Activities of 210Po and 210Pb on particles in two size classes obtained by in situ pumping on 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 Oct-Nov 2018

Website: https://www.bco-dmo.org/dataset/892360
Data Type: Cruise Results
Version: 1
Version Date: 2023-03-23

Project
» US GEOTRACES Pacific Meridional Transect (GP15) (U.S. GEOTRACES PMT)
» Collaborative Research: Lead-210 and Polonium-210 as tracers for scavenging and export: GEOTRACES Pacific Meridional Section (PMT Lead-210 and Polonium-210)

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

Contributors	Affiliation	Role
Cochran, J. Kirk	Stony Brook University - SoMAS (SUNY-SB SoMAS)	Principal Investigator
Stephens, Mark	Florida International University (FIU)	Co-Principal Investigator
Rauch, Shannon		BCO-DMO Data Manager

Abstract
This project is part of the international GEOTRACES program, which was created to allow a comprehensive, coordinated study of trace elements and isotopes (TEIs) in the oceans. This project uses the radionuclide pair Lead-210 (210Pb) and its grand-daughter Polonium-210 (210Po) to provide important biogeochemical rate information pertinent to the TEIs that were measured during the US GEOTRACES Meridional Transect in the Pacific from Alaska to Tahiti in late 2018. Many processes in the ocean cannot be directly observed and, as such, tracers such as 210Po and 210Pb can be used to provide important constraints on their rates and pathways. 210Po (half-life = 138 days) and 210Pb (half-life = 22.3 years) decay on timescales that are useful to study 1) atmospheric deposition of trace elements, 2) scavenging of particle-reactive trace elements, 3) export of particulate organic carbon (POC) from the photic zone, and 4) the fate of hydrothermal plumes dispersed from the mid-ocean ridge system. Data reported here are activities of 210Po and 210Pb on particles in two size classes obtained by in situ pumping. Sampling was conducted in 2018 at various depths through the water column at eleven stations along the GEOTRACES Pacific Meridional Transect (GP15). Particulate samples were collected by Phoebe Lam's group using McLane in-situ pumps (Lam et al., 2015). Two particle sizes were collected by pumping: a large particle fraction collected on a 142-millimeter (mm) 51-micrometer (µm) polyester mesh prefilters (Sefar 07-51/33) and a small particle fraction collected on paired 0.8-µm polyethersulfone Pall Supor 800 membrane filters. The filters were dried on board in a laminar flow hood, split, and placed in a polyethylene bag. Aliquots sent to Stony brook comprised 28-280 liters (L) (average ~100L) filtered for the small particle fraction and 60-330L (average ~250L) for the large particle fraction.

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Coverage

Spatial Extent: **N**:11 **E**:-152 **S**:-20 **W**:-152

Temporal Extent: 2018-10-30 - 2018-11-23

Methods & Sampling

Sampling was conducted in 2018 at various depths through the water column at eleven stations along the GEOTRACES Pacific Meridional Transect (GP15), carried out on R/V Roger Revelle (cruises RR1814 and RR1815). Particulate samples were collected by Phoebe Lam's group using McLane in-situ pumps (Lam et al., 2015). Two particle sizes were collected by pumping: a large particle fraction collected on a 142-millimeter (mm) 51-micrometer (µm) polyester mesh prefilters (Sefar 07-51/33) and a small particle fraction collected on paired 0.8-µm polyethersulfone Pall Supor 800 membrane filters. The filters were dried on board in a laminar flow hood, split, and placed in a polyethylene bag. Aliquots sent to Stony brook comprised 28-280 liters (L) (average ~100L) filtered for the small particle fraction and 60-330L (average ~250L) for the large particle fraction. More details on pump operation can be found in the GP15 Cruise Report (see Supplemental Files section).

The particulate filters were dried on board the ship in a laminar flow hood, split, and placed in a polyethylene bag. Aliquots sent to Stony Brook comprised 28-280 liters (L) (average ~100L) filtered for the small particle fraction and 60-330L (average ~250L) for the large particle fraction. Due to the equipment limitations and potential hazards when doing acid digestions at sea, on-board treatment was not possible for these samples. Instead, filter aliquots from Leg 1 were sent to the lab during the port stop in Hilo, Hawaii on 21 October. Leg 2 filters were sent back from Papeete, Tahiti at the conclusion of the cruise on 24 November.

In the laboratory, filters were placed in microwave digestion vessels and spiked with Polonium-209 (209Po) tracer (1.76 disintegrations per minute (dpm)) and 10 milligrams (mg) stable lead (Pb). 5 milliliters (mL) each of concentrated HCl, HNO3, and HF were then added to the vessel. The mixture was microwave-digested for 1 hour at 180° Celsius (C). After digestion, the resulting solution was decanted into a 25 mL Falcon tube, and the digestion vessels were rinsed with small aliquots of deionized (DI) water. The Falcon tubes were centrifuged for 10 minutes at 2000 rotations per minute (rpm) and the supernatant was pipetted into 50 mL Teflon beakers. The beakers were heated to almost complete dryness before 10 mL of concentrated HCl was added. This process was repeated to ensure that the HCl was the only acid present. 20 mL of 6 molar (M) HCl was added, the solution was decanted into a glass beaker and the Teflon beaker was rinsed with two aliquots of 30 mL DI water. The beakers were labeled, and ascorbic acid was added to the solution to reduce any Fe(III) to Fe(II) and prevent its plating. A silver planchet embedded in a Teflon stirring magnet was added to each sample, which was then plated at 80°C for 3 hours (Flynn, 1968; Lee et al., 2014), rinsed with DI water and acetone and counted in a Canberra/Mirion Quad Alpha spectrometer to determine initial 210Po. Residual Po was removed from solution by adding scrap silver for ~5 days and then transferring the samples to 125 ml polycarbonate bottles for storage and ingrowth of additional 210Po. The second plating was carried out after 6 to 8 months of storage. Data reduction was carried out using the methods reported in Rigaud et al. (2013).

Known Problems/Issues:
Calculation of the particulate 210Pb activity requires measurement of the concentration of stable Pb added during sample dissolution to determine the recovery of 210Pb from dissolution through plating. The sample solutions were stored for 6 to 8 months after the initial Po plating and removal of residual Po to permit ingrowth of additional 210Po from 210Pb decay. At the time of the second plating, aliquots were taken to measure the stable Pb. A discrete number of samples were completed in late 2019 to early 2020 and Pb recoveries were determined. However, Stony Brook University closed for an extended period starting in March 2020 due to the Covid-19 pandemic. Upon reopening, measurement of stable Pb in the stored aliquots showed losses in storage. As well, analytical instrumentation used to measure Pb (Element 2 ICP-MS) was no longer functioning and required extensive maintenance and repair. Because of these problems, it was decided to use average Pb recoveries for these samples, based on the Pb recoveries of samples analyzed before the shutdown.

Data Processing Description

Data Processing:
Calculation of radioactivities (disintegrations per minute (dpm) or Becquerels (Bq)) from count rates (counts per minute) measured in the alpha spectrometers were made using the procedure outlined in Rigaud et al. (2013).

Quality flags were applied following the GEOTRACES flag definitions where 1 = "good data". The Quality Flag Policy is available at https://www.geotraces.org/geotraces-quality-flag-policy/ or via the attached Supplemental File.

The following notation is used in the dataset: NS = not sampled; NC = not calculated.

BCO-DMO Processing:
- moved rows for station 18.3 from the RR1815 file to the RR1814 file;
- renamed fields to comply with BCO-DMO naming conventions;
- converted dates and times to ISO 8601 format (UTC);
- added the following columns/values from the RR1815 Bottle File (v6): Cast_number, Event_ID. Data were joined to the

bottle data using the GEOTRACES sample number (Sample_ID).

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Data Files

File
gp15_1815_particulate_po_pb.csv (Octet Stream, 16.35 KB) MD5:7b0374889861b0b36fd4af8f65c9615b Primary data file for dataset ID 892360

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Supplemental Files

File
GEOTRACES Quality Flag Policy filename: GEOTRACES_Quality_Flag_Policy.pdf (Octet Stream, 1,020.15 KB) MD5:15bdace93b45a09ff523f154e70f7b75 GEOTRACES Quality Flag Policy; obtained from https://www.geotraces.org/geotraces-quality-flag-policy/ on 2023-03-23.
GP15 Cruise Report filename: GP15_Cruise_Report_with_ODF_Report.pdf (Portable Document Format (.pdf), 3.89 MB) MD5:9685af1941935ff0c248193fe0472a14 US GEOTRACES Pacific Meridional Transect GP15 Cruise Report (cruise IDs: RR1814 and RR1815)

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Related Publications

Flynn, W. W. (1968). The determination of low levels of polonium-210 in environmental materials. Analytica Chimica Acta, 43, 221–227. doi:10.1016/s0003-2670(00)89210-7 https://doi.org/10.1016/S0003-2670(00)89210-7
Methods

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

Lee, H. M., Hong, G. H., Baskaran, M., Kim, S. H., & Kim, Y. I. (2014). Evaluation of plating conditions for the recovery of 210Po on a Ag planchet. Applied Radiation and Isotopes, 90, 170–176. https://doi.org/10.1016/j.apradiso.2014.03.025
Methods

Rigaud, S., Puigcorbé, V., Cámara-Mor, P., Casacuberta, N., Roca-Martí, M., Garcia-Orellana, J., … Church, T. (2013). A methods assessment and recommendations for improving calculations and reducing uncertainties in the determination of210Po and210Pb activities in seawater. Limnology and Oceanography: Methods, 11(10), 561–571. doi:10.4319/lom.2013.11.561
Methods

Wei, Z., Cochran, J. K., Horowitz, E., Fitzgerald, P., Heilbrun, C., Kadko, D., Stephens, M., Marsay, C. M., Buck, C. S., & Landing, W. M. (2022). 210Pb and 7Be as Coupled Flux and Source Tracers for Aerosols in the Pacific Ocean. Global Biogeochemical Cycles, 36(8). Portico. https://doi.org/10.1029/2022gb007378
Results

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Parameters

Parameter	Description	Units
Station_ID	Station number	unitless

Start_ISO_DateTime_UTC	Date and time (UTC) at start of sample collection in ISO8601 format	unitless
Start_Latitude	Latitude at start of sample collection	degrees North
Start_Longitude	Longitude at start of sample collection	degrees East
Cast_number	Cast number; added by BCO-DMO from GP15 Bottle File version 6	unitless
Event_ID	Event number; added by BCO-DMO from GP15 Bottle File version 6	unitless
Sample_ID	GEOTRACES sample number	unitless
Sample_Depth	Sample depth	meters (m)
Po_210_LPT_CONC_PUMP_ovl6zp	210Po activities in large particle size fraction (>51 um); NS = not sampled	milliBecquerels per kilogram of water (mBq/kg)
SD1_Po_210_LPT_CONC_PUMP_ovl6zp	Propagated 1 sigma uncertainty on large particle 210Po activity; NS = not sampled	milliBecquerels per kilogram of water (mBq/kg)
Flag_Po_210_LPT_CONC_PUMP_ovl6zp	Quality flag for Po_210_LPT_CONC_PUMP_ovl6zp (1 = "good data")	unitless
Po_210_SPT_CONC_PUMP_bsktj4	210Po activities in small particle size fraction (0.8 - 51 um)	milliBecquerels per kilogram of water (mBq/kg)
SD1_Po_210_SPT_CONC_PUMP_bsktj4	Propagated 1 sigma uncertainty on small particle 210Po activity	milliBecquerels per kilogram of water (mBq/kg)
Flag_Po_210_SPT_CONC_PUMP_bsktj4	Quality flag for Po_210_SPT_CONC_PUMP_bsktj4 (1 = "good data")	unitless
Po_210_TP_CONC_PUMP_rzbji2	Total particulate 210Po activities (sum of small and large size fractions); NC = not calculated	milliBecquerels per kilogram of water (mBq/kg)
SD1_Po_210_TP_CONC_PUMP_rzbji2	Propagated 1 sigma uncertainty on total particle 210Po activity; NC = not calculated	milliBecquerels per kilogram of water (mBq/kg)
Flag_Po_210_TP_CONC_PUMP_rzbji2	Quality flag for Po_210_TP_CONC_PUMP_rzbji2 (1 = "good data")	unitless
Pb_210_LPT_CONC_PUMP_n2vyur	210Pb activities in large particle size fraction (>51 um); NS = not sampled	milliBecquerels per kilogram of water (mBq/kg)
SD1_Pb_210_LPT_CONC_PUMP_n2vyur	Propagated 1 sigma uncertainty on large 210Pb particle activity; NS = not sampled	milliBecquerels per kilogram of water (mBq/kg)
Flag_Pb_210_LPT_CONC_PUMP_n2vyur	Quality flag for Pb_210_LPT_CONC_PUMP_n2vyur (1 = "good data")	unitless
Pb_210_SPT_CONC_PUMP_v6jmpp	210Pb activities in small particle size fraction (>51 um)	milliBecquerels per kilogram of water (mBq/kg)
SD1_Pb_210_SPT_CONC_PUMP_v6jmpp	Propagated 1 sigma uncertainty on small particle 210Pb activity	milliBecquerels per kilogram of water (mBq/kg)
Flag_Pb_210_SPT_CONC_PUMP_v6jmpp	Quality flag for Pb_210_SPT_CONC_PUMP_v6jmpp (1 = "good data")	unitless
Pb_210_TP_CONC_PUMP_c4onej	Total particulate 210Pb activities (sum of small and large size fractions); NC = not calculated	milliBecquerels per kilogram of water (mBq/kg)

SD1_Pb_210_TP_CONC_PUMP_c4onej	Propagated 1 sigma uncertainty on total particle 210Pb activity; NC = not calculated	milliBecquerels per kilogram of water (mBq/kg)
Flag_Pb_210_TP_CONC_PUMP_c4onej	Quality flag for Pb_210_TP_CONC_PUMP_c4onej (1 = "good data")	unitless

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Instruments

Dataset-specific Instrument Name	modified WTS-LV-upright
Generic Instrument Name	McLane Large Volume Pumping System WTS-LV
Dataset-specific Description	Pump samples were collected using dual-flow battery-operated McLane pumps with two cartridge holders (modified WTS-LV-upright)
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	
Generic Instrument Name	Spectrometer
Dataset-specific Description	210Po and 210Pb activities were measured on Canberra passivated implanted planar silicon (PIPS) detectors coupled to a Mirion Alpha Analyst™ alpha spectrometer (Stony Brook University) or Ortec Alpha System (Florida International University).
Generic Instrument Description	A spectrometer is an optical instrument used to measure properties of light over a specific portion of the electromagnetic spectrum.

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Deployments

RR1815

Website	https://www.bco-dmo.org/deployment/776917
Platform	R/V Roger Revelle
Report	https://datadocs.bco-dmo.org/docs/geotraces/GEOTRACES_PMT/casciotti/data_docs/GP15_Cruise_Report_with_ODF_Report.pdf
Start Date	2018-10-24
End Date	2018-11-24
Description	Additional cruise information is available from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/RR1815

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Project Information

US GEOTRACES Pacific Meridional Transect (GP15) (U.S. GEOTRACES PMT)

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

Coverage: Pacific Meridional Transect along 152W (GP15)

A 60-day research cruise took place in 2018 along a transect form 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.

Collaborative Research: Lead-210 and Polonium-210 as tracers for scavenging and export: GEOTRACES Pacific Meridional Section (PMT Lead-210 and Polonium-210)

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. These chemical species play important roles in the ocean as nutrients, tracers of current and past oceanographic processes, and as contaminants from human activity. Their biogeochemical cycling has direct implications for research in such diverse areas as the carbon cycle, climate change, and ocean ecosystems. This project will use measurement of two natural radionuclides -- lead-210 and polonium-210 -- to provide important information about the rates of processes that affect trace elements and isotopes (TEIs) that will be measured during a U.S. GEOTRACES expedition in the Pacific Ocean in 2018. The research proposed here will address key tasks formulated within the GEOTRACES Science Plan.

Many processes in the ocean cannot be observed directly but tracers such as polonium-210 (half-life = 138 days) and lead-210 (half-life = 22.3 years) that have unique chemical properties and relevant decay timescales can be used to provide important constraints on their rates and pathways. The goals of this research are to: 1) use Pb-210, along with another project measuring Be-7, in aerosols and precipitation to characterize aerosol and TEI sources, 2) determine scavenging rates of particle-reactive TEIs through the water column using Po-210 and Pb-210, 3) use Po-210 / Pb-210 disequilibrium in the upper water column as a proxy for the sinking flux of particulate organic carbon (POC), and 4) use Pb-210as a tracer of the influence of hydrothermal processes on water column distributions of TEIs. This work will build on a database of Po/Pb distributions in the world ocean (and the Pacific Ocean, in particular) obtained through programs such as GEOSECS, GEOTRACES, and independent studies. A graduate student will be trained as part of this project. The lead investigator, Cochran, plans to incorporate information about GEOTRACES sampling strategies in the planning for a travelling exhibition on "The Oceans" through his adjunct appointment at the American Museum of Natural History (New York). Project partner Kadko plans to incorporate GEOTRACES work in an international graduate course through the Nippon Foundation, Partnership for Observation of the Global Oceans Center of Excellence.

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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-1736591
NSF Division of Ocean Sciences (NSF OCE)	OCE-1736612

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