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Mesocosm experiment on carbonate formation in algal blooms

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We conducted a mesocosm experiment to simulate carbonate mineral formation in an algal bloom in a freshwater system, focusing on the influence of environmental changes on carbonate precipitation. Very few studies have explored the formation of distinct carbonate phases (ACC, aragonite, calcite, dolomite) during algal blooms, their transitions over time, and how external factors, such as temperature and precipitation, influence these processes. Our study tested hypotheses about the roles of algae in calcite formation and the effects of clay mineral surfaces on carbonate nucleation and transformation.

We performed a month-long experiment using 12 containers filled with filtered water from Lake Balaton, Hungary. Triplets of containers were treated as: (1) control (water only), (2) algae added, (3) algae and smectite added, and (4) algae and smectite, and heated by 6°C relative to the other containers. Throughout the experiment, water chemistry and the concentrations of chlorophyll and phosphate were monitored. Solid particles were filtered from the water and taken from the sediment, then characterized using scanning transmission electron microscopy (STEM) and X-ray diffractometry (XRD).

The experiment successfully replicated an algal bloom, showing that Mg-ACC forms first, followed by distinct pathways of carbonate transformation, depending on the presence or absence of smectite. Heavy rainfall and temperature fluctuations further influenced the precipitation and transformation of carbonates, with aragonite, Mg-bearing calcite and nanoscale dolomite forming under specific conditions.

Our study succesfully simulated a geological process, the accumulation of carbonate sediment in a shallow lake. Our findings demonstrate that carbonate formation involves rapid (hours to days) dissolution-reprecipitation cycles, influenced by environmental factors such as rainfall and temperature. By tracking the sequence of events, we obtained important details both on the time constraints of phase transformations and the external conditions affecting carbonate precipitation, including that of dolomite [1].

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