Experimental and modelling studies of fluid-rock interaction during CO_2 reinjection

CO_2 as an effective silica anti-scalant during reinjection of acid-dosed geothermal brines

B.W. Mountain
J.W. Patterson
D.J. Byrne
L. Sajkowski
P.M. Rendel

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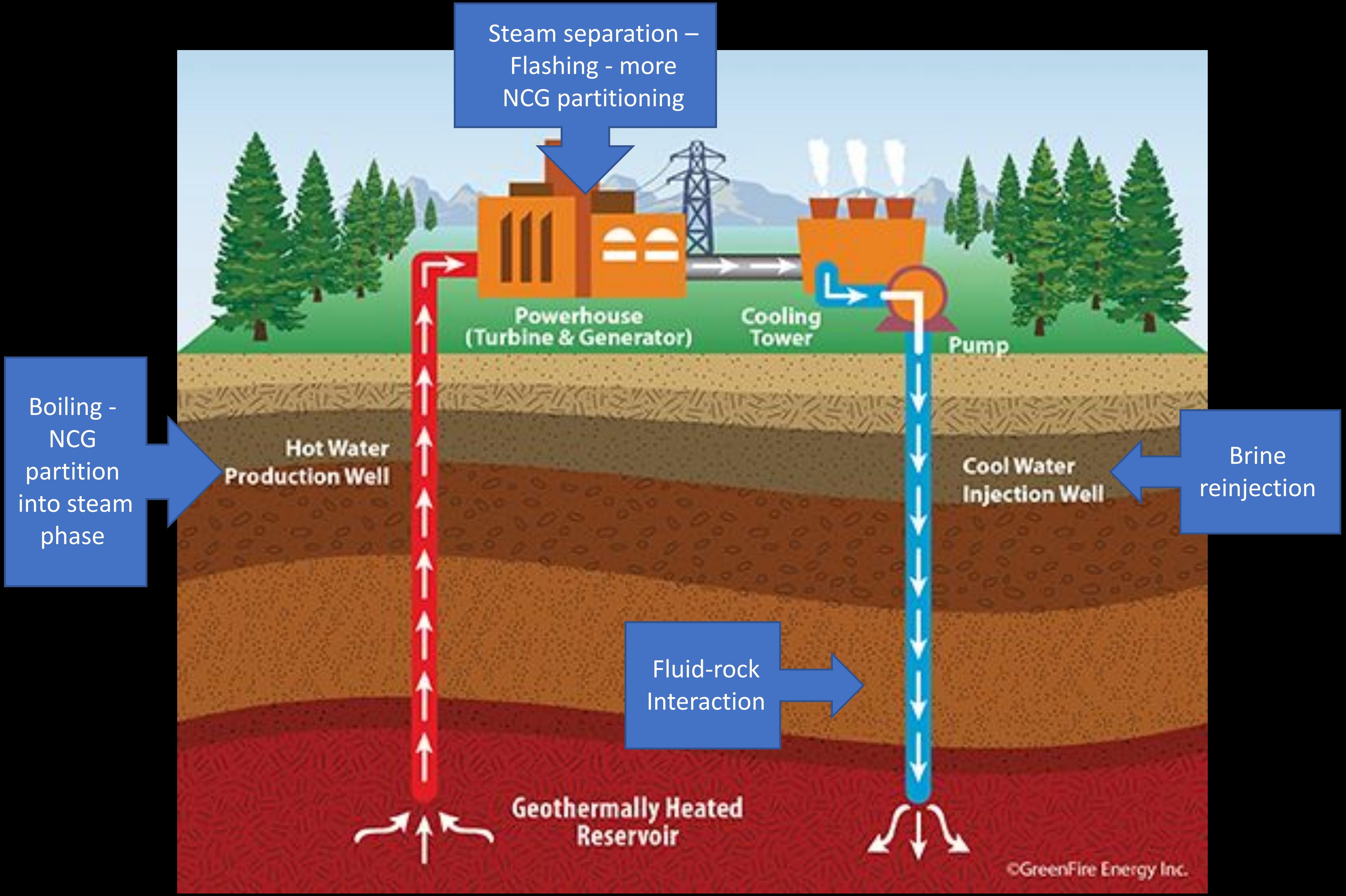
Steam separation – Flashing - more NCG partitioning
Boiling - NCG partition into steam phase
Brine reinjection
Fluid-rock Interaction
Powerhouse (Turbine & Generator)
Cooling Tower
Pump
Hot Water Production Well
Cool Water Injection Well
Geothermally Heated Reservoir
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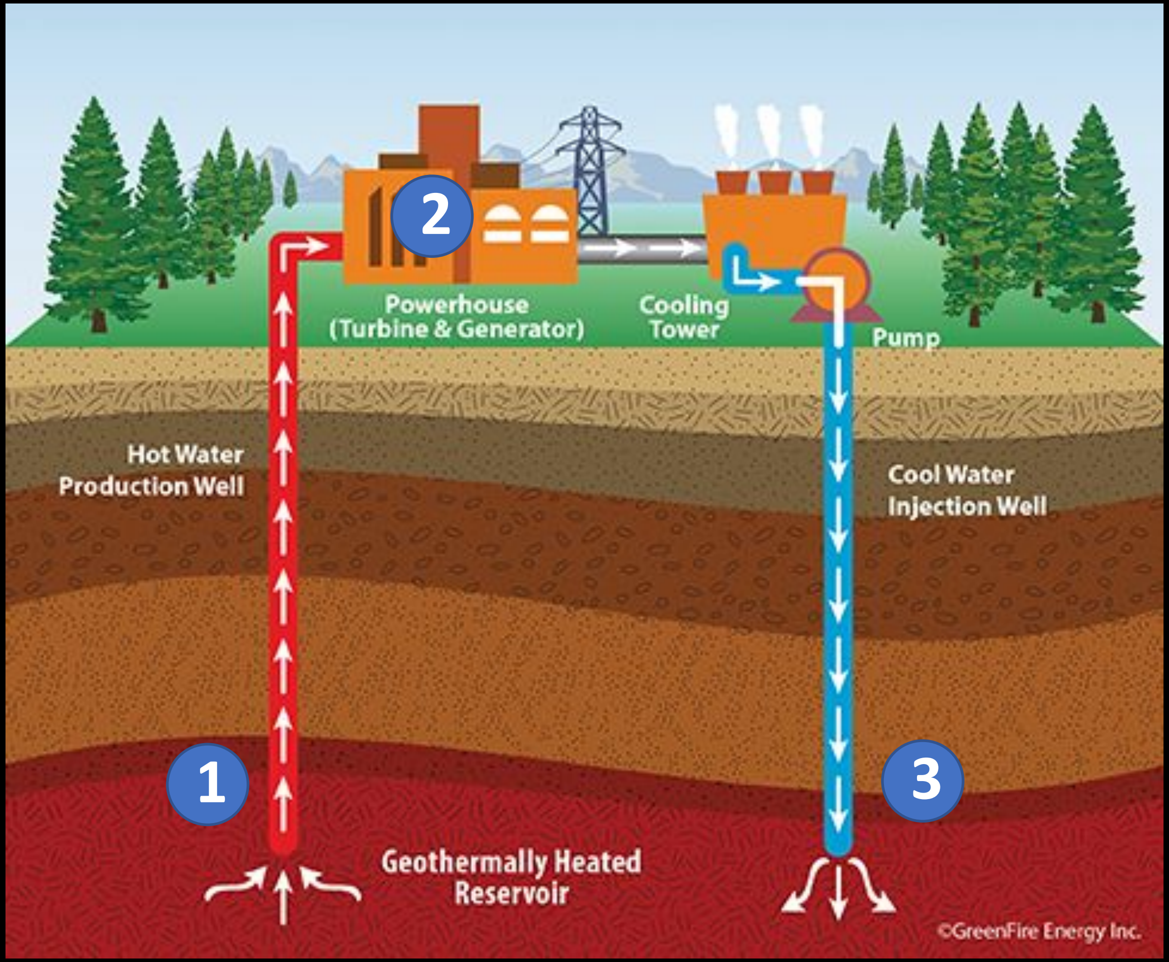

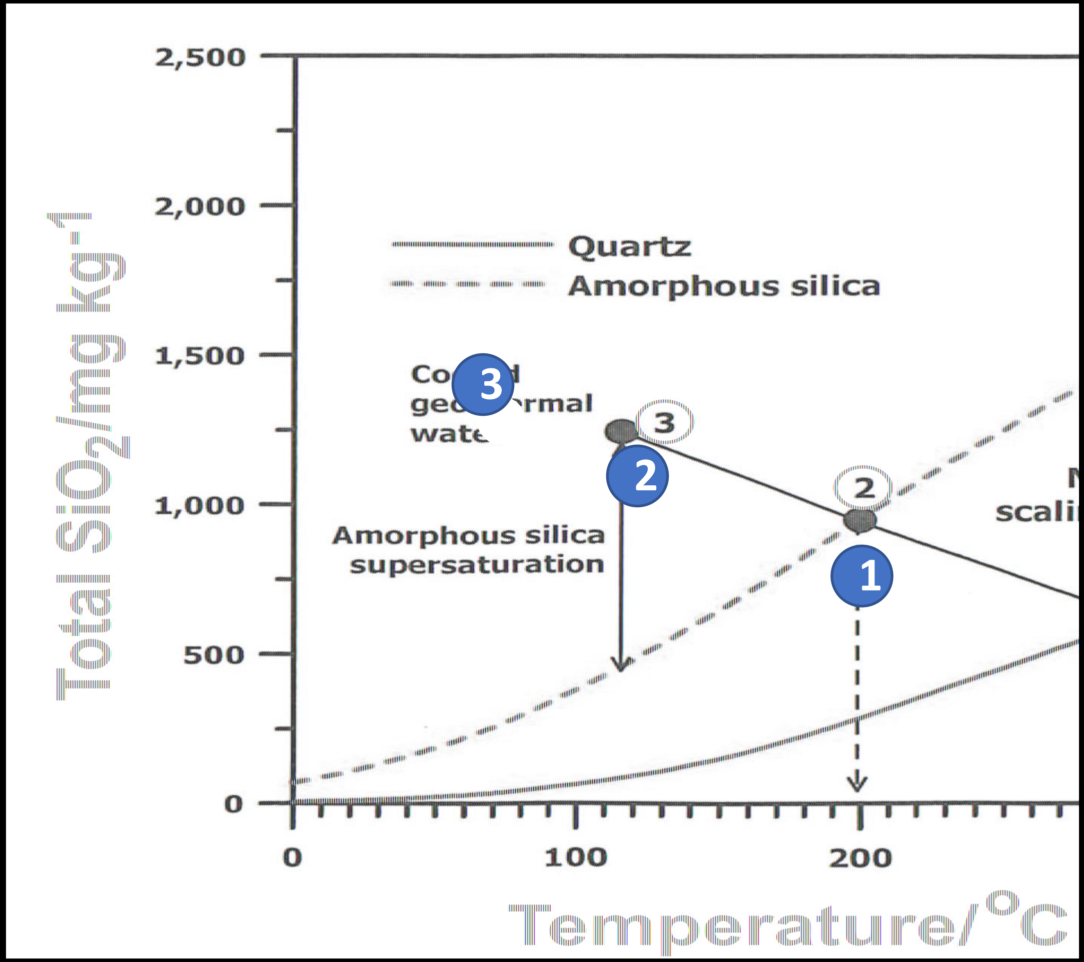

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- amorphous silica becomes supersaturated and silica polymerisation begins
- will lead to silica scaling and fouling of the plant infrastructure
- prevented by acid-dosing which slows silica polymerisation and mitigates silica scaling
- however, after reinjection, fluid-rock interaction causes pH to increase and silica scaling ensues
- leads to injectivity declines in the reinjection formation
- extensive experimentation at GNS has shown that calcite in the reinjection formation is likely responsible for rapid injectivity declines

Question: Can increasing the pCO_2 in the reinjection brine reduce pH, slow silica scaling, extend formation injectivity, and at the same time reinject/store CO_2?

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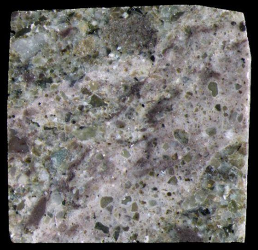
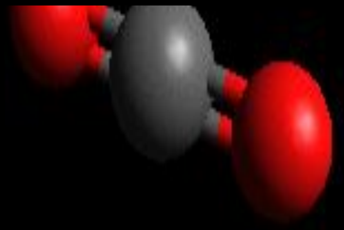
Carbon Dioxide

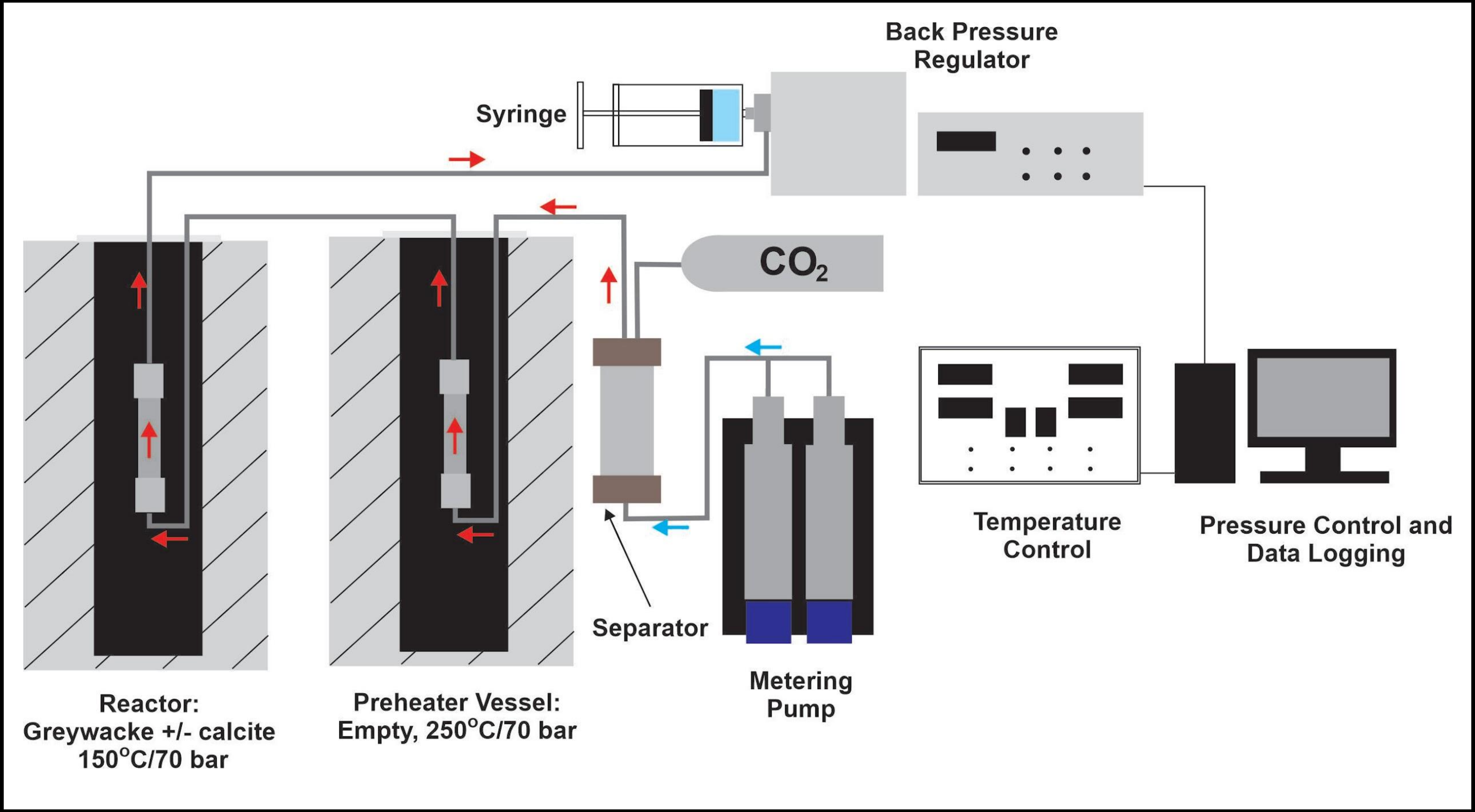
Four brine - rock interaction experiments wer



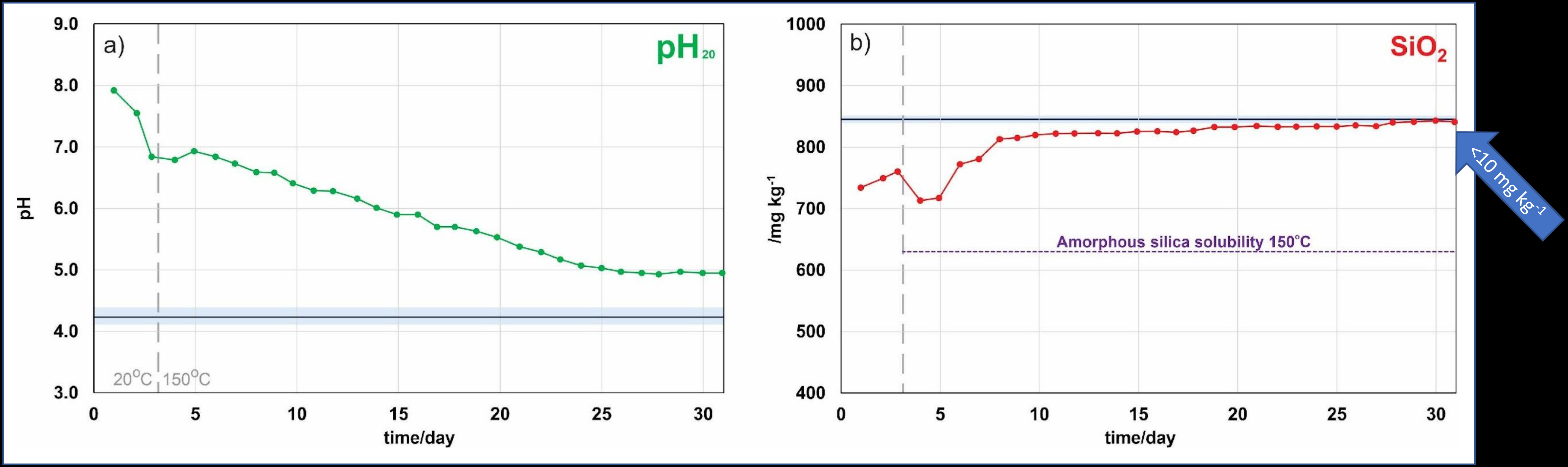


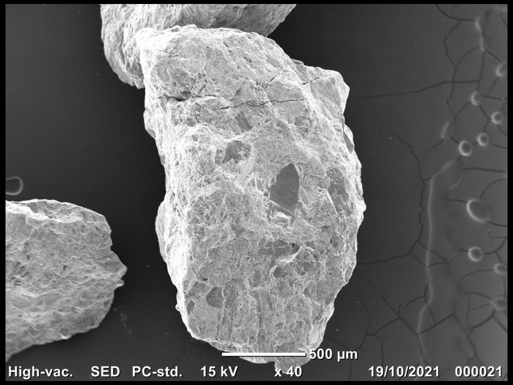
1. Brine with greywacke
2. Brine with greywacke + calcite
3. Brine with greywacke + calcite 2000 ppm CO_2 added
4. Brine with greywacke + calcite 600 ppm CO_2 added

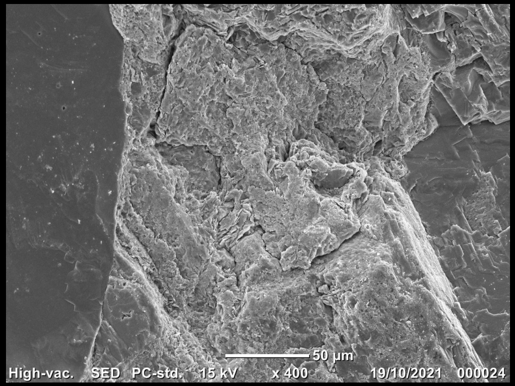
Hydrothermal Flow Simulator



Brine with greywacke

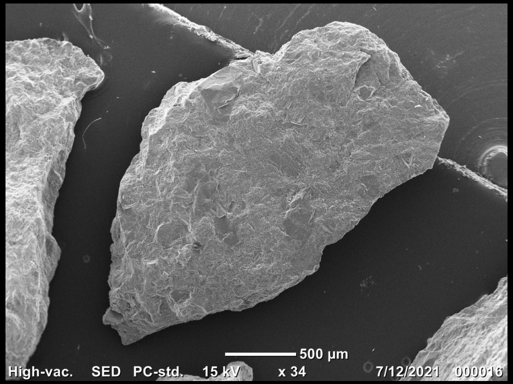






Unreacted

Brine with greywacke



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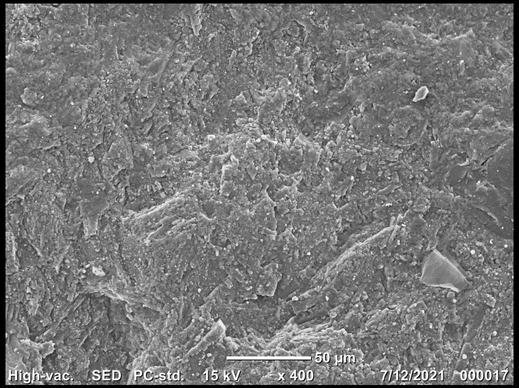

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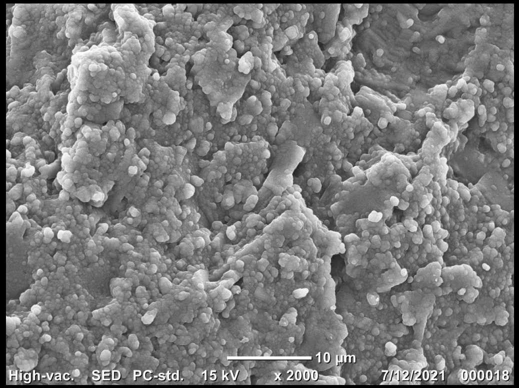
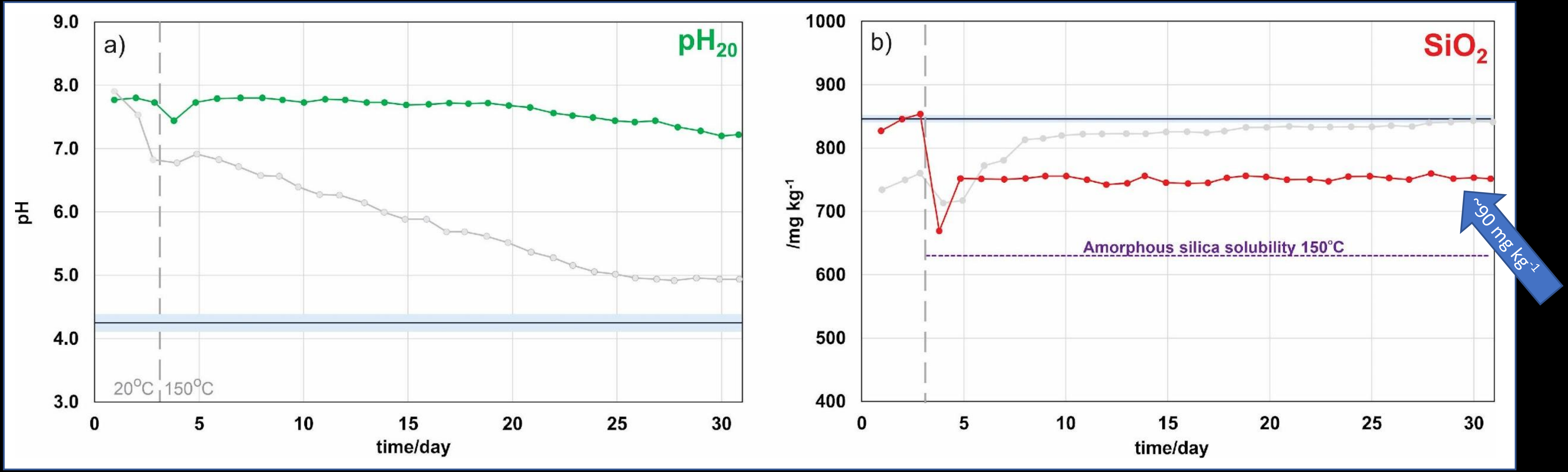


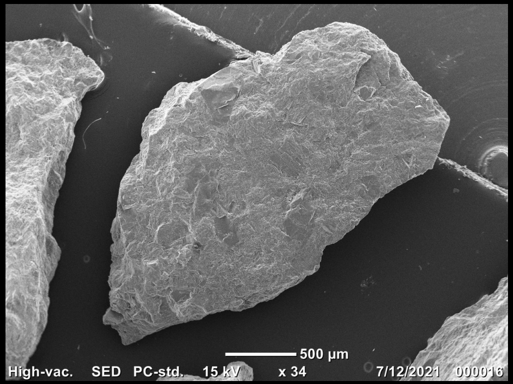
2000x

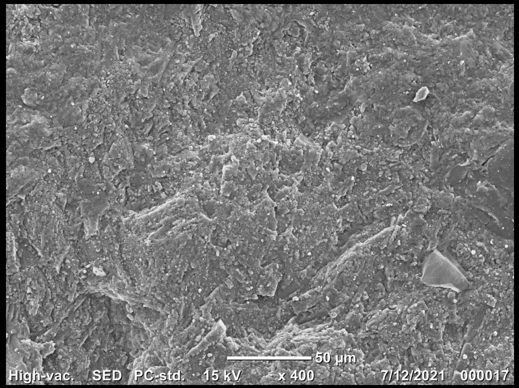
4000x

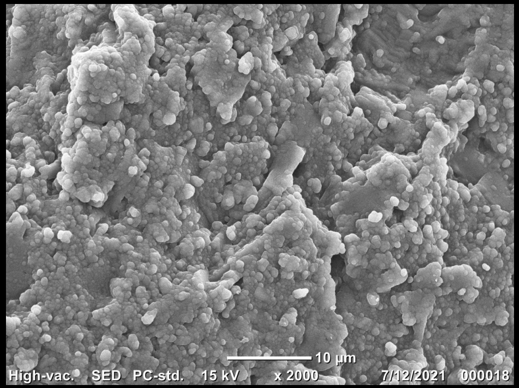
Brine with greywacke + calcite

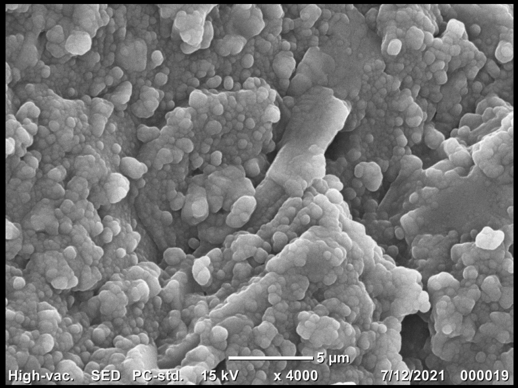


Brine with greywacke

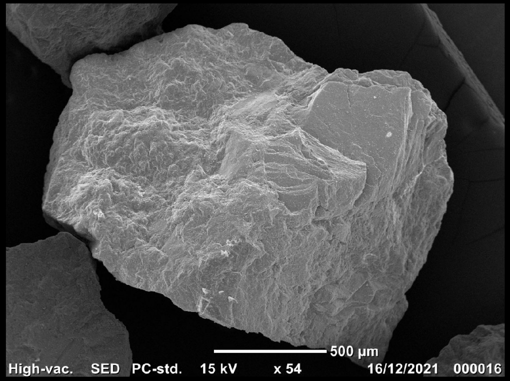


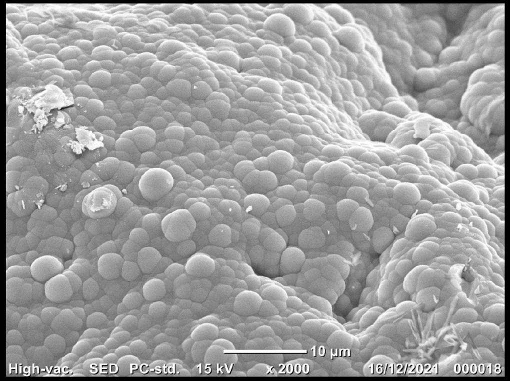


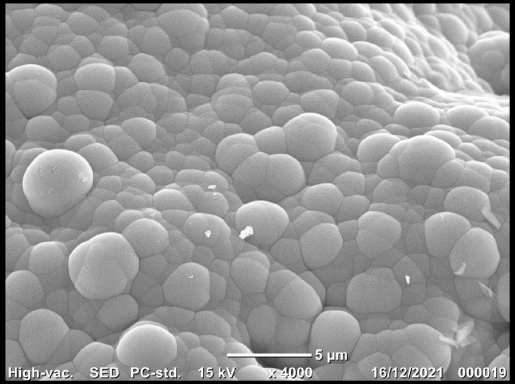


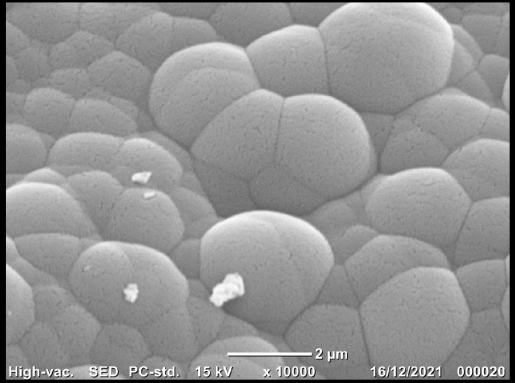


Brine with greywacke + calcite



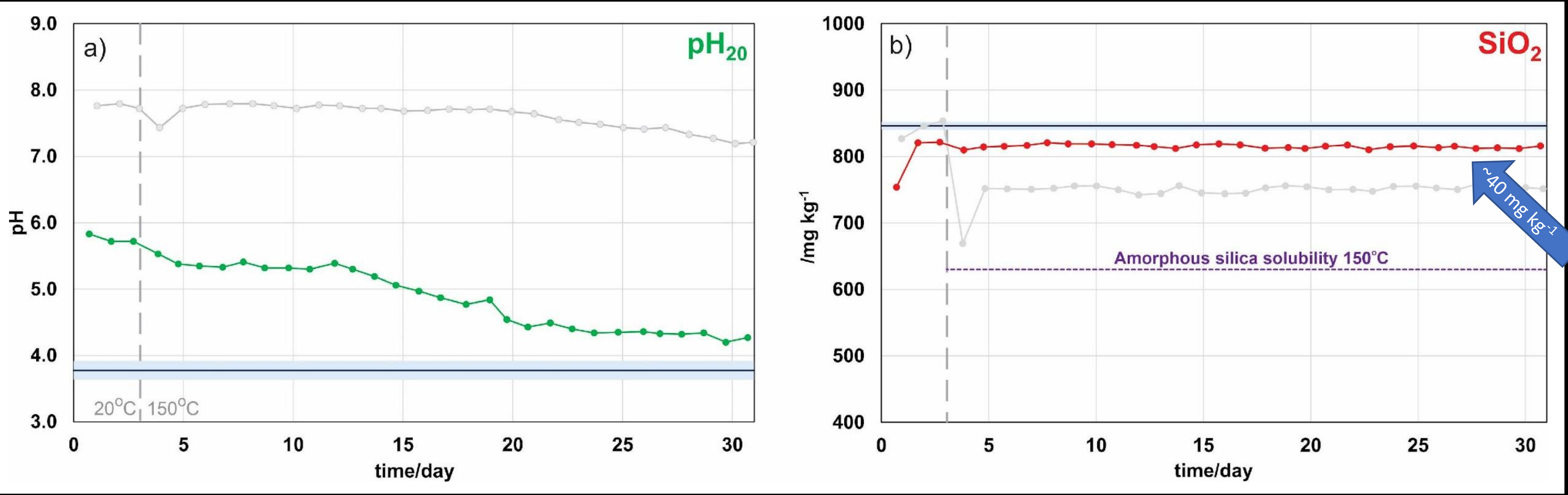




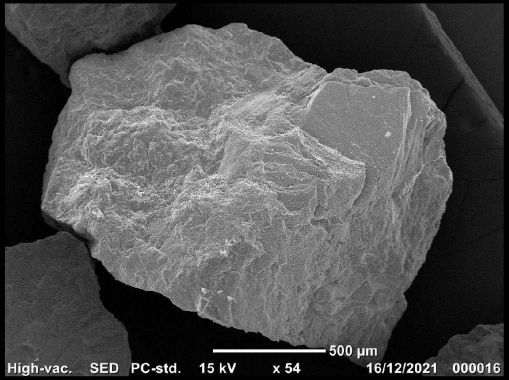


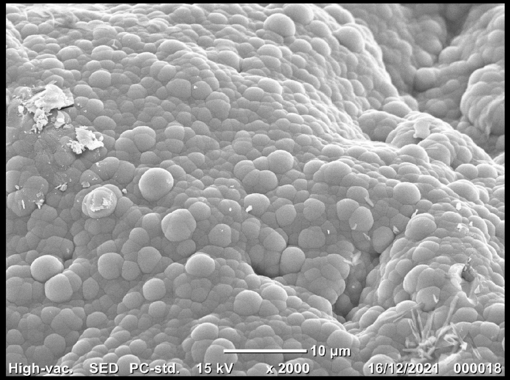
Low | 400x | 2000x | 4000x

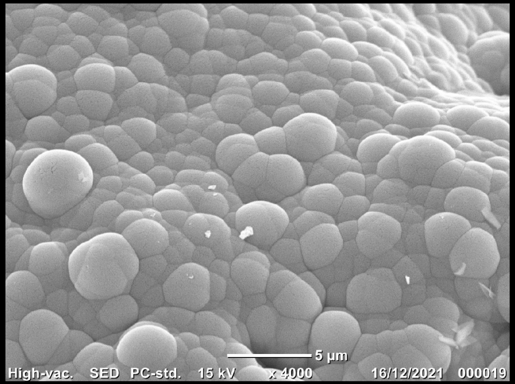
Brine with greywacke + calcite 2000 ppm CO_2 added

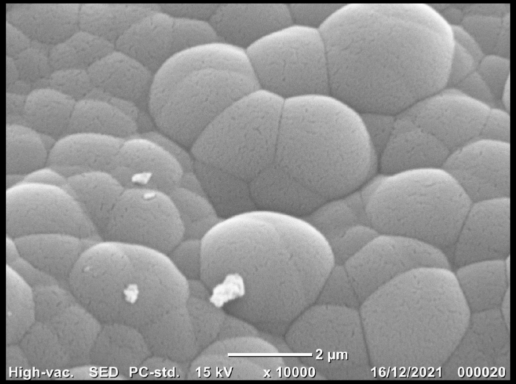


Brine with greywacke + calcite

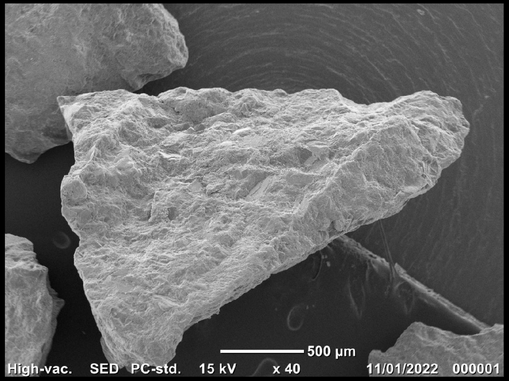








Brine with greywacke + calcite 2000 ppm CO_2 added



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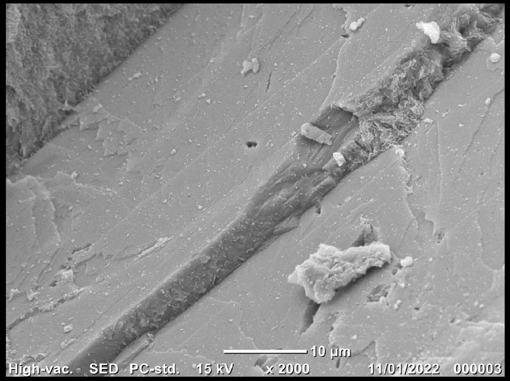
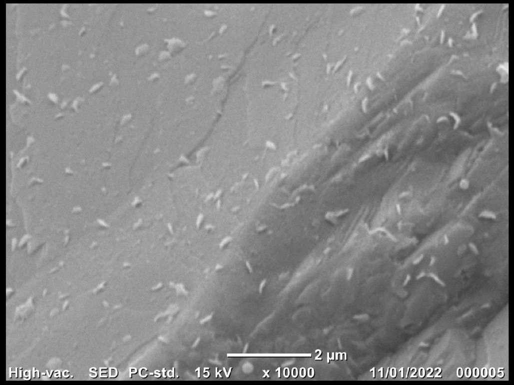


400x

2000x

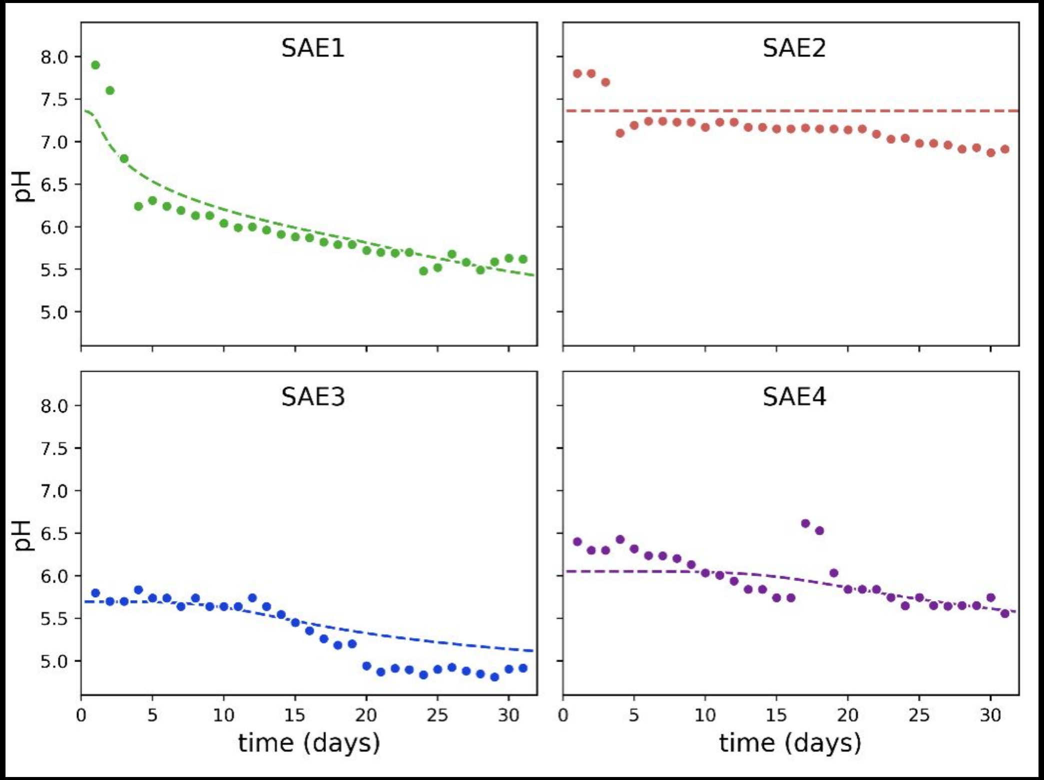


4000x

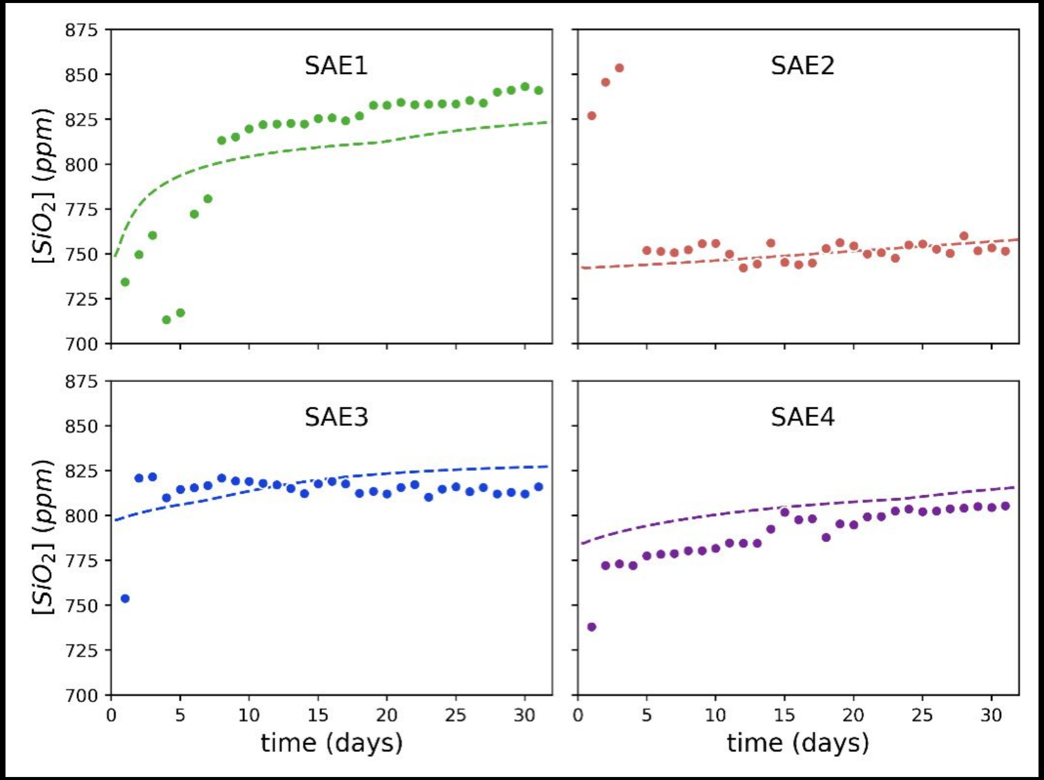
Modelling the effects of CO_2 reinjection on fluid – rock interactions and silica scaling

Using a reservoir simulator, we match the effluent chemistries from the experiments

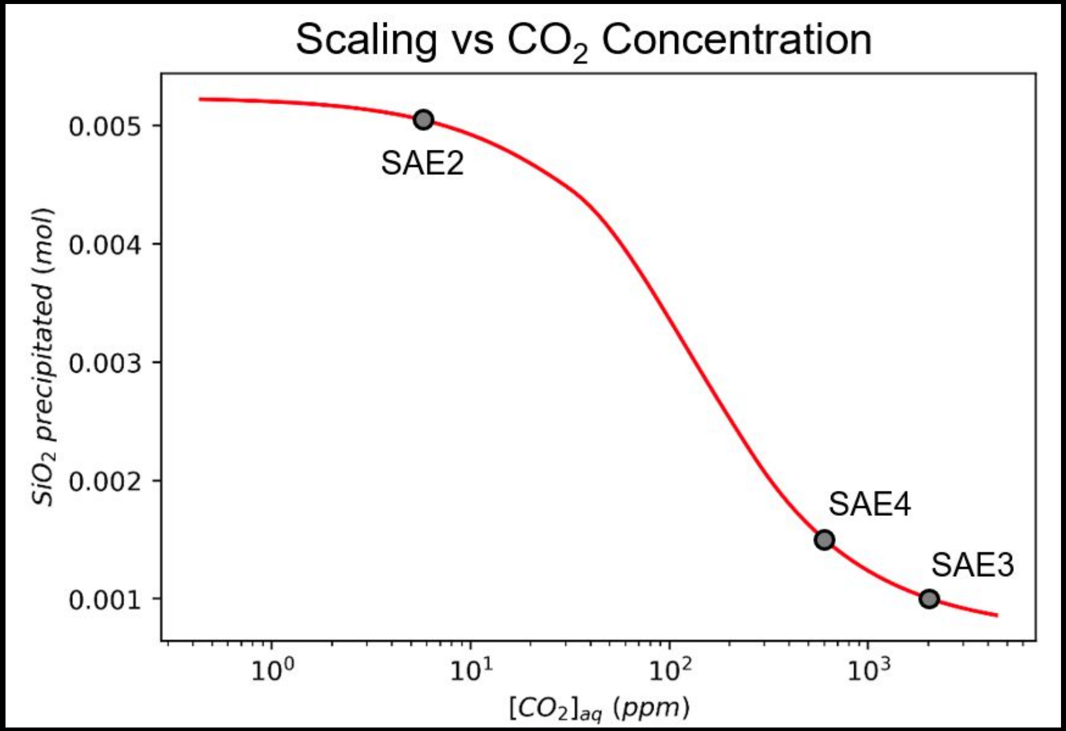
Effluent pH

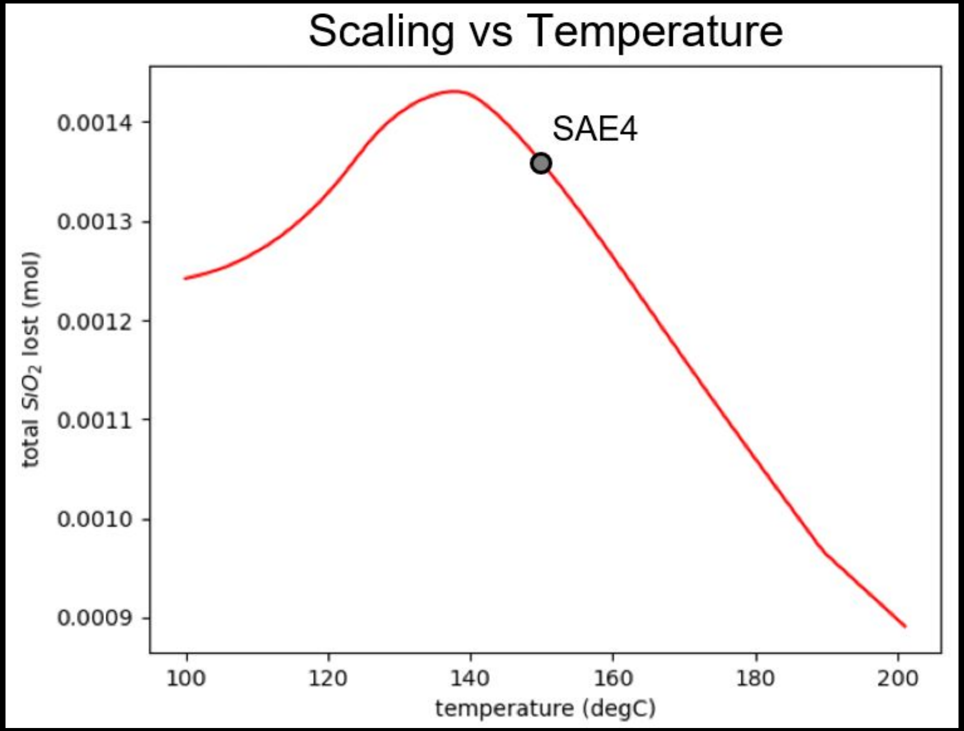


Effluent SiO_2 Concentration

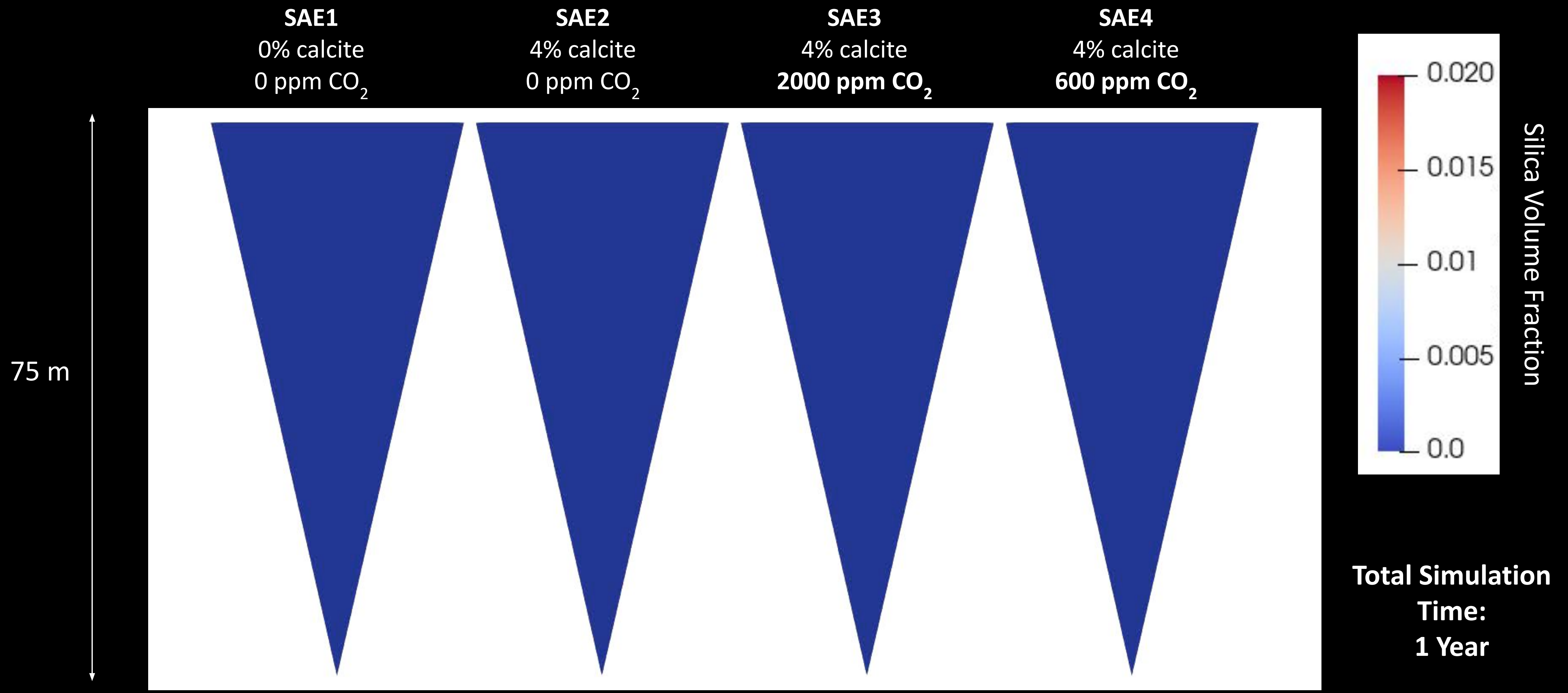


- Model can then be extended: longer time, larger reservoir, etc.
- Numerical model helps us answer new questions:
  - Where does scale get deposited?
  - How much CO_2 is required to inhibit it?
  - What is the effect of temperature?





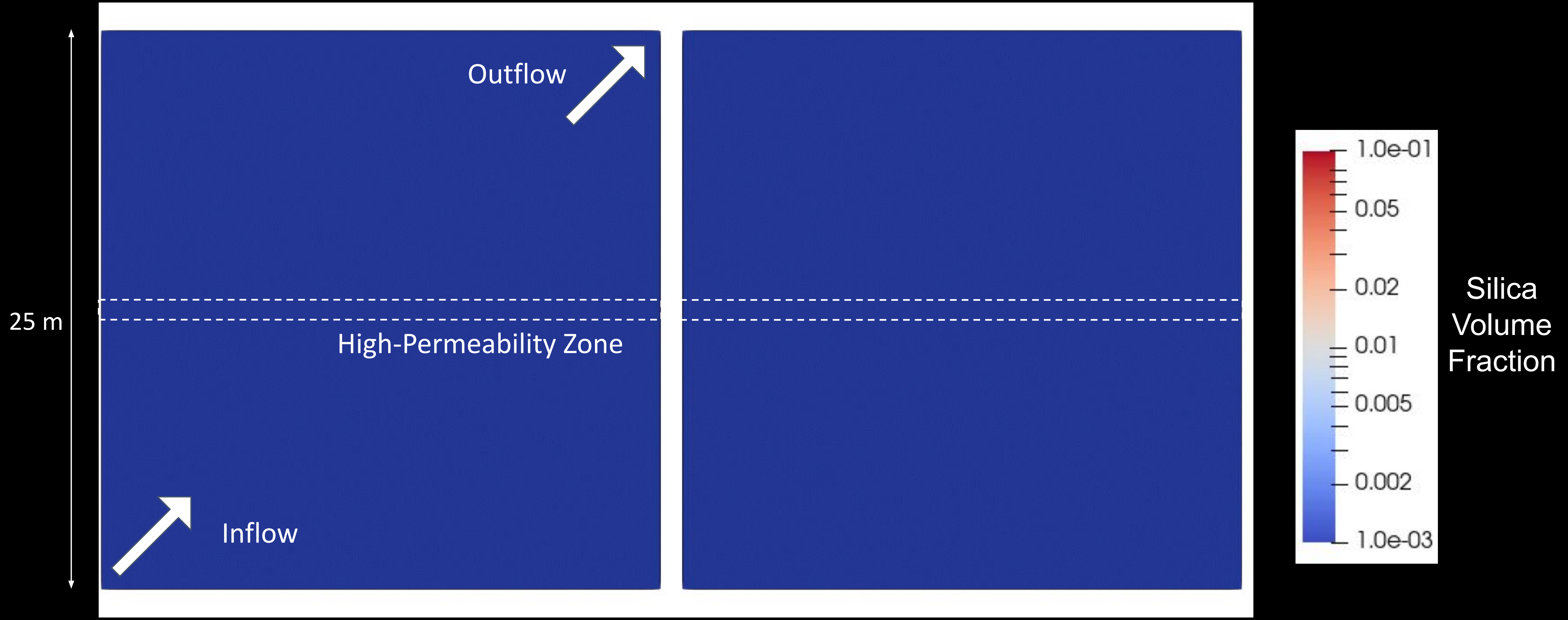
Radial CO_2 Reinjection Models



Total Simulation Time: 1 Year

Base Case:
More scaling, near injection

With added 600 ppm CO_2:
Less scaling, further from injection



Summary

- Fluid – rock interaction between brine and greywacke produced a small amount of silica scaling
- The presence of calcite, however, induces pH increase and causes the maximum amount of scaling
- The addition of CO_2, keeps the pH lower, even though calcite is dissolving
- SiO_2 scaling is reduced by 65%, but amorphous silica scaling appears to be reduced to zero
- As long as pCO_2 remains high, pH will be too acidic for calcite to saturate and it is expected that the brine would eventually dissolve calcite from the formation
- Numerical models calibrated using experimental data can be used to investigate further scenarios such as longer times, larger scales, variable CO_2 and temperature
- These results show that CO_2 reinjection may not solely be a cost but a benefit

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