Radiochemistry data for rocks and deposits from the Lost City Hydrothermal Field at the Atlantis Massif from 2018-2020

Website: https://www.bco-dmo.org/dataset/864460
Data Type: Cruise Results
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Project
» Collaborative Research: Investigating the Lost City as an ultramafic urban center of the subseafloor, fueled by energy and carbon from the mantle (Lost City Limits to Life)

Contributors	Affiliation	Role
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Abstract
Radiochemistry of serpentinite, carbonate-brucite chimney, and other solid samples from the Lost City Hydrothermal Field at the Atlantis Massif from 2018 and four previous expeditions in 2015, 2005, 2003, and 2000 (Kelley et al., 2001; Kelley et al., 2005; Früh-Green et al.,2018).

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Coverage

Spatial Extent: **N**:30.1249298 **E**:-42.08361 **S**:30.083427 **W**:-42.150056
Temporal Extent: 2000-12 - 2018-09

Methods & Sampling

Solid samples were obtained from the 2018 Return to Lost City and four previous expeditions in 2015, 2005, 2003, and 2000 (Kelley et al., 2001; Kelley et al., 2005; Früh-Green et al., 2018). In all years except 2015, chimney and local rock materials were gathered as grab samples by the manipulators of either the ROV or Human Occupied Vehicle (HOV) Alvin and stowed in rock boxes. In 2015, rock samples were recovered with

seabed rock drills as part of International Ocean Discovery Program (IODP) Expedition 357, which drilled a series of shallow boreholes across the Atlantis Massif (Früh-Green et al., 2018). In 2015 and 2018, samples were wrapped in Teflon sheeting and stored at -20°C. In previous years, samples were dried and stored at room temperature.

The solid rock samples were analyzed for uranium (Ur) and thorium (Thr) concentrations by a Thermo Element 2 inductively coupled plasma mass spectrometer (ICP-MS). Approximately 40 mg of sample and approximately 80 mg of an Sm-Nd (145Nd) spike were weighed into a Teflon vial. The samples were digested for four days in a 4 mL dissolution mixture (3:1 concentrated HF: concentrated HNO3) in a closed beaker at 100°C. The digest was dried, 1 mL of concentrated HNO3 added, and the sample dried again. This was repeated three times. The digestion was brought into solution with 2.2 mL of 7N HNO3 and 4.8 mL of water and stored overnight. The contents were transferred to a 50 mL tube and diluted with an additional 33 mL of water. A 1:1 dilution (1 mL of sample and 1 ml of 2% HNO3) was distributed into 4 mL omnivials, and the samples were analyzed by ICP-MS.

Analyses of Ra in the solid samples (Rar) were conducted on seven carbonates, 19 serpentinites, four gabbro. The carbonates were crushed with a mortar and pestle while the other rocks were crushed with an impact mortar. An aliquot of dry, crushed sample (2 – 10 g) was then measured for 227Ac, 226Ra, 228Ra and 228Th via gamma spectrometry.

Data Processing Description

Data Processing:
226Ra, 238U and 232Th activities are reported in dpm kg-1.
226Ra was determined by gamma spectrometry.
238U and 232Th were determined by ICP-MS, except for samples marked *, which were determined by gamma spectrometry.
"bdl" indicates measurements that were below detection.
Expected 1σ errors are <10%.

HYPERMET software (Phillips and Marlow, 1976) was used in data processing.

BCO-DMO Processing:
- Adjusted field/parameter names to comply with BCO-DMO naming conventions;
- Missing data identifier '--' replaced with 'nd' (BCO-DMO's default missing data identifier);
- Added a conventional header with dataset name, PI names, version date;
- Converted dates to format: YYYY-MM-DD.

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Data Files

File	
Lost_City_Solids_Radiochem.csv	(Comma Separated Values (.csv), 2.29 KB) MD5:14a8d6cabe03c6f68fe6bee438bc65fa
Primary data file for dataset ID 864460	

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Related Publications

Früh-Green, G. L., Orcutt, B. N., Rouméjon, S., Lilley, M. D., Morono, Y., Cotterill, C., … Bilenker, L. (2018). Magmatism, serpentinization and life: Insights through drilling the Atlantis Massif (IODP Expedition 357). Lithos, 323, 137–155. doi:10.1016/j.lithos.2018.09.012
Methods

Kelley, D. S., Karson, J. A., Blackman, D. K., Früh-Green, G. L., Butterfield, D. A., … Rivizzigno, P. (2001). An off-axis hydrothermal vent field near the Mid-Atlantic Ridge at 30° N. Nature, 412(6843), 145–149.

doi:10.1038/35084000
Methods

Kelley, D. S., Karson, J. A., Früh-Green, G. L., Yoerger, D. R., Shank, T. M., Butterfield, D. A., … Sylva, S. P. (2005). A Serpentinite-Hosted Ecosystem: The Lost City Hydrothermal Field. Science, 307(5714), 1428–1434. doi:10.1126/science.1102556
Methods

Ludwig, K. A., Shen, C.-C., Kelley, D. S., Cheng, H., & Edwards, R. L. (2011). U–Th systematics and 230Th ages of carbonate chimneys at the Lost City Hydrothermal Field. Geochimica et Cosmochimica Acta, 75(7), 1869–1888. doi:10.1016/j.gca.2011.01.008
Methods

Moore, W. S. (1984). Radium isotope measurements using germanium detectors. Nuclear Instruments and Methods in Physics Research, 223(2-3), 407–411. doi:10.1016/0167-5087(84)90683-5
Methods

Moore, W. S., Frankle, J. D., Benitez-Nelson, C. R., Früh-Green, G. L., & Lang, S. Q. (2021). Activities of 223-Ra and 226-Ra in Fluids From the Lost City Hydrothermal Field Require Short Fluid Residence Times. Journal of Geophysical Research: Oceans, 126(12). Portico. https://doi.org/10.1029/2021jc017886
https://doi.org/10.1029/2021JC017886
Results

Phillips, G. W., & Marlow, K. W. (1976). Automatic analysis of gamma-ray spectra from germanium detectors. Nuclear Instruments and Methods, 137(3), 525–536. doi:10.1016/0029-554x(76)90472-9
https://doi.org/10.1016/0029-554X(76)90472-9
Methods

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Parameters

Parameter	Description	Units
Sample_ID	Expedition-based sample identifier	unitless
Collection_Date	Date sample collected in Format: YYYY-MM-DD UTC	unitless
Depth	Water depth	meters
Latitude	Latitude North	decimal degrees
Longitude	Longitude East (West is negative)	decimal degrees
Rock_Type	Rock type sampled	unitless
U238	measured activity of 238U	decays per minute per kilogram
Ra226	measured activity of 226Ra	decays per minute per kilogram
Th232	measured activity of 232Th	decays per minute per kilogram
Ra226_U238_Activity_Ratio	Activity ratio of 226Radium/238Uranium in rock	unitless

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Instruments

Dataset-specific Instrument Name	Gamma Spectrometer, ORTEC
Generic Instrument Name	Gamma Ray Spectrometer
Generic Instrument Description	Instruments measuring the relative levels of electromagnetic radiation of different wavelengths in the gamma-ray waveband.

Dataset-specific Instrument Name	Thermo Element 2 inductively coupled plasma mass spectrometer (ICP-MS)
Generic Instrument Name	Inductively Coupled Plasma Mass Spectrometer
Generic Instrument Description	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

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Deployments

AT42-01

Website	https://www.bco-dmo.org/deployment/782074
Platform	R/V Atlantis
Report	https://datadocs.bco-dmo.org/docs/Lost_City_Limits_to_Life/data_docs/AT42-01_Cruise%20Report_reduced.pdf
Start Date	2018-09-08
End Date	2018-10-01

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Project Information

Collaborative Research: Investigating the Lost City as an ultramafic urban center of the subseafloor, fueled by energy and carbon from the mantle (Lost City Limits to Life)

Coverage: Lost City Hydrothermal Field

NSF Award Abstract:
The vast majority of deep seafloor sediments are inhabited by microbial communities that survive under extreme energy limitation, with apparent generation times of centuries to millennia. Hydrothermal systems are a stark contrast to these energy-starved environments and may represent important, high-activity, 'population centers' in the oceanic subsurface. When rocks from the Earth's mantle are uplifted and exposed to water, the resulting reactions lead to acidic fluids with high concentrations of hydrogen. Under certain circumstances, small organic molecules such as methane can also form in the absence of biology. These compounds can provide energy to subseafloor microbial communities and, given the ubiquity of mantle rocks, such reactions may fuel a significant proportion of the active subsurface biosphere. The current project will characterize the microbial communities inhabiting an iconic example of this type of system, the Lost City Hydrothermal Field, using a remotely operated vehicle. The ghostly spires of Lost City are highly telegenic and have been featured

in professional documentaries. The high definition underwater video footage collected during the expedition will provide the raw material for an 8 week educational training program in digital media focused on kindergarten through 12th grade high school students and undergraduate students. The resulting short documentaries will be published on YouTube and the Utah Education Network.

Mantle rocks comprise significant portions of the seafloor, and microbial communities hosted within them may be important mediators of carbon and energy exchange between the deep Earth and the surface biosphere. Upon tectonic uplift and exposure to water, the serpentinization of these materials releases potential energy in the form of hydrogen, methane, and heat, and further reaction of these products can sustain the abiogenic synthesis of small organic molecules. Recent studies have highlighted, however, the lack of alkalithermophiles that are capable of survival at the high pH (9-11) and elevated temperatures found in these systems. The almost complete lack of carbon dioxide (CO2) represents a second, and possibly more significant, limitation to growth. To better understand the extent of the serpentinite subsurface, this project will address the question: What limits biological activity in the serpentinite subsurface? Specifically, the proposed work will test the hypotheses: (1) microbial diversity spans a wider range of temperature-pH conditions than currently recognized and (2) the scarcity of CO2 is a key biological limitation to serpentinization-driven ecosystems that can be overcome by the metabolic activity of one or a few foundation species. These hypotheses will be tested during a 20 day (10 days on site) expedition to the Lost City Hydrothermal Field, focusing on fluids as windows to the subsurface biosphere. The sampling approach will capitalize on the differences in temperature, carbon availability, and microbial activity across the field. The analytical approach will integrate multidisciplinary techniques performed on replicate subsamples and feature the application of next-generation sequencing technologies to these marine serpentinizing fluids for the first time. This study will generate extensive sequence data from environmental DNA, environmental mRNA, and single-cell genomes, allowing us to identify the in situ expression of metabolic pathways and the genomics of active single cells. These efforts will be closely linked with a thorough characterization of carbon in these fluids that will focus on identifying available substrates (e.g. methane, CO2, organic acids) and on characterizing biomarkers that reflect specific metabolic pathways (e.g. lipids, amino acids).

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536702
NSF Division of Ocean Sciences (NSF OCE)	OCE-1736321

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