

Element quotas of individual phytoplankton cells from samples collected on the US GEOTRACES Arctic cruise GN01 (HLY1502) on USCGC Healy in August-October 2015

Website: <https://www.bco-dmo.org/dataset/904895>

Data Type: Cruise Results

Version: 1

Version Date: 2023-09-05

Project

» [U.S. Arctic GEOTRACES Study \(GN01\)](#) (U.S. GEOTRACES Arctic)

» [GEOTRACES Arctic Section: Collaborative Research: Biogeochemical cycling of particulate trace elements in the western Arctic basin](#) (Arctic GEOTRACES bottle particles)

Program

» [U.S. GEOTRACES](#) (U.S. GEOTRACES)

Contributors	Affiliation	Role
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Abstract

Individual phytoplankton cells were collected on the US GEOTRACES Arctic cruise GN01 (HLY1502) on USCGC Healy in August-October 2015. The elemental (Si, P, S, Mn, Fe, Co, Ni, Cu, Zn) content of each cell was measured with synchrotron x-ray fluorescence (SXRF). Carbon was calculated from biovolume. Data can be used to assess biogenic particulate metal fraction, as well as changes in the accumulation of these elements across environmental gradients. Data are part of the larger international GEOTRACES dataset.

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Coverage

Spatial Extent: N:89.99 E:89.25 S:60.26 W:-149.43

Temporal Extent: 2015-08-12 - 2015-10-05

Methods & Sampling

Single-cell SXRF samples were collected from the surface mixed layer using the GEOTRACES rosette. Whole water samples were preserved with 0.25% trace-metal clean buffered glutaraldehyde (Twining et al., 2003) and centrifuged onto Au or SiN TEM windows. Grids were briefly rinsed with a drop of ultrapure water and dried in a Class-100 cabinet. SXRF analysis was performed using the 2-ID-E beamline at the Advanced Photon source

(Argonne National Laboratory) following the protocols of Twining et al. (2011). Each cell was raster scanned with a focused 10 keV x-ray beam with a diameter of approximately 0.5 micrometers (μm).

Data Processing Description

Data Processing:

Fluorescence spectra from the pixels covering the cell were averaged to calculate whole-cell quotas, and a fluorescence spectrum from a neighboring empty section of the grid was subtracted. Cellular elemental fluorescence intensities were fit with a modified-Gaussian model using custom software and peak areas converted to areal element concentrations using NBS-certified standard reference materials (Núñez-Milland et al., 2010; Twining et al., 2011). Spatial regions of interest (ROI) representing the whole cell (including any adsorbed elements, if present) were prepared for each cell and used to calculate element quotas. Cellular C quotas were calculated from cell biovolume using the equations of Menden-Deuer and Lessard (2000). Cell biovolume was calculated for each cell from measurements of cell diameter, length, and height using digital image processing software Image J. Shape and volume equations were taken from Hillebrand et al. (1999).

BCO-DMO Processing Description

- imported original file named "Arctic SXRF.csv" into the BCO-DMO system;
- removed "NA" as a missing data value (missing data is blank/empty in the final CSV file);
- replaced spaces with underscores in column names to comply with BCO-DMO naming conventions;
- changed Date format to YYYY-mm-dd;
- added the date-time field in ISO 8601 format;
- named the final file "904895_v1_gn01_phytoplankton_element_quotas.csv".

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Data Files

File
904895_v1_gn01_phytoplankton_element_quotas.csv (Comma Separated Values (.csv), 72.74 KB) MD5:e33cd35ebb35ccc4f8cfad27f6f6fbff
Primary data file for dataset ID 904895, version 1.

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Supplemental Files

File
maps.zip (ZIP Archive (ZIP), 26.90 MB) MD5:62c5e0264eb99a930054df7f1fd98c96
Supplemental file for dataset 904895, version 1. Contains 2D heatmaps of elemental contents of cells (in .jpg format). Files in this folder correspond to file names in the "maps_file" column of the primary data file.
spectra_gifs.zip (ZIP Archive (ZIP), 4.96 MB) MD5:4a1ff7c795e5d17da723c4983b1b326c
Supplemental file for dataset 904895, version 1. Contains SXRF spectra of cells (in .gif format). Files in this folder correspond to file names in the "spectral_file" column of the primary data file.
vlm.zip (ZIP Archive (ZIP), 30.97 MB) MD5:2f0f29945c0366a33a26d8aaf1433f09
Supplemental file for dataset 904895, version 1. Contains light microscope images of cells (in .jpg format). Files in this folder correspond to file names in the "cell_image_file" column of the primary data file.

Related Publications

Bundy, R. M., Tagliabue, A., Hawco, N. J., Morton, P. L., Twining, B. S., Hatta, M., ... Saito, M. A. (2020). Elevated sources of cobalt in the Arctic Ocean. *Biogeosciences*, 17(19), 4745–4767. doi:[10.5194/bg-17-4745-2020](https://doi.org/10.5194/bg-17-4745-2020)
Results

Hillebrand, H., Dürselen, C.-D., Kirschtel, D., Pollinger, U., & Zohary, T. (1999). Biovolume calculation for pelagic and benthic microalgae. *Journal of Phycology*, 35(2), 403–424. doi:[10.1046/j.1529-8817.1999.3520403.x](https://doi.org/10.1046/j.1529-8817.1999.3520403.x)
Methods

Jensen, L. T., Wyatt, N. J., Twining, B. S., Rauschenberg, S., Landing, W. M., Sherrell, R. M., & Fitzsimmons, J. N. (2019). Biogeochemical Cycling of Dissolved Zinc in the Western Arctic (Arctic GEOTRACES GN01). *Global Biogeochemical Cycles*, 33(3), 343–369. doi:[10.1029/2018gb005975](https://doi.org/10.1029/2018gb005975)
Results

Menden-Deuer, S., & Lessard, E. J. (2000). Carbon to volume relationships for dinoflagellates, diatoms, and other protist plankton. *Limnology and Oceanography*, 45(3), 569–579. doi:[10.4319/lo.2000.45.3.0569](https://doi.org/10.4319/lo.2000.45.3.0569)
Methods

Núñez-Milland, D. R., Baines, S. B., Vogt, S., & Twining, B. S. (2010). Quantification of phosphorus in single cells using synchrotron X-ray fluorescence. *Journal of Synchrotron Radiation*, 17(4), 560–566. <https://doi.org/10.1107/s0909049510014020>
Methods

Sofen, L. E., O. A. Antipova, K. N. Buck, S. Caprara, L. Chacho, R. J. Johnson, G. Kim, P. Morton, D. C. Ohnemus, S. Rauschenberg, P. N. Sedwick, A. Tagliabue, and B. S. Twining. (2023). Authigenic iron is a significant component of oceanic labile particulate iron inventories. *Global Biogeochemical Cycles* In revision.
Results

Twining, B. S., Baines, S. B., Bozard, J. B., Vogt, S., Walker, E. A., & Nelson, D. M. (2011). Metal quotas of plankton in the equatorial Pacific Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography*, 58(3-4), 325–341. doi:[10.1016/j.dsr2.2010.08.018](https://doi.org/10.1016/j.dsr2.2010.08.018)
Methods

Twining, B. S., Baines, S. B., Fisher, N. S., Maser, J., Vogt, S., Jacobsen, C., Tovar-Sanchez, A., & Sañudo-Wilhelmy, S. A. (2003). Quantifying Trace Elements in Individual Aquatic Protist Cells with a Synchrotron X-ray Fluorescence Microprobe. *Analytical Chemistry*, 75(15), 3806–3816. <https://doi.org/10.1021/ac034227z>
Methods

Parameters

Parameter	Description	Units
Run	APS run during which each cell was analyzed: 2016r1 or 2016r3 (runs 1 and 3, respectively)	unitless
Cruise	GEOTRACES cruise the sample was collected from: Arctic (GN01, HLY02)	unitless
Station	Station sample was collected from	unitless
Lat_N	Latitude	degrees North
Lon_E	Longitude	degrees East
Date	Date of cast (UTC)	unitless
Start_time	Time of cast start (UTC)	unitless
ISO_DateTime.UTC	Date and time of cast start (UTC) in ISO 8601 format	unitless
Depth	Depth	meters (m)
DepthDescr	Descriptive depth designation: ML (mixed layer) or in ice	unitless
ParticleSampleID	GEOTRACES sample ID for particulate trace metal sample from which phytoplankton were sampled	unitless
CellType	Taxonomic classification of cell: Chaet = chaetoceros, centric = centric diatom, Cosco = coscinodiscus, Dino = dinoflagellage, flag = flagellate, Melosira, Oval diatom, pennate = pennate diatom, Silicaflag = silicaflagellate	unitless
MDA	SXRF scan number	unitless
UniqueCell	Unique cell ID, formatted as {RUN}_{MDA}_{ROI}	unitless
GridType	Material of TEM grid used for analysis: SiN (silicon nitride) or Au (gold)	unitless
Volume	Cell volume	cubic microns
cellC	cellular carbon contents	moles
cellSi	cellular silicon contents	moles
cellP	cellular phosphorus	moles
cellS	cellular sulfur contents	moles
cellMn	cellular manganese contents	moles
cellFe	cellular iron contents	moles
cellCo	cellular cobalt contents	moles
cellNi	cellular nickel contents	moles
cellCu	cellular copper contents	moles
cellZn	cellular zinc contents	moles
cell_image_file	filename of light microscope image of cell	unitless
spectral_file	filename of SXRF spectrum of cell	unitless
maps_file	filename of 2D heatmap of elemental contents of cell	unitless

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Instruments

Dataset-specific Instrument Name	Synchrotron X-ray Fluorescence microscope
Generic Instrument Name	X-ray fluorescence analyzer
Dataset-specific Description	SXRF analysis was performed on the 2-ID-E beamline at the Advanced Photon source (Argonne National Laboratory). The synchrotron consists of a storage ring which produces high energy electromagnetic radiation. X-rays diverted to the 2-ID-E beamline are used for x-ray fluorescence mapping of biological samples. X-rays were tuned to an energy of 10 keV to enable the excitation of K-alpha fluorescence for the elements reported. The beam is focused using Fresnel zoneplates to achieve high spatial resolution; for our application a focused spot size of 0.5um was used. A multi-element germanium energy dispersive detector is used to record the X-ray fluorescence spectrum.
Generic Instrument Description	Instruments that identify and quantify the elemental constituents of a sample from the spectrum of electromagnetic radiation emitted by the atoms in the sample when excited by X-ray radiation.

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Deployments

HLY1502

Website	https://www.bco-dmo.org/deployment/638807
Platform	USCGC Healy
Report	https://datadocs.bco-dmo.org/docs/302/geotraces/GEOTRACES_ARCTIC/data_docs/cruise_reports/healy1502.pdf
Start Date	2015-08-09
End Date	2015-10-12
Description	Arctic transect encompassing Bering and Chukchi Shelves and the Canadian, Makarov and Amundsen sub-basins of the Arctic Ocean. The transect started in the Bering Sea (60°N) and traveled northward across the Bering Shelf, through the Bering Strait and across the Chukchi shelf, then traversing along 170-180°W across the Alpha-Mendeleev and Lomonosov Ridges to the North Pole (Amundsen basin, 90°N), and then back southward along ~150°W to terminate on the Chukchi Shelf (72°N). Additional cruise information is available in the GO-SHIP Cruise Report (PDF) and from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/HLY1502

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Project Information

U.S. Arctic GEOTRACES Study (GN01) (U.S. GEOTRACES Arctic)

Website: <https://www.geotraces.org/>

Coverage: Arctic Ocean; Sailing from Dutch Harbor to Dutch Harbor (GN01)

Description from NSF award abstract:

In pursuit of its goal "to identify processes and quantify fluxes that control the distributions of key trace

elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions", in 2015 the International GEOTRACES Program will embark on several years of research in the Arctic Ocean. In a region where climate warming and general environmental change are occurring at amazing speed, research such as this is important for understanding the current state of Arctic Ocean geochemistry and for developing predictive capability as the regional ecosystem continues to warm and influence global oceanic and climatic conditions. The three investigators funded on this award, will manage a large team of U.S. scientists who will compete through the regular NSF proposal process to contribute their own unique expertise in marine trace metal, isotopic, and carbon cycle geochemistry to the U.S. effort. The three managers will be responsible for arranging and overseeing at-sea technical services such as hydrographic measurements, nutrient analyses, and around-the-clock management of on-deck sampling activities upon which all participants depend, and for organizing all pre- and post-cruise technical support and scientific meetings. The management team will also lead educational outreach activities for the general public in Nome and Barrow, Alaska, to explain the significance of the study to these communities and to learn from residents' insights on observed changes in the marine system. The project itself will provide for the support and training of a number of pre-doctoral students and post-doctoral researchers. Inasmuch as the Arctic Ocean is an epicenter of global climate change, findings of this study are expected to advance present capability to forecast changes in regional and global ecosystem and climate system functioning.

As the United States' contribution to the International GEOTRACES Arctic Ocean initiative, this project will be part of an ongoing multi-national effort to further scientific knowledge about trace elements and isotopes in the world ocean. This U.S. expedition will focus on the western Arctic Ocean in the boreal summer of 2015. The scientific team will consist of the management team funded through this award plus a team of scientists from U.S. academic institutions who will have successfully competed for and received NSF funds for specific science projects in time to participate in the final stages of cruise planning. The cruise track segments will include the Bering Strait, Chukchi shelf, and the deep Canada Basin. Several stations will be designated as so-called super stations for intense study of atmospheric aerosols, sea ice, and sediment chemistry as well as water-column processes. In total, the set of coordinated international expeditions will involve the deployment of ice-capable research ships from 6 nations (US, Canada, Germany, Sweden, UK, and Russia) across different parts of the Arctic Ocean, and application of state-of-the-art methods to unravel the complex dynamics of trace metals and isotopes that are important as oceanographic and biogeochemical tracers in the sea.

GEOTRACES Arctic Section: Collaborative Research: Biogeochemical cycling of particulate trace elements in the western Arctic basin (Arctic GEOTRACES bottle particles)

Coverage: Arctic Ocean

NSF Award Abstract:

As part of this project, two investigators will participate in the 2015 U.S. GEOTRACES Arctic expedition to determine the trace element composition of different suspended particles in the water column of the Arctic Ocean to identify the sources and scavenging capabilities of these particles. In common with other multinational initiatives in the International GEOTRACES Program, the goals of the U.S. Arctic expedition are to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions. Some trace elements are essential to life, others are known biological toxins, and still others are important because they can be used as tracers of a variety of physical, chemical, and biological processes in the sea. This team of trace element scientists will focus on the measurement of particulate trace elements, which will enable scientists to better estimate the sources of particulate metals to the Arctic Ocean and to better understand their contribution to biological processes. This project will also provide educational opportunities for undergraduate students, K-12 teachers, and the general public.

Particulate trace element distributions, sources, sinks and cycling are predicted to be controlled by physical, biological, anthropogenic and geochemical processes in the Arctic. Furthermore, many trace elements are required nutrients for marine phytoplankton, playing a key role in oceanic primary productivity. However, few integrated oceanographic studies have been conducted to specifically investigate these relationships in this region, despite the changing conditions and global significance of the Arctic. This project will significantly advance understanding of the complete geochemical cycles of a number of trace elements in the Arctic Ocean basin by measuring the concentrations of particulate trace elements in bulk particles collected through the water column and in sediments, as well as in phytoplankton from the upper water column. These measurements will enable scientists to constrain the inputs of particulate elements from rivers, shelves and ice,

and to assess the removal of dissolved trace elements via passive scavenging and biological uptake.

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Program Information

U.S. GEOTRACES (U.S. GEOTRACES)

Website: <http://www.geotraces.org/>

Coverage: Global

GEOTRACES is a [SCOR](#) sponsored program; and funding for program infrastructure development is provided by the [U.S. National Science Foundation](#).

GEOTRACES gained momentum following a special symposium, S02: Biogeochemical cycling of trace elements and isotopes in the ocean and applications to constrain contemporary marine processes (GEOSECS II), at a 2003 Goldschmidt meeting convened in Japan. The GEOSECS II acronym referred to the Geochemical Ocean Section Studies To determine full water column distributions of selected trace elements and isotopes, including their concentration, chemical speciation, and physical form, along a sufficient number of sections in each ocean basin to establish the principal relationships between these distributions and with more traditional hydrographic parameters;

- * To evaluate the sources, sinks, and internal cycling of these species and thereby characterize more completely the physical, chemical and biological processes regulating their distributions, and the sensitivity of these processes to global change; and

- * To understand the processes that control the concentrations of geochemical species used for proxies of the past environment, both in the water column and in the substrates that reflect the water column.

GEOTRACES will be global in scope, consisting of ocean sections complemented by regional process studies. Sections and process studies will combine fieldwork, laboratory experiments and modelling. Beyond realizing the scientific objectives identified above, a natural outcome of this work will be to build a community of marine scientists who understand the processes regulating trace element cycles sufficiently well to exploit this knowledge reliably in future interdisciplinary studies.

Expand "Projects" below for information about and data resulting from individual US GEOTRACES research projects.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1435862

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