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Cellular iron release and associated metabolic changes during tissue damage and oxidative stress

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The data contained within this data set is arranged according to the main text and the supplementary information of this publication. Details of the files are outlined below:

Background information

Field site: Stordalen mire, Abisko, Sweden (68 22′ N, 19 03′ E)

Thaw stages: Palsa, bog and fen

Type of samples: Porewater samples, soil core samples

Main text

1) Porewater analysis

This file contains the porewater analysis along a permafrost thaw gradient: from palsa with an active layer and permafrost underneath to bog, water-saturated soil with permafrost below to fen, completely water-saturated and fully developed wetland. The file consists of three sheets:

(A) Porewater analysis (iron)

Four columns per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Aqueous Fe^{2+} [mM] (Average of triplicate measurements)
- Error bars (Standard deviation of triplicate measurements)

Method used: spectrophotometrically in triplicates with the ferrozine assay (Stookey, L. L. Ferrozine - a New Spectrophotometric Reagent for Iron. Anal Chem 42, 779-781 (1970))

(B) Porewater analysis (DOC)

Four columns per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Dissolved organic carbon [mg/L] (Average of triplicate measurements)
- Error bars (Standard deviation of triplicate measurements)

Method used: quantified in triplicate with a total organic carbon analyzer (High TOC II, Elementar, Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying the samples with 2M HCl

(C) Porewater analysis (fatty acids)

Four columns per each thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Fatty acids [mM] (Average of triplicate measurements)
- Error bars (Standard deviation of triplicate measurements)

Method used: High performance liquid chromatography (HPLC; class VP with refractive index detector [RID] 10A and photo-diode array detector SPD-M10A VP detectors; Shimadzu, Japan)

2) Most Probable Numbers

This file contains the most probable number estimates of Fe(III)-reducing bacteria along a permafrost thaw gradient. The file consists of one sheet:

(A) MPNs (FeRed)

Five columns per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Most probable number of Fe(III)-reducing bacteria (FeRed) per 1 g soil (Seven replicate analyses)
- Lower 95% confidence intervals (Seven replicate analyses)

- Upper 95% confidence intervals (Seven replicate analyses)

Method used: dilution to extinction (see also as an example: Laufer, K. et al. Coexistence of Microaerophilic, Nitrate Reducing, and Phototrophic Fe(II) Oxidizers and Fe(III) Reducers in Coastal Marine Sediment (vol 82, pg 1433, 2016). Appl Environ Microbiol 82, 3694-3694 (2016))

3) Sequencing data

This folder contains raw sequencing results obtained after further isolation efforts from the fen yielding a microorganism with 99% similarity on the 16S rRNA level to *Cupravidus metallidurans* (Proteobacteria). The folder consists of six raw data files:

(A) 24HJ44 represents sequencing results (replicate 1)
(B) 24HJ46 represents sequencing results (replicate 2)

Method used: UltraClean® Microbial DNA Isolation Kit (MO BIO Labratories, Carlsbad, CA, US); sequencing results analyzed using using nucleotide BLAST (Basic Local Alignment Search Tool)

4) Selective Fe extractions

This file contains selective iron (Fe) extractions to identify different iron minerals along the permafrost thaw gradient. Cores were taken at three sampling spots:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The file consists out of one sheet:

(A) Selective Fe extractions

Eleven columns per core per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Dithionite/citrate extractable Fe (control corrected) = reactive Fe [mg/g soil] (Duplicate analyses)
- Error bars (Combined standard deviation of sodium chloride bicarbonate extractable Fe and dithionite/citrate extractable Fe (not control corrected))
- Hydroxylamine-HCl extractable Fe = poorly crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

- Sodium pyrophosphate extractable Fe = colloidal/OM-Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- 6M HCl extractable Fe = more crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- Sodium chloride bicarbonate extractable Fe = control (same ionic strength and pH as the dithionite/citrate extraction) [mg/g soil]
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for iron in the extracts: by ferrozine assay, MP-AES (microwave plasma atomic emission spectroscopy) and ICP-MS (inductively coupled plasma mass spectrometry)

Method used for DOC in the extracts: total organic carbon analyzer (High TOC II, Elementar, Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying the samples with 2M HCl

5) EXAFS (Extended X-ray Absorption Fine Structure)

This file contains extended X-ray adsorption fine structure analysis of two soil layers (transition zone, mineral horizon) for palsa (Palsa A) and fen (Fen E). Cores were taken at the following sample spots:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

File consists out of two sheets:

(A) Plotted values

Four columns are shown for the best fits and the reference in the text:

- Palsa A (transition zone)
- Palsa A (mineral horizon)
- Fen E (transition zone)
- Fen E (mineral horizon)

(B) Fitting

Raw data for fitting available on request. Please contact the corresponding author.

Method used: Fe K-edge X-ray absorption spectroscopic analyses were conducted at Beamline 11−2 at the Stanford Synchrotron Radiation Light source (SSRL) in Menlo Park, CA. The Si(220) phi = 0° monochromator was used, and beam size of 1 mm vertical and 10 mm horizontal. EXAFS fluorescence spectra were collected with the PIPS detector simultaneously with the transmission spectrum of Fe foil, which was used for internal energy calibrations. Multiple scans (3-4) per sample were acquired as necessary to achieve satisfactory data quality. Scans were calibrated to 7112 eV (the first inflection point of Fe(0), and then averaged over 3 or 4 scans using SixPack software. They were deglitched at 7250 and 7600 eV, and then normalized with the E0 value, determined by finding the inflection point of the first derivative of each sample. A set of Fe reference compounds was used to perform linear combination fitting (LCF) of EXAFS spectra in SixPack from chi values of 2 to 12 with an x-weight of 3. Non-negative fits were performed. All contributions below 5 wt% were eliminated since we have previously determined that the limit of detection for mixed Fe species is around 5 wt%. We determined the best least square fitting based on fitting parameters such as the reduced chi2 (X2) and R-factor values. Reference compounds were chosen based on prior knowledge of the sample including, for example, criteria such as elemental composition (determined by element composition of in the soil extracts), site characteristics (e.g. redox conditions, pH), and principal component analysis (PCA).

6) Dithionite citrate extractable carbon

The file contains dithionite citrate extractable carbon, referred to as reactive Fe-associated organic carbon (OC) along the permafrost thaw gradient. The solid phase of three cores were analyzed:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The dithionite citrate extractable carbon was already control corrected (same ionic strength and pH). Sodium chloride bicarbonate was used to quantify iron and carbon which can be leached by the soil. The sodium chloride bicarbonate was subtracted from the obtained dithionite citrate extractable carbon.

This file consists out of one sheet:

(A) Dithionite citrate extractable carbon

Six columns are shown per thaw stage (palsa, bog and fen) and contain

- Soil horizons
- Depth intervals [cm]

- Dithionite/citrate extractable OC (control corrected) = reactive Fe-associated OC [mg/g soil] (Duplicate analyses)
- Error bars (Combined standard deviation of sodium chloride bicarbonate extractable OC, citrate blank and dithionite/citrate extractable OC (not control corrected))
- Sodium chloride bicarbonate extractable OC = control (same ionic strength and pH as the dithionite/citrate extraction) [mg/g soil]
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used: quantified in triplicate with a total organic carbon analyzer (High TOC II, Elementar, Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying the samples with 2M HCl

7) TOC

The file contains total organic carbon (TOC) analyses along the permafrost thaw gradient. The solid phase of three cores were analyzed:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

This file consists out of one sheet:

(A) TOC

Six columns are shown per thaw stage (palsa, bog and fen) and contain

- Soil horizons
- Depth intervals [cm]
- TOC [%]
- TOC [g/g]
- TOC [mg/g]
- Error bars (Standard deviation of triplicate analyses)

Method used: analyzed by an Elementar vario El (Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying with 16% HCl prior analysis

8) nanoSIMS anylsis

(also contains the raw data files of the nanoSIMS images shown in the Supplementary Information)

This folder contains raw data of nanoSIMS analysis of the fine fraction of palsa and fen.

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The folder consists out of six further folders containing the raw data files of fine particle analysis:

(A) Palsa A (organic horizon) (1 fine particle) (S18096_I08_pa_ho2)
(B) Palsa A (transition zone) (4 fine particles) (S18096_I06_pa_ho3; S18096_I06_pa_ho4)
(C) Palsa A (mineral horizon) (1 fine particle) (S18097_I08_pa_ho6)
(D) Fen C (organic horizon) (1 fine particle) (S18098_I10_fe_ho1)
(E) Fen C (transition zone) (4 fine particles) (S18099_I12_fe_ho2)
(F) Fen C (mineral horizon) (1 fine particle) (S18100_I14_fe_ho4)

Method used: performed at the Cameca nanoSIMS 50L of the Chair of Soil Science (TU München, Germany); primary beam (~1.2 pA) was focused at a lateral resolution ~100 nm and scanned over the sample with 12C-, 16O-, 12C14N-, 31P-, 32S-, 27Al16O- and 56Fe16O- secondary ions collected using electron multipliers; the nanoSIMS images were analyzed using the Open MIMS Image plugin available within ImageJ

Supplementary Information

1) Replicate cores (2019)

This file contains the selective iron and carbon extractions along a permafrost thaw gradient: from palsa with an active layer and permafrost underneath to bog, water-saturated soil with permafrost below to fen, completely water-saturated and fully developed wetland. Cores were taken in 2019:

Palsa a (68°21'18.03"N, 19° 2'35.20"E)

Bog c (68°21'18.02"N, 19° 2'36.53"E)

Fen e (68°21'17.24"N, 19° 2'37.44"E)

The file consists out of two sheets:

(A) Iron

Eight columns per core per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Dithionite/citrate extractable Fe (control corrected) = reactive Fe [mg/g soil] (Duplicate analyses)
- Error bars (Combined standard deviation of sodium chloride bicarbonate extractable Fe and dithionite/citrate extractable Fe (not control corrected))
- 6M HCl extractable Fe = more crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- Sodium chloride bicarbonate extractable Fe = control (same ionic strength and pH as the dithionite/citrate extraction) [mg/g soil]
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(B) Carbon

Eight columns per core per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Dithionite/citrate extractable OC (control corrected) = reactive Fe associated OC [mg/g soil] (Duplicate analyses)
- Error bars (Combined standard deviation of sodium chloride bicarbonate extractable OC, citrate blank and dithionite/citrate extractable OC (not control corrected))
- Sodium chloride bicarbonate extractable OC = control (same ionic strength and pH as the dithionite/citrate extraction) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- Total organic carbon = TOC [mg/g soil]
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for iron in the extracts: by ferrozine assay, MP-AES (microwave plasma atomic emission spectroscopy) and ICP-MS (inductively coupled plasma mass spectrometry)

Method used for DOC in the extracts: total organic carbon analyzer (High TOC II, Elementar, Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying the samples with 2M HCl

Method used for TOC: analyzed by an Elementar vario El (Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying with 16% HCl prior analysis

2) Replicate cores (2018)

This file contains the selective iron and carbon extractions along a permafrost thaw gradient: from palsa to bog to fen. Cores were taken in 2018:

Palsa B (68°21'18.50"N, 19° 2'38.80"E)

Bog D (68°21'18.30"N, 19° 2'40.00"E)

Fen F (68°21'17.80"N, 19° 2'41.30"E)

The file consists out of two sheets:

(A) Iron

Eight columns per core per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]
- Dithionite/citrate extractable Fe (control corrected) = reactive Fe [mg/g soil] (Duplicate analyses)
- Error bars (Combined standard deviation of sodium chloride bicarbonate extractable Fe and dithionite/citrate extractable Fe (not control corrected))
- 6M HCl extractable Fe = more crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- Sodium chloride bicarbonate extractable Fe = control (same ionic strength and pH as the dithionite/citrate extraction) [mg/g soil]
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(B) Carbon

Eight columns per core per thaw stage (palsa, bog and fen) contain

- Soil horizons
- Depth intervals [cm]

- Dithionite/citrate extractable OC (control corrected) = reactive Fe associated OC [mg/g soil] (Duplicate analyses)
- Error bars (Combined standard deviation of sodium chloride bicarbonate extractable OC, citrate blank and dithionite/citrate extractable OC (not control corrected))
- Sodium chloride bicarbonate extractable OC = control (same ionic strength and pH as the dithionite/citrate extraction) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- Total organic carbon = TOC [mg/g soil]
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for iron in the extracts: by ferrozine assay, MP-AES (microwave plasma atomic emission spectroscopy) and ICP-MS (inductively coupled plasma mass spectrometry)

Method used for DOC in the extracts: total organic carbon analyzer (High TOC II, Elementar, Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying the samples with 2M HCl

Method used for TOC: analyzed by an Elementar vario El (Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying with 16% HCl prior analysis

3) Replicate cores (2017)

This file contains the selective iron extractions and total organic carbon analysis along a permafrost thaw gradient: from palsa to bog to fen. Cores were taken in 2017:

Palsa (68°21'26.56"N, 19° 3'0.19"E)

Bog (68°21'16.02"N, 19° 2'49.21"E)

Fen (68°21'17.16"N, 19° 2'36.29"E)

The file consists out of six sheets:

(A) Iron (palsa)

Six columns per replicate (triplicates) contain

- Soil horizons
- Depth intervals [cm]
- 0.5M HCl extractable Fe = readily extractable Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

- 6M HCl extractable Fe = more crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(B) Iron (bog)

Six columns per replicate (triplicates) contain

- Soil horizons
- Depth intervals [cm]
- 0.5M HCl extractable Fe = readily extractable Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- 6M HCl extractable Fe = more crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(C) Iron (fen)

Six columns per replicate (triplicates) contain

- Soil horizons
- Depth intervals [cm]
- 0.5M HCl extractable Fe = readily extractable Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- 6M HCl extractable Fe = more crystalline Fe [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for iron in the extracts: by ferrozine assay

(D) Carbon (palsa)

Four columns per replicate (triplicates) contain

- Soil horizons
- Depth intervals [cm]
- Total organic carbon = TOC [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for TOC: analyzed by an Elementar vario El (Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying with 16% HCl prior analysis

(E) Carbon (bog)

Four columns per replicate (triplicates) contain

- Soil horizons
- Depth intervals [cm]
- Total organic carbon = TOC [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for TOC: analyzed by an Elementar vario El (Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying with 16% HCl prior analysis

(F) Carbon (fen)

Four columns per replicate (triplicates) contain

- Soil horizons
- Depth intervals [cm]
- Total organic carbon = TOC [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for TOC: analyzed by an Elementar vario El (Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying with 16% HCl prior analysis

4) Fe(III) reduction with isolates

This file contains data obtained during batch experiments with further isolated *Cupravidus metallidurans* to determine its capability to reduce Fe(III) and Fe(III) reduction rates.

The file consists out of four sheets:

(A) Fe2+ (aq)

Seventeen columns contain

- Setup (with acetate, with lactate, with lactate and acetate amendments, no addition (control))
- Aqueous Fe2+ [mM] at the beginning of the experiment (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 1 day (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 2 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 3 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 4 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 5 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 6 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Aqueous Fe2+ [mM] after 31 days (Triplicates)
- Error bars (Standard deviation of triplicates)

Method used: by ferrozine assay

(B) Fe(II)/Fe(tot)

Nine columns contain

- Setup (with acetate, with lactate, with lactate and acetate amendments, no addition (control))
- Fe(II)/Fe(tot) [%] at the beginning of the experiment
- Fe(II)/Fe(tot) [%] after 1 day
- Fe(II)/Fe(tot) [%] after 2 days
- Fe(II)/Fe(tot) [%] after 3 days
- Fe(II)/Fe(tot) [%] after 4 days
- Fe(II)/Fe(tot) [%] after 5 days
- Fe(II)/Fe(tot) [%] after 6 days
- Fe(II)/Fe(tot) [%] after 31 days

Method used: by ferrozine assay

(C) Lactate

Seventeen columns contain

- Setup (with acetate, with lactate, with lactate and acetate amendments, no addition (control))
- Lactate [mM] at the beginning of the experiment (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 1 day (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 2 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 3 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 4 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 5 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 6 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Lactate [mM] after 31 days (Triplicates)
- Error bars (Standard deviation of triplicates)

Method used: High performance liquid chromatography (HPLC; class VP with refractive index detector [RID] 10A and photo-diode array detector SPD-M10A VP detectors; Shimadzu, Japan)

(D) Acetate

Seventeen columns contain

- Setup (with acetate, with lactate, with lactate and acetate amendments, no addition (control))
- Acetate [mM] at the beginning of the experiment (Triplicates)
- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 1 day (Triplicates)
- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 2 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 3 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 4 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 5 days (Triplicates)

- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 6 days (Triplicates)
- Error bars (Standard deviation of triplicates)
- Acetate [mM] after 31 days (Triplicates)
- Error bars (Standard deviation of triplicates)

Method used: High performance liquid chromatography (HPLC; class VP with refractive index detector [RID] 10A and photo-diode array detector SPD-M10A VP detectors; Shimadzu, Japan)

5) Sodium pyrophosphate extractable carbon

This file contains sodium pyrophosphate extractable organic carbon along the thaw gradient of the following cores:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The file consists out of one sheet:

(A) Sodium pyrophosphate extractable organic carbon

Four columns per core per thaw stage contain

- Soil horizons
- Depth intervals [cm]
- Sodium pyrophosphate extractable carbon [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Method used for DOC in the extracts: total organic carbon analyzer (High TOC II, Elementar, Elementar Analysensysteme GmbH, Germany); inorganic carbon was removed by acidifying the samples with 2M HCl

6) Stock of reactive Fe and reactive Fe associated organic carbon

This file contains stock calculations of reactive Fe and reactive Fe associated organic carbon along the permafrost thaw gradient for three cores (discussed in the main text):

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The file consists out of three sheets:

(A) Not compaction corrected

Seven columns per core at each thaw stage (palsa, bog and fen):

- Soil horizons
- Layer thickness of cores in liner [cm]
- Bulk density [g/cm^3]
- Dithionite/citrate extractable iron = reactive Fe (control corrected) [g/cm^2] (Duplicate analyses)
- Error bars (Standard deviation of the absolute values and the bulk density per horizon per thaw stage)
- Dithionite citrate extractable OC = reactive Fe associated OC (control corrected) [g/cm^2] (Duplicate analyses)
- Error bars (Standard deviation of the absolute values and the bulk density per horizon per thaw stage)

(B) Compaction corrected

Seven columns per core at each thaw stage (palsa, bog and fen):

- Soil horizons
- Layer thickness with compaction correction [cm]
- Bulk density [g/cm^3]
- Dithionite/citrate extractable iron = reactive Fe (control corrected) [g/cm^2] (Duplicate analyses)
- Error bars (Standard deviation of the absolute values and the bulk density per horizon per thaw stage)
- Dithionite citrate extractable OC = reactive Fe associated OC (control corrected) [g/cm^2] (Duplicate analyses)
- Error bars (Standard deviation of the absolute values and the bulk density per horizon per thaw stage)

(C) Calculation of compaction

Eight columns per core at each thaw stage (palsa, bog and fen):

- Core hole depth from surface [cm]
- Core length in liner [cm]
- Bulk density [g/cm^3]
- Assumption (Compaction was assumed, based on the bulk density, to occur for palsa organic horizon, transition zone, bog organic horizon and fen organic horizon)
- Soil horizon
- Layer thickness of cores in liner [cm]
- Layer thickness with compaction [cm]
- Compaction factor

7) Additional elements (P, S, Al)

This file contains additional elements extracted with the performed selective extractions on the cores of the main text:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The file consists out of three sheets:

(A) 6M HCl

Eight columns contain per core at each thaw stage (palsa, bog and fen):

- Soil horizons
- Depth intervals [cm]
- 6M HCl extractable P [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- 6M HCl extractable S [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- 6M HCl extractable Al [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(B) HA-HCl (hydroxylamine-HCl)

Eight columns contain per core per thaw stage (palsa, bog and fen):

- Soil horizons
- Depth intervals [cm]
- HA-HCl extractable P [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- HA-HCl extractable S [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- HA-HCl extractable Al [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(C) Sodium pyrophosphate

Six columns contain per core per thaw stage (palsa, bog and fen):

- Soil horizons
- Depth intervals [cm]
- Sodium pyrophosphate extractable S [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- Sodium pyrophosphate extractable Al [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Methods used: Phosphorous (P) and sulphur (S) concentrations were measured with ICP-MS (inductively coupled plasma mass spectrometry). Aluminum (Al) concentrations were analyzed using MP-AES (microwave plasma atomic emission spectroscopy).

8) Different iron analysis

The file contains different analytical approaches (ferrozine assay, MP-AES, ICP-MS) to determine Fe in the extracts of the cores discussed in the main text, to rule out matrix effects:

Palsa A (68°21'18.70"N, 19° 2'38.00"E)

Bog C (68°21'18.60"N, 19° 2'39.20"E)

Fen E (68°21'16.80"N, 19° 2'40.30"E)

The file consists out of three sheets:

(A) 6M HCl extractable Fe

Eight columns contain per core per thaw stage (palsa, bog and fen):

- Soil horizons
- Depth intervals [cm]
- Ferrozine values of 6M HCl extractable Fe (more crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- MP-AES values of 6M HCl extractable Fe (more crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- ICP-MS values of 6M HCl extractable Fe (more crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(B) Hydroxylamine-HCl extractable Fe

Eight columns contain per core per thaw stage (palsa, bog and fen):

- Soil horizons
- Depth intervals [cm]
- Ferrozine values of Ha-HCl extractable Fe (poorly crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- MP-AES values of HA-HCl extractable Fe (poorly crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- ICP-MS values of HA-HCl extractable Fe (poorly crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

(C) Sodium pyrophosphate extractable Fe

Eight columns contain per core per thaw stage (palsa, bog and fen):

- Soil horizons
- Depth intervals [cm]
- Ferrozine values of sodium pyrophosphate extractable Fe (colloidal/OM-Fe) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

- MP-AES values of sodium pyrophosphate extractable Fe (colloidal/OM-Fe) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)
- ICP-MS values of sodium pyrophosphate extractable Fe (colloidal/OM-Fe crystalline) [mg/g soil] (Duplicate analyses)
- Error bars (Range of duplicate analyses of each layer in each thaw stage)

Methods used: ferrozine assay, MP-AES (microwave plasma atomic emission spectroscopy), ICP-MS (inductively coupled plasma mass spectrometry)