficiently accurate initial assessment of CO2 storage at relatively very little cost. The ability to scrutinize CCS sites globally based on limited input data and cost effectively will be crucial for implementation of international monitoring of CO2 sequestration agreements.