AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

HYDROGEOCHEMICAL PROCESS MODELLING AND LABORATORY EXPERIMENTS FOR HIGH-TEMPERATURE ATES IN VIENNA, AUSTRIA

WORKSHOP „AQUIFER STORAGE FOR GERMANY“
GEOTHERM OFFENBURG, 19.02.2025

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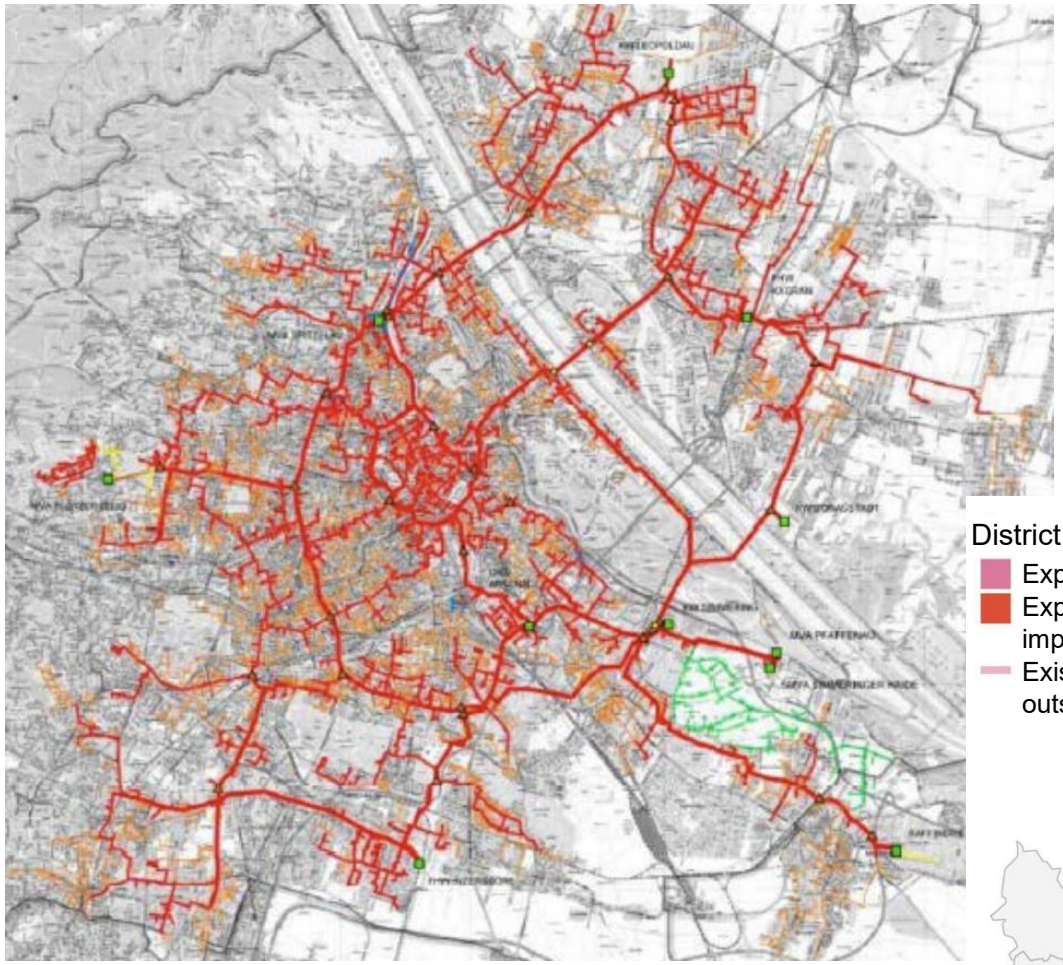
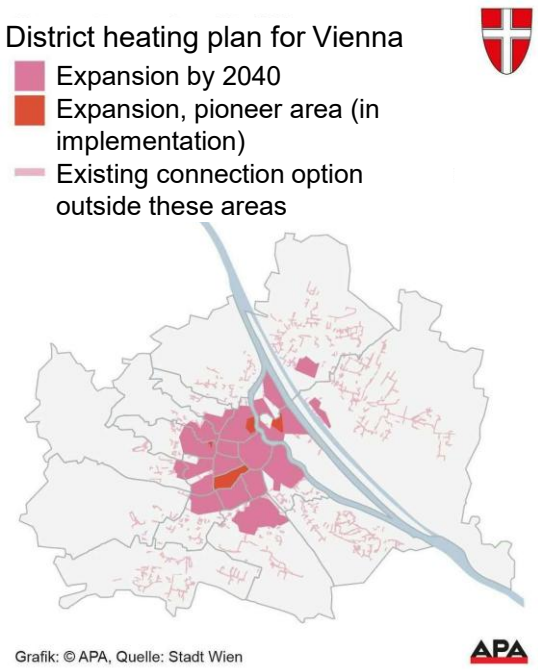
DECARBONISATION OF VIENNAS DISTRICT HEATING GRID



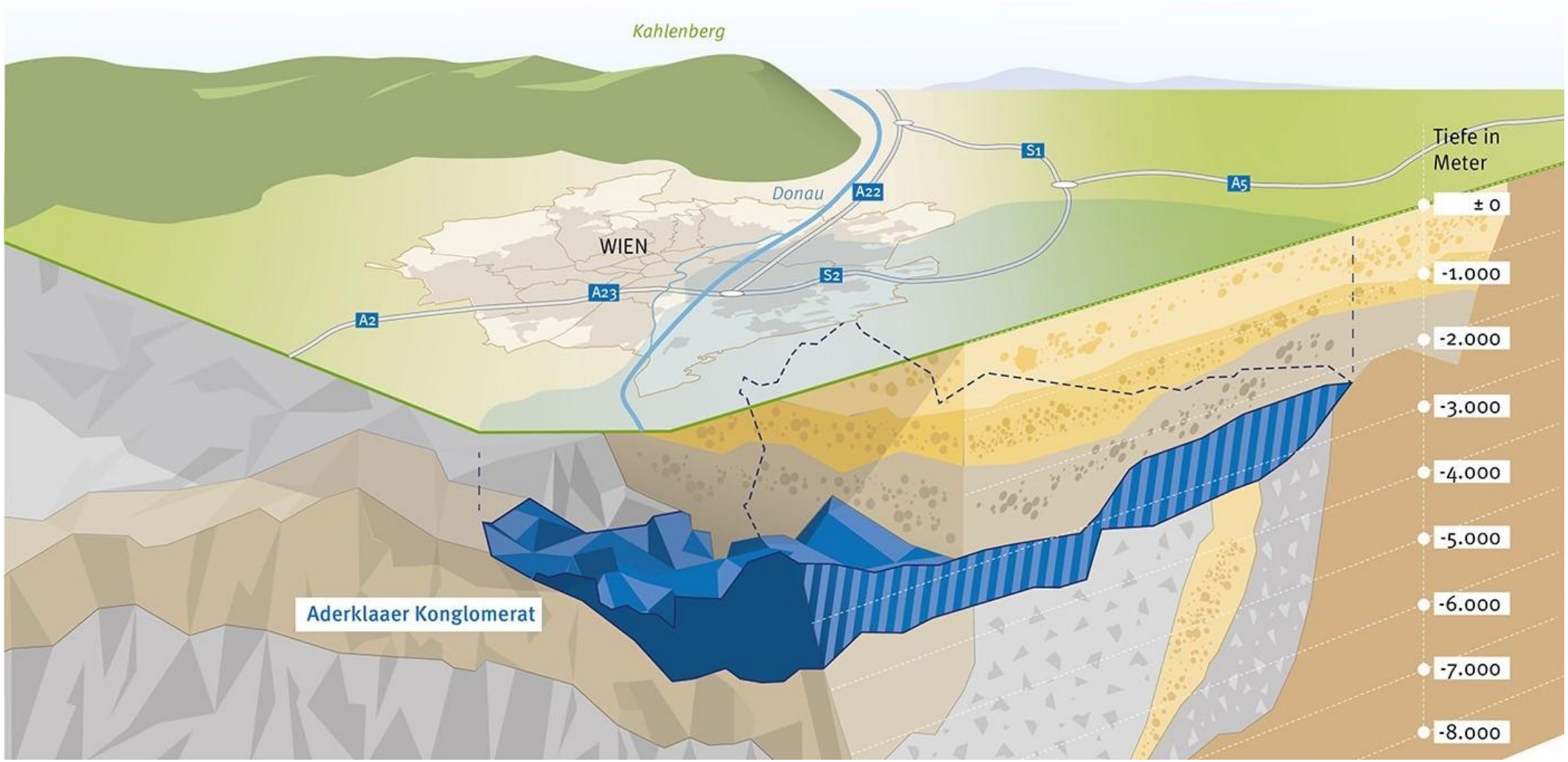


One of the biggest district heating networks in Europe with > 400000 households and >200000 commercial and industrial customers connected

Decarbonisation until 2040 with use of

- Deep geothermal
- Waste heat
- HT-heat pumps
- Green gas

DEEP GEOTHERMAL RESERVOIR



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JOINT VENTURE DEEEP

deeep – Deep geothermal joint venture of Wien Energie and OMV

WIEN ENERGIE

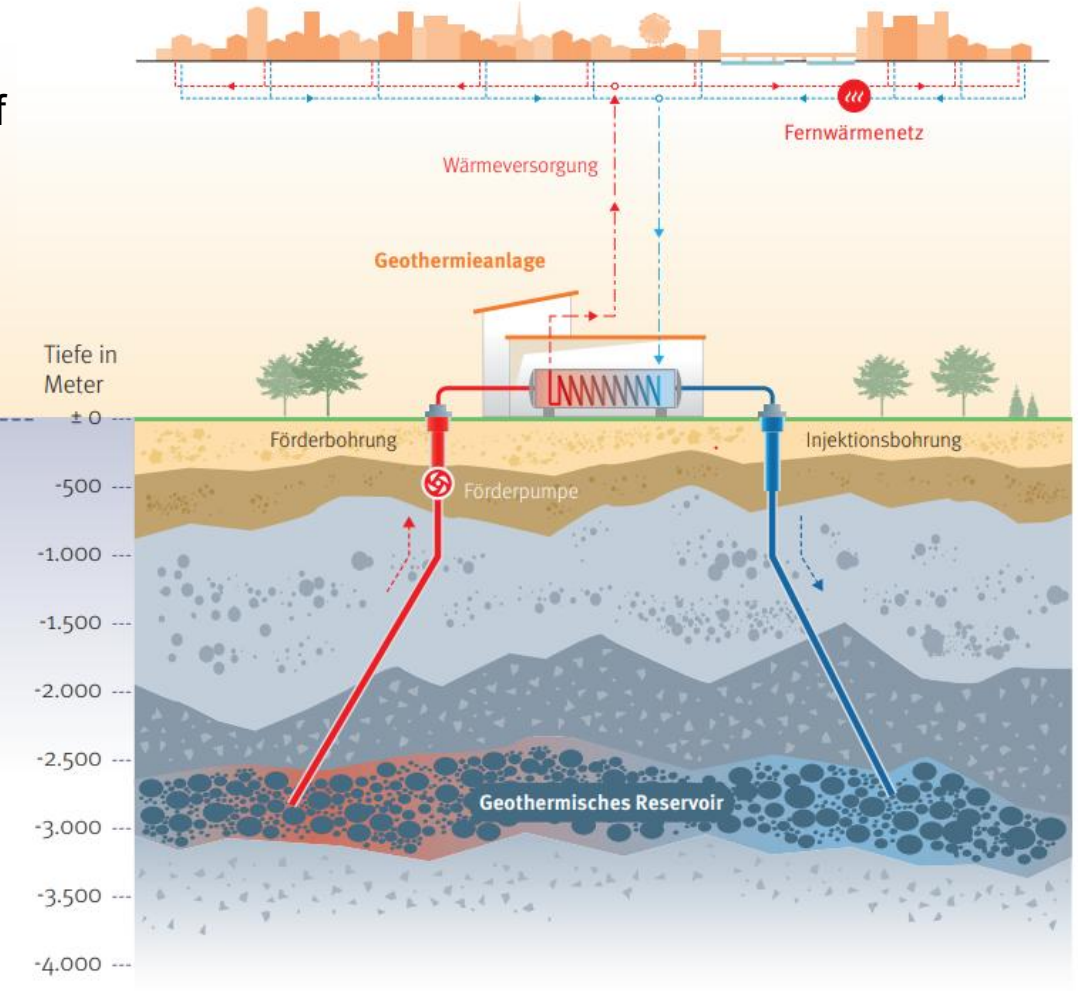
deeep Tiefengeothermie für Wien.

- Planning of surface facilities
- Construction and operation of heat exchangers and heat pumps
- Integration into DH grid

deeep Tiefengeothermie GmbH
Gemeinschaftsunternehmen

OMV

- Geology and geophysics
- Subsurface engineering
- Well planning



BEGINNING OF DRILLING 16/12/2024!

powered by klima+ energie fonds

WIEN ENERGIE
WIENER STADTWERKE GRUPPE

RESEARCH PROJECT: ATES VIENNA

Credit: iStock.com/Grigorev_Vladimir

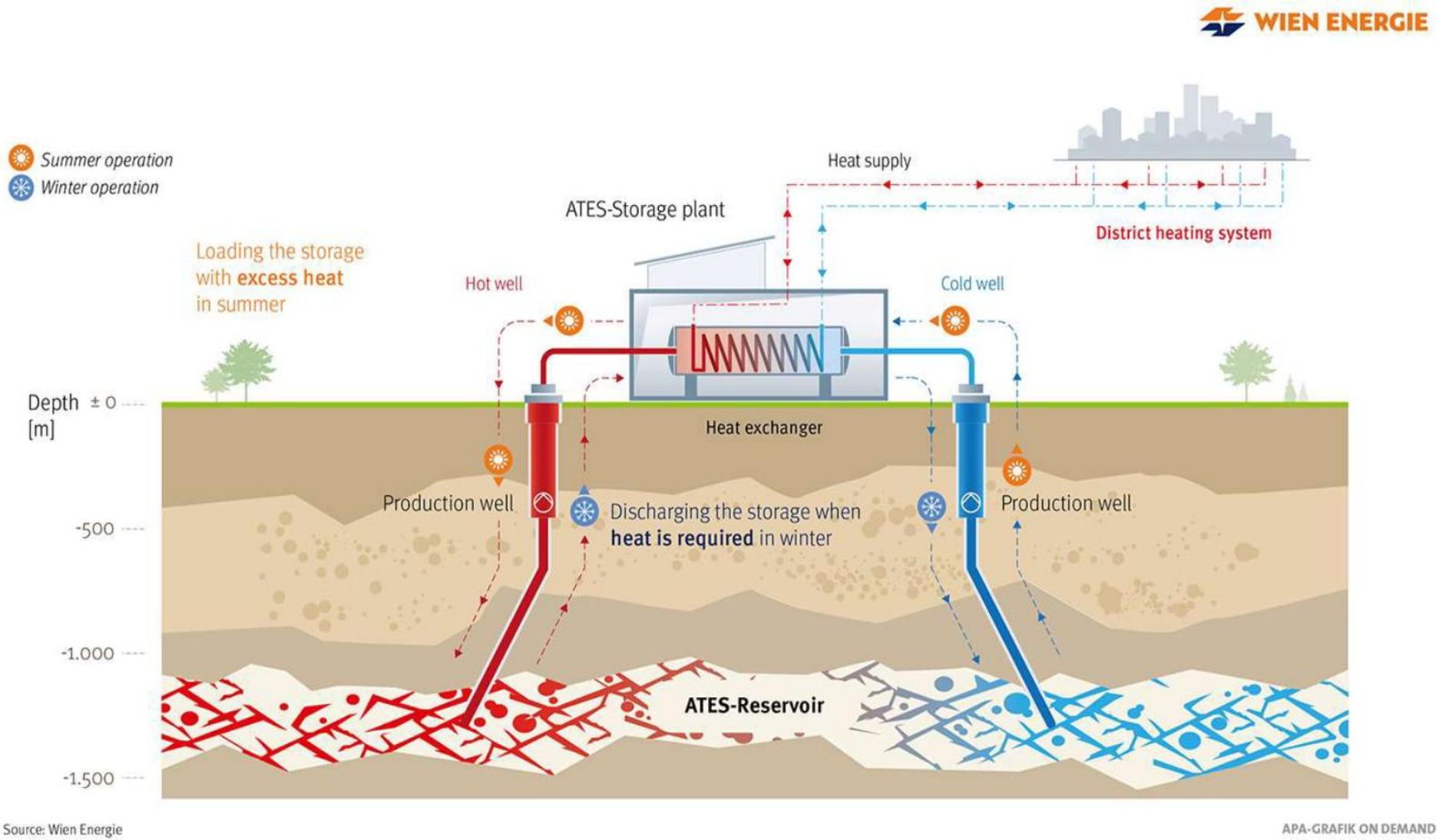
ATES VIENNA: PROJECT OVERVIEW

- **Project partners:**

- **Project duration:** 4/2021 – 12/2024
- **Project costs:** 952.305 EUR (492.379 EUR funding)

The ATES Vienna project addresses the **integration of aquifer heat storage into the Vienna district heating network** for the first time with the aim of designing the first technical pilot system in Austria.

ATES PRINCIPLE



ASSESSMENT OF GEOFLUIDS IN THE WHOLE ATES CYCLE

Chemical-mineralogical process modelling
Laboratory experiments

RELEVANCE OF TOPIC

- Precipitation in hydrogeothermal systems is widely known
- Currently **insufficiently investigated in ATES systems**
- During the pumping of the thermal water, **pressure and temperature changes** occur
- Influences on the **hydrochemical balance between thermal water and the surrounding rock matrix**
- Subsequent hydrochemical reactions: **dissolution and precipitation processes**
- Problems e.g. with **reinjection (porosity changes)**, with the pumps or heat exchangers can occur soon or after a few years of operation of the system

Examples for scaling in hydrogeothermal plants

Heat pumps, pipes, heat exchangers

EXPERIMENTAL DESIGN

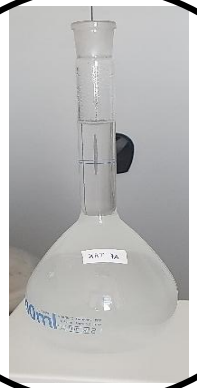
Autoclave tests		Formation 1	Formation 2	Formation 3
1 month	90 °C	x	x	x
	120 °C	x	x	x
4 months	90 °C	x	x	x
	120 °C	x	x	x
Reference sample with ultrapure water				
1 month	120 °C	x	x	x

Brine composition

1427 - 1429 m	1428,5 - 1429,5 m
15015	13770
95	85
56	32
52	128
487	310
59	155
9615	8764

PHREEQC

Mixing



Drill cuttings

Washing
Drying
Sieving

Washed cuttings

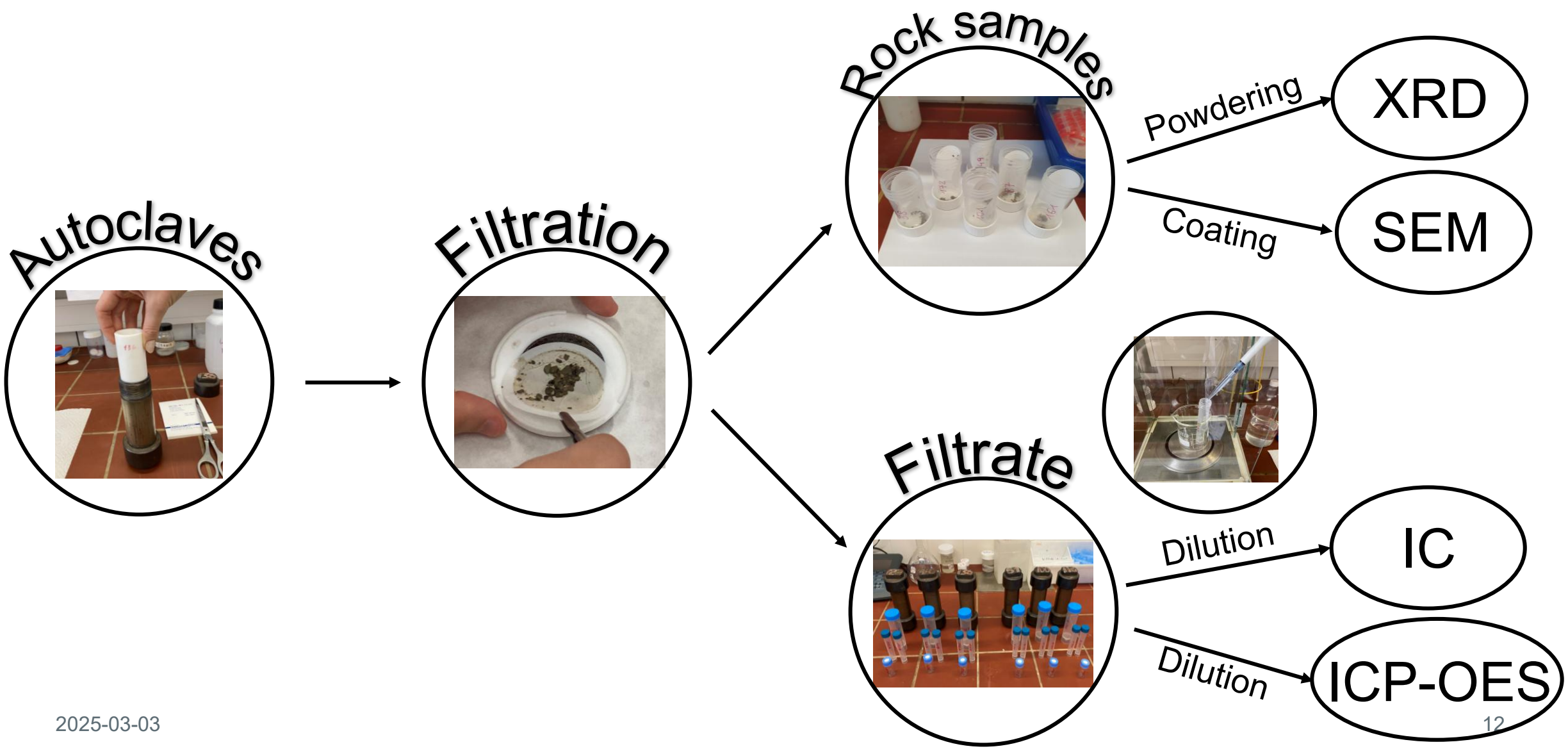
Autoclaves

Drying

Pre-experiments: 2 and 4 weeks at 120 ºC

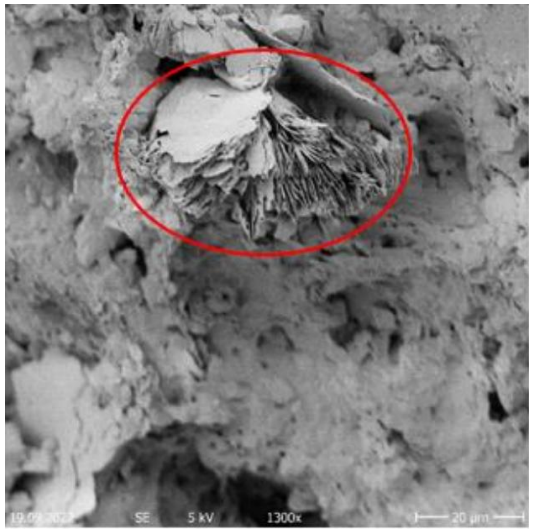
Main experiments: 1 and 4 months at 90 ºC and 120 ºC

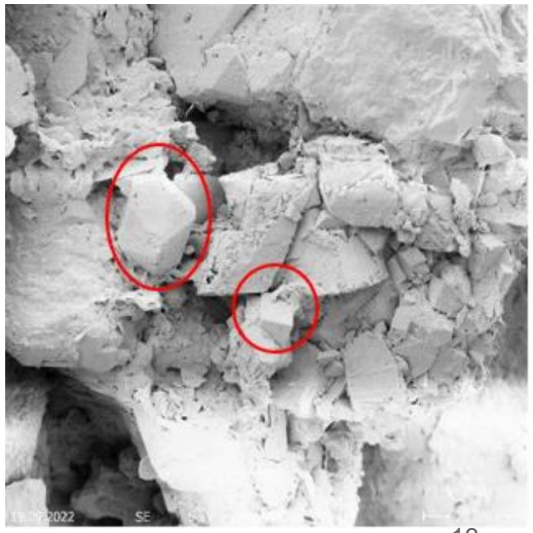
EXPERIMENTAL PREPARATION AND SETUP



PRE-EXPERIMENTS: RESULTS MINERALOGY

- XRD: **Albite decreased** in all investigated sandstone samples in comparison to original material → Mineral dissolution
  - **Precipitation of kaolinite**, which is not present in sandstone sample 1 → can lead to **porosity changes in reservoir and clogging**
- SEM: **Calcite crystallisations** with typical (rhombohedral) growth form in certain sandstone samples
  - **Kaolinite precipitates** with the characteristic book stack structure





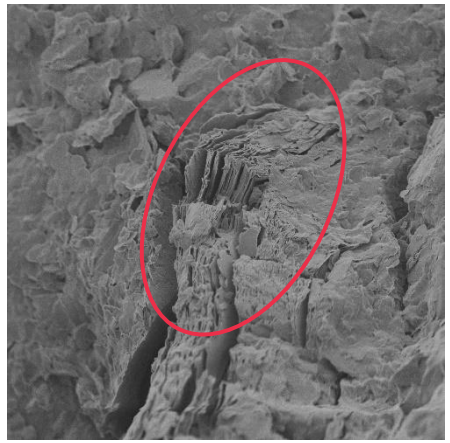
Sample	Quartz %	Dol_1 %	Dol_2 %	Kalzit %	Albit %	Mikroklin %	Muskovit %	Klinochlor %	Kaolinit %
1_S	63,2	17,5	5,3	7,5	4,0	1,4	0,2	0,9	-
1 b)	62,6	20,1	8,2	5,2	3,1	0,2	0,4	-	0,2
21 d)	64,4	21,5	5,6	5,6	1,8	0,4	0,6	-	0,2
106 a)	56,6	19,0	10,0	6,7	3,3	1,5	1,4	1,5	-
125 c)	55,9	24,5	5,9	6,1	2,9	1,3	3,2	-	0,1
2_S	84,9	2,4	1,0	4,8	2,6	2,9	1,1	-	0,3
6 a)	85,6	3,6	1,1	4,6	1,8	1,5	1,9	-	-
23 d)	85,3	3,6	1,3	6,7	0,9	1,1	1,0	-	0,1
96 c)	84,0	6,2	1,7	5,4	0,5	0,5	1,3	-	0,4
161 b)	87,8	2,0	0,4	6,1	1,7	0,9	1,2	-	-

1_S.....Sandstone Baden 1
2_S.....Sandstone Baden 2

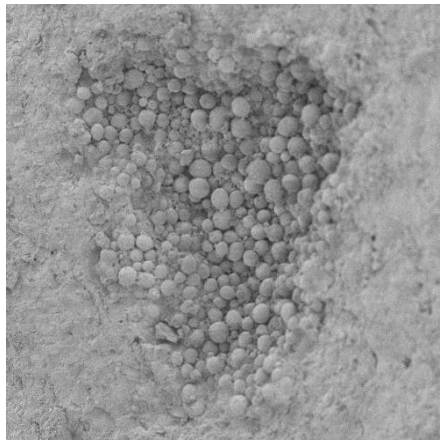
salt solution + week
a).....1 (Baden) + after 2 weeks
b).....1 (Baden) + after 4 weeks
c).....2 (Sarmat) + after 2 weeks
d).....2 (Sarmat) + after 4 weeks

RESULTS EXPERIMENTS LOCATION 1 – MINERALOGY

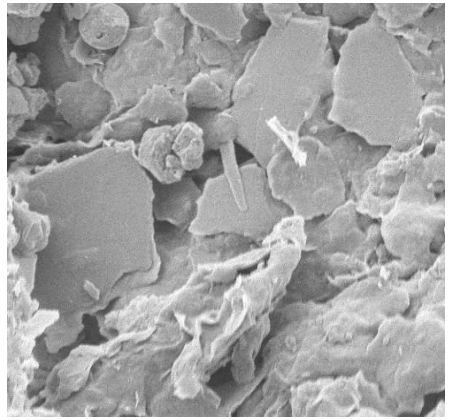
Original material	90 °C, 1 Month	90 °C, 4 Months	120 °C, 1 Months
Quartz O2 Si1	Quartz O2 Si1	Quartz O2 Si1	Quartz O2 Si1
Dolomite C2 Ca1 Mg1 O6	Dolomite C2 Ca1 Mg1 O6	Dolomite C2 Ca1.07 Mg0.93 O6	Dolomite C2 Ca1 Mg1 O6
Calcite C1 Ca1 O3	**Mg-Calcite C1 Ca0.97 Mg0.03 O3**	**Mg-Calcite C1 Ca0.97 Mg0.03 O3**	**Mg-Calcite C1 Ca0.97 Mg0.03 O3**
Muscovite H2 Al2.9 K1 O12 Si3.1		Muscovite H2 Al3 K1 O12 Si3	Muscovite H2 Al2.97 Fe0.03 K0.82 Na0.18 O12 Si3
	Illite H3 Al4 K1 O12 Si2	**Albite Al1 Na1 O8 Si3**	



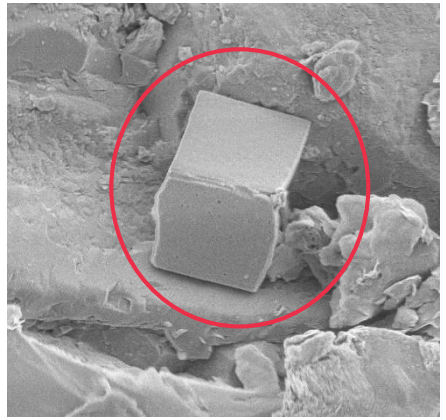
Muscovite



Mg-Calcite

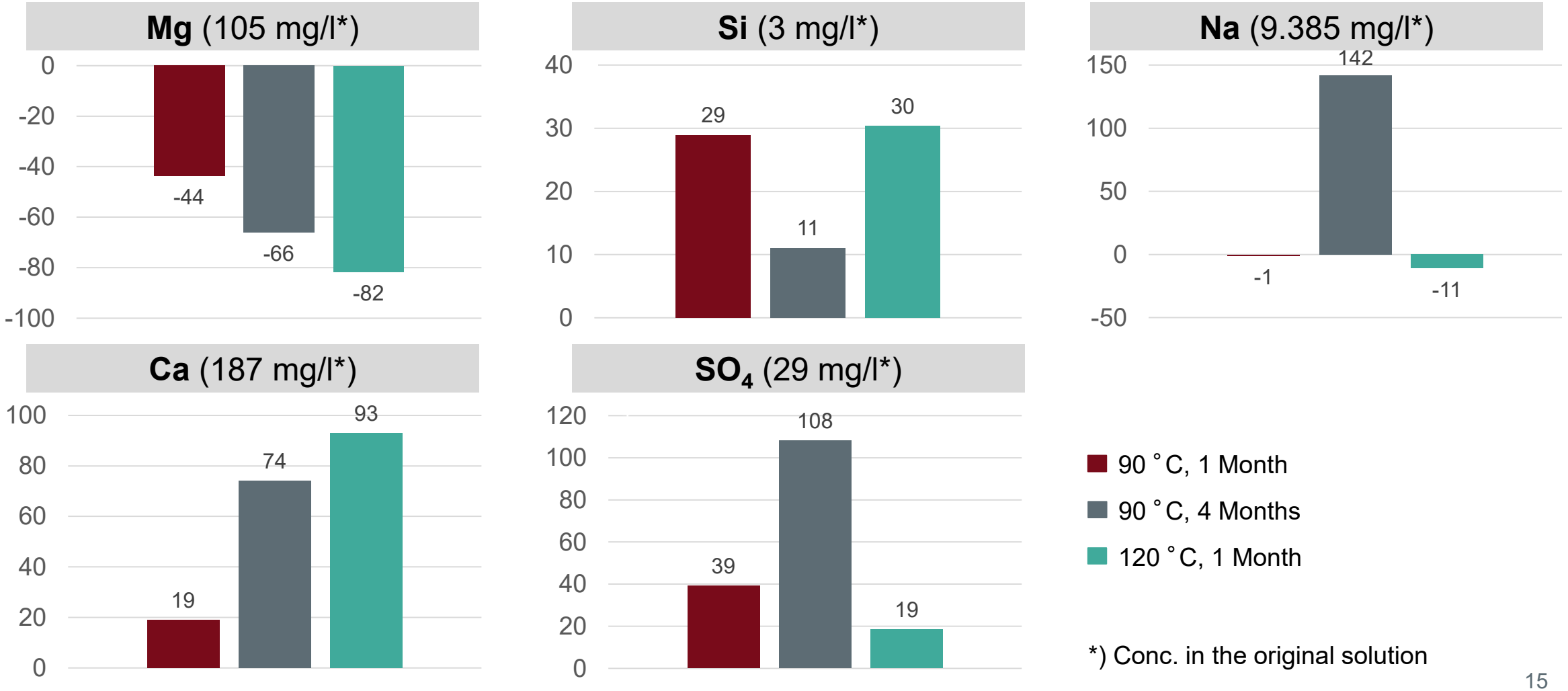


Illite



Calcite

LOCATION 1 – WATER CHEMISTRY
INCREASE/DECREASE OF ELEMENTS IN SOLUTION



SUMMARY

- **ATES** system represents a **promising technology** that can also **advance the decarbonization of the heating sector**
- The hydrochemical studies show that **changes in the thermodynamic equilibrium (scaling)** and **porosity changes** can occur and thus the use of ATES can be impaired
- **Temperature** and **loading time of the ATES** are **significant for the chemical-mineralogical processes** and the associated **risk assessment**
- The experiments made it clear that the **hydrochemistry and the resulting precipitation** should be **monitored** during operation so that **continuous risk assessment** can be guaranteed
- **Choice of material** and **operating conditions** should be adapted to hydrochemical processes
- Elaboration of a basic hydrochemical model (e.g. PHREEQC) → „**Calibration**“ **of model** with the results from the **laboratory experiments**

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THANK YOU!