Concentrations, d13C and D14C data for DOC and DIC in fluids collected from North Pond Cork Observatories U1382A and U1383C and from bottom seawater in 2012, 2014 and 2017.

Website: https://www.bco-dmo.org/dataset/876729
Data Type: Other Field Results
Version: 2
Version Date: 2024-06-11

Project
» Collaborative Research: A multidimensional approach to understanding microbial carbon cycling beneath the seafloor during cool hydrothermal circulation (Subseafloor Microbial Carbon Cycling)

Program
» Center for Dark Energy Biosphere Investigations (C-DEBI)

Contributors	Affiliation	Role
Girguis, Peter	Harvard University	Principal Investigator
Shah Walter, Sunita R.	University of Delaware	Co-Principal Investigator, Contact
Soenen, Karen	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Carbon geochemistry is presented for subsurface fluids collected from Cork Observatories U1382A and U1383C installed on the Mid-Atlantic Ridge at North Pond as well as from bottom seawater. Data are summarized from fluids collected in 2012, 2014 and 2017. Parameters measured or calculated are pH, total alkalinity, DIC concentrations, d13C and D14C values and DOC concentrations, d13C and D14C values. Understanding carbon cycling in cool oceanic crust at sites like North Pond contributes to quantifying fluxes of carbon from hydrothermal systems to the deep ocean. These data assess the evolution of carbon reservoirs in fluids that are isolated from the crust and were collected by Dr. Sunita Shah Walter at the University of Delaware

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Coverage

Location: Mid-Atlantic Ridge, North Pond, IODP CORK observatories U1382A, U1383C
Spatial Extent: **N**:22.8127 **E**:-46.0528 **S**:22.7559 **W**:-46.0815
Temporal Extent: 2017-10-11 - 2017-10-15

Dataset Description

Results from fluids sampled in 2012 and 2014 are published in Table 1 of Shah Walter et al., 2018. Revised results for DOC isotopic values were subsequently released by NOSAMS radiocarbon facility and publisshed in an addendum: Shah Walter et al., 2022. Results from fluids sampled in 2017 were published in Table 1 of Trembath-Reichert et al., 2021 and Shah Walter et al., in prep.

Methods & Sampling

Samples were taken during cruise R/V Atlantis AT39-01. ROV Jason II dives 1024 – 1035, IODP CORK observatories U1382A,

U1383C

Detailed methodology for sample collection, shipboard procedures and sample storage conditions provided in BCO-DMO dataset “Carbon Geochemistry Samples List” (see related datasets)

Briefly, DIC samples for isotopic analysis were transferred from sampling bags through Masterflex Bio-Pharm silicone tubing pre-cleaned with 10% HCl to 100 mL Wheaton wide-mouth reagent bottles with ground-glass stoppers such that turbulence during fluid transfer was minimized. Samples were preserved according to NOSAMS DIC sampling protocol: http://www.whoi.edu/fileserver.do?id=75006&pt=2&p=75096 and stored at room temperature in the dark. DIC samples were submitted to the NOSAMS AMS facility for analysis (https://www2.whoi.edu/site/nosams/). DIC was extracted from fluid samples by acidification and water stripping. d13C values are measured on CO2 splits by IRMS and reported with a conservative uncertainty of 0.1‰, higher than each individual measurement. D14C values are measured by AMS and uncertainty is reported for each individual measurement. All isotopic measurements and error estimations were made according to standard NOSAMS protocols.

For fluids sampled in 2012, DIC concentration is measured as CO2 yield after acidification and water stripping reported with an uncertainty of 5%. For fluids sampled in 2014, DIC concentrations are calculated from pH and alkalinity concentrations reported by Wheat et al. (2020) using Matlab package CO2SYS (https://github.com/jonathansharp/CO2-System-Extd). Propagated uncertainty for calculated DIC concentrations is 1%. For fluids sampled in 2017, DIC was measured on an AS-C3 analyzer (Apollo Scitech, Newark, DE, USA). After acidification with phosphoric acid, the evolved CO2 was extracted and carried by pure N2 gas to an infrared CO2 detector (Li-Cor 6262). Total alkalinity was measured by Gran titration with an open-cell titration system (AS-ALK-2, Apollo SciTech, Newark, DE, USA). Alkalinity and DIC analyses were calibrated with Certified Reference Materials (A. G. Dickson, Scripps Institution of Oceanography) and measured in duplicate with repeat concentrations within 0.1% and measurement uncertainty of 2 umol/kg for both parameters on each bottle. pH values were calculated from measured alkalinity and DIC concentrations using Matlab package CO2SYS with propagated uncertainty of pH values is ± 0.01.

DOC samples were transferred to 1000-mL amber glass bottles. A parallel set of samples was filtered through pre-combusted GF/F filters to remove particulate matter but these samples yielded more carbon than observed in previous years and it was determined that they were likely to be contaminated. Values reported are from whole, unfiltered fluids which yielded less CO2 than filtered fluids supporting our hypothesis that filtered samples were contaminated. Particles were not observed in the whole fluids during transfer. Frozen DOC samples were submitted to the NOSAMS AMS facility for analysis (https://www2.whoi.edu/site/nosams/). DOC concentrations are measured as CO2 yield after UV-oxidation of samples. d13C values are measured on CO2 splits by IRMS and original values reported with a conservative uncertainty of 0.5‰, higher than each individual measurement. D14C values are measured by AMS and uncertainty is reported for each individual measurement. All measurements and error estimations were made according to standard NOSAMS protocols. NOSAMS revised all previously reported DOC data in 2019 according to new internal estimation and correction for carbon blank in their DOC oxidation procedure. Original and corrected DOC data are both reported in the dataset for samples measured before 2019. For corrected d13C values, individual error estimates are reported as well.

Procedures for 13C and 14C analysis of DIC and DOC as well as concentrations of DOC are described in Shah Walter, S. R., et al. (2018).

Alkalinity and DIC analyses were calibrated with Certified Reference Materials (A. G. Dickson, Scripps Institution of Oceanography)

Data Processing Description

Missing values are from fluids samples not taken in 2012 and 2014.

BCO-DMO processing notes:
* Converted latitude and longitude to decimal degrees

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Data Files

File	
876729_v2_carbonchemistry.csv	(Comma Separated Values (.csv), 2.56 KB) MD5:e042135ecaf8a264218b57171c67d0c5
Primary data file for dataset ID 876729, version 2	

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Related Publications

Shah Walter, S. R., Jaekel, U., Osterholz, H., Fisher, A. T., Huber, J. A., Pearson, A., Dittmar, T., & Girguis, P. R. (2022). Addendum: Microbial decomposition of marine dissolved organic matter in cool oceanic crust. Nature Geoscience, 16(2), 190–191. https://doi.org/10.1038/s41561-022-01107-w
Results

Shah Walter, S. R., Jaekel, U., Osterholz, H., Fisher, A. T., Huber, J. A., Pearson, A., … Girguis, P. R. (2018). Microbial decomposition of marine dissolved organic matter in cool oceanic crust. Nature Geoscience, 11(5), 334–339. doi:10.1038/s41561-018-0109-5
Results

Shah Walter, S.R., Wood, L.J., Yoshimura, K.M., Gonski, S.F., Cai, W.J., Huber, J., Girguis. P.R. Microbial and Abiotic Drivers of Carbon Removal in Cool Hydrothermal Fluids. Geochimica et Cosmochimica, in review.
Results

Trembath-Reichert, E., Shah Walter, S. R., Ortiz, M. A. F., Carter, P. D., Girguis, P. R., & Huber, J. A. (2021). Multiple carbon incorporation strategies support microbial survival in cold subseafloor crustal fluids. Science Advances, 7(18), eabg0153. doi:10.1126/sciadv.abg0153
Results

Wheat, C. G., Becker, K., Villinger, H., Orcutt, B. N., Fournier, T., Hartwell, A., & Paul, C. (2020). Subseafloor Cross-Hole Tracer Experiment Reveals Hydrologic Properties, Heterogeneities, and Reactions in Slow-Spreading Oceanic Crust. Geochemistry, Geophysics, Geosystems, 21(1). doi:10.1029/2019gc008804 https://doi.org/10.1029/2019GC008804
Methods

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Related Datasets

References

Girguis, P., Shah Walter, S. R. (2021) **Inventory of fluid and filter samples collected for carbon composition and isotope analysis from R/V Atlantis cruise AT39-01 at the North Pond CORK Sites U1382A and U1383C during October 2017.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2018-01-12 doi:10.26008/1912/bco-dmo.723493.1 [view at BCO-DMO]
Relationship Description: Dataset describing the specific sampling procedures.

IsRelatedTo

Steward, G. (2019) **CTD data from AT39-01 (North Pond 2017 expedition) from the R/V Atlantis in the central North Atlantic during October 2017.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2019-03-07 doi:10.1575/1912/bco-dmo.757722.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
sampling_year	year of sample collection in format YYYY	unitless
location	description or name of sample location	unitless
latitude	latitude of sample location in degrees decimal minutes	unitless
longitude	longitude of sample location in degrees decimal minutes	unitless
latitude_dd	latitude of sample location in decimal degrees	decimal degrees
longitude_dd	longitude of sample location in decimal degrees	decimal degrees

sample_date	date of sampling in format YYYY-MM-DD	unitless
DIC_conc	concentration of dissolved inorganic carbon (DIC)	mmol/kg (millimolar)
DIC_conc_error	DIC concentration error	mmol/kg (millimolar)
Total_Alk	total alkalinity concentration	mmol/kg (millimolar)
pH	log hydrogen ion concentration	unitless
delta_13C_DIC	Delta 13C (d13C) is the ratio of stable isotopes 13C:12C relative to the PeeDee Belemnite standard	parts per thousand, per mil (‰)
delta_13C_DIC_error	d13C measurement error	parts per thousand, per mil (‰)
delta_14C_DIC	Delta^14C (D14C)/Radiocarbon is the per mil deviation of 14C/12C ratio relative to the standard of 1950 atmospheric 14C concentration, normalized to a d13C of -25 per mil	parts per thousand, per mil (‰)
delta_14C_DIC_error	D14C measurement error	parts per thousand, per mil (‰)
DIC_NOSAMS_accession_number	original NOSAMS sample identifier	unitless
DOC_conc	concentration of dissolved organic carbon (DOC)	umol/kg (micromolar)
delta_13C_DOC_original	delta 13C (d13C) is the ratio of stable isotopes 13C:12C relative to the PeeDee Belemnite standard originally reported by NOSAMS	parts per thousand, per mil (‰)
delta_13C_DOC_original_error	d13C measurement error	parts per thousand, per mil (‰)
Delta_14C_DOC_original	Delta^14C (D14C)/Radiocarbon is the per mil deviation of 14C/12C ratio relative to the standard of 1950 atmospheric 14C concentration, normalized to a d13C of -25 per mil originally reported by NOSAMS	parts per thousand, per mil (‰)
Delta_14C_DOC_original_error	D14C measurement error originally reported by NOSAMS	parts per thousand, per mil (‰)
DOC_NOSAMS_accession_number_original	original NOSAMS sample identifier	unitless
delta_13C_DOC_corrected	delta 13C (d13C) is the ratio of stable isotopes 13C:12C relative to the PeeDee Belemnite standard, corrected value reported by NOSAMS	parts per thousand, per mil (‰)
delta_13C_DOC_corrected_error	d13C measurement error	parts per thousand, per mil (‰)

Delta_14C_DOC_corrected	Delta^14C (D14C)/Radiocarbon is the per mil deviation of 14C/12C ratio relative to the standard of 1950 atmospheric 14C concentration, normalized to a d13C of -25 per mil corrected value reported by NOSAMS	parts per thousand, per mil (‰)
Delta_14C_DOC_corrected_error	D14C measurement error originally reported by NOSAMS	parts per thousand, per mil (‰)
DOC_NOSAMS_accession_number_corrected	NOSAMS sample identifier for corrected values	unitless

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Instruments

Dataset-specific Instrument Name	AS-ALK-2 analyzer
Generic Instrument Name	Apollo SciTech AS-ALK2 total alkalinity titrator
Dataset-specific Description	Total Alkalinity: AS-ALK-2 analyzer (Apollo SciTech, Newark, DE, USA)
Generic Instrument Description	An automated acid-base titrator for use in aquatic carbon dioxide parameter analysis. The titrator provides standardisation and sample analysis, using the Gran titration procedure for alkalinity determination of seawater and brackish waters. It is designed for both shipboard and land based laboratory use. The precision of the instrument is 0.1 percent or higher, and sample volumes may range from 10-25 ml. Titration takes approximately 8 minutes per sample, and the repeatability is within plus or minus 1-2 micromoles per kg.

Dataset-specific Instrument Name	AS-C3 analyzer (Apollo Scitech, Newark, DE, USA)
Generic Instrument Name	Apollo SciTech AS-C3 Dissolved Inorganic Carbon (DIC) analyzer
Dataset-specific Description	DIC concentrations: AS-C3 analyzer (Apollo Scitech, Newark, DE, USA)
Generic Instrument Description	A Dissolved Inorganic Carbon (DIC) analyzer, for use in aquatic carbon dioxide parameter analysis of coastal waters, sediment pore-waters, and time-series incubation samples. The analyzer consists of a solid state infrared CO2 detector, a mass-flow controller, and a digital pump for transferring accurate amounts of reagent and sample. The analyzer uses an electronic cooling system to keep the reactor temperature below 3 degrees Celsius, and a Nafion dry tube to reduce the water vapour and keep the analyzer drift-free and maintenance-free for longer. The analyzer can handle sample volumes from 0.1 - 1.5 milliliters, however the best results are obtained from sample volumes between 0.5 - 1 milliliters. It takes approximately 3 minutes per analysis, and measurement precision is plus or minus 2 micromoles per kilogram or higher for surface seawater. It is designed for both land based and shipboard laboratory use.

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Deployments

AT39-01

Website	https://www.bco-dmo.org/deployment/723337
Platform	R/V Atlantis
Report	http://datadocs.bco-dmo.org/docs/Subseafloor_Microbial_Carbon_Cycling/data_docs/North_Pond_2017_Expedition%20Report_FINAL.pdf
Start Date	2017-10-02
End Date	2017-11-02

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Project Information

Collaborative Research: A multidimensional approach to understanding microbial carbon cycling beneath the seafloor during cool hydrothermal circulation (Subseafloor Microbial Carbon Cycling)

Coverage: The “North Pond” sedimented site in the Mid-Atlantic ridge. This is an IODP study site. The coordinates are 22 ° and 23°N by 44°30 ' to 46°20'W

NSF abstract:

The global ocean comprises Earth’s largest microbiome, with at least half of the ocean’s microbial biomass occurring beneath the ocean floor. In particular, oceanic crust encompasses the largest aquifer on Earth, with a liquid volume equal to approximately 2% of the ocean’s volume. It also harbors a substantial reservoir of microbial life that may influence global-scale biogeochemical cycles. This project investigates this largest actively flowing aquifer system on Earth- the fluids circulating through oceanic crust underlying the oceans and sediments. Despite advancing knowledge about life in the deep ocean, the understanding of microorganisms in the rocky oceanic crust and the fluids flowing through it remains rudimentary. This project is focused on understanding the linkages between microbial activity and the cycling of carbon in the cool, subseafloor biosphere. The balance between organic carbon-consuming and organic carbon-producing metabolisms within the crustal biosphere will be determined using seafloor observatories put in place by the International Ocean Discovery Program (IODP) on the flanks of the Mid-Atlantic Ridge, likely representative of the majority of global hydrothermal fluid circulation. The rates of microbial transformations of carbon will be determined using both geochemical and biological approaches. Results will help establish the extent to which microbially-mediated processes in the subseafloor influence carbon cycling in the ocean. This work will represent the first comprehensive description of carbon cycling in the cold oxic crustal aquifer. Two female postdocs will be supported on the grant, and both high school and community college students will also be involved through collaborations with Cape Cod Community College and Cambridge-Rindge and Latin School. The goal is to promote science, technology, engineering and math literacy among high-school and community college students through hand-on research experiences, peer-to-peer mentoring, and professional development opportunities.

The goal of the project is to answer the question "is the cool crustal subseafloor biosphere net autotrophic or net heterotrophic?" The focus of the effort is at North Pond, an isolated sediment pond located on ridge flank oceanic crust 7-8 million years old on the western side of the Mid-Atlantic Ridge. The two objectives of the project are to:

1. Characterize suspended particles in subseafloor fluids with respect to their inorganic and organic carbon content, and natural ^{14}C and ^{13}C isotopic ratios, to determine microbially-mediated fluxes and processes.

2. Characterize the net influence of particle-associated and free-living microbial communities on subseafloor fluid primary production and remineralization, as well as the taxon-specific contributions to these same processes.

The integration of isotope geochemical and molecular biological approaches represents a significant cross-disciplinary advance in the understanding of the microbial ecology and geochemistry of the subseafloor biosphere in young oceanic crust and their role in maintaining global deep-sea redox balance. Expected outcomes include identifying signatures of autotrophic and heterotrophic metabolism in particle-associated and free-living subseafloor microbial communities as well as quantification of autotrophic and heterotrophic metabolism and associated taxon-abundances to provide insights into the net and specific microbial processes in crustal fluids on carbon fluxes.

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Program Information

Center for Dark Energy Biosphere Investigations (C-DEBI)

Website: http://www.darkenergybiosphere.org

Coverage: Global

The mission of the Center for Dark Energy Biosphere Investigations (C-DEBI) is to explore life beneath the seafloor and make transformative discoveries that advance science, benefit society, and inspire people of all ages and origins.

C-DEBI provides a framework for a large, multi-disciplinary group of scientists to pursue fundamental questions about life deep in the sub-surface environment of Earth. The fundamental science questions of C-DEBI involve exploration and discovery, uncovering the processes that constrain the sub-surface biosphere below the oceans, and implications to the Earth system. What type of life exists in this deep biosphere, how much, and how is it distributed and dispersed? What are the physical-chemical conditions that promote or limit life? What are the important oxidation-reduction processes and are they unique or important to humankind? How does this biosphere influence global energy and material cycles, particularly the carbon cycle? Finally, can we discern how such life evolved in geological settings beneath the ocean floor, and how this might relate to ideas about the origin of life on our planet?

C-DEBI's scientific goals are pursued with a combination of approaches:
(1) coordinate, integrate, support, and extend the research associated with four major programs—Juan de Fuca Ridge flank (JdF), South Pacific Gyre (SPG), North Pond (NP), and Dorado Outcrop (DO)—and other field sites;
(2) make substantial investments of resources to support field, laboratory, analytical, and modeling studies of the deep subseafloor ecosystems;
(3) facilitate and encourage synthesis and thematic understanding of submarine microbiological processes, through funding of scientific and technical activities, coordination and hosting of meetings and workshops, and support of (mostly junior) researchers and graduate students; and
(4) entrain, educate, inspire, and mentor an interdisciplinary community of researchers and educators, with an emphasis on undergraduate and graduate students and early-career scientists.

Note: Katrina Edwards was a former PI of C-DEBI; James Cowen is a former co-PI.

Data Management:
C-DEBI is committed to ensuring all the data generated are publically available and deposited in a data repository for long-term storage as stated in their Data Management Plan (PDF) and in compliance with the NSF Ocean Sciences Sample and Data Policy. The data types and products resulting from C-DEBI-supported research include a wide variety of geophysical, geological, geochemical, and biological information, in addition to education and outreach materials, technical documents, and samples. All data and information generated by C-DEBI-supported research projects are required to be made publically available either following publication of research results or within two (2) years of data generation.

To ensure preservation and dissemination of the diverse data-types generated, C-DEBI researchers are working with BCO-DMO Data Managers make data publicly available online. The partnership with BCO-DMO helps ensure that the C-DEBI data are discoverable and available for reuse. Some C-DEBI data is better served by specialized repositories (NCBI's GenBank for sequence data, for example) and, in those cases, BCO-DMO provides dataset documentation (metadata) that includes links to those external repositories.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635365

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