

Reinjection Workshop



Understanding Clogging Phenomena in DG Reinjection: Insights from Microscopy, Flooding Tests, and Mineralogical Analysis

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Problem Overview

Is geothermal really sustainable?

Not without reinjection. Hence the importance of reinjection in geothermal energy systems.

Research Objective

- Understanding reinjection processes and clogging issues
- Focus: Processes of physical clogging

Methods

Hg Porosimetry, Gas permeability, SEM, XRD, Micro-CT Imaging

Artificial sample manufacture and lab flooding experiments

Further Micro-CT Visualization, Simulation

Outline

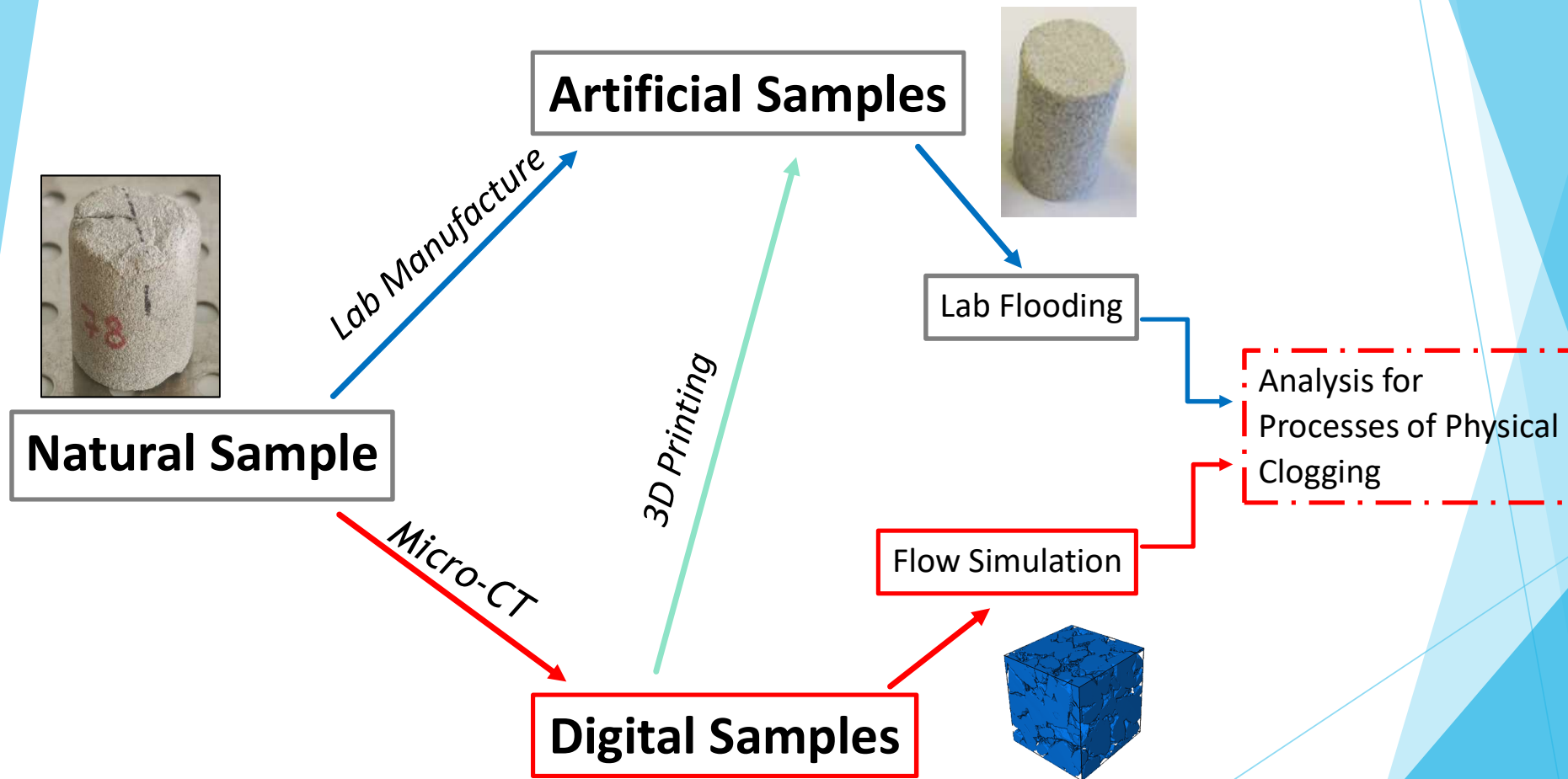
- Introduction to the problem at hand
- Overview of the work
- Broader look into 3 “potential” reinjection rock samples
- Narrowing down into what could work
- Artificial sample and lab reinjection tests
- Results and conclusion
- Recap and what next

Same look yet so different for reinjection



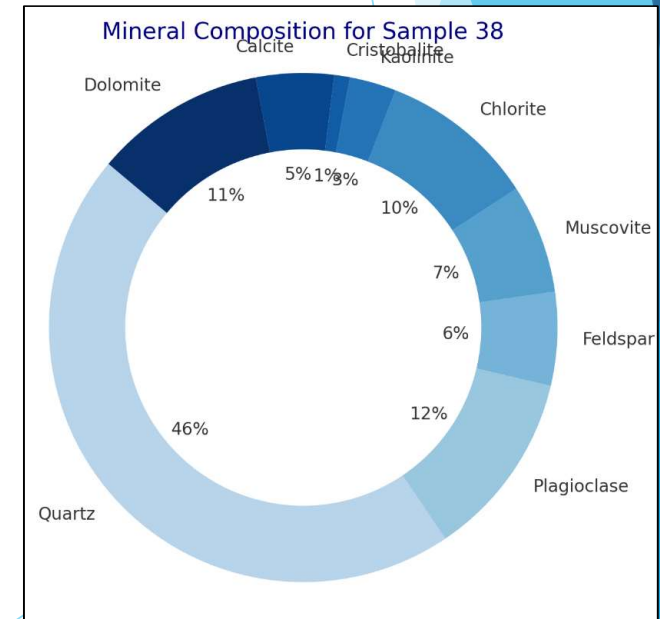
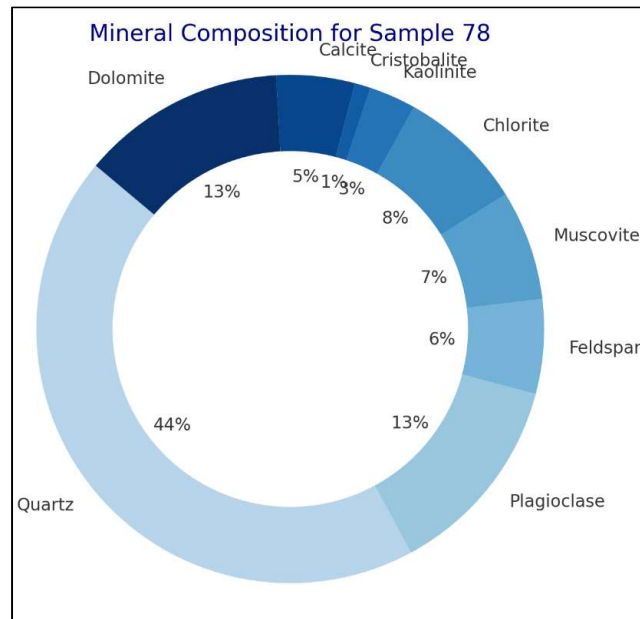
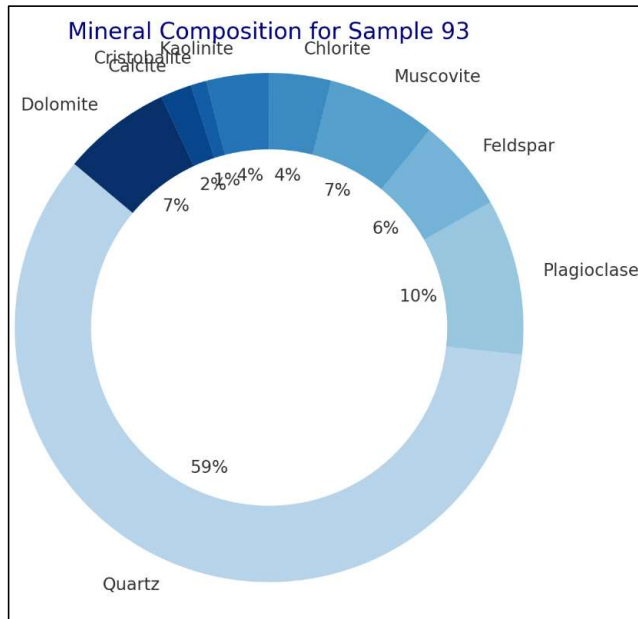
Late Miocene samples: Depths 1936 m to 1960 m

A Complete View of the Research

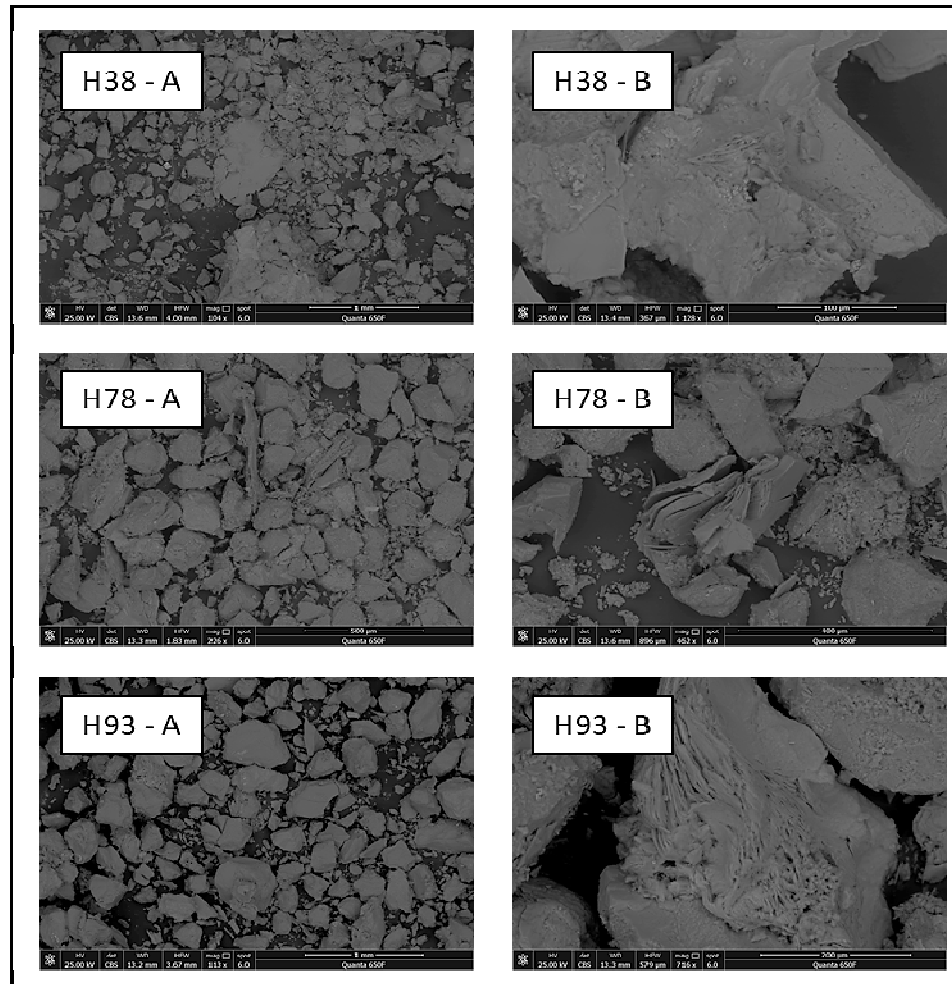


Petrology & Mineralogy

Sample ID	Porosity (%) (High porosity)	Apparent Permeability (mD)	Klinkenberg Permeability (mD)
H38	27.7	65.8	59.3
H78	29.5	260.5	244.4
H93	31.2	409.5	388.3

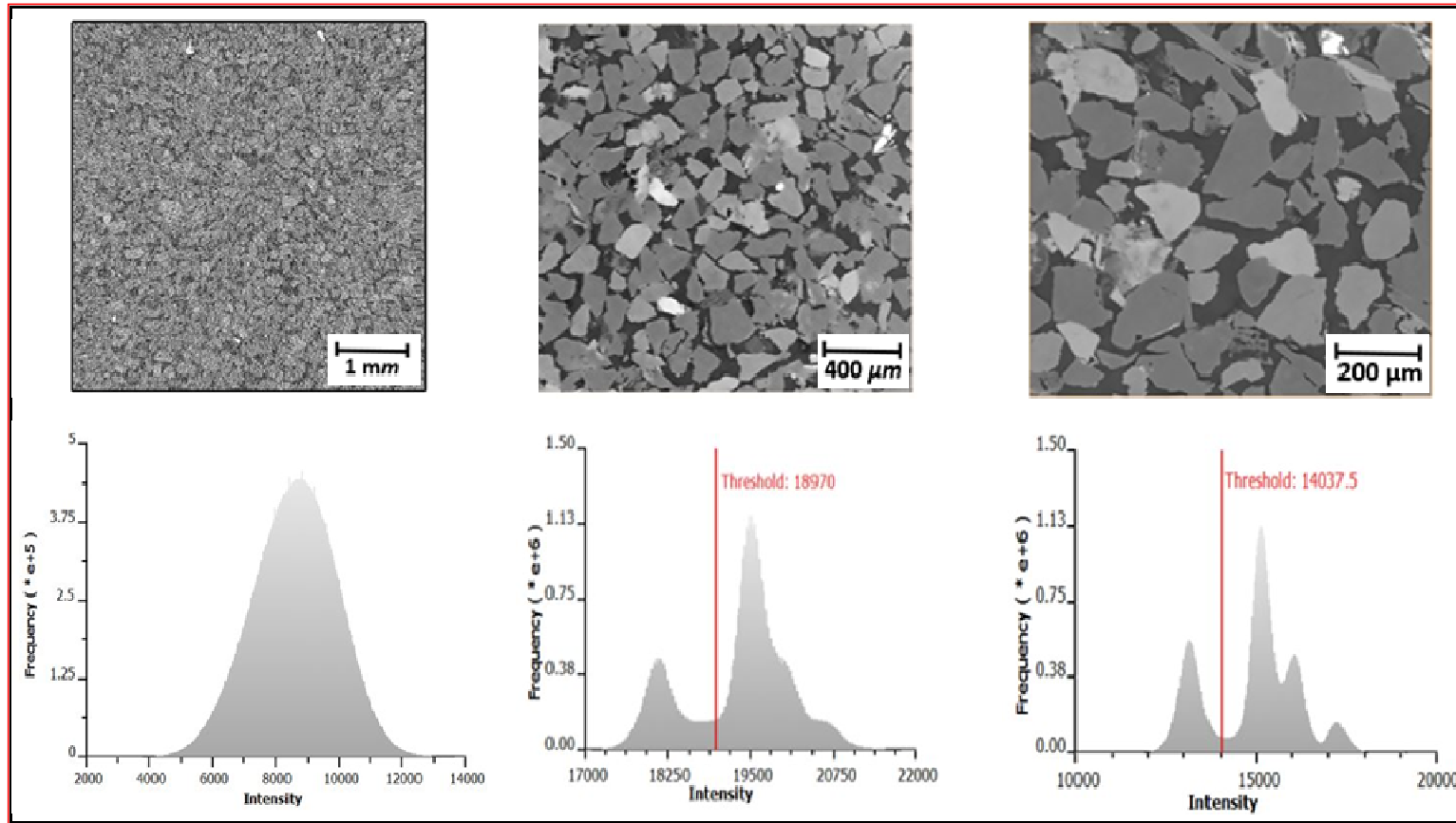


SEM



Fine-grained materials and weak cementation - Potential contributors to injection well clogging

Micro-CT and image Segmentation



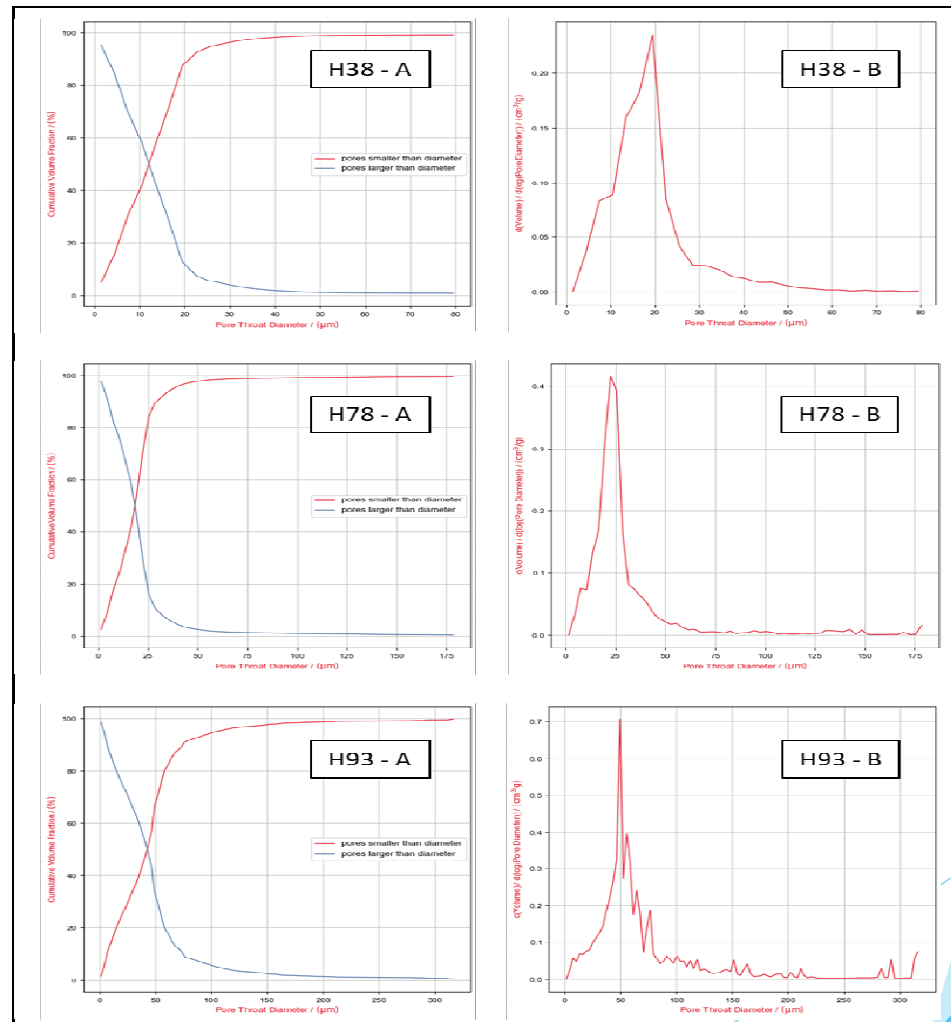
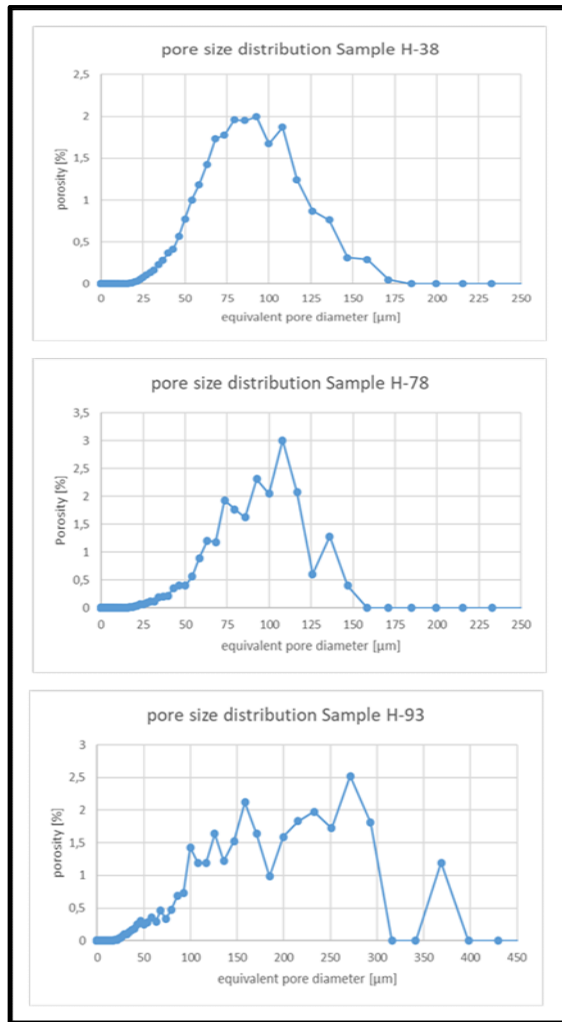
5 μm

2 μm

1 μm

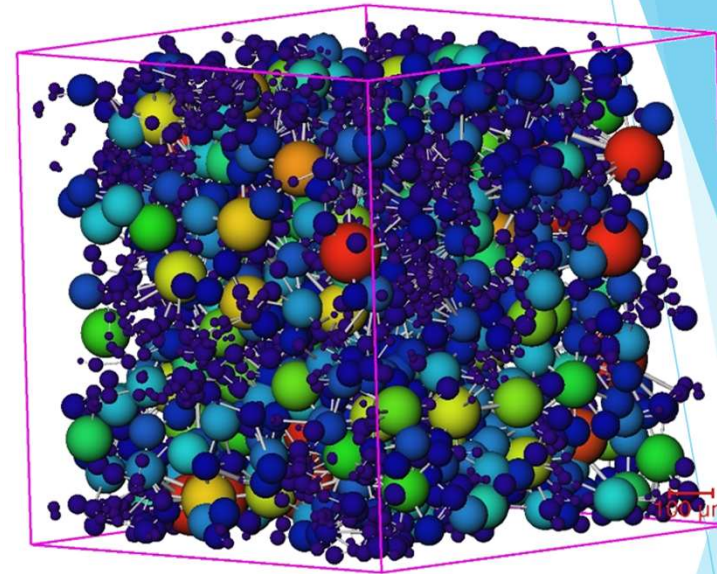
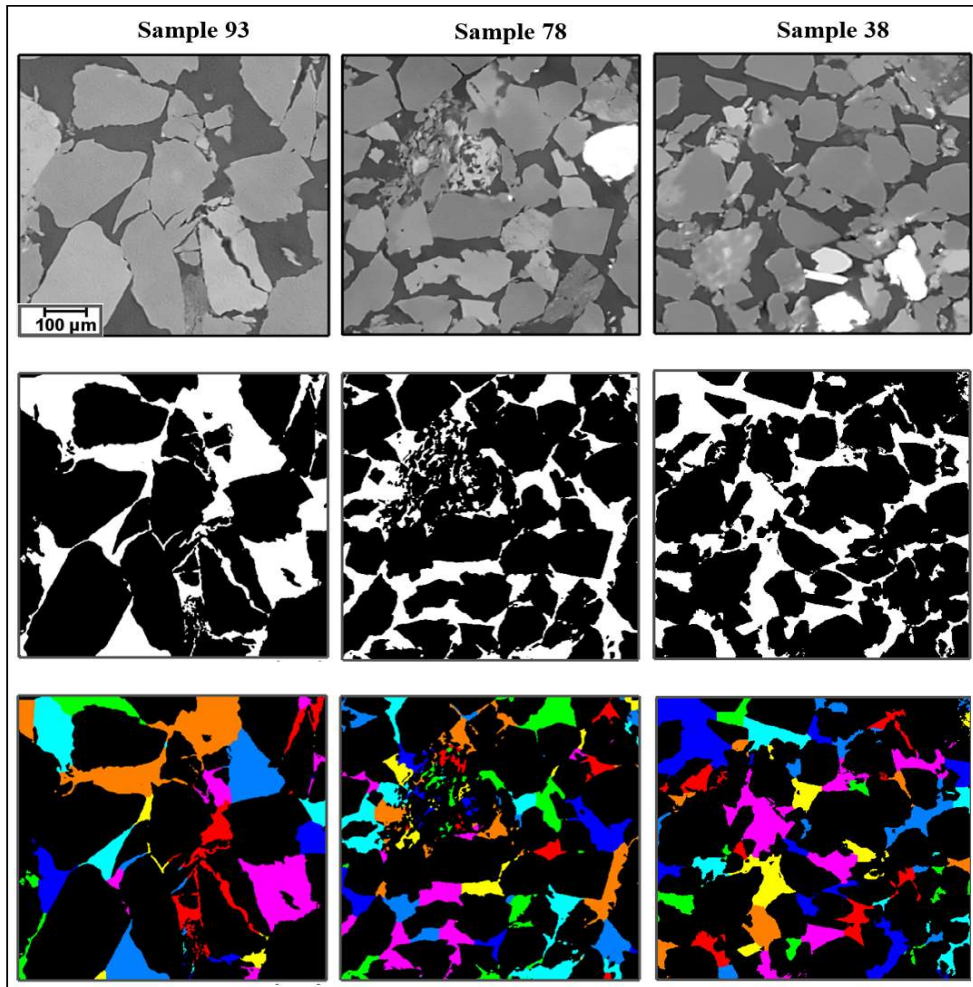
What works in simple image segmentation

Pore and pore throat size distribution



Majority Throat size: H38= ~20 μm . H78= ~25 μm . H93=~50 μm .

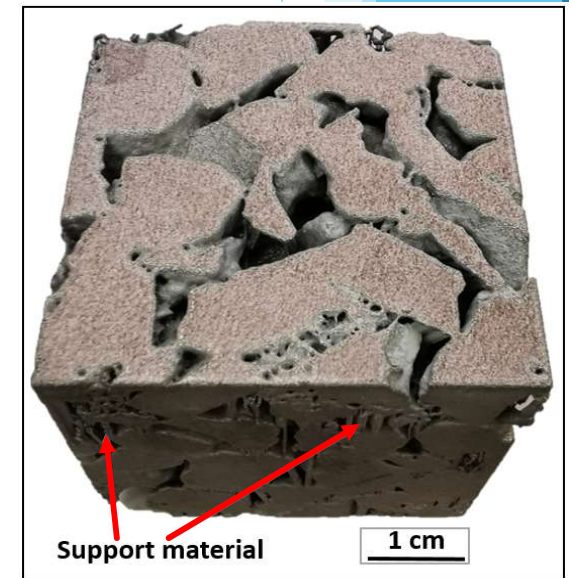
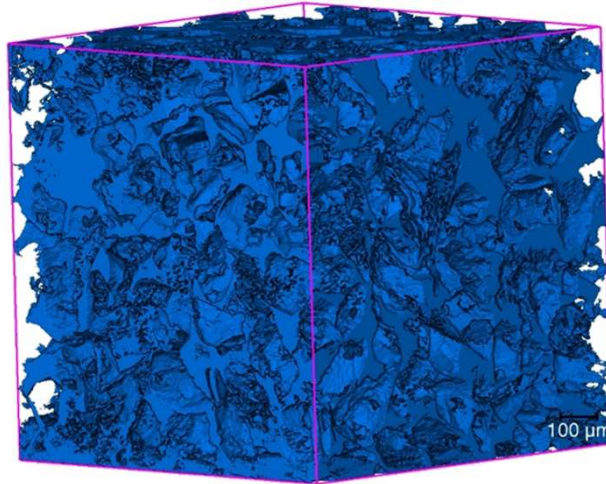
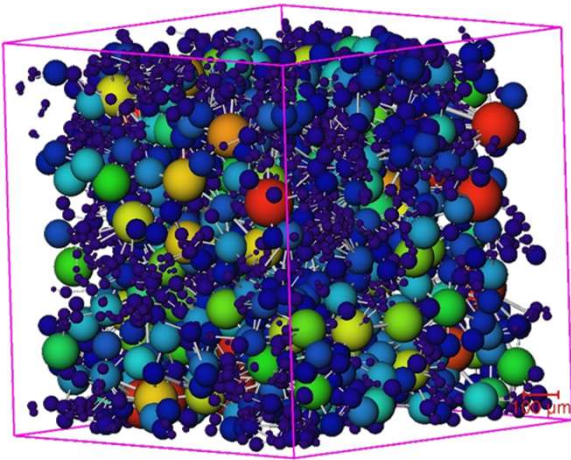
Segmentation and 3-D Model Preparation



Pore Network Model

Segmented and separated pores
2D and 3D

From natural to printed sample: Challenge



Re-evaluation.

Investigation Without Risk - Artificial sample preparation

- Preparation of samples similar to sample 78
- Artificial Sample pre-investigations to match sample 78
 - Porosity
 - Permeability
 - Pore size distribution,
 - Pore throat size distribution

Laboratory Flooding Tests



**Seeking either phenomenon
A, B, or C or a combination**

Surface filtration (A)

Deep filtration (B)

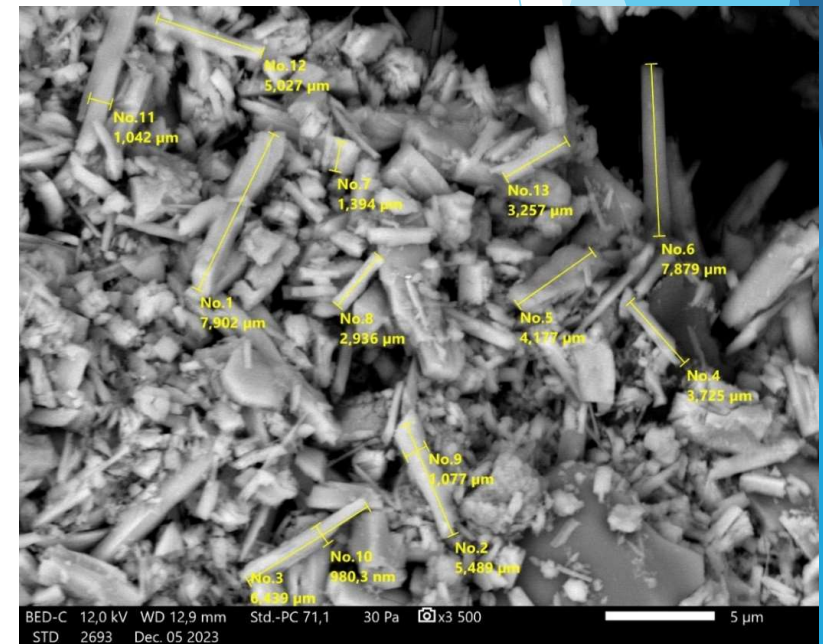
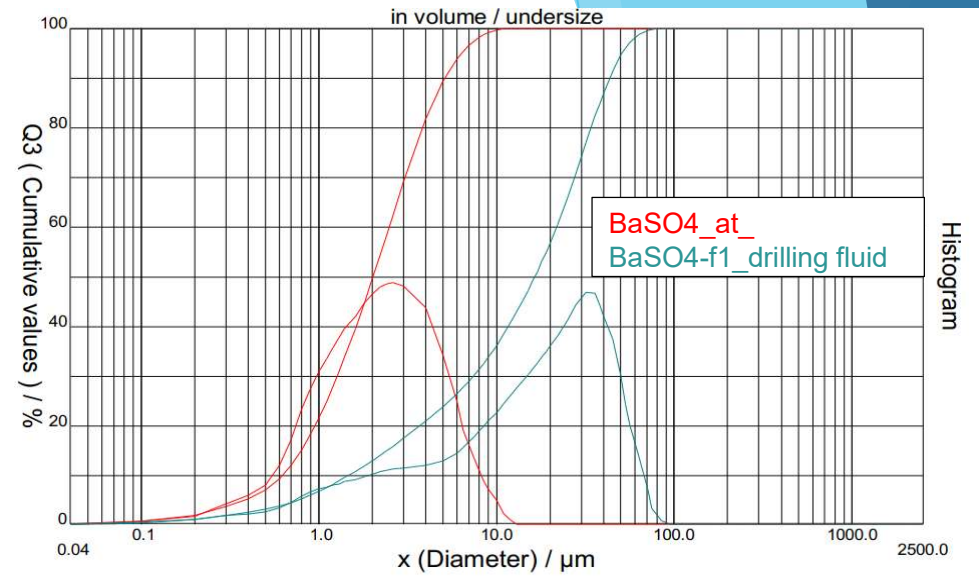
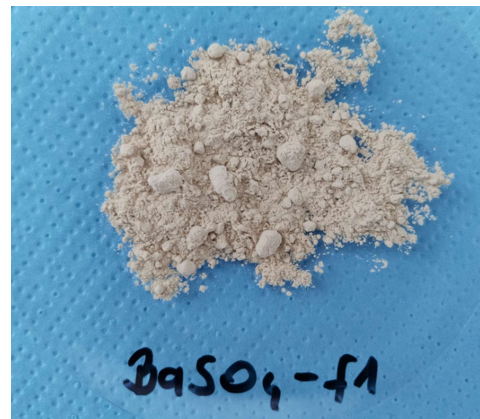
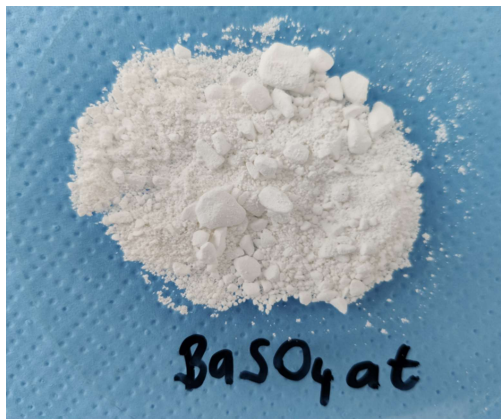
No filtration (C.)

(Szanyi et al. 2015)



Early Lab Stage Challenges

Reinjection fluid preparation
&
Choice of damaging particles type
 BaSO_4 (drilling fluid & Commercial)
 CaSiO_3
Particle size and concentration

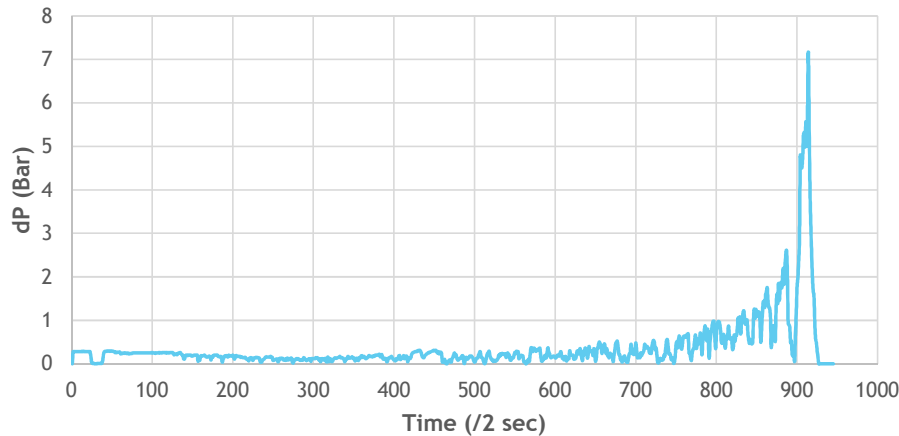


Early Lab Stage Challenges. Cont'

Determination of the boundary conditions. Confining pressure and pore pressure

Coming up with a working set up

Clogging sample Artificial

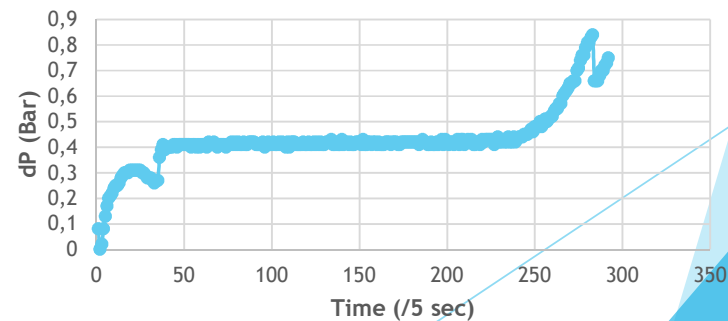


Broken sample

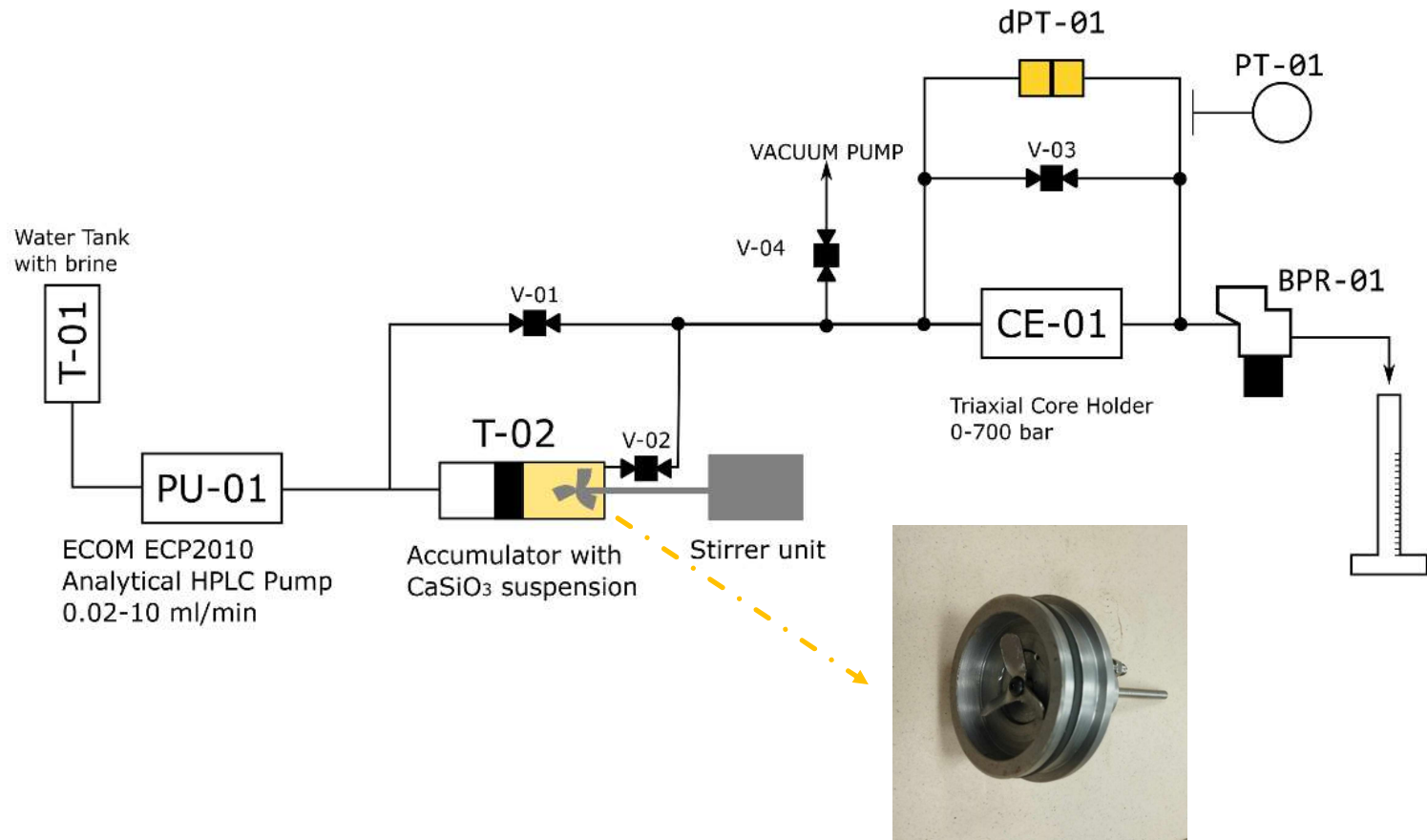


Challenges with the set up

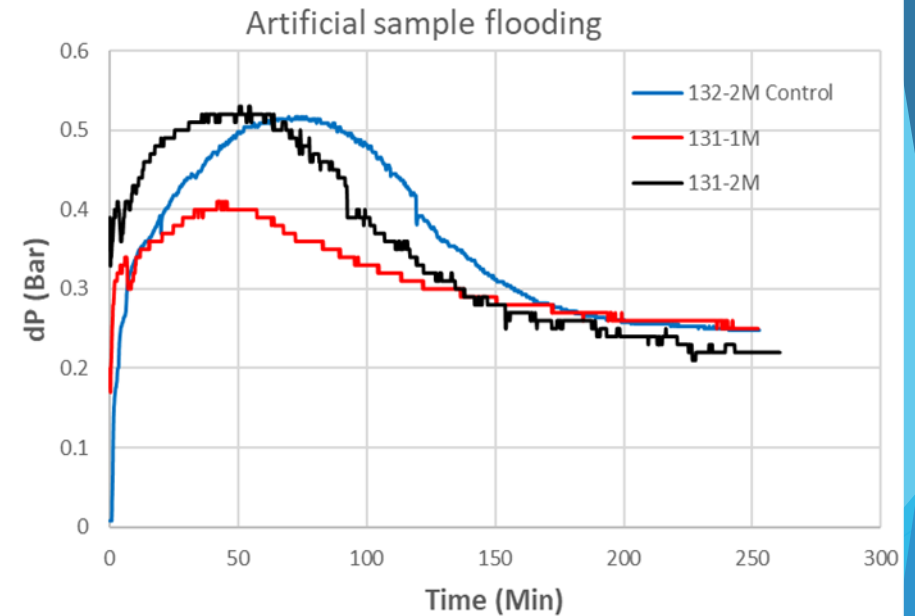
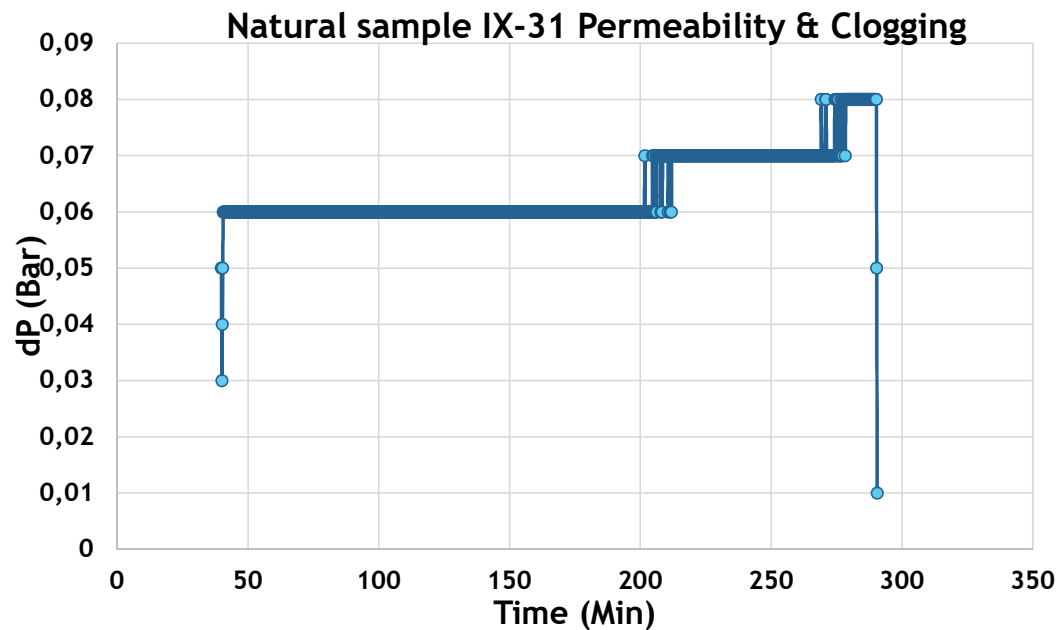
Clogging Sample. Artificial



Schematic experimental setup for core flooding tests

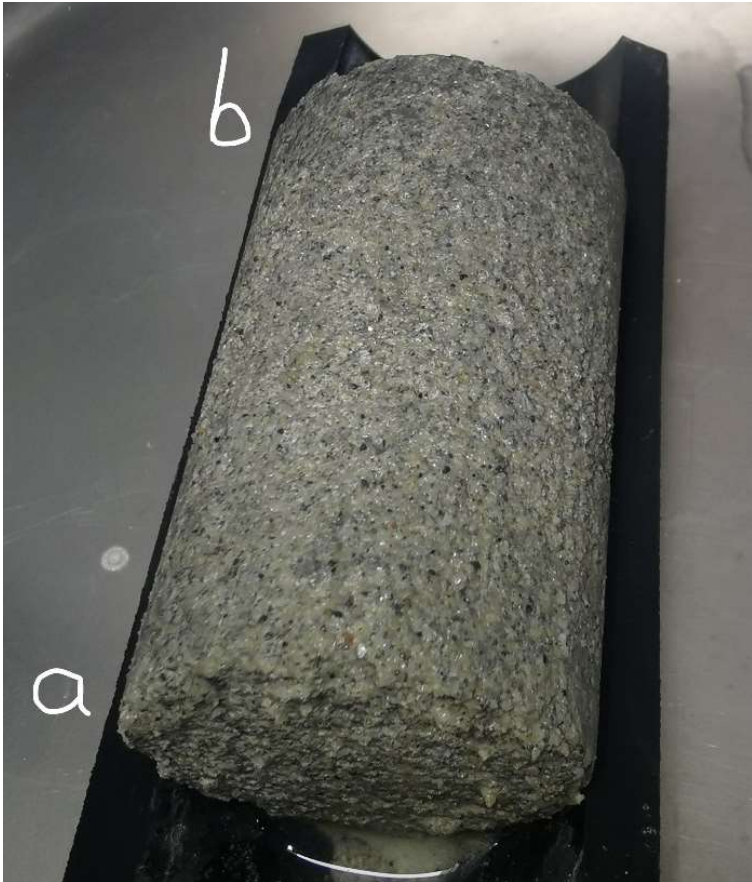


Selected flooding test results



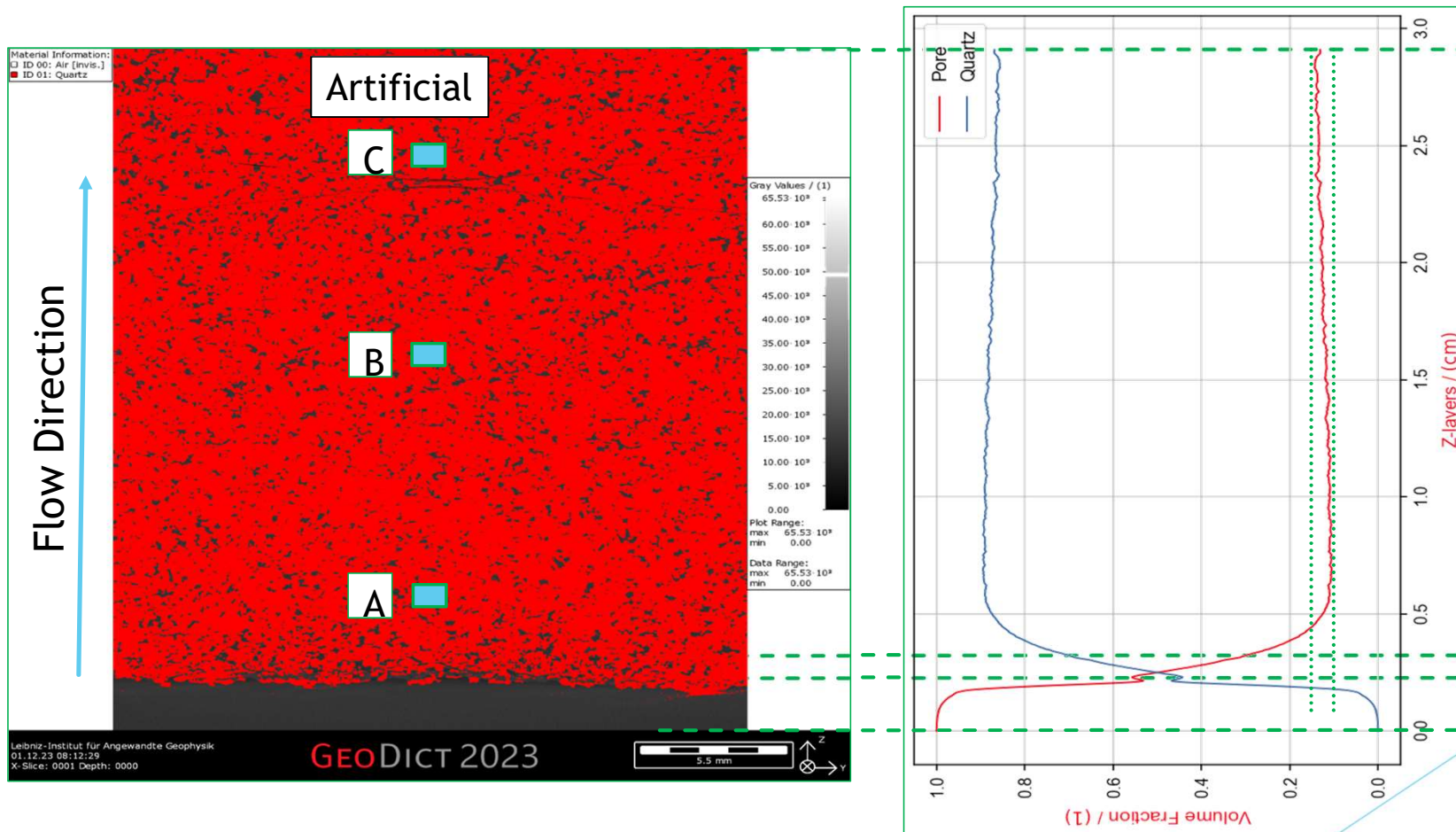
Permeability decline noticed in the initial stages of flooding for all the tests carried out.

Clogged samples



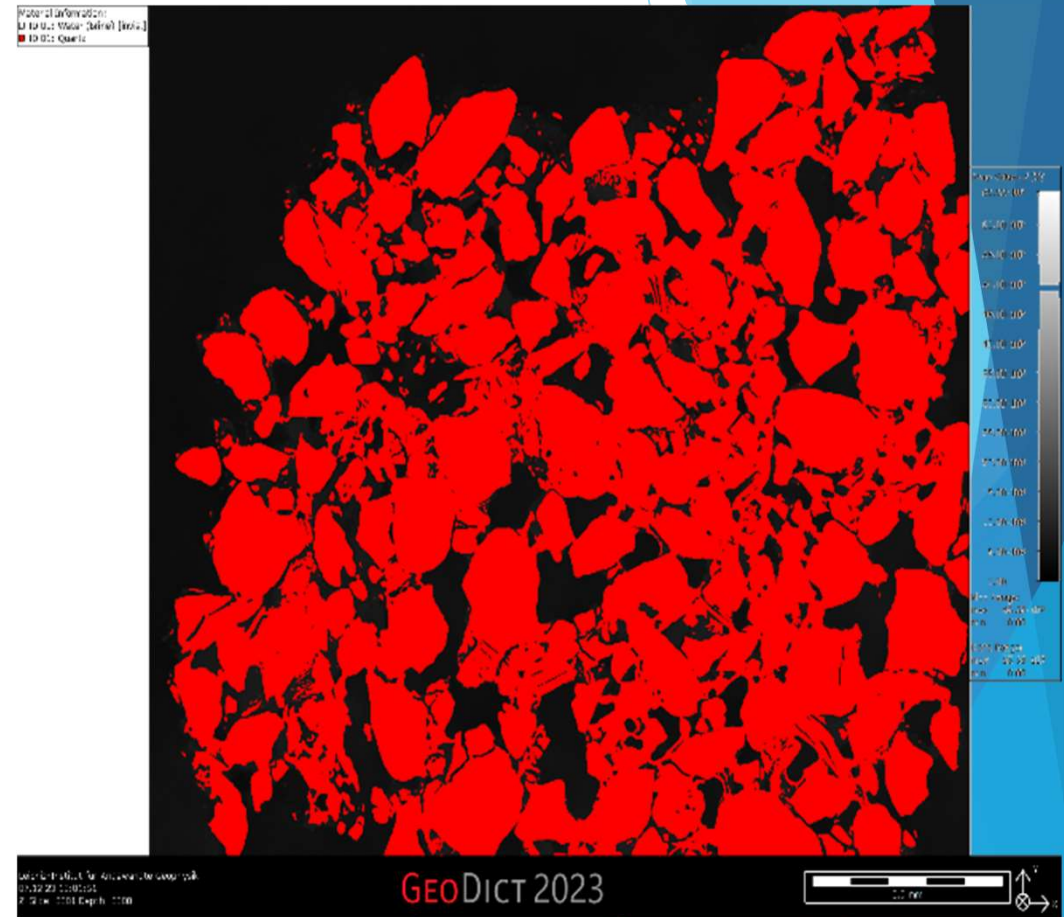
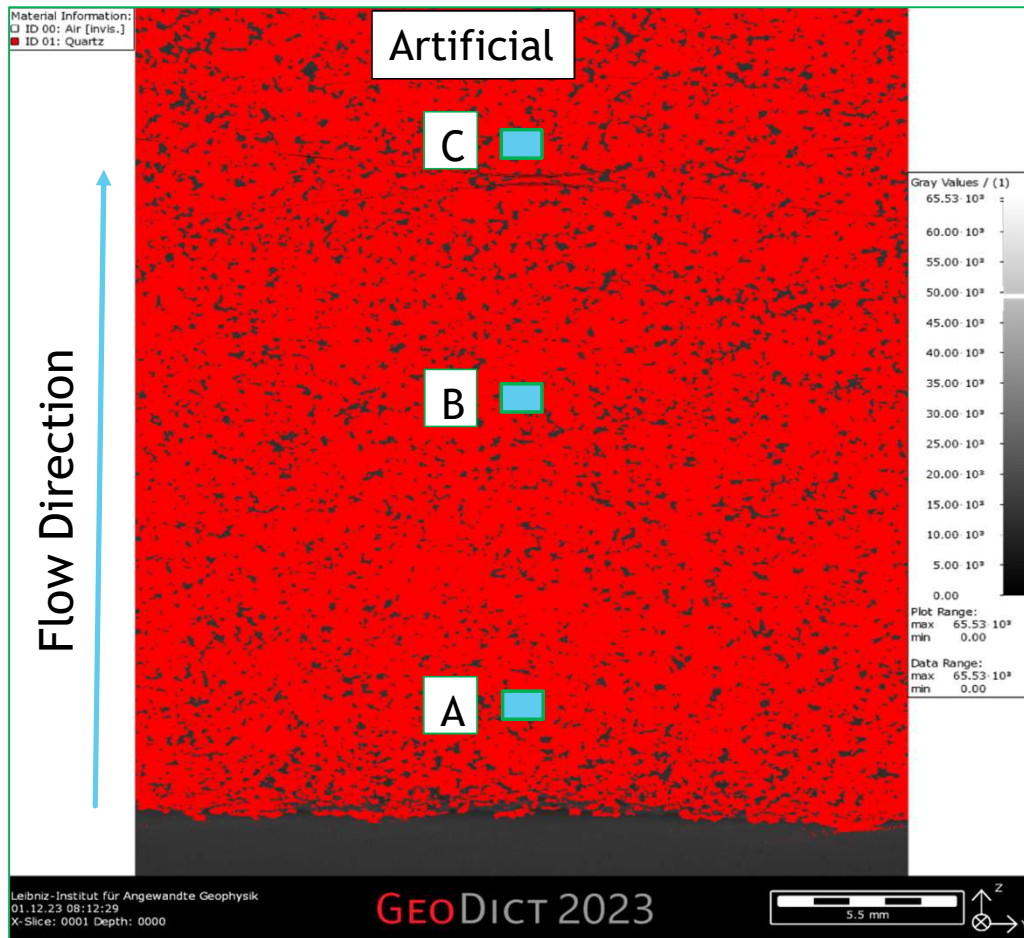
Filter cake observed on the clogged samples

Micro-CT investigations of the clogged samples

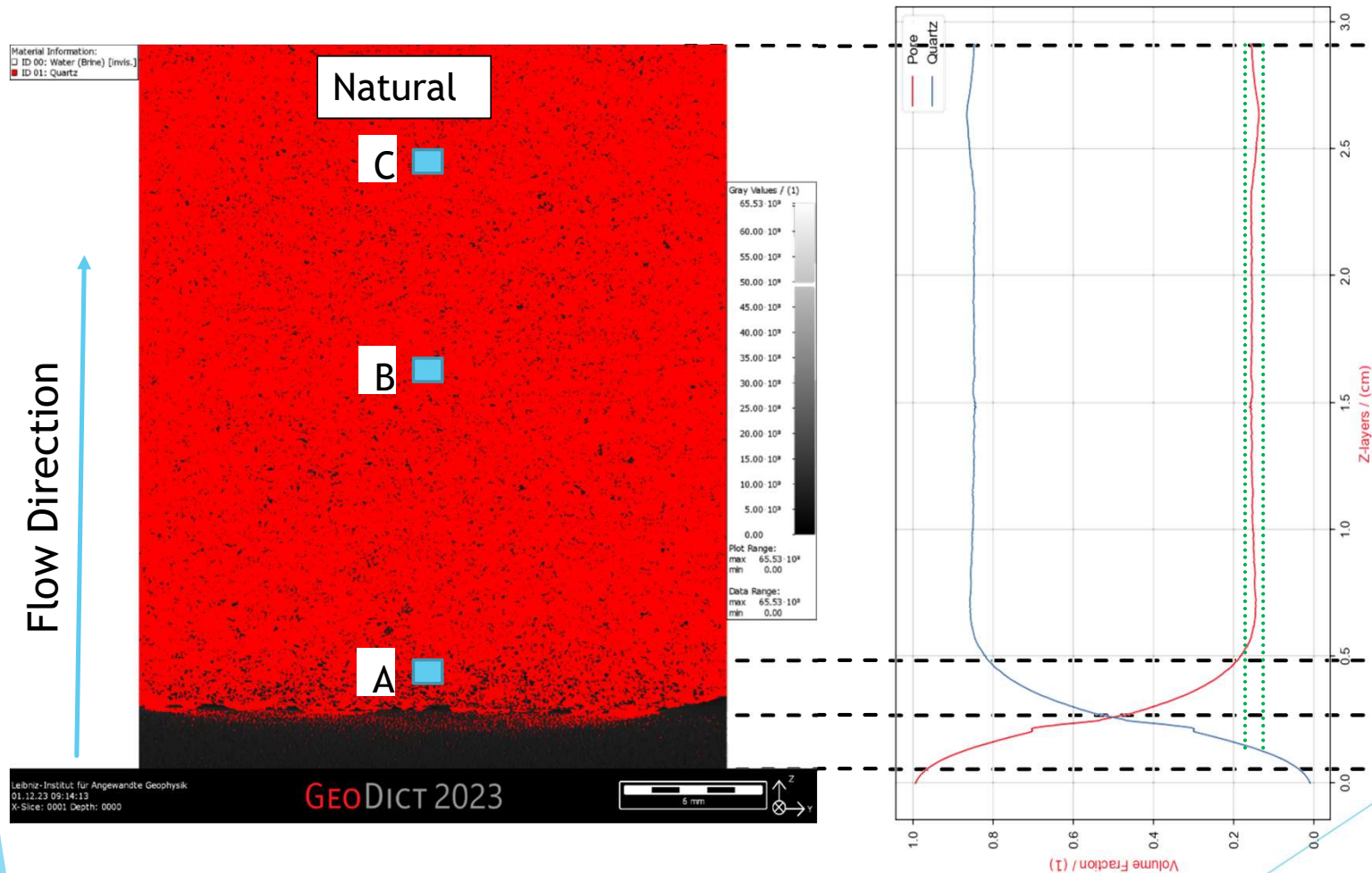


Porosity profile show porosity increase from inlet to outlet

High resolution scan

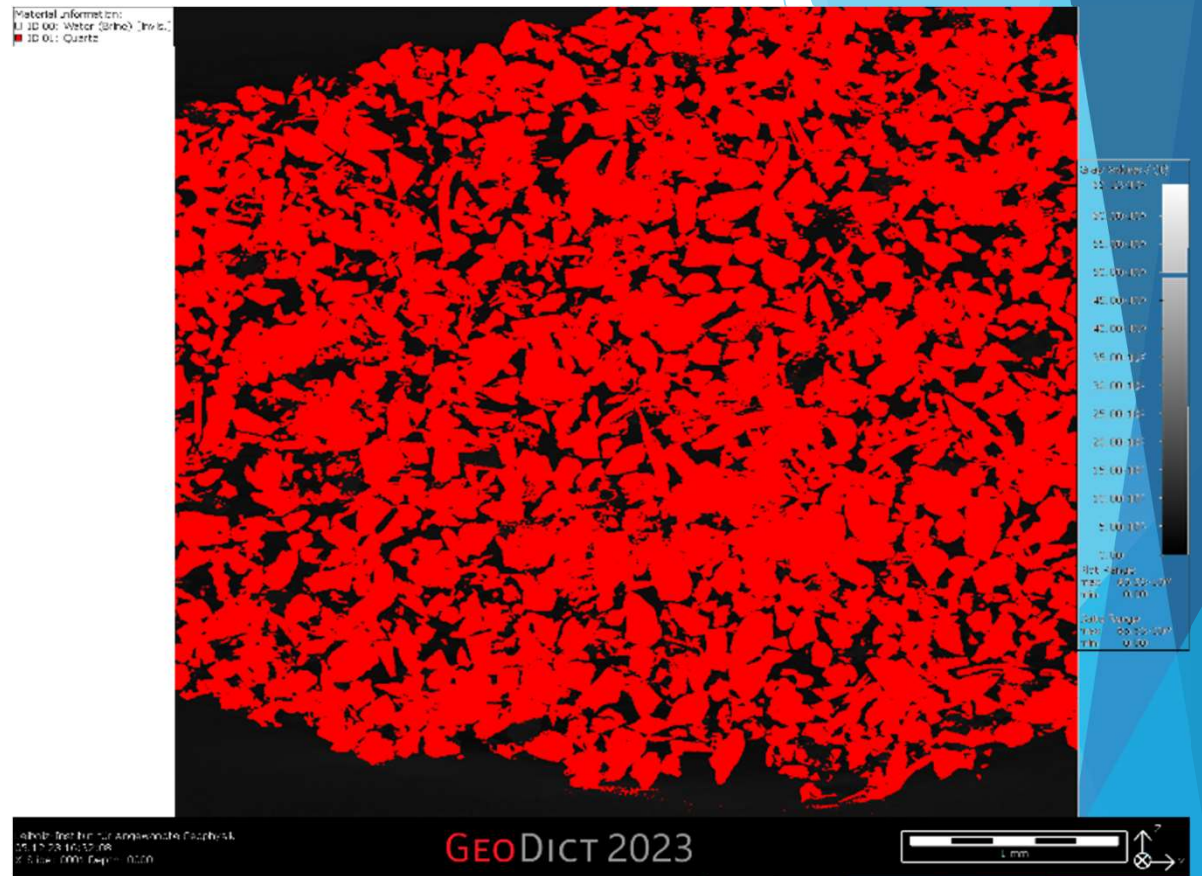
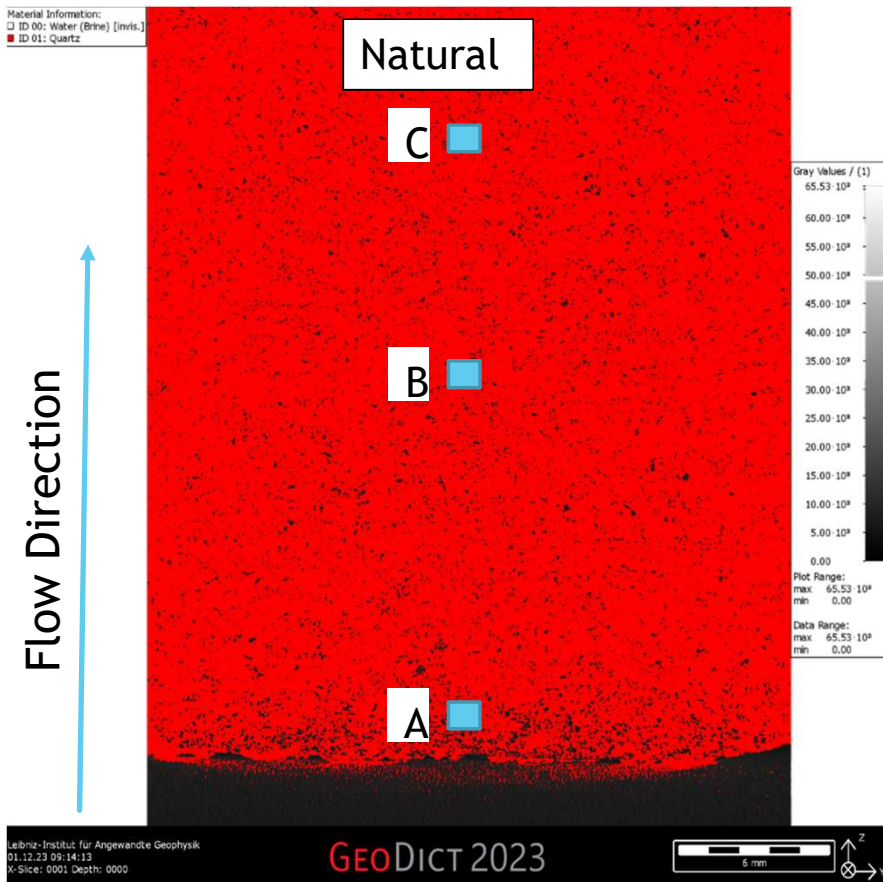


Micro-CT investigations of the clogged samples: Porosity profile



Profile shows porosity increase from inlet to outlet

High resolution scan



Profile shows porosity decline from inlet to outlet

Conclusion

- Sample 93: Features large pore throats; low clogging risk - optimal for reinjection.
- Samples 78 & 38: Small pore throats; prone to clogging due to size variability
- 38 has high porosity but poor pore connection. Suboptimal for reinjection
- Clogging Phenomena in Rock Samples:
Laboratory and micro-CT analysis indicate clogging occurring through both surface and deep filtration mechanisms.
- Fine grains and weak cementation also contribute to clogging.

Gradual clogging for the artificial rock. Stepwise clogging for the natural rock.

Acknowledgement

Miskolc Un.

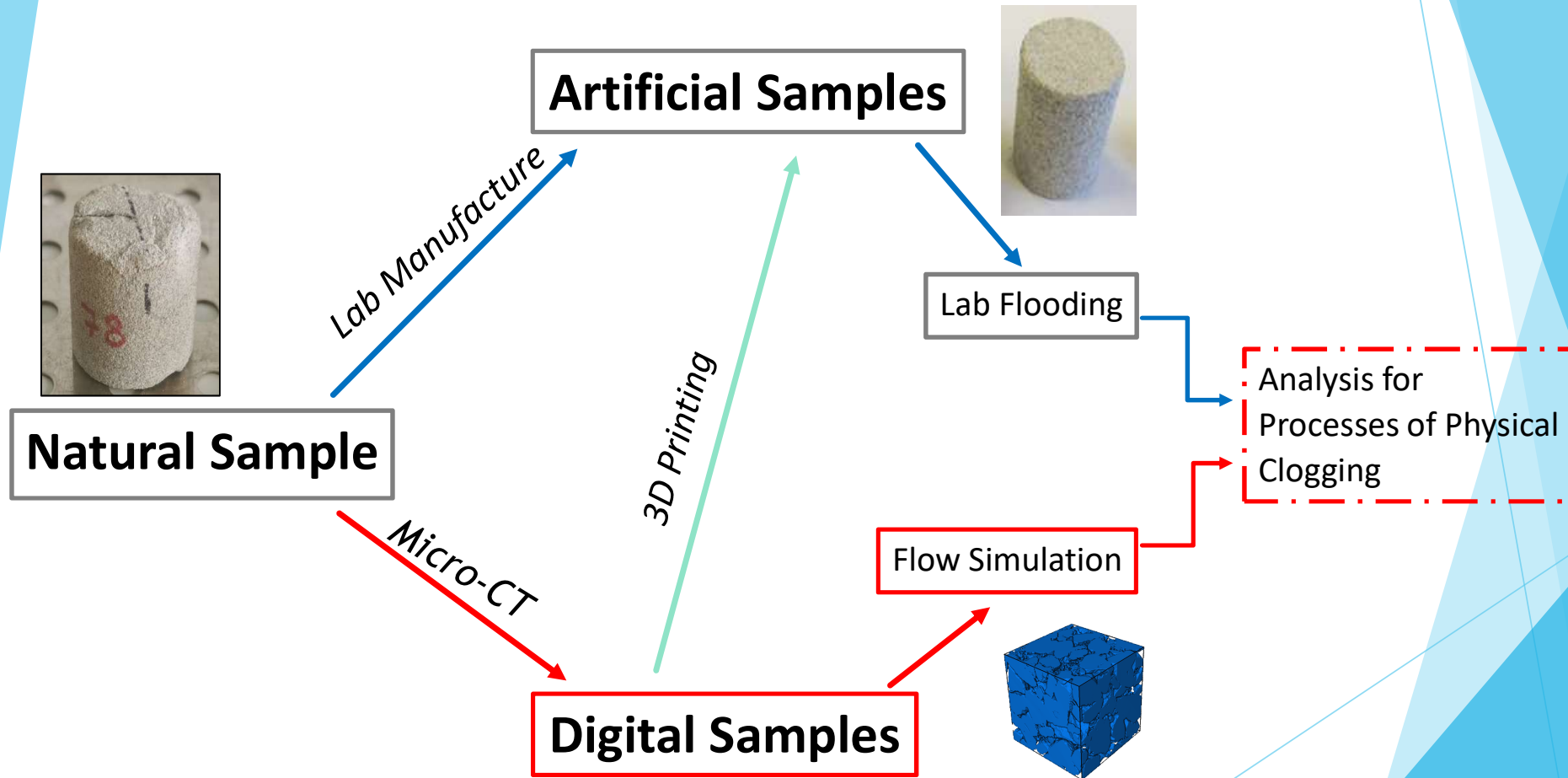
SZTE.

GEOCHEM.

LIAG.



What next!





THANK YOU

Questions & Further Discussions