Depth profiles of seawater dissolved 232Th, 230Th, and 231Pa from RVIB Nathaniel B. Palmer cruise NBP1702 from January to March 2017

Website: https://www.bco-dmo.org/dataset/813379
Data Type: Cruise Results
Version: 2
Version Date: 2021-08-03

Project
» Water Mass Structure and Bottom Water Formation in the Ice-age Southern Ocean (GSc02) (SNOWBIRDS)

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

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Abstract
This dataset contains depth profiles of seawater dissolved 232Th, 230Th, and 231Pa from cruise NBP1702 (GEOTRACES-compliant).

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Coverage

Spatial Extent: **N**:-53.835 **E**:-169.598 **S**:-66.975 **W**:-173.907
Temporal Extent: 2017-01-29 - 2017-03-01

Dataset Description

This dataset contains depth profiles of seawater dissolved 232Th, 230Th, and 231Pa from cruise NBP1702 (GEOTRACES-compliant).

Dataset Notes:
Radionuclide concentrations are given as micro-Becquerel (10-6 Bq, µBq or micro-Bq) per kg seawater for 230Th and 231Pa, and pmol (10-12 mol) per kg seawater for 232Th. A Becquerel is the SI unit for radioactivity and is defined as 1 disintegration per second. These units are recommended by the GEOTRACES community.

"Dissolved" (D) here refers to that which passed through a 0.45 µm AcropakTM 500 filter capsule sampled

from conventional Niskin bottles.

For dissolved, seawater was weighed directly in the laboratory to determine sample size, taking into account acid added at sea. Concentrations below detection are listed as "bdl". The abbreviation "nd" refers to no data available.

Parameter names are adopted based on a recommendation from the GEOTRACES community (http://www.egeotraces.org/Parameter_Naming_Conventions.html).

This is data measured at Lamont-Doherty Earth Observatory of Columbia University (LDEO).

Methods & Sampling

Dissolved data:
Water samples were collected with a Sea-Bird Electronics CTD carousel fitted with 24 12-liter PVC Niskin bottles.The carousel was lowered from the ship with steel wire. Niskin bottles were equipped with nylon-coated closure springs and Viton O-rings. After collection seawater was drained with Teflon-lined TygonTM tubing and filtered through Pall AcropakTM 500 filters on deck (gravity filtration, 0.8/0.45 µm pore size) into Fisher I-Chem series 300 LDPE cubitainers. Approximately 5L was collected per desired depth. Prior to the cruise, the tubing, filters and cubitainers were cleaned by immersion in 1.2 M HCl (Fisher Scientific Trace Metal Grade) for 4-5 days. Once filtered, samples were adjusted to a pH ~2 with ultra-clean 6 M HCl (Fisher Scientific OPTIMA grade), double-bagged, stored in pallet boxes until the end of the cruise and then at room temperature once shipped to the participating laboratories analysis.

Analytical methods for dissolved radionuclides:
LDEO:
In the on-shore laboratory, seawater samples were weighed to determine sample size, taking into account the weight of the cubitainer and of the acid added at sea. Then weighed aliquots of the artificial isotope yield monitors 229Th (20 pg) and 233Pa (0.5 pg) and 15 mg dissolved Fe were added to each sample. After allowing 1 day for spike equilibration, the pH of each sample was raised to 8.3-8.7 by adding ~12 mL of concentrated NH4OH (Fisher Scientific OPTIMA grade) which caused iron (oxy)hydroxide precipitates to form. Each sample cubitainer was fitted with a nozzle cap, inverted, and the Fe precipitate was allowed to settle for 2 days. After 2 days, the nozzle caps were opened and the pH~8.3-8.7 water was slowly drained, leaving only the iron oxyhydroxide precipitate and 250-500mL of water. The Fe precipitate was transferred to centrifuge tubes for centrifugation and rinsing with Milli-Q H2O (>18 MΩ) to remove the major seawater ions. The precipitate was then dissolved in 16 M HNO3 (Fisher Scientific OPTIMA grade) and transferred to a Teflon beaker for a high-temperature (180-200°C) digestion with HClO4 and HF (Fisher Scientific OPTIMA grade) on a hotplate in a HEPA-filtered laminar flow hood. After total dissolution of the sample, another precipitation of iron (oxy)hydroxide followed and the precipitate was washed with Mill-Q H2O, centrifuged, and dissolved in 12 M HCl for a series of anion-exchange chromatography using 6 mL polypropylene columns each containing a 1 mL bed of Bio-rad resin (AG1-X8, 100-200 mesh size) and a 45 µm porous polyethylene frit (Anderson et al. 2012). The final column elutions were dried down at 180°C in the presence of 2 drops of HClO4 and taken up in approximately 1 mL of 0.16 M HNO3/0.026 M HF for mass spectrometric analysis.

Concentrations of 232Th, 230Th and 231Pa were calculated by isotope dilution, relative to the calibrated tracers 229Th and 233Pa added at the beginning of sample processing. Analyses were carried out on a Thermo-Finnegan ELEMENT XR Single Collector Magnetic Sector ICP-MS, equipped with a high-performance Interface pump (Jet Pump), and specially-designed sample (X) and skimmer (Jet) cones to ensure the highest possible sensitivity. All measurements were made in low-resolution mode (Δm/M≈300), peak jumping in Escan mode across the central 5% of the flat-topped peaks. Measurements were made on a MasCom™ SEM; 229Th, 230Th,231Pa and 233Pa were measured in Counting mode, while the 232Th signals were large enough that they were measured in Analog mode. Two solutions of SRM129, a natural U standard, were run multiple times throughout each run. One solution was in a concentration range where 238U and 235U were both measured in counting mode, allowing us to determine the mass bias/amu (typical values varied from -0.01/amu to 0.03/amu). In the other, more concentrated solution, 238U was measured in Analog mode and 235U was measured in Counting mode, yielding a measurement of the Analog/Counting Correction Factor. These corrections assume that the mass bias and Analog Correction Factor measured on U isotopes can be applied to Th and Pa isotope measurements. Each sample measurement was bracketed by measurement of an aliquot of the run solution, used to correct for the instrumental background count rates. To correct for tailing of 232Th into the minor Th and Pa isotopes, a series of 232Th standards were run at concentrations bracketing the expected 232Th concentrations in the samples. The analysis routine for these standards was identical to

the analysis routine for samples, so we could see the changing beam intensities at the minor masses as we increased the concentration of the 232Th standards. The 232Th count rates in our Pa fractions are quite small, reflecting mainly reagent blanks, compared to the 232Th signal intensity in the Th fraction. The regressions of 230Th, 231Pa, and 233Pa signals as a function of the 232Th signal in the standards was used to correct for tailing of 232Th in samples.

Water samples were analyzed in batches of 15. Procedural blanks were determined by processing two 4-5 L of Milli-Q water in an acid-cleaned cubitainer acidified to pH ~2 with 6 M HCl as a sample in each batch. An aliquot of two intercalibrated working standard solutions of 232Th, 230Th and 231Pa, SW STD 2010-1 referred to by Anderson et al. (2012) and SW STD 2015-1 which has lower 232Th activity (more similar to Pacific seawater conditions), were also processed like a sample in each batch. Samples were corrected using the pooled average of all procedural blanks run during processing of NBP1702 samples, with the exception of two batches (30 samples). It was discovered that the 233Pa spike added to these batches also contained ~0.4fg of 231Pa. The samples which had this contaminated spike added were blank corrected for 231Pa using the average 231Pa values in the two procedural blanks run in each of those two batches. The average procedural blanks (not including two batches with high 231Pa in the 233Pa spike) for 232Th, 230Th, and 231Pa were 3.2 pg, 0.25 fg, and 0.01 fg respectively.

Derived Parameters:

Th_230_D_XS_CONC_BOTTLE - The dissolved excess Th-230 concentration refers to the measured dissolved Th-230 corrected for a contribution of Th-230 due to the partial dissolution of uranium-bearing minerals, or lithogenics. Thereby the dissolved excess represents solely the fraction of Th-230 produced in the water by decay of dissolved uranium-234. We estimate the lithogenic Th-230 using measuring dissolved Th-232 and a lithogenic Th-230/Th-232 ratio of 4.0e-6 (atom ratio) as determined by Roy-Barman et al. (2002) and a conversion factor to convert picomoles to micro-Becquerels.

Th_230_D_XS_CONC_BOTTLE = Th_230_D_CONC_BOTTLE – 4.0e-6 *1.7473e5 * Th_232_D_CONC_BOTTLE

Pa_231_D_XS_CONC_BOTTLE - The dissolved excess Pa-231 concentration refers to the measured dissolved Pa-231 corrected for a contribution of Pa-231 due to the partial dissolution of uranium-bearing minerals, or lithogenics. Thereby the dissolved excess represents solely the fraction of Pa-231 produced in the water by decay of dissolved uranium-235. We estimate the lithogenic Pa-231 using measuring dissolved Th-232 and a lithogenic Pa-231/Th-232 ratio of 8.8e-8 (atom ratio) which is derived from assuming an average upper continental crustal U/Th ratio (Taylor and McClennan, 1995) and secular equilibrium between Pa-231 and U-235 in the lithogenic material. An additional conversion factor is needed to convert picomoles to micro-Becquerels.

Pa_231_D_XS_CONC_BOTTLE = Pa_231_D_CONC_BOTTLE – 8.8e-8 * 4.0370e5 * Th_232_D_CONC_BOTTLE

The correction for dissolved 231Pa and 230Th derived from dissolution of lithogenic particles, when calculating xs230Th and xs231Pa is small. Therefore, even for a sample where the 232Th, used to make the correction, is flagged as bad, the error contributed in calculating xs230Th nd xs231Pa is small, so they are flagged as questionable (2). See the Processing Description for complete quality flag definitions.

Data Processing Description

Data Processing:
The reported errors for radionuclide concentrations represent the propagation of one sigma errors based on the standard isotope ratios collected by ICP-MS, estimated error in the 229Th or 233Pa spike concentration, and the blank correction of the individual isotopes.

Analysis of all samples was completed over the course of multiple years. A correction was made to account for the ingrowth of 230Th and 231Pa due to the decay of the natural 234U and 235U preserved in the acidified samples during the period of time between sample collection and U-Th/Pa separation during anion exchange chromatography. Thus, the reported 230Th and 231Pa concentrations have been corrected to represent their concentrations at the time of sampling. U concentrations in the samples were estimated using the salinity (S) measured from the CTD and the U-Salinity relationship in seawater (Owens et al. 2011), [U] = (0.100*S – 0.326) ng U (g seawater)-1. We used seawater U-isotopic compositions of 234U/238 U = 1.1468 activity ratio (Andersen et al., 2010), and 238U/235U = 137.824 mole ratio (Weyer et al., 2008), to calculate [234U] and [235U] respectively based on [U].

Individual uncertainties for thorium were calculated to include contributions from (a) blank correction using the

variance of the blanks measured over the course of the analyses, (b) standard error of the ratios of the analysis (typically close to counting statistics) and (c) spike calibration. For Pa we also included assessment of the uncertainty from the yield correction, mass bias and machine background. In order to assess the reproducibility of the procedure, repeat analyses were performed on the GEOTRACES 2010-1 and 2015-1 standards. For standards run alongside NBP1702 samples, the reproducibility for each isotope was 2.12% for 230Th, 0.87% for 232Th and 1.76% for 231Pa on SW STD 2010-1, and was 0.87% for 230Th, 3.78% for 232Th and 2.69% for 231Pa on SW STD 2015-1.

Data quality flags:
SeaDataNet data quality flags have been assigned to all reported parameters except for the derived parameters Th_230_D_XS_CONC_BOTTLE and Pa_231_D_XS_CONC_BOTTLE. More information on SeaDataNet flags is available from GEOTRACES at http://www.geotraces.org/library-88/geotraces-policies/1577-geotraces-quality-flag-policy and from SeaDataNet at https://www.seadatanet.org/Standards/Data-Quality-Control. In summary:
0 = no quality control;
1 = good value;
2 = probably good value;
3 = probably bad value;
4 = bad value;
5 = changed value;
6 = value below detection (BDL);
7 = value in excess;
8 = interpolated value;
9 = missing value.

Flag definitions for Th_230_D_XS_CONC_BOTTLE:
1 = Both 230Th and 232Th data good;
2 = 232Th data bad but 230Th data good;
3 = 230Th data bad.

Flag definitions for Pa_231_D_XS_CONC_BOTTLE:
1 = Both 231Pa and 232Th data good;
2 = 232Th data bad but 231Pa data good;
3 = 231Pa data bad.

BCO-DMO Processing:
- renamed fields;
- rounded values to precision request by data submitter;
- added ISO8601 date/time columns.
Version history:
  2021-08-03 (v2; current) - dataset updated to version 2, which includes the addition of CTD hydrographic data columns.
  2020-06-03 (v1) - version 1 published at BCO-DMO.

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Data Files

File
dissolved_Th_Pa.csv(Comma Separated Values (.csv), 26.89 KB) MD5:f79eb34cad89f5db280bb64d1669dba4 Primary data file for dataset ID 813379

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Related Publications

Andersen, M. B., Stirling, C. H., Zimmermann, B., & Halliday, A. N. (2010). Precise determination of the open ocean 234U/238U composition. Geochemistry, Geophysics, Geosystems, 11(12), n/a–n/a. doi:[10.1029/2010gc003318](10.1029/2010gc003318)

Methods

Anderson, R. F., Fleisher, M. Q., Robinson, L. F., Edwards, R. L., Hoff, J. A., Moran, S. B., … Francois, R. (2012). GEOTRACES intercalibration of 230Th, 232Th, 231Pa, and prospects for 10Be. Limnology and Oceanography: Methods, 10(4), 179–213. doi:10.4319/lom.2012.10.179
Methods

Auro, M. E., Robinson, L. F., Burke, A., Bradtmiller, L. I., Fleisher, M. Q., & Anderson, R. F. (2012). Improvements to 232-thorium, 230-thorium, and 231-protactinium analysis in seawater arising from GEOTRACES intercalibration. Limnology and Oceanography: Methods, 10(7), 464–474. doi:10.4319/lom.2012.10.464
General

Cheng, H., Edwards, R. L., Hoff, J., Gallup, C. D., Richards, D. A., & Asmerom, Y. (2000). The half-lives of uranium-234 and thorium-230. Chemical Geology, 169(1-2), 17–33. doi:10.1016/s0009-2541(99)00157-6
General

Owens, S. A., Buesseler, K. O., & Sims, K. W. W. (2011). Re-evaluating the 238U-salinity relationship in seawater: Implications for the 238U–234Th disequilibrium method. Marine Chemistry, 127(1-4), 31–39. doi:10.1016/j.marchem.2011.07.005
Methods

Roy-Barman, M., Coppola, L., & Souhaut, M. (2002). Thorium isotopes in the western Mediterranean Sea: an insight into the marine particle dynamics. Earth and Planetary Science Letters, 196(3-4), 161–174. doi:10.1016/s0012-821x(01)00606-9
Methods

Taylor, S. R., & McLennan, S. M. (1995). The geochemical evolution of the continental crust. Reviews of Geophysics, 33(2), 241. doi:10.1029/95rg00262
Methods

Weyer, S., Anbar, A. D., Gerdes, A., Gordon, G. W., Algeo, T. J., & Boyle, E. A. (2008). Natural fractionation of 238U/235U. Geochimica et Cosmochimica Acta, 72(2), 345–359. doi:10.1016/j.gca.2007.11.012
Methods

Parameters

Parameter	Description	Units
Station_ID	Station number	unitless
Start_Date_UTC	Start date (UTC); format: DD/MM/YYYY	unitless
Start_Time_UTC	Start time (UTC); format: hh:mm	unitless
Start_ISO_DateTime_UTC	Start date and time (UTC) formatted to ISO8601 standard: YYYY-MM-DDThh:mmZ	unitless
End_Date_UTC	End date (UTC); format: DD/MM/YYYY	unitless
End_Time_UTC	End time (UTC); format: hh:mm	unitless

End_ISO_DateTime_UTC	End date and time (UTC) formatted to ISO8601 standard: YYYY-MM-DDThh:mmZ	unitless
Start_Latitude	Start latitude	degrees North
Start_Longitude	Start longitude	degrees East
End_Latitude	End latitude	degrees North
End_Longitude	End longitude	degrees East
Event_ID	Event number	unitless
Sample_ID	Sample number	unitless
Sample_Depth	Sample depth	meters (m)
Th_230_D_CONC_BOTTLE_xucmu6	Dissolved Th-230 concentration	uBq/kg
SD1_Th_230_D_CONC_BOTTLE_xucmu6	One standard deviation of Th_230_D_CONC_BOTTLE_xucmu6	uBq/kg
Flag_Th_230_D_CONC_BOTTLE_xucmu6	Quality flag for Th_230_D_CONC_BOTTLE_xucmu6	None
Th_232_D_CONC_BOTTLE_bwiimj	Dissolved Th-232 concentration	pmol/kg
SD1_Th_232_D_CONC_BOTTLE_bwiimj	One standard deviation of Th_232_D_CONC_BOTTLE_bwiimj	pmol/kg
Flag_Th_232_D_CONC_BOTTLE_bwiimj	Quality flag for Th_232_D_CONC_BOTTLE_bwiimj	None
Pa_231_D_CONC_BOTTLE_yq8ckw	Dissolved Pa-231 concentration	uBq/kg
SD1_Pa_231_D_CONC_BOTTLE_yq8ckw	One standard deviation of Pa_231_D_CONC_BOTTLE_yq8ckw	uBq/kg
Flag_Pa_231_D_CONC_BOTTLE_yq8ckw	Quality flag for Pa_231_D_CONC_BOTTLE_yq8ckw	None

Th_230_D_XS_CONC_BOTTLE	Dissolved Th-230 concentration corrected for the dissolution of lithogenic minerals, thereby isolating the dissolved Th-230 produced by decay of dissolved uranium	uBq/kg
Th_230_D_XS_CONC_BOTTLE_ERR	One standard deviation of Th_230_D_XS_CONC_BOTTLE	uBq/kg
Th_230_D_XS_CONC_BOTTLE_FLAG	Quality flag for Th_230_D_XS_CONC_BOTTLE	none
Pa_231_D_XS_CONC_BOTTLE	Dissolved Pa-231 concentration corrected for the dissolution of lithogenic minerals (see metadata for full explanation)	uBq/kg
Pa_231_D_XS_CONC_BOTTLE_ERR	One standard deviation of Pa_231_D_XS_CONC_BOTTLE	uBq/kg
Pa_231_D_XS_CONC_BOTTLE_FLAG	Quality flag for Pa_231_D_XS_CONC_BOTTLE	none
Pressure	CTD pressure	decibars (db)
CTDSAL_D_CONC_SENSOR	CTD salinity	unitless
CTDTMP_T_VALUE_SENSOR	CTD temperature	degrees Celsius
CTDOXY_D_CONC_SENSOR	CTD oxygen	(umol/kg) micromoles per kilogram

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Instruments

Dataset-specific Instrument Name	
Generic Instrument Name	Centrifuge
Generic Instrument Description	A machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g., cream from milk) or liquids from solids.

Dataset-specific Instrument Name	Sea-Bird Electronics CTD
Generic Instrument Name	CTD Sea-Bird
Generic Instrument Description	A Conductivity, Temperature, Depth (CTD) sensor package from SeaBird Electronics. This instrument designation is used when specific make and model are not known or when a more specific term is not available in the BCO-DMO vocabulary. Refer to the dataset-specific metadata for more information about the specific CTD used. More information from: http://www.seabird.com/

Dataset-specific Instrument Name	Thermo-Finnegan ELEMENT XR Single Collector Magnetic Sector 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.

Dataset-specific Instrument Name	24 12-liter PVC Niskin bottles
Generic Instrument Name	Niskin bottle
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

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Deployments

NBP1702

Website	https://www.bco-dmo.org/deployment/813372
Platform	RVIB Nathaniel B. Palmer
Report	https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/nathanielbpalmer1702.pdf
Start Date	2017-01-23
End Date	2017-03-05
Description	See additional cruise information from the Marine Geoscience Data System (MGDS): http://www.marine-geo.org/tools/entry/NBP1702

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Project Information

Water Mass Structure and Bottom Water Formation in the Ice-age Southern Ocean (GSc02) (SNOWBIRDS)

Website: https://www.snowbirdstransect.org/

Coverage: Pacific Southern Ocean (170ºW from 67ºS to 54ºS)

NSF Award Abstract:
Scientists established more than 30 years ago that the climate-related variability of carbon dioxide levels in the atmosphere over Earth's ice-age cycles was regulated by the ocean. Hypotheses to explain how the ocean regulates atmospheric carbon dioxide have long been debated, but they have proven to be difficult to test. Work proposed here will test one leading hypothesis, specifically that the ocean experienced greater density stratification during the ice ages. That is, with greater stratification during the ice ages and slower replacement of deep water by cold dense water formed near the poles, the deep ocean would have held more carbon dioxide, which is produced by biological respiration of the organic carbon that constantly rains to the abyss in the form of dead organisms and organic debris that sink from the sunlit surface ocean. To test this hypothesis, the degree of ocean stratification during the last ice age and the rate of deep-water replacement will be constrained by comparing the radiocarbon ages of organisms that grew in the surface ocean and at the sea floor within a critical region around Antarctica, where most of the replacement of deep waters occurs. Completing this work will contribute toward improved models of future climate change. Climate scientists rely on models to estimate the amount of fossil fuel carbon dioxide that will be absorbed by the ocean in the future. Currently the ocean absorbs about 25% of the carbon dioxide produced by burning fossil fuels. Most of this carbon is absorbed in the Southern Ocean (the region around Antarctica). How this will change in the future is poorly known. Models have difficulty representing physical conditions in the Southern Ocean accurately, thereby adding substantial uncertainty to projections of future ocean uptake of carbon dioxide. Results of the proposed study will provide a benchmark to test the ability of models to simulate ocean processes under climate conditions distinctly different from those that occur today, ultimately leading to improvement of the models and to more reliable projections of future absorption of carbon dioxide by the ocean.

The proposed work will add a research component to an existing scientific expedition to the Southern Ocean, in the region between the Ross Sea and New Zealand, that will collect sediment cores at three to five locations down the northern flank of the Pacific-Antarctic Ridge at approximately 170°W. The goal is to collect sediments at each location deposited since early in the peak of the last ice age. This region is unusual in the Southern Ocean in that sediments deposited during the last ice age contain foraminifera, tiny organisms with calcium carbonate shells, in much greater abundance than in other regions of the Southern Ocean. Foraminifera are widely used as an archive of several geochemical tracers of past ocean conditions. In the proposed work the radiocarbon age of foraminifera that inhabited the surface ocean will be compared with the age of contemporary specimens that grew on the seabed. The difference in age between surface and deep-swelling organisms will be used to discriminate between two proposed mechanisms of deep water renewal during the ice age: formation in coastal polynyas around the edge of Antarctica, much as occurs today, versus formation by open-ocean convection in deep-water regions far from the continent. If the latter mechanism prevails, then it is expected that surface and deep-dwelling foraminifera will exhibit similar radiocarbon ages. In the case of dominance of deep-water formation in coastal polynyas, one expects to find very different radiocarbon ages in the two populations of foraminifera. In the extreme case of greater ocean stratification during the last ice age, one even expects the surface dwellers to appear to be older than contemporary bottom dwellers because the targeted core sites lie directly under the region where the oldest deep waters return to the surface following their long circuitous transit through the deep ocean. The primary objective of the proposed work is to reconstruct the water mass age structure of the Southern Ocean during the last ice age, which, in turn, is a primary factor that controls the amount of carbon dioxide stored in the deep sea. In addition, the presence of foraminifera in the cores to be recovered provides a valuable resource for many other paleoceanographic applications, such as: 1) the application of nitrogen isotopes to constrain the level of nutrient utilization in the Southern Ocean and, thus, the efficiency of the ocean?s biological pump, 2) the application of neodymium isotopes to constrain the transport history of deep water masses, 3) the application of boron isotopes and boron/calcium ratios to constrain the pH and inorganic carbon system parameters of ice-age seawater, and 4) the exploitation of metal/calcium ratios in foraminifera to reconstruct the temperature (Mg/Ca) and nutrient content (Cd/Ca) of deep waters during the last ice age at a location near their source near Antarctica.

Note: Project Acronym "SNOWBIRDS" = **S**ilicon and **N**itrogen **O**bserved in the **W**ater column **B**iologic **I**sotope **R**ecords **D**uring **S**edimentation

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.

Funding

Funding Source	Award
NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)	OPP-1542962