Utrecht University

Faculty of Geosciences
Department of Earth Sciences

Scientific challenges concerning long-term CO_2 sequestration

Research topics covered at the department of Earth Sciences, Utrecht University

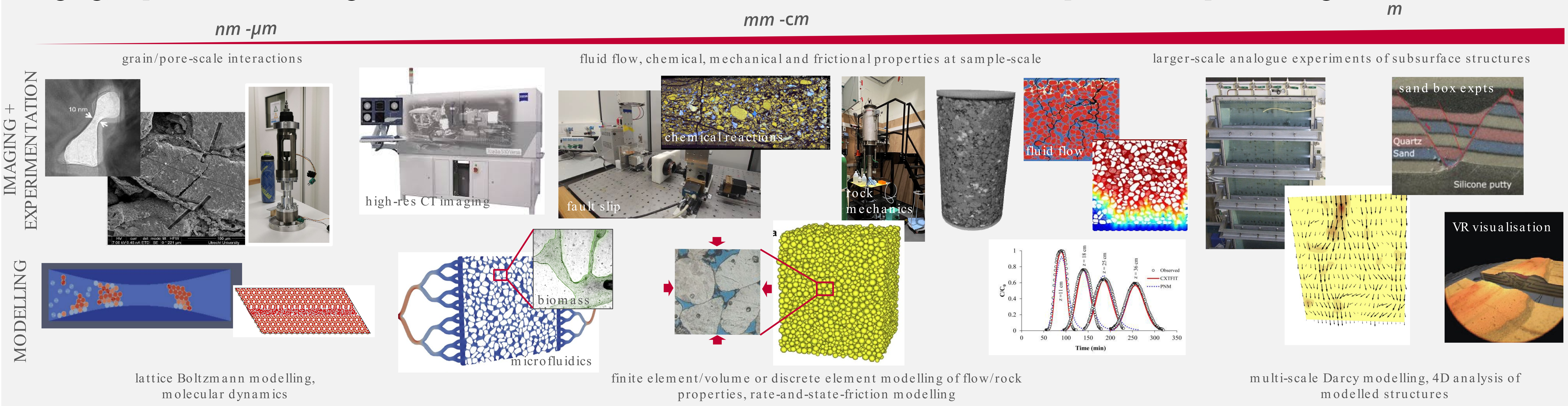
Interested in our research or do you have a research question?
Contact our Impact Coordinator, Dr. Eldert Advokaat, to see whom of our colleagues can help you (e.l.advokaat@uu.nl)

CO_2 storage: a challenge on all scales

It ranges from understanding the complex, coupled thermal, hydrological, mechanical and (bio-)chemical (THMC) changes caused by injection, to site localisation, characterisation and monitoring, and hazard assessment. **At Utrecht University, we provide the fundamental understanding and quantification from the nano- to m-scale needed to assess behaviour on the km-/field-scale in real-time.**

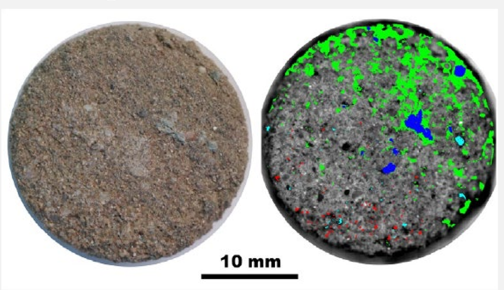
Much of our CO_2 storage-related research is performed through involvement in large (inter)national research programmes, such as CATO-1, CATO-2, UltimateCO$_2$ and ACT. Furthermore, we regularly collaborate with other universities (e.g. VU Amsterdam through DOCS, TU-ITC), as well as institutes and companies (e.g. TNO, EBN, IFP Energies Nouvelles and CCS operators) through (student) research projects and internships. Many of our state-of-the-art facilities are part of international infrastructure initiatives, providing transnational access and promoting collaborations (e.g. EPOS-NL, Excite[2] Network).

Imaging, experimental investigation and numerical simulation at the nano- to m-scale: THMC processes at pore- and grain-scale

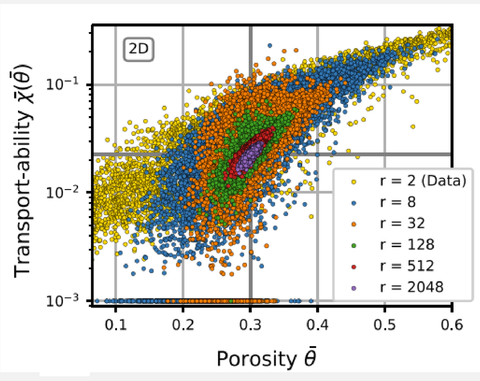


Upscaling to (heterogeneous) field-scale

Mineralogy and rock texture play a key role in controlling the impact of THMC processes. Upscaling lab observations should be based on true reservoir petrography (realistic grain size, mineralogy, porosity etc. distribution), relevant (bio)reactions and realistic flow dynamics, including reservoir heterogeneities and geostatistics.



Infrared Imaging Spectroscopy of reservoir core for scalable, efficient petrography (collab with UT).

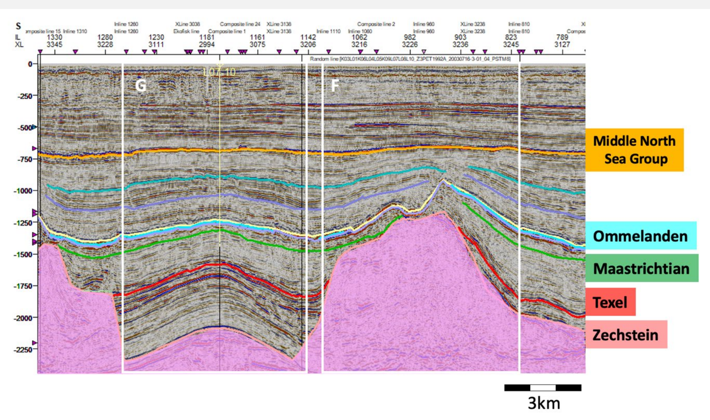


Upscaling of diffusive transport properties taking into account complex pore space geometries.

Site characterisation and assessment

Prospect evaluation is crucial to assess the storage potential of sites. We contribute to this through student projects, and visualisation and interpretation of geologically relevant data.

Evaluation of the Upper Cretaceous Chalk Fm (top L and K blocks) for CCS, through a student project within the DOCS framework.
Soon a second project will start focusing on the Early Cretaceous Bentheimer sandstone.

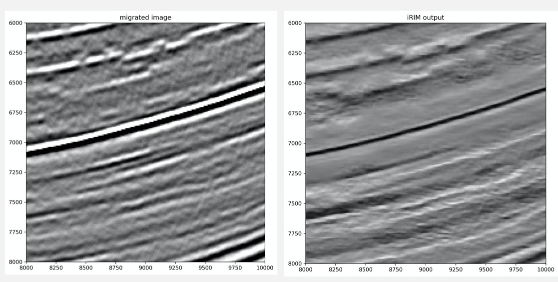


Integrated framework of the public geological database of the Dutch subsurface, for geological interpretation

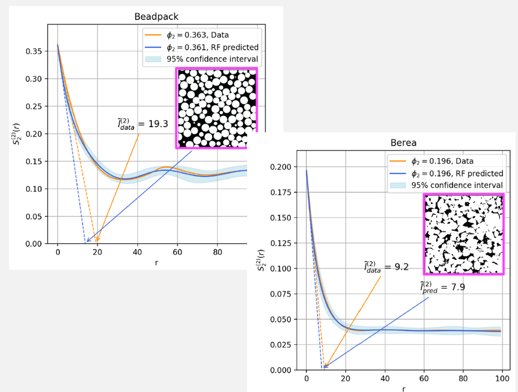
Download via QR code (left): Petrel-based project integrating publicly available data of 10,599 2D seismic lines, 280 3D seismic cubes, 6,590 wells and 4,752 composite wells logs.

Subsurface imaging and monitoring

Mapping fluid fronts and/or geomechanical changes is important to assessing the impact of storage. AI-based physics upscaling and downscaling can help to use remote physical observations to make inferences on the microstructural state of the subsurface.



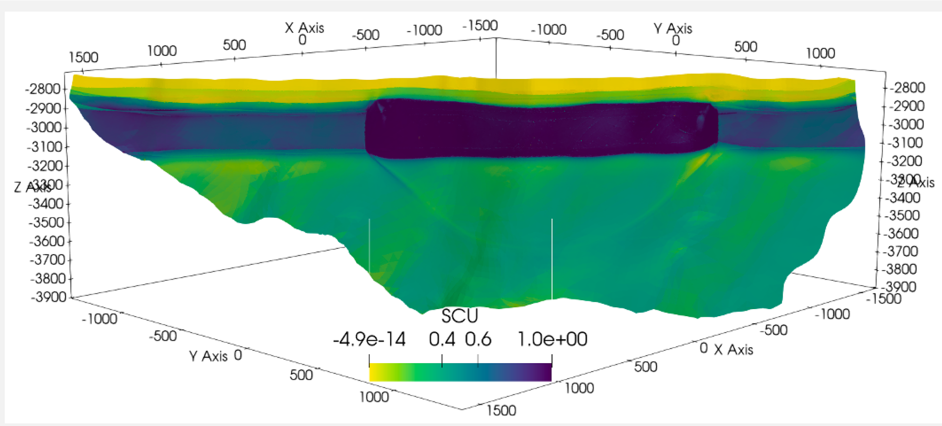
Waveform-based seismic images (left) and deep learning-based deblurring thereof (right) to yield a wide-band, denoised, sharp representation of the subsurface geology.



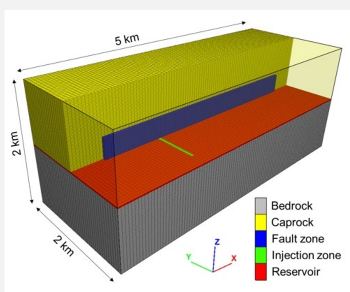
Machine-learning-based inference of subwavelength microstructures of a bead pack (left) and Berea sandstone (right).

Assessing hazards related to CO_2 storage

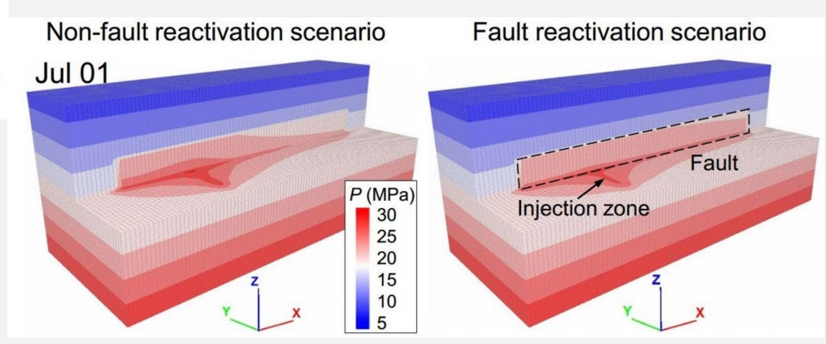
Taking into account the complex THMC processes resulting from CO_2 injection is key to predicting the impact of subsurface storage. Numerical modelling capability is needed to extrapolate the nano- to m-scale observations in space and time. Only by including the true pore/grain-scale behaviour can we accurately predict the impact of storage on induced seismicity and deformation.



Top: High-resolution model of a fault in the Groningen gas field allowing for detailed THM assessment of the potential for fault slip due to gas production.



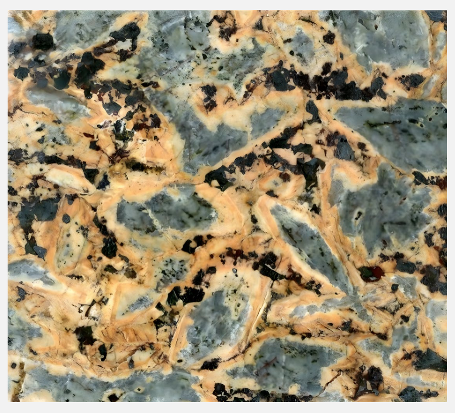
Left and below: Hypothetical fault model assessing the pressure build-up along the fault due to CO_2 injection. The pressure build-up changes the state of stress on the fault, and hence the potential for slip.



CO_2 mineralisation

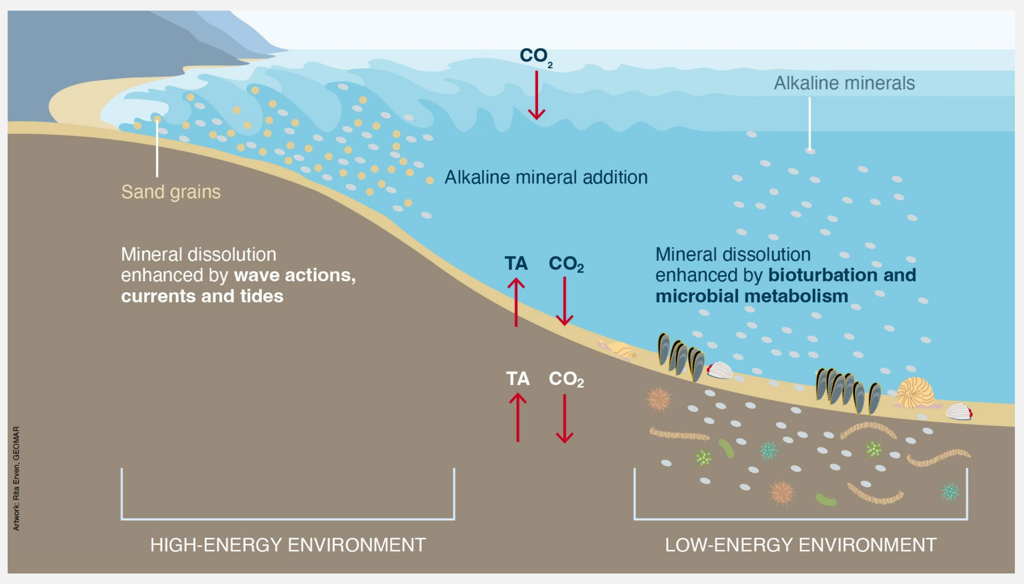
In addition to investigating the scientific challenges concerning subsurface storage of CO_2, we also look into using mineralisation processes to permanently trap CO_2.

- What can we learn from natural carbonation reactions in ultramafic rocks (see image in the centre)?
- Is it possible to carbonate large ultramafic bodies, such as the Oman ophiolite?
- Can we use crushed ultramafic rocks to buffer CO_2 acidification (Ocean Alkalinity Enhancement, OAE)?



Top: Natural carbonation reactions in ultramafic rock.

Right: For OAE, two environments are considered: 1) high-energy environments in the surf zone, where the constant collision with sand grains provides a natural grinding mechanism, and 2) low-energy environments at the continental shelves, where the interactions with macro- and microorganism impact ambient fluid geochemistry. We are setting up lab experiments to investigate the CO_2-sequestration potential of each environment, as well as the impact on marine biota.



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EPOS-NL EUROPEAN PLATE OBSERVING SYSTEM EPOS-Netherlands
Excite[2] Network