Porewater and hydrocarbon geochemistry constraining carbon monoxide and hydrogen cycling in subsurface sediments from R/V JOIDES Resolution IODP-385 drilling expedition in the Guaymas Basin between September and November, 2019

Website: https://www.bco-dmo.org/dataset/990848
Data Type: Cruise Results
Version: 1
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Project
» Pathways and regulation of transformation of low molecular weight carbon compounds in subseafloor sediments from the Guaymas Basin (Gulf of California) (Guaymas Basin Sediments)

Contributors	Affiliation	Role
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Abstract

Deep marine sediments are the largest reservoir of methane on Earth. Yet, the metabolic pathways and activity of methanogenesis in deep, hot sediments remain poorly understood. In this study, we quantified methanogenic activity using five different 14C-labeled substrates, and combined these potential rates with geochemical data to identify the dominant methanogenic pathways and their environmental controls in the subsurface sediments of the Guaymas Basin. Samples were collected during IODP Expedition 385 from September to November 2019. This dataset presents porewater and hydrocarbon geochemical measurements from five drilling sites, including methane concentrations, methane to higher alkane (C_1/C_2^+) ratios, sulfate, chloride, sulfide, dissolved inorganic carbon, ammonium, temperature, water depth, and sediment depth.

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Coverage

Location: Guaymas Basin, Gulf of California
Spatial Extent: **N**:27.637 **E**:-111.48 **S**:27.472 **W**:-111.889
Temporal Extent: 2019-09-15 - 2019-11-15

Dataset Description

Study Results

Thermodynamic calculations and C1/C2+ ratios indicated that methane in the relatively cooler, shallower layers, was predominantly of biogenic origin. Radiotracer experiments provided direct evidence for the coexistence of multiple methanogenic pathways, hydrogenotrophic, acetoclastic, and methylotrophic, across the sediment column. Methanogenic activity from multiple methanogenic pathways occurred over a wide temperature range (3°C to 80°C), highlighting the unexpectedly high metabolic versatility of methanogens in deep, thermally heated sediments. High methanogenesis rates were detected in near-surface sediments driven predominantly by methylotrophic methanogenesis, followed by hydrogenotrophic pathways. However, these rates declined sharply with depth, particularly within the 40–60°C interval, indicating a transition from mesophilic to thermophilic microbial communities, due to rising temperatures, reductions in gene expression, and decreasing microbial cell densities. Methylotrophic methanogenesis remained detectable down to 320 meters below the seafloor and was the dominant methane-producing pathway at temperatures up to 60°C. In sediments increasingly influenced by sill intrusions, hydrogenotrophic and acetoclastic methanogenesis became the predominant modes of methane production.

Methanogenic activity rates from multiple substrates at 80°C were comparable to rates in near-surface sediments. This deep, hot activity is attributed to the presence of active microbial biomass and the enhanced reactivity and bioavailability of organic matter in deep, hydrothermally-heated sediments, which provided abundant substrates for methanogenesis. These findings expand the current understanding of methanogenesis in the deep biosphere and reveal the discovery of the contemporaneous activity of multiple methanogenic pathways in deep, hydrothermally-influenced sediments.

See related datasets for all data referenced in these findings.

Methods & Sampling

Subsurface sediment samples were collected from sites in the Guaymas Basin, Gulf of California during IODP Expedition 385 “*Guaymas Basin Tectonics and Biosphere*” using the research vessel (R/V) JOIDES Resolution from September to November 2019 (Teske et al. 2021). Profiles and dynamics of carbon monoxide and hydrogen cycling were examined at five sites. Site 1545 (27º38.230’N, 111º53.329’W; water depth 1594.2m) and 1546 (27º37.884’N, 111º52.781’W; water depth 1585.6m) were located roughly 52 km and 51 km, respectively, northwest of the axial graben of the northern spreading segment. Both sites are highly sedimented and a 75-meter thick inactive (~thermally equilibrated) basaltic/doleritic/gabbroic sill was present at site 1546 between ~355 to 431 meters below the seafloor (mbsf). Site U1545B is considered a reference site since it was free of sill intrusions and unaffected by active hydrothermal circulation. The geothermal gradient at hole U1545B was 227ºC/km. The geothermal gradient at site U1546 was similar to that measured in hole U1545B, 221ºC/km. The sill present at 1546B was clearly thermally equilibrated. Sites U1547 (27º30.413’N, 111º40.734’W; water depth 1739.9 m) and U1548 (27°30.2540′N, 111°40.8601′W; water depth 1738.9m) were located inside the periphery of an active, sill-associated hydrothermal mound located about 27 km northwest of the axial graben of the northern spreading segment. Temperatures in hole U1547B exceeded 50°C in the upper 50 mbsf. The geothermal gradient at this site was between 511ºC to 960ºC/km. Site U1549 (27°28.3383′N, 111°28.7927′W; water depth 1841.2) was located near a cold seep sustained by a deeply buried, thermally equilibrated sill intrusion at several hundred meters depth. The geothermal gradient at hole U1549B was 194ºC/km. Of the five sites where we examined CO and H_2 dynamics, only site U1547/hole U1547B was impacted by active sill-associated hydrothermal circulation.

Sediment samples were collected using an advanced piston coring system (APC) and a half-length APC (Teske et al. 2021). After retrieval on deck, sediment cores were sectioned in a designated core cutting area. Approximately 0.5 cm of the outer sediment layer was carefully removed to minimize potential contamination. For the analysis of hydrocarbon gases, ~ 5 mL sediment was transferred into 21.5 mL clean, pre-combusted glass vials using a cut-off syringe. The vials were sealed immediately with polytetrafluoroethylene septa and aluminum caps and were incubated for 30 min at 70°C to allow dissolved hydrocarbon gases to equilibrate with the headspace before analysis, as described in Teske et al. (2021). For molecular hydrogen and carbon monoxide analysis, duplicate 3 mL sediment samples were collected immediately after core recovery using a cut-off syringe. The subsample was transferred into a 21.5 mL glass vials and incubated and processed according to the procedures of Lin et al. (2012).

Data describing in situ geochemistry, pressure, and temperature were generated shipboard, as outlined in Teske et al. (2021). Porewater for geochemical analyses was extracted from subsurface sediments using a shipboard squeezing apparatus, following established protocols (Manheim and Sayles 1974, Teske et al. 2021). To prevent contamination, ~0.5 cm of the outer sediment was carefully removed prior to transferring 150–300 cm^3 of uncontaminated interior material into a titanium squeezing vessel. The vessel was placed in a Carver hydraulic press (Manheim and Sayles 1974). The recovered porewater was filtered through a DI-prewashed Whatman No. 1 filter placed in the squeezer cell above a titanium screen. Then the expressed porewater was filtered through a 0.2 µm polyethersulfone membrane. Filtrates were collected in HCl-washed syringes and subsampled into acid-cleaned high-density polyethylene vials for onboard determinations of sulfate and chloride, sulfide and ammonium were fixed (acidification with trace metal grade nitric acid for sulfate, fixation of sulfide as ZnS by adding 50 µL of 100 g L^{-1} zinc acetate per mL of the sulfide subsample, and fixation with phenol solution for ammonium) and samples were stored at 4 °C until analysis.

Hydrocarbon gas analysis was performed by extracting about 5 mL of headspace gas from the 21.5 mL vials using a gas-tight syringe and directly injecting it into an Agilent 7890A gas chromatograph with a flame ionization detector (FID) (Teske et al. 2021). Sulfate and chloride concentrations were measured by ion chromatography using a Metrohm 850 Professional IC system (Murray et al. 2000, Teske et al. 2021b). Ammonium concentrations were determined by a colorimetric method involving phenol diazotization followed by oxidation with bleach (Clorox) to produce a blue color, measured at 640 nm using a Cary Series 100 UV-Vis spectrophotometer (Agilent Technologies) (Solorzano 1969, Teske et al. 2021). Samples were diluted beforehand to keep ammonium below 1000 µM. Total alkalinity was measured by Gran titration with a Metrohm 794 Basic Titrino autotitrator (Gieskes et al. 1991, Teske et al. 2021). The molar fraction of H_2 in headspace gas was quantified using a Reduction Gas Analyzer (Peak Performer 1, Peak Laboratories LLC, USA). Geochemical data - except hydrogen and carbon monoxide - were retrieved from the IODP database (https://web.iodp.tamu.edu/OVERVIEW/) (Teske et al. 2021).

Sulfide concentrations were determined using standard methods (Cline 1969, Grasshoff et al. 1999). Samples were not diluted if concentrations were between 1 and 60 µM. Samples were diluted by 10X with N2-purged distilled water for concentrations up to 600 µM. The absorbance at 670 nm was determined using a Cary Series 100 UV-Vis spectrophotometer (Agilent Technologies). For most samples, sulfide concentrations were greater than 600 µM. High sulfide concentration was determined using a triiodide (I^{3-}) solution (Grasshoff et al. 1999) that forms a yellow color. Sulfide reacts with triiodide to form I^- and S, lowering the absorbance at 400 nm. A reagent grade sodium sulfide solution was used to generate standards of known concentration for both methods.

The net amount of SO_4^{2-} consumption (SRnet) and the stoichiometry between DIC and SO_4^{2-} was calculated from porewater profiles (Weston et al. 2006). The total sediment inventory was determined by integrating profiles by depth using trapezoidal approximation (correcting for porosity). Overlying water concentrations of DIC and SO_4^{2-} were assumed as 2 mmol L^{-1} and 28 mmol L^{-1}, respectively. The total inventory per cm^2 of sediment area was calculated to the depth of SO42- depletion as:

$$SR_{net} = [(Cl^-) / R_{SW}] - (SO_4^{2-})$$

where SR_{net} is the SO_4^{2-} depletion of the inventory in µmol cm^{-2}, (Cl^-) and (SO_4^{2-}) are the measured (Cl-) and (SO42-) inventory in µmol cm^{-2}, respectively, and R_{SW} is the molar ratio of (Cl^-) and (SO_4^{2-}) in surface seawater (R_{SW} = 19.33; Pilson 2012).

The carbon to SRnet (C:SO_4^{2-}) stoichiometries of organic matter mineralization in these sediments was estimated by dividing DIC by SRnet:

$$R = (DIC_{INV} / SR_{net})(D_{DIC} / D_{SO42-})$$

The ratio was corrected for the appropriate diffusion coefficient ratio ($D_{DIC} / D_{SO4^{2-}}$) (Boudreau 1997).

The molar fraction of H_2 and CO in headspace gas was quantified using a Reduction Gas Analyzer (Peak Performer 1, Peak Laboratories LLC, USA).

The instrument was calibrated using a primary standard of 10ppm H_2 and CO balanced in N_2. We generated a 5-point calibration curve (0, 1, 2.5, 5, 10 ppm) by diluting the 10 ppmv H_2 and CO with N_2 gas (99.999%) in a gas-tight syringe.

We calculated concentrations of hydrogen and carbon monoxide in the interstitial water using the approach of Lin et al. (2012), as described below. The molar concentration of H_2 gas ($[H_2]g$) or CO gas ([CO]g) in nmol L^{-1} in each sample was calculated using the molar fraction of H_2 or CO in the headspace gas (Xgas in ppm measured with the Reduction Gas Analyzer), P, the pressure in the headspace (1 atm), R, the universal gas constant in (L × atm)/(mol×K), and T, the temperature in kelvin, using the following equation:

$$[H_2]g = XH_2 \times P \times R^{-1} \times T^{-1}$$

$$[CO]g = XCO \times P \times R^{-1} \times T^{-1}$$

At equilibrium, the corresponding concentration of dissolved H_2 ($[H_2]aq$) and CO ($[CO]aq$) in the liquid phase is:

$$[H_2]aq = \beta H_2 \times [H_2]g$$

$$[CO]aq = \beta CO \times [CO]g$$

where β is an experimentally determined solubility constant corrected for temperature and salinity.

The concentration of dissolved H_2 and CO in the interstitial water (IW) ($[H_2]IW$ or $[CO]IW$) was expressed in nmol L^{-1} and was determined via mass balance:

$$[H_2]IW = ([H_2]g \times Vg + [H_2]aq \times Vaq) \times Vsed^{-1} \times \varphi^{-1}$$

$$[CO]IW = ([CO]g \times Vg + [CO]aq \times Vaq) \times Vsed^{-1} \times \varphi^{-1}$$

where Vaq is the volume of the aqueous phase (L), Vsed is the volume of sediment samples (L), and φ represents sediment porosity.

To determine the limit of detection, eleven blanks were prepared by filling deionized water (18 MΩ) into 21.5 mL vials with no headspace and no sediment added. These vials were then measured identically to samples to determine the background H_2 and CO concentrations. The average concentration of the blanks was estimated at 4.3 ± 0.5 nmol L^{-1} for H_2, and at 9.3 ± 4.6 nmol L^{-1} for CO. These average concentrations are equivalent to 58.5 ± 6.5 pmol and 125.7 ± 62.3 pmol of H_2 and CO, respectively. We normalized the background H_2/CO to the average IW volume of the samples as follows: sediment volume of 3 mL × the average porosity of 0.7 = 2.1 mL. Using these normalizations, we corrected the H_2 and CO blanks to 27.9 ± 3.1 nmol L^{-1} and 59.9 ± 29.7 nmol L^{-1} and calculated the detection limit of our method. The limit of detection (LOD) (blank mean + 3× SD) was 37.2 nmol L^{-1} for H_2 and 148.9 nmol L^{-1} for CO.

BCO-DMO Processing Description

- Imported "OCE-2023575_CO-H2_geochemistry.csv" into BCO-DMO system
- Created new field "methane_flag" and moved all "b.d.l." and "<0.01" values to this new flag field and removed them from the "methane" field
- Created new field "methane_higher_alkane_ratio_bdl_flag" and moved all "b.d.l." values to this new flag field and removed them from the "methane/ higher alkanes" field
- Renamed fields to comply with BCO-DMO naming conventions, removing units, special characters, and spaces
- Exported file as "990848_v1_co_h2_guaymas_basin.csv"

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Related Publications

Cline, J. D. (1969). Spectrophotometric Determination of Hydrogen Sulfide in Natural Waters. Limnology and Oceanography, 14(3), 454–458. doi:10.4319/lo.1969.14.3.0454
Methods

Gieskes, J., Gamo, T., & Brumsack, H. (1991). Chemical Methods for Interstitial Water Analysis aboard JOIDES Resolution. Ocean Drilling Program Technical Notes. https://doi.org/10.2973/odp.tn.15.1991
Methods

Grasshoff, K., Kremling, K., & Ehrhardt, M. (Eds.). (1999). Methods of Seawater Analysis. doi:10.1002/9783527613984
Methods

Lin, Y.-S., Heuer, V. B., Goldhammer, T., Kellermann, M. Y., Zabel, M., & Hinrichs, K.-U. (2012). Towards constraining H2 concentration in subseafloor sediment: A proposal for combined analysis by two distinct approaches. Geochimica et Cosmochimica Acta, 77, 186–201. https://doi.org/10.1016/j.gca.2011.11.008
Methods

Manheim, F.T., and Sayles, F.L., 1974. Composition and origin of interstitial waters of marine sediments, based on deep sea drill cores. In Goldberg, E.D. (Ed.), The Sea (Vol. 5): Marine Chemistry: The Sedimentary Cycle: New York (Wiley), 527–568. https://pubs.usgs.gov/publication/70207491
Methods

Murray, R. W., Miller, D. J., & Kryc, K. A. (2000). Analysis of Major and Trace Elements in Rocks, Sediments, and Interstitial Waters by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES). Ocean Drilling Program Technical Notes. https://doi.org/10.2973/odp.tn.29.2000
Methods

Pilson, M. E. Q. (2012). An Introduction to the Chemistry of the Sea. https://doi.org/10.1017/cbo9781139047203 https://doi.org/10.1017/CBO9781139047203
Methods

Solórzano, L. (1969). Determination of ammonia in natural waters by the phenolhypochlorite method 1 1.This research was fully supported by U.S. Atomic Energy Commission Contract No. ATS (11-1) GEN 10, P.A. 20. Limnology and Oceanography, 14(5), 799–801. doi:10.4319/lo.1969.14.5.0799
Methods

Teske, A., Lizarralde, D., Höfig, T. W., Aiello, I. W., Ash, J. L., Bojanova, D. P., Buatier, M. D., Edgcomb, V. P., Galerne, C. Y., Gontharet, S., Heuer, V. B., Jiang, S., Kars, M. A. C., Khogenkumar Singh, S., Kim, J., Koornneef, L. M. T., Marsaglia, K. M., Meyer, N. R., Morono, Y., … Zhuang, G. (2021). Expedition 385 methods. Guaymas Basin Tectonics and Biosphere. Internet Archive. https://doi.org/10.14379/iodp.proc.385.102.2021
Methods

Torres, M. E., & Kim, J. (2022). Data report: concentration and carbon isotopic composition in pore fluids from IODP Expedition 385. Guaymas Basin Tectonics and Biosphere. Internet Archive. https://doi.org/10.14379/iodp.proc.385.201.2022
Methods

Weston, N. B., Porubsky, W. P., Samarkin, V. A., Erickson, M., Macavoy, S. E., & Joye, S. B. (2006). Porewater Stoichiometry of Terminal Metabolic Products, Sulfate, and Dissolved Organic Carbon and Nitrogen in Estuarine Intertidal Creek-bank Sediments. Biogeochemistry, 77(3), 375–408. doi:10.1007/s10533-005-1640-1
Methods

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Parameters

Parameter	Description	Units
Site	Drilling site identifier	unitless
Hole	Hole Designation Letter, where "B" represents the second hole drilled at the site location	unitless
Latitude	Sampling latitude	decimal degrees
Longitude	Sampling longitude	decimal degrees
Water_Depth	Water column depth	m
Sediment_Depth	Depth below the seafloor in meters	mbsf
Temperature	Temperature	degrees Celsius
methane	Methane concentration in interstitial water	mM
methane_flag	Flag field where "b.d.l." = below detection limit and "<0.01" is a concentration below .01 mM	unitless
methane_higher_alkane_ratio	Molar ratio of methane (C_1) concentration to the summed concentrations of higher alkanes (C_2^+; ethane and heavier hydrocarbons) in interstitial water gas	molar ratio (C_1/C_2^+)
methane_higher_alkane_ratio_bdl_flag	Flag field where "b.d.l." = below detection limit	unitless
chloride	Chloride concentration in interstitial water	mM
sulfate	Sulfate concentration in interstitial water	mM
sulfide	Hydrogen sulfide concentration in interstitial water	µmolar
dissolved_inorganic_carbon	Dissolved inorganic carbon concentration in interstitial water	mM
ammonium	Ammonium concentration in interstitial water	mM

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Instruments

Dataset-specific Instrument Name	Advanced piston coring system (APC)
Generic Instrument Name	Advanced Piston Corer
Dataset-specific Description	Sediment samples were collected using an advanced piston coring system (APC) and a half-length APC (Teske et al. 2021).
Generic Instrument Description	The JOIDES Resolution's Advanced Piston Corer (APC) is used in soft ooze and sediments. The APC is a hydraulically actuated piston corer designed to recover relatively undisturbed samples from very soft to firm sediments. More information is available from IODP (PDF).

Dataset-specific Instrument Name	Peak Laboratories LLC (USA) Peak Performer 1 Reduction Gas Analyzer
Generic Instrument Name	Gas Analyzer
Dataset-specific Description	The molar fraction of H2 in headspace gas was quantified using a Reduction Gas Analyzer (Peak Performer 1, Peak Laboratories LLC, USA).
Generic Instrument Description	Gas Analyzers - Instruments for determining the qualitative and quantitative composition of gas mixtures.

Dataset-specific Instrument Name	Agilent 7890A gas chromatograph with a flame ionization detector (FID)
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	Hydrocarbon gas analysis was performed by extracting about 5 mL of headspace gas from the 21.5 mL vials using a gas-tight syringe and directly injecting it into an Agilent 7890A gas chromatograph with a flame ionization detector (FID) (Teske et al. 2021).
Generic Instrument Description	Instrument separating gases, volatile substances, or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay. (from SeaDataNet, BODC)

Dataset-specific Instrument Name	Metrohm 850 Professional IC system
Generic Instrument Name	Ion Chromatograph
Dataset-specific Description	Sulfate and chloride concentrations were measured by ion chromatography using a Metrohm 850 Professional IC system (Murray et al. 2000, Teske et al. 2021b).
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	Cary Series 100 UV-Vis spectrophotometer (Agilent Technologies)
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	Ammonium concentrations were determined by a colorimetric method involving phenol diazotization followed by oxidation with bleach (Clorox) to produce a blue color, measured at 640 nm using a Cary Series 100 UV-Vis spectrophotometer (Agilent Technologies) (Solorzano 1969, Teske et al. 2021).
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

Dataset-specific Instrument Name	Metrohm 794 Basic Titrino autotitrator
Generic Instrument Name	Titrator
Dataset-specific Description	Total alkalinity was measured by Gran titration with a Metrohm 794 Basic Titrino autotitrator (Gieskes et al. 1991, Teske et al. 2021).
Generic Instrument Description	Titrators are instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

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Deployments

IODP-385

Website	https://www.bco-dmo.org/deployment/869491
Platform	R/V JOIDES Resolution
Start Date	2019-09-16
End Date	2019-11-16
Description	Guaymas Basin Tectonics and Biosphere - International Ocean Discovery Program Expedition 385, General information: https://iodp.tamu.edu/scienceops/expeditions/guaymas_basin_tectonics_bio...

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Project Information

Pathways and regulation of transformation of low molecular weight carbon compounds in subseafloor sediments from the Guaymas Basin (Gulf of California) (Guaymas Basin Sediments)

Coverage: Guaymas Basin (Gulf of California)

NSF Award Abstract:
This research will explore carbon cycling in one of the largest carbon reservoirs on Earth, marine sediments, located at bottom of the ocean. This carbon is recycled gradually over time through interacting geological, chemical, and biological processes. This project will document how each of these processes transforms carbon in marine sediments from the Guaymas Basin (Gulf of California). This setting offers the chance to study

carbon cycling across a broad range of chemical and temperature gradients, providing an opportunity to tease apart the factors regulating carbon cycling in marine sediments. This project will investigate the role of ocean sediments in the global carbon cycle. These research objectives represent key science priorities in a time of global environmental change. For outreach activities, the scientist, in collaboration with Jim Toomey Education, would continue the "Adventures of Zack and Molly" educational video series. In this instance, the video would document results from this study and its broader significance. The scientist also would create a learning guide for teachers. Both the video and the learning guide would be disseminated to educators. One graduate and one undergraduate student would be supported and trained as part of this project.

Subsurface sediments in the Guaymas Basin (Gulf of California) offer an accessible window for investigating carbon cycling in a dynamic, yet tractable, marine environment. This work will study how heating of subsurface sediments affects the production, consumption, and fate of low molecular weight dissolved organic carbon. The research will track the fate of key carbon species – including formate, acetate, and methanol – as they are processed through a gauntlet of microbial-mediated processes. Samples were collected during Expedition 385 of the International Ocean Discovery Program in September-October 2019. Some experiments were conducted on the research vessel and additional experiments will be conducted in the laboratory. The study will constrain the magnitudes of transformation and the fate of low molecular weight carbon substrates using a combination of direct rate, pool size, and stable isotopic measurements coupled to thermodynamic modeling and probative laboratory experiments. Key topics for investigation include: (1) What is the dominant production mode for organic compounds in subsurface sediments? (2) What are the dominant pathways of methanogenesis along geochemical and temperature gradients? (3) What are the temperature limits of microbially-driven carbon cycling processes? (4) How does the fate of organic compounds change along geochemical and/or temperature gradients?

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-2023575

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