Surface Sedimentary Black Carbon Concentrations, Flux, and Carbon Isotopes Values from the R.V. Endeavor EN651 in the Equatorial Atlantic Ocean from March 2020

Website: https://www.bco-dmo.org/dataset/935435
Data Type: Cruise Results
Version: 1
Version Date: 2024-09-16

Project
» Concentrations and source assessment of black carbon across tropical Atlantic air and sediment (Tropical Atlantic Black Carbon)

Contributors	Affiliation	Role
Lohmann, Rainer	University of Rhode Island (URI)	Co-Principal Investigator
Pockalny, Robert	University of Rhode Island (URI)	Co-Principal Investigator
Pavia, Frank J.	California Institute of Technology (Caltech)	Scientist
Robinson, Rebecca	University of Rhode Island (URI)	Scientist
Katz, Samuel	University of Rhode Island (URI)	Student
Merchant, Lynne M.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Surface sediments (0-1 cm) were obtained from the equatorial Atlantic Ocean and isolated for black carbon using the chemothermal oxidation at 375°C method (CTO 375). Multicores were taken aboard the R.V. Endeavor (EN651) from March 1st through March 15th, 2020, using a multi corer MC-800. Sediment samples were collected from 12 multicore stations along a west-to-east transect of the equatorial Atlantic centered on about 5˚N. Sediment deposition environments included the Amazon Submarine Fan, a series of sites across the Mid-Atlantic Ridge, and sites on the Sierra Leone Rise and adjacent Sierra Leone Basin. See Figure 1 in the EN651 cruise report (Lohmann 2020) for an illustration of coring site locations. Background information taken from the EN651 cruise report (Lohmann 2020): Black carbon (BC) is a highly graphitized incomplete combustion byproduct that could be a sink for fixed carbon, especially when deposited to pelagic sediments (Kuhlbusch 1998). There is a general assumption that rivers deliver most or all BC to the ocean (Coppola et al. 2018; Elmquist et al. 2008; Kuhlbusch 1998; Masiello and Druffel 2001; Mitra et al. 2014, 2002; Suman et al. 1997). Yet the effects and fluxes of BC are not well constrained in general circulation models. For example, few BC flux measurements are available in remote ocean sediments due to the expense and difficulty of obtaining samples. The formation of BC during incomplete combustion results in a fraction of carbon not being available for the biological pump and deep ocean respiration. Once deposited to the ocean, BC is buried in sediments and can account for significant fractions of the organic matter preserved in sediments. Hence, our results would contribute towards accounting for some of the 'missing' terrestrial OC in sediments, as all BC is landmass derived (Hedges et al. 1997).

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Coverage

Location: Transect of the Equatorial Atlantic Ocean at approximately 5˚ N
Spatial Extent: **N**:10.375 **E**:-17.5 **S**:4.9969 **W**:-48.145
Temporal Extent: 2020-03-01 - 2020-03-15

Methods & Sampling

Core collection

MC-800 tubes were labeled (EN651-"Site number"-MC"coring attempt number""letter of core",ex: EN651-01-MC01A) and photographed before sectioning. The water on top of the core was syphoned off and a thin piece of stainless-steel sheet was slid under the foot of the tube. The foot was bent up and the stainless-steel sheet was used to transfer the core to the core extruder. Cores were sectioned at 1 cm intervals down to 10 cm, then 2 cm intervals down to 20 cm, using the piece of stainless-steel and a cake spatula to cut them. The remainder of the core was wrapped in combusted aluminum foil and placed in a zip-lock bag for storage. Sections of cores were stored in amber glass jars placed in a freezer. One core was transferred with the extruder to a PVC tube and capped for archival storage. If 5 or more cores were recovered, 0.5 cm sections would be taken down to 10 cm and the remainder of the core wrapped in foil and zip-lock bagged before being frozen. Due to a limited supply of jars, the 0.5 cm core sections were wrapped in combusted aluminum foil and placed in a ziplock bag before being stored with other samples. All cores and core sections were stored at -20˚C.

Analytical methods

Surface sediment samples (0 – 1 cm) were dried at 60 ˚C until dry and passed through a 420 µm sieve before analysis. Total organic carbon (TOC) samples were weighed into silver capsules (Elemental microanalysis silver capsules ultra-clean pressed 8 x 5 mm, D2030), acidified to remove inorganic carbon (2 M HCl), and folded into tin capsules (Costech tin capsules 10 x 10 mm, 041073). Black carbon was isolated using the CTO 375 method (Gustafsson et al. 1997, 2001). 100 mg of samples where weighed out into ceramic crucibles and spread into a thin layer to prevent charring. Samples were combusted at 375 ˚C for 24 hrs. under the flow of ultra high purity air (0.4 L min^{-1}). The remaining sediment was transferred to GC (gas chromatography) vials for storage, then processed the same as the TOC samples to remove any inorganic carbon present (as detailed above).

Sampling equipment

Sediment cores were collected using an MC-800

Analytical instrumentation

An Elemental Analyzer (Costech 4010 Elemental Analyzer) was used for quantification of the BC and TOC fractions. The same elemental analyzer coupled to an Isotope Ratio Mass Spectrometer (Thermo Delta V Advantage) was used for the sample carbon isotopes. Radiocarbon isotopes were measured at the National Ocean Sciences Accelerator Mass spectrometry.

Sediment cores availability

Sediment cores are stored at the NSF-funded Rock and Core Repository at GSO-URI and access to the samples is available through established protocols. Solid material, in the form of cores are curated and retained after the expedition and are available to other investigators that wish to use them for other means (Lohmann 2020).

Data Processing Description

Data was processed using Microsoft Excel and python (version: 3.9.18) with pandas package (version: 2.2.2)

BCO-DMO Processing Description

Loaded the submitted file "Surface Sedimentary Black Carbon Concentrations and Stable and Radiocarbon Isotopes.xlsx" into BCO-DMO's data processor Laminar for processing.

Renamed parameters following the BCO-DMO convention of replacing spaces with underscores and replacing Greek symbols by their name.

Reformatted the parameter Collection_date into an ISO 8601 format of %Y-%m-%d.

Added the parameter columns ‘Cruise_ID’, ‘Site_ID’, ‘Coring_Attempt’, and 'Core_Letter' with values taken from the 'Name' parameter. Each Name value is of the format --, ex: EN651-01-MC01A.

Saved the dataset table to a CSV file named 935435_v1_surface_sedimentary_black_carbon.csv

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Data Files

File
Equatorial Atlantic Sedimentary Black Carbon filename: 935435_v1_surface_sedimentary_black_carbon.csv (Comma Separated Values (.csv), 1.43 KB) MD5:0eb8890c2c6300ace8a72a6b00208fc8 Primary data file for dataset ID 935435, version 1 Surface sediments from Equatorial Atlantic Ocean. containing surface concentrations, stable carbon isotopes, and radiocarbon isotope values of the total organic carbon and black carbon.

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Related Publications

Coppola, A. I., Wiedemeier, D. B., Galy, V., Haghipour, N., Hanke, U. M., Nascimento, G. S., Usman, M., Blattmann, T. M., Reisser, M., Freymond, C. V., Zhao, M., Voss, B., Wacker, L., Schefuß, E., Peucker-Ehrenbrink, B., Abiven, S., Schmidt, M. W. I., & Eglinton, T. I. (2018). Global-scale evidence for the refractory nature of riverine black carbon. Nature Geoscience, 11(8), 584–588. https://doi.org/10.1038/s41561-018-0159-8
Related Research

Elmquist, M., Semiletov, I., Guo, L., & Gustafsson, Ö. (2008). Pan-Arctic patterns in black carbon sources and fluvial discharges deduced from radiocarbon and PAH source apportionment markers in estuarine surface sediments. Global Biogeochemical Cycles, 22(2). Portico. https://doi.org/10.1029/2007gb002994 https://doi.org/10.1029/2007GB002994
Related Research

Gustafsson, Ö., Bucheli, T. D., Kukulska, Z., Andersson, M., Largeau, C., Rouzaud, J., Reddy, C. M., & Eglinton, T. I. (2001). Evaluation of a protocol for the quantification of black carbon in sediments. Global Biogeochemical Cycles, 15(4), 881–890. Portico. https://doi.org/10.1029/2000gb001380 https://doi.org/10.1029/2000GB001380
Methods

Gustafsson, Ö., Haghseta, F., Chan, C., MacFarlane, J., & Gschwend, P. M. (1996). Quantification of the Dilute Sedimentary Soot Phase: Implications for PAH Speciation and Bioavailability. Environmental Science & Technology, 31(1), 203–209. https://doi.org/10.1021/es960317s
Methods

Hedges, J. I., Keil, R. G., & Benner, R. (1997). What happens to terrestrial organic matter in the ocean? Organic Geochemistry, 27(5–6), 195–212. https://doi.org/10.1016/s0146-6380(97)00066-1 https://doi.org/10.1016/S0146-6380(97)00066-1
Related Research

Kuhlbusch, T. A. J. (1998). Black Carbon and the Carbon Cycle. Science, 280(5371), 1903–1904. https://doi.org/10.1126/science.280.5371.1903

Related Research

Lohmann, R., Pockalny, R. A., and Members of the Scientific Shipboard Party. (2020). Cruise report. R/V Endeavor, Cruise EN651, February 27-March 17, 2020 Bridgetown, Barbados - Praia, Cape Verde. Rolling Deck to Repository (R2R) Program. Rolling Deck to Repository (R2R) Program. https://doi.org/10.7284/908428
Methods

Masiello, C. A., & Druffel, E. R. M. (2001). Carbon isotope geochemistry of the Santa Clara River. Global Biogeochemical Cycles, 15(2), 407–416. Portico. https://doi.org/10.1029/2000gb001290
https://doi.org/10.1029/2000GB001290
Related Research

Mitra, S., Bianchi, T. S., McKee, B. A., & Sutula, M. (2002). Black Carbon from the Mississippi River: Quantities, Sources, and Potential Implications for the Global Carbon Cycle. Environmental Science & Technology, 36(11), 2296–2302. https://doi.org/10.1021/es015834b
Related Research

Mitra, S., Zimmerman, A. R., Hunsinger, G., & Woerner, W. R. (2013). Blackcarbon in coastal and large river systems. In T. S. Bianchi, M. A. Allison, & W.-J. Cai (Eds.), Biogeochemical Dynamics at Major River-Coastal Interfaces: Linkages with Global Change (pp. 200–234). chapter, Cambridge: Cambridge University Press.
Related Research

Suman, D. O., Kuhlbusch, T. A. J., & Lim, B. (1997). Marine Sediments: A Reservoir for Black Carbon and their Use as Spatial and Temporal Records of Combustion. Sediment Records of Biomass Burning and Global Change, 271–293. https://doi.org/10.1007/978-3-642-59171-6_12
Related Research

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Parameters

Parameter	Description	Units
Name	Name of the sediment core from which the top 1 cm was sectioned	unitless
Cruise_ID	Cruise ID	unitless
Site_ID	Site ID	unitless
Coring_Attempt	Coring attempt number	unitless
Core_Letter	Core letter	unitless
Collection_Date	Date the multicore was collected	unitless
Lat	Latitude of sampling site, south is negative	decimal degrees
Lon	Longitude of sampling site, west is negative	decimal degrees
Depth	Water depth of sample site	meters (m)

MAR	extraterrestrial 3He mass accumulation rate	grams per square centimeters per thousand years (g cm-2 kyr-1)
TOC	Total organic carbon concentration	milligrams per gram dry weight (mg/g)
TOC_d13C	Total organic carbon delta 13C value	per mill (‰)
TOC_D14C	Delta 14C value of total organic carbon	per mill (‰)
BC	Black carbon concentration	milligrams per gram dry weight (mg/g)
BC_sd	Black carbon concentration standard deviation	milligrams per gram dry weight (mg/g)
BC_d13C	Black carbon delta 13C value	per mill (‰)
BC_D14C	Delta 14C value of the black carbon	per mill (‰)
BC_flux	Flux of black carbon to sediments	milligrams per square centimeters per thousand years (mg cm-2 kyr-1)
BC_flux_sd	The standard deviation of the flux of black carbon to sediments	milligrams per square centimeters per thousand years (mg cm-2 kyr-1)

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Instruments

Dataset-specific Instrument Name	Costech 4010 Elemental Analyzer
Generic Instrument Name	Costech International Elemental Combustion System (ECS) 4010
Generic Instrument Description	The ECS 4010 Nitrogen / Protein Analyzer is an elemental combustion analyser for CHNSO elemental analysis and Nitrogen / Protein determination. The GC oven and separation column have a temperature range of 30-110 degC, with control of +/- 0.1 degC.

Dataset-specific Instrument Name	Isotope Ratio Mass Spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Isotope Ratio Mass Spectrometer (Thermo Delta V Advantage)
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	MC-800
Generic Instrument Name	Multi Corer
Generic Instrument Description	The Multi Corer is a benthic coring device used to collect multiple, simultaneous, undisturbed sediment/water samples from the seafloor. Multiple coring tubes with varying sampling capacity depending on tube dimensions are mounted in a frame designed to sample the deep ocean seafloor. For more information, see Barnett et al. (1984) in Oceanologica Acta, 7, pp. 399-408.

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Deployments

EN651

Website	https://www.bco-dmo.org/deployment/935451
Platform	R/V Endeavor
Start Date	2020-02-27
End Date	2020-03-17
Description	Project:Tropical Atlantic BC

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Project Information

Concentrations and source assessment of black carbon across tropical Atlantic air and sediment (Tropical Atlantic Black Carbon)

Coverage: Tropical North Atlantic Ocean

NSF Award Abstract:
Black carbon is formed during the incomplete burning of fuels (e.g., the black clouds of smoke emitted by buses and trucks). Black carbon does not degrade easily in the environment and can be transported long distances, even reaching the seafloor. Yet the fluxes of black carbon in the environment are not well known, particularly in the oceans. Rivers are considered the dominant source of black carbon to the oceans. However,

recent results suggest that there may be regions of the ocean where the atmospheric delivery of black carbon may be important. This study investigates whether biomass burning (e.g., wildfires) in Africa is a source of black carbon to the tropical Atlantic Ocean. The unique molecular and isotopic properties of black carbon will be used to identify black carbon in the atmosphere, water and sediment in the study region. Sediment, water column and atmospheric particles will be collected during a 3-week research cruise across the tropical Atlantic Ocean. Two different approaches will be used to quantify black carbon in the environment. The research is relevant and timely for our understanding of the carbon cycle, a key component of our ability to forecast climate and its change. The project supports a graduate student and provide opportunities for high school students participating in the SMILE Program (Science and Math Investigative Learning Experiences). This project is jointly funded by the Chemical Oceanography Program and the Established Program to Stimulate Competitive Research (EPSCoR).

Surface sediment samples will be collected at ten sites across the tropical Atlantic Ocean in a region known to be impacted by biomass burning events (wildfires) in Africa. Appropriate locations for sediment sampling will be identified using state-of-the-art ship equipment to ensure a successful coring operation. Once collected, the black carbon and organic carbon fractions of the sediment will be isolated and measured. A range of isotopic and molecular marker approaches will be used to identify the likely source of these carbon fractions. The central hypothesis is that the black carbon residing in the sediment of the tropical Atlantic Ocean is derived from biomass burning and delivered through atmospheric deposition. Carbon derived from recent biomass burning contains C-14 isotopes that indicate 'young' (or recently produced) carbon, while carbon from fossil fuels ('old carbon') has no C-14 due to radioactive decay. To further assess the origin of the black carbon in the region, water column and atmospheric particles will be collected during the research cruise. The origin of the atmospheric black carbon particles (biomass burning or fossil fuel emissions) will be established through a collaboration with colleagues in Sweden. The broader impacts of this research include the engagement of high school students through The SMILE Program (Science and Math Investigative Learning Experiences) at the University of Rhode Island. The project also provides training opportunities for graduate and undergraduate students, with a focus on recruitment of students from under-represented groups.

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-1924191

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