

## **From atoms to minerals: how calcium carbonates form and why we should care.**

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Calcium carbonate minerals are ubiquitous on Earth where they play a key role in many marine and terrestrial biomineralization processes, controlling the evolution of past and future ocean chemistry and a large part of the global carbon cycle. However, the mechanisms by which biominerals form and transform are not well understood because these processes frequently involve the formation of poorly-ordered and crystalline metastable phases (e.g., amorphous calcium carbonate, vaterite, monohydrocalcite). Furthermore, the degree of ordering, hydration and particle size of these phases and their crystallisation pathways are largely controlled by their origin and conditions of formation. These include a number of factors like temperature, pH, and concentration of foreign ions in solution (e.g., Mg<sup>2+</sup>, Sr<sup>2+</sup>, SO<sub>4</sub><sup>2-</sup>, organics, etc.).

Over the last few years, new experimental and characterization approaches have been developed, combining classical characterization techniques with synchrotron-based methods that allow in situ and real-time monitoring of the reactions (e.g., time-resolved synchrotron-based scattering and diffraction, pair distribution function). These techniques have provided very useful data to attain the mechanisms and quantify the kinetics of crystallization in abiotic systems.

I will present a series of results obtained from synchrotron- and lab-based experiments that shed light on the mechanisms of formation of a number of biominerals (e.g., vaterite, calcite, aragonite, monohydrocalcite, dolomite). These results provide a detailed understanding of how calcium carbonate phases form during biomineralization processes, the effects of seawater ions and organics during the formation and transformation of biominerals, and the implications for past and future ocean chemistry, CO<sub>2</sub> capture and storage and industrial mineral synthesis.