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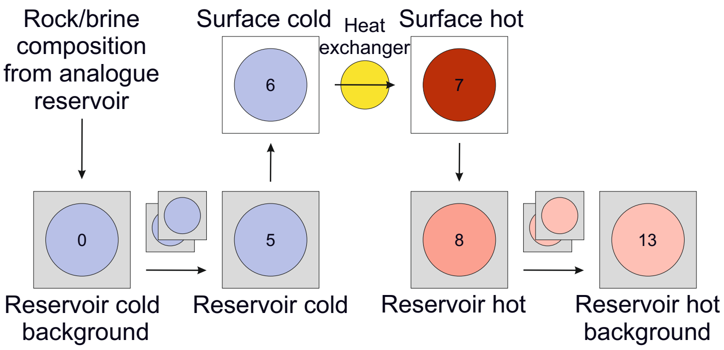
Hydrochemical simulation of ATES systems

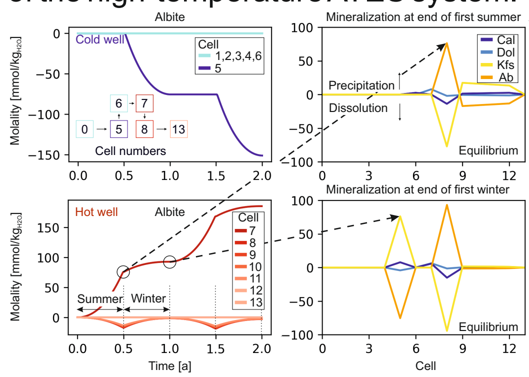
Aquifer Thermal Energy Storage (ATES)

Aquifer Thermal Energy Storage (ATES) utilizes aquifers to temporarily store heat in the subsurface. This heat is then reproduced from the aquifer and supplied to customers according to the heat demand via heat exchangers and district heating networks. Seasonal heat storage has an important role for decarbonizing district heating networks.



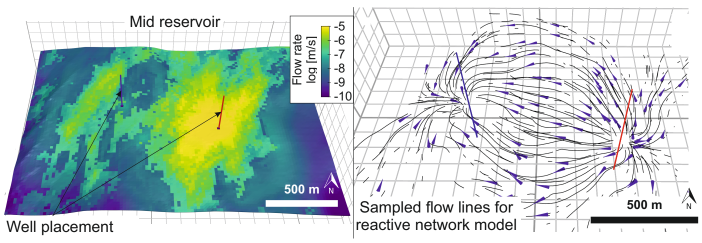
Hydrochemical simulations

The initial results represent a simulation run at equilibrium, while activated reaction kinetics decrease the effect of silicate scaling substantially due to the relatively lower reaction speeds in the Na/K-silicate system. Since this effect is visible at both the end of the summer and winter seasons, however, it might accumulate over the operative period of the high-temperature ATES system.



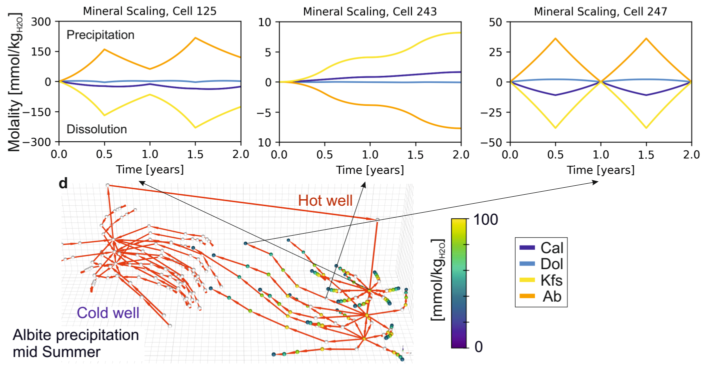
Reactive network simulations

This study aimed at developing a new multi-step simulation workflow to mimic hydrochemical changes in deep ATES doublet systems. Terranta software based on the geochemical solver Reaktoro was used for hydrochemical modelling. Calcite and dolomite, as well as albite and potassium feldspar, were selected to represent the most reactive phases. After setup of the hydrochemical models, reactive network models were used to analyze mineral dissolution/precipitation vs. time and distance from the wells.



Discussion

Both the carbonate and silicate systems are prone to ATES-induced changes. The different mineral systems show complex interactions. Scaling patterns must be modelled for the individual rock-brine system. Long-term, local pore-scale phenomena might not be captured by global models, however, and should be validated experimentally.



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TERRANTA

Chair of Energy Geosciences

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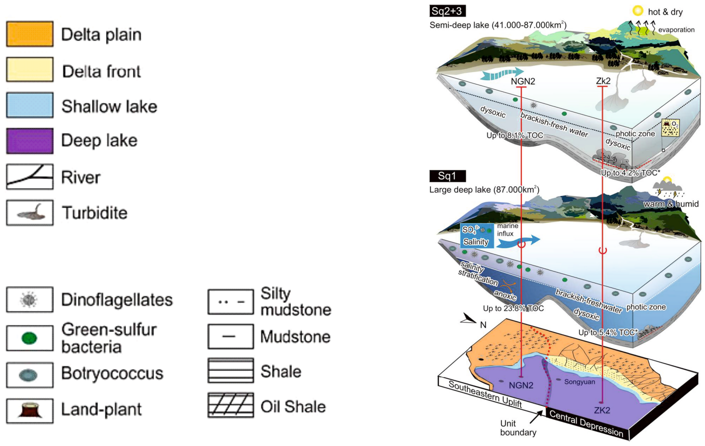
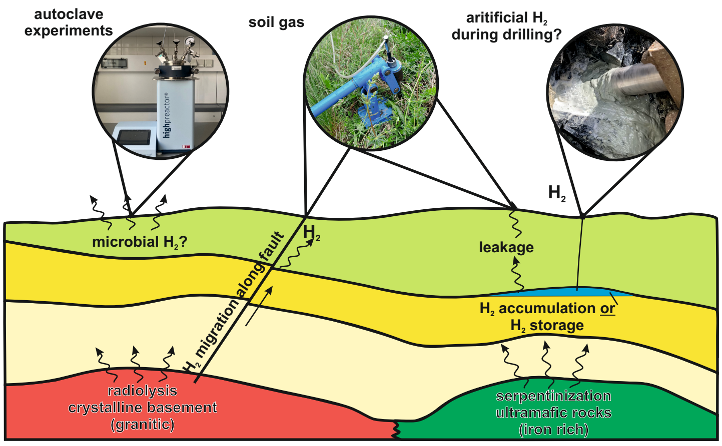
Paleoclimate Research

Understand the past, find hints for the present-day global change. At the Chair of Energy Geosciences, we analyse paleo-depositional environments to learn for present day climate research. Students learn to understand sedimentary systems as geological archives and geoenergy plays.



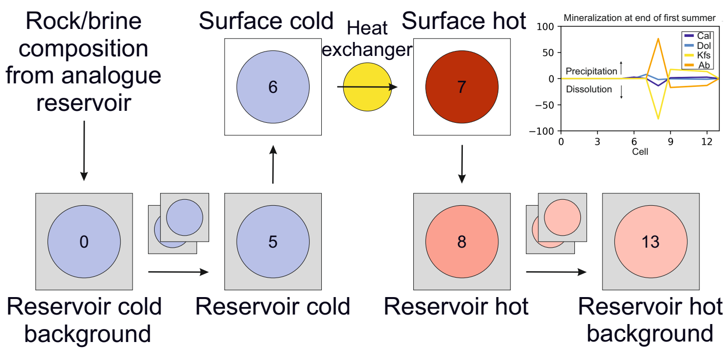
Natrual Hydrogen Exploration

Natural hydrogen is a potential energy source. The geological challenges involve different generation processes, migration paths, accumulation and exploration. At the Chair of Energy Geosciences we perform leading research and education in natural hydrogen exploration.



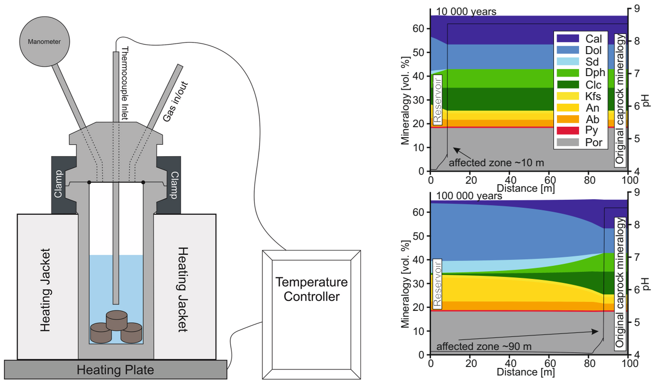
Aquifer Thermal Energy Storage

Excess heat produced in summer could be used for carbon neutral district heating. The subsurface provides massive storage capacity with almost perfect insulation. Challenges arise from high flow rates, scaling effects and biological growth. At the Chair of Energy Geosciences we process and interpret geological data for geoenergy applications.



Long-term seal integrity

Hard-to-abate emissions from the steel or cement industries could be stored underground. Geological challenges arise from rock-fluid interactions, migration, and cyclic injection. To provide insights for storage integrity the Chair of Energy Geosciences uses static autoclave tests, caprock fluid flow, nano-indentation and compaction analyses.



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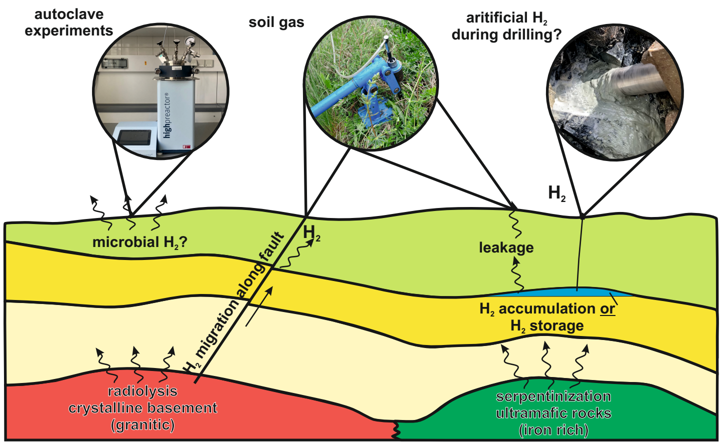
Natural Hydrogen Exploration

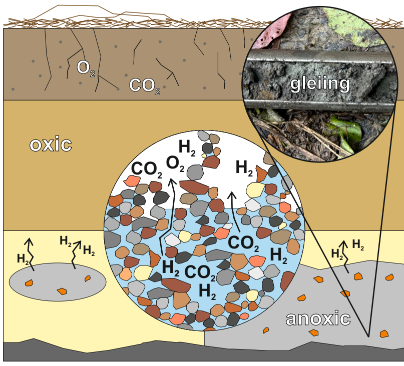
The Hydrogen System

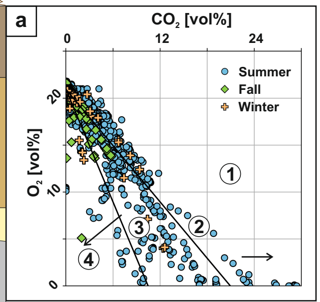
Natural hydrogen is a potential carbon free energy source. The geological challenges involve different generation processes, migration paths, accumulation, and exploration. Natural hydrogen is commonly associated with radiolysis in crystalline rocks or serpentinization in ultramafic rocks.



Soil Gas studies

More than 500 single soil gas measurements have been conducted in the Czech Republic where H_2 associated with radioactive decay of U and Th in the crystalline basement is assumed. High H_2 (> 1000 ppmv) and CH_4 (≤ 47.6 vol%) contents were observed, however soil gas analysis, isotopic signature, and significant seasonal variation argue for dominantly microbial sources.

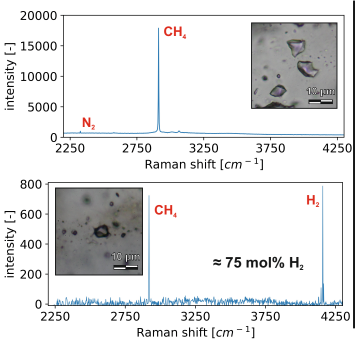


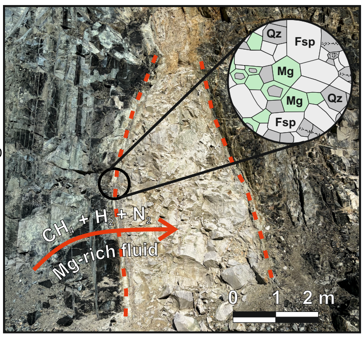


(1) addition of CO_2 (2) soil respiration
(3) CH_4 oxidation (4) CO_2 consumption

Fluid Inclusions

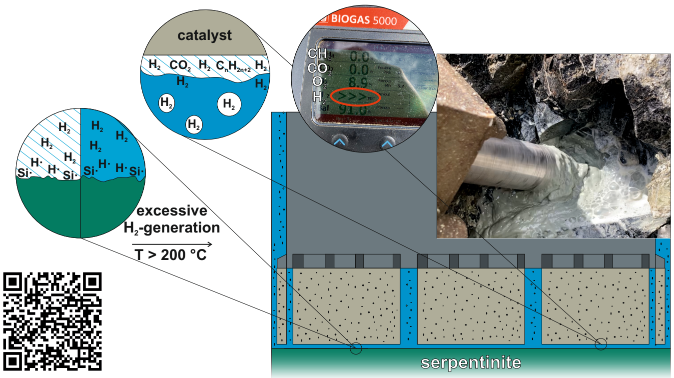
Felsic granulite and serpentinized garnet peridotite of the Gföhl unit from a hydrothermally altered contact zone were analyzed with Raman spectroscopy, microthermometry, SEM, XRD, EOS for secondary fluid inclusions. From the genetic model it gets evident that the fluids migrated at 200 – 300°C ≈ 100 MPa and that there is a substantial production of abiotic H_2 and CH_4 during exhumation.





Drill Bit Metamorphism

In natural hydrogen exploration, artificial hydrogen is generated by drill bit metamorphism (DBM). This study presents cases where shallow drilling with water in ultramafic and carbonate rocks generated high amounts of hydrogen and hydrocarbons. It can be shown that these gases can be attributed to reactions initiated during drilling.



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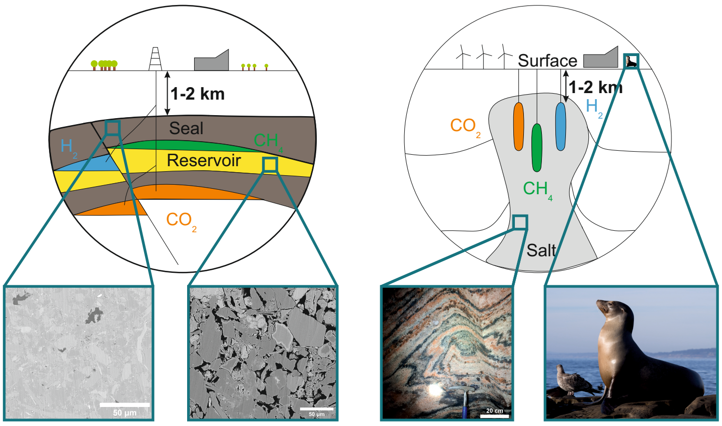
Seal integrity for subsurface gas storage: Innovative assesment workflows

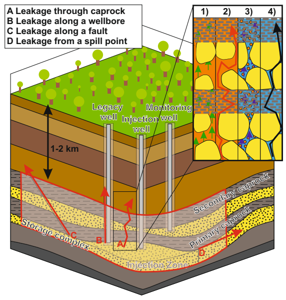
Subsurface gas storage

The long-term integrity of geological barriers (e.g. shales or salt) is essential for the usage of the subsurface as carbon sink or energy storage system. Within the frame of this study, workflows have been adapted to predict seal quality for different settings, timescales, targets, fluids, and available data.

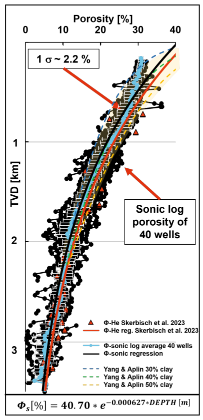


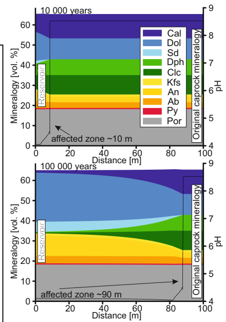
Is there a risk of migration?

The approach is extended to wire line logging data and the quantification of dynamic migration processes. Furthermore, rock-fluid interactions of a representative caprock mineralogy of the Vienna Basin with carbon dioxide are quantified.



1) CO_2 gas phase flow (Darcy equation)
2) CO_2 gas phase with Knudsen cor.
3) CO_2 dissolved in water with water phase flow (Darcy equation)
4) CO_2 diffusion within water





How to predict seal quality?

The first workflow aims for the prediction of breakthrough pressure, which controls the seal capacity in absence of faults or other discontinuities. It is based on a basin wide compaction trend derived from theoretical models which are calibrated with measured capillary pressure curves of 40 samples.

Yang & Aplin 2004
Porosity

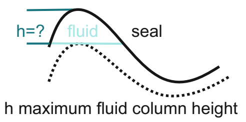
Input: Clay content (<2 µm)
Result: Porosity

Yang & Aplin 2010
Permeability

Input: Clay content (<2 µm) & porosity
Result: Vertical permeability

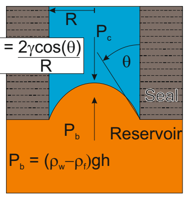
Yang & Aplin 2007, 1998
Pore throat model

Input: Porosity & permeability
Output: Pore throat radius



Column height

$$CH = \frac{2 * \sigma * \cos\theta}{r * (\rho_{wa} - \rho_{oil}) * g}$$

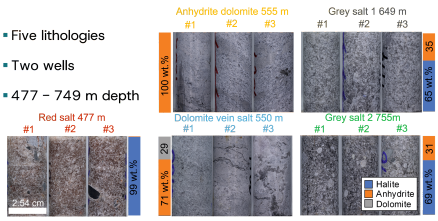


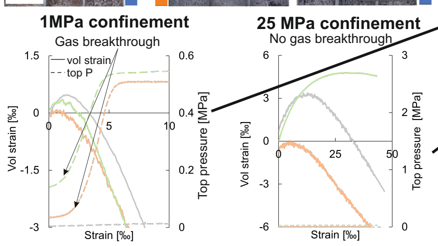
σ Interfacial tension
θ Wetting angle
r Mean pore throat radius
ρ_{oil} Hydrocarbon density
ρ_w Water density
g Gravity constant

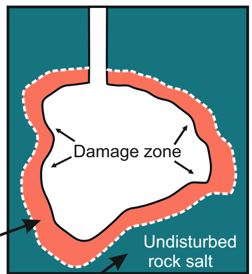
Austrian salts as hydrogen seals?

Lastly, a petrophysical investigation workflow for the challenging engineering environment of the tectonically deformed and strongly heterogeneous salt bodies of the Haselgebirge Formation is established.

- Five lithologies
- Two wells
- 477 – 749 m depth







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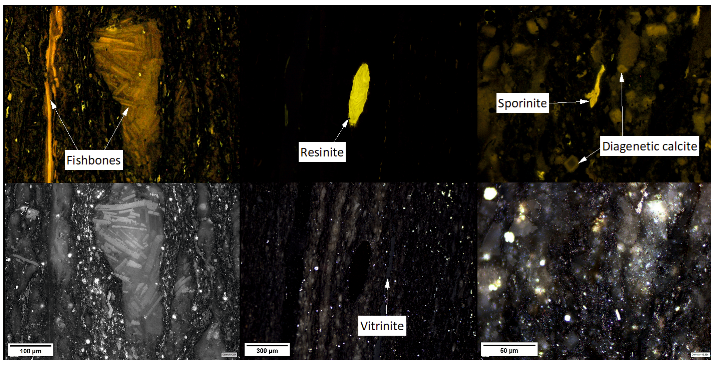
The Göstling formation
Implications for climate change and HC potential

The Scheiblingbachgraben

The lower Carnian Göstling formation forms the basal part of the Upper Triassic succession in the Northern Calcareous Alps. The type and amount of present organic matter are currently unkonwn. Therefore, the main aim of the present study is to characterize the organic matter in the Göstling formation, which is about 5 m thick and excellently exposed in the Scheiblingbachgraben near Großreifling (Styria).

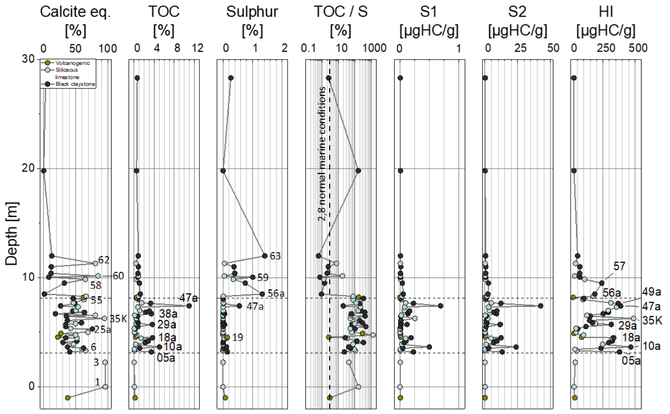
High organic matter contents

Macerals were analyzed in polished blocks under oil immersion. They are shown under UV light (top) and reflected light (bottom). Most prevalent are Liptinite macerals, of which most indicate aquatic origin. Still, a significant number of macerals stemming from landplants indicates detrital input from land.



Potential source rocks?

About 50 siliceous limestone beds, gradually evolving into thinly laminated dark mudstones were sampled for geochemical analysis. From a total of 50 samples, total inorganic carbon (TIC), total sulphur (TS), total organic carbon (TOC) and the hydrocarbon (HC) potential was determined.



Implications

The strata observed in the outcrop was deposited during the climate change of the late Triassic Carnian Pluvial Episode (CPE). In the course of the CPE carbonate platforms drowned and carbonate productivity decreased drastically, due to increased siliciclastic input in the marine domain caused by increased precipitation.

The bulk geochemical data shows hydrocarbon potential in the Göstling formation. However, in the Scheiblingbachgraben the formation has not reached sufficient maturity to generate hydrocarbons. In areas where it was subject to sufficient pressure and temperature conditions it might be a source rock. Further investigation are needed to evaluate possible oil to source relations.

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