Sediment geochemistry data from cores collected on R/V Rachel Carson cruise RC0107 in Clayoquot Sound, Vancouver Island, British Columbia during October 2023

Website: https://www.bco-dmo.org/dataset/992723
Data Type: Cruise Results
Version: 1
Version Date: 2026-01-21

Project
» CAREER: Cryptic sulfur cycling and organic matter preservation in marine oxygen deficient zones (Sulfur in Particles)

Contributors	Affiliation	Role
Raven, Morgan Reed	University of California-Santa Barbara (UCSB)	Principal Investigator
Evans, Natalya	University of California-Santa Barbara (UCSB)	Scientist
Martinez, Aaron	University of California-Santa Barbara (UCSB)	Scientist
Neibauer, Jacquelyn A.	University of Washington (UW)	Scientist
Crotteau, Molly	University of California-Santa Barbara (UCSB)	Student
Fishburn, Jordan	University of California-Santa Barbara (UCSB)	Student
Karagiannis, Marianna	University of California-Santa Barbara (UCSB)	Student
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract

This dataset includes sediment geochemistry data for samples collected on the R/V Rachel Carson cruise RC0107 between October 2nd and 8th, 2023 in Clayoquot Sound, Vancouver Island, British Columbia. Sediment cores were collected at three sites in Clayoquot Sound. Data reported here include: bulk geochemistry (TOC, d13C, C/N/S), concentrations of pyrite and acid volatile sulfur, and proto-kerogen chemistry (C/N/S, d13C). These data will be useful for those interested in understanding organic matter preservation in fjords and other coastal environments. Samples were collected by Molly Crotteau, Morgan Raven, Aaron Martinez, Natalya Evans, Marianna Karagiannis, Jordan Fisburn, and Jaqui Neibauer. Data were interpreted by Morgan Raven and Molly Crotteau.

Table of Contents

Coverage

Location: Clayoquot Sound, Vancouver Island, British Columbia
Spatial Extent: **N**:49.2265 **E**:-125.59724 **S**:49.16826 **W**:-125.6963
Temporal Extent: 2023-10-04 - 2023-10-06

Dataset Description

This dataset is one of three datasets presenting marine biogeochemistry data from four sites in Clayoquot Sound, Vancouver Island, British Columbia from water, sediment, and porewater samples that were collected aboard the R/V Rachel Carson in October 2023. These sites were selected because they represent hotspots of organic carbon burial spanning a range of geochemical conditions. They represent a range of oxic to historically anoxic water columns, and receive organic matter inputs varying from predominantly terrestrial to predominantly marine sources. Together, these datasets provide a framework to evaluate the controls and drivers of organic matter preservation in fjord sediments. See the "Related Datasets" section for the other datasets.

Methods & Sampling

Nine sediment cores were collected from three different sites in Clayoquot Sound, Vancouver Island, Canada in October 2023. One core was used for porewater sampling; this core was sampled immediately with Rhizon samplers. (See "Related Datasets" for the porewater data.) A second core was extruded under argon for geochemical measurements. 1 milliliter (mL) of sediment was added to a cryovial and frozen at -20 degrees Celsius (°C) for future DNA extraction. 5 mL of sediment was added to an exetainer containing 5 mL of 1 N NaOH to measure sediment methane concentrations. The remaining sediment from each extruded interval was added immediately to falcon tubes containing 10 mL of 20% zinc acetate to precipitate sulfides and halt microbial activity. A third archive core was immediately frozen at -20°C.

To determine bulk elemental concentrations (organic C/N/S) of sediments, 1 N HCl was added to ~100 milligrams (mg) of sediment to remove carbonate minerals. To isolate major carbon and sulfur pools, ~1 gram (g) of sediment (preserved in zinc acetate) was subjected to a strong acid hydrolysis (6 N HCl, 60°C, 2 hours) under N_2 to isolate acid-volatile sulfur (AVS; i.e., iron monosulfides). AVS was bubbled into a 5% zinc acetate solution and precipitated as zinc sulfide. Residual solid was rinsed with MQ, freeze dried, and subjected to two sequential microwave extractions (MARS-6, CEM, 70°C, 15 minutes) in a 9:1 dichloromethane: methanol solution to remove lipids and elemental S (Raven et al. 2016). Solvent-extracted solids were dried and underwent a chromium (II) chloride reduction (1:1 chromium (II) chloride: 6 N HCl, 60°C, 2 h) under N_2 to isolate chromium reducible sulfur (CRS; pyrite) (Canfield et al. 1986). CRS was bubbled into a zinc acetate solution and precipitated as zinc sulfide. The residual following CRS extraction was rinsed with MQ water, freeze dried, and is functionally defined as proto-kerogen (hydrolysis-resistant OM) (Burdige 2007; Raven et al. 2016).

De-carbonated bulk sediment samples and proto-kerogen samples were analyzed on an Elementar vario ISOTOPE select elemental analyzer interfaced to a Nu Horizon isotope ratio mass spectrometer to measure organic C/N/S and δ13C. AVS and CRS (precipitated as zinc sulfide) were oxidized to sulfate using 30% H_2O_2. Their concentrations were determined via ion chromatography (Metrohm 930 Compact IC Flex).

Samples analyzed in this study were collected within Ahousaht Territory, on the west coast of Vancouver Island, British Columbia. We respectfully acknowledge the Ahousaht Nation and the Maaqutusiis Hahoulthee Stewardship Society for their stewardship of these lands and for the opportunity to conduct research within their territory.

Data Processing Description

Organic C/N/S concentrations were calculated with a sulfanilamide standard curve (0.5 – 25 micromoles (µmole) N, 1.5 – 75 µmole C, 0.25 – 12 µmole S). Sample δ13C values were calibrated using carbon isotope standards USGS-61 (35.05‰), 62 (-14.79‰), and 63 (1.17‰) run in triplicate and are reported relative to Vienna Pee Dee Belemnite. Sulfate concentrations were calibrated using a sulfate standard curve (0.1 – 100 parts per million (ppm)). Fe(II) concentrations were calibrated using a Fe(II) standard curve (0 – 80 µM).

BCO-DMO Processing Description

- Imported original file "20251007_FJ_sediments.csv" into the BCO-DMO system.
- Converted the date field to YYYY-MM-DD format.
- Saved the final file as "992723_v1_sediment_geochemistry.csv".

[table of contents | back to top]

Related Publications

Burdige, D. J. (2007). Preservation of Organic Matter in Marine Sediments: Controls, Mechanisms, and an Imbalance in Sediment Organic Carbon Budgets? Chemical Reviews, 107(2), 467–485. https://doi.org/10.1021/cr050347q
Methods

Canfield, D. E., Raiswell, R., Westrich, J. T., Reaves, C. M., & Berner, R. A. (1986). The use of chromium reduction in the analysis of reduced inorganic sulfur in sediments and shales. Chemical Geology, 54(1-2), 149–155. doi:10.1016/0009-2541(86)90078-1
Methods

Raven, M. R., Sessions, A. L., Fischer, W. W., & Adkins, J. F. (2016). Sedimentary pyrite δ34S differs from porewater sulfide in Santa Barbara Basin: Proposed role of organic sulfur. Geochimica et Cosmochimica Acta, 186, 120–134. https://doi.org/10.1016/j.gca.2016.04.037
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Crotteau, M., Raven, M. R., Martinez, A., Evans, N., Karagiannis, M., Fishburn, J., Neibauer, J. A. (2026) **Porewater geochemistry data from sediment cores collected on R/V Rachel Carson cruise RC0107 in Clayoquot Sound, Vancouver Island, British Columbia during October 2023.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-01-21 http://lod.bco-dmo.org/id/dataset/992752 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
site	Site number (51.5, 47, or 48) where sediment core was taken	unitless
latitude	Latitude of sampling location	decimal degrees
longitude	Longitude of sampling location	decimal degrees
date	Date sample was collected	unitless
core	The sediment cores were labeled porewater, highres, and archive	unitless
depth	Sampling depth relative to sediment-water interface	centimeters

carbonate	Weight percent of carbonate minerals in sediment samples	weight percent
OC	Organic carbon content in sediments	weight percent
OC_se	Standard error associated with OC	weight percent
SC	Molar total sulfur to organic carbon ratio	percent
SC_se	Standard error associated with SC	percent
CN	Molar total organic carbon to nitrogen ratio	unitless
CN_se	Standard error associated with CN	unitless
d13C	Total organic carbon isotope composition	per mille
d13C_se	Standard error associated with d13C	per mille
AVS	Concentration of acid volatile sulfur in sediment	micromole S per gram sediment
AVS_se	Standard error associated with AVS	micromole S per gram sediment
CRS	Concentration of chromium reducible sulfur (pyrite) in sediment	micromole S per gram sediment
CRS_se	Standard error associated with CRS	micromole S per gram sediment
SCPK	Molar sulfur to carbon ratio in proto-kerogen	percent
SCPK_se	Molar sulfur to carbon ratio in proto-kerogen	percent
CNPK	Molar ratio of carbon to nitrogen in proto-kerogen	unitless
CNPK_se	Standard error associated with CNPK	unitless
PKd13C	Carbon isotope composition of proto-kerogen	per mille
PKd13C_se	Standard error associated with PKd13C	per mille

CH4	Sediment methane concentration	micromolar

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Elementar vario ISOTOPE select elemental analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Elementar vario ISOTOPE select elemental analyzer coupled to a Nu Horizon isotope ratio mass spectrometer. Used to measure organic C/N/S and δ13C.
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	Metrosep A Supp 5 100/4.0 column and Metrohm 930 Compact IC Flex
Generic Instrument Name	Ion Chromatograph
Dataset-specific Description	Used to measure concentrations of sulfate, sulfide, AVS, and CRS.
Generic Instrument Description	Ion chromatography is a form of liquid chromatography that measures concentrations of ionic species by separating them based on their interaction with a resin. Ionic species separate differently depending on species type and size. Ion chromatographs are able to measure concentrations of major anions, such as fluoride, chloride, nitrate, nitrite, and sulfate, as well as major cations such as lithium, sodium, ammonium, potassium, calcium, and magnesium in the parts-per-billion (ppb) range. (from http://serc.carleton.edu/microbelife/research_methods/biogeochemical/ic....)

Dataset-specific Instrument Name	Nu Horizon isotope ratio mass spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Elementar vario ISOTOPE select elemental analyzer coupled to a Nu Horizon isotope ratio mass spectrometer. Used to measure organic C/N/S and δ13C.
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	MARS-6 microwave CEM
Generic Instrument Name	Microwave Digestion Platform
Dataset-specific Description	Used to extract lipids from sediments.
Generic Instrument Description	Microwave digestion is a chemical technique used to decompose sample material into a solution suitable for quantitative elemental analysis

Dataset-specific Instrument Name	Mulitcorer
Generic Instrument Name	Multi Corer
Dataset-specific Description	Used to collect sediment cores.
Generic Instrument Description	The Multi Corer is a benthic coring device used to collect multiple, simultaneous, undisturbed sediment/water samples from the seafloor. Multiple coring tubes with varying sampling capacity depending on tube dimensions are mounted in a frame designed to sample the deep ocean seafloor. For more information, see Barnett et al. (1984) in Oceanologica Acta, 7, pp. 399-408.

[table of contents | back to top]

Deployments

RC0107

Website	https://www.bco-dmo.org/deployment/992743
Platform	R/V Rachel Carson (UW)
Start Date	2023-10-02
End Date	2023-10-08
Description	See more information from R2R: https://www.rvdata.us/search/cruise/RC0107

[table of contents | back to top]

Project Information

CAREER: Cryptic sulfur cycling and organic matter preservation in marine oxygen deficient zones (Sulfur in Particles)

Coverage: Eastern tropical North Pacific

NSF Award Abstract:

CAREER: Particle-Hosted Sulfur Cycling and Organic Matter Burial in Oxygen Deficient Zones

Areas of the ocean without dissolved oxygen are called anoxic zones. These environments are increasing due to human activities and climate change. Large amounts of organic carbon are buried in sediments below anoxic zones. However, we do not fully understand why organic carbon is preserved in these zones. This project seeks to understand a newly discovered process that may contribute to carbon preservation in anoxic zones. The process is called organic matter sulfurization. Through this process, organic matter is transformed and effectively ?pickled? by reacting with sulfide. Rapid sulfurization reactions were identified for the first time in sinking marine particles and may have larger effect on carbon burial in sediments than previously thought. This project will be the first to provide measurements of the scale and significance of rapid organic matter sulfurization in modern anoxic zones. This project includes field and laboratory studies. The research will involve a team of students, including a graduate student and six undergraduates, who will be supported through a peer mentorship program. Undergraduate researchers will be recruited from the inaugural class of a newly developed Practical Research Skills course (Earth 101A) at the University of California Santa Barbara. It seeks to help undergraduates develop critical thinking and observational skills that have broad applicability. This project will launch a self-sustaining and vigorous research program in marine biogeochemistry, heavily invested in undergraduate research education, with impacts that will outlast its five-year duration.

The overarching research goal of this project is to assess the contribution of sulfurization reactions to organic carbon preservation in anoxic environments. After constructing and testing a set of customized particle traps, an expedition will be conducted to the marine anoxic zone off the coast of Mexico. Sinking particles, suspended materials, and surface sediments will be collected at three sites on the Mexican shelf and slope, that have generally high local productivity and gradients in bottom-water oxygen concentration. In the field, the rates and isotopic fractionation of microbial sulfate reduction and organic sulfur formation will be measured with stable and radioactive isotope tracers. Subsequently, organic sulfur sources from both natural samples and laboratory experiments will be characterized using mass spectrometry, X-ray absorption spectroscopy, and other geochemical techniques. Together, the results of this work will identify the timing and location of organic matter sulfurization in this environment, which have substantial implications for both modeling marine carbon fluxes and interpreting the geologic record. This study will provide the first quantitative estimates of the scale of organic matter sulfurization in anoxic marine zones, its contribution to sedimentary carbon burial, and its sensitivities to environmental change. Simultaneously, this project will improve the Earth Science undergraduate curriculum at the University of California Santa Barbara through the development of a clear, supportive, and accessible mechanism for including students in research.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2143817

[table of contents | back to top]