

Corrosion Evolution Interface studies of CO₂ Exposed Steelinfused Cement Sample using Micro-Computed Tomography

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AFFORDABLE AND CLEAN ENERGY

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Introduction

Carbon capture and storage (CCS) relies on the long-term stability of wellbore materials like cement and steel casing, which can degrade upon exposure to supercritical CO₂ (ScCO₂). We primarily use X-ray micro-computed tomography (μ-CT) to investigate microstructural changes in steel infused cement sample after ScCO₂ exposure for interfacial studies.

CO₂ Exposure Test

PARAMETERS	DETAILS	
Objective	Degradation and reaction front studies	
Sample Type	Steel-infused cement (steel balls : 27–30 µm)	
Cement Type	Class G Portland cement	
Curing Conditions	3 days at 60 °C	
CO₂ Exposure	Temperature: 66 °C, Pressure:	
Environment	110 bar	
Exposure time	Up to 100 days	
Table 1 · CO. exposure	e conditions	

Table 1: CO_2 exposure conditions.

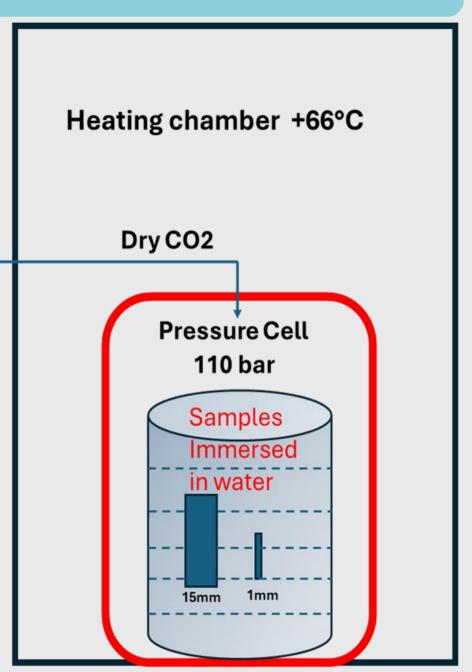
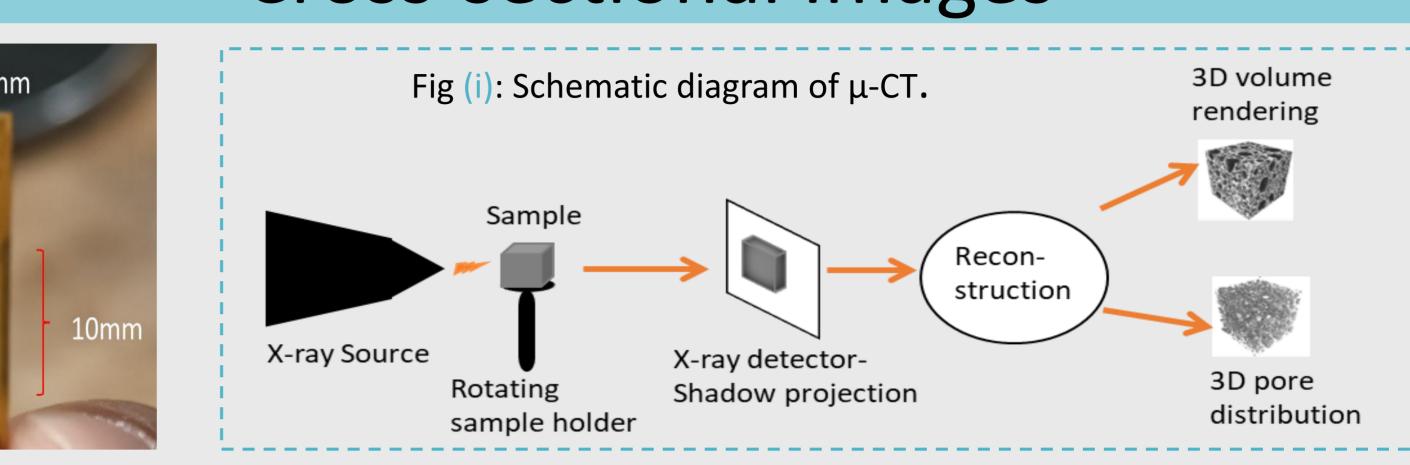
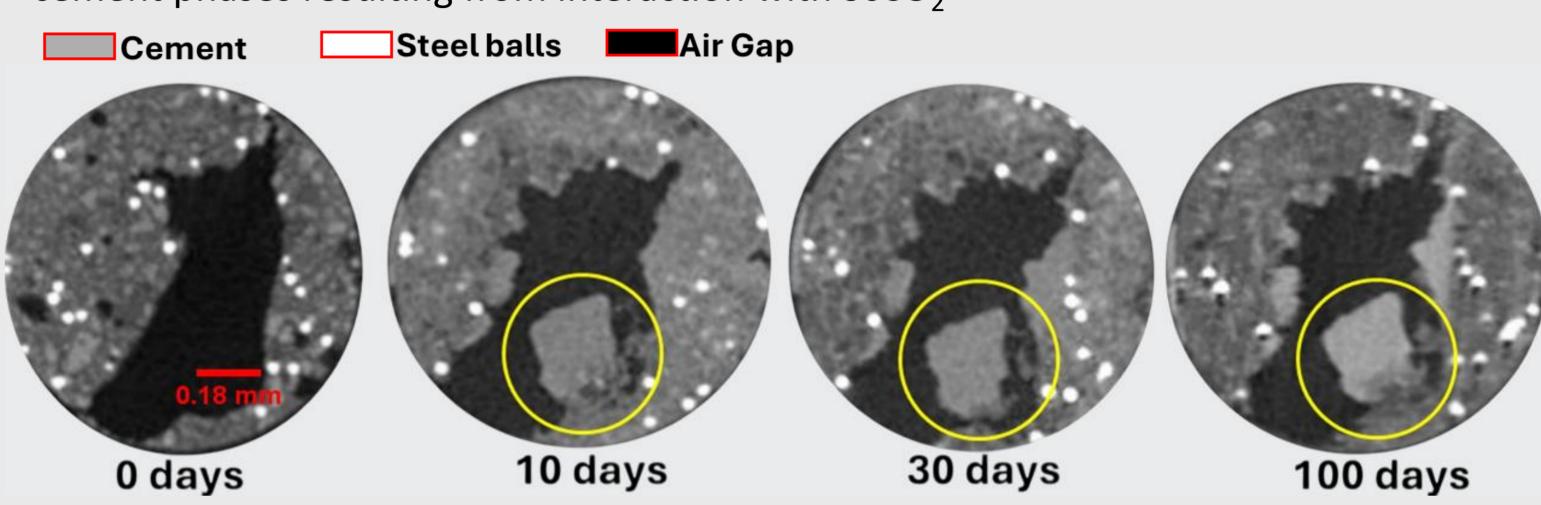


Fig (ii) Reaction chamber

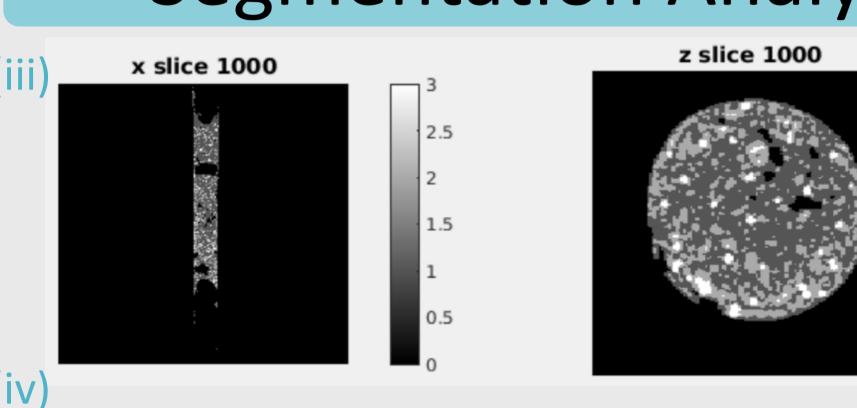
Cross-sectional Images



Reaction front in a steel (27-30 µm) infused cement sample of diameter 1mm after exposure to CO₂ up to 100days. Yellow circles indicate regions of degraded/carbonated cement phases resulting from interaction with ScCO₂



Segmentation Analysis

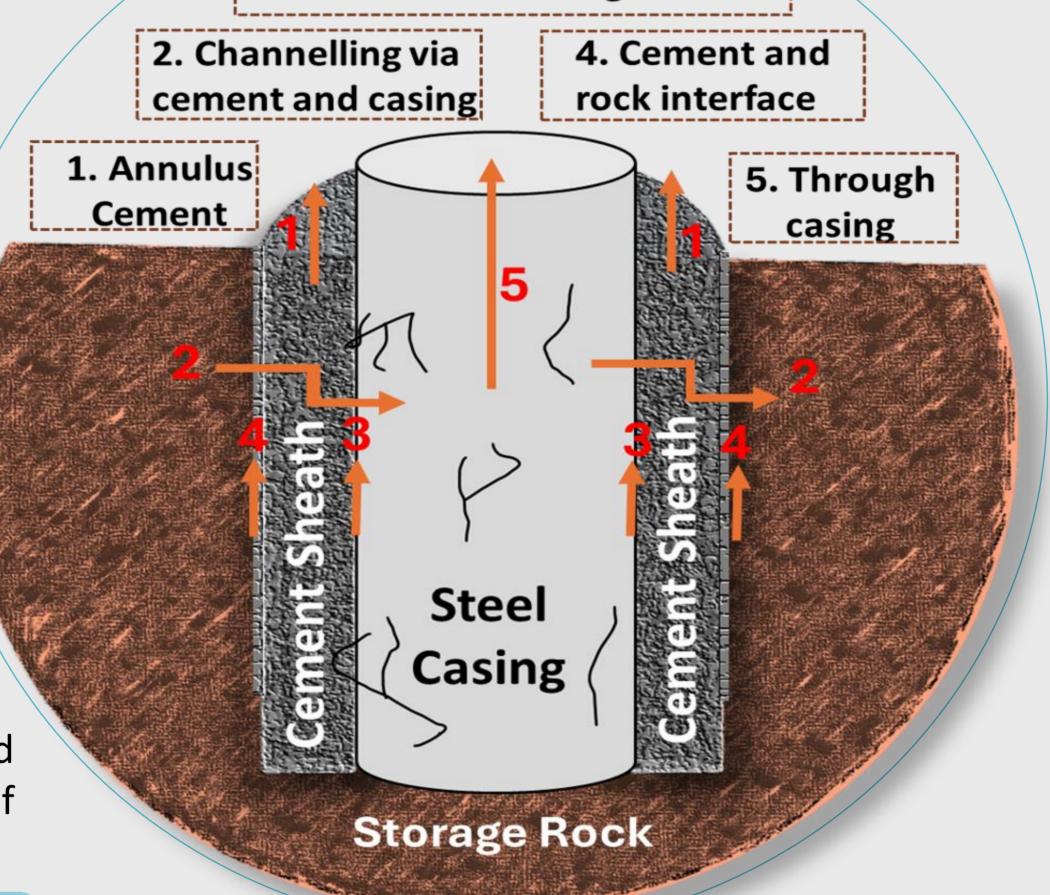


IV)			
Exposure Time/Days	Cement (%)	Aggregates (%)	Steel balls (%)
0	47	49	4
10	46	50	4
30	38	58	4
100	33	63	4

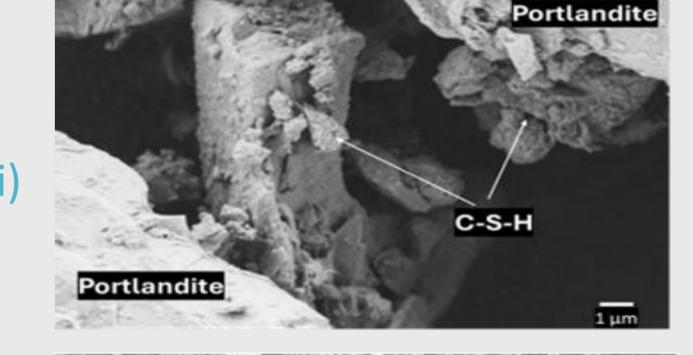
Fig (iii): Vertical and horizontal cross-sectional segmented images of the sample, (iv): Tabulated volumetric analysis of the different phases present within the sample.

Leakage Pathways

3. Cement and casing interface



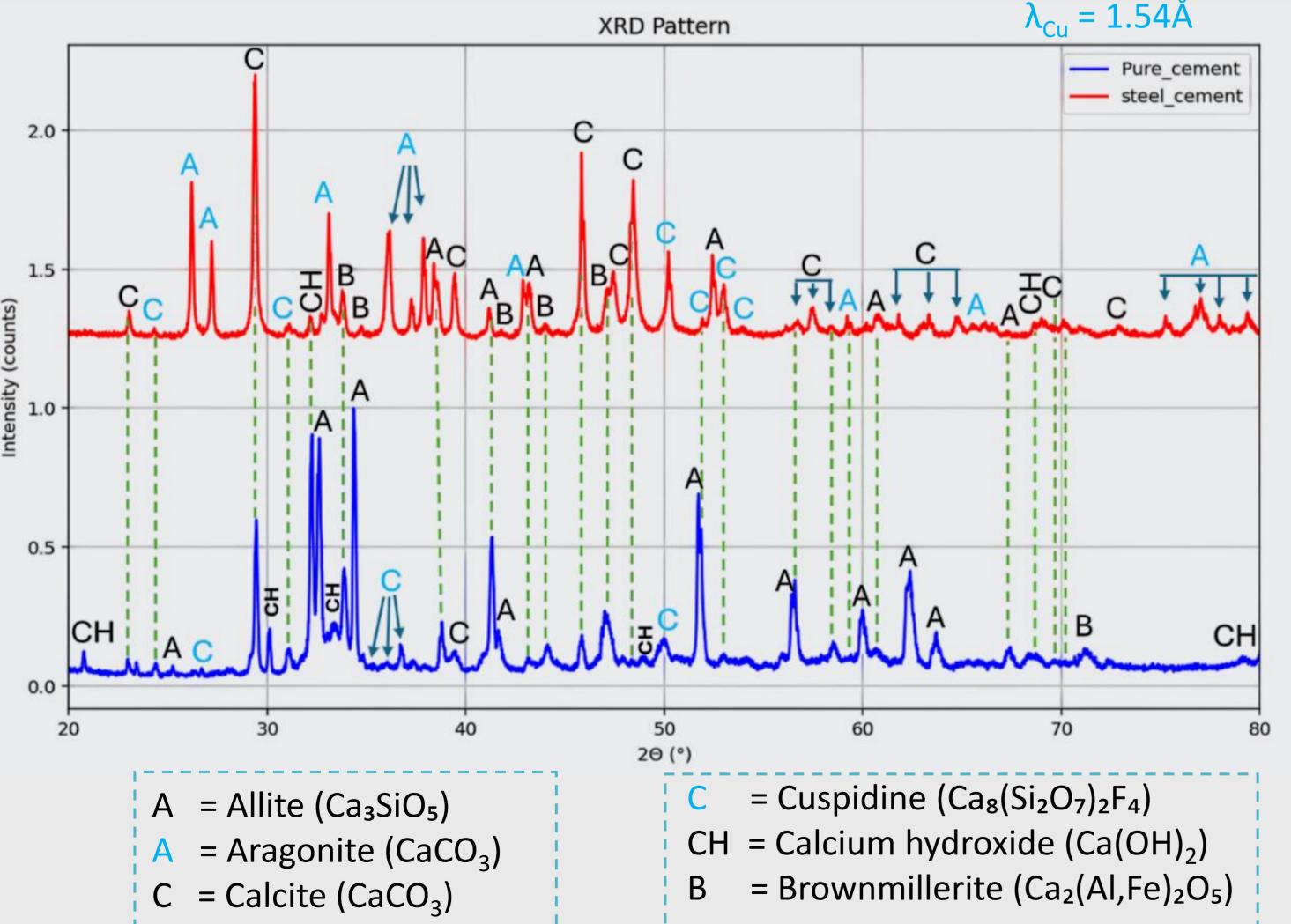
Scanning Electron Microscopy





The scanning electron microscopy images reveals that C-S-H phases in (v) unexposed Portland cement powder and, (vi) CO₂ exposed steel infused cement dehydrated under high temperatures, forming a flocculent structure.

Powder Diffraction



The above graph illustrates the X-ray diffraction peaks of unexposed Portland cement powder and CO₂ exposed steel infused cement sample.

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Conclusion and Future Goals

- μCT analysis of the steel-infused cement revealed progressive phase degradation and carbonation from CO₂ exposure, with SEM and XRD providing complementary insights into morphological changes and hydration compounds.
- As part of future work, an electrochemical cell will be developed to evaluate corrosion rates. Fig (vii), gives the rough sketch of the cell, which will be connected to a Potentiostat and integrated with the CT system for in-situ analysis. (The design might be modified based on the requirements)

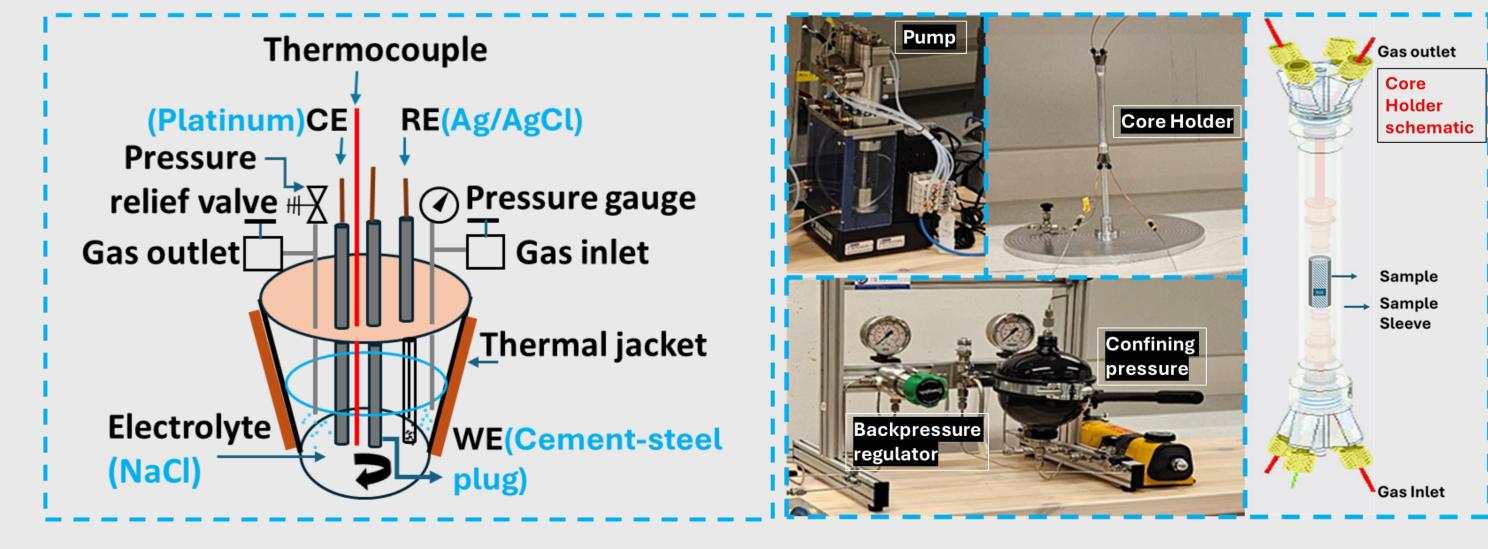


Fig (Vii): Electrochemical cell with three Fig (Viii): shows the home laboratory electrodes, CO₂ inlets/outlets and core flooding setup for precipitation temperature/pressure control systems.

studies.

References

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[2] Tantawy, M. A. (2017). J. Mater. Sci. Chem. Eng., 5(11), 33–48. https://doi.org/10.4236/msce.2017.511004.