Radiocarbon dating of archived sediment cores in the Southeast Pacific from 1960 to 2000

Website: https://www.bco-dmo.org/dataset/886679
Data Type: Other Field Results
Version: 1
Version Date: 2023-01-12

Project
» Collaborative Research: Did the SE Pacific Gyre become a Hot Spot for N2 Fixation during Dusty Glacial Conditions? (N2 Fixation Glacial Dust Pacific Gyre)

Contributors	Affiliation	Role
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Abstract
There were likely large changes in Southeast (SE) Pacific Ocean biogeochemistry over the last glacial cycle as a consequence of coincident changes in dust flux, oxygenation, and latitudinal position of the Subantarctic and Antarctic Fronts. However, there are few available sediment core records with reliable chronologies for this time interval despite the large number of archived cores collected between the 1960s and 1990s. The apparent reason is that, except for sites in proximity to the South American continental margin, sedimentation rates are often lower than 1 cm/kyr and calcium carbonate is only well preserved on topographic highs. As part of a project to study past nitrogen fixation, we surveyed archived cores from the SE Pacific and selected the most promising for radiocarbon dating of the planktonic foraminiferal fraction. While many cores have core tops were found to be older than detectable with radiocarbon, a number have core tops ages within the Holocene and sediment accumulation rates centering on 1.5 cm/kyr.

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Coverage

Spatial Extent: **N**:-17 **E**:-73.608 **S**:-44.55 **W**:-120.193
Temporal Extent: 1960 - 2000

Methods & Sampling

This dataset was developed for sediment cores from the SE Pacific that were archived in a variety of repositories. The most promising cores were selected for radiocarbon dating of the planktonic foraminiferal fraction. Sediment handling and processing were similar to Cleaveland and Herbert (2007). Sediment samples of 2 cc size were requested from the core libraries where the target cores have been archived. Upon delivery, they were kept refrigerated. Bulk calcium carbonate for radiocarbon dating was isolated from the greater than 150-millimeter (mm) fraction of wet-sieved bulk sediment and dried prior to analysis.

Samples were sent to the WHOI NOSAMS facility and were prepared according to the methods for carbonate 14C analysis listed at https://www2.whoi.edu/site/nosams/client-

services/submitting_guidelines/sample_processes (see related publications).

Carbonate samples are treated with phosphoric acid to generate CO2 which, in turn, is converted to a graphite target. The target is analyzed for 14C on an accelerator mass spectrometer (AMS).

Carbonate samples are treated with phosphoric acid while under vacuum. The acidification of the sample material generates carbon dioxide (CO2) which is then converted to graphite. The graphite is pressed into a target to be analyzed for 14C on an accelerator mass spectrometer (AMS).

Data Processing Description

Data processing including error estimates are as in https://www2.whoi.edu/site/nosams/client-services/radiocarbon-data-calculations/ and as in Stuvier and Polach (1977).

In short, the fraction of 14C expected for modern samples (FM) is calculated from the AMS-measured 14C/12C ratio. The radiocarbon age is then calculated from the radioactive decay equation and decay constant for 14C. Where warranted corrections were made by NOSAMS for background 14C.

BCO-DMO Processing Description:
- Adjusted field/parameter names to comply with BCO-DMO naming conventions
- Added a conventional header with dataset name, PI names, version date

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Data Files

File
14c_dates.csv (Comma Separated Values (.csv), 3.00 KB) MD5:543a23d86332f34a2d05414915f9b767 Primary data file for dataset ID 886679

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Related Publications

Cleaveland, L. C., & Herbert, T. D. (2007). Coherent obliquity band and heterogeneous precession band responses in early Pleistocene tropical sea surface temperatures. Paleoceanography, 22(2). Portico. https://doi.org/10.1029/2006pa001370 https://doi.org/10.1029/2006PA001370
Methods

Hvorslev, M. J. (1951). Time lag and soil permeability in ground-water observations (No. 36). Waterways Experiment Station, Corps of Engineers, US Army.
Methods

Olsson, I. U. (1970). The use of oxalic acid as a standard. In 'Radiocarbon Variations and Absolute Chronology. In Proceedings of the 12th Nobel Symposium.'(Ed. IU Olsson.) p (Vol. 17).
Methods

Stuiver, M. (1980). Workshop On 14C Data Reporting. Radiocarbon, 22(3), 964–966. https://doi.org/10.1017/s0033822200010389 https://doi.org/10.1017/S0033822200010389
Methods

Stuiver, M., & Polach, H. A. (1977). Discussion Reporting of 14C Data. Radiocarbon, 19(3), 355–363. doi:10.1017/s0033822200003672 https://doi.org/10.1017/S0033822200003672

Parameters

Parameter	Description	Units
Sediment_Core_ID	Core designation at the time of collection and used by the core library where it is archived. All cores were piston cores except when a trigger core was available and then 'PC' or 'TC' is added to the designation. 'replicate' indicates a replicate analysis from the same sediment sample	unitless
Core_latitude	Latitude of the core site North (South is negative)	decimal degrees
Core_Longitude	Longitude of the core site East (West is negative)	decimal degrees
Depth_in_core	Depth below core top from which the sample was taken	centimeters (cm)
Measured_Fraction_Modern	Fraction of modern radiocarbon in the sample as measured by the AMS	unitless
Measured_Fraction_Modern_Error	± Error in fraction of modern radiocarbon determined by NOSAMS	unitless
Radiocarbon_Age	Radiocarbon age derived from fraction of modern radiocarbon. Where a '>' is shown, statistical certainty permitted only a lower bound to be determined.	unitless
Radiocarbon_Age_Error	Age error determined from the error in fraction of modern radiocarbon, in years. Where age was only lower bounded no error is calculated.	unitless

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Instruments

Dataset-specific Instrument Name	WHOI NOSAMS Accelerator Mass Spectrometer
Generic Instrument Name	Accelerator Mass Spectrometer
Dataset-specific Description	The WHOI NOSAMS Accelerator Mass Spectrometer is as described in https://www2.whoi.edu/site/nosams/about/laboratory-capabilities/ams-inst...
Generic Instrument Description	An AMS measures "long-lived radionuclides that occur naturally in our environment. AMS uses a particle accelerator in conjunction with ion sources, large magnets, and detectors to separate out interferences and count single atoms in the presence of 1x1015 (a thousand million million) stable atoms, measuring the mass-to-charge ratio of the products of sample molecule disassociation, atom ionization and ion acceleration." AMS permits ultra low-level measurement of compound concentrations and isotope ratios that traditional alpha-spectrometry cannot provide. More from Purdue University: http://www.physics.purdue.edu/primelab/introduction/ams.html

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Project Information

Collaborative Research: Did the SE Pacific Gyre become a Hot Spot for N2 Fixation during Dusty Glacial Conditions? (N2 Fixation Glacial Dust Pacific Gyre)

Coverage: Southeast Pacific Gyre

NSF Award Abstract
The element nitrogen is a fundamental component of all living things and its cycling through the environment is an important component of Earth's biosphere. As a vital nutrient, the availability of nitrogen in a biologically usable form often "limits" the growth of plants both on land as well as in the ocean. Paradoxically, nitrogen is very abundant as dinitrogen gas (N2) in both the Earth's atmosphere and dissolved in seawater. However in this chemical form, nitrogen cannot be used by most living things. Only a small subset of microbes has the ability to "fix" N2 gas, that is, to convert it into a biologically usable chemical form. Thus, these N2 fixing organisms provide a critical environmental function sustaining life on this planet. In the ocean, N2 fixation is a major control on the total amount of biologically available nitrogen, balancing over the time losses back to N2 gas. The amount of biologically available nitrogen in turn controls the growth (productivity) of photosynthetic organisms (phytoplankton) in the sunlit region of the surface ocean which form the base of the food chain and contribute to oceanic control of the atmospheric levels of greenhouse gases.

This project concerns itself with understanding the fundamental, large-scale controls of oceanic N2 fixation and how they are influenced by climate change over time. N2 fixing microbes themselves appeared to be limited by the availability of other nutrient elements such as phosphorous and iron. While it is known in which parts of the ocean there is at present greater or lesser availability of phosphorous and iron, it remains unclear if either is of overriding importance or if changes in the past produced significant variations in N2 fixation. Past changes in N2 fixation may have been an important feedback on oceanic control of atmospheric greenhouse gases. Understanding these past changes and their controls will provide the knowledge base for improving prediction of how ocean N2 fixation may respond to future changes in climate. This is of great societal relevance as changes in oceanic N2 fixation will ultimately impact marine ecosystems and living resources as feedback on the greenhouse gases driving climate change.

To address these questions, the research team will undertake a study the climate-sensitivity of N2 fixation in the southeast Pacific gyre over the last glacial cycle as well as its plausible "master controls". This oligotrophic region experiences little modern N2 fixation despite proximity to a large supply of excess phosphate from the adjacent Peru-Chile oxygen minimum zone. This is consistent with modern iron limitation due to low aeolian supply that would have been relieved during past dusty conditions. The research team will use the natural experiment of the last full glacial cycle, captured in the foraminiferal-bound N isotopes of gyre sites as well as sites at its southern margin, to probe controls on the marine N cycle exerted by variable dust inputs and changes in N-loss in the adjacent oxygen minimum zone, and relate these to known changes in greenhouse forcing of climate. Through numerical modeling, the research team will also consider whether past variations in N2 fixation in this region may have impacted the global ocean N cycle and budget.

This project will also fund the training of undergraduate and graduate students and support participation of high school students from underrepresented groups in original research. The research team will continue their outreach efforts through established partnerships with elementary, middle, and high schools, engaging a diverse school population and their families with exciting and relevant science.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1602810

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