Phytoplankton in silicate sands column experiment

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Project
» Chromatographic separation and degradation of dissolved and particulate organic matter in permeable shelf sediment (Sand Chromatography)

Contributors	Affiliation	Role
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Abstract
In coastal environments with sandy seafloor, water is pushed through the surface layers of the permeable sediment by currents and wave orbital motion. The water penetrating the sands carries particles that may be slowed or trapped in the sediment matrix. The Phytoplankton in silicate sands column experiment investigated the transport and separation of phytoplankton algae through sand columns. Silicate sands of two grain sizes common in coastal and shelf environments were tested. Water with a natural phytoplankton community dominated by green algae (~5-10 um diameter) and cyanobacteria (~2-5 um) was pumped through the sands. Time series of phytoplankton cells released from the columns were analyzed using flow cytometry. The data set presents the data produced by the flow cytometer. This data set is associated with the data set "Phytoplankton in carbonate sands column experiment" that presents the cytometer results for carbonate sands of the same grain sizes that were treated with the same phytoplankton.

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Coverage

Location: Silicate sands were obtained from the public beaches at Pensacola Beach, FL (30.209 ºN, -87.02906 ºW)
Spatial Extent: **Lat**:30.209 **Lon**:-87.02906
Temporal Extent: 2025-06-01 - 2025-07-01

Methods & Sampling

The columns used for this experiment had a length of 10 cm and a diameter of 1 cm. The sands used were silicate sands with the grain size diameter ranges 1) 125 to 250 um and 2) 250-500 um. Prior to the experiments, the sands were cleaned through repeated washing in NaCl solution (salinity 35). For testing particle separation within these sands, seawater with a natural phytoplankton community dominated by green algae (5-10 um cell diameter) and cyanobacteria (1-5 nm cell diameter) were pumped through the sand. Computer-controlled syringe pumps pushed the seawater with the algae through the columns at a pore front velocity of 20 cm per hour. The eluent of the 2 columns were collected in a rotating sampler at 15 minute intervals. A total of 36 fractions was collected for each of the sand column for a flushing period of 9 h. The resulting samples were analyzed in a Cytoflex flow cytometer with gating adjusted to capture the green algae

and cyanobacteria. Data collected include the area under the forward scatter peak, which provides information on cell size side scatter data, which are related to cell granularity. Calibration of the instrument used calibration beads with particle size ranging from 0.29 to 16.8 um. Explanations regarding flow cytometer analysis of phytoplankton samples as performed here are presented in Trask et al. (1982), best practices in Gallot et al. (2025), and details on the more recent instrumentation in Ugawa et. al 2024.

Data Processing Description

Cells penetrating through the sand columns were identified by analyzing forward (FSC) and sideward scatter (SSC) signals. The signals are used to gate and identify different cell populations. By combining information from the two scatter signals, particles can be distinguished based on their size and granularity.

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Related Publications

Gallot, C., Hubert, Z., Haraguchi, L., Aardema, H., Artigas, L. F., Bellaaj Zouari, A., Cauvin, A., Casotti, R., Créach, V., Dubelaar, G., Epinoux, A., Grégori, G., Grosso, O., Kolasinki, J., Kools, H., Lievaart, R., Louchart, A. P., Moreira Fragoso, G., Palazot, M., et al. (2025). Best Practices for Optimization of Phytoplankton Analysis in Natural Waters Using CytoSense Flow Cytometers. Cytometry Part A, 107(11), 730–744. Portico. https://doi.org/10.1002/cyto.a.24964
Methods

Trask, B. J., van den Engh, G. J., & Elgershuizen, J. H. B. W. (1982). Analysis of phytoplankton by flow cytometry. Cytometry, 2(4), 258–264. Portico. https://doi.org/10.1002/cyto.990020410
Methods

Ugawa, M., & Ota, S. (2024). Recent Technologies on 2D and 3D Imaging Flow Cytometry. Cells, 13(24), 2073. https://doi.org/10.3390/cells13242073
Methods

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Beckman CytoFlex flow cytometer
Generic Instrument Name	Flow Cytometer
Dataset-specific Description	The resulting samples were analyzed in a Cytoflex flow cytometer with gating adjusted to capture the green algae and cyanobacteria.
Generic Instrument Description	Flow cytometers (FC or FCM) are automated instruments that quantitate properties of single cells, one cell at a time. They can measure cell size, cell granularity, the amounts of cell components such as total DNA, newly synthesized DNA, gene expression as the amount messenger RNA for a particular gene, amounts of specific surface receptors, amounts of intracellular proteins, or transient signalling events in living cells. (from: http://www.bio.umass.edu/micro/immunology/facs542/facswhat.htm)

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Project Information

Chromatographic separation and degradation of dissolved and particulate organic matter in permeable shelf sediment (Sand Chromatography)

Coverage: Gulf of Mexico

NSF Award Abstract:
This project will study the role of sandy sediments in the carbon cycle. Sandy sediments cover about one-third of the continental shelf but are not well studied. Like a sand filter, marine sands separate and trap dissolved and particulate materials as seawater moves through. These processes influence organic matter cycling in sediments. Because smaller particles travel more easily through the pore space than larger ones, they move deeper into the seabed. This causes a separation of particulate matter by size. Likewise, changes in oxygen and dissolved chemicals with depth alter the surface properties of the sediment grains. Molecules with different properties are separated based on these surface characteristics. The fates of organic carbon, dissolved nutrients and pollutants in the coastal ocean are linked to uptake by sediments, physical and microbial processes within sediments, and release. Thus, it is important to understand the processes that control the transport and accumulation of materials in the seabed. This project will study the separation of particulate and dissolved organic matter transported through marine sands. It will provide information critical for understanding the cycling of carbon and nutrients at the seafloor. Graduate and undergraduate students working on this project will receive training in marine sediment functions and state-of-the-art methods that can help solve pressing environmental issues.

The main objectives of this research are to: 1) demonstrate and quantify the chromatographic separation of organic matter in shelf sediments through the analysis of sediment cores from silicate and carbonate sand beds, 2) characterize and quantify the separation process of dissolved and particulate organic matter and identify key factors controlling this separation in the sands, and 3) quantify the influence of organic matter chromatographic separation on sedimentary oxygen consumption and dissolved inorganic carbon production in these sands. The researchers will test the hypothesis that chromatographic separation of particles and solutes takes place in both sand types but differs with respect to the substances affected and the effectiveness of the separation. Intra-grain permeability of biogenic sands can enhance separation in carbonate sands through exclusion chromatography effects. The separation process is expected to enhance decomposition activities through the concentration of degradable materials in specific sediment layers. The research objectives will be addressed with a combination of field and laboratory studies that include tracer experiments and the analysis of dissolved and particulate organic matter distribution in sand sediment cores sampled in the field. Oxygen consumption and dissolved inorganic carbon production will be measured to reveal the relevance of this process for the sedimentary degradation process. The demonstration of chromatographic separation of particles and solutes in marine sands will close a gap in our understanding of

the chemical processes that govern the fate of organic matter, nutrients, and pollutants. This project will provide research training opportunities for graduate and undergraduate students. Results from this study will help improve models of the global cycles of elements that can be used for predicting global environmental change.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2148635

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