

Sediment iron data from sediment cores collected on the R/V Nathaniel B. Palmer cruise NBP1601 to the West Antarctic continental shelf in January of 2016

Website: <https://www.bco-dmo.org/dataset/813152>

Data Type: Cruise Results

Version: 1

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Project

» [Organic Carbon Oxidation and Iron Remobilization by West Antarctic Shelf Sediments](#) (Antarctic Shelf Sediments)

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Abstract

Sediment iron data from sediment cores collected on the R/V Nathaniel B. Palmer cruise NBP1601 to the West Antarctic continental shelf in January of 2016.

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Coverage

Spatial Extent: N:-64.1583 E:-62.7317 S:-67.7717 W:-71.2217

Temporal Extent: 2016-01-14 - 2016-01-28

Dataset Description

Sediment iron data from sediment cores collected on the R/V Nathaniel B. Palmer cruise NBP1601 to the West Antarctic continental shelf in January of 2016.

Methods & Sampling

Sediment and pore water collection:

Short sediment cores were collected using a Bowers & Connelly megacorer, a multiple coring device that can collect ~20-40 cm long sediment cores with undisturbed sediment surfaces. At two sites (stations 41 and 64) longer cores (up to ~2 m) were also collected with a Kasten corer.

Megacorer cores were either sectioned for solid phase analysis, profiled with polarographic micro-electrodes to determine dissolved O₂ concentrations, or sectioned in a cold van under N₂ for pore water sample extraction (for details see, Komada et al., 2016). Samples for solid phase analyses were placed in Whirl-Pak plastic bags and frozen for solid phase Fe speciation analyses at ODU.

Kasten cores were brought into a large cold room on-board ship, laid on their side and one side of the core box removed to expose the sediment in the core. A plastic block was placed against the top of the core to prevent slumping of the sediment during processing, and pore waters were collected from these cores using Rhizon samplers (Seeberg-Elverfeldt et al., 2005) inserted directly into the cores at measured intervals. After pore water sampling was complete, samples for solid phase analyses were removed from the cores with plastic spoons and again placed in Whirl-Pak plastic bags (Fe speciation analyses) and immediately frozen.

While it is possible to recover cores with intact sediment-water interfaces using a megacorer, loss of surface sediments is typical during Kasten coring, making it not possible to directly determine absolute depths below the sediment-water interface in a Kasten core. We therefore determined the absolute depths of pore water and solid phase sample intervals from Kasten cores by aligning Kasten core profiles of pore water alkalinity to megacore alkalinity profiles from the same site (Berelson et al., 2005; Komada et al., 2016).

Sediment iron speciation:

This was determined using sequential extraction techniques (Goldberg et al., 2012; Poulton and Canfield, 2005). Sediments were freeze-dried and homogenized before use, and in each step a 10 ml extraction volume was used (except where noted) starting with 200-300 mg of sediment. Samples were shaken during all extractions, except when heated during extractions. At the end of each extraction step, the samples were centrifuged, the extract solution was removed, and the sediments were then rinsed twice with distilled, deionized water before moving on to the next extraction. Except where noted all extracts were analyzed for iron by flame AAS (Atomic Absorption Spectrometry).

Sediments were initially treated with 0.5 M HCl for 1 h to remove highly reactive, poorly crystalline iron oxides such as ferrihydrite and lepidochroite, as well as any unsulfidized Fe(II) produced during early diagenesis. Fe(II) released by the 0.5 M HCl extraction (termed Fe_{II_HCl}) was determined immediately by the ferrozine method (Viollier et al., 2000) without the addition of hydrolyamine HCl using an aliquot of the extract solution. Subtraction of the Fe concentration determined by the Fe_{II_HCl} measurement from the total Fe present in the 0.5 M HCl extract (Fe_{HCl}) yields the concentration of highly reactive, poorly crystalline Fe oxides (Fe_{ox1}),

$$\text{Fe}_{\text{ox1}} = \text{Fe}_{\text{HCl}} - \text{Fe}_{\text{II_HCl}} \quad (1)$$

Next, the sediment was extracted for 6 hr with a citrate-dithionite solution (50 g /l sodium dithionite buffered to pH 4.8 with 0.35 M acetic acid/0.2 M sodium citrate) to extract less reactive crystalline iron oxides such as goethite and hematite (Fe_{ox2}). After this, the sediment was extracted with ammonium oxalate (0.2 M ammonium oxalate/0.17 M oxalic acid) at pH 3.2 for 6 hr to dissolve iron in the mineral phase magnetite (Fe_{mag}). Finally, the remaining sediment was placed in boiling 12N HCl (5 ml) for 1 min to extract Fe found in poorly reactive sheet silicates (Fe_{prs}; i.e., “structural” Fe(III) in clays).

Total sediment iron (Fe_T) was determined in a separate sediment aliquot by ashing the sediment at 450°C for 8 h followed by extraction for 24 h in near boiling 6 N HCl. Finally, iron in the sulfide-containing phases AVS and pyrite (termed Fe_{pyr}) was determined in a separate sediment aliquot by acidic chromium reduction/distillation and colorimetric analysis of the sulfide liberated by the process. This procedure was based on that described in Canfield et al. (1986) with the exception that we used 150-200 mg sediment samples, and collected the sulfide produced by the distillation process in three sequential traps (trap volumes of 30, 30 and 20 ml) containing 5 mM each ZnCl₂ and NaOH (final concentrations; Ingvorsen and Jørgensen, 1979). The distillation was done using a sparging rate of 250 ml N₂/min for 45 – 60 min. Sulfide in the traps was determined colorimetrically (Cline, 1969), and the concentration of iron in this pool was calculated by assuming that all of the sulfide liberated by this procedure is pyrite-S (i.e., that there is no AVS in these sediments) with a 1:2 Fe:S molar ratio in the pyrite.

Finally, we also defined a pool of unreactive iron (Fe_U) whose concentration is given by

$$\text{Fe}_{\text{U}} = \text{Fe}_{\text{T}} - (\text{Fe}_{\text{ox1}} + \text{Fe}_{\text{ox2}} + \text{Fe}_{\text{II_HCl}} + \text{Fe}_{\text{mag}} + \text{Fe}_{\text{prs}} + \text{Fe}_{\text{pyr}}) \quad (2)$$

This iron is presumably found in mineral phases that are even less reactive towards reductive dissolution than iron in any of these other extracts.

Data Processing Description

BCO-DMO Data Manager Processing Notes:

- * Data from file "iron data.txt" imported into the BCO-DMO data system.
- * added a conventional header with dataset name, PI name, version date
- * modified parameter names to conform with BCO-DMO naming conventions (spaces, +, and - changed to underscores).
- * blank values in this dataset are displayed as "nd" for "no data." nd is the default missing data identifier in the BCO-DMO system.
- * Joined with supplemental station information file to add station lat, lon, and ISO 8601 timestamp (UTC) into the dataset.

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Data Files

File
iron.csv (Comma Separated Values (.csv), 23.01 KB) MD5:b0a7d6e2816cc7c3fa994b03cf907f4c Primary data file for dataset ID 813152

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Supplemental Files

File
NBP 1601 Station Information filename: stations.csv (Comma Separated Values (.csv), 1.63 KB) MD5:2d8b6e6a1341ed3f9d2e6e61d7368c6c Station locations and sampling information on cruise NBP 1601 (R/V Nathaniel B. Palmer, January 2016). Comma delimited file with column names: St_ID,Mo,Da,Yr,Time,Lon,Activity,ISO_DateTime_UTC Parameter information: St_ID,Station identifier,unitless Mo,"Month (local time, Punta Arenas, UTC-3)",unitless Da,"Day (local time, Punta Arenas, UTC-3)",unitless Yr,"Year in format yyyy (local time, Punta Arenas, UTC-3)",unitless Time,"Time in format HH:MM (local time, Punta Arenas, UTC-3)",unitless Lat,Station latitude,decimal degrees Lon,Station longitude,decimal degrees Activity,"C = CTD cast; M = Mega-core collected; K = Kasten core collected",unitless ISO_DateTime_UTC,Station date and time (UTC) in ISO 8601 format yyyy-mm-ddTHH:MMZ,unitless

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Related Publications

Berelson, W. M., Prokopenko, M., Sansone, F. J., Graham, A. W., McManus, J., & Bernhard, J. M. (2005).

Anaerobic diagenesis of silica and carbon in continental margin sediments: Discrete zones of TCO₂ production. *Geochimica et Cosmochimica Acta*, 69(19), 4611–4629. doi:[10.1016/j.gca.2005.05.011](https://doi.org/10.1016/j.gca.2005.05.011)

Methods

Canfield, D. E., Raiswell, R., Westrich, J. T., Reaves, C. M., & Berner, R. A. (1986). The use of chromium reduction in the analysis of reduced inorganic sulfur in sediments and shales. *Chemical Geology*, 54(1-2), 149–155. doi:[10.1016/0009-2541\(86\)90078-1](https://doi.org/10.1016/0009-2541(86)90078-1)

Methods

Cline, J. D. (1969). Spectrophotometric Determination of Hydrogen Sulfide in Natural Waters. *Limnology and Oceanography*, 14(3), 454–458. doi:[10.4319/lo.1969.14.3.0454](https://doi.org/10.4319/lo.1969.14.3.0454)

Methods

Goldberg, T., Archer, C., Vance, D., Thamdrup, B., McAnena, A., & Poulton, S. W. (2012). Controls on Mo isotope fractionations in a Mn-rich anoxic marine sediment, Gullmar Fjord, Sweden. *Chemical Geology*, 296-297, 73–82. doi:[10.1016/j.chemgeo.2011.12.020](https://doi.org/10.1016/j.chemgeo.2011.12.020)

Methods

Ingvorsen, K., & Jorgensen, B. B. (1979). Combined measurement of oxygen and sulfide in water samples. *Limnology and Oceanography*, 24(2), 390–393. doi:[10.4319/lo.1979.24.2.0390](https://doi.org/10.4319/lo.1979.24.2.0390)

Methods

Komada, T., Burdige, D. J., Li, H.-L., Magen, C., Chanton, J. P., & Cada, A. K. (2016). Organic matter cycling across the sulfate-methane transition zone of the Santa Barbara Basin, California Borderland. *Geochimica et Cosmochimica Acta*, 176, 259–278. doi:[10.1016/j.gca.2015.12.022](https://doi.org/10.1016/j.gca.2015.12.022)

Methods

Poulton, S. W., & Canfield, D. E. (2005). Development of a sequential extraction procedure for iron: implications for iron partitioning in continentally derived particulates. *Chemical Geology*, 214(3-4), 209–221.

doi:[10.1016/j.chemgeo.2004.09.003](https://doi.org/10.1016/j.chemgeo.2004.09.003)

Methods

Seeborg-Elverfeldt, J., Schlüter, M., Feseker, T., & Kölling, M. (2005). Rhizon sampling of porewaters near the sediment-water interface of aquatic systems. *Limnology and Oceanography: Methods*, 3(8), 361–371.

doi:[10.4319/lom.2005.3.361](https://doi.org/10.4319/lom.2005.3.361)

Methods

Stookey, L. L. (1970). Ferrozine---a new spectrophotometric reagent for iron. *Analytical Chemistry*, 42(7), 779–781. doi:[10.1021/ac60289a016](https://doi.org/10.1021/ac60289a016)

Methods

Viollier, E., Inglett, P. ., Hunter, K., Roychoudhury, A. ., & Van Cappellen, P. (2000). The ferrozine method revisited: Fe(II)/Fe(III) determination in natural waters. *Applied Geochemistry*, 15(6), 785–790.

doi:10.1016/S0883-2927(99)00097-9 [https://doi.org/10.1016/S0883-2927\(99\)00097-9](https://doi.org/10.1016/S0883-2927(99)00097-9)

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Parameters

Parameter	Description	Units
St_ID	station ID number	unitless
Sa_ID	sample ID (stat ID #-core ID #- sample number)	unitless
Core	core type (M = mega-corer; K = Kasten corer)	unitless
Depth	sediment depth (relative to the sediment-water interface)	centimeters (cm)

error	Half of the thickness of the sediment sample	centimeters (cm)
Fe_II_HCl	concentration of iron in the Fe(II) HCl extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_ox1	concentration of iron in the Fe ox1 extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_ox2	concentration of iron in the Fe ox2 extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_mag	concentration of iron in the Fe(mag) extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_prs	concentration of iron in the Fe(prs) extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_AVs	concentration of iron in the acid volatile sulfide (AVS) extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_pyr	concentration of iron in the AVS + pyrite extract. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_U	concentration of “unreactive” iron. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
Fe_T	concentration of total sediment iron. See methodology for more details.	grams of iron per 100 grams dried sediment (wt% Fe)
ISO_DateTime_UTC	station timestamp (UTC) in ISO 8601 format yyyy-mm-ddTHH:MMZ	unitless
Lat	station latitude, south is negative	decimal degrees
Lon	station longitude, west is negative	decimal degrees

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Instruments

Dataset-specific Instrument Name	Kasten corer
Generic Instrument Name	Gravity Corer
Generic Instrument Description	The gravity corer allows researchers to sample sediment layers at the bottom of lakes or oceans. The coring device is deployed from the ship and gravity carries it to the seafloor. (http://www.whoi.edu/instruments/viewInstrument.do?id=1079).

Dataset-specific Instrument Name	Bowers & Connelly megacorer
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.

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Deployments

NBP1601

Website	https://www.bco-dmo.org/deployment/813143
Platform	RVIB Nathaniel B. Palmer
Start Date	2016-01-08
End Date	2016-02-03

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Project Information

Organic Carbon Oxidation and Iron Remobilization by West Antarctic Shelf Sediments (Antarctic Shelf Sediments)

Coverage: West Antarctic Continental Shelf

NSF Award Abstract:

General Statement:

The continental shelf region west of the Antarctic Peninsula has recently undergone dramatic changes and ecosystem shifts, and the community of organisms that live in, or feed off, the sea floor sediments is being impacted by species invasions from the north. Previous studies of these sediments indicate that this community may consume much more of the regional productivity than previously estimated, suggesting that sediments are a rich and important component of this ecosystem and one that may be ripe for dramatic change. Furthermore, under richer sediment conditions, iron is mobilized and released back to the water

column. Since productivity in this ecosystem is thought to be limited by the availability of iron, increased rates of iron release from these sediments could stimulate productivity and promote greater overall ecosystem change. In this research, a variety of sites across the shelf region will be sampled to accurately evaluate the role of sediments in consuming ecosystem productivity and to estimate the current level of iron release from the sediments. This project will provide a baseline set of sediment results that will present a more complete picture of the west Antarctic shelf ecosystem, will allow for comparison with water column measurements and for evaluation of the fundamental workings of this important ecosystem. This is particularly important since high latitude systems may be vulnerable to the effects of climate fluctuations. Both graduate and undergraduate students will be trained. Presentations will be made at scientific meetings, at other universities, and at outreach events. A project web site will present key results to the public and explain how this new information improves understanding of Antarctic ecosystems.

Technical Description of Project:

In order to determine the role of sediments within the west Antarctic shelf ecosystem, this project will determine the rates of sediment organic matter oxidation at a variety of sites across the Palmer Long Term Ecosystem Research (LTER) study region. To estimate the rates of release of iron and manganese from the sediments, these same sites will be sampled for detailed vertical distributions of the concentrations of these metals both in the porewaters and in important mineral phases. Since sediment sampling will be done at LTER sites, the sediment data can be correlated with the rich productivity data set from the LTER. In detail, the project: a) will determine the rates of oxygen consumption, organic carbon oxidation, nutrient release, and iron mobilization by shelf sediments west of the Antarctic Peninsula; b) will investigate the vertical distribution of diagenetic reactions within the sediments; and c) will assess the regional importance of these sediment rates. Sediment cores will be used to determine sediment-water fluxes of dissolved oxygen, total carbon dioxide, nutrients, and the vertical distributions of these dissolved compounds, as well as iron and manganese in the pore waters. Bulk sediment properties of porosity, organic carbon and nitrogen content, carbonate content, biogenic silica content, and multiple species of solid-phase iron, manganese, and sulfur species will also be determined. These measurements will allow determination of total organic carbon oxidation and denitrification rates, and the proportion of aerobic versus anaerobic respiration at each site. Sediment diagenetic modeling will link the processes of organic matter oxidation to metal mobilization. Pore water and solid phase iron and manganese distributions will be used to model iron diagenesis in these sediments and to estimate the iron flux from the sediments to the overlying waters. Finally, the overall regional average and distribution of the sediment processes will be compared with the distributions of seasonally averaged chlorophyll biomass and productivity.

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Funding

Funding Source	Award
NSF Office of Polar Programs (formerly NSF PLR) (NSF OPP)	OPP-1551195

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