# Radium and Thorium isotopes sampled by in situ pump on R/V Knorr cruises KN199-04 and KN204-01 in the Subtropical northern Atlantic Ocean from 2010-2011 (U.S. GEOTRACES NAT project)

**Website**: https://www.bco-dmo.org/dataset/3846
**Version**: 20 Jan 2015
**Version Date**: 2015-01-20

**Project**
» U.S. GEOTRACES North Atlantic Transect (GA03) (U.S. GEOTRACES NAT)

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


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|---|---|---|
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## Dataset Description

This dataset contains samples collected on the 2010 and 2011 GEOTRACES cruise on the R/V Knorr (cruises KN199-04 and KN204-01). Radium and Thorium isotopes were collected on manganese oxide impregnated acrylic cartridges using an insitu pump filtering 1500-2000L at depth.

### Methods & Sampling

Radium was collected onto a manganese-coated acrylic cartridge filtered at depth using an adapted McLane (WTS-LV). The pumps were programmed to filter 1500-2000L of seawater per deployment. Water was also collected at the same depth using a 30L niskin which was filtered (at <1L/min) through a manganese-coated acrylic fiber to calculate radium extraction efficiency of the pumped samples. The cartridges were rinsed with radium-free fresh water and excess moisture was removed using compressed air. Samples were analyzed three times using an Alpha delayed coincidence counter (RaDeCC) for 223Ra, 224Ra, 228Th, and 227Ac. The cartridges were ashed at 820 degrees C and measured on gamma detectors for long lived radium (226Ra, 228Ra) and thorium isotopes. Cartridge blanks (dip and water rinses) were also measured for potential contamination.

Cartridge preparation reference:
Henderson, P. B., Morris, P. J., Moore, W. S., and Charette, M. A. (2012) Methodological advances for measuring low-level radium isotopes in seawater, J. Radioanal. Nucl. Chem., 293, 1–6. doi:10.1007/s10967-012-2047-9.

Insitu pump modifications reference:
Lam, P.J. and P.J. Morris. In situ marine sample collection system and methods. Patent Pending. U.S. Non Provisional Patent Application No. 13/864,655, submitted April 17, 2013.

**Data Processing Description**

The data were corrected for decay from the time of sampling. 223Ra was corrected for 227Ac (ex223Ra), 224Ra was corrected for 228Th (ex224Ra). The radium activity of the water samples (cartridges) were corrected from the measured radium on acrylic fiber (<1L/min) using the emanation technique.

**Quality flag definitions:**
1 = 228Radium undetectable for 224Radium correction.
2 = No fiber collected, radium efficiency based on silicate correlation.
3 = Below detection.
4 = Vial broken; sample lost.
5 = Efficiency cannot be determined.
6 = 228Radium measured through 228Thorium (gamma spectroscopy).
7 = 228Radium measured through 228Actinium (gamma spectroscopy).
8 = Pump Failure, no sample collected.
9 = Interpolated value based on neighboring data points.
10 = Based on the Barium / Radium relationship.

BCO-DMO made the following modifications:
- Replaced blank cells and #DIV/0! errors with 'nd' to indicate 'no data'.
- Separated original date field into year, month, and day columns.
- Added 'cruise_part' column to distinguish between the 2 legs of KN204-01 cruise.

**Additional GEOTRACES Processing:**
After the data were submitted to the International Data Management Office, BODC, the office noticed that important identifying information was missing in many datasets. With the agreement of BODC and the US GEOTRACES lead PIs, BCO-DMO added standard US GEOTRACES information, such as the US GEOTRACES event number, to each submitted dataset lacking this information. To accomplish this, BCO-DMO compiled a 'master' dataset composed of the following parameters: station_GEOTRC, cast_GEOTRC (bottle and pump data only), event_GEOTRC, sample_GEOTRC, sample_bottle_GEOTRC (bottle data only), bottle_GEOTRC (bottle data only), depth_GEOTRC_CTD (bottle data only), depth_GEOTRC_CTD_rounded (bottle data only), BTL_ISO_DateTime_UTC (bottle data only), and GeoFish_id (GeoFish data only). This added information will facilitate subsequent analysis and inter comparison of the datasets.

Bottle parameters in the master file were taken from the GT-C_Bottle_GT10, GT-C_Bottle_GT11, ODF_Bottle_GT10, and ODF_Bottle_GT11 datasets. Non-bottle parameters, including those from GeoFish tows, Aerosol sampling, and McLane Pumps, were taken from the Event_Log_GT10 and Event_Log_GT11 datasets. McLane pump cast numbers missing in event logs were taken from the Particulate Th-234 dataset submitted by Ken Buesseler.

A standardized BCO-DMO method (called "join") was then used to merge the missing parameters to each US GEOTRACES dataset, most often by matching on sample_GEOTRC or on some unique combination of other parameters.

If the master parameters were included in the original data file and the values did not differ from the master file, the original data columns were retained and the names of the parameters were changed from the PI-submitted names to the standardized master names. If there were differences between the PI-supplied parameter values and those in the master file, both columns were retained. If the original data submission included all of the master parameters, no additional columns were added, but parameter names were modified to match the naming conventions of the master file.

See the dataset parameters documentation for a description of which parameters were supplied by the PI and which were added via the join method.

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## Data Files

| File |
|---|
| **Ra_Th_GT10_joined.csv** (Comma Separated Values (.csv), 49.18 KB)<br>MD5:0c44100eb691d678cc18e42d35b26cc9<br>Primary data file for dataset ID 3846 |

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## Parameters

| Parameter | Description | Units |
|---|---|---|
| cruise_id | Official cruise identifier e.g. KN199-04 = R/V Knorr cruise number 199-04. | text |
| lat | Latitude. South is negative. | decimal degrees |
| lon | Longitude. West is negative. | decimal degrees |
| event_GEOTRC | Unique identifying number for US GEOTRACES sampling events; ranges from 2001 to 2225 for KN199-04 events and from 3001 to 3282 for KN204-01 events. Values were added from the intermediate US GEOTRACES master file (see Processing Description). | integer |
| sample_GEOTRC | Unique identifying number for US GEOTRACES samples; ranges from 5033 to 6078 for KN199-04 and from 6112 to 8148 for KN204-01. PI-supplied values were identical to those in the intermediate US GEOTRACES master file. Originally submitted as 'GT No.', this parameter name has been changed to conform to BCO-DMO's GEOTRACES naming conventions. | integer |
| station_GEOTRC | GEOTRACES station number; ranges from 1 through 12 for KN199-04 and 1 through 24 for KN204-01. Stations 7 and 9 were skipped on KN204-01. Values were added from the intermediate US GEOTRACES master file (see Processing Description). | integer |
| cast_GEOTRC | Cast identifier, numbered consecutively within a station. PI-supplied values were identical to those in the intermediate US GEOTRACES master file. Values were added from the intermediate US GEOTRACES master file (see Processing Description). | integer |
| instr | Type of sampling instrument used. | text |

| | | |
|---|---|---|
| depth_w | Bottom depth. | meters |
| depth | Sample depth; provided by PI in original data submission. | meters |
| Ra223 | Radium-223 disintegrations per minute per 100 liters. | dpm/100L |
| Ra223_flag | Quality flag for Ra223. See 'Processing Description' for code definitions. | unitless |
| Ra224 | Radium-224 disintegrations per minute per 100 liters. | dpm/100L |
| Ra224_flag | Quality flag for Ra224. See 'Processing Description' for code definitions. | unitless |
| Ra228 | Radium-228 disintegrations per minute per 100 liters. | dpm/100L |
| Ra228_flag | Quality flag for Ra228. See 'Processing Description' for code definitions. | unitless |
| Ra226 | Radium-226 disintegrations per minute per 100 liters. | dpm/100L |
| Ra226_flag | Quality flag for Ra226. See 'Processing Description' for code definitions. | unitless |
| Th228_tot | Total Thorium-228 disintegrations per minute per 100 liters. | dpm/100L |
| Th228_tot_flag | Quality flag for Th228_tot. See 'Processing Description' for code definitions. | unitless |
| Th228_part | Particulate Thorium-228 disintegrations per minute per 100 liters. | dpm/100L |
| Th228_part_flag | Quality flag for Th228_part. See 'Processing Description' for code definitions. | unitless |
| Th228_diss | Dissolved Thorium-228 disintegrations per minute per 100 liters. | dpm/100L |
| Th228_diss_flag | Quality flag for Th228_diss. See 'Processing Description' for code definitions. | unitless |
| exRa224 | Radium-224 corrected for 228Th. | dpm/100L |

| | | |
|---|---|---|
| exRa224_flag | Quality flag for exRa224. See 'Processing Description' for code definitions. | unitless |
| exRa223 | Radium-223 corrected for 227Ac . | dpm/100L |
| exRa223_flag | Quality flag for exRa223. See 'Processing Description' for code definitions. | unitless |
| year | 4-digit year (UTC). | YYYY |
| month | 2-digit month of year (UTC). | mm (01 to 12) |
| day | 2-digit day of month (UTC). | dd (01 to 31) |
| depth_GEOTRC_CTD | Observation/sample depth in meters, calculated from CTD pressure. Values were added from the intermediate US GEOTRACES master file (see Processing Description). | meters |
| sample_bottle_GEOTRC | Unique identification numbers given to samples taken from bottles; ranges from 1 to 24; often used synonymously with bottle number.<br>Values were added from the intermediate US GEOTRACES master file (see Processing Description). | unitless |
| bottle_GEOTRC | Alphanumeric characters identifying bottle type (e.g., NIS representing Niskin and GF representing GOFLO) and position on a CTD rosette.<br>Values were added from the intermediate US GEOTRACES master file (see Processing Description). | unitless |
| BTL_ISO_DateTime_UTC | Date and time (UTC) variable recorded at the bottle sampling time in ISO compliant format. Values were added from the intermediate US GEOTRACES master file (see Processing Description).<br><br>This standard is based on ISO 8601:2004(E) and takes on the following form:<br>2009-08-30T14:05:00[.xx]Z (UTC time) | YYYY-mm-ddTHH:MM:SS.ssZ |
| cruise_part | Part of cruise. For KN204-01: A = 11/6/2011 to 11/18/2011 (Woods Hole to Bermuda); B = 11/19/2011 to 12/11/2011 (Bermuda to Praia, Cabo Verde). | A or B |

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## Instruments

| | |
|---|---|
| **Dataset-specific Instrument Name** | Large Volume Pumping System -WTS-LV |
| **Generic Instrument Name** | McLane Large Volume Pumping System WTS-LV |
| **Dataset-specific Description** | Radium was collected onto a manganese-coated acrylic cartridge filtered at depth using an adapted McLane (WTS-LV) pump programmed to filter 1500-2000L of seawater per deployment. |
| **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. |

| | |
|---|---|
| **Dataset-specific Instrument Name** | Radium Delayed Coincidence Counter |
| **Generic Instrument Name** | Radium Delayed Coincidence Counter |
| **Dataset-specific Description** | Samples were analyzed three times using an Alpha delayed coincidence counter (RaDeCC) for 223Ra, 224Ra, 228Th, and 227Ac. |
| **Generic Instrument Description** | The RaDeCC is an alpha scintillation counter that distinguishes decay events of short-lived radium daughter products based on their contrasting half-lives. This system was pioneered by Giffin et al. (1963) and adapted for radium measurements by Moore and Arnold (1996). References: Giffin, C., A. Kaufman, W.S. Broecker (1963). Delayed coincidence counter for the assay of actinon and thoron. J. Geophys. Res., 68, pp. 1749-1757. Moore, W.S., R. Arnold (1996). Measurement of 223Ra and 224Ra in coastal waters using a delayed coincidence counter. J. Geophys. Res., 101 (1996), pp. 1321-1329. Charette, Matthew A.; Dulaiova, Henrieta; Gonneea, Meagan E.; Henderson, Paul B.; Moore, Willard S.; Scholten, Jan C.; Pham, M. K. (2012). GEOTRACES radium isotopes interlaboratory comparison experiment. Limnology and Oceanography - Methods, vol 10, pg 451. |

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## Deployments

**KN199-04**

| | |
|---|---|
| **Website** | https://www.bco-dmo.org/deployment/58066 |
| **Platform** | R/V Knorr |
| **Report** | http://bcodata.whoi.edu/US_GEOTRACES/AtlanticSection/Cruise_Report_for_Knorr_199_Final_v3.pdf |
| **Start Date** | 2010-10-15 |
| **End Date** | 2010-11-04 |
| **Description** | This cruise constitutes the first survey section as part of the U.S. participation in an international program named GEOTRACES. Funding: NSF OCE award 0926423 Science Objectives: To obtain state of the art trace metal and isotope measurements on a suite of samples taken on a mid-latitude zonal transect of the North Atlantic. In particular, sampling targeted the oxygen minimum zone extending off the west African coast near Mauritania, the TAG hydrothermal field, and the western boundary current system along Line W. For additional information, please refer to the GEOTRACES program Web site (https://www.geotraces.org/) for overall program objectives and a summary of properties measured. Science Activities include seawater sampling via GoFLO and Niskin carousels, in situ pumping (and filtration), CTDO2 and transmissometer sensors, underway pumped sampling of surface waters, and collection of aerosols and rain. Hydrography, CTD and nutrient measurements were supported by the Ocean Data Facility (J. Swift) at Scripps Institution of Oceanography and funded through NSF Facilities. They provided an additional CTD rosette system along with nephelometer and LADCP. A trace metal clean Go-Flo Rosette and winch were provided by the group at Old Dominion University (G. Cutter) along with a towed underway pumping system. Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/KN199-04 Other Relevant Links: List of cruise participants: [ PDF ] Cruise track: JPEG image (from Woods Hole Oceanographic Institution, vessel operator) ADCP data are available from the Currents ADCP group at the University of Hawaii: KN199-04 ADCP |

**KN204-01**

| | |
|---|---|
| **Website** | https://www.bco-dmo.org/deployment/58786 |
| **Platform** | R/V Knorr |
| **Report** | http://bcodata.whoi.edu/US_GEOTRACES/AtlanticSection/STS_Prelim_GT11_Doc.pdf |
| **Start Date** | 2011-11-06 |
| **End Date** | 2011-12-11 |
| **Description** | The US GEOTRACES North Atlantic cruise aboard the R/V Knorr completed the section between Lisbon and Woods Hole that began in October 2010 but was rescheduled for November-December 2011. The R/V Knorr made a brief stop in Bermuda to exchange samples and personnel before continuing across the basin. Scientists disembarked in Praia, Cape Verde, on 11 December. The cruise was identified as KN204-01A (first part before Bermuda) and KN204-01B (after the Bermuda stop). However, the official deployment name for this cruise is KN204-01 and includes both part A and B. Science activities included: ODF 30 liter rosette CTD casts, ODU Trace metal rosette CTD casts, McLane particulate pump casts, underway sampling with towed fish and sampling from the shipboard "uncontaminated" flow-through system. Full depth stations are shown in the accompanying figure (see below). Additional stations to sample for selected trace metals to a depth of 1000 m are not shown. Standard stations are shown in red (as are the ports) and "super" stations, with extra casts to provide large-volume samples for selected parameters, are shown in green. Station spacing is concentrated along the western margin to evaluate the transport of trace elements and isotopes by western boundary currents. Stations across the gyre will allow scientists to examine trace element supply by Saharan dust, while also contrasting trace element and isotope distributions in the oligotrophic gyre with conditions near biologically productive ocean margins, both in the west, to be sampled now, and within the eastern boundary upwelling system off Mauritania, sampled last year. Funding: The cruise was funded by NSF OCE awards 0926204, 0926433 and 0926659. Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/KN204-01 Other Relevant Links: ADCP data are available from the Currents ADCP group at the University of Hawaii at the links below: KN204-01A (part 1 of 2011 cruise; Woods Hole, MA to Bermuda) KN204-01B (part 2 of 2011 cruise; Bermuda to Cape Verde) |

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## Project Information

**U.S. GEOTRACES North Atlantic Transect (GA03) (U.S. GEOTRACES NAT)**

**Website**: https://www.geotraces.org/

**Coverage**: Subtropical western and eastern North Atlantic Ocean (GA03)

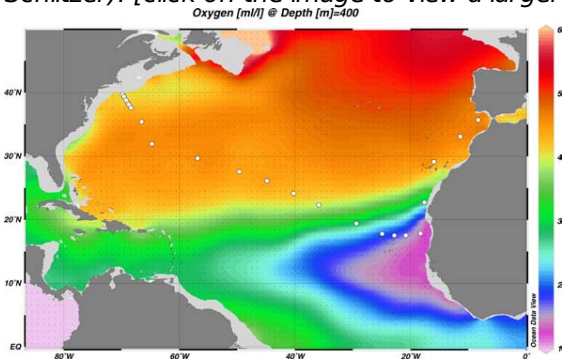
*Much of this text appeared in an article published in OCB News, October 2008, by the OCB Project Office.*

The first U.S. GEOTRACES Atlantic Section will be specifically centered around a sampling cruise to be carried out in the North Atlantic in 2010. Ed Boyle (MIT) and Bill Jenkins (WHOI) organized a three-day planning workshop that was held September 22-24, 2008 at the Woods Hole Oceanographic Institution. The main goal of the workshop, sponsored by the National Science Foundation and the U.S. GEOTRACES Scientific Steering Committee, was to design the implementation plan for the first U.S. GEOTRACES Atlantic Section. The primary cruise design motivation was to improve knowledge of the sources, sinks and internal cycling of Trace Elements and their Isotopes (TEIs) by studying their distributions along a section in the North Atlantic (Figure 1). The North Atlantic has the full suite of processes that affect TEIs, including strong meridional advection, boundary scavenging and source effects, aeolian deposition, and the salty Mediterranean Outflow. The North Atlantic is particularly important as it lies at the "origin" of the global Meridional Overturning Circulation.

It is well understood that many trace metals play important roles in biogeochemical processes and the carbon cycle, yet very little is known about their large-scale distributions and the regional scale processes that affect them. Recent advances in sampling and analytical techniques, along with advances in our understanding of their

roles in enzymatic and catalytic processes in the open ocean provide a natural opportunity to make substantial advances in our understanding of these important elements. Moreover, we are motivated by the prospect of global change and the need to understand the present and future workings of the ocean's biogeochemistry. The GEOTRACES strategy is to measure a broad suite of TEIs to constrain the critical biogeochemical processes that influence their distributions. In addition to these "exotic" substances, more traditional properties, including macronutrients (at micromolar and nanomolar levels), CTD, bio-optical parameters, and carbon system characteristics will be measured. The cruise starts at Line W, a repeat hydrographic section southeast of Cape Cod, extends to Bermuda and subsequently through the North Atlantic oligotrophic subtropical gyre, then transects into the African coast in the northern limb of the coastal upwelling region. From there, the cruise goes northward into the Mediterranean outflow. The station locations shown on the map are for the "fulldepth TEI" stations, and constitute approximately half of the stations to be ultimately occupied.

*Figure 1. The proposed 2010 Atlantic GEOTRACES cruise track plotted on dissolved oxygen at 400 m depth. Data from the World Ocean Atlas (Levitus et al., 2005) were plotted using Ocean Data View (courtesy Reiner Schlitzer). [click on the image to view a larger version]*

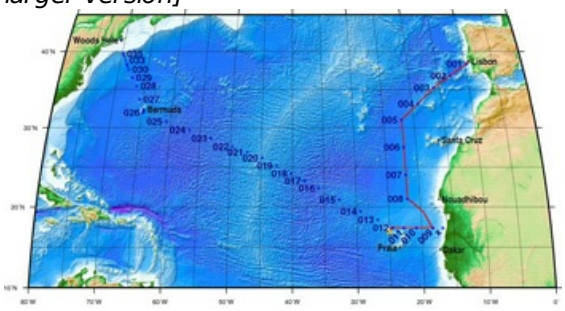



Hydrography, CTD and nutrient measurements will be supported by the Ocean Data Facility (J. Swift) at Scripps Institution of Oceanography and funded through NSF Facilities. They will be providing an additional CTD rosette system along with nephelometer and LADCP. A trace metal clean Go-Flo Rosette and winch will be provided by the group at Old Dominion University (G. Cutter) along with a towed underway pumping system.

The North Atlantic Transect cruise began in 2010 with KN199 leg 4 (station sampling) and leg 5 (underway sampling only) (Figure 2).

KN199-04 Cruise Report (PDF)

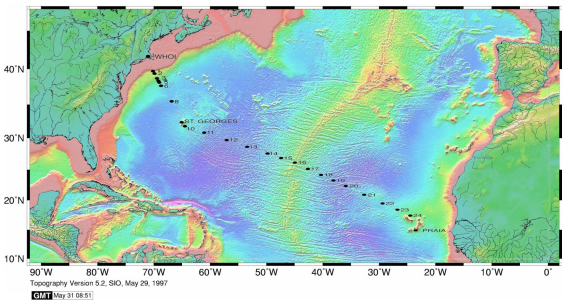
*Figure 2. The red line shows the cruise track for the first leg of the US Geotraces North Atlantic Transect on the R/V Knorr in October 2010. The rest of the stations (beginning with 13) will be completed in October-December 2011 on the R/V Knorr (courtesy of Bill Jenkins, Chief Scientist, GNAT first leg). [click on the image to view a larger version]*




The section completion effort resumed again in November 2011 with KN204-01A,B (Figure 3).

KN204-01A,B Cruise Report (PDF)

*Figure 3. Station locations occupied on the US Geotraces North Atlantic Transect on the R/V Knorr in November 2011. [click on the image to view a larger version]*




Data from the North Atlantic Transect cruises are available under the Datasets heading below, and consensus values for the SAFe and North Atlantic GEOTRACES Reference Seawater Samples are available from the GEOTRACES Program Office: Standards and Reference Materials

**ADCP data** are available from the Currents ADCP group at the University of Hawaii at the links below:
KN199-04 (leg 1 of 2010 cruise; Lisbon to Cape Verde)
KN199-05 (leg 2 of 2010 cruise; Cape Verde to Charleston, NC)
KN204-01A (part 1 of 2011 cruise; Woods Hole, MA to Bermuda)
KN204-01B (part 2 of 2011 cruise; Bermuda to Cape Verde)

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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-0925158 |


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