Geochemical composition of water column samples collected in the Equatorial Pacific during October and November 2020 on R/V Kilo Moana cruise KM2012

Website: https://www.bco-dmo.org/dataset/928152
Data Type: Cruise Results
Version: 1
Version Date: 2024-05-23

Project
» Collaborative Research: How and Why eNd Tracks Ocean Circulation (Pacific Porewater Nd)

Contributors	Affiliation	Role
Haley, Brian	Oregon State University (OSU)	Co-Principal Investigator
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Abstract
Water column, sediment, and pore water samples were collected during R/V Kilo Moana cruise KM2012 in the Equatorial Pacific during October and November 2020. This dataset includes elemental concentrations, Neodymium isotope ratios, pH, and nutrients from the water column samples.

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Coverage

Location: Equatorial Pacific
Spatial Extent: **N**:11 **E**:-152 **S**:3 **W**:-152
Temporal Extent: 2020-10-14 - 2020-10-24

Methods & Sampling

Water column, sediment, and pore water samples were collected following the methods in Abbott et al. (2015) during R/V Kilo Moana cruise KM2012 in October and November 2020. Water column samples were collected and filtered (<0.45 micrometers (µm)) from Niskin bottles on a CTD Rosette. See 'Related Datasets' for the data from pore water and sediment cores.

Elemental concentrations, including the REEs, were analyzed at Oregon State University (OSU) using an Elemental Scientific seaFAST-pico offline preconcentration technique, and the procedure has been extensively documented as part of the GEOTRACES intercalibration effort (Behrens et al., 2016). Elemental concentrations of the εNd aliquots (~10 milliliters (mL)) were analyzed at ETH Zurich using Nobias Chelate-PA1 resin in a manual column procedure (K. Deng et al., 2022).

Isotope analysis of the εNd aliquots (400~700 mL of pore water or ~1.5 liters (L) of seawater) were done at ETH Zurich. Samples were buffered to a pH of 5.5 ± 5 and pre-concentrated using an in-house extraction manifold containing Nobias Chelate-PA1 resin. After pre-concentration, separation of Nd from the matrix elements and other REE was done using Eichrom RE and LN spec resins. Procedural blanks are <3 picograms (pg). Isotope analysis was done on an Neptune Plus MC-ICP-MS (Thermo-Fisher) following the procedure of Vance and Thirlwall (2002). Internally normalized sample data was renormalized to the 143Nd/144Nd ratio of La Jolla (Thirlwall, 1991). Repeated analysis of 8 parts per billion (ppb) La Jolla solutions results in a long-term external reproducibility of 0.27 ε (2σ). Nd isotope analysis was also quality-controlled by repeated measurements of the USGS reference materials BCR-2 (εNd = -0.11 ± 0.25, 2σ) and BHVO-2 (εNd = 6.70 ± 0.24, 2σ) at the same concentration (5-10 ppb) as the pore water samples in agreement with literature results (Jochum et al., 2005).

Nutrients were analyzed at Oregon State University using Technicon AutoAnalyzer II (phosphate and ammonium) and Alpkem RFA 300 (silicic acid, nitrate+nitrite). The method and data processing follow Gordon et al. (1993). DOC was analyzed with a V-CSN/TNM-1 (Shimadzu Corp, Kyoto, Japan) at the Scripps Institution of Oceanography following White et al. (2023).

Sediment samples were analysed for total organic carbon contents using a GVI (now Elementar) Isoprime 1000 with Eurovector EA at Bigelow Laboratory for Ocean Sciences. Samples were measured for the total carbon (organic plus inorganic) and a separate sample split was acidified to remove carbonate and then measured for the organic fraction.

X-ray diffraction (XRD) of freeze-dried raw samples were made at K/T GeoServices Inc. (Colorado, USA), using a Siemens D500 automated powder diffractometer equipped with a copper X-ray source (40kV, 30mA) and a scintillation X-ray detector. Semi-quantitative determinations of whole-sediment mineral amounts were done using Jade Software (Materials Data, Inc.) with the Whole Pattern Fitting option.

BCO-DMO Processing Description

- Imported sheet "BCO-DMO water column" from original file "BCO-DMOv2.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Saved the final file as "928152_v1_water_column_geochemical_composition.csv".

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Data Files

File
928152_v1_water_column_geochemical_composition.csv (Comma Separated Values (.csv), 6.15 KB) MD5:91b8cc17e22abbfa94663bfb49ff82d6 Primary data file for dataset ID 928152, version 1

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Related Publications

Abbott, A. N., Haley, B. A., McManus, J., & Reimers, C. E. (2015). The sedimentary flux of dissolved rare earth elements to the ocean. Geochimica et Cosmochimica Acta, 154, 186–200. https://doi.org/10.1016/j.gca.2015.01.010
Methods

Behrens, M. K., Muratli, J., Pradoux, C., Wu, Y., Böning, P., Brumsack, H.-J., … Pahnke, K. (2016). Rapid and precise analysis of rare earth elements in small volumes of seawater - Method and intercomparison. Marine Chemistry, 186, 110–120. doi:10.1016/j.marchem.2016.08.006
Methods

Deng, Kai, Yang, Shouye, Du, Jianghui, Lian, Ergang, & Vance, Derek. (2022). Dominance of benthic flux of REEs on continental shelves: implications for oceanic budgets. *ETH Zurich*. https://doi.org/10.3929/ETHZ-B-

000559675 https://doi.org/10.3929/ethz-b-000559675
Methods

Gordon, L.I., J.C. Jennings, Jr., A.A. Ross, and J.M. Krest (1993) A Suggested Protocol For Continuous Flow Automated Analysis of Seawater Nutrients, in WOCE Operation Manual, WHP Office Report 90-1, WOCE Report 77 No. 68/91, 1-52. https://cchdo.github.io/hdo-assets/documentation/manuals/pdf/91_1/gordnut.pdf
Methods

Jochum, K. P., Nohl, U., Herwig, K., Lammel, E., Stoll, B., & Hofmann, A. W. (2005). GeoReM: A New Geochemical Database for Reference Materials and Isotopic Standards. Geostandards and Geoanalytical Research, 29(3), 333–338. https://doi.org/10.1111/j.1751-908x.2005.tb00904.x https://doi.org/10.1111/j.1751-908X.2005.tb00904.x
Methods

Thirlwall, M. F. (1991). Long-term reproducibility of multicollector Sr and Nd isotope ratio analysis. Chemical Geology, 94(2), 85–104. https://doi.org/10.1016/s0009-2541(10)80021-x https://doi.org/10.1016/S0009-2541(10)80021-X
Methods

Vance, D., & Thirlwall, M. (2002). An assessment of mass discrimination in MC-ICPMS using Nd isotopes. Chemical Geology, 185(3–4), 227–240. https://doi.org/10.1016/s0009-2541(01)00402-8 https://doi.org/10.1016/S0009-2541(01)00402-8
Methods

White, M. E., Nguyen, T. B., Koester, I., Lardie Gaylord, M. C., Beman, J. M., Smith, K. L., McNichol, A. P., Beaupré, S. R., & Aluwihare, L. I. (2023). Refractory Dissolved Organic Matter has Similar Chemical Characteristics but Different Radiocarbon Signatures With Depth in the Marine Water Column. Global Biogeochemical Cycles, 37(4). Portico. https://doi.org/10.1029/2022gb007603 https://doi.org/10.1029/2022GB007603
Methods

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Related Datasets

IsRelatedTo

Haley, B., McManus, J. (2024) **Geochemical composition of sediment pore water samples collected in the Equatorial Pacific during October and November 2020 on R/V Kilo Moana cruise KM2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-23 doi:10.26008/1912/bco-dmo.928246.1 [view at BCO-DMO]

Haley, B., McManus, J. (2024) **Geochemical composition of sediment samples collected in the Equatorial Pacific during October and November 2020 on R/V Kilo Moana cruise KM2012.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-05-23 doi:10.26008/1912/bco-dmo.928400.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Station_Number	Station number	unitless
Latitude	Latitude of sampling site in degrees North	degrees North
Longitude	Longitude of sampling site in degrees East (negative values are West)	degrees East

Date	Date of sampling	unitless
bottom_depth	Depth to seafloor	meters (m)
sample_name	Sample name	unitless
Depth	Depth of sample	meters (m)
La_pM	REE concentration: Lanthanum (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Ce_pM	REE concentration: Cesium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Pr_pM	REE concentration: Praseodymium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Nd_pM	REE concentration: Neodymium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Sm_pM	REE concentration: Samarium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Eu_pM	REE concentration: Europium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Gd_pM	REE concentration: Gadolinium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Tb_pM	REE concentration: Terbium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Dy_pM	REE concentration: Dysprosium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Ho_pM	REE concentration: Holmium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Er_pM	REE concentration: Erbium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Tm_pM	REE concentration: Thulium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Yb_pM	REE concentration: Ytterbium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Lu_pM	REE concentration: Lutetium (filtered at <0.45um; error=10%)	picomolar (pmol/L)
Co_nM	Trace metal concentration: Cobalt (filtered at <0.45um)	nanomolar (nmol/L)

Ni_nM	Trace metal concentration: Nickel (filtered at <0.45um)	nanomolar (nmol/L)
Cu_nM	Trace metal concentration: Copper (filtered at <0.45um)	nanomolar (nmol/L)
Zn_nM	Trace metal concentration: Zinc (filtered at <0.45um)	nanomolar (nmol/L)
Mo_nM	Trace metal concentration: Molybdenum (filtered at <0.45um)	nanomolar (nmol/L)
Pb_nM	Trace metal concentration: Lead (filtered at <0.45um)	nanomolar (nmol/L)
U_nM	Trace metal concentration: Uranium (filtered at <0.45um)	nanomolar (nmol/L)
Nd143_Nd144_ratio	Isotope ratio of Neodymium-143 to Neodymium-144	unitless
SD2_int_1	Two sigma standard deviation of 143Nd/144Nd integrated measurements	unitless
eNd	Neodymium isotope composition given in epsilon notation (deviation of 143Nd/144Nd ratio from CHUR)	unitless
SD2_int_2	Two sigma standard deviation of 143Nd/144Nd integrated measurements in epsilon notation	unitless
pH	pH	unitless
NO3_NO2_uM	Total dissolved nitrate plus nitrite	micromolar (umol/L)
PO4_uM	Total dissolved phosphate	micromolar (umol/L)
Si_uM	Dissolved silicious acid	micromolar (umol/L)

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Instruments

Dataset-specific Instrument Name	Alpkem RFA 300
Generic Instrument Name	Alpkem RFA300
Generic Instrument Description	A rapid flow analyser (RFA) that may be used to measure nutrient concentrations in seawater. It is an air-segmented, continuous flow instrument comprising a sampler, a peristaltic pump which simultaneously pumps samples, reagents and air bubbles through the system, analytical cartridge, heating bath, colorimeter, data station, and printer. The RFA-300 was a precursor to the smaller Alpkem RFA/2 (also RFA II or RFA-2).

Dataset-specific Instrument Name	GVI (now Elementar) Isoprime 1000
Generic Instrument Name	Elemental Analyzer
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	Niskin bottles on a CTD Rosette
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.

Dataset-specific Instrument Name	Elemental Scientific seaFAST-pico
Generic Instrument Name	SeaFAST Automated Preconcentration System
Generic Instrument Description	The seaFAST is an automated sample introduction system for analysis of seawater and other high matrix samples for analyses by ICPMS (Inductively Coupled Plasma Mass Spectrometry).

Dataset-specific Instrument Name	V-CSN/TNM-1 (Shimadzu Corp)
Generic Instrument Name	Shimadzu TOC-V Analyzer
Generic Instrument Description	A Shimadzu TOC-V Analyzer measures DOC by high temperature combustion method.

Dataset-specific Instrument Name	Technicon AutoAnalyzer II
Generic Instrument Name	Technicon AutoAnalyzer II
Generic Instrument Description	A rapid flow analyzer that may be used to measure nutrient concentrations in seawater. It is a continuous segmented flow instrument consisting of a sampler, peristaltic pump, analytical cartridge, heating bath, and colorimeter. See more information about this instrument from the manufacturer.

Dataset-specific Instrument Name	Neptune Plus MC-ICP-MS (Thermo-Fisher)
Generic Instrument Name	Thermo Finnigan Neptune inductively coupled plasma mass spectrometer
Generic Instrument Description	A laboratory high mass resolution inductively coupled plasma mass spectrometer (ICP-MS) designed for elemental and isotopic analysis. The instrument is based on a multicollector platform, comprising eight moveable collector supports and one fixed center channel equipped with a Faraday cup and, optionally, an ion counter with or without a retardation lens. The Faraday cup is connected to a current amplifier, whose signal is digitized by a high linearity voltage to frequency converter. The instrument was originally manufactured by Thermo Finnigan, which has since been replaced by Thermo Scientific (part of Thermo Fisher Scientific). This model is no longer in production.

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Deployments

KM2012

Website	https://www.bco-dmo.org/deployment/928159
Platform	R/V Kilo Moana
Start Date	2020-10-09
End Date	2020-11-02
Description	See more information at R2R: https://www.rvdata.us/search/cruise/KM2012

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Project Information

Collaborative Research: How and Why eNd Tracks Ocean Circulation (Pacific Porewater Nd)

Coverage: Central Pacific

NSF Award Abstract:
Circulation of water is a fundamental trait of the oceans that impacts its physics, chemistry and biology; however, understanding modern and past patterns of circulation - especially in the vast bodies of deep water - is challenging because global circulation defies direct measurement. The problems with direct measurement

largely stem from the vast scales of space and time that are of interest in understanding global circulation. One tool for estimating global circulation patterns that holds promise is seen in neodymium isotopes which appear to be powerful tracers of deep ocean circulation, over a variety of timescales. Unfortunately, the elemental behavior of neodymium contrasts the isotopic behavior of neodymium in the oceans, a puzzle branded the "neodymium paradox." This inconsistency of geochemical behavior opens to question the application of neodymium isotopes as a tracer of circulation. Therefore, scientists from Oregon State University, Tulane University, and Bigelow Laboratory of Ocean Sciences propose to test the hypothesis that there is a yet unconstrained (even poorly identified) source of neodymium to the oceans that can explain the discrepancies seen between the elemental and isotopic neodymium marine budgets. The scientists further seek to understand the mechanistic cause of this source and thus be able to start making global constraints on its influence. Understanding these processes will fundamentally change our interpretations of neodymium data and allow us to more accurately quantify ocean circulation with a greater degree of confidence. For outreach activities, the scientists plan to participate in open house days held at Oregon State University, da Vinci days, National Ocean Science Bowls, Salmon Bowl and Bigelow Laboratory for Ocean Sciences' Cafe Scientifique. Undergraduate students and one graduate student from Tulane University would be supported and trained as part of this project.

Scientists from Oregon State University, Tulane University, and Bigelow Laboratory for Ocean Sciences propose to test the hypothesis that there is a benthic source of neodymium (Nd) to the oceans that exerts a primary control over the distribution of this element and its isotopes (eNd) in the ocean. This benthic flux results from early diagenetic reactions that release rare earth elements (REEs) from the solid phase to pore fluid. The scientists contend this flux will explain eNd distributions throughout the modern and past global oceans. The planned research will be guided by three questions:

(1) What are the mechanisms that control the magnitude and isotope composition of the benthic flux?
(2) What are the relationships among bottom water, pore fluid, and the terminal solid phase compositions? Particularly, how and under what chemical conditions does an eNd signature become part of a preserved archival record of [Nd] and eNd?
(3) Can our understanding of the deep water benthic fluxes account for the integrated bottom water eNd as a function of apparent water mass age and circulation path (e.g., how do the pore fluid and solid phase values reconcile with the existing water column signature and water mass age data)?

To test these ideas, sediments and their pore fluids will be collected from a diverse set of deep sea sites in the Pacific Ocean that reflect slow-to-fast sedimentation rates, carbonate-, terrigenous-, volcaniclastic- and siliceous-sediment, and low-to-high organic carbon. The sediments and porewater samples, as well as samples from the overlying water column will be characterized for the following parameters: major, minor, and trace metals, Nd isotopes, carbonate chemistry, oxygen, nutrients, particulate organic carbon, particulate organic nitrogen, radiocarbon, porosity, and grain size. With these observations we will build a quantitative numeric geochemical model (e.g., PHREEQC, Geochemist's Workbench, Humic Ion Binding Model) that can capture the cardinal controls over the benthic source. Our goal is to provide a new interpretive framework for Nd and eNd, such that we can offer quantitative estimates of benthic fluxes for use in models of global circulation. This work has potentially transformative implications on our understanding and application of REEs and Nd isotope data in both the modern and ancient oceans.

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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1850765
NSF Division of Ocean Sciences (NSF OCE)	OCE-1850789

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