# Effects of solution composition on the spectral induced polarization signals of calcite precipitation

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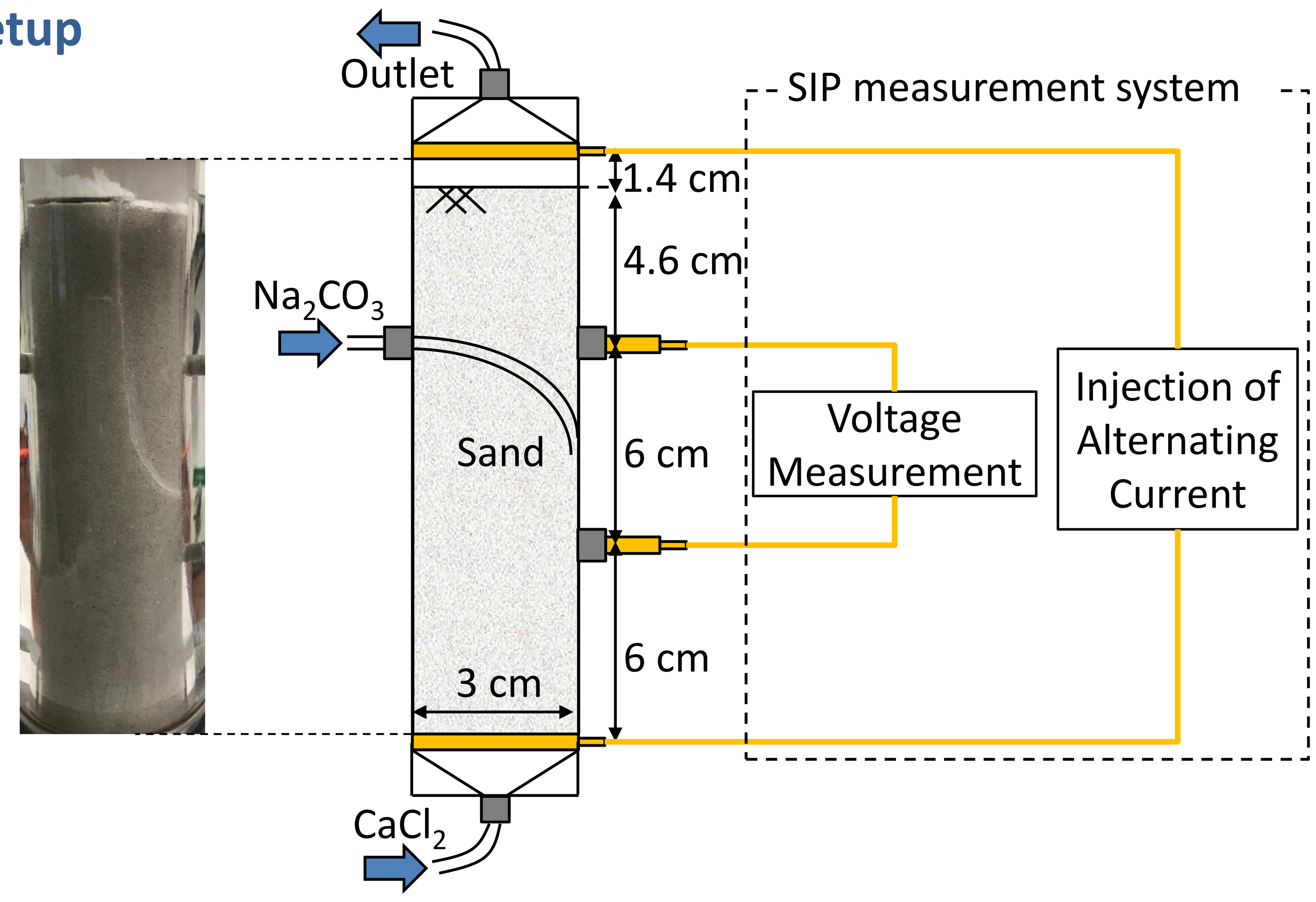
## Introduction

Beneficial effects of calcite precipitation have been explored in relation to applications of microbes in geotechnical engineering. Field tests of microbially-induced calcite precipitation have demonstrated its potential for bioremediation, stabilization of soil and changing liquid permeability. In many of these studies, the effectiveness of calcite precipitation was monitored by spatially and temporally limited methods, such as analysis of sampled ground water. Several studies showed that spectral induced polarization (SIP) is sensitive to calcite precipitation. SIP is able to provide higher spatial and temporal resolution. Within this context, the aim of this study is to investigate the sensitivity of the SIP response of calcite to changes in solute composition using laboratory column experiments.

## Setup




## Experimental procedure

*Phase I* : 29.0 mM $Na_2CO_3$ and 26.2 mM $CaCl_2$ (No.1 in the below table) were injected with a flow rate of 2.93 ml $h^{-1}$ for 12 days to generate calcite.

*Phase II* : The injected solutions were increasingly diluted in steps as described in the table below (No.2 to No.5).

*Phase III* : The injection of the two solutions was stopped for 50 hours.

*Phase IV* : The injection rate of Na2CO3 was reduced to 45% of the original injection rate for 7 hours to shift the position of mixing zone.

*Phase V* : The column was flushed with a solution in equilibrium with calcite.

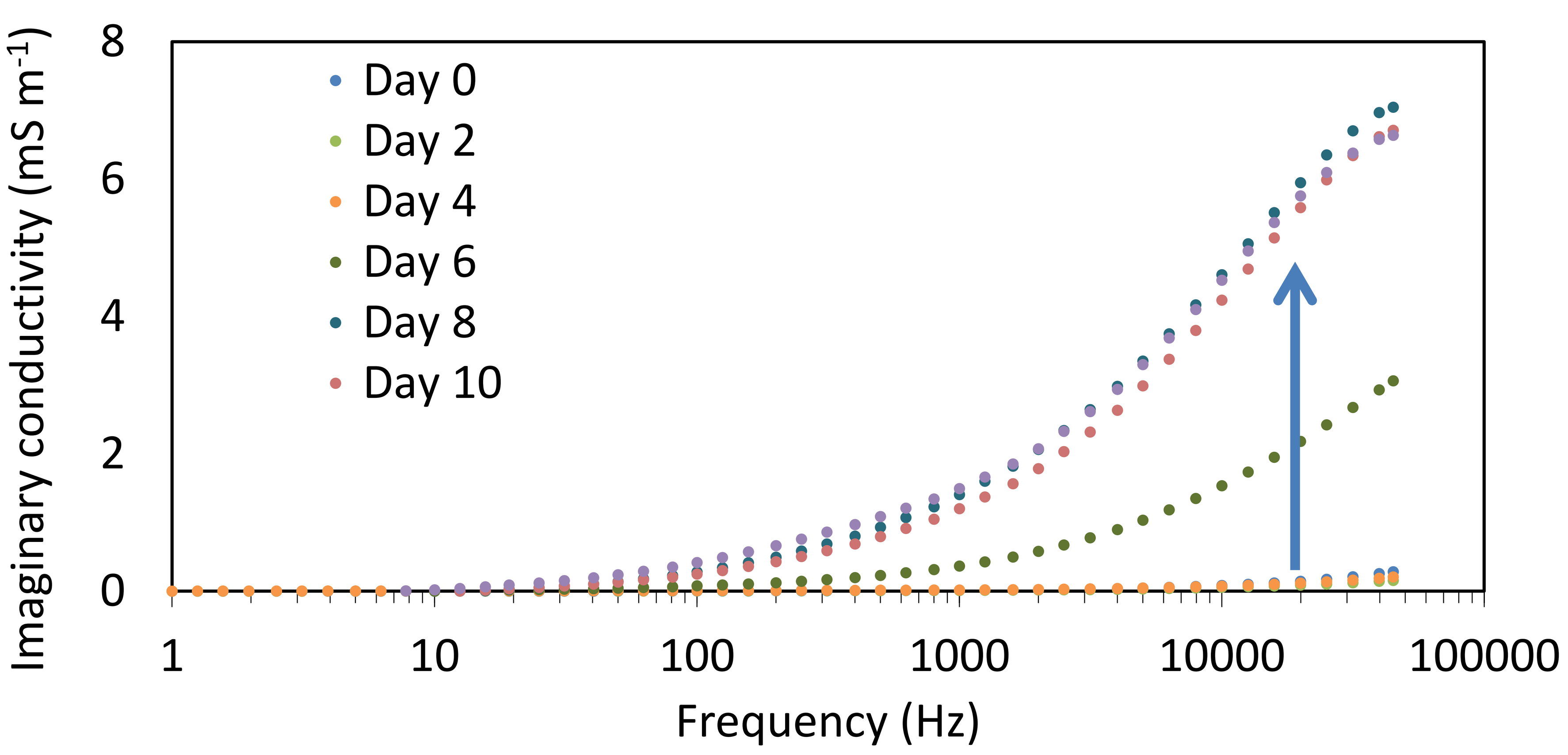
- Between each phase, the original solution was injected to re-establish the SIP signal.

| | Solution pair No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | Saturation index⁺ | 3.18 | 3.18 | 2.85 | 2.50 | 2.00 |
| $CaCl_2$ | EC (mS $cm^{-1}$) | 4.95 | 4.95 | 2.69 | 1.46 | 0.619 |
| | pH | 6.07 | 6.64 | 6.76 | 6.38 | 6.98 |
| | Conc. (mmol $L^{-1}$) | 26.2 | 26.2 | 13.6 | 7.07 | 2.88 |
| $Na_2CO_3$ | EC (mS $cm^{-1}$) | 4.43 | 4.44 | 2.51 | 1.44 | 0.620 |
| | pH | 11.2 | 11.2 | 11.2 | 11.1 | 11.0 |
| | Conc. (mmol $L^{-1}$) | 29.0 | 29.0 | 15.1 | 7.83 | 3.19 |

⁺Saturation index = log([Ion activity product]/[solubility product])

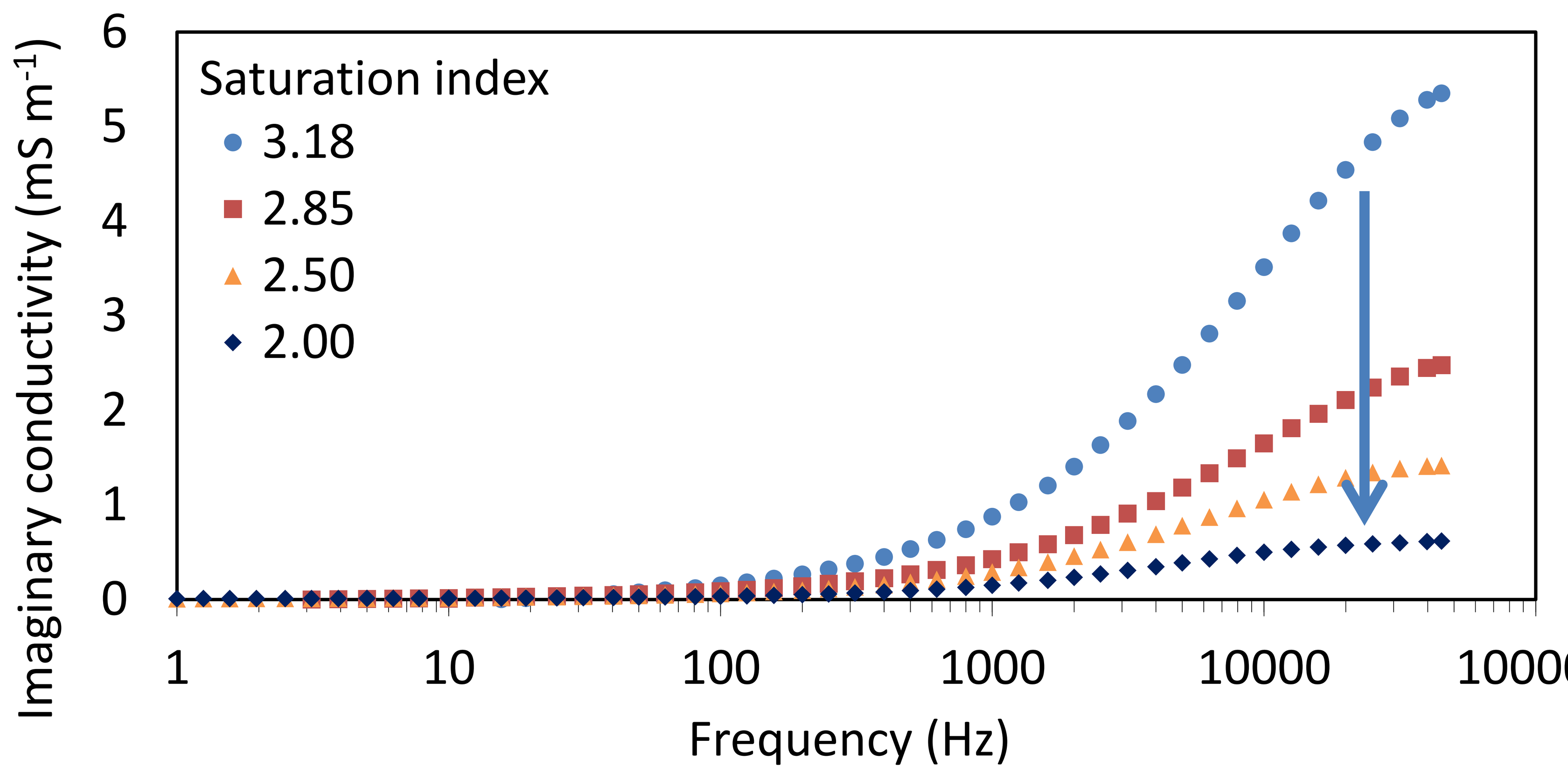
## Results

### Phase I



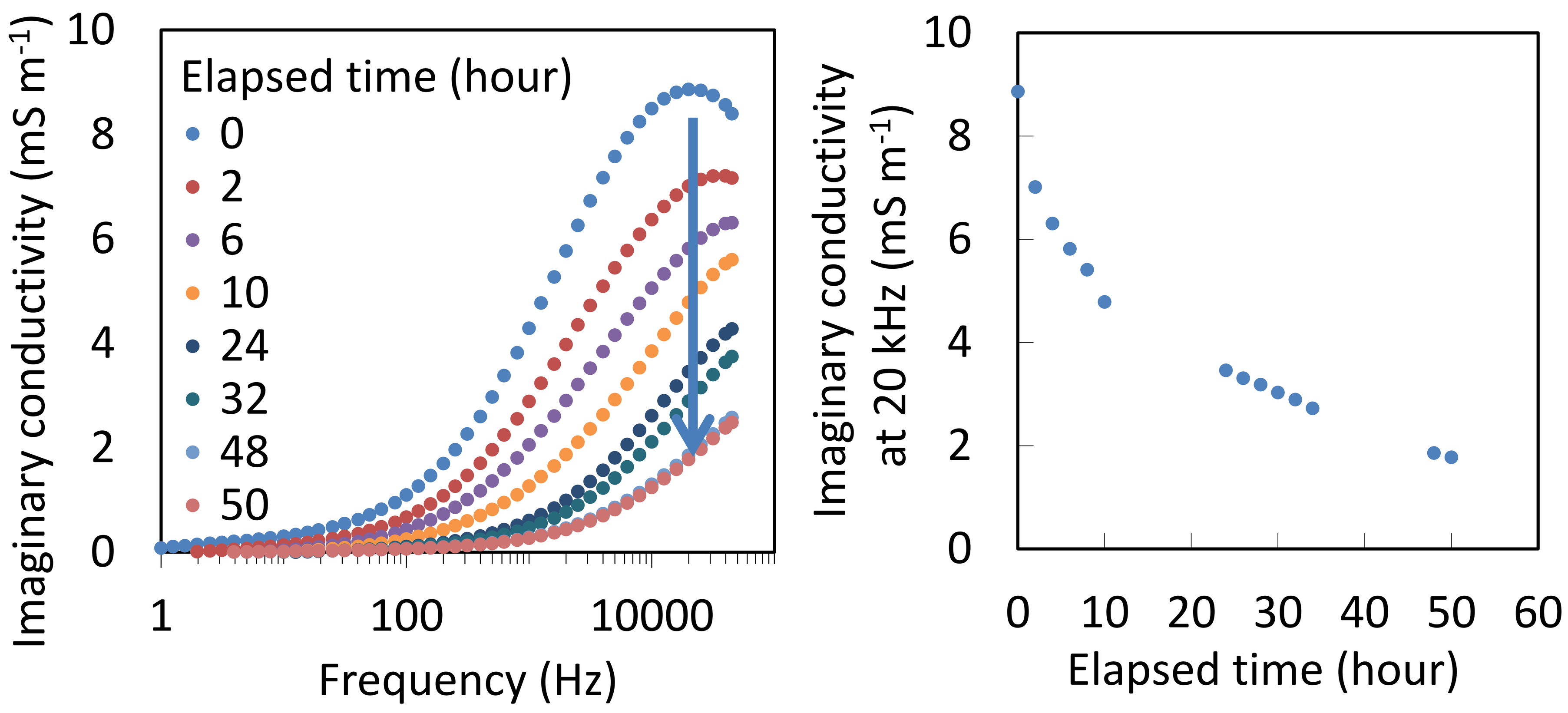

✓ Imaginary conductivity increased due to calcite precipitation.

### Phase II



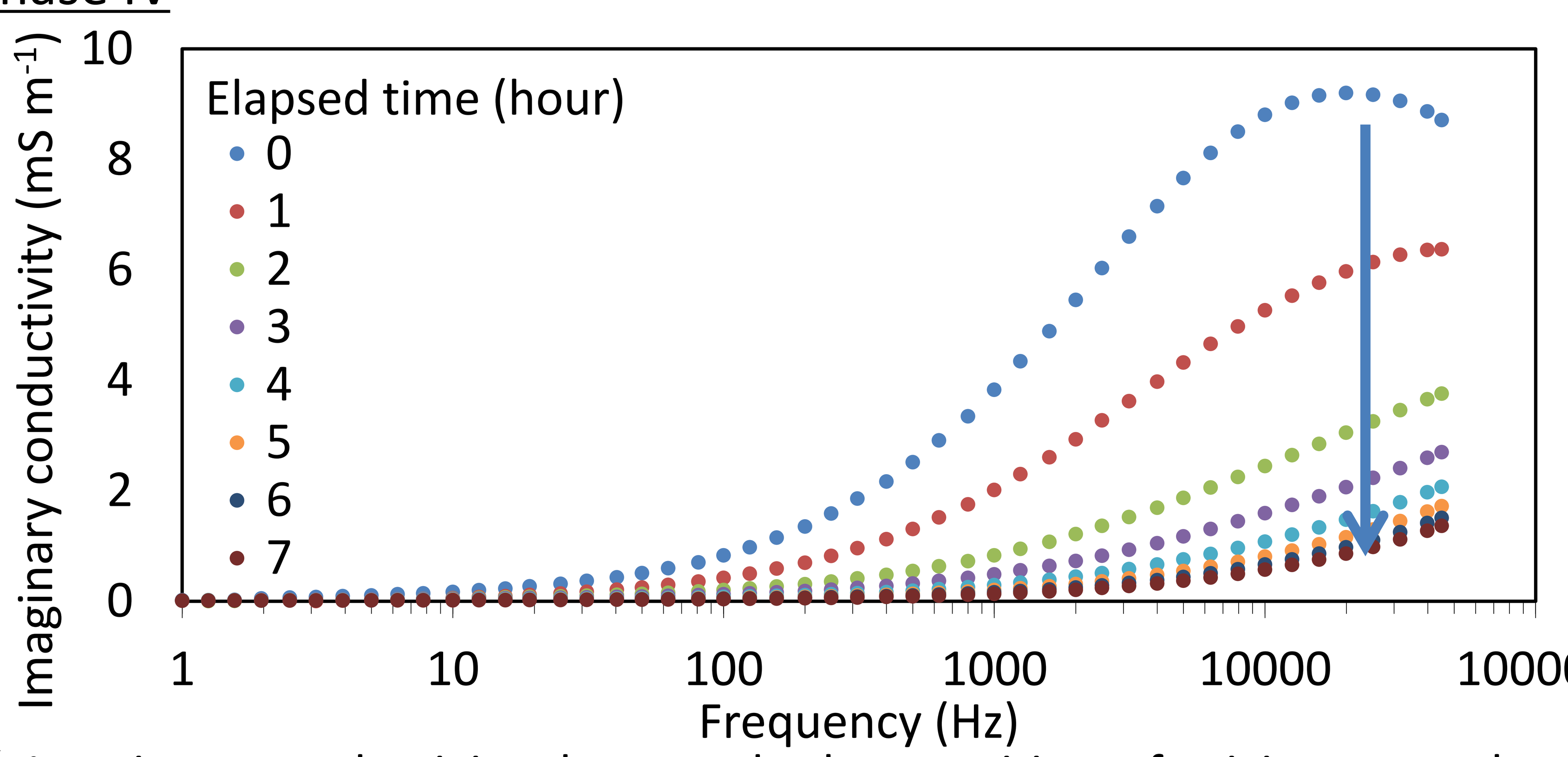

✓ Imaginary conductivity decreased when calcite was in contact with solutions with lower saturation index.

### Phase III



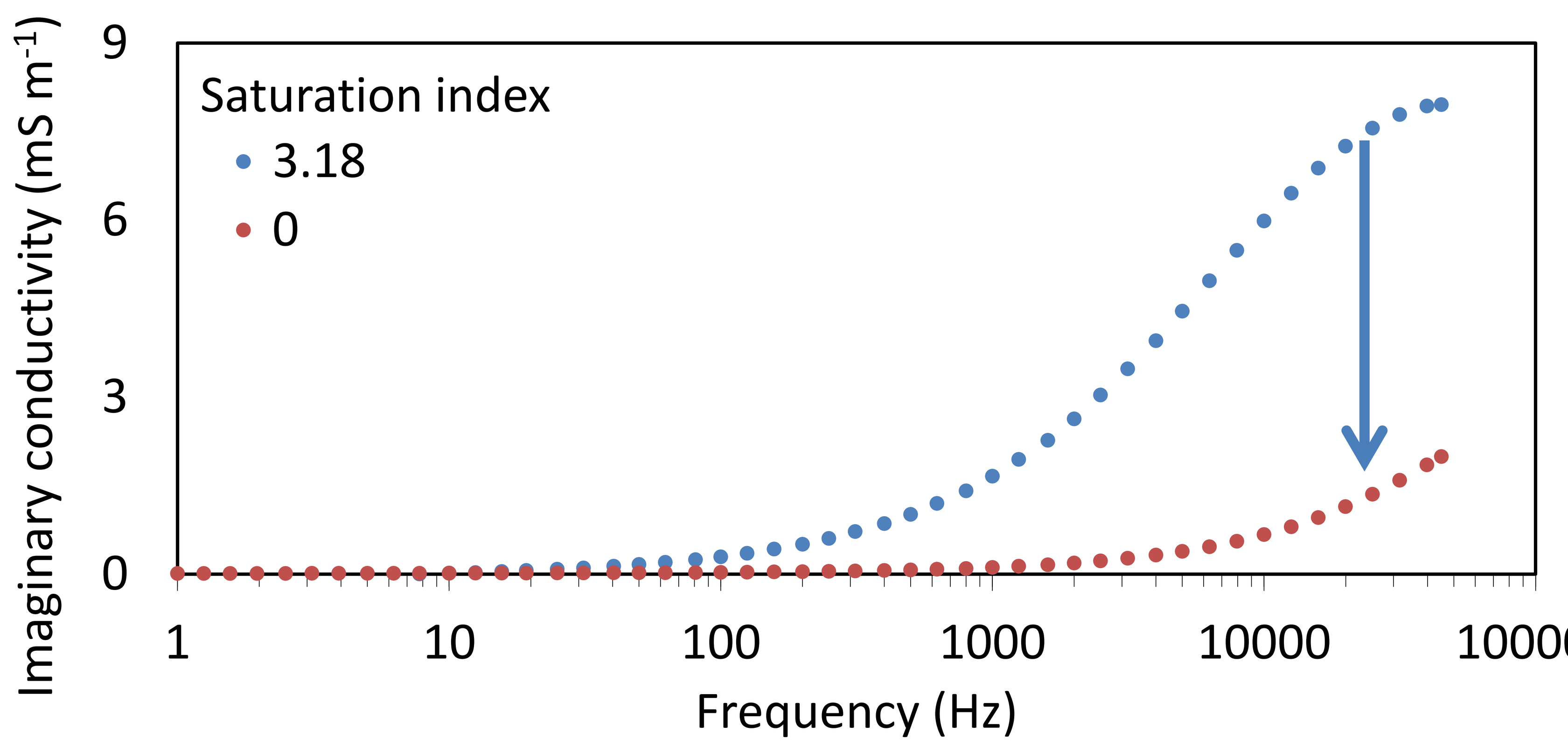

✓ Calcite precipitation reaction in the mixing zone decreased solute concentration near the calcite, which led to a decrease in the imaginary conductivity

### Phase IV




✓ Imaginary conductivity decreased when position of mixing zone changed (lower concentration)

### Phase V




✓ Calcite did not generate SIP signal when it was in contact with equilibrium solution

## Conclusions and Outlook

- Calcite precipitation generates SIP signal only when it is in contact with solution with high saturation index.
- Understanding can be further improved by surface complexation and reactive transport modelling.

Member of the Helmholtz Association

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie Grant Agreement No 722028.