Geochemical composition of sediment pore water 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/928246
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 sediment pore water 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. Pore water aliquots for REE (Rare Earth Elemental) concentration and εNd were collected by centrifuge and filtration (<0.45 micrometers (µm)). The REE aliquots were extracted from one core, while the εNd aliquots were multiple, combined extractions from corresponding layers of 20 to 25 cores. See 'Related Datasets' for the data from the water column samples and sediment cores.

Pore water aliquots for nutrient analyses were extracted using Rhizon samplers and filtered (<0.2 µm). Pore water aliquots for DOC analysis were extracted via Rhizon, filtered (<0.45 µm with GFF filter), poisoned with mercuric chloride, and stored in a glass vial.

Pore water dissolved O2 concentration was measured using a fiber-optic oxygen microsensor inserted into pre-drilled holes through the core into the sediments. The sensor readings are converted to oxygen concentration by linearly calibrating against the published bottom water O2 concentration at the study sites.

Pore water pH was measured on unfiltered samples using a portable pH sensor post-extraction via centrifugation. Analyses of pH in pore waters is notoriously difficult due to the changes in pressure upon recovery, and thus the pH data have finite utility.

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 pore water" from original file "BCO-DMOv2.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Corrected bottom depth of station 4 from 505 to 5050.
- Saved the final file as "928246_v1_pore_water_geochemical_composition.csv".

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Data Files

File
928246_v1_pore_water_geochemical_composition.csv(Comma Separated Values (.csv), 24.82 KB) MD5:4159424d117ec8b9d4574ac64379a536 Primary data file for dataset ID 928246, 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 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]

Haley, B., McManus, J. (2024) **Geochemical composition of water column 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.928152.1 [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)
nominal_depth	Due to the nature of pore water sampling, the exact depth of sampling is not exact. We have provided the best median-depth for the sample taken such that it is comparable to other data/pore water/sediment. The resolution we used for these "nominal depths" is 0.5 cm.	centimeters (cm)
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; error=5%)	nanomolar (nmol/L)
Ni_nM	Trace metal concentration: Nickel (filtered at <0.45um; error=5%)	nanomolar (nmol/L)
Cu_nM	Trace metal concentration: Copper (filtered at <0.45um; error=5%)	nanomolar (nmol/L)
Zn66_nM	Trace metal concentration: Zinc (filtered at <0.45um; error=5%) based on analyses of 66Zn	nanomolar (nmol/L)
Zn68_nM	Trace metal concentration: Zinc (filtered at <0.45um; error=5%) based on analyses of 68Zn	nanomolar (nmol/L)
Mo_nM	Trace metal concentration: Molybdenum (filtered at <0.45um; error=5%)	nanomolar (nmol/L)
Cd_nM	Trace metal concentration: Cadmium (filtered at <0.45um; error=5%)	nanomolar (nmol/L)
Pb_nM	Trace metal concentration: Lead (filtered at <0.45um; error=5%)	nanomolar (nmol/L)
U_nM	Trace metal concentration: Uranium (filtered at <0.45um; error=5%)	nanomolar (nmol/L)
Ca_mmol_L	Major ion: Calcium (Filtered at <0.45um)	millimolar (mmol/L)
Ca_error	Calcium error of analysis	millimolar (mmol/L)
K_mmol_L	Major ion: Potassium (Filtered at <0.45um)	millimolar (mmol/L)
K_error	Potassium error of analysis	millimolar (mmol/L)
Mg_mmol_L	Major ion: Magnesium (Filtered at <0.45um)	millimolar (mmol/L)
Mg_error	Magnesium error of analysis	millimolar (mmol/L)

Na_mmol_L	Major ion: Sodium (Filtered at <0.45um)	millimolar (mmol/L)
Na_error	Sodium error of analysis	millimolar (mmol/L)
S_mmol_L	Major ion: Sulfur (Filtered at <0.45um)	millimolar (mmol/L)
S_error	Sulfur error of analysis	millimolar (mmol/L)
Sr_umol_L_1	Major ion: Strontium (Filtered at <0.45um)	micromolar (umol/L)
Sr_error_1	Strontium error of analysis	micromolar (umol/L)
B_umol_L	Major ion: Boron (Filtered at <0.45um)	micromolar (umol/L)
B_error	Boron error of analysis	micromolar (umol/L)
Ba_umol_L	Major ion: Barium (Filtered at <0.45um)	micromolar (umol/L)
Ba_error	Barium error of analysis	micromolar (umol/L)
Li_umol_L	Major ion: Lithium (Filtered at <0.45um)	micromolar (umol/L)
Li_error	Lithium error of analysis	micromolar (umol/L)
P_umol_L	Major ion: Phosphorus (Filtered at <0.45um)	micromolar (umol/L)
P_error	Phosphorus error of analysis	micromolar (umol/L)
Si_umol_L	Major ion: Silicon (Filtered at <0.45um)	micromolar (umol/L)
Si_error	Silicon error of analysis	micromolar (umol/L)
Sr_umol_L_ICPOES	Major ion: Strontium (Filtered at <0.45um; Measured by ICP-OES)	micromolar (umol/L)
Sr_error_ICPOES	Strontium error of analysis	micromolar (umol/L)
Nd143_Nd144	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
DOC_uM	Dissolved organic carbon (Filtered at <0.45um)	micromolar (umol/L)
pcnt_STDEV	Two sigma standard deviation of DOC measurements	unitless
Oxygen_Optode_pcnt_as	Dissolved oxygen concentration	percent saturation
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	centrifuge
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	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	MC800 multi-corer
Generic Instrument Name	Multi Corer
Generic Instrument Description	The Multi Corer is a benthic coring device used to collect multiple, simultaneous, undisturbed sediment/water samples from the seafloor. Multiple coring tubes with varying sampling capacity depending on tube dimensions are mounted in a frame designed to sample the deep ocean seafloor. For more information, see Barnett et al. (1984) in Oceanologica Acta, 7, pp. 399-408.

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	Rhizon samplers
Generic Instrument Name	Sediment Porewater Sampler
Generic Instrument Description	A device that collects samples of pore water from various horizons below the seabed.

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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