Supporting Information for:

**Linkages between geochemistry and microbiology in a proglacial terrain in the High-Arctic.**

Robin Wojcik \*(1), Johanna Donhauser \*(2), Stine Holm (1), Lucie Malard (3), Alexandra Holland (4), Beat Frey (2), Dirk Wagner (1, 3), David A. Pearce (4), Alex Anesio (5), and Liane G. Benning (1,6)

1 GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany; 2 Swiss Federal Research Institute WSL, 8903 Zurich, Switzerland; 3 University of Potsdam, Institute of Earth and Environmental Sciences, 14476 Potsdam, Germany; 4 Northumbria University, Newcastle, NE1 8ST United Kingdom; 5 University of Bristol, BS8 1TH Bristol, United Kingdom; 6 Department of Earth Sciences, Free University of Berlin, 12248 Berlin, Germany. \* The ﬁrst two authors contributed equally to this work.

**This SI file contains:**

Supplementary Information Materials and Methods

Supplementary Figure S1-S3

Supplementary Tables S1-S5

**Supplementary Material and Methods**

Carbon and nitrogen content and isotopes measurements

The isotopic composition is given in delta notation relative to a standard: d (‰) = [(Rsample – Rstandard)/Rstandard)] x 1000. The ratio (R) and standard for carbon is 13C/12C and VPDB (Vienna PeeDee Belemnite) and for nitrogen 15N/14N and air. The TOC contents and d13Corg values were determined on in-situ decalcified samples. Around 3 mg of sample material was weighted in Ag-capsules, dropped first with 3% and second with 20% HCl, heated for 3 h at 75°C, and finally wrapped into Ag-capsules and measured as described above. The calibration was performed using elemental (Urea) and certified isotope standards (USGS24, CH-7) and proofed with an internal soil reference sample (Boden3, HEKATECH). The reproducibility for replicate analyses is 0.2 % for TOC and 0.2‰ for d13Corg. For total C, N and d15N determination, around 25 mg of sample material were loaded in tin capsules and burned in the elemental analyzer. TOC and TN were calibrated against Acetanilide whereas for the nitrogen isotopic composition two ammonium sulfate standards (e.g. IAEA N-1 and N-2) were used. The analytical precision was 0.1% for TC, TOC and TN and was 0.2‰ for δ13Corg and δ15N.

X-ray fluorescence measurements

All soil size fractions (excluding particulates) and boulder samples were melted into glass tablet for X-ray fluorescence (XRF) measurements using 1 g of grounded sample, 6 g of di-Lithiumtetraborate (FX-X65-2) and 0.5 g of ammonium nitrate. XRF measurements were performed on a ‘PANalytical AXIOS Advanced’ equipped with a rhodium tube. The measurements were calibrated using 130 standards made of different material, including basalts, granites and soil sediments (e.g. JSO-1, JSO-2 GXR-2-GXR-5, GXR-5, GXR-6). The detection limit is 0,01 % for major elements (SiO2, TiO2, Al2O3, Fe2O3, MnO, MgO, CaO, Na2O, K2O, P2O5, CO2 and H2O) is ≤ 10 ppm for minor elements (Ba, Cr, Ga, Nb, Ni, Rb, Sr, Y, Zn, Zr).

PCR amplification of archaeal 16S rRNA genes

The archaeal 16S rRNA gene was amplified using the primers 20F and 958R (100μM) 0.5μM, dNTP MiX (5mM), 0.2mM, and mgCl2 (25mM) using (0.5mM). The polymerase Optitaq (Roboklon, Germany) in a concentration of 1.25U was used. A template concentration of 5ng and a total of 25 μL reaction volume was used. PCR conditions were as follows: initial denaturation at 95°C for 5 min, followed by 40 cycles of denaturation (95°C for 30 s), annealing (55°C for 30 s) and elongation (72°C for 1 min), and a final extension step of 72°C for 7 min. The second PCR was performed with the primers Arch349R (10 μM) and Arch806-R (10 μM). As template, 3 μL of PCR reaction one was used. A total of 50 μL reaction volume was amplified by 95°C for 5 min, followed by 35 cycles of denaturation (95°C for 30 s), annealing (55°C for 30 s) and elongation (72°C for 1 min), and a final extension step of 72°C for 7 min. The PCR amplification was carried out with a T100™ Thermal Cycler (Bio-Rad Laboratories, CA, USA) comprising different combinations of barcodes. The PCR products were purified using Agencourt Ampure Xp (Agencourt Bioscience, USA), using 50 μL PCR product and 180uL magnetic bead solution.

* + 1. Quantitative real-time PCR

Each reaction (20 μL) contained 2× concentrate of KAPA HiFi SYBR Green (KAPA Biosystems), 100 μM of the forward (0.04 μL), and reverse primer (0.04 μL), sterile water, and 5 μL of DNA template. The environmental DNA samples were diluted 10-fold and run in three technical replicates. The PCR reactions comprised an initial denaturation (3 min at 95°C), followed by 35 cycles of 0.03min at 95°C, 0.20 min an annealing temperature of 60°C, 0.30min at 72°C, and a plate read step at 80°C for 0.03 min, as positive control E.coli was usedFor Archaea 45 cycles was used and an annealing temperature of 57°C. As a positive control SMA-21, *Methanosarcina solegilidi* was used, furthermore a bacterial positive control, E.coli, was included to asses potential bacterial 16S rRNA targeting. Melt curve analysis from 65 to 95°C with 0.5°C temperature increment per 0.5 s cycle was conducted at the end of each run to identify nonspecific amplification of DNA. All cycle data were collected using the single threshold Cq determination mode.

**Supplementary figures**

Supplementary Information Figure S1: Bacterial (A), fungal (B) and archaeal (C) relative abundances (mean per site) at the phylum level.



Supplementary Information Figure S2: Title: PCoA on (A) TOC, TN, δ13C, δ15N and (B) major and minor oxides.



Supplementary Information Figure S3: Title: Heatmap showing pairwise Pearson correlations of geochemical variables. Variables are grouped according to the degree of correlation.



**Supplementary tables**

Supplementary Information Table S1: Primers for archaea

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sample name | Gene | Forward barcode | Forward primer (including Linker) | Reverse barcode | Reverse primer (including linker) |
| Site 1.1 | 16S rRNA Archaea | TACACGTGAT | gYg CAS CAg KCg MgA AW | CGACGTGACT | GGACTACVSGGGTATCTAAT |
| Site 1.2 | 16S rRNA Archaea | TACAGATCGT | gYg CAS CAg KCg MgA AW | TACACACACT | GGACTACVSGGGTATCTAAT |
| Site 1.3 | 16S rRNA Archaea | TACGCTGTCT  | gYg CAS CAg KCg MgA AW | TACACGTGAT | GGACTACVSGGGTATCTAAT |
| Site 2.1 | 16S rRNA Archaea | TAGTGTAGAT  | gYg CAS CAg KCg MgA AW | TACAGATCGT  | GGACTACVSGGGTATCTAAT |
| Site 2.2 | 16S rRNA Archaea | TCGATCACGT | gYg CAS CAg KCg MgA AW | TACGCTGTCT  | GGACTACVSGGGTATCTAAT |
| Site 2.3 | 16S rRNA Archaea | TCTAGCGACT | gYg CAS CAg KCg MgA AW | TAGTGTAGAT  | GGACTACVSGGGTATCTAAT |
| Site 3.1 | 16S rRNA Archaea | TCTATACTAT | gYg CAS CAg KCg MgA AW | TCTAGCGACT | GGACTACVSGGGTATCTAAT |
| Site 3.2 | 16S rRNA Archaea | TGTGAGTAGT | gYg CAS CAg KCg MgA AW | TCTATACTAT  | GGACTACVSGGGTATCTAAT |
| Site 3.3 | 16S rRNA Archaea | ACGCGATCGA  | gYg CAS CAg KCg MgA AW | TGACGTATGT  | GGACTACVSGGGTATCTAAT |

Supplementary Information Table S2: Major ions in soil water

Caption: b.d. below detection limit

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | Chloride | Nitrate | Sulfate | Sodium | Ammonium | Potassium | Magnesium | Calcium |
|   | (µmol/L) | (µmol/L) | (µmol/L) | (µmol/L) | (µmol/L) | (µmol/L) | (µmol/L) | (µmol/L) |
| Site 1 | 13.73 | 1.13 | 7.69 | 14.47 | b.d | 7.05 | 44.43 | 48.83 |
| Site 2 | 13.09 | 0.46 | 3.36 | 21.17 | b.d | 1.92 | 7.11 | 8.99 |
| Site 3 | 20.63 | b.d | 2.64 | 27.39 | 5.37 | 1.17 | 2.43 | 3.34 |

Supplementary Information Table S3: Descriptive analyses for soil major oxides group (oxides presented as percentage by weight). Values are shown as the average (± standard deviation) of the triplicate soil samples or average of all sites.

Caption: \* The standard deviation was not calculated if less than three samples were available. n.a. No data available.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   |   | **SiO2** | **TiO2** | **Al2O3** | **Fe2O3** | **MnO** | **MgO** | **CaO** | **Na2O** | **K2O** | **P2O5** | **H2O** | **CO2** |
|  |  | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** | **(%)** |
| Site 1 | <2mm | 62.53 ± 0.77 | 0.71 ± 0.01 | 13.17 ± 0.31 | 5.61 ± 0.03 | 0.06 ± 0 | 1.41 ± 0 | 0.6 ± 0.04 | 0.86 ± 0.16 | 2.49 ± 0.07 | 0.2 ± 0.01 | 5.35 ± 0.16 | 6.46 ± 0.37 |
| Site 1 | 2-8mm | 61.93 ± 2.66 | 0.73 ± 0.01 | 13.53 ± 0.61 | 5.59 ± 0.47 | 0.06 ± 0 | 1.46 ± 0.1 | 0.64 ± 0.05 | 1.22 ± 0.6 | 2.57 ± 0.16 | 0.21 ± 0.01 | 5.42 ± 0.49 | 6.12 ± 1.78 |
| Site 1 | 8-15mm | 66.6 ± 3.3 | 0.68 ± 0.02 | 12.97 ± 1 | 5.23 ± 0.53 | 0.05 ± 0.01 | 1.39 ± 0.13 | 0.55 ± 0.08 | 0.88 ± 0.15 | 2.47 ± 0.18 | 0.19 ± 0.02 | 4.44 ± 0.56 | 3.7 ± 0.9 |
| Site 1 | 15-50 mm | 70.77 ± 3.14 | 0.7 ± 0.08 | 11.53 ± 0.6 | 4.47 ± 0.32 | 0.04 ± 0 | 1.24 ± 0.05 | 0.7 ± 0 | 0.84 ± 0.07 | 2.19 ± 0.14 | 0.2 ± 0.05 | 3.64 ± 0.61 | 3.28 ± 1.24 |
| Site 1 | >50mm | 79.3 \* | 0.49 \* | 9.3 \* | 3.07 \* | 0.04 \* | 0.92 \* | 0.63 \* | 1.02 \* | 1.57 \* | 0.09 \* | 2.27 \* | 1.02 \* |
| Site 1 | host rock | 75.9 \* | 0.64 \* | 10.9 \* | 3.79 \* | 0.06 \* | 1.09 \* | 0.79 \* | 0.86 \* | 2 \* | 0.13 \* | 2.67 \* | 0.99 \* |
| Site 2 | <2mm | 55.27 ± 2.55 | 0.62 ± 0.06 | 11.9 ± 1.67 | 5.14 ± 0.86 | 0.05 ± 0.01 | 1.08 ± 0.17 | 0.41 ± 0.04 | 0.76 ± 0.07 | 2.19 ± 0.27 | 0.16 ± 0.03 | 7.68 ± 0.69 | 14.29 ± 4.36 |
| Site 2 | 2-8mm | 55.7 ± 11.2 | 0.57 ± 0.16 | 11.03 ± 3.29 | 5.34 ± 1.82 | 0.07 ± 0.02 | 0.99 ± 0.28 | 0.38 ± 0.04 | 0.96 ± 0.28 | 2.12 ± 0.66 | 0.15 ± 0.05 | 7.42 ± 3.28 | 14.96 ± 14.44 |
| Site 2 | 8-15mm | 68.27 ± 3.17 | 0.69 ± 0.05 | 12.47 ± 0.45 | 5.16 ± 1.05 | 0.06 ± 0.03 | 1.17 ± 0.09 | 0.57 ± 0.11 | 1.11 ± 0.18 | 2.46 ± 0.12 | 0.16 ± 0.01 | 3.45 ± 0.33 | 4.14 ± 3.34 |
| Site 2 | 15-50 mm | 73.9 ± 7.16 | 0.59 ± 0.12 | 10.23 ± 2.07 | 4.03 ± 0.28 | 0.03 ± 0.01 | 0.88 ± 0.3 | 0.37 ± 0.07 | 1.02 ± 0.12 | 2.28 ± 0.17 | 0.13 ± 0.02 | 2.72 ± 0.83 | 3.53 ± 3.77 |
| Site 2 | >50mm | 72.4 \* | 0.52 \* | 11 \* | 5.36 \* | 0.01 \* | 0.63 \* | 0.4 \* | 2.06 \* | 3.16 \* | 0.14 \* | 2.69 \* | 1.12 \* |
| Site 2 | host rock | 76.5 \* | 0.45 \* | 8.5 \* | 3.26 \* | 0.16 \* | 0.41 \* | 2.35 \* | 1.77 \* | 2.57 \* | 0.1 \* | 1.37 \* | 2.29 \* |
| Site 3 | <2mm | 55.73 ± 4.92 | 0.64 ± 0.06 | 12.63 ± 1.41 | 5.49 ± 0.73 | 0.05 ± 0.01 | 1.11 ± 0.12 | 0.39 ± 0.01 | 0.86 ± 0.04 | 2.29 ± 0.22 | 0.17 ± 0.02 | 7.42 ± 1.21 | 12.74 ± 6.11 |
| Site 3 | 2-8mm | 63.23 ± 1.19 | 0.67 ± 0.04 | 13.23 ± 0.98 | 6.3 ± 0.13 | 0.07 ± 0 | 1.16 ± 0.12 | 0.41 ± 0.03 | 1.01 ± 0.09 | 2.52 ± 0.14 | 0.19 ± 0.01 | 5.44 ± 0.45 | 5.37 ± 0.71 |
| Site 3 | 8-15mm | 69.37 ± 6.19 | 0.55 ± 0.07 | 10.67 ± 0.95 | 4.31 ± 0.5 | 0.03 ± 0.01 | 0.82 ± 0.13 | 0.44 ± 0.1 | 1.32 ± 0.25 | 2.28 ± 0.06 | 0.13 ± 0.02 | 5.55 ± 3.53 | 4.27 ± 3.98 |
| Site 3 | 15-50 mm | 75.77 ± 2.25 | 0.59 ± 0.09 | 9.97 ± 1.05 | 4.4 ± 0.46 | 0.05 ± 0.02 | 0.87 ± 0.08 | 0.54 ± 0.09 | 1.42 ± 0.23 | 2 ± 0.43 | 0.14 ± 0.03 | 2.56 ± 0.12 | 1.38 ± 0.26 |
| Site 3 | >50mm | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Site 3 | host rock | 74 \* | 0.44 \* | 9.8 \* | 6.69 \* | 0.03 \* | 0.61 \* | 0.46 \* | 1.81 \* | 3.01 \* | 0.17 \* | 2.07 \* | 0.56 \* |

Supplementary Information Table S4: Descriptive analyses for soil minor oxides group (oxides presented as percentage by weight). Values are shown as the average (± standard deviation) of the triplicate soil samples or average of all sites.

Caption: \* The standard deviation was not calculated if less than three samples were available. n.a. No data available.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   |   | **Ba** | **Cr** | **Ga** | **Nb** | **Ni** | **Rb** | **Sr** | **V** | **Y** | **Zn** | **Zr** |
|  |  | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** | **(ppm)** |
| Site 1 |   | 451 ± 13.93 | 85.33 ± 1.25 | 17.33 ± 0.94 | 13.33 ± 0.47 | 35.67 ± 1.25 | 102 ± 2.83 | 99.67 ± 2.62 | 112.67 ± 0.94 | 25.33 ± 0.47 | 79.67 ± 0.47 | 217.33 ± 8.34 |
| Site 1 | 2-8mm | 485 ± 68.07 | 85.33 ± 5.79 | 16.33 ± 0.47 | 14.67 ± 0.94 | 34 ± 1.41 | 102.67 ± 7.32 | 101.33 ± 2.05 | 115.33 ± 7.72 | 24.67 ± 1.25 | 77.67 ± 3.4 | 210.33 ± 18.12 |
| Site 1 | 8-15mm | 456.67 ± 17.13 | 82.33 ± 3.3 | 16.33 ± 2.05 | 12 ± 0.82 | 29.67 ± 1.89 | 99.67 ± 8.38 | 95 ± 6.68 | 117 ± 15.3 | 25.67 ± 1.25 | 74 ± 6.38 | 224.67 ± 67.36 |
| Site 1 | 15-50 mm | 425 ± 21.12 | 75.67 ± 7.72 | 15 ± 0.82 | 13 ± 1.63 | 31.33 ± 1.7 | 92 ± 1.41 | 101.33 ± 10.62 | 84.33 ± 20.15 | 26.67 ± 2.36 | 75.67 ± 13.82 | 273.67 ± 2.87 |
| Site 1 | >50mm | 323 \* | 72 \* | 11 \* | 10 \* | 22 \* | 65 \* | 78 \* | 44 \* | 16 \* | 43 \* | 191 \* |
| Site 1 | host rock | 409 \* | 65 \* | 14 \* | 11 \* | 27 \* | 79 \* | 84 \* | 56 \* | 22 \* | 52 \* | 367 \* |
| Site 2 | <2mm | 415.67 ± 36.94 | 76.67 ± 10.66 | 15.67 ± 1.89 | 12 ± 0.82 | 30.67 ± 3.68 | 92 ± 19.65 | 120.67 ± 10.62 | 118 ± 27.65 | 23.33 ± 3.68 | 72.67 ± 10.34 | 193.33 ± 23.61 |
| Site 2 | 2-8mm | 420.67 ± 125.02 | 67.33 ± 17.21 | 17 ± 1 | 13 ± 1 | 27.67 ± 7.72 | 81.33 ± 28.66 | 99.67 ± 24.23 | 97.33 ± 36.38 | 21.67 ± 4.71 | 64.33 ± 20.07 | 187.33 ± 41.33 |
| Site 2 | 8-15mm | 551 ± 9.8 | 71.67 ± 5.44 | 16.67 ± 0.94 | 13 ± 0.82 | 29.67 ± 1.25 | 95.67 ± 5.31 | 104.67 ± 17.25 | 81 ± 12.08 | 25.67 ± 1.89 | 65.67 ± 4.92 | 324.33 ± 52.82 |
| Site 2 | 15-50 mm | 529 ± 16.08 | 70.33 ± 8.96 | 15 ± 3 | 12.5 ± 1.5 | 22.33 ± 5.79 | 83.33 ± 13.6 | 104.33 ± 9.46 | 92 ± 23.37 | 20.67 ± 4.5 | 58 ± 10.2 | 344.67 ± 81.18 |
| Site 2 | >50mm | 801 \* | 69 \* | 13 \* | 14 \* | 10 \* | 102 \* | 205 \* | 199 \* | 19 \* | 36 \* | 295 \* |
| Site 2 | host rock | 678 \* | 63 \* | 10 \* | \*\* | 13 \* | 75 \* | 442 \* | 93 \* | 23 \* | 40 \* | 285 \* |
| Site 3 | <2mm | 437.33 ± 44.9 | 81.67 ± 10.08 | 15.67 ± 1.89 | 11.67 ± 1.25 | 30.33 ± 3.68 | 92.67 ± 12.5 | 123.33 ± 4.19 | 139 ± 16.67 | 23.67 ± 2.05 | 77.67 ± 6.94 | 171 ± 11.43 |
| Site 3 | 2-8mm | 480.67 ± 11.09 | 83.67 ± 5.56 | 17 ± 1.63 | 11.67 ± 0.47 | 33 ± 2.94 | 98 ± 7.26 | 119.67 ± 5.25 | 135.33 ± 4.92 | 24.67 ± 0.94 | 78 ± 4.24 | 206 ± 13.59 |
| Site 3 | 8-15mm | 666.33 ± 205.69 | 64 ± 5.1 | 13.33 ± 1.25 | 12.5 ± 1.5 | 21.67 ± 6.13 | 89.67 ± 11.81 | 137 ± 17.38 | 103.67 ± 20.07 | 21 ± 3.74 | 50.33 ± 10.34 | 285.33 ± 42.32 |
| Site 3 | 15-50 mm | 538.67 ± 214.45 | 65 ± 8.04 | 11.67 ± 0.94 | 12 ± 0 | 25.33 ± 5.73 | 73.67 ± 11.79 | 114 ± 39.3 | 85.33 ± 25.77 | 21.67 ± 1.7 | 56 ± 8.83 | 283 ± 86.74 |
| Site 3 | >50mm | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Site 3 | host rock | 801 \* | 73 \* | 13 \* | 13 \* | 14 \* | 85 \* | 197 \* | 197 \* | 23 \* | 55 \* | 318 \* |

Supplementary Information Table S5: Variance of prokaryotic and fungal community structure constrained by geochemical variables.

Caption: Variance in the microbial data explained by each variable individually was assessed based on the marginal test of the DistLM procedure. P values are obtained from a permutational tests implemented in DistLM; ∗∗∗P < 0.001, ∗∗P < 0.01, ∗P < 0.05, n.s. = not significant.

|  |  |  |
| --- | --- | --- |
| **Bacteria** | **Archaea** | **Fungi** |
| Variable | P | Variance explained | Variable | P | Variance explained | Variable | P | Variance explained |
| CaO | 0.0026∗∗ | 49% | CaO | 0.005∗∗ | 40% | CaO | 0.0015∗∗ | 37% |
| H2O | 0.0014∗∗ | 48% | Sr | 0.003∗∗ | 40% | MgO | 0.0013∗∗ | 32% |
| MgO | 0.0003∗∗∗ | 48% | MgO | 0.010∗ | 33% | H2O | 0.0125∗ | 30% |
| SiO2 | 0.0053∗∗ | 44% | P2O5 | 0.022∗ | 29% | Sr | 0.0151∗ | 28% |
| TOC | 0.0047∗∗ | 44% | TN | 0.039∗ | 28% | SiO2 | 0.0144∗ | 27% |
| TN | 0.0036∗∗ | 43% | H2O | 0.0412∗ | 28% | TN | 0.013∗ | 27% |
| TC | 0.0093∗∗ | 42% | TiO2 | 0.0497∗ | 26% | TOC | 0.0151∗ | 27% |
| CO2 | 0.0111∗ | 41% | TOC | 0.0593n.s. | 26% | Ni | 0.0232∗ | 27% |
| Ni | 0.0092∗∗ | 41% | V | 0.0615n.s. | 26% | TN | 0.0203∗ | 27% |
| TiO2 | 0.005∗∗ | 40% | Ni | 0.0786n.s. | 25% | Zr | 0.0293∗ | 26% |
| Nb | 0.0091∗∗ | 38% | SiO2 | 0.066n.s. | 25% | TiO2 | 0.0228∗ | 25% |
| P2O5 | 0.0063∗∗ | 37% | TC | 0.0688n.s. | 24% | MnO | 0.0383∗ | 25% |
| K2O | 0.016∗ | 34% | K2O | 0.0554n.s. | 24% | CO2 | 0.0179∗ | 25% |
| MnO | 0.0192∗ | 34% | CO2 | 0.0674n.s. | 24% | Nb | 0.0245∗ | 25% |
| Zr | 0.0416∗ | 32% | MnO | 0.0988n.s. | 23% | P2O5 | 0.03∗ | 25% |
| Sr | 0.0456∗ | 31% | Nb | 0.0859n.s. | 23% | K2O | 0.0513n.s. | 22% |
| δ15N | 0.0444∗ | 30% | Zn | 0.1n.s. | 22% | Y | 0.0731n.s. | 21% |
| Y | 0.0378∗ | 30% | δ15N | 0.1197n.s. | 21% | Rb | 0.1107n.s. | 19% |
| Rb | 0.0499∗ | 28% | Al2O3 | 0.1158n.s. | 21% | Zn | 0.0885n.s. | 19% |
| Cr | 0.0578n.s. | 28% | Cr | 0.1271n.s. | 21% | Cr | 0.107n.s. | 19% |
| Zn | 0.0444n.s. | 28% | Ga | 0.1332n.s. | 21% | δ15N | 0.1191n.s. | 19% |
| Al2O3 | 0.0581n.s. | 27% | Fe2O3 | 0.1327n.s. | 20% | Al2O3 | 0.1034n.s. | 18% |
| Ba | 0.0694n.s. | 26% | Zr | 0.1353n.s. | 20% | Ga | 0.1322n.s. | 18% |
| Ga | 0.0825n.s. | 26% | Y | 0.1692n.s. | 19% | V | 0.133n.s. | 17% |
| Fe2O3 | 0.13n.s. | 21% | Rb | 0.1943n.s. | 18% | Ba | 0.1914n.s. | 16% |
| δ13Corg | 0.1427n.s. | 21% | Ba | 0.1908n.s. | 18% | Fe2O3 | 0.1791n.s. | 16% |
| V | 0.322n.s. | 13% | CIA | 0.2746n.s. | 16% | CIA | 0.3007n.s. | 14% |
| CIA | 0.507n.s. | 10% | Na2O | 0.6399n.s. | 9% | δ13Corg | 0.3163n.s. | 14% |
| Na2O | 0.6445n.s. | 9% | δ13Corg | 0.6224n.s. | 9% | Na2O | 0.8143n.s. | 9% |