Microbial biomineralization: Formation, biosignatures and function

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Magnetotactic bacteria forming <u>magnetosomes</u> Magnetite Fe<sub>3</sub>0<sub>4</sub>

> Coccolithophore microalgae forming <u>coccoliths</u> Calcite CaCO<sub>3</sub>





Trace element incorporation in abiotic and biological magnetite nanocrystals Amor *et al.* ACS Nano 2023





Trace metal doped (100 ppb) chemical reaction and cultures analyzed by ICP-MS

Partition coefficients (solution-crystal) compared to lattice strain model

Metal incorporation into magnetosome controlled but not according to ion radius

Higher incorporation of 3d metals for abiotic magnetite

D<sup>x</sup> = [X<sub>crystal</sub>] / [X<sub>solution</sub>]

Findings outline limitations for metal doping approach to tune magnetite nanoparticle properties (e.g., magnetic susceptibility) and further understanding of biosignatures of biominerals

### Coccolithophore microalgae













# Calcification and photosynthesis

### Sedimentation and carbon cycle contribution



## Climate change and ocean acidification



What will be the effects of

- $\rightarrow$  Lower pH
- $\rightarrow$  Warmer waters
- $\rightarrow$  Nutrient stratification
- $\rightarrow$  Stronger sunlight

on coccolith production and proliferation ?

 $CO_{2(aq)} + H_2O \implies H_2CO_{3(aq)} \implies H^+ + HCO_{3(aq)} \implies 2H^+ + CO_{3(aq)}^{2-}$ 

 $CO_{2(aq)} + H_2O + CO_{3(aq)}^2 \longrightarrow 2HCO_{3(aq)}$ 



## How do coccolithophores control calcification ?







Kadan *et al.* PNAS 2021



Gal *et al.* PNAS 2018



Sviben et al. Nat. Comm. 2016

## How to reveal calcification *in vivo*?



### Nanoprobe imaging of coccolithophores (more on the poster)



#### Future projects

Trace metal uptake into coccolith calcite

- $\rightarrow$  Quantitative analysis of D<sup>X</sup>
- → Functionalizing coccolith materials for application

Role of coccosphere in photosynthesis activity

Utilization of Raman spectromicroscopy to provide (bio-)chemical details on coccolith formation



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And thank you for your attention

...perhaps more!

#### Nano-spectromicroscopy to study intracellular iron in MTB Chevrier *et al.* Small Science 2022





#### Nano-spectromicroscopy to study intracellular iron in MTB Chevrier *et al.* Small Science 2022



Study demonstrates the utility of nanoprobe imaging at high energy Xrays to distinguish iron heterogeneities in MTB.

Results confirm large fraction of intracellular iron likely related to ferritin and not directly involved in magnetite precipitation.

Technique compatible for wide variety of samples and materials