Size-fractionated particulate inorganic carbon (PIC) in particles collected by in-situ filtration on the US GEOTRACES GP17-OCE cruise on R/V Roger Revelle (RR2214) in the South Pacific and Southern Oceans from December 2022 to January 2023

Website: https://www.bco-dmo.org/dataset/945724
Data Type: Cruise Results
Version: 1
Version Date: 2024-12-10

Project
» US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE) (GP17-OCE)
» Collaborative Research: US GEOTRACES GP17-OCE: Size-Fractionated Particle Collection and Analysis from Ultra-Oligotrophic to Antarctic Waters (GP17-OCE Particle Composition)

Program
» U.S. GEOTRACES (U.S. GEOTRACES)

Contributors	Affiliation	Role
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Abstract
This dataset is the first of many that describe the major, minor, and trace element composition of size-fractionated particles collected by in-situ filtration on the US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE). The cruise departed Papeete, Tahiti (French Polynesia) on December 1, 2022 and arrived in Punta Arenas, Chile on January 25, 2023, sampling in the South Pacific and Southern Oceans aboard the R/V Roger Revelle (RR2214). This dataset focuses on particulate inorganic carbon (PIC) concentrations.

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Coverage

Location: South Pacific and Southern Oceans
Spatial Extent: **N**:-20 **E**:-75.75116667 **S**:-67 **W**:-152
Temporal Extent: 2022-12-04 - 2023-01-22

Methods & Sampling

Sampling:
Size-fractionated particles were collected using dual-flow McLane Research in-situ pumps (WTS-LV) and 142-millimeter (mm) "mini-MULVFS" filter holders (Bishop et al., 2012; Lam et al., 2018; Lam et al., 2015a; Xiang and Lam, 2020). At most stations through station 14, two casts of 8 pumps each and two filter holders per pump

were deployed to collect samples at 16 depths throughout the water column. At one super station, a 24-depth profile was obtained with three casts. The targeted depths of the wire-out were corrected using pressure readings from a self-recording Seabird 19plus CTD at the end of the line.

At station 16, the entire string of 8 pumps and self-recording Seabird CTD was lost at sea. Starting at station 18, stations had 0-3 pump casts consisting of 1-4 pumps each.

One filter holder/flowpath was loaded with a Sefar polyester mesh prefilter (51-micrometers (um) pore size, called the "Qp" filter) and paired Whatman QMA quartz fiber filters (1 um pore size) in series ("QMA-side"). The other filter holder/flowpath was also loaded with a 51 um prefilter (called the "Sp" filter), but it was followed by paired 0.8 um Pall Supor800 polyethersulfone filters ("Supor-side"). A 150 um Sefar polyester mesh was placed underneath all 51 um prefilters and QMA filters as a support to facilitate filter handling but not analyzed. All filters and filter holders were acid leached before use based on the recommended methods in the GEOTRACES sample and sample-handling protocols (Cutter et al., 2010). QMA filters were pre-combusted at 450 degrees Celsius for 4 hours after acid leaching.

A special plate was manufactured for one of the pumps that could hold two additional mini-MULVFS filter holders that were loaded with full filter sets but not connected to plumbing. These 'dipped blank' filters included the full filter sets (51 um prefilter on top of paired QMA or paired Supor filters) with a 0.2 um Supor polyethersulfone filter on top of the 51 um polyester prefilters to exclude all particles from the main filter set. These were processed identically to the regular filters and functioned as full process blanks. Subsequent to the pump loss at station 16, dipped blank filter sets were wrapped in 1 um polyester mesh held in perforated plastic containers that were zip-tied to the pump frames.

In this dataset, data reported from the 51 um prefilter are referred to with an "LPT" suffix to indicate large particulate total concentrations (>51 um). Samples could come from the QMA side ("Qp" filter) or the Supor side ("Sp" filter) and are treated equivalently. Data reported from the main filters (QMA (1-51 um) or Supor (0.8-51 um)) are from the top filter of the pair only, and are referred to with an "SPT" suffix to indicate the small particulate total concentrations.

After Station 14, there were more instances of failed pumps. From Station 1 to 14, approximately 17% of the attempted samples failed, whereas from Station 18 to 34 approximately 45% failed. A failed pump did not move water through the filter, or it did not read the correct volume as the water entered, so particle concentration could not be determined. These samples are included in the dataset but have "NaN" entered for the values and errors, and a bad quality flag (QV=4). A few samples were missing; these have a missing quality flag (QV=9). (See "Data Processing" section for more on quality flags).

Analysis:
A UIC Carbon dioxide coulometer was used for PIC measurement. Briefly, PIC on SPT QMA punches or 1/16 LPT QMA-side prefilter was converted to CO2 by addition of 3 milliliters (mL) of 2 N sulfuric acid. CO2 produced is carried by a gas stream into a coulometer cell where CO2 is quantitatively absorbed by a cathode solution, reacted to form a titratable acid and measured based on the change in current. Machine blanks were run at the beginning of each run period until the CO2 values were stable and less than 1 microgram (ug). For every ten PIC samples run, a machine blank was run, which was the 3 mL H2SO4 with no filter. Three blanks were also collected at the end of each run period.

Data Processing Description

The coulometer data were run through a series of quality controls. For each rundate, the average of the machine blanks measured that period were subtracted from each sample value to correct for any background CO2 added during sample acidification. Dipped blank filters collected during particle sampling at sea were used to correct for background carbon as a slightly different process. The dipped blanks plotted against station number showed that the average dipped blank value decreased between Stations 1-14 and 18-37 for both LSF and SSF filters. A t-test determined that the averages of the dipped blanks collected from Stations 1-14 were statistically different from the dipped blanks collected from Stations 18-37 for the LSF filters but not for the SSF filters. The mean of all SSF dipped blank filters (0.59±0.32 ug) was subtracted from the SSF samples; the means of the LSF dipped blank filters from Stations 1-14 and Stations 18-37 were subtracted from the corresponding LSF samples (0.81±0.42ug and 0.20±0.15 ug, respectively). This allowed us to correct for any background carbon that could have been added during the handling of the pumps and filters on the boat while also addressing any changes in background carbon input that might have come from changing oceanographic conditions or at-sea sampling methods. We could not routinely run replicates, so errors reported are determined from the standard deviation of dipped blank filters, converted to concentrations using volume

filtered. This assumes that the blank subtraction is the largest source of error.

The machine- and dipped blank corrected samples were then converted from the ug carbon values given by the coulometer into nanomolar (nM) carbon using the equivalent volume of water moved through the fraction of the original filter that was analyzed and the molecular weight of carbon (12.011 grams per mole).

Before finalizing our data set, we examined which samples were below the limit of detection. The limit of detection was defined to be three times the standard deviation of the dipped blanks associated with that sample. Any PIC values less than the limit of detection were not significantly different than zero.

Quality Flags:
The detection limit was defined as three times the standard deviation of the dipped blank filters. Values below the detection limit were flagged as QF=6 in the GTSPP convention (also adopted by SeaDataNet and recommended by the GEOTRACES programme).

All data have been assigned quality flags using the GTSPP convention and interpretation:

1 = good; passed lab QC and oceanographically consistent.

2 = possibly good; oceanographically consistent, but have minor sampling/instrumental issues.

3 = possibly bad; not oceanographically consistent, or have major sampling/instrumental issues.

4 = bad; failed lab QC (including all failed pumps when only small or no volume was pumped through the filter), or known issue with samples.

6 = below detection limit.

9 = data missing (including all "nd"). For a measured parameter, this QF applies to lost or missing samples that were not measured.

BCO-DMO Processing Description

- Imported original file "Lam_GP17-OCE_PIC_BCO-DMO.csv" into the BCO-DMO system.
- Replaced "#N/A" with "NaN" for sample 17995 in the STANDARD_DEV:PIC_SPT_nM column.
- Renamed fields to comply with BCO-DMO naming conventions.
- Created ISO_DateTime_UTC column from original date and time columns; removed original columns.
- Saved final file as "945724_v1_gp17-oce_size-fractionated_pic.csv".

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Related Publications

Bishop, J. K. B., Lam, P. J., & Wood, T. J. (2012). Getting good particles: Accurate sampling of particles by large volume in-situ filtration. Limnology and Oceanography: Methods, 10(9), 681–710. doi:10.4319/lom.2012.10.681
Methods

Cutter, G., Andersson, P., Codispoti, L., Croot, P., François, R., Lohan, M. C., Obata, H. and Rutgers v. d. Loeff, M. (2010). Sampling and Sample-handling Protocols for GEOTRACES Cruises, [Miscellaneous] Version 1. http://www.geotraces.org/libraries/documents/Intercalibration/Cookbook.pdf
Methods

Lam, P. J., Lee, J.-M., Heller, M. I., Mehic, S., Xiang, Y., & Bates, N. R. (2018). Size-fractionated distributions of suspended particle concentration and major phase composition from the U.S. GEOTRACES Eastern Pacific Zonal Transect (GP16). Marine Chemistry, 201, 90–107. doi:10.1016/j.marchem.2017.08.013
Methods

Lam, P. J., Ohnemus, D. C., & Auro, M. E. (2015). Size-fractionated major particle composition and concentrations from the US GEOTRACES North Atlantic Zonal Transect. Deep Sea Research Part II: Topical Studies in Oceanography, 116, 303–320. doi:10.1016/j.dsr2.2014.11.020
Methods

Xiang, Y., & Lam, P. J. (2020). Size-Fractionated Compositions of Marine Suspended Particles in the Western Arctic Ocean: Lateral and Vertical Sources. Journal of Geophysical Research: Oceans, 125(8). doi:10.1029/2020jc016144
Methods

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Parameters

Parameter	Description	Units
GTNum	Sample ID number	unitless
Station	Station number	unitless
Cast_Type	Cast type. S = ? D = ? M = ? ML = ?	unitless
Pump	Pump number	unitless
Cast_Number	Cast number	unitless
Latitude	Latitude; negative values = South	decimal degrees
Longitude	Longitude; negative values = West	decimal degrees
Bot_Depth	Bottom depth	meters (m)
ISO_DateTime_UTC	Date and time (UTC) in ISO 8601 format	unitless
Depth	Sample depth	meters (m)
QMA_volume_filtered	Volume filtered through QMA side	liters (L)
PIC_SPT_nM	PIC concentrations for small size fraction (SPT) in units of nM	nanomolar (nM)
QV_SEADATANET_PIC_SPT_nM	Quality flag for PIC_SPT_nM (SEADATANET)	unitless
STANDARD_DEV_PIC_SPT_nM	Error for PIC_SPT_nM in units of nM	nanomolar (nM)
PIC_LPT_nM	PIC concentrations for large size fraction (LPT) in units of nM	nanomolar (nM)
QV_SEADATANET_PIC_LPT_nM	Quality flag for PIC_LPT_nM (SEADATANET)	unitless
STANDARD_DEV_PIC_LPT_nM	Error for PIC_SPT_nM in units of nM	nanomolar (nM)

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Instruments

Dataset-specific Instrument Name	UIC Carbon dioxide coulometer
Generic Instrument Name	CO2 Coulometer
Dataset-specific Description	PIC was measured with a UIC Carbon dioxide coulometer.
Generic Instrument Description	A CO2 coulometer semi-automatically controls the sample handling and extraction of CO2 from seawater samples. Samples are acidified and the CO2 gas is bubbled into a titration cell where CO2 is converted to hydroxyethylcarbonic acid which is then automatically titrated with a coulometrically-generated base to a colorimetric endpoint.

Dataset-specific Instrument Name	dual-flow McLane Research in-situ pumps (WTS-LV)
Generic Instrument Name	McLane Large Volume Pumping System WTS-LV
Dataset-specific Description	More details can be found in the patent description (https://patents.google.com/patent/US20130298702) and official website of the manufacturer (https://mclanelabs.com/wts-lv-large-volume-pump/).
Generic Instrument Description	The WTS-LV is a Water Transfer System (WTS) Large Volume (LV) pumping instrument designed and manufactured by McLane Research Labs (Falmouth, MA, USA). It is a large-volume, single-event sampler that collects suspended and dissolved particulate samples in situ. Ambient water is drawn through a modular filter holder onto a 142-millimeter (mm) membrane without passing through the pump. The standard two-tier filter holder provides prefiltering and size fractioning. Collection targets include chlorophyll maximum, particulate trace metals, and phytoplankton. It features different flow rates and filter porosity to support a range of specimen collection. Sampling can be programmed to start at a scheduled time or begin with a countdown delay. It also features a dynamic pump speed algorithm that adjusts flow to protect the sample as material accumulates on the filter. Several pump options range from 0.5 to 30 liters per minute, with a max volume of 2,500 to 36,000 liters depending on the pump and battery pack used. The standard model is depth rated to 5,500 meters, with a deeper 7,000-meter option available. The operating temperature is -4 to 35 degrees Celsius. The WTS-LV is available in four different configurations: Standard, Upright, Bore Hole, and Dual Filter Sampler. The high-capacity upright WTS-LV model provides three times the battery life of the standard model. The Bore-Hole WTS-LV is designed to fit through a narrow opening such as a 30-centimeter borehole. The dual filter WTS-LV features two vertical intake 142 mm filter holders to allow simultaneous filtering using two different porosities.

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Deployments

RR2214

Website	https://www.bco-dmo.org/deployment/905754
Platform	R/V Roger Revelle
Report	https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/rogerrevelle_rr2214.pdf
Start Date	2022-12-01
End Date	2023-01-25
Description	The U.S. GEOTRACES GP17-OCE expedition departed Papeete, Tahiti (French Polynesia) on December 1st, 2022 and arrived in Punta Arenas, Chile on January 25th, 2023. The cruise took place in the South Pacific and Southern Oceans aboard the R/V Roger Revelle with a team of 34 scientists led by Ben Twining (Chief Scientist), Jessica Fitzsimmons, and Greg Cutter (Co-Chief Scientists). GP17 was planned as a two-leg expedition, with its first leg (GP17-OCE) as a southward extension of the 2018 GP15 Alaska-Tahiti expedition and a second leg (GP17-ANT; December 2023-January 2024) into coastal and shelf waters of Antarctica's Amundsen Sea. The GP17-OCE section encompassed three major transects: (1) a southbound pseudo-meridional section (~152-135 degrees West) from 20 degrees South to 67 degrees South; (2) an eastbound zonal transect from 135 degrees West to 100 degrees West; (3) and a northbound section returning to Chile (100-75 degrees West). Additional cruise information is available from the following sources: R2R: https://www.rvdata.us/search/cruise/RR2214 CCHDO: https://cchdo.ucsd.edu/cruise/33RR20221201 More information can also be found at: https://usgeotraces.ldeo.columbia.edu/content/gp17-oce

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Project Information

US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE) (GP17-OCE)

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

Coverage: Papeete, Tahiti to Punta Arenas, Chile

The U.S. GEOTRACES GP17-OCE expedition departed Papeete, Tahiti (French Polynesia) on December 1st, 2022 and arrived in Punta Arenas, Chile on January 25th, 2023. The cruise took place in the South Pacific and Southern Oceans aboard the R/V Roger Revelle (cruise ID RR2214) with a team of 34 scientists lead by Ben Twining (Chief Scientist), Jessica Fitzsimmons and Greg Cutter (Co-Chief Scientists). GP17 was planned as a two-leg expedition, with its first leg (GP17-OCE) as a southward extension of the 2018 GP15 Alaska-Tahiti expedition and a second leg (GP17-ANT; December 2023-January 2024) into coastal and shelf waters of Antarctica's Amundsen Sea.

The South Pacific and Southern Oceans sampled by GP17-OCE play critical roles in global water mass circulation and associated global transfer of heat, carbon, and nutrients. Specific oceanographic regions of interest for GP17-OCE included: the most oligotrophic gyre in the global ocean, the Antarctic Circumpolar Current (ACC) frontal region, the previously unexplored Pacific- Antarctic Ridge, the Pacific Deep Water (PDW) flow along the continental slope of South America, and the continental margin inputs potentially emanating from South America.

Further information is available on the US GEOTRACES website and in the cruise report (PDF).

NSF Project Title: Collaborative Research: Management and Implementation of US GEOTRACES GP17 Section: South Pacific and Southern Ocean (GP17-OCE)

NSF Award Abstract:
This award will support the management and implementation of a research expedition from Tahiti to Chile that will enable sampling for a broad suite of trace elements and isotopes (TEI) across oceanographic regions of importance to global nutrient and carbon cycling as part of the U.S. GEOTRACES program. GEOTRACES is a global effort in the field of Chemical Oceanography, the goal of which is to understand the distributions of trace elements and their isotopes in the ocean. Determining the distributions of these elements and isotopes will

increase understanding of processes that shape their distributions, such as ocean currents and material fluxes, and also the processes that depend on these elements, such as the growth of phytoplankton and the support of ocean ecosystems. The proposed cruise will cross the South Pacific Gyre, the Antarctic Circumpolar Current, iron-limited Antarctic waters, and the Chilean margin. In combination with a proposed companion GEOTRACES expedition on a research icebreaker (GP17-ANT) that will be joined by two overlapping stations, the team of investigators will create an ocean section from the ocean's most nutrient-poor waters to its highly-productive Antarctic polar region - a region that plays an outsized role in modulating the global carbon cycle. The expedition will support and provide management infrastructure for additional participating science projects focused on measuring specific external fluxes and internal cycling of TEIs along this section.

The South Pacific Gyre and Pacific sector of the Southern Ocean play critical roles in global water mass circulation and associated global transfer of heat, carbon, and nutrients, but they are chronically understudied for TEIs due to their remote locale. These are regions of strong, dynamic fronts where sub-surface water masses upwell and subduct, and biological and chemical processes in these zones determine nutrient stoichiometries and tracer concentrations in waters exported to lower latitudes. The Pacific sector represents an end member of extremely low external TEI surface fluxes and thus an important region to constrain inputs from the rapidly-changing Antarctic continent. Compared to other ocean basins, TEI cycling in these regions is thought to be dominated by internal cycling processes such as biological uptake, regeneration, and scavenging, and these are poorly represented in global ocean models. The cruise will enable funded investigators to address research questions such as: 1) what are relative rates of external TEI fluxes to this region, including dust, sediment, hydrothermal, and cryospheric fluxes? 2) What are the (micro) nutrient regimes that support productivity, and what impacts do biomass accumulation, export, and regeneration have on TEI cycling and stoichiometries of exported material? 3) What are TEI and nutrient stoichiometries of subducting water masses, and how do scavenging and regeneration impact these during transport northward? This management project has several objectives: 1) plan and coordinate a 55-day research cruise in 2021-2022; 2) use both conventional and trace-metal 'clean' sampling systems to obtain TEI samples, as well as facilitate sampling for atmospheric aerosols and large volume particles and radionuclides; 3) acquire hydrographic data and samples for salinity, dissolved oxygen, algal pigments, and macro-nutrients; and deliver these data to relevant repositories; 4) ensure that proper QA/QC protocols, as well as GEOTRACES intercalibration protocols, are followed and reported; 5) prepare the final cruise report to be posted with data; 6) coordinate between all funded cruise investigators, as well as with leaders of proposed GP17-ANT cruise; and 7) conduct broader impact efforts that will engage the public in oceanographic research using immersive technology. The motivations for and at-sea challenges of this work will be communicated to the general public through creation of immersive 360/Virtual Reality experiences, via a collaboration with the Texas A&M University Visualization LIVE Lab. Through Virtual Reality, users will experience firsthand what life and TEI data collection at sea entail. Virtual reality/digital games and 360° experiences will be distributed through GEOTRACES outreach websites, through PI engagement with local schools, libraries, STEM summer camps, and adult service organizations, and through a collaboration with the National Academy of Sciences.

Collaborative Research: US GEOTRACES GP17-OCE: Size-Fractionated Particle Collection and Analysis from Ultra-Oligotrophic to Antarctic Waters (GP17-OCE Particle Composition)

Coverage: South Pacific

NSF Award Abstract:
GEOTRACES is an ongoing international effort to study and understand how low-abundance (“trace”) elements and isotopes are distributed in the world’s oceans. Trace elements include both naturally occurring and human-influenced chemical components of seawater. They have several important roles in the functioning of the Earth that make them a focus of study: 1) their rarity is known to limit the growth of microscopic plants which are the base of ocean food webs; 2) the distributions of trace elements in remote parts of the world show how Earth’s atmosphere, ocean, crust, and ecosystems work together on large, planetary scales; 3) knowledge of these trace components is difficult to acquire but is also an important component to improving computer models of Earth’s climate in a rapidly changing world. The Pacific Ocean covers nearly a third of the planet, and the rarely sampled South Pacific Ocean at the focus of this project includes approximately a quarter of the world’s ocean volume. As part of a GEOTRACES expedition to this remote region, this project has three main goals: 1) to provide the sampling equipment and personnel to collect large volumes of particles from the ocean, because many chemical components in seawater are in particle forms; 2) to document and distribute ocean particle samples to collaborators of many GEOTRACES laboratories; 3) to analyze ocean particles for abundances of approximately two dozen trace elements at laboratories in Savannah, GA and

Santa Cruz, CA. A post-doctoral scholar and two graduate students will participate in both field and laboratory aspects of the research.

The GP-17 OCE research expedition to the South Pacific Ocean is planned for two months in late 2022 into early 2023. It comprises two transects: a southward transect along approximately 150ºW between French Polynesia and the Southern Ocean which will sample large biological and geochemical gradients from the low-dust, low-biomass oligotrophic sub-tropical gyre, though more productive regions of complex regions of watermass formation and frontal mixing, and into the Southern Ocean. An eastward transect along 67ºS and into Chile will sample the high-opal and Antarctic-influenced Southern Ocean, deep-water hydrothermal influences, and across the South American continental margin. The investigators will use large-volume in-situ pumps to collect size-fractionated particles from the water column which will be distributed to multiple collaborators; and they will operate and maintain particle-sensitive optical equipment to be deployed on the expedition. The research aims to address three main hypotheses: 1) that the large biological gradients from pico-plankton dominated gyre through frontal regions into opal- and Phaeocystis-dominated polar waters will present large gradients in particle export, particle composition, scavenging of trace elements and isotopes (TEIs), and remineralization length-scales of both carbon and TEIs; 2) that particulate iron is dominated by lithogenic (crustally-derived) phases throughout most of the water column, with the exception of regions of strong hydrothermal influence, and that lithogenic particle origins will reflect inputs of external aerosol dust, sediments, hydrothermal sources, and continental inputs as evident via TEI ratios determined after total digestion; 3) that the optical ratio of turbidity to beam attenuation coefficient is sensitive to iron-oxyhydroxide abundances thus acting as a high-resolution indicator of iron-rich authigenic and lithogenic particle inputs.

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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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-2049297

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