Coccolith morphology data from an experiment examining the effect of Sr on the coccolithophore Scyphosphaera apsteinii calcification

Website: https://www.bco-dmo.org/dataset/866738
Data Type: experimental
Version: 1
Version Date: 2021-12-10

Project
» NSFGEO-NERC: An unexpected requirement for silicon in coccolithophore calcification: physiological, ecological and evolutionary implications (Coccolithophore Silicon Requirements)

Contributors	Affiliation	Role
Taylor, Alison	University of North Carolina - Wilmington (UNC-Wilmington)	Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
The effect of Sr on the coccolithophore Scyphosphaera apsteinii calcification was assessed over a 10 day period. This dataset includes scores for each morphometric category assigned from SEM image analysis.

Table of Contents

Coverage

Temporal Extent: 2019-04-19 - 2019-05-09

Acquisition Description

Experiment Overview:
The effect of strontium (Sr) on the coccolithophore *Scyphosphaera apsteinii* calcification was assessed over a 10 d period. This species of coccolithophore has unusually high levels of Sr in its calcite coccoliths as detected with Energy-dispersive X-ray spectroscopy (EDS), whereas Si levels are undetectable with EDS. The goal of the experiment was to determine whether Sr in seawater plays a significant role in coccolith production and/or coccolith crystal morphology. *S. apsteinii* was acclimated and grown in a range of Sr concentrations (deplete: 0.33 mmol/mol Sr/Ca, ambient: 9 mmol/mol Sr/Ca, and higher than ambient: 36 and 72 mmol/mol Sr/Ca). All treatments had four replicate flasks. Aliquots of cultures for cell counts and Fv/Fm were taken every two days between the start (T0 for cell counts, T4 for Fv/Fm) and end (T10) of the experiment. When cells were at mid-exponential phase (T4-T6) aliquots were collected for scanning electron microscopy (SEM) and EDS analysis to observe morphology and determine Sr incorporation into calcite coccoliths, respectively.

The laboratory experiments were conducted in March 2019 at the University of North Carolina -

Wilmington. SEM/EDS analysis was done at the Analytical Instrumentation Facility at NC State from April 19th to May 9th, 2019.

Scanning Electron Microscopy (SEM) and Energy-dispersive X-ray Spectroscopy (EDS):
For EDS analysis, 1-3 mL of culture were filtered onto 13 mm 0.4 um isopore filters (Merck Millipore Ltd.) and rinsed with Nanopure water buffered to pH 8.0 with 1 mM HEPES to remove salts. Filters were air-dried and mounted onto a SEM stub with carbon adhesive tabs before coating with 10 nm Pt/Pd. EDS analysis was performed at North Carolina State University (FEI Verios 460L SEM, with an Oxford Xmax silicon drift EDS detector and AZtec acquisition and analysis software). A minimum of 500,000 counts were collected, between 2,000 – 8,000 cps with an average deadtime < 5%. Standardless quantification was used to determine atomic % and weight % for each element.

Processing Description

Coccolith Scoring:
Forty cells from each treatment were imaged and attached coccoliths were scored. Coccoliths were only scored if the majority of the coccolith could be seen. Muroliths were scored into four categories: normal, incomplete, malformed, and aberrant (descriptions for each can be seen in the Sr Metadata Parameters.xls spreadsheet). Lopadoliths were scored into five categories: normal, expected malformed, incomplete, Type S, Type T, and Type R. Scores for each morphometric category were counted, added, then divided by the total number of muroliths or lopadoliths (example: total # of normal muroliths/total # of muroliths) to determine frequency. Scores for each morphometric category from each replicate flask were then averaged (n = 4).

BCO-DMO Processing:
- removed units from data columns so values can be typed as numeric;
- renamed fields to conform with BCO-DMO naming conventions.

[table of contents | back to top]

Related Datasets

IsRelatedTo

Taylor, A. (2021) **Cell counts from an experiment examining the effect of Sr on the coccolithophore Scyphosphaera apsteinii calcification.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-12-10 http://lod.bco-dmo.org/id/dataset/866456 [view at BCO-DMO]

Taylor, A. (2021) **Energy-dispersive X-ray spectroscopy (EDS) from an experiment examining the effect of Sr on the coccolithophore Scyphosphaera apsteinii calcification.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-12-10 http://lod.bco-dmo.org/id/dataset/866679 [view at BCO-DMO]

Taylor, A. (2021) **Quantum yield of photosystem II (Fv/Fm) from an experiment examining the effect of Sr on the coccolithophore Scyphosphaera apsteinii calcification.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-12-10 http://lod.bco-dmo.org/id/dataset/866648 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
Sr_Concentration	The Sr concentration of the growth media that S. apsteinii was exposed to. The concentrations were 3.3, 90, 360, and 720 micromoles Sr.	micromoles per liter Si (umol/L)
Flask_Replicate	The replicate flask number for each Sr treatment. Each Sr concentration had 4 replicate flasks.	unitless
Cell_Number	The replicate number for each Sr treatment of which coccoliths were scored. Each treatment had a total of 40 cells counted.	unitless
Murolith_Normal	Scoring category: muroliths displayed expected morphology	unitless
Murolith_Incomplete	Scoring category: muroliths were not fully formed, but otherwise had normal morphology	unitless
Murolith_Malformed	Scoring category: muroliths displayed minor malformations commonly seen in control cultures	unitless
Murolith_Aberrant	Scoring category: muroliths displayed complete disruption, or disorganized calcite	unitless
Lopadolith_Normal	Scoring category: lopadoliths displayed expected morphology	unitless
Lopadolith_Expected_Malformed	Scoring category: lopadoliths displayed minor malformations commonly seen in control cultures	unitless
Lopadolith_Incomplete_Type_S	Scoring category: lopadoliths were not fully formed, but otherwise had normal morphology	unitless
Lopadolith_Malformed_Type_R	Scoring category: lopadoliths displayed a large longitudinal cleave	unitless
Lopadolith_Aberrant_Type_T	Scoring category: lopadolith displayed complete disruption, or disorganized calcite	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	FEI Verios 460L SEM
Generic Instrument Name	Scanning Electron Microscope
Dataset-specific Description	SEM and EDS: Energy-dispersive X-ray spectroscopy (EDS) is a technique that can be performed in a scanning electron microscope (SEM) whereby accelerated electrons interact with the specimen generating x-ray photons that are characteristic for specific elements. Therefore, EDS allows for element identification and quantification. Below is the SEM used with respective EDS analysis system: FEI Verios 460L SEM equipped with Oxford Xmax silicon drift EDS detector and AZtec acquisition and analysis software for elemental analysis.
Generic Instrument Description	A scanning electron microscope (SEM) scans a focused electron beam over a surface to create an image. The electrons in the beam interact with the sample, producing various signals that can be used to obtain information about the surface topography and composition.

[table of contents | back to top]

Project Information

NSFGEO-NERC: An unexpected requirement for silicon in coccolithophore calcification: physiological, ecological and evolutionary implications (Coccolithophore Silicon Requirements)

NSF Abstract:
Biomineralization by marine phytoplankton has had a profound impact on our planet. The production of special cell wall material, calcite coccoliths by coccolithophores and silica frustules by diatoms, are major drivers in global biogeochemical cycles, but the underlying cellular processes remain poorly understood. It is widely considered that calcification in coccolithophores occurs through a very different process to silicification in diatoms, however some ecologically important coccolithophore lineages possess diatom-like silicon (Si) transport systems and have an absolute requirement for Si during coccolith formation. Importantly, the abundant bloom-forming coccolithophores such as Emiliania huxleyi exhibit no requirement for Si. There is a clear need to understand how these different physiological requirements for dissolved Si have driven the ecology and evolution of the coccolithophores. The project will yield a more complete understanding of the Si requirements of coccolithophores, its role in the calcification process, and the impacts of Si availability on the biogeography of these important bloom forming phytoplankton. The results are expected to strengthen our ability to predict the responses of coccolithophores to short and long-term environmental change, and therefore the consequences for the marine biogeochemical cycles in which they participate. In addition to the scientific outcomes, the project provides independent research opportunities to a diverse pool of undergraduate students, provide interdisciplinary training for graduate students, and facilitate the professional development of post-doctoral researchers. Public engagement in the research is facilitated through participant involvement in regional science festivals, public outreach events, production of educational resources, and targeted K-12 summer camp activities.

Calcification in coccolithophores appears to represent a distinct process from silicification in diatoms, another major group of biomineralized phytoplankton. The apparent absence of a requirement for silicon (Si) in coccolithophores has been proposed to play a critical role in their ability to out-compete the otherwise dominant diatoms in areas of low dissolved Si availability. However, the investigators recently demonstrated that some globally important coccolithophores possess diatom-like Si transporters and exhibit an obligate requirement for Si in the calcification process. This discovery has important implications both for phytoplankton ecology and for the evolution of biomineralization. Using a range of physiological,

molecular and computational approaches the project will 1) Establish Si requirements of ecologically important coccolithophore groups; 2) Determine the physiological role of Si in coccolithophores; 3) Determine the evolutionary events leading to the differing requirements for Si in calcification; 4) Examine the ecological distribution of Si-requiring coccolithophores, and 5) Determine the impact of the Si requirement on coccolithophore ecology. This project therefore integrates the molecular identification of genes (Si transporters), the physiological role of these transporters, and ecosystem scale models in order to examine how the requirement for Si influences ecosystem functioning and coccolithophore biogeography. The results of this work provides essential data that describes the cellular mechanisms of calcification and the range of physiological diversity between major coccolithophore lineages. The research also explores a previously unforeseen aspect of phytoplankton ecology; examining how the differing requirements for Si in calcifying coccolithophores may have shaped competitive interactions with other phytoplankton over both contemporary and evolutionary timescales. Overall, the research provides novel insights into physiology, ecology and evolution of coccolithophores, including information on how and why coccoliths are produced, which is currently poorly understood. This information is vital in order to understand how coccolithophores have been influenced by past changes in the Earth's climate, and their potential responses to future oceans.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1638838

[table of contents | back to top]