

---

## Sahra Homaee

Martin Rudolph, Krassimir Garbev

Helmholtz Institute Freiberg for Resource Technology, Chemnitz Str. 40, Freiberg, Germany

[s.homaee@hzdr.de](mailto:s.homaee@hzdr.de)

[m.rudolph@hzdr.de](mailto:m.rudolph@hzdr.de)

[krassimir.garbev@kit.edu](mailto:krassimir.garbev@kit.edu)

---

# Raman Spectroscopy Investigations on Carbon Dioxide Sequestration through Wet Carbonation of Ca and Mg Silicate-Rich Minerals

The rise in carbon dioxide (CO<sub>2</sub>) emissions from fossil fuel combustion has become a significant environmental concern, necessitating urgent global action to mitigate climate change. The Paris Agreement, established in 2015, aims to limit the global temperature increase to well below 2°C above pre-industrial levels, with efforts to restrict the increase to 1.5°C. This agreement underscores the importance of balancing anthropogenic emissions with the removal of greenhouse gases.

To address this challenge, the widespread deployment of negative emissions technologies (NETs) and carbon capture and storage (CCS) is crucial [1, 2]. CO<sub>2</sub> sequestration presents a promising strategy for capturing emissions, particularly in industries such as cement production. Utilizing carbonated materials as Supplementary Cementitious Materials (SCMs) offers a dual solution by capturing emitted CO<sub>2</sub> and recycling it within the cement industry. Wet carbonation emerges as a promising method for mineral carbonation due to its rapid reaction rates in an aqueous environment. However, further research is needed to understand the chemical carbonation reaction mechanisms and enhance reaction rates.

This study focuses on the carbonation of wollastonite, a calcium silicate-rich material, and olivine, a magnesium silicate-rich material, and their carbonation processes. Various factors influencing CO<sub>2</sub> uptake and the chemical carbonation reaction mechanisms are explored. Raman spectroscopy is employed to study these chemical reactions, using Raman mapping, providing new insights into phase changes during wollastonite and olivine carbonation. Complementary methods such as X-ray diffraction (XRD), X-ray fluorescence (XRF), automated mineralogy (SEM-EDX), Calcimeter, and thermogravimetric analysis (TGA) are also utilized.

The findings reveal the occurrence of passive layer formation during wollastonite carbonation via a double carbonation process. Additionally, the study highlights the beneficial impact of grinding on wollastonite CO<sub>2</sub> uptake, attributed to both size reduction and mechanochemical activation. Remarkably, over 80 % of the estimated calcium oxide in wollastonite, with potential for carbonation, has been successfully carbonated. These findings offer valuable insights into the potential of wollastonite carbonation for CO<sub>2</sub> sequestration and demonstrate the effectiveness of Raman spectroscopy in investigating the carbonation process.

## References

- [1] Fuglestedt, J., Rogelj, J., Millar, R. J., Allen, M., Boucher, O., Cain, M., ... & Shindell, Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119), 20160445D. (2018), Implications of possible interpretations of 'greenhouse gas balance' in the Paris Agreement.
- [2] Regufe, M. J., Pereira, A., Ferreira, A. F., Ribeiro, A. M., & Rodrigues, A. E. , Energies, 14(9), 2406. (2021), Current developments of carbon capture storage and/or utilization—looking for net-zero emissions defined in the Paris agreement.