Porewater geochemistry, including methane, CO2, sulfate, and sulfide from Guaymas Basin hydrothermal sediments collected on R/V Atlantis cruise AT15-56 in Nov-Dec 2009

Website: https://www.bco-dmo.org/dataset/886536
Data Type: Cruise Results
Version: 1
Version Date: 2023-02-24

Project
» Microbial carbon and sulfur cycling in the hydrothermally altered sediments of Guaymas Basin (Guaymas Basin Vents)

Contributors	Affiliation	Role
Teske, Andreas	University of North Carolina at Chapel Hill (UNC-Chapel Hill)	Principal Investigator
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Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Porewater geochemistry of Guaymas Basin hydrothermal sediments (Southern Spreading segment, 27°00.44'N and 111°24.55'W, 2000 m water depth) including methane, CO2, sulfate, and sulfide, were measured during R/V Atlantis cruise AT15-56 to Guaymas Basin in 2009. Sampling was conducted on Alvin dives 4562 to 4573. The association of bacterial and archaea communities with hydrothermal seepage and the habitat preferences of various types of microbes were investigated by geochemical and microbiological characterization of hydrothermally active sediments in combination with temperature measurements down to 40 centimeters (cm) sediment depth. This dataset includes sulfide, sulfate, dissolved inorganic carbon (DIC), delta 13C-DIC, methane, delta 13C-methane, and VFAs. Corresponding temperature gradients of hydrothermal sediments for Alvin dives during AT15-56 are available at https://www.bco-dmo.org/dataset/3676

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Coverage

Spatial Extent: **Lat**:27.007333 **Lon**:-111.4091667
Temporal Extent: 2009-11-23 - 2009-12-04

Methods & Sampling

Geochemical Analyses:
Sulfate concentration measurements were completed shipboard; after centrifuging sediment-filled 15-milliliter (ml) tubes, the overlying porewater was filtered through 0.45-micrometer (um) filters, acidified with 50 microliters (ul) of 50% HCl and bubbled with nitrogen for 4 minutes to remove sulfide. Sulfate concentrations were then measured shipboard using a 2010i Dionex Ion Chromatograph (Sunnyvale, CA, USA) through Ag exchange columns (Dionex) so as to remove Cl (Martens et al., 1999). For sulfide, 1 ml porewater samples were combined with 0.1 molar (M) zinc acetate and concentrations were analyzed spectrophotometrically on the ship (Cline, 1969).

Headspace methane concentrations were determined onboard by standard gas chromatography with a flame ionization detector (FID), specifically using a HACH Carle Series 100 AGC Gas Chromatograph (GC) with an Alltech Molecular Sieve 5A packed column (80/100 mesh, 3.05 meters (m) length, 3.2 millimeter internal diameter (mm ID)) and an 80 degree Celsius (C) isothermal temperature profile. Stable isotopic compositions of the same methane samples were measured post-cruise at the University of North Carolina (UNC) via gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) on a Finnigan MAT 252 Isotope Ratio Mass Spectrometer, using an HP 5890 Series II Gas Chromatograph with an HP Plot Q column (30 m length, 0.32 mm ID, 20 um film thickness) and a 30 degree C isothermal temperature profile.

To measure DIC, 2 ml of unamended porewater from each sediment horizon were injected into evacuated serum vials (30 ml) and stored upside down at -20 degrees C. At UNC, the samples were thawed, and DIC was reacted to gaseous CO2 by adding 1 ml of a 30% phosphoric acid solution to each serum vial and shaking vigorously before GC analysis (Kelley et al., 1990). Stable isotopic values and concentrations of DIC were analyzed via coupled GC (Hewlett Packard 5890) and Isotope Ratio Mass Spectrometer (Finnigan MAT

252).

Porewater concentrations of dissolved organic acids were measured via High-Pressure Liquid Chromatography (HPLC) after the cruise, using a Beckman Model 332 gradient liquid chromatograph combined with an ISCO V4 UV/VIS detector and a Shimadzu CR3-A integrator (Albert and Martens, 1997).

Data Processing Description

BCO-DMO Processing Notes:
- combined the following original files/sheets into one dataset:
-- sheet named "Annotated clean data" of file named "guaymas methane 2009.xls"
-- sheet named "Clean Data" of file named "Guaymas DIC 2009.xls"
-- sulfate and sulfide data in file named "Sulfate_sulfide_temperatures 2009.xlsx" (re-organized from separate sheets into one table)
- renamed fields to comply with BCO-DMO naming conventions.

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Related Publications

Albert, D. B., & Martens, C. S. (1997). Determination of low-molecular-weight organic acid concentrations in seawater and pore-water samples via HPLC. Marine Chemistry, 56(1–2), 27–37. https://doi.org/10.1016/s0304-4203(96)00083-7 https://doi.org/10.1016/S0304-4203(96)00083-7
Methods

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

Kelley, C. A., Martens, C. S., & Chanton, J. P. (1990). Variations in sedimentary carbon remineralization rates in the White Oak River estuary, North Carolina. Limnology and Oceanography, 35(2), 372–383. doi:10.4319/lo.1990.35.2.0372
Methods

Martens, C. S. (1999). Stable isotope tracing of anaerobic methane oxidation in the gassy sediments of Eckernfoerde Bay, German Baltic Sea. American Journal of Science, 299(7-9), 589–610. doi:10.2475/ajs.299.7-9.589
Methods

McKay, L. J., MacGregor, B. J., Biddle, J. F., Albert, D. B., Mendlovitz, H. P., Hoer, D. R., … Teske, A. P. (2012). Spatial heterogeneity and underlying geochemistry of phylogenetically diverse orange and white Beggiatoa mats in Guaymas Basin hydrothermal sediments. Deep Sea Research Part I: Oceanographic Research Papers, 67, 21–31. doi:10.1016/j.dsr.2012.04.011
Results

McKay, L., Klokman, V. W., Mendlovitz, H. P., LaRowe, D. E., Hoer, D. R., Albert, D., Amend, J. P., & Teske, A. (2016). Thermal and geochemical influences on microbial biogeography in the hydrothermal sediments of Guaymas Basin, Gulf of California. Environmental Microbiology Reports, 8(1), 150–161. Portico. https://doi.org/10.1111/1758-2229.12365
Results

Su, L., Teske, A. P., MacGregor, B. J., McKay, L. J., Mendlovitz, H., Albert, D., Ma, Z., & Li, J. (2023). Thermal Selection of Microbial Communities and Preservation of Microbial Function in Guaymas Basin Hydrothermal Sediments. Applied and Environmental Microbiology, 89(3). https://doi.org/10.1128/aem.00018-23
Results

Teske, A., de Beer, D., McKay, L. J., Tivey, M. K., Biddle, J. F., Hoer, D., Lloyd, K.G., Lever, M.A., Roy, H., Mendlovitz, H., & MacGregor, B. J. (2016). The Guaymas Basin Hiking Guide to Hydrothermal Mounds, Chimneys, and Microbial Mats: Complex Seafloor Expressions of Subsurface Hydrothermal Circulation. Frontiers in Microbiology, 7. doi:10.3389/fmicb.2016.00075
Results

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Parameters

Parameter	Description	Units
Date	Date of sample collection/dive	unitless
Alvin_Dive_Number	Alvin dive number	unitless
Core_Number	Core number	unitless
Dive_Core	Identifier composed of dive number and core number	unitless
Core_Depth_Range	Depth range within the core	centimeters (cm)
Mid_Depth	Mid-depth within the core	centimeters (cm)
Peak_Area	Peak area	?
Calculated_SO4_Concentration	Calculated porewater SO4-2 concentration	millimolar (mM)
Sulfide	Sulfide porewater concentration	millimolar (mM)
CH4_mM	Methane porewater concentration	millimolar (mM)
d13C_CH4	delta 13C of methane values	per mil?
DIC_mM	Dissolved inorganic carbon (DIC) porewater concnetration	millimolar (mM)
d13C_DIC	delta 13C of DIC values	per mil?
Notes_DIC	Notes on DIC measurements	unitless

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Instruments

Dataset-specific Instrument Name	centrifuge
Generic Instrument Name	Centrifuge
Generic Instrument Description	A machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g., cream from milk) or liquids from solids.

Dataset-specific Instrument Name	flame ionization detector (FID)
Generic Instrument Name	Flame Ionization Detector
Dataset-specific Description	Headspace methane concentrations were determined onboard by standard gas chromatography with a flame ionization detector (FID).
Generic Instrument Description	A flame ionization detector (FID) is a scientific instrument that measures the concentration of organic species in a gas stream. It is frequently used as a detector in gas chromatography. Standalone FIDs can also be used in applications such as landfill gas monitoring, fugitive emissions monitoring and internal combustion engine emissions measurement in stationary or portable instruments.

Dataset-specific Instrument Name	HACH Carle Series 100 AGC Gas Chromatograph
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	Headspace methane concentrations were determined onboard by standard gas chromatography with a flame ionization detector (FID).
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	HP 5890 Series II Gas Chromatograph
Generic Instrument Name	Hewlett Packard 5890 Series II gas chromatograph
Dataset-specific Description	Stable isotopic compositions of the methane samples were measured via gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) on a Finnigan MAT 252 Isotope Ratio Mass Spectrometer, using a HP 5890 Series II Gas Chromatograph with a HP Plot Q column (30 m length, 0.32 mm ID, 20 um film thickness) and a 30 degree C isothermal temperature profile. Stable isotopic values and concentrations of DIC were analyzed via coupled GC (Hewlett Packard 5890) and Isotope Ratio Mass Spectrometer (Finnigan MAT 252).
Generic Instrument Description	A gas chromatograph that separates and analyses compounds that do not degrade or decompose in the gas phase. The sample is dissolved in a solvent and vaporised in the instrument. A chemically inert gas, (e.g. helium or nitrogen) carries the vaporised analyte through a stationary phase which is coated inside the capillary column that is maintained at an elevated temperature. The analyte mixture separates on the stationary phase leading to chromatographic separation of the molecules. The HP 5890 Series II is completely customisable depending on the application, with choices of inlets, columns, detectors, sampling systems, flow and pressure control components. Optional detectors include Flame Ionization Detector (FID), Nitrogen-Phosphorus Detector (NPD), Electron Capture Detector (ECD), Thermal Conductivity Detector (TCD), Photoionisation Detector (PID), Flame Photometric Detector (FPD) and mass spectrometer. The instrument was originally manufactured by Hewlett Packard (HP), but part of this business was sold to Agilent Technologies in 1999. This model is no longer in production.

Dataset-specific Instrument Name	Beckman Model 332 gradient liquid chromatograph
Generic Instrument Name	High-Performance Liquid Chromatograph
Dataset-specific Description	Porewater concentrations of dissolved organic acids were measured via High-Pressure Liquid Chromatography (HPLC) after the cruise, using a Beckman Model 332 gradient liquid chromatograph combined with an ISCO V4 UV/VIS detector and a Shimadzu CR3-A integrator.
Generic Instrument Description	A High-performance liquid chromatograph (HPLC) is a type of liquid chromatography used to separate compounds that are dissolved in solution. HPLC instruments consist of a reservoir of the mobile phase, a pump, an injector, a separation column, and a detector. Compounds are separated by high pressure pumping of the sample mixture onto a column packed with microspheres coated with the stationary phase. The different components in the mixture pass through the column at different rates due to differences in their partitioning behavior between the mobile liquid phase and the stationary phase.

Dataset-specific Instrument Name	Alvin dives 4562-4574
Generic Instrument Name	HOV Alvin
Generic Instrument Description	Human Occupied Vehicle (HOV) Alvin is part of the National Deep Submergence Facility (NDSF). Alvin enables in-situ data collection and observation by two scientists to depths reaching 6,500 meters, during dives lasting up to ten hours. Commissioned in 1964 as one of the world's first deep-ocean submersibles, Alvin has remained state-of-the-art as a result of numerous overhauls and upgrades made over its lifetime. The most recent upgrades, begun in 2011 and completed in 2021, saw the installation of a new, larger personnel sphere with a more ergonomic interior; improved visibility and overlapping fields of view; longer bottoms times; new lighting and high-definition imaging systems; improved sensors, data acquisition and download speed. It also doubled the science basket payload, and improved the command-and-control system allowing greater speed, range and maneuverability. With seven reversible thrusters, it can hover in the water, maneuver over rugged topography, or rest on the sea floor. It can collect data throughout the water column, produce a variety of maps and perform photographic surveys. Alvin also has two robotic arms that can manipulate instruments, obtain samples, and its basket can be reconfigured daily based on the needs of the upcoming dive. Alvin's depth rating of 6,500m gives researchers in-person access to 99% of the ocean floor. Alvin is a proven and reliable platform capable of diving for up to 30 days in a row before requiring a single scheduled maintenance day. Recent collaborations with autonomous vehicles such as Sentry have proven extremely beneficial, allowing PIs to visit promising sites to collect samples and data in person within hours of their being discovered, and UNOLs driven technological advances have improved the ability for scientific outreach and collaboration via telepresence Alvin is named for Allyn Vine, a WHOI engineer and geophysicist who helped pioneer deep submergence research and technology. (from https://www.whoi.edu/what-we-do/explore/underwater-vehicles/hov-alvin/, accessed 2022-09-09)

Dataset-specific Instrument Name	2010i Dionex Ion Chromatograph
Generic Instrument Name	Ion Chromatograph
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	Finnigan MAT 252 Isotope Ratio Mass Spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Stable isotopic compositions of the methane samples were measured via gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) on a Finnigan MAT 252 Isotope Ratio Mass Spectrometer, using a HP 5890 Series II Gas Chromatograph with a HP Plot Q column (30 m length, 0.32 mm ID, 20 um film thickness) and a 30 degree C isothermal temperature profile. Stable isotopic values and concentrations of DIC were analyzed via coupled GC (Hewlett Packard 5890) and Isotope Ratio Mass Spectrometer (Finnigan MAT 252).
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).

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Deployments

AT15-56

Website	https://www.bco-dmo.org/deployment/58832
Platform	R/V Atlantis
Report	http://www.marine.whoi.edu/at_synop.nsf/9452cb38d8d28f30852568cd004b8077/13f181c7f933dbac052574e4006399a9?OpenDocument
Start Date	2009-11-22
End Date	2009-12-06
Description	R/V Atlantis cruise in Guaymas Basin where 12 Alvin dives were made. Cruise information and original data are available from the NSF R2R data catalog.

AT15-56_Alvin_Dives

Website	https://www.bco-dmo.org/deployment/58838
Platform	Alvin
Start Date	2009-11-23
End Date	2009-12-05
Description	The Alvin dives of cruise AT15-56 (dive numbers 4562 through 4574) are listed below, with dive targets and shipfix position. Dive 4562 November 23, Monday Pilot: Sean Kelley Portside Observer: Andreas Teske Starboard Observer: Kai Hinrichs Dive target: Marker 14 Position: 27°00.47 N, 111°24.431 W Dive 4563 November 24, Tuesday Pilot: Bob Waters Portside Observer: Jennifer Biddle Starboard Observer: Marc Mussmann Dive target: Marker 14 Position: 27°00.47 N, 111°24.43 W Dive 4564 November 25, Wednesday Pilot: Bruce Strickrott Portside Observer: Dirk DeBeer Starboard Observer: Howard Mendlovitz Dive target: Marker 14 Position: 27°00.47 N, 111°24.43 W Dive 4565 November 26, Thursday Pilot: Dave Walter Portside Observer: Andreas Teske Starboard Observer: Dan Albert Dive target: Cathedral Hill Position: 27°00.696 N, 111°24.265 W Dive 4566 November 27, Friday Pilot: Sean Kelley Portside Observer: John MaDonald Starboard Observer: Hans Røy Dive target: Marker 14 Position: 27°00.47 N, 111°24.431 W Dive 4567 November 28, Saturday Pilot: Mark Spear Portside Observer: Luke McKay Starboard Observer: Javier Caraveo Dive target: Cold sediment Dive 4568 November 29, Sunday Pilot: Bob Waters Portside Observer: Barbara MacGregor Starboard Observer: Gunter Wegener Dive target: Marker 6 Position: 27°00.419 N, 111°24.888 W Dive 4569 November 30, Monday Pilot: Bruce Strickrott Portside Observer: Howard Mendlovitz Starboard Observer: Dan Hoer Dive target: Marker 14 Position: 27°00.47 N, 111°24.431 W Dive 4570 December 1, Tuesday Pilot: David Walter Portside Observer: Dirk deBeer Starboard Observer: Kaspar Kjeldsen Dive target: Marker 14 Position: 27°00.47 N, 111°24.431 W Dive 4571 December 2, Wednesday Pilot: Mark Spear Portside Observer: Meg Tivey Starboard Observer: Kristen Myers Dive target: Busted Mushroom Position: 27°00.63 N, 111°24.41 W Dive 4572 December 3, Thursday Pilot: David Walter Portside Observer: Jeff McDonald Starboard Observer: Kai Ziervogel Dive target: Marker 27 Position: 27°00.445 N, 111°24.529 W Dive 4573 December 4, Friday Pilot: Sean Kelly Portside Observer: Thomas Holler Starboard Observer: Yu-Shih Lin Dive target: Cathedral Hill, Marker 24 Position: 27°00.696 N, 111°24.265 W Dive 4574 December 5, Saturday Pilot: Bruce Strickrott Portside Observer: Mark A. Lever Starboard Observer: Nancy Cabanillas Dive target: Big Pagoda Position: 27°00.901 N, 111°24.635 W

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Project Information

Microbial carbon and sulfur cycling in the hydrothermally altered sediments of Guaymas Basin (Guaymas Basin Vents)

Website: https://sites.google.com/site/teskelab/Home/guaymas-basin

Coverage: Guaymas Basin hydrothermal vents, Southern Spreading segment, 27° 00.44N and 111° 24.55W; 2000 m water depth

While microbial communities in marine sediments are generally sustained by sedimentation of organic matter from the water column, the Guaymas Basin hydrothermal sediments provide a model system for the microbial utilization and transformation of thermally released microbial substrates from deeply buried marine organic matter. Thermal generation of subsurface organic carbon compounds is usually restricted to deeply buried subsurface sediments, where it sustains deep subsurface microbiota. However, in the Guaymas Basin, the thermally generated organic substrates of subsurface origin fuel a complex microbial ecosystem in surficial sediments that can be sampled by submersible. As a working hypothesis, the physiologically distinct, layered microbial communities force the geothermally produced substrates through a double “microbial gauntlet” of anaerobic metabolism and autotrophic carbon fixation, where terminal anaerobic degradation of organic matter is performed by methanogenic and methane-oxidizing archaea, by sulfate-reducing bacteria and archaea, and (to be tested) by novel subsurface archaeal populations within the upper sediments, while inorganic and organic remineralization products are assimilated by sulfur-oxidizing *Beggiatoa* mats at the sediment surface. We aim at a quantitative understanding of how the dense and highly active benthic microbial populations of the Guaymas system utilize and recycle organic and inorganic carbon and sulfur of subsurface origin, how geochemical controls affect the community structure, and how uncultured, globally occurring subsurface archaea and bacteria thrive in their sediment habitat. More generally, microbial utilization and recycling of deeply buried, fossil carbon and sulfur in benthic sediments and the sedimentary subsurface is a “seldom seen“ but essential part of these microbially driven processes in the marine biosphere. To analyze the complex interplay of thermogenic and biogenic carbon sources and sinks, and the role of uncultured microbial populations in these processes, geochemical and molecular-biological approaches are integrated and combined. The microbial community composition and activity patterns will be analyzed quantitatively (rRNA membrane slot blot hybridization; single-strand rRNA conformation polymorphism) and with qualitative diversity surveys (PCR, cloning and sequencing). Carbon assimilation patterns in specific functional and phylogenetic groups of prokaryotes will be analyzed using carbon-isotopic analysis of ribosomal RNA, intact polar lipids, and whole microbial cells (using FISH-SIMS). Carbon substrate profiles and microbial process rates (sulfate reduction, methanogenesis, methane oxidation) across hydrothermally active sediment sites and down-core will correlate microbial populations and substrate utilization. Stable carbon isotopic analysis of key microbial substrates will further constrain the microbial utilization patterns of isotopically distinct carbon pools in specific sediment layers.

To summarize, in situ and lab results indicate that newly discovered, phylogenetically distinct populations of Anaerobic Methane-oxidizing archaea (ANMEs) in Guaymas Basin, and their presumed syntrophic bacterial partners, are capable of methane oxidation at high temperatures, at least up to 70-75°C. Isotopically light carbon (indicative of a methane-derived contribution) permeates into sedimentary microbial populations and microbial mats in hydrothermally active areas, as shown by 13C analysis of extracted bacterial and archaeal rRNA. Manipulative incubations with Guaymas sediments suggest a mode of anaerobic methane oxidation which appears to operate uncoupled to sulfate reduction, and requires near in situ methane concentration. Rigorous testing is required for validation of the process and identification of the organisms responsible. High-temperature tolerant and sulfate-uncoupled anaerobic methane oxidation require re-evaluation of the classical controls of this process, temperature and sulfate availability.

By installing autonomous temperature loggers in Guaymas sediments covered with *Beggiatoa* spp. mats, we have obtained continuous temperature profiles, from the sediment surface to 40 cm depth, over up to 11 days. In contrast to previous one-time temperature measurements that provided only a static snapshot, these data revealed substantial temperature fluctuations in the upper cm layers underlying orange *Beggiatoa* mats, indicative of fluctuations in hydrothermal flux and/or advective in-mixing of seawater. Such temperature regimes would select for eurythermal bacteria and archaea that tolerate a broad mesophilic/thermophilic temperature range, or for microbial communities that consist of members with different temperature optima, that co-occur or overlap in the same sediment layer but vary in activity depending on temperature and associated geochemical conditions.

Anaerobic microbial processes in sediments (sulfate reduction, remineralization of biomass, anaerobic methane oxidation) produce DIC and sulfide that, in turn, sustain the *Beggiatoa* mats, assuming autotrophic capability. To examine this link between sediment processes and surface mats, we quantified temperature gradients, porewater concentration gradients (sulfide, sulfate, methane, DIC, volatile organic acids), and 13C-isotopic signatures of methane and DIC underneath orange and white *Beggiatoa* mats (differentiated by 16S rRNA sequencing), and the bare sediment. The steepest temperature and porewater concentration gradients (sulfide and DIC) are mostly found under orange *Beggiatoa* mats that occur in the center of *Beggiatoa* patches. Temperature and geochemical gradients are attenuated under white *Beggiatoa mats*, which surround the orange mats in a sunny-side up pattern, and flatten out or disappear in the surrounding mat-free sediment

We are annotating the genome of an orange *Beggiatoa* spp. from Guaymas Basin [taxonomically revised as *Maribeggiatoa*], recovered from a single filament after whole genome amplification. Sequencing was completed at JCVI, supported by the Gordon and Betty Moore Foundation. The single-filament genome is not completely assembled, but is of approximately the expected total length and includes a full complement of ribosomal protein, tRNA, and tRNA synthetase genes. So far, the genome content is broadly consistent with a nitrate-reducing, facultatively autotrophic sulfur-oxidizing bacterium.

Publications associated with this project are as follows:
Note: this is now a list of all publications that use samples collected from the NSF-funded Guaymas cruises AT15-40 and AT15-56. All these publications were funded from NSF award OCE-0647633, the grant that funded these two cruises. Those publications that were written and published after 2013 continue to use samples collected and analyzed on cruises AT15-40 and AT15-56 under NSF award OCE-0647633, but the effort in analyzing the data and writing the manuscript also relied on funding by OCE-1357238. Since we will not have new samples until late in 2016, current work and publications on OCE-1357238 will continue to rely on samples collected during cruises AT15-40 and AT15-56.

Holler, T. F. Widdel, K. Knittel, R. Amann, M. Y. Kellermann, K.-. Hinrichs, A. Teske, A. Boetius, and G. Wegener. 2011. Thermophilic anaerobic oxidation of methane by marine microbial consortia. The ISME Journal 5:1946-1956. doi:10.1038/ismej.2011.77

Biddle, J.F., Z. Cardman, H. Mendlovitz, D.B. Albert, K.G. Lloyd, A. Boetius, and A. Teske. 2012. Anaerobic oxidation of methane at different temperature regimes in Guaymas Basin hydrothermal sediments. The ISME Journal 6:1018-1031. doi:10.1038/ismej.2011.164

McKay, L.J., B.J. MacGregor, J.F. Biddle, H.P. Mendlovitz, D. Hoer, J.S. Lipp, K.G. Lloyd, and A.P. Teske. 2012. Spatial heterogeneity and underlying geochemistry of phylogenetically diverse orange and white *Beggiatoa* mats in Guaymas Basin hydrothermal sediments. Deep-Sea Research I, 67:21-31. doi:10.1016/j.dsr.2012.04.011

Bowles, M.W., L.M. Nigro, A.P. Teske, and S.B. Joye.. 2012. Denitrification and environmental factors influencing nitrate removal in Guaymas Basin hydrothermally-altered sediments. Frontiers in Microbiology 3:377. doi:10.3389/fmicb.2012.03377

MacGregor, B.J., J.F. Biddle, J.R. Siebert, E. Staunton, E. Hegg, A.G. Matthysse, and A. Teske. 2013. Why orange Guaymas Basin *Beggiatoa* spp. are orange: Single-filament genome-enabled identification of an abundant octaheme cytochrome with hydroxylamine oxidase, hydrazine oxidase and nitrite reductase activities. Applied and Environmental Microbiology 79:1183-1190. doi:10.1128/AEM.02538-12

MacGregor, B.J., J.F. Biddle, and A. Teske. 2013. Mobile elements in a single-filament orange Guaymas Basin *Beggiatoa* ("Candidatus Maribeggiatoa") sp. draft genome; evidence for genetic exchange with cyanobacteria. Applied and Environmental Microbiology 79:3974-3985. doi:10.1128/AEM.03821-12

Meyer, S., G. Wegener, K.G. Lloyd, A. Teske, A. Boetius, and A. Ramette. 2013. Microbial habitat connectivity across spatial scales and hydrothermal temperature gradients at Guaymas Basin. Frontiers in Microbiology 4:207. doi:10.3389/fmic.2013.00207

MacGregor, B.J., J.F. Biddle, C. Harbort, A.G. Matthysse, and A. Teske. 2013. Sulfide oxidation, nitrate respiration, carbon acquisition and electron transport pathways suggested by the draft genome of a single orange Guaymas Basin *Beggiatoa* (*Cand.* Maribeggiatoa) sp. filament. Marine Genomics 11:53-65. doi:10.1016/j.margen.2013.08.001

Ruff, E., J.F. Biddle, A. Teske, K. Knittel, A. Boetius, and A. Ramette. 2015. Global dispersion and local diversification of the methane seep microbiome. Proc. Natl. Acad. Sci. USA, 112:4015-4020. doi:10.1073/pnas.1421865112

McKay, L., V. Klokman, H. Mendlovitz, D. LaRowe, M. Zabel, D. Hoer, D. Albert, D. de Beer, J. Amend, A. Teske. Thermal and geochemical influences on microbial biogeography in the hydrothermal sediments of Guaymas Basin. Environmental Microbiology, in revision.

Dowell, F., Z. Cardman, S. Dasarathy, M.Y. Kellermann, L.J. McKay, B.J. MacGregor, S.E. Ruff, J.F. Biddle, K.G. Lloyd, J.S. Lipp, K-U. Hinrichs, D.B. Albert, H. Mendlovitz, and A. Teske. Microbial communities in methane and short alkane-rich hydrothermal sediments of Guaymas Basin. Frontiers in Microbiology, In Revision.

Conference abstracts (post 2013, only NSF-OCE 1357238):
B.J. MacGregor. 2014. Receiver (REC) domains in the orange Guaymas "Maribeggiatoa" (BOGUAY) draft genome: an evolutionary network of sensor networks. The Human and Environmental Microbiome Symposium 2014. Duke Center for the Genomics of Microbial Systems, Durham, NC.

B.J. MacGregot. 2015. Abundant intergenic repeats and a possible alternate RNA polymerase betra subunit in the orange Guaymas "Maribeggiatoa" genome. American Society for Microbiology 2015 General Meeting. New Orleans, LA.

Z. Cardman, L.J. McKay, E. Dowell, S. Dasarathy, V. Klokman, J.F. Biddle, K.G. Lloyd, H. Mendlovitz, D. Albert, M. Kellermann, K.-U.

Hinrichs, B.J. MacGregir and A.P. Teske. 2014. American Society for Microbiology 2014 General Meeting. Boston, MA.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0647633

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