Professional Development Workshop on

Critical Raw Materials Content in Thermal Waters: Analysis and Assessment

30th March 2023
University of Miskolc, Hungary

Smart Reservoir Laboratory(R) - an innovative tool to characterize reservoirs and assess the sustainability of extracting critical elements from reservoirs

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GEOCHEM Ltd.

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- GEOCHEM was established in 2003 (2006).
- Located in South Hungary, near Pécs city

- Our R&D activity is focused mainly on:
  - complex laboratory investigation of different materials, i.e very tight and unconsolidated rocks, concretes
  - special instruments, equipment and methodological development, laboratory automation, Smartlab

- Our measurement and development services are demanded in the fields of geology, like hydrocarbon and raw material exploration, geothermal research, radioactive and hazardous waste disposal.

- MSZ EN ISO 14001 Environmental Management System and the MSZ EN ISO 9001 Quality Management System.
  Temperature, humidity and ambient pressure are controlled separately in each laboratory room.
  Safety of continuous power supply is supported by Riello MST-80 UPS and standby DPG 150 diesel generator.

- Member of the Cluster of Applied Earth Sciences

CAPES

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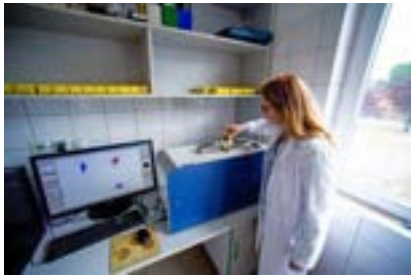
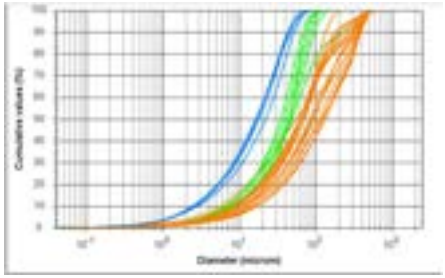
OUR SERVICES

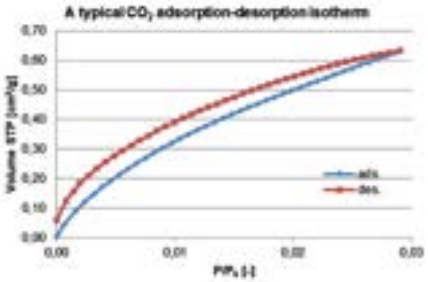


- **Reservoir qualification**
  - Acoustic velocity measurement – SRL-A1000
  - Reservoir state permeability measurement – RS-PPD-1
  - Gas permeability measurement – Coreval-700
  - Measurement of electrical properties – EPS 700

- **Pore structure investigation**
  - Porosity and density measurements – gas pycnometer - Pentapyc 5200e
  - Pore size distribution measurement – mercury-porosimeter - Poremaster-60 GT
  - Physisorption-, microporosity measurement – Autosorb-1-MPV

- **Grain size/shape analysis-sedimentology**
  - Particle size distribution measurement – CILAS 1180 LD
  - OCCHIO Zephyr ESR
  - ISO/ASTM Sieve analysis





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- **Drilling & Stimulation Properties (joint operation with Mecsekérc)**
  - Core Flooding system – self designed
  - Fracture conductivity measurement system – self designed
  - Leak-off measurement system – self designed
  - Proppant qualification (ISO 13503-5)
  - HPHT mud/gel viscosity - CHANDLER 5550
- **Aging**
  - Benchtop Temperature Humidity Test Chamber (Xi'an LIB)
- **Sample preparation**
  - Drilling, end-facing, embedding, drying, 3D scanning, etc.
- **Product, method and software development (R&D)**
  - Cryodesiccation
  - Smartlab
  - etc.

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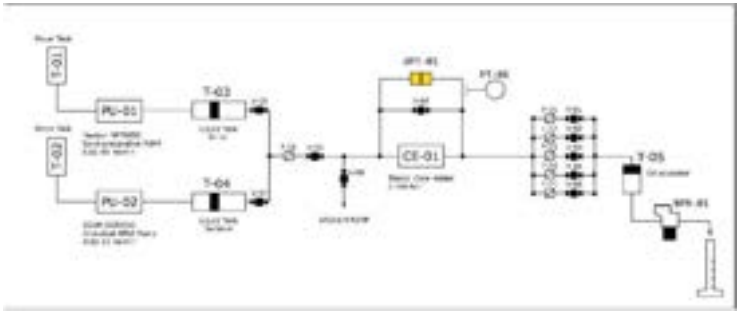
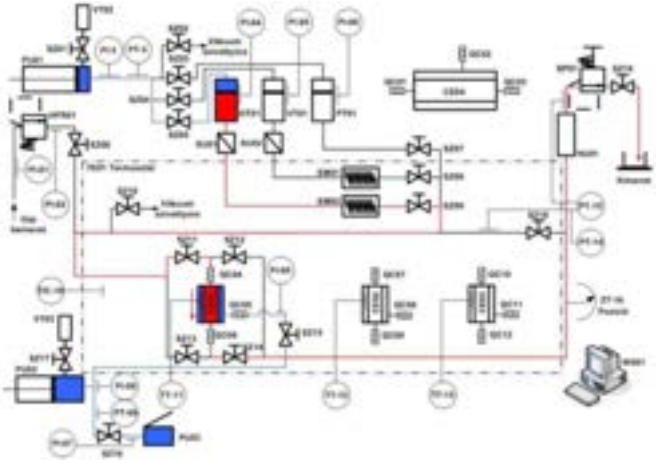
Drilling & Stimulation Properties





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Why we need laboratory automation?

Basic requirements for all the processes:

- traceable
- repeatable
- available

Problems arise related to:

- Human resource
- Technology
- Methodology
- Finance

Source of problems – some of the reasons

- Laboratory staff:
  - different qualification
  - different motives
- Plenty of equipment and sundry programs
- Various spreadsheets and charts
- The devices often not connected

Redundancy

Is it possible to build an „error-free" system?

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Human reasons

- People differ in
  - knowledge
  - commitment
  - capacity
  - work attitude

→ **Company-level standard**

Way to prevent major errors

Quality Management System (QMS)	Accrediting the laboratory	Laboratory Management Software (LMS)
Principles **NOT** solutions Overruled by the system → · extra workload · hindering utilization · eliminating creativity	In lack of validation of measurements ↓ **Theoretical obstacles** Redundant data entry	Sometimes it is too expensive (both implementation and development)

Technological reasons

Equipment of a laboratory:

- hardware
- instruments (in-house developed or purchased)
- software

Instruments are supplied:

- Processing software
- Control software
- Both of them

Almost all elements are different

Transforming the system into an evolving framework

- Maintenance and further improvement costs

Methodological reasons

The problems may ensue from

Technology:

- Programs are developed by large teams
- Lack of following up the scientific development
- Interpretation like a routine task
- Improvement of databases

Structure of the system:

- The components are close coupled
- How to integrate new elements
- Too complicated for further improvements

Capacity planning

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Financial reasons

For smaller labs it is hard to

- implement
- accredit
- audit again every year
- the system mentioned above

Development of the IT

The maintenance cost is higher than the initial procurement

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What could be the solution?

The system needs to provide

Standard framework involving processes to

- reduce errors
- minimize redundancy → instruments into data flow stream

Open interface system

- industry standards
- help improvements

But …
Automation of processes should not be about replacing the human brain, but about relieving humans of monotonous labour!

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Problems with traditonal laboratory service and future activities

Given a sample from anywhere …

Transportation (permits, phyiscal and chemical changes, dustiness, dilapidation, carbon footprint, time, costs)
Technology (high spectrum of instruments and softwares, difficult, maintenance, expensive, data management problems, qualified staff need, capacity)
Qualified staff (education and experience, time, maintenance, carbon footprint, salary and insurrance, work attitude, capacity)
Data management (security, redundance, errors, interpretation, carbon footprint)

time-consuming (3-6 months), expensive and cause high carbon footprint

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New directions in exploration and exploitation require changes

Unconventional and renewable resources (H_2, CO_2, petroleum, geothermal)
Automation (cobots, machine learning, AI, big data)
Principles: Industry 4.0, „Design as you go”
Environmental protection (using renewable energy, less chemicals)
Social distance (pandemic)
Change of attitude (new generation, VR/AR, less lexical more practical)

Lack of real data, which need for calibration, upscaling!

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The SmartLab concept

On-site laboratory service anywhere

Highly automated (a technician need for maintenance using expended reality tool, next step robotization and AI)

VR/AR tools for education and service

Sustainability

- Energetically independent (solar, wind, accumulator)
- Chemicals not need (water, air, nitrogen from surroundings)

Data transportation via secure satellite internet to the Headquarters

Interpretation by experts living anywhere in the world

Payment via internet

Complement geophysical and remote sensing activity (calibration, upscaling)

Goal: time-saving service (1-5 days), cost effective, less carbon footprint

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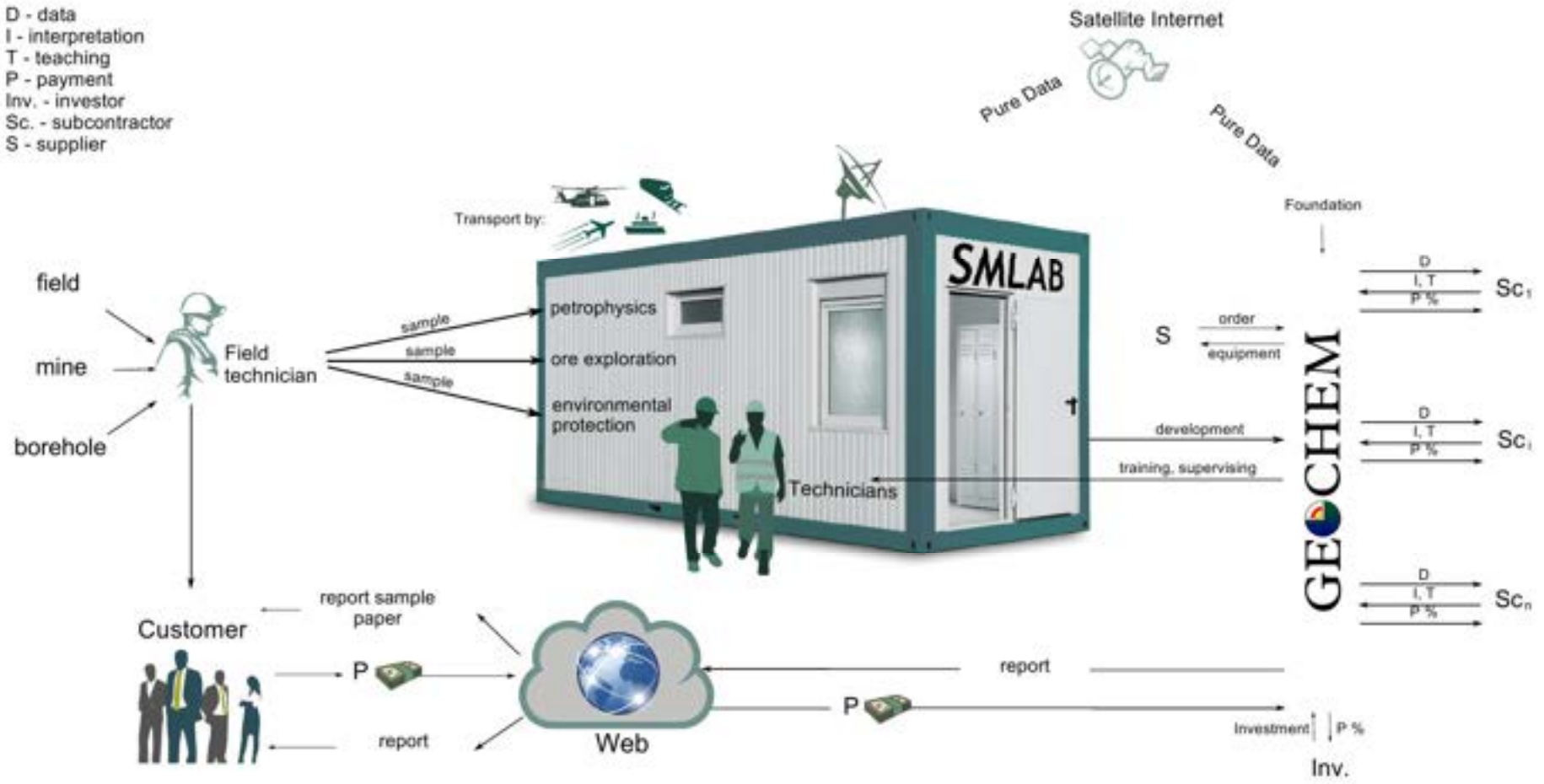
Schematic figure of the concept



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Smart Reservoir Lab - The Solution, all-in-one

Reservoir state measurements in one automized step – porosity, permeability, acoustic velocity, electric resistance (later induced polarization tomography), thermal conductivity (and later diffusivity) using water or gas.

SRL needs only 4 m^2 area, a technician instead of 100 m^2 reservoir laboratory and 2-3 high qualified expert.

First and second realizations

SRL

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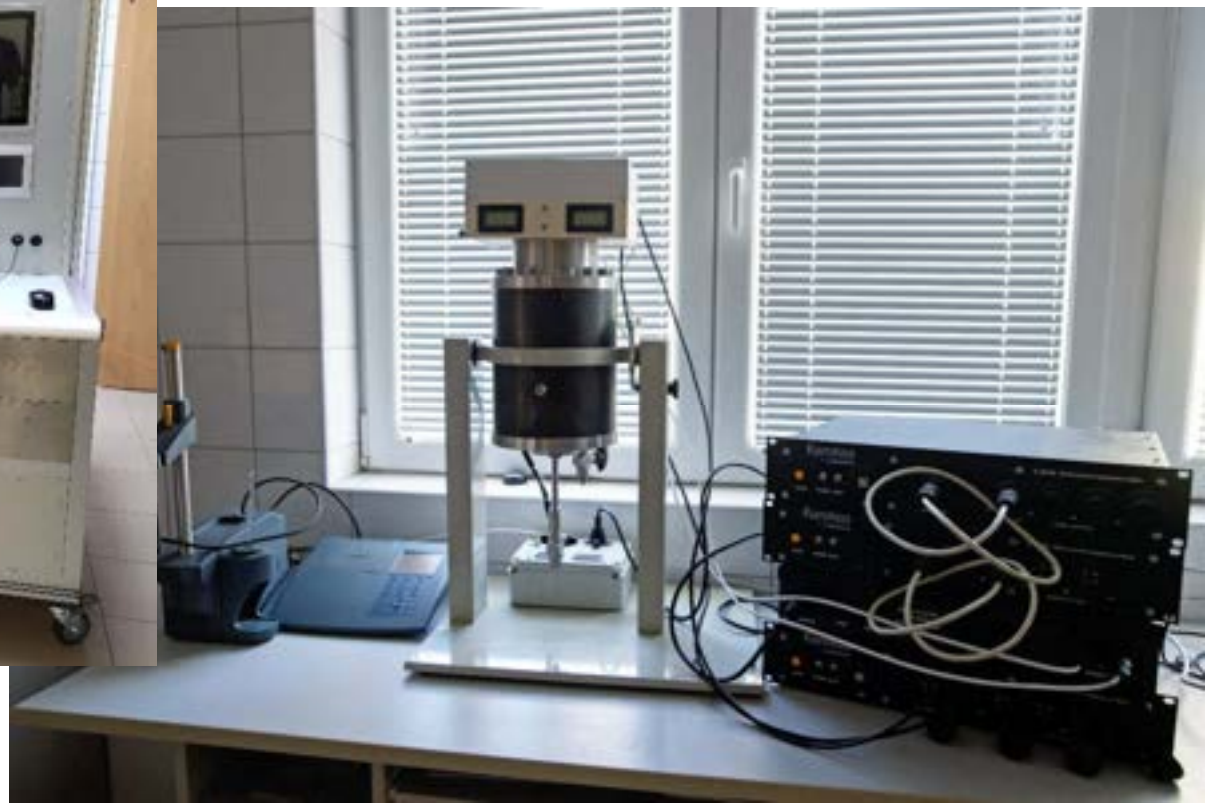
Smart Reservoir Lab - SRL-AP1000 in progress



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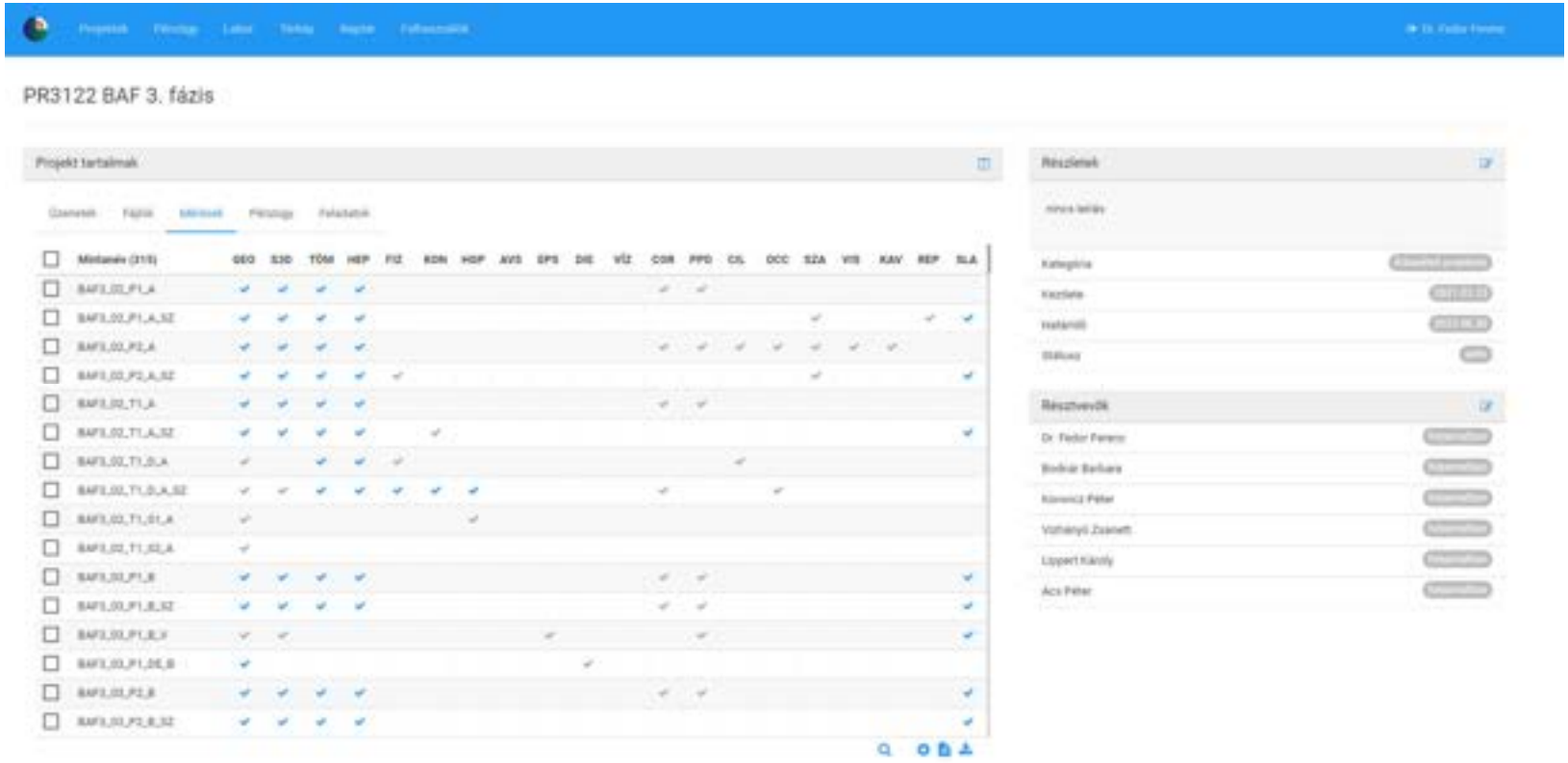
Smart Reservoir Lab
software background



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Role of SRL in litium extraction experiments

Question: sustainability of Li (or other critical element) production process

The process: primary litium production (extraction) from brine – change of brine composition (unbalanced system) – **water re-injection** – **extraction Li from source rock/rock** – secundary production – …

1. The process could be modelled by reaction transport modelling tools, but the system is very difficult in most cases.
2. Have to validate the modell by laboratory experiments.
3. **Reservoir state experiments need.**
4. **Have to follow the change of petrophysical character and water composition.**

In SRL we can measure many petrophysical parameters in one step (not need to move the sample from one equipment to another) in different pressure and temperature steps and we can sample the brine step by step.

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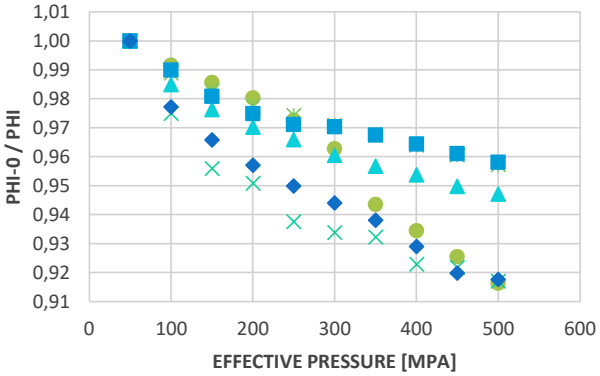
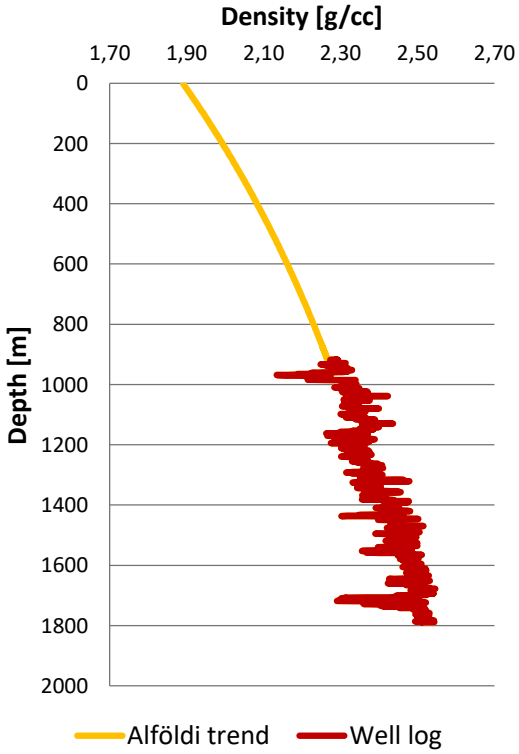
Measurements at HPHT reservoir conditions





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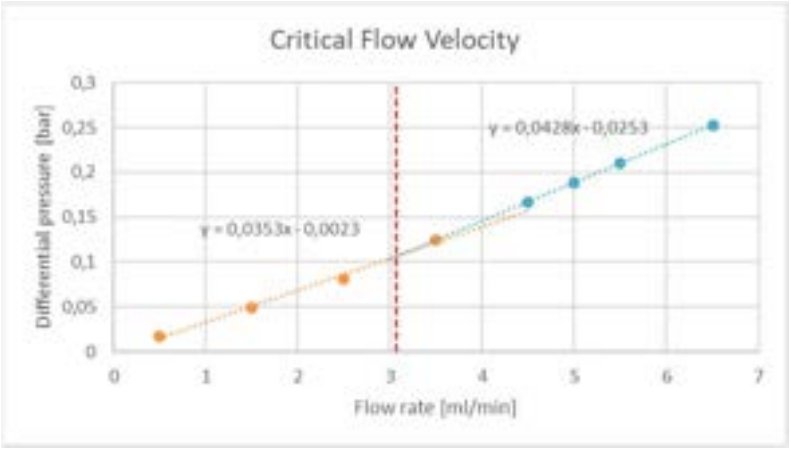
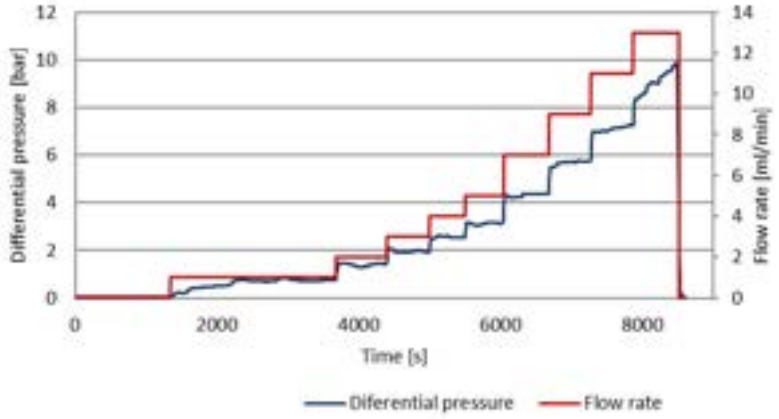
Investigation of formation damage

- Critical flow velocity measurements
- Water-rock interaction tests
- Core flooding
- Matrix acidizing





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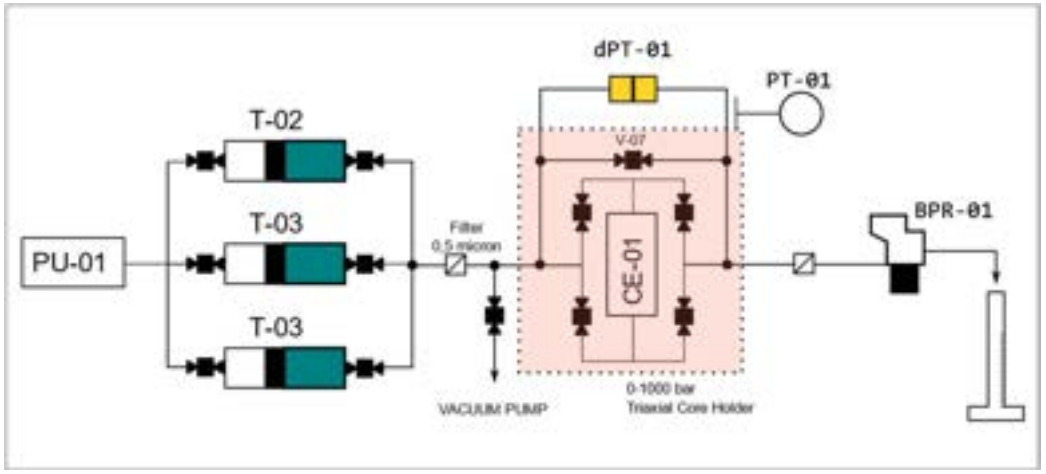
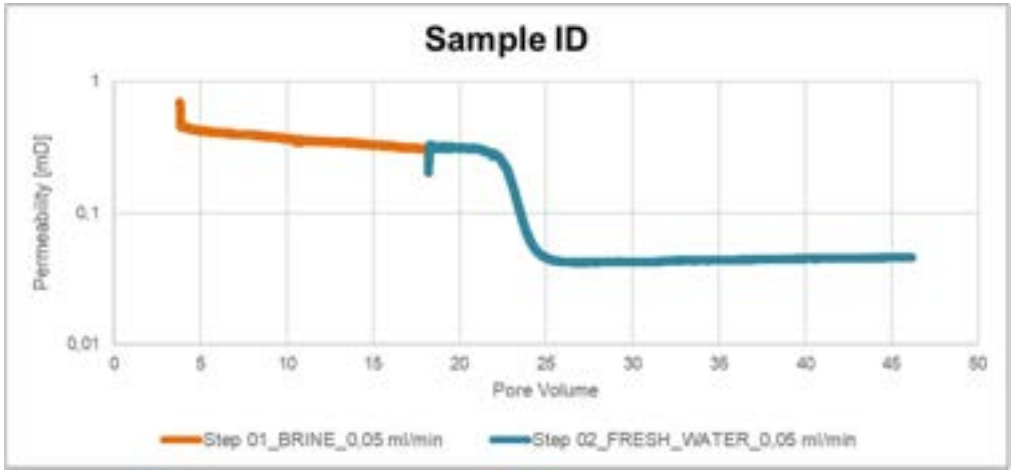
Long-term water-rock interaction tests





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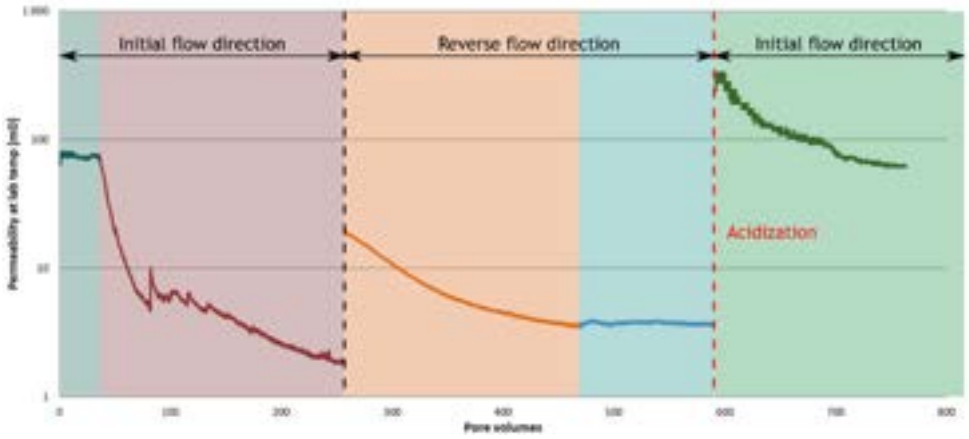
Rock water interaction, matrix acidizing



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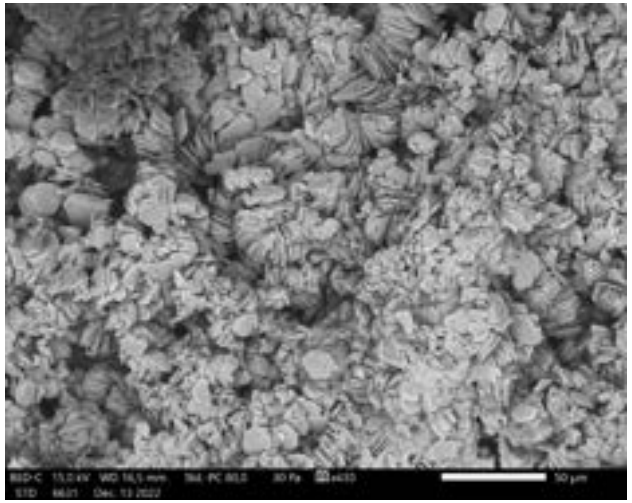
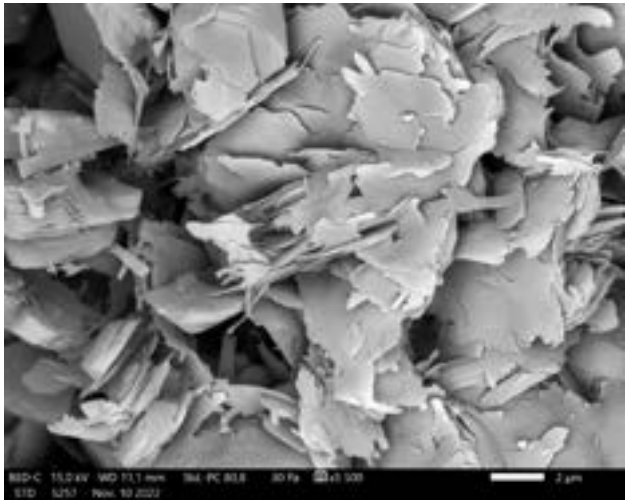
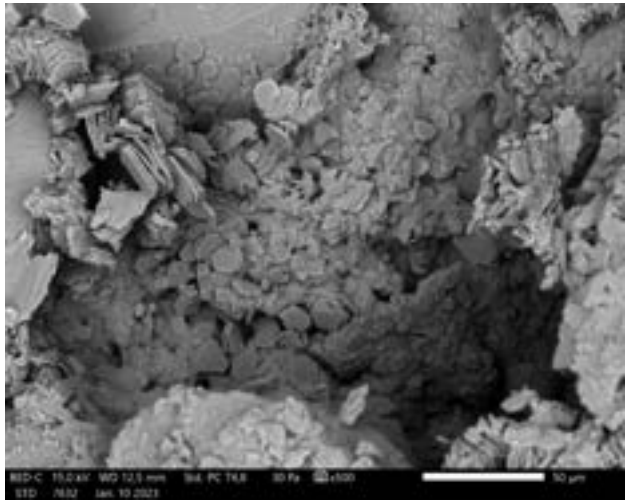
Petrological analysis before and after the experiments







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Summary

GEOCHEM's main activity is laboratory petrophysical measurements service which provide reliable information on the physical properties of rocks in a range of a given scale, helping to calibrate of larger (e.g. geophysical) and smaller scales (e.g. microCT) measurements.

Automation of laboratory can eliminate many potential sources of error, like human, technological, methodological and financial problems. Smartlab is a concept for laboratory automation.

Reservoir condition measurements help to understand the variation of physical parameters with temperature and pressure (closer to realistic calibration), and help to validate theoretical models.

The main question is in case of Li or other element extraction process is the sustainability and it could be strongly depended on the successful re-injection process and sustainable extraction from source rock.

In SRL many petrophysical parameter can be performed on a single sample at different pressure and temperature steps (less chance of core damage) and the change of brine chemistry is also followable.

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Thank you for your kind attention!

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