

# Water column total and particulate Thorium-234 from Leg 2 (Hilo, HI to Papeete, French Polynesia) of the US GEOTRACES Pacific Meridional Transect (PMT) cruise (GP15, RR1815) on R/V Roger Revelle from October to November 2018

**Website:** <https://www.bco-dmo.org/dataset/812589>

**Data Type:** Cruise Results

**Version:** 1

**Version Date:** 2020-11-18

## Project

» [US GEOTRACES Pacific Meridional Transect](#) (U.S. GEOTRACES PMT)

» [Quantifying Upper Ocean Export and Remineralization of Bioactive and Particle Reactive Trace Elements along the US GEOTRACES Tahiti to Alaska Transect](#) (PMT Upper Ocean Trace Elements)

## Program

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

Contributors	Affiliation	Role
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## Abstract

Water column total and particulate Thorium-234 from Leg 2 (Hilo, HI to Papeete, French Polynesia) of the US GEOTRACES Pacific Meridional Transect (PMT) cruise (GP15, RR1814) on R/V Roger Revelle from October to November 2018.

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## Coverage

**Spatial Extent:** N:18.91 E:-151.95 S:-20 W:-155.26

**Temporal Extent:** 2015-10-25 - 2018-11-23

## Acquisition Description

### Total water-column Thorium-234

<sup>234</sup>Th was determined by the widely-adopted 4 L method (now reduced to a 2 L method, see Pike et al. 2005). (Buesseler et al., 2001), which has been utilized previously for other GEOTRACES efforts (e.g. Owens et al., 2015). An exact 1 mL aliquot of <sup>230</sup>Th (50.03 dpm g<sup>-1</sup>) 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 mm discs, covered with a mylar layer and 2 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  $^{234}\text{Th}$  activity ( $\text{mBq kg}^{-1}$ ). Activities for  $^{234}\text{Th}$  are generally reported in dpm L<sup>-1</sup>, but have been converted here using a standard density of  $1.025 \text{ kg L}^{-1}$  and  $1 \text{ dpm} = 16.667 \text{ mBq}$ . 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 ( $< 1000 \text{ m}$ ) samples were collected from the ODF Rosette and deep samples ( $>1000 \text{ m}$ ) 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  $^{230}\text{Th} / ^{229}\text{Th}$  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.

In order to calculate flux, Th-234 disequilibrium from its parent U-238 must be calculated. U-238 can be calculated via the equation described in Owens et al. (2011):  $\text{U-238 (dpm/L)} = (\text{Salinity} * 0.0786) - 0.315$

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 (16-24 depths per station, see also PMT data from Lam group). All samples were analyzed using Risø Laboratory Anti-coincidence Beta Counters, using a helium/1% butane mixture. All Th-234 are measured 3 times for at least 12 hours or to  $<5\%$  error. All data were decay corrected back to mid-pumping times.

#### **>51 $\mu\text{m}$ Th-234 (LPT, large particulate Thorium)**

Mesh screens were provided by the Lam 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 406 L.

#### **1-51 $\mu\text{m}$ Th-234 (SPT, small particulate Thorium)**

Whole QMAs, located below a mesh screen in the filter head housing, were provided by the Lam 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 41 L (1042 L for entire QMA).

### **Processing Description**

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 underway (fish tow) samples. Overall method efficiency was determined by minimizing the percent difference between mean  $^{238}\text{U}$  and  $^{234}\text{Th}$  values for samples from  $>1000 \text{ m}$  to  $>500 \text{ m}$  from the bottom (44.18 %). Stations that were included to determine method efficiency were chosen to not include samples with potential coastal or hydrothermal influences.

**Problem Report:** Data were flagged with quality indicators: 1 = Good Value; 2 = Probably Good Value; Data is originally calculated in dpm/L and is converted to mBq/kg using the standard ocean  $\rho = 1.0235 \text{ kg/L}$  and  $1 \text{ dpm} = 16.667 \text{ mBq}$ . If pumps failed during deployment, the data is 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/>).

#### **BCO-DMO Processing:**

- renamed fields
- added ISO8601 date/time fields
- corrected years of 2017 and 2019 to 2018

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### **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](https://doi.org/10.1016/j.dsr.2009.04.001)

*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](https://doi.org/10.4319/lom.2012.10.631)

*Methods*

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

doi:[10.1016/j.marchem.2011.07.005](https://doi.org/10.1016/j.marchem.2011.07.005)

*Results*

Pike, S. M., Buesseler, K. O., Andrews, J., & Savoye, N. (2005). Quantification of <sup>234</sup>Th recovery in small volume sea water samples by inductively coupled plasma-mass spectrometry. *Journal of Radioanalytical and Nuclear Chemistry*, 263(2), 355–360. doi:10.1007/s10967-005-0062-9 <https://doi.org/10.1007/s10967-005-0594-z>

*Methods*

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## Related Datasets

### Continues

Buesseler, K. O. (2020) **Water column total and particulate Thorium-234 from Leg 1 (Seattle, WA to Hilo, HI) of the US GEOTRACES Pacific Meridional Transect (PMT) cruise (GP15, RR1814) on R/V Roger Revelle from September to October 2018**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2020-11-18 <http://lod.bco-dmo.org/id/dataset/812511> [[view at BCO-DMO](#)]  
*Relationship Description: GP15 was made up of two cruise legs, RR1814 (Leg 1) and RR1815 (Leg 2).*

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## Parameters

Parameter	Description	Units
Station_ID	GEOTRACES station number.	unitless
Start_Date_UTC	Event start date (UTC); format: dd/mm/yyyy	unitless
Start_Time_UTC	Event start time (UTC); format: HH:MM	unitless
Start_ISO_DateTime_UTC	Event start date and time (UTC) formatted to ISO8601 standard: yyyy-mm-ddTHH:MMZ	unitless
End_Date_UTC	Event end date (UTC). For CTD casts, this is not provided. Format: dd/mm/yyyy	unitless
End_Time_UTC	Event end time (UTC). For CTD casts, this is not provided. Format: HH:MM	unitless
End_ISO_DateTime_UTC	Event end date and time (UTC) formatted to ISO8601 standard: yyyy-mm-ddTHH:MMZ	unitless
Start_Latitude	Latitude. Negative = South.	degrees North
Start_Longitude	Longitude. Negative = West.	degrees East
End_Latitude	Latitude. Negative = South.	degrees North
End_Longitude	Longitude. Negative = West.	degrees East
Event_ID	GEOTRACES event number.	unitless

Sample_ID	Unique identifying number for US GEOTRACES samples.	unitless
Sample_Depth	Actual sample depth from CTD rosette readout.	meters (m)
Niskin_Bottle	Niskin bottle number from the CTD rosette for Th-234 total sample collection.	None
Th_234_SPT_CONC_PUMP_r3u1b	Total Th-234 concentration collected from Niskin bottles on the CTD rosette.	mBq/kg
SD1_Th_234_SPT_CONC_PUMP_r3u1b	Th-234 uncertainty. Derived from counting statistics and error propagation for mass/volume measurements and ICP-MS recovery analysis.	mBq/kg
Flag_Th_234_SPT_CONC_PUMP_r3u1b	Data were flagged with quality indicators: 1 = Good Value; 2 = Probably Good Value (SeaDataNet flag system).	unitless
Th_234_LPT_CONC_PUMP_dpcdrs	Particulate Thorium-234 from QMA filters. Particle size of 1 to 51 um. Data were decay corrected back to mid-pump times.	mBq/kg
SD1_Th_234_LPT_CONC_PUMP_dpcdrs	Th_234_SPT_CONC_PUMP uncertainty.	mBq/kg
Flag_Th_234_LPT_CONC_PUMP_dpcdrs	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_T_CONC_BOTTLE_unblcb	Particulate Thorium-234 from mesh screens, filtered onto silver filters. Particle size greater than 51 um. Data were decay corrected back to mid-pump times.	mBq/kg
SD1_Th_234_T_CONC_BOTTLE_unblcb	Th_234_LPT_CONC_PUMP uncertainty.	mBq/kg
Flag_Th_234_T_CONC_BOTTLE_unblcb	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

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## Instruments

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

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	McLane Pump
<b>Generic Instrument Description</b>	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.

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	Riso Laboratory Anti-coincidence Beta Counters
<b>Dataset-specific Description</b>	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 <sup>234</sup> Th beta counting method. A 'non-detect' for <sup>234</sup> Th or a case where there is no <sup>234</sup> Th 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 <sup>234</sup> Th.
<b>Generic Instrument Description</b>	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%.

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## Deployments

### RR1815

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/776917">https://www.bco-dmo.org/deployment/776917</a>
<b>Platform</b>	R/V Roger Revelle
<b>Report</b>	<a href="https://datadocs.bco-dmo.org/docs/geotraces/GEOTRACES_PMT/casciotti/data_docs/GP15_Cruise_Report_with_ODF_Report.pdf">https://datadocs.bco-dmo.org/docs/geotraces/GEOTRACES_PMT/casciotti/data_docs/GP15_Cruise_Report_with_ODF_Report.pdf</a>
<b>Start Date</b>	2018-10-24
<b>End Date</b>	2018-11-24

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## Project Information

### US GEOTRACES Pacific Meridional Transect (U.S. GEOTRACES PMT)

**Website:** [http://www.usgeotraces.org/USGEOTRACES\\_website/html/pacific-alaska.html](http://www.usgeotraces.org/USGEOTRACES_website/html/pacific-alaska.html)

**Coverage:** Pacific Meridional Transect along 152W (GP15)

A 60-day research cruise took place in 2018 along a transect from Alaska to Tahiti at 152° W. A description of the project titled "*Collaborative Research: Management and implementation of the US GEOTRACES Pacific Meridional Transect*", funded by NSF, is below. Further project information is available on the [US GEOTRACES website](#) and on the [cruise blog](#). A detailed [cruise report is also available](#) as a PDF.

*Description from NSF award abstract:*

GEOTRACES is a global effort in the field of Chemical Oceanography in which the United States plays a major role. The goal of the GEOTRACES program is to understand the distributions of many elements and their isotopes in the ocean. Until quite recently, these elements could not be measured at a global scale. Understanding the distributions of these elements and isotopes will increase the understanding of processes that shape their distributions and also the processes that depend on these elements. For example, many "trace elements" (elements that are present in very low amounts) are also important for life, and their presence or absence can play a vital role in the population of marine ecosystems. This project will launch the next major U.S. GEOTRACES expedition in the Pacific Ocean between Alaska and Tahiti. The award made here would support all of the major infrastructure for this expedition, including the research vessel, the sampling equipment, and some of the core oceanographic measurements. This project will also support the personnel needed to lead the expedition and collect the samples.

This project would support the essential sampling operations and infrastructure for the U.S. GEOTRACES Pacific Meridional Transect along 152° W to support a large variety of individual science projects on trace element and isotope (TEI) biogeochemistry that will follow. Thus, the major objectives of this management proposal are: (1) plan and coordinate a 60 day research cruise in 2018; (2) obtain representative samples for a wide variety of TEIs using a conventional CTD/rosette, GEOTRACES Trace Element Sampling Systems, and in situ pumps; (3) acquire conventional CTD hydrographic data along with discrete samples for salinity, dissolved oxygen, algal pigments, and dissolved nutrients at micro- and nanomolar levels; (4) ensure that proper QA/QC protocols are followed and reported, as well as fulfilling all GEOTRACES intercalibration protocols; (5) prepare and deliver all hydrographic data to the GEOTRACES Data Assembly Centre (via the US BCO-DMO data center); and (6) coordinate all cruise communications between investigators, including preparation of a hydrographic report/publication. This project would also provide baseline measurements of TEIs in the Clarion-Clipperton fracture zone (~7.5°N-17°N, ~155°W-115°W) where large-scale deep sea mining is planned. Environmental impact assessments are underway in partnership with the mining industry, but the effect of mining activities on TEIs in the water column is one that could be uniquely assessed by the GEOTRACES community. In support of efforts to communicate the science to a wide audience the investigators will recruit an early career freelance science journalist with interests in marine science and oceanography to participate on the cruise and do public outreach, photography and/or videography, and social media from the ship, as well as to submit articles about the research to national media. The project would also support several graduate students.

### **Quantifying Upper Ocean Export and Remineralization of Bioactive and Particle Reactive Trace Elements along the US GEOTRACES Tahiti to Alaska Transect (PMT Upper Ocean Trace Elements)**

**Coverage:** GEOTRACES Pacific Meridional Transect (Alaska to Tahiti along 151 W)

*NSF Award Abstract:*

The goal of the international GEOTRACES program is to understand the distributions of trace chemical elements and their isotopes in the oceans. A core approach of GEOTRACES involves coordinated expeditions that measure multiple trace elements and isotopes (TEIs) across key gradients in the ocean, such as changes in productivity, redox/oxygen, boundary scavenging intensity, and hydrothermal activity. However, trace elemental distributions are not enough to meet the GEOTRACES goal to "identify processes and quantify fluxes that control the distribution of TEIs in the ocean and to establish the sensitivity of these changing distributions to environmental conditions." To measure rates of processes requires the use of other measurements, such as naturally occurring radioactive isotopes. This project involves the measurement of two isotopes of the element thorium on a U.S. GEOTRACES expedition in the Pacific Ocean, from Alaska to Tahiti. Thorium has a tendency to become associated with particles in the oceans, and therefore it can be used to measure the sinking of other elements out of the ocean surface. Thorium isotopes with short half-lives can be used to track processes that occur on faster timescales (weeks or seasons), such as those related to biology in the surface waters of the ocean, while isotopes with longer half-lives are useful for studying processes that occur on longer time scales like that of ocean circulation. This project would use measurements of thorium-234 and thorium-228, with half-lives of 24.1 days and 1.9 years, respectively, to

estimate sinking rates of thorium and other elements in the upper ocean.

The proposal is broken down into four main activities: 1) Use short-lived Th-234 to estimate particle export and remineralization rates; 2) use ratios of Th-234 to major biogenic phases (e.g., carbon, nitrogen, biogenic silica) and trace elements (e.g. iron, manganese, etc.) to derive flux profiles of other major and trace elements; 3) extend the export and remineralization rates in time/depth using Th-228; 4) examine how changes in #1-3 are related to expected gradients in particle concentration and type, plankton community shifts, net community production, aerosol inputs/dust, physical forcing (e.g. upwelling), hydrothermal plumes, and other features along this GEOTRACES transect. Profiles of total Th-234:U-238 provide quantitative estimates of Th-234 flux vs. depth, which along with parallel size-fractionated particulate profiles of Th-234 and TEIs allow us to empirically calculate the vertical profile of net particle export for any TEI. With high resolution vertical and spatial sampling, the application of Th-234 can be extended below the zone of net removal in the surface ocean to include quantification of particle export and remineralization in the upper several hundred meters. Based upon prior studies, the Th-234 flux model will need to be adjusted for physical transport, especially upwelling across the equator. Selected Th-228 profiles can extend these flux and remineralization estimates even further with depth and over longer time scales. The project will support a Ph.D. student.

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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
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1735445</a>

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