Carbonation and grinding of recycled cement powder as an effective new method of carbon capture, utilization, and storage

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Introduction

- The manufacturing of cement accounts for ~7% of global anthropogenic carbon dioxide (CO_2) emissions [1]
- Current methods of Carbon Capture, Utilization, and Storage (CCUS) technology in the cement industry are based in an energy intensive process called calcium looping
- A proposed new process involves taking recycled cement powder (RCP), carbonizing it, then using it as a Supplementary Cementitious Material (SCM) in order to be reused in construction
- One limitation of carbonation is packing density and particle size of the carbonation products which limits the diffusion of the CO_2 and therefore reduces its ability to react and form more products. Finding ways to improve this carbonation degree will make this process more efficient
- **This study aims to investigate the carbonation of RCP as well as determine if grinding during the carbonation process improves the carbonation degree**

Methods

- Two samples of 10g of RCP were carbonated in an incubator with a concentration of 20% CO_2
- CO_2 uptake was determined by weighing periodically over the course of 18 days, with sample 1 being ground after the mass increase reached a plateau
- Phase changes were found by performing Thermogravimetric/Differential Thermogravimetric analysis (TGA-DTG) after 0, 96, and 361 hours of carbonation

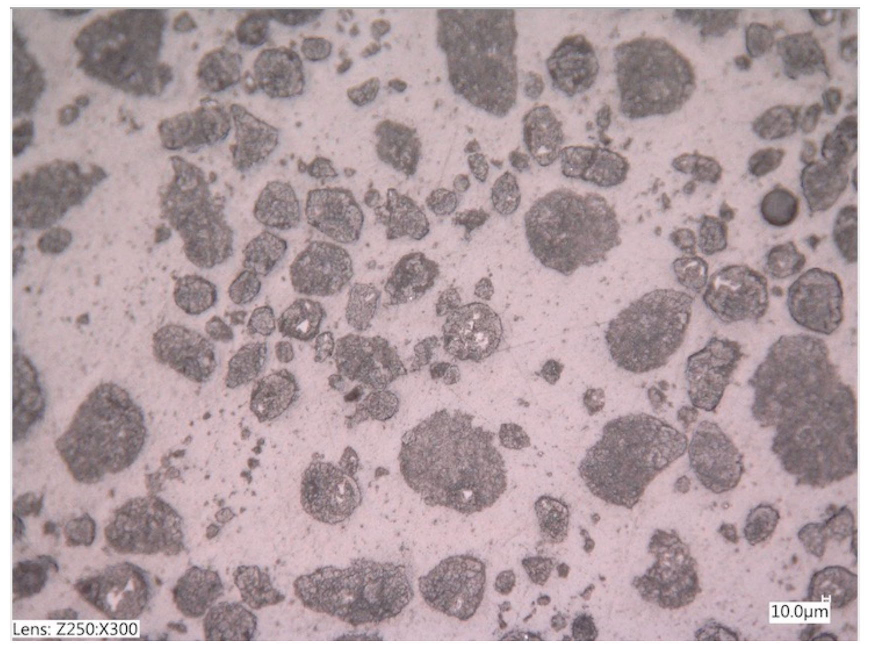

Figure 1: RCP sample under optical microscope ($10\mu m$)

Results

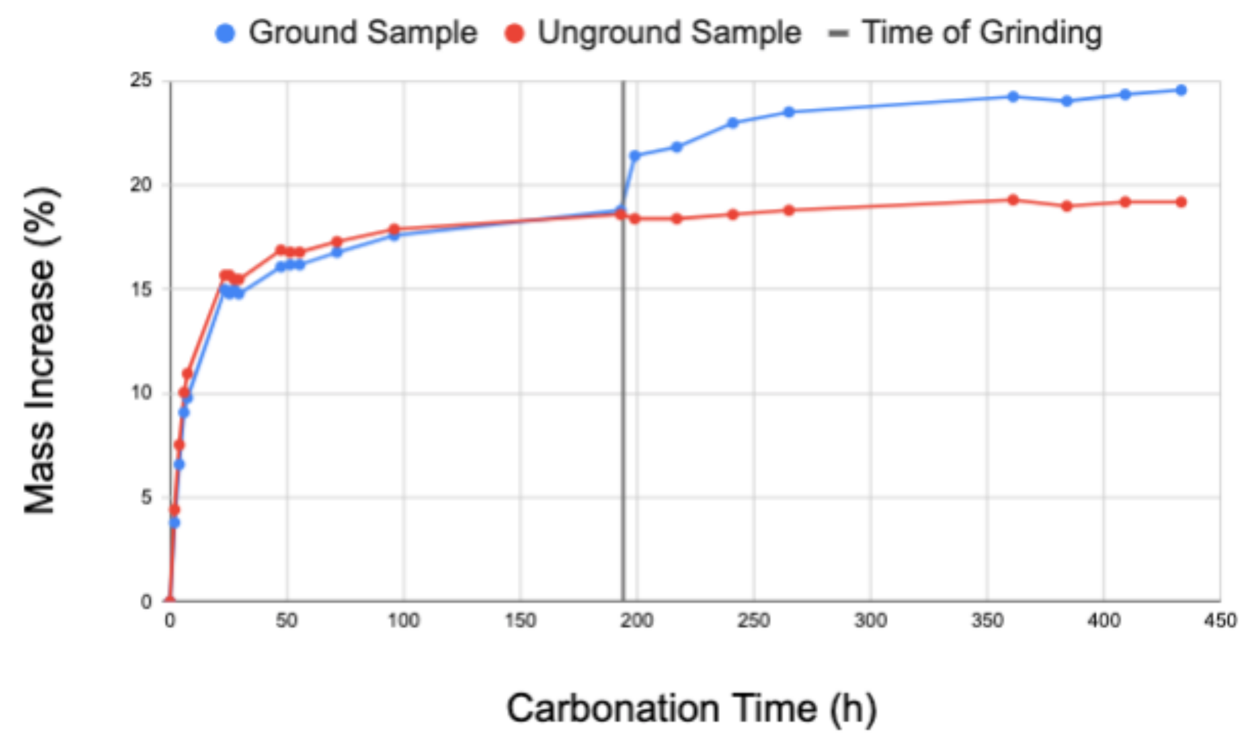

Figure 2: Mass increase due to carbonation. After grinding sample 1 was able to uptake more CO_2

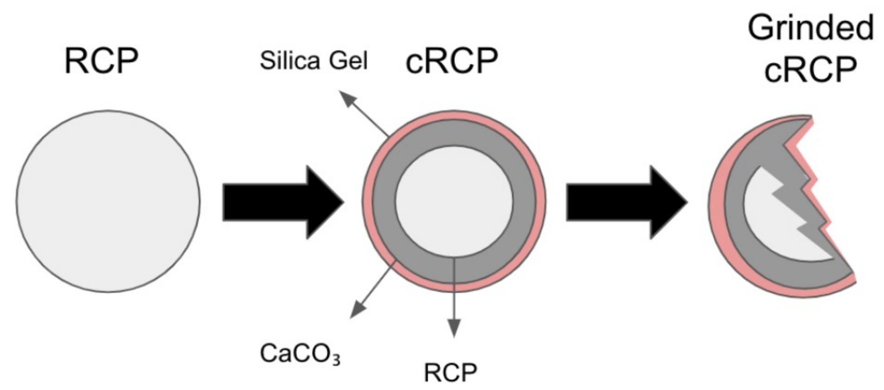

Figure 3: Schematic of grinding. Grinding exposes more surface area of the RCP and removes outer layer of carbonation products

Results

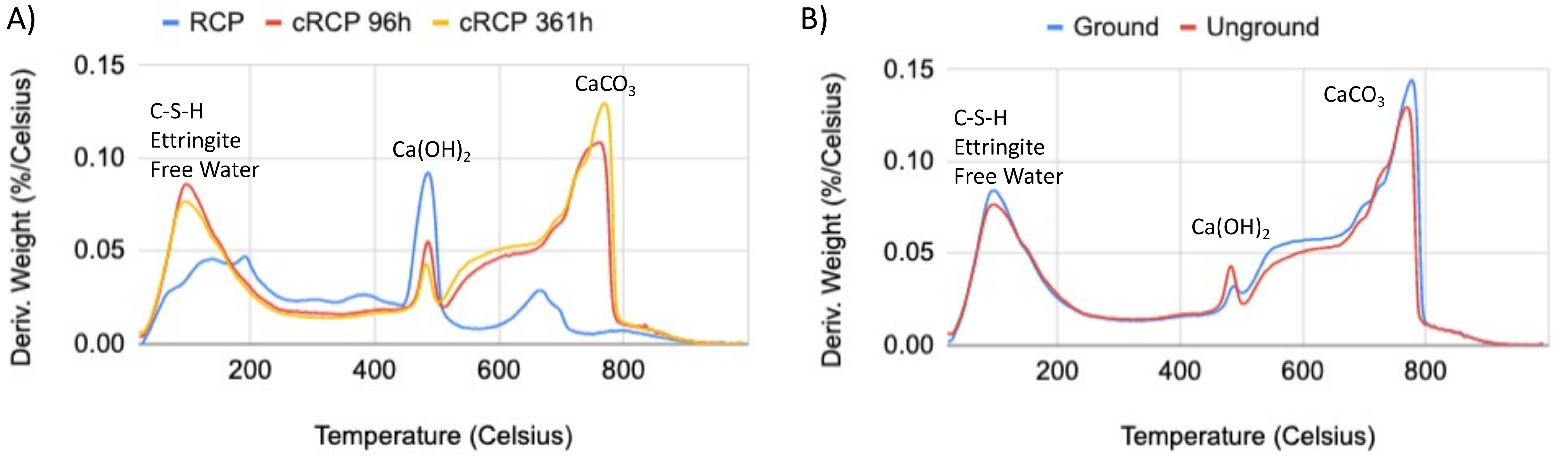

Figure 4: (A) DTG comparing carbonation times (B) DTG comparing ground vs unground cement powder

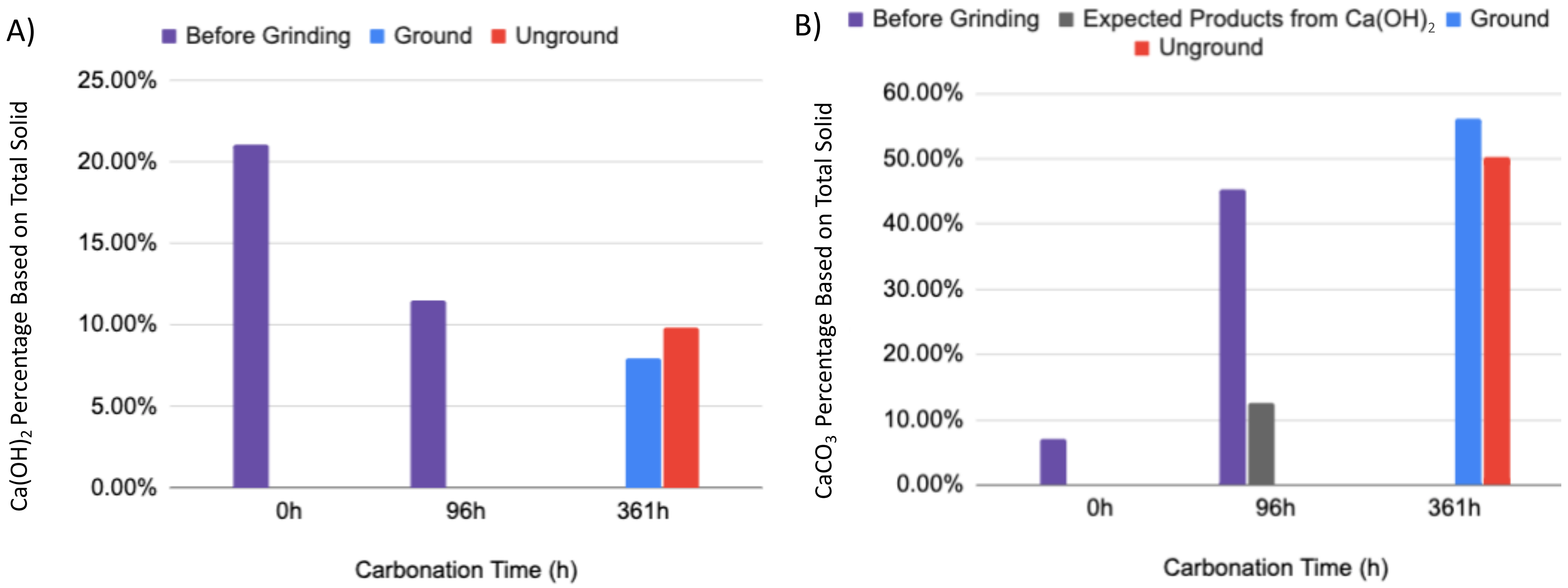

Figure 5: (A) $Ca(OH)_2$ content (B) $CaCO_3$ content at different carbonation times with expected $CaCO_3$ at 96h

Conclusions/Future Work

The goal of this research was to observe the carbonation of RCP as well as to study the impact of grinding on the carbonation process. Based on the analysis of the reaction we can conclude the following:

- Grinding results in the formation of more products and therefore is an effective way of improving the carbonation degree of RCP
- The carbonation product of $CaCO_3$ is formed from the consumption of both $Ca(OH)_2$ and C-S-H

Future work:

- Use scanning electron microscope (SEM) to observe and compare carbonation products
- Comparison of RCP vs carbonated RCP compressive strengths

References

1. Schneider M. Cem Concr Res. 2019; 124: 105792

Acknowledgements: Columbia University SURE Program, Kawashima Lab team and Carleton Lab staff