Description and isotopic composition of the carbonate deposits in the Santa Elena Ophiolite (Costa Rica) and expeditions 149, 173, and 209 on R/V JOIDES Resolution in the Iberia Abyssal Plain, Iberian Margin, and Mid-Atlantic Ridge from 1993-2003

Website: https://www.bco-dmo.org/dataset/663937
Data Type: Cruise Results
Version: 03 November 2016
Version Date: 2016-11-03

Project
» Identifying the controls on biological activity in serpentinites (Controls on biological activity)

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

Contributors	Affiliation	Role
Schwarzenbach, Esther	Freie Universität Berlin	Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

- Dataset Description
  - Methods & Sampling
  - Data Processing Description
- Data Files
- Parameters
- Instruments
- Deployments
- Project Information
- Program Information
- Funding

Dataset Description

Description and isotopic composition of the carbonate deposits in the Santa Elena Ophiolite (Costa Rica).

Related publications:
Schwarzenbach EM, Gill BC, Gazel E, Madrigal P (2016) Sulfur and carbon geochemistry of the Santa Elena peridotites: Comparing oceanic and continental processes during peridotite alteration. Lithos 252–253:92-108. doi:10.1016/j.lithos.2016.02.017

Methods & Sampling

Santa Elena samples:
Sample preparation and mineralogy: Ultramafic basement rocks were sampled throughout the Santa Elena Ophiolite. Carbonate deposits associated with Mg-HCO_3 and Ca-OH springs in the eastern part of the ophiolite were sampled at various locations within riverbeds. All analytical measurements and sample preparation of the Santa Elena peridotites and carbonates were performed at the Department of Geosciences at Virginia Tech. The carbonate samples were prepared by drilling out individual depositional layers of carbonates to reveal heterogeneities within different layers or crushed with an agate mortar for bulk rock analysis. Carbonate precipitates from the rivers were first dried at 40 degrees C in the oven. Before sample analyses all samples were homogenized by hand with the agate mortar. The mineralogy of the carbonates was then determined by X-ray diffraction on a Rigaku MiniFlex XRD using the powder diffraction analysis package PDXL.

Bulk rock powders were prepared for all the ultramafic rocks. To remove contamination from weathering, the outermost 1-2 cm of the rock samples were cut away. The samples were then cleaned in an ultrasonic bath prior to powdering them with a shatter box using an alumina dish. These bulk rock powders were subsequently analyzed for their carbon and sulfur geochemistry.

Carbon geochemistry:
Carbon in these systems is typically detected as inorganic (e.g. carbonate carbon) or organic carbon. Organic carbon has also been referred to as reduced carbon or non-carbonate carbon. Here we refer to it as total organic carbon (TOC) even though the presence of traces of graphite and other reduced carbon species cannot entirely be excluded. Total carbon (TC) and total inorganic carbon (TIC) contents, $d^{13}C$ of TC, $d^{13}C$ of TOC and $d^{13}C$ and $d^{18}O$ of TIC were analyzed on the basement rocks, while only $d^{13}C$ and $d^{18}O$ of TIC were determined for the carbonate deposits and precipitates.

TC contents, $d^{13}C_{TC}$ and $d^{13}C_{TOC}$ were determined on a Vario ISOTOPE elemental analyzer (EA) coupled to an Isoprime 100 isotope ratio mass spectrometer (IRMS). For analyses of $d^{13}C_{TOC}$, bulk rock samples were reacted for three days with 3N HCl to remove all acid soluble carbon. They were then rinsed with H_2O, dried at 40 degrees C in the oven and homogenized in the agate mortar. TC and TOC isotope values are reported in the standard delta notation relative to the Vienna-Pee Dee Belemnite (V-PDB) standard and calibrated to this scale using international [IAEA-CH-6 (sucrose; $d^{13}C$ = -10.449‰) and IAEA-CH-7 (polyethylene; $d^{13}C$ = -32.151‰)] and commercial standards [Elemental Microanalysis wheat flour; $d^{13}C$ = -27.21‰]. TOC was calculated from the difference between TC and TIC and errors are within 10% of the TOC contents. %TIC was calculated as TIC/TC*100. Reproducibility of $d^{13}C_{TC}$ and $d^{13}C_{TOC}$ is better than 0.1‰.

The $d^{13}C_{TIC}$ and $d^{18}O_{TIC}$ and TIC contents were analyzed on a MultiFlowGeo headspace sampler attached to an Isoprime 100 IRMS. Samples were prepared in septum vials, flushed with helium and acidified with phosphoric acid. Samples were then reacted for at least 3 hours at room temperature if no magnesite was present (as determined by XRD analysis). Magnesite-bearing samples were reacted for 72 hours at 90 degrees C. Carbon and oxygen isotope values are reported in the standard delta-notation relative to the Vienna-Pee Dee Belemnite (V-PDB) standard and calibrated to this scale using the international standards IAEA-CO-1 (marble; $d^{13}C$ = +2.492‰, $d^{18}O$ = -2.4‰), IAEA-CO-9 ($BaCO_3$; $d^{13}C$ = -47.321‰, $d^{18}O$ = -15.6‰) and NBS18 (calcite, $d^{13}C$ = -5.014‰, $d^{18}O$ = -23.2‰). Reproducibility for the analysis of the samples was better than +/- 0.07‰ for $d^{13}C$ and better than +/- 0.3‰ for $d^{18}O$. Reproducibility of TIC contents is typically better than 5%.

Data Processing Description

Detection limits:
Carbon contents: approximately100 ppm

BCO-DMO Processing:
- modified parameter names to conform with BCO-DMO naming conventions;
- repalced blanks (missing data) with "nd".

[table of contents | back to top]

Data Files

File
table2.csv (Comma Separated Values (.csv), 3.02 KB) MD5:e6d226c86d212db85f5af047a8ba792a Primary data file for dataset ID 663937

[table of contents | back to top]

Parameters

Parameter	Description	Units
sample_name	Sample name	unitless
lat	Latitude; positive values = North	decimal degrees
lon	Longitude; positive values = East	decimal degrees
description	Sample description	unitless
sample_powder	Sample powder	unitless
cc	Mineral model percentages estimated from XRD spectra: XX: greater than or equal to 50%, X: 20-50%, O: 5-20%, T: < 5%	unitless
mgs	Mineral model percentages estimated from XRD spectra: XX: greater than or equal to 50%, X: 20-50%, O: 5-20%, T: < 5%	unitless
arg	Mineral model percentages estimated from XRD spectra: XX: greater than or equal to 50%, X: 20-50%, O: 5-20%, T: < 5%	unitless
qz	Mineral model percentages estimated from XRD spectra: XX: greater than or equal to 50%, X: 20-50%, O: 5-20%, T: < 5%	unitless
srp	Mineral model percentages estimated from XRD spectra: XX: greater than or equal to 50%, X: 20-50%, O: 5-20%, T: < 5%	unitless
del13C	Delta 13C	per mille
del18O	Delta 18O	per mille
temp	Equilibration tempertures between fluid and magnesite; calculated after Aharon, 1988	degrees Celsius

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Vario ISOTOPE elemental analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	TC contents, d13CTC and d13CTOC were determined on a Vario ISOTOPE elemental analyzer (EA) coupled to an Isoprime 100 isotope ratio mass spectrometer (IRMS).
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	Isoprime 100
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	TC contents, d13CTC and d13CTOC were determined on a Vario ISOTOPE elemental analyzer (EA) coupled to an Isoprime 100 isotope ratio mass spectrometer (IRMS). The d13CTIC and d18OTIC and TIC contents were analyzed on a MultiFlowGeo headspace sampler attached to an Isoprime 100 IRMS.
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	Rigaku MiniFlex XRD
Generic Instrument Name	X-ray diffractometer
Dataset-specific Description	The mineralogy of the carbonates was then determined by X-ray diffraction on a Rigaku MiniFlex XRD using the powder diffraction analysis package PDXL.
Generic Instrument Description	Instruments that identify crystalline solids by measuring the characteristic spaces between layers of atoms or molecules in a crystal.

[table of contents | back to top]

Deployments

JRES-149

Website	https://www.bco-dmo.org/deployment/663681
Platform	R/V JOIDES Resolution
Report	http://dmoserv3.whoi.edu/data_docs/C-DEBI/cruise_reports/149PREL.PDF
Start Date	1993-03-10
End Date	1993-05-25

JRES-173

Website	https://www.bco-dmo.org/deployment/663682
Platform	R/V JOIDES Resolution
Report	http://dmoserv3.whoi.edu/data_docs/C-DEBI/cruise_reports/173prel.PDF
Start Date	1997-04-15
End Date	1997-06-15

JRES-209

Website	https://www.bco-dmo.org/deployment/663685
Platform	R/V JOIDES Resolution
Report	http://dmoserv3.whoi.edu/data_docs/C-DEBI/cruise_reports/209PREL.PDF
Start Date	2003-05-06
End Date	2003-07-03

[table of contents | back to top]

Project Information

Identifying the controls on biological activity in serpentinites (Controls on biological activity)

Coverage: Costa Rica; Mid-Atlantic Ridge; Iberian Margin

Project description from C-DEBI:
Serpentinization – the hydrothermal alteration of ultramafic rocks – is a unique mineralogical process that results in H2 and CH4 – rich fluids that can support microbial communities. Using a combination of petrographic observations, bulk rock and *in-situ* sulfur isotope signatures of variably serpentinized peridotites from four different geotectonic environments we provide new constraints on the factors that support microbial activity. The studied samples overall suggest that redox conditions reflected by the presence of pyrite and pyrrhotite represent the fluid chemistry that favors microbial activity. This fluid chemistry, i.e., the prevailing hydrogen and sulfur fugacities of the fluid, are thereby correlated to high water-rock ratios and increased incorporation of seawater-derived species such as sulfate and carbonate. These species serve as major energy sources of microbial activity. In contrast, highly reducing conditions and limited fluid input limits or even prevents microbial activity within serpentinites due to insufficient availability of these species. Interaction with carbonate and sulfate-bearing meteoric waters is likely an essential process that supports microbial activity in continental serpentinization environments. Overall, this study shows that apart from fluid temperatures being within the limits of life, the fluid chemistry (redox conditions and availability of e.g. carbonate and sulfate) are the primary factors that control the presence or absence of microbial communities within serpentinizing peridotites. This study highlights the importance of combining bulk rock and *in-situ* stable isotope data with petrographic and mineralogical observations in order to better constraint the presence of microbial communities within the subsurface of peridotite-hosted hydrothermal systems.

Note: This project was funded by a C-DEBI Research Grant.

[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]