

Micro Raman Mapping (carbonated sample)

Area: 1-2 cm² & spatial resolution: μm

Image size [px]: [375/450]



Hydrothermal carbonation of RCA: Influence of water addition on process control and CO₂ uptake

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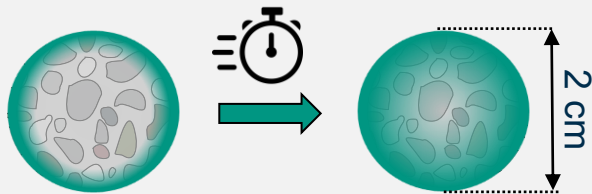
Introduction

Hydrothermal Carbonation of RCA

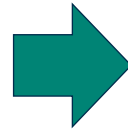


Aim:

Complete carbonation in a short time (min to h)

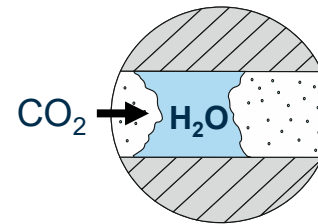


- closed system
- $T > 100^\circ\text{C}$

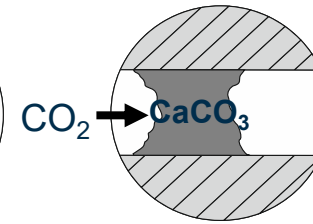


Main Rate Limiting steps

Slow CO_2 transport into the sample

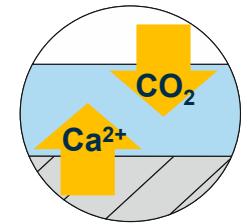


Pore saturation



Clogging

Limited CO_2 dissolution

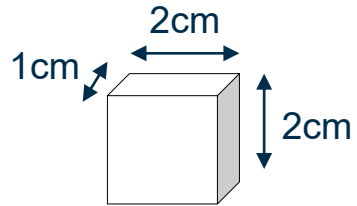


Insufficient H_2O availability

Investigation

How water addition can be used to control and optimize the carbonation process

Methodology



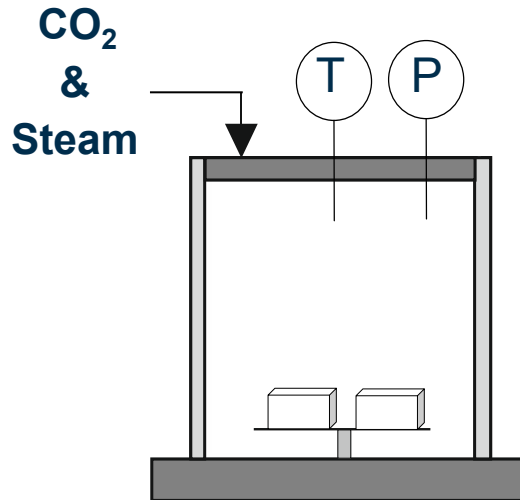
Material

Carbonation of hardened cement paste ($w/c = 0,5$) as a model system

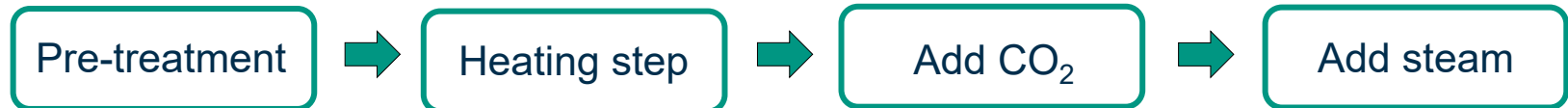
- Characterisation of real, inhomogeneous RCA is difficult (time-consuming + requires statistical data analysis¹)

¹ Frankenhauser, L., (2025). Characterisation of Recycled Concrete Aggregates with TGA and XRF coupled with Statistical Data Analysis [PDF]. Karlsruher Institut für Technologie (KIT). <https://publikationen.bibliothek.kit.edu/1000185147>

Experimental approach:



Reaction chamber



① dry

$T = 170\text{ °C}, t = 2\text{ h}$

$p_{\text{CO}_2} = 3.5\text{ bar}, t = 2\text{ h}$

✗

② pre-wetted

③ dry

$T = 170\text{ °C}, t = 2\text{ h}$

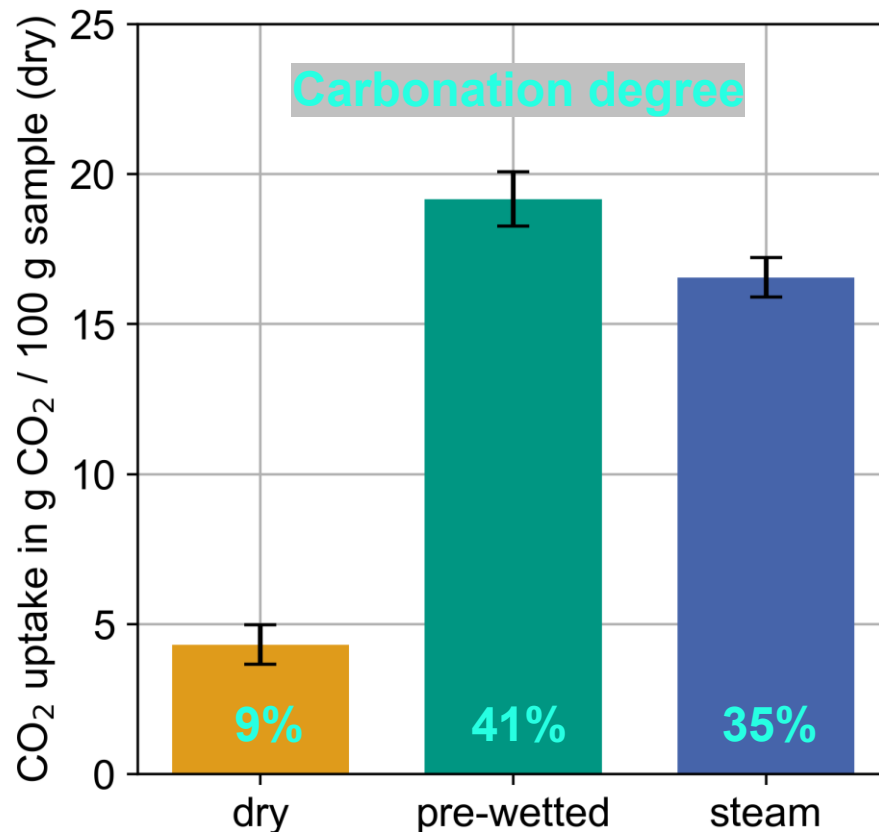
$p_{\text{CO}_2} = 3.5\text{ bar}, t = 1\text{ h}$

$t = 1\text{ h}$

Analysis: CO₂ uptake & lateral distribution of carbonate

Results – CO₂ Uptake

TGA & p_{H_2O} measurement



Increase p_{H_2O} during heating

- **Dry** $\Delta p_{H_2O} = 0.6$ bar
 - Water vapour saturation level: 9%
- **Pre-wetted** $\Delta p_{H_2O} = 1.1$ bar
 - Water vapour saturation level: 15%

Experiment No. 3 (Steam):

- Estimated water vapour saturation level: 34%

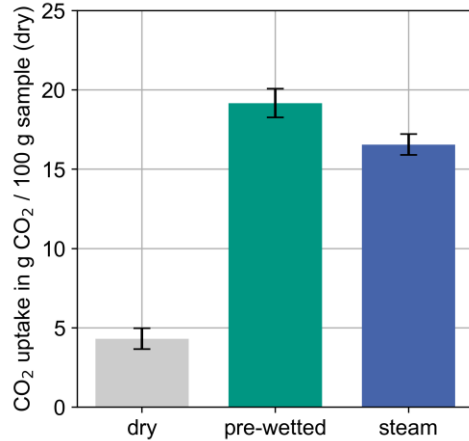
Still carbonation potential after carbonation

- CO₂ transport limitation?

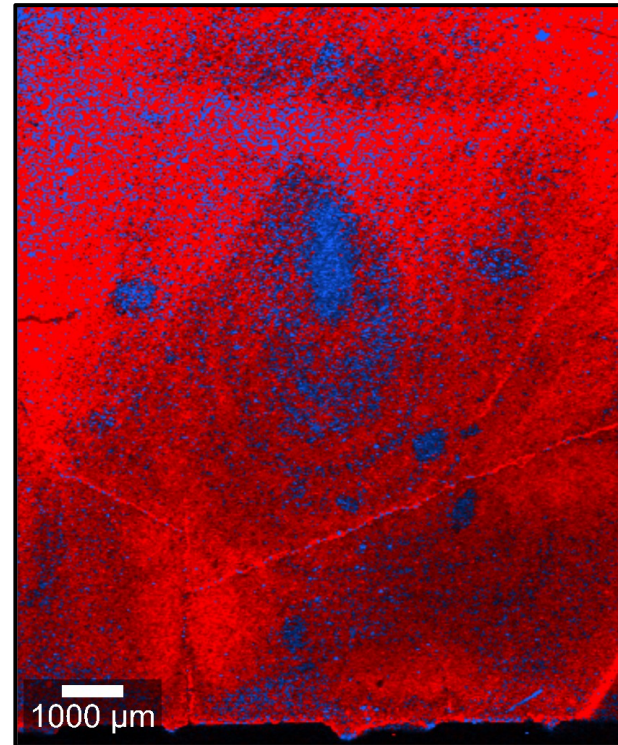
Results – Lateral Distribution of Carbonate

TGA & Raman Spectroscopy

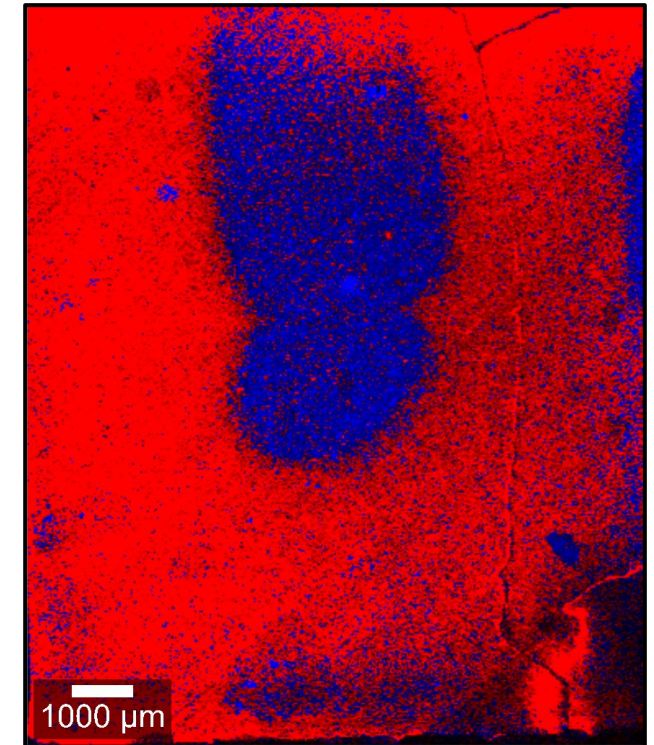
CO₂ uptake



■ CaCO₃ ■ Ca(OH)₂



No. 2 – pre-wetted

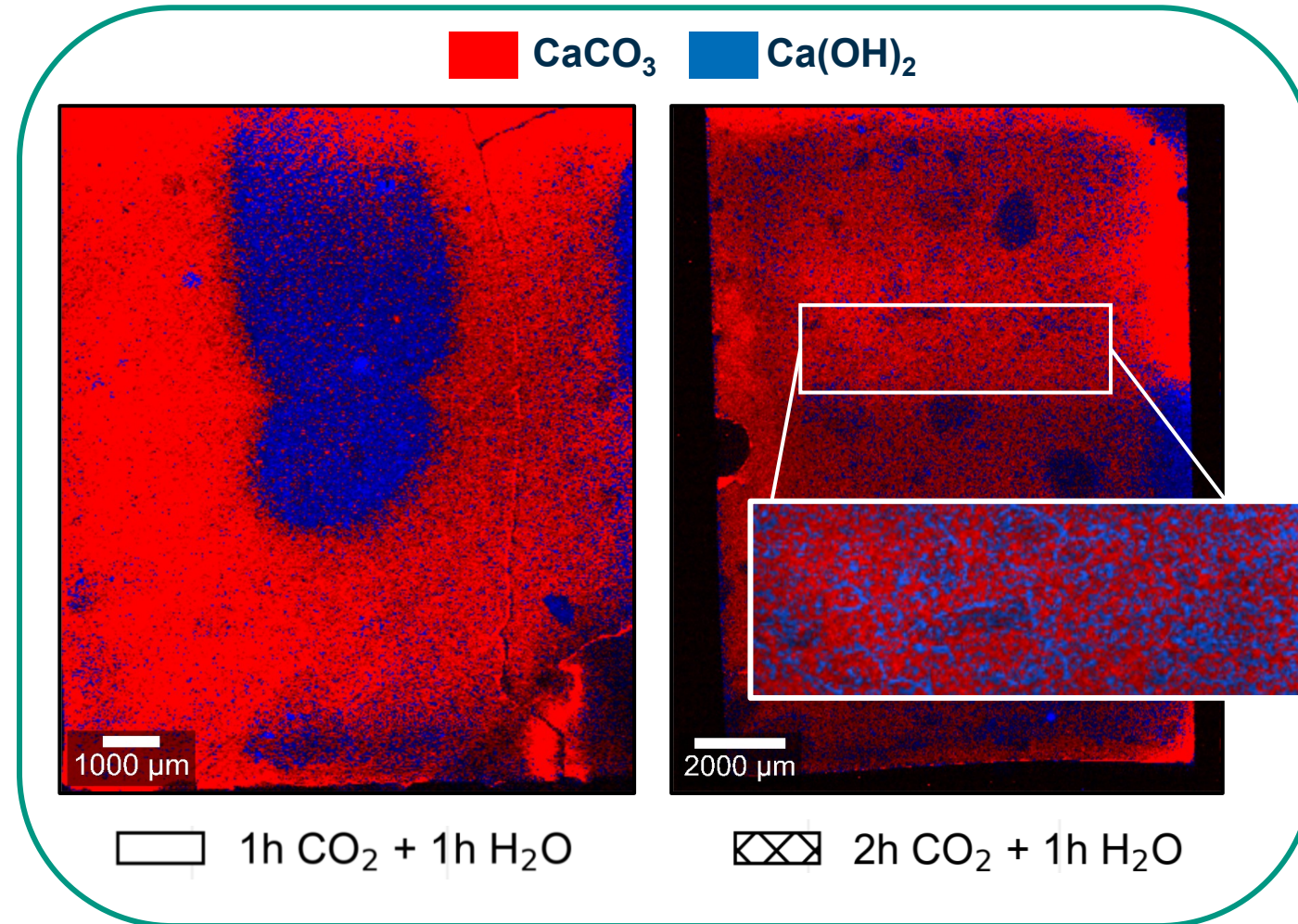
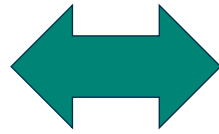
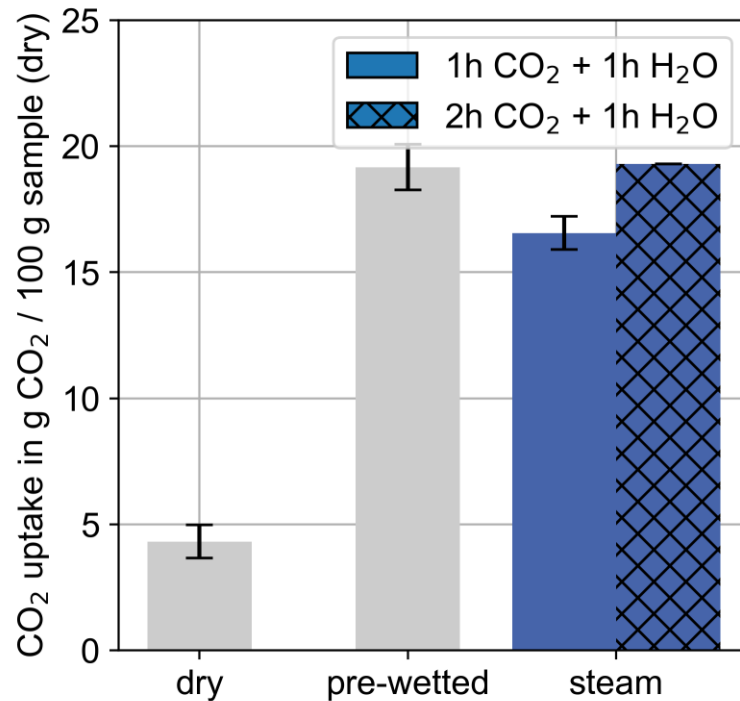


No. 3 – steam

- CO₂ transport limitation (carbonation front)
 - Trapped N₂?
 - Closed pores?

Results – Lateral Distribution of Carbonate

TGA & Raman Spectroscopy



Findings

- Ca(OH)₂ adjacent to CaCO₃
- Uniform CaCO₃ distribution

Conclusions & Outlook



- ✓ **Effective carbonation** at 170 °C with **superheated steam**
- ✓ **Precise adjustment of $p_{\text{H}_2\text{O}}$** before CO_2 addition enables a **defined amount of steam**
- ✓ **Uniform CaCO_3 distribution** throughout the sample



Carbonation at higher moisture contents

🔍 **Aim: 70% carbonation degree**

Thank you!

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