Microbial power production per cell in Quaternary-age sediment quantified from bio-energetic modeling of subseafloor parameters on a 0.25°×0.25° resolution global grid

Website: https://www.bco-dmo.org/dataset/828871
Data Type: model results
Version: 1
Version Date: 2020-11-13

Project
» Develop a 1D biogeochemical-evolutionary model for deep sediments (BIO-SED)

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

Contributors	Affiliation	Role
Bradley, James	Queen Mary University of London	Principal Investigator
LaRowe, Doug	University of Southern California (USC)	Co-Principal Investigator
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Microbial power production per cell in Quaternary-age sediment at 10cm beneath the seafloor, at the layer of sediment deposited at the beginning of the Holocene (11,700 years ago), and the layer of sediment deposited at the beginning of the Pleistocene (2.59 million years ago). These data are part of a project that used bio-energetic modeling to quantify a number of subseafloor parameters on a 0.25°×0.25° resolution global grid. These data were published in Bradley et al. (2020).

Table of Contents

Coverage

Spatial Extent: **N**:90 **E**:180 **S**:-90 **W**:-180

Dataset Description

Additional funding to the Center for Dark Energy Biosphere Investigations [C-DEBI] award OCE-0939564:

Deep Carbon Observatory (the Deep Life Modelling and Visualization (DLMV) and Deep Energy programs); NASA Astrobiology Institute–Life Underground (NAI-LU, NNA13AA92A); the NASA Astrobiology Program under the Joint NASA-NSF Ideas Lab on the “Origins of Life” (NSF Solicitation 16-570); the Alexander von Humboldt Foundation; NERC (NE/T010967/1); European Union Horizon 2020 under the Marie Skłodowska-Curie grant agreement no. 643052 (C-CASCADES); USC Zumberge Fund Individual Grant Program.

Methods & Sampling

This project used bio-energetic modeling to quantify a number of subseafloor parameters on a 0.25°×0.25° resolution global grid. We calculate, in three dimensions, for all Quaternary-age sediment (i.e. global sediment deposited in the last 2.59 million years):
• The global distribution and rate of particulate organic carbon (POC) degradation.
• The global distribution of cells, using data from Kallmeyer et al, 2012. (DOI: 10.1073/pnas.1203849109).
• The global distribution of electron acceptors, using data from D'Hondt et al, 2015 (DOI: 10.1038/ngeo2387) and Egger et al, 2018 (DOI: 10.1038/s41561-018-0122-8)
• The thermodynamic properties of POC degradation.
• The cell-specific power (i.e. energy per unit time) per individual microbial cell.

Data are provided on a 721×1441 grid, where each cell represents 0.25°×0.25°. Grid cell (1,1) corresponds to (-90.00,-180.00). Separate grids are provided for sediment at 10cm beneath the seafloor, at the layer of sediment deposited at the beginning of the Holocene (11,700 years ago), and the layer of sediment deposited at the beginning of the Pleistocene (2.59 million years ago).

Data Processing Description

Data were processed using Matlab (R_2017a). Data are provided on a 721×1441 grid, where each cell represents 0.25°×0.25°. Grid cell (1,1) corresponds to (-90.00,-180.00).

BCO-DMO data manager processing notes:
* Zipped together the three power cell .mat files to serve in this dataset.
* Also exported the matrices as csv files using Matlab's writematrix() function.

[table of contents | back to top]

Data Files

File
power per cell z10, zpleisto, and zholo (Matlab .mat format) filename: power_per_cell_z10-zholo-zpleisto_mat.zip (ZIP Archive (ZIP), 12.94 MB) MD5:f2762478740e02a07d62c584046fc70d Zip file containing gridded data in matrices within three Matlab *.mat files. Name: power_per_cell_z10.mat Description: Microbial power production per cell in sediment 10cm beneath the seafloor. Units: log10 watts per cell Missing data identifier: NaN Name: power_per_cell_zholo.mat Description: Microbial power production per cell in sediment deposited at the beginning of the Holocene (11,700 years ago). Units: log10 watts per cell Missing data identifier: NaN Name: power_per_cell_zpleisto.mat Description: Microbial power production per cell in sediment deposited at the beginning of the Pleistocene (2.59 million years ago). Units: log10 watts per cell Missing data identifier: NaN

[table of contents | back to top]

Related Publications

Bradley, J. A., Arndt, S., Amend, J. P., Burwicz, E., Dale, A. W., Egger, M., & LaRowe, D. E. (2020). Widespread energy limitation to life in global subseafloor sediments. Science Advances, 6(32), eaba0697. doi:10.1126/sciadv.aba0697
Results

D'Hondt, S., Inagaki, F., Zarikian, C. A., Abrams, L. J., Dubois, N., Engelhardt, T., … Ziebis, W. (2015). Presence of oxygen and aerobic communities from sea floor to basement in deep-sea sediments. Nature Geoscience, 8(4), 299–304. doi:10.1038/ngeo2387
Methods

Egger, M., Riedinger, N., Mogollón, J. M., & Jørgensen, B. B. (2018). Global diffusive fluxes of methane in marine sediments. Nature Geoscience, 11(6), 421–425. doi:10.1038/s41561-018-0122-8
Methods

Kallmeyer, J., Pockalny, R., Adhikari, R. R., Smith, D. C., & D'Hondt, S. (2012). Global distribution of microbial abundance and biomass in subseafloor sediment. Proceedings of the National Academy of Sciences, 109(40), 16213–16216. doi:10.1073/pnas.1203849109
Methods

MathWorks (2017), MATLAB version R2017a (9.2) Documentation, The Mathworks, Inc. Retrieved November 13, 2020 from https://www.mathworks.com/help/releases/R2017a/index.html
Software

[table of contents | back to top]

Related Datasets

References

Bradley, J., LaRowe, D. (2020) **Cell-specific power utilization (power per cell) in methanogenic, oxic, and sulfate-reducing sediments quantified from bio-energetic modeling of subseafloor parameters on a 0.25°×0.25° resolution global grid.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-11-13 http://lod.bco-dmo.org/id/dataset/828884 [view at BCO-DMO]
Relationship Description: Other data from the same project gridded at the same resolution.

Bradley, J., LaRowe, D. (2020) **Major catabolic pathway of organic carbon oxidation in Quaternary-age sediment quantified from bio-energetic modeling of subseafloor parameters on a 0.25°×0.25° resolution global grid.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-11-13 http://lod.bco-dmo.org/id/dataset/828821 [view at BCO-DMO]
Relationship Description: Other data from the same project gridded at the same resolution and sediment depths.

Bradley, J., LaRowe, D. (2020) **Power produced by microbial POC degradation in Quaternary-age sediment quantified from bio-energetic modeling of subseafloor parameters on a 0.25°×0.25° resolution global grid.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-11-13 http://lod.bco-dmo.org/id/dataset/828861 [view at BCO-DMO]
Relationship Description: Other data from the same project gridded at the same resolution and sediment depths.

IsReferencedBy

Bradley, J., LaRowe, D. (2020) **POC concentration at the sediment water interface quantified from bio-energetic modeling on a 0.25°×0.25° resolution global grid.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-11-13 http://lod.bco-dmo.org/id/dataset/828893 [view at BCO-DMO]
Relationship Description: Other data from the same project gridded at the same resolution.

[table of contents | back to top]

Parameters

Parameters for this dataset have not yet been identified

[table of contents | back to top]

Project Information

Develop a 1D biogeochemical-evolutionary model for deep sediments (BIO-SED)

Website: https://www.darkenergybiosphere.org/award/develop-a-1d-biogeochemical-evolutionary-model-for-deep-sediments/

Microorganisms buried in marine sediments endure prolonged energy-limitation over geological timescales. This C-DEBI project will investigate energy and activity levels among microbial communities in the marine subsurface. We use thermodynamic and microbial-biogeochemical modelling principles to explore and quantify:
- The energy sources to deeply buried microorganisms and their demand for energy.
- The activity of microorganisms and the factors that determine physiological transitions between active and dormant states.
- The varying energy requirements of active and dormant microbes and the allocation of energy between maintenance and growth.
- The cell-specific energy utilization (i.e. power) of subsurface life on a global scale.

[table of contents | back to top]

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0939564

[table of contents | back to top]