Water column total and particulate Thorium-234 from 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/985536
Data Type: Cruise Results
Version: 1
Version Date: 2025-10-16

Project
» Collaborative Research: US GEOTRACES GP17-OCE and GP17-ANT: Export and remineralization rates of bioactive and particle reactive trace elements using thorium-234 (GP17-OCE and GP17-ANT Th-234)

Contributors	Affiliation	Role
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Abstract
This dataset reports water column total Thorium-234 from GP17-OCE (Tahiti, French Polynesia to Punta Arenas, Chile) of the US GEOTRACES cruise on R/V Roger Revelle from December 2022 to January 2023. U-238 from U-salinity relationship was also determined but not reported in this dataset. This data can be made available upon request from the PI and/or dataset contact. Methods are described below.

Table of Contents

- Coverage
- Dataset Description
  - Methods & Sampling
  - Data Processing Description
  - BCO-DMO Processing Description
  - Problem Description
- Data Files
- Related Publications
- Parameters
- Instruments
- Deployments
- Project Information
- Funding

Coverage

Spatial Extent: **N**:-20 **E**:-75.748 **S**:-67.005 **W**:-152
Temporal Extent: 2022-12-04 - 2023-01-23

Methods & Sampling

Sampling details:
Approximately 28 discrete total Th-234 samples were collected throughout the water column, a minimum of 12 depths were chosen in the upper 1000 meters (m).

Full stations: approximately 20 discrete total Th-234 samples were collected throughout the water column, a minimum of 12 depths were chosen in the upper 1000 m.

Demi and Shelf Stations: 13 discrete total Th-234 samples were collected. At shelf stations, depths spanned the entire water column, and at demi stations, the upper 1000 m was sampled.

The shipboard procedures follow Pike et al. (2005) and Clevenger et al., 2021.

Total water-column Thorium-234:
234Th was determined by following the methods of Pike, et al. (2005) and Clevenger, et al. (2021) on 2-liter (L) water column samples, which have been utilized previously for other GEOTRACES efforts (e.g. Owens et al., 2015). An exact 1-milliliter (mL) aliquot of 230Th (50.03 disintegrations per minute per gram (dpm g^{-1})) was used as the yield monitor and added during initial acidification of the samples. QMAs were used to collect the precipitate from the 2 L process and immediately dried. Once dried, they were mounted onto plastic 25-millimeter (mm) discs, covered with a mylar layer and two layers of aluminum foil, and immediately beta counted at sea. The filters were counted again, 5 to 6 months later to quantify the background radioactivity due to the beta decay of long-lived natural radionuclides that are also precipitated. The mean value of the at-sea counts (decay-corrected to the time of collection) minus the background value for each filter is reported as the 234Th activity (milliBecquerels per kilogram (mBq kg^{-1})). Activities for 234Th are generally reported in disintegrations per minute per liter (dpm L^{-1}) but have been converted here using a standard density of 1.028 kilogram per liter (kg L^{-1}) and 1 dpm = 16.667 mBq. Data are decay-corrected to the mid-point time between when the first and last bottles were fired for shallow casts, when the messenger was dropped for deep casts, and the time of collection for fish tow samples. Generally, shallow water column (< 1000 meters (m)) samples were collected from the ODF Rosette, and deep samples (>1000 m) were collected from Niskin bottles hung above in-situ pumps. All fish samples (namely intermediate surface and surface samples) were collected directly from the clean fish tow (denoted as either arriving or intermediate fish, depth 3 m). All data have been recovery-corrected using the 230Th /229Th recovery method (see References) to account for any loss of sample material during processing. All samples were analyzed using Risø Laboratory Anti-Coincidence Beta Counters, using a helium/1% butane mixture.

Uranium-238:
U-238 can be calculated via the equation described in Owens et al. (2011):

U-238 (dpm/L) = (Salinity * 0.0786) – 0.315

Salinity was measured on board the ship by the Scripps Ocean Data Facility (ODF).

Particulate Thorium-234:
Particulate material was collected using in situ McLane pumps (5-24 depths per station, see also GP17-OCE data from Ohnemus group). Approximately 24 discrete particulate Th-234 samples were collected throughout the water column for super stations before losing the pumps on December 25, 2022. The discrete particulate samples per station decreased to an average of 6 per station after December 25. All samples were analyzed using Risø Laboratory Anti-Coincidence Beta Counters, using a helium/1% butane mixture. All Th-234 are measured three times for at least 12 hours or to <5% error. All data were decay-corrected back to mid-pumping times.

>51-micrometer (µm) Th-234 (LPT, large particulate Thorium):
Mesh screens were provided by the Ohnemus group. A whole or partial (3/4) mesh screen was rinsed onto a 25 mm silver filter for beta counting. The mean volume pumped through the whole Supor mesh screens was 800 L.

1-51 µm Th-234 (SPT, small particulate Thorium):
Whole QMAs, located below a mesh screen in the filter head housing, were provided by the Ohnemus group and oven-dried upon recovery. A 25 mm subsample was taken from this whole filter for beta counting for Th-234. The mean effective volume for the 25 mm QMA subsample was 32 L (804 L for entire QMA).

Data Processing Description

Data are decay corrected to the mid-point time between when the first and last bottles were fired for shallow casts and when the messenger was dropped for deep casts samples. Overall method efficiency was determined by minimizing the percent difference between mean 238U and 234Th values for samples from >1000 m to >500 m from the bottom (44.18 %).

BCO-DMO Processing Description

- Imported original file "RR2214_dataThorium Total and Particles.xlsx" into the BCO-DMO system.
- Marked "nd" as a missing data value (missing data are empty/blank in the final CSV file).
- Renamed fields to comply with BCO-DMO naming conventions.
- Created date-time columns in ISO 8601 format.
- Converted dates to YYYY-MM-DD format.
- Removed "N" before bottle numbers in the "Rosette_Position" column.
- Saved final file as "985536_v1_gp17-oce_th-234_total_and_particulate.csv".

Problem Description

Data are originally calculated in dpm/L and then converted to mBq/kg using the standard ocean rho = 1.028 kg/L and 1 dpm = 16.667 mBq. If pumps fail during deployment, the data are either not included or marked with 'nd' for 'no data'.

Quality Flags:
Data flags are according to the SeaDataNet scheme (https://www.geotraces.org/geotraces-quality-flag-policy/) using the following quality indicators:
1 = Good Value;
2 = Probably Good Value.

[table of contents | back to top]

Data Files

File	
985536_v1_gp17-oce_th-234_total_and_particulate.csv	(Comma Separated Values (.csv), 120.78 KB) MD5:2b9dc7d55f3a01d19324b62068a8d83b
Primary data file for dataset ID 985536, version 1	

[table of contents | back to top]

Related Publications

Buesseler, K. O., Pike, S., Maiti, K., Lamborg, C. H., Siegel, D. A., & Trull, T. W. (2009). Thorium-234 as a tracer of spatial, temporal and vertical variability in particle flux in the North Pacific. Deep Sea Research Part I: Oceanographic Research Papers, 56(7), 1143–1167. doi:10.1016/j.dsr.2009.04.001
Methods

Clevenger, S. J., Benitez-Nelson, C. R., Drysdale, J., Pike, S., Puigcorbé, V., & Buesseler, K. O. (2021). Review of the analysis of 234Th in small volume (2–4 L) seawater samples: improvements and recommendations. Journal of Radioanalytical and Nuclear Chemistry, 329(1), 1–13. https://doi.org/10.1007/s10967-021-07772-2
Methods

Maiti, K., Buesseler, K. O., Pike, S. M., Benitez-Nelson, C., Cai, P., Chen, W., … Xu, C. (2012). Intercalibration studies of short-lived thorium-234 in the water column and marine particles. Limnology and Oceanography: Methods, 10(9), 631–644. doi:10.4319/lom.2012.10.631
Methods

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

Pike, S. M., Buesseler, K. O., Andrews, J., & Savoye, N. (2005). Quantification of 234Th recovery in small volume sea water samples by inductively coupled plasma-mass spectrometry. Journal of Radioanalytical and

Nuclear Chemistry, 263(2), 355–360. https://doi.org/10.1007/s10967-005-0062-9
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
Station_ID	GEOTRACES station number	unitless
Event_ID	Event number	unitless
Gear_ID	Type of sampling instrument	unitless
Start_Date_UTC	Event start date (UTC)	unitless
Start_Time_UTC	Event start time (UTC)	unitless
Start_ISO_DateTime_UTC	Date and time (UTC) at start of event in ISO 8601 format	unitless
End_Date_UTC	Event end date (UTC)	unitless
End_Time_UTC	Event end time (UTC). For CTD casts, this is not provided.	unitless
End_ISO_DateTime_UTC	Date and time (UTC) at end of event in ISO 8601 format	unitless
Start_Latitude	Latitude at start of event (+N, -S)	decimal degrees
Start_Longitude	Longitude at end of event (+N, -S)	decimal degrees
End_Latitude	Latitude at end of event (+N, -S)	decimal degrees
End_Longitude	Longitude at end of event (+N, -S)	decimal degrees
Rosette_Position	Position of Niskin Bottle used for sample collection	unitless
Sample_ID	Unique identifying number for US GEOTRACES samples	unitless

Sample_Depth	Actual sample depth from CTD rosette readout	meters (m)
Th_234_T_CONC_BOTTLE_82mvlk	Total Thorium-234 from 2L unfiltered water. Data were decay corrected back to mid-collection time.	milliBecquerel per kilogram (mBq/kg)
SD1_Th_234_T_CONC_BOTTLE_82mvlk	Th_234_T_CONC_BOTTLE uncertainty	milliBecquerel per kilogram (mBq/kg)
Flag_Th_234_T_CONC_BOTTLE_82mvlk	Quality flag for Th_234_T_CONC_BOTTLE. Data were flagged with quality indicators: 1 = Good Value; 2 = Probably Good Value (SeaDataNet flag system). Empty fields denote that there were pump or filterhead issues that resulted in a compromised sample or no sample at this depth for either the QMA or screen or both.	unitless
Th_234_LPT_CONC_PUMP_cgdpur	Particulate Thorium-234 from QMA filters. Particle size of 1 to 51um. Data were decay corrected back to mid-pump times.	milliBecquerel per kilogram (mBq/kg)
SD1_Th_234_LPT_CONC_PUMP_cgdpur	Th_234_LPT_CONC_PUMP uncertainty	milliBecquerel per kilogram (mBq/kg)
Flag_Th_234_LPT_CONC_PUMP_cgdpur	Quality flag for Th_234_LPT_CONC_PUMP. Data were flagged with quality indicators: 1 = Good Value; 2 = Probably Good Value (SeaDataNet flag system). Empty fields denote that there were pump or filterhead issues that resulted in a compromised sample or no sample at this depth for either the QMA or screen or both.	unitless
Th_234_SPT_CONC_PUMP_sgquid	Particulate Thorium-234 from QMA filters. Particle size of 1um. Data were decay corrected back to mid-pump times.	milliBecquerel per kilogram (mBq/kg)
SD1_Th_234_SPT_CONC_PUMP_sgquid	Th_234_SPT_CONC_PUMP uncertainty	milliBecquerel per kilogram (mBq/kg)
Flag_Th_234_SPT_CONC_PUMP_sgquid	Quality flag for Th_234_SPT_CONC_PUMP. Data were flagged with quality indicators: 1 = Good Value; 2 = Probably Good Value (SeaDataNet flag system). Empty fields denote that there were pump or filterhead issues that resulted in a compromised sample or no sample at this depth for either the QMA or screen or both.	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	in situ McLane pumps
Generic Instrument Name	McLane Pump
Dataset-specific Description	Particulate material was collected using in situ McLane pumps (5-24 depths per station, see also GP17-OCE data from Ohnemus group).
Generic Instrument Description	McLane pumps sample large volumes of seawater at depth. They are attached to a wire and lowered to different depths in the ocean. As the water is pumped through the filter, particles suspended in the ocean are collected on the filters. The pumps are then retrieved and the contents of the filters are analyzed in a lab.

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Shallow samples for 234Th were taken using the ODF Rosette and deep samples were taken using niskin bottles hung above in-situ pumps.
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.

Dataset-specific Instrument Name	Riso Laboratory Anti-coincidence Beta Counters
Generic Instrument Name	Riso Laboratory Anti-coincidence Beta Counters
Dataset-specific Description	Efficiency Calibrations: The detectors are intercalibrated with each other and across the transect using high-energy U standards. Limits of Detection: Limits of detection are not reported because they are not applicable to the 234Th beta counting method. A 'non-detect' for 234Th or a case where there is no 234Th present (initially or after 6 months of decay) will still result in a measurable amount of background radioactivity due to the beta decay of long-lived natural radionuclides that are also present. These background values are utilized and therefore, they are not reported as non-detections of 234Th.
Generic Instrument Description	Low-level beta detectors manufactured by Riso (now Nutech) in Denmark. These instruments accept samples that can be mounted on a 25mm filter holder. These detectors have very low backgrounds, 0.17 counts per minute, and can have counting efficiencies as high as 55%. Typically used in laboratory analyses. Designed to measure low levels of beta particle emission. The systems work on the principle of anticoincidence.

[table of contents | back to top]

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

[table of contents | back to top]

Project Information

Collaborative Research: US GEOTRACES GP17-OCE and GP17-ANT: Export and remineralization rates of bioactive and particle reactive trace elements using thorium-234 (GP17-OCE and GP17-ANT Th-234)

NSF Award Abstract:
The overarching goal of the international GEOTRACES Program is 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 environmental conditions.” These trace elements exist at exceeding low concentrations in the ocean, yet play a key role in the growth and distribution of marine organisms, in particular marine phytoplankton. In addition, many trace elements are important to study as pollutants, such as copper and lead, which at high levels can be harmful to marine life. Thus, studies of the trace metal sources and sinks are needed. To meet this goal, the project is designed to measure how quickly these trace elements are cycled through marine food webs, in particular as they are transported by marine snow, i.e. slowly settling marine particles that carry these trace elements and carbon to the deep sea. The work will be conducted aboard two upcoming US GEOTRACES expeditions to the South Pacific, Southern Ocean, and Amundsen Sea. The project will provide training for two postdoctoral investigators, one focused on sample analysis and one on the modeling.

To carry out this study, this proposal will use the naturally occurring particle reactive radionuclide Thorium-234 (234Th, half-life = 24.1 d) to quantify variability in trace elements and isotopes scavenging, residence times, and particle export from the surface ocean and their attenuation into the deep sea. This project will sample across extreme biogeographical and trace elemental gradients that range from the clear waters of the low dust, low productivity South Pacific (GP17-OCE) to the “greenest” high productivity Amundsen Sea and its polynyas in the Southern Ocean (GP17-ANT). Assessing these spatial and vertical gradients requires 234Th sampling at every station (n=66 casts x 13 depths) and measuring the TEI/234Th ratio on particles (n=43 x 8 depths x 2 size classes). There results of this project will lead to an increased understanding of how the trace elements are modified by removal and regeneration associated with scavenging on to, and remineralization off of, sinking particles.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2046790
NSF Division of Ocean Sciences (NSF OCE)	OCE-2046807
NSF Division of Ocean Sciences (NSF OCE)	OCE-2045408

[table of contents | back to top]