**Supporting information**

**Methods**

*Field sampling*

Twenty-four snow, ice and water samples were collected. For inorganic aqueous analyses samples were collected either in sterile 50 mL centrifuge tubes or sterile sample bags. The snow/ice samples were melted at room temperature over a ~ 6 hour period and all samples were filtered through single use 0.2 uM cellulose-acetate syringe filters. For cation analyses by inductively coupled plasma mass spectrometry (ICP-MS), samples were directly filtered into acid-washed (HCl) and pre-acidified (Aristar grade HNO3) Nalgene HDPE bottles, while for anion analyses by ion chromatography (IC), samples were stored un-acidified in 15 mL centrifuge tubes.

For dissolved organic and inorganic carbon (DOC and DIC, respectively) and organic particulate analysis, samples were collected in 250 mL glass jars that had been ashed at 450 °C. After melting at room temperature these samples were filtered through ashed 0.7 µm glass fibre filters (GFF) directly into either pre-acidified (for DOC, 100µl Aristar grade HNO3) or non-acidified (for DIC) 40 mL, amber glass vials with Teflon® seals (Supelco). The filters containing particulates were folded into quarters and preserved cold and in ashed aluminium foil for pigment analysis. From these solution samples particulates for XRD, FTIR and Raman analysis were also collected by filtering through 0.2 µm polycarbonate filters. Finally, for imaging and cell counts using light microscopy (LM) as well as for scanning and transmission electron microscopy (SEM, TEM) melted but unconcentrated samples were preserved in 2.5% glutaraldehyde. Samples were returned to Leeds either frozen in liquid nitrogen in a cryo-shipper or in an ice-box at ~ 4 ˚C.

*Field measurements*

To evaluate community activity and the proportion of autotrophy *vs.* heterotrophy, respiration experiments were carried out by measuring O2 concentrations using different substrates (red snow, biofilms, ice algae and cryoconites). For this a large volume of each sample was collected in sterile sampling bags and slowly (~ 3-4 h) thawed on-site. For each sample type, melted but homogenous subsamples were transferred into 50 mL glass bottles that had been each rinsed multiple times with the respective sample. The bottles were completely filled up, initial (time zero) O2 concentrations measured and subsequently air-tightly sealed with ground glass stoppers.  O2 concentrations were measured with a O2 meter (Hach HQ30d). Per sample three bottles were wrapped in light impermeable, white plastic to measure net community O2 respiration, while three bottles each were left unwrapped to measure O2 production and respiration. The bottles were left for up to two days on the glacial surface and final O2 concentrations were measured after 24 or 48 h. Net O2 production was calculated by the difference between wrapped and unwrapped bottles. At each measurement point the temperature, was simultaneously measured with the O2 meter and temperature corrections (ref) were applied.

*Analyses of returned samples*

Aqueous samples

Nutrients (NO2-, NO3-, Cl-, SO42-) were analysed in filtered samples by ion chromatography (IC) on a Dionex DX 600 system with an autosampler, an IonPac AS16 analytical column with an AG16 guard column, an eluent gradient of 0-15 mM KOH and an ED50 conductivity detector. Injection volume was 25 uL and flow rate was set to 0.35 mL min-1. For NO2- analysis the UV detector was set to 211 nm. Error of measurement was <5%. Major, minor and trace elements were measured by inductively coupled plasma mass spectrometry (ICP-MS) on an Agilent 7500ce with collision cell Octopole Reaction System (ORS) technology (ICP-MS facility, University of Portsmouth). Analytical errors for both IC and ICP-MS are below 5%.

Dissolved organic and inorganic carbon (DOC and DIC, respectively) were analysed on a Shimadzu TOC analyser (University of Plymouth). Due to an error in sample handling all DOC and DIC became contaminated and the analyses gave unrealistically high values and were therefore not used.

Solid analyses

Cell morphologies and organic and inorganic debris distributions were imaged by light microscopy and scanning and transmission electron microscopy (LM, SEM and TEM). For SEM imaging of cell morphologies and distribution of organic and inorganic debris an ethanol exchange series (30, 50, 70, 90, 100%; 30 min per step) was prepared on samples that had been preserved in 2.5 % glutaraldehyde. A droplet of the fixed and exchanged sample was dispersed on an Al stub, air-dried and coated with 3 nm of Pt. Images were acquired on a Phillips Environmental Scanning Electron Microscope (E-SEM) at an accelerating voltage of 10 kV and a working distance of 10-12 mm and a LEO 1530 Field-Emission Gun SEM (FEG-SEM) at an accelerating voltage of 3 kV and working distance of 3-4 mm. For TEM, microtomed sections of the fixed and ethanol exchanged samples were prepared and resulting grids were imaged on a JEOL 1200-TEM at an accelerating voltage of 80 keV.

Functional groups distributions were determined on bulk, dried samples by Fourier transform infrared (FTIR) using an A2 Technology Microlab Portable mid-IR spectrometer with a Diamond internal

reﬂection cell (DATR), with spectra acquired in the mid-infrared range (650- 4000 cm-1). From the bulk spectra, the peak area ratios of the main functional groups representing the *lipids* (CH2 and CH3 stretching modes between 3050 and 2800 cm-1), and *proteins* (amide I and II bands at 1700-1500 cm-1) to those of the *carbohydrates* (C-O-C, C-O-P, P-O-P ring vibrations between 1204-815 cm-1) were evaluated. Raman analyses were performed on a Renishaw InVia Raman spectrometer with two lasers at 514 nm and 785 nm excitation wavelengths, an attached microscope with a 50x magnification objective and a resolution of 4 cm-1. Raman spectra were collected on singe algal cells or individual mineral grains with the aim to cross-confirm organic compound specificity and mineral composition.

The mineralogical composition of each sample was determined by X-ray diffraction (XRD) with dried and ground samples analysed on a Bruker D8 Advance diffractometer. XRD spectra were recorded from 2-75°2Θ using a copper diffraction source and a run time of 12 min per sample.

To determine the carotenoid and chlorophyll contents in the snow algae samples, high pressure liquid chromatography (HPLC) and a modified carotenoid/chlorophyll specific extraction protocol (after Remias and Lutz (2007) was used. Cells were disrupted by shock freezing in liquid nitrogen for 10 min followed by grinding in a Teflon® mortar and pestle. The resulting powder was re-suspended in 1 mL of dimethylformamide (DMF) and 1.0 mm glass beads and horizontally shaken on a laboratory shaker (MoBio Vortex Genie 2) at maximum speed (3000 rpm) for 10 min followed by centrifugation for 5 min 10 000 rpm. The supernatant was separated from the debris by filtering through a 0.45 µm Teflon® filter and the filtrate was mixed with methanol (25 vol %). Extracted samples were analysed immediately on an Agilent Technologies 1200 Infinity HPLC instrument with a gradient pump, an autosampler, a variable wavelength detector and ODS Hypersil column (250x4.6 mm; 5 um particle size). Two solvents were used: solvent A consisted of a mixture of acetonitrile/water/methanol/hexane/tris buffer at ratios of 80:7:3:1:1 while solvent B was a mix of methanol and hexane at a ratio of 5:1. The HPLC was run at a flow rate of 1 mL min-1 and with an injection volume of 25 µL. Spectra were recorded from 200 to 800 nm and chromatograms were quantified at 450 nm for carotenoids and 660 nm for chlorophyll a and b. Run time was 60 min and the protocol required a 15 minute run with 100% of solvent A followed by a linear gradient from 100 % solvent A to 100% solvent B between 32 and 45 min and finally with 15 minutes of column re-equilibration through a 5 min linear gradient from solvent B back to 100% solvent to A, followed by a further column conditioning with 100 % solvent A for 10 min. Various commercially available standards (Sigma, Carotenature) and published retention times were used for peak identification. Chromatogram peak areas were calculated and the carotenoid data is reported as normalized to the peak area of chlorophyll a. The error of measurements for the HPLC was <5%.

**Details of all microbial activity measurements**

Red snow, biofilm and grey ice samples all showed positive values with + 194 ugC L-1 day-1 for red snow, between +182 and +480 ugC L-1 day-1 for the different grey ice samples and with the highest values (+ 682 ugC L-1 day-1) for the biofilm sample. Only the cryoconites showed overall negative rates with one exemption (-1601/-283.75/-27.5/+156 ugC L-1). The positive values for the snow and ice algae samples indicates accumulation of organic matter in all surface glacial habitats, except for the cryoconites which most likely were dominated by a heterotrophic community at the time of sampling,

**Table S1.** Albedo measurements across the 1 km2 area shown in Figure 1 main text with coordinates and 10 measurements/site; the five up and down values represent five incident and five reflected radiation measurements at each point.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Category | Measure-  Ment no. | 24 H | UTM | Up #1 | Down #1 | U/ D #1 | Up #2 | Down #2 | U/D #2 | Up #3 | Down #3 | U/D #3 | Up #4 | Down #4 | U/D#4 | Up #5 | Down #5 | U/D #5 | Average  [%] |
| Clean | ALB-19 | 0552166 | 7285960 | 142 | 106 | 75 | 142 | 105 | 74 | 142 | 111 | 78 | 142 | 110 | 77 | 144 | 102 | 71 | 75 |
| Snow | ALB-20 | 0552166 | 7285960 | 141 | 108 | 77 | 142 | 108 | 76 | 146 | 108 | 74 | 145 | 106 | 73 | 144 | 106 | 74 | 75 |
|  | ALB-21 | 0552166 | 7285960 | 139 | 105 | 76 | 140 | 102 | 73 | 141 | 103 | 73 | 141 | 104 | 74 | 141 | 104 | 74 | 74 |
|  | ALB-66 | 0552141 | 7285611 | 320 | 242 | 76 | 329 | 240 | 73 | 315 | 240 | 76 | 315 | 240 | 76 | 311 | 237 | 76 | 75 |
|  | ALB-69 | 0552141 | 7285611 | 312 | 233 | 75 | 315 | 236 | 75 | 338 | 231 | 68 | 313 | 231 | 74 | 310 | 234 | 75 | 73 |
|  | ALB-70 | 0552141 | 7285611 | 317 | 210 | 66 | 299 | 210 | 70 | 298 | 209 | 70 | 304 | 212 | 70 | 299 | 208 | 70 | 69 |
|  | ALB-83 | 0552201 | 7285775 | 278 | 193 | 69 | 276 | 191 | 69 | 268 | 189 | 71 | 268 | 185 | 69 | 262 | 184 | 70 | 70 |
|  | ALB-84 | 0552201 | 7285775 | 243 | 201 | 83 | 241 | 200 | 83 | 262 | 199 | 76 | 253 | 200 | 79 | 250 | 202 | 81 | 80 |
|  | MIT-3 | 0551579 | 7285535 | 268 | 228 | 85 | 266 | 224 | 84 | 272 | 232 | 85 | 279 | 233 | 84 | 258 | 211 | 82 | 84 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **75 ± 5** |
| Green | ALB-25 | 0552071 | 7286234 | 110 | 50 | 45 | 112 | 49 | 44 | 112 | 48 | 43 | 112 | 50 | 45 | 114 | 50 | 44 | 44 |
| snow | MIT-11 | 0551435 | 7285308 | 197 | 81 | 41 | 214 | 81 | 38 | 212 | 84 | 40 | 234 | 96 | 41 |  |  |  | 40 |
|  | MIT-22 | 0551778 | 7286368 | 330 | 158 | 48 | 337 | 155 | 46 | 317 | 153 | 48 | 290 | 139 | 48 | 317 | 145 | 46 | 47 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **44 ± 4** |
| Light | ALB-16 | 0552166 | 7285960 | 150 | 107 | 71 | 149 | 108 | 72 | 149 | 107 | 72 | 148 | 105 | 71 | 147 | 106 | 72 | 72 |
| Red | ALB-17 | 0552166 | 7285960 | 144 | 102 | 71 | 146 | 107 | 73 | 147 | 104 | 71 | 149 | 108 | 72 | 149 | 106 | 71 | 72 |
| Snow | ALB-18 | 0552166 | 7285960 | 147 | 107 | 73 | 147 | 106 | 72 | 149 | 105 | 70 | 149 | 106 | 71 | 148 | 105 | 71 | 71 |
|  | ALB-48 | 0551681 | 7285613 | 319 | 264 | 83 | 351 | 265 | 75 | 335 | 265 | 79 | 325 | 265 | 82 | 329 | 262 | 80 | 80 |
|  | ALB-49 | 0551681 | 7285613 | 309 | 260 | 84 | 313 | 258 | 82 | 305 | 255 | 84 | 307 | 258 | 84 | 309 | 255 | 83 | 83 |
|  | ALB-51 | 0551690 | 7285639 | 302 | 130 | 43 | 340 | 130 | 38 | 318 | 130 | 41 | 318 | 132 | 42 | 331 | 132 | 40 | 41 |
|  | ALB-53 | 0551690 | 7285639 | 324 | 220 | 68 | 323 | 220 | 68 | 321 | 224 | 70 | 324 | 222 | 69 | 319 | 222 | 70 | 69 |
|  | ALB-54 | 0551690 | 7285639 | 317 | 261 | 82 | 315 | 260 | 83 | 328 | 258 | 79 | 323 | 255 | 79 | 321 | 259 | 81 | 81 |
|  | ALB-55 | 0551690 | 7285639 | 317 | 281 | 89 | 311 | 281 | 90 | 329 | 283 | 86 | 334 | 281 | 84 | 354 | 284 | 80 | 86 |
|  | ALB-58 | 0551716 | 7285652 | 314 | 199 | 63 | 313 | 198 | 63 | 330 | 192 | 58 | 324 | 190 | 59 | 321 | 192 | 60 | 61 |
|  | ALB-59 | 0551716 | 7285652 | 328 | 235 | 72 | 328 | 234 | 71 | 327 | 234 | 72 | 331 | 236 | 71 | 325 | 235 | 72 | 72 |
|  | ALB-60 | 0551716 | 7285652 | 312 | 258 | 83 | 304 | 215 | 71 | 311 | 256 | 82 | 310 | 258 | 83 | 317 | 258 | 81 | 80 |
|  | ALB-74 | 0552318 | 7285716 | 292 | 205 | 70 | 283 | 206 | 73 | 267 | 205 | 77 | 302 | 203 | 67 | 297 | 205 | 69 | 71 |
|  | ALB-75 | 0552318 | 7285716 | 278 | 175 | 63 | 285 | 175 | 61 | 280 | 173 | 62 | 280 | 170 | 61 | 267 | 169 | 63 | 62 |
|  | ALB-79 | 0552292 | 7285836 | 271 | 149 | 55 | 276 | 150 | 54 | 274 | 151 | 55 | 268 | 150 | 56 | 262 | 150 | 57 | 56 |
|  | ALB-81 | 0552201 | 7285775 | 273 | 193 | 71 | 268 | 200 | 75 | 289 | 200 | 69 | 287 | 203 | 71 | 285 | 203 | 71 | 71 |
|  | ALB-90 | 0551766 | 7285796 | 86 | 40 | 47 | 86 | 41 | 48 | 87 | 41 | 47 | 85 | 41 | 48 | 86 | 41 | 48 | 47 |
|  | ALB-112 | 0552166 | 7285960 | 139 | 101 | 73 | 140 | 99 | 71 | 141 | 99 | 70 | 141 | 99 | 70 | 142 | 100 | 70 | 71 |
|  | ALB-113 | 0552166 | 7285960 | 142 | 96 | 68 | 142 | 97 | 68 | 141 | 96 | 68 | 143 | 97 | 68 | 143 | 100 | 70 | 68 |
|  | ALB-131 | 0552131 | 7286079 | 129 | 90 | 70 | 128 | 91 | 71 | 129 | 88 | 68 | 130 | 88 | 68 | 127 | 89 | 70 | 69 |
|  | ALB-132 | 0552131 | 7286079 | 128 | 88 | 69 | 129 | 96 | 74 | 130 | 97 | 75 | 129 | 96 | 74 | 129 | 96 | 74 | 73 |
|  | ALB-133 | 0552131 | 7286079 | 131 | 96 | 73 | 130 | 94 | 72 | 132 | 93 | 70 | 134 | 96 | 72 | 135 | 95 | 70 | 72 |
|  | ALB-134 | 0552131 | 7286079 | 133 | 86 | 65 | 129 | 88 | 68 | 132 | 86 | 65 | 131 | 86 | 66 | 134 | 86 | 64 | 66 |
|  | ALB-135 | 0552131 | 7286079 | 140 | 90 | 64 | 139 | 94 | 68 | 140 | 93 | 66 | 143 | 96 | 67 | 144 | 96 | 67 | 66 |
|  | MIT-17 | 0552441 | 7285291 | 339 | 200 | 59 | 362 | 204 | 56 | 354 | 199 | 56 | 345 | 197 | 57 |  |  |  | 57 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **69 ± 11** |
| Very | ALB-23 | 0552071 | 7286234 | 165 | 109 | 66 | 172 | 109 | 63 | 172 | 110 | 64 | 171 | 110 | 64 | 171 | 109 | 64 | 64 |
| red | ALB-24 | 0552071 | 7286234 | 165 | 88 | 53 | 161 | 87 | 54 | 155 | 87 | 56 | 158 | 87 | 55 | 157 | 87 | 55 | 55 |
| snow | ALB-56 | 0551716 | 7285652 | 331 | 161 | 49 | 335 | 161 | 48 | 347 | 162 | 47 | 326 | 160 | 49 | 334 | 163 | 49 | 48 |
|  | ALB-92 | 0551972 | 7285813 | 109 | 48 | 44 | 111 | 49 | 44 | 111 | 50 | 45 | 112 | 50 | 45 | 113 | 50 | 44 | 44 |
|  | MIT-15 | 0552463 | 7285438 | 322 | 183 | 57 | 324 | 188 | 58 | 333 | 186 | 56 | 324 | 180 | 56 | 325 | 184 | 57 | 57 |
|  | MIT-19 | 0551778 | 7286368 | 320 | 123 | 38 | 334 | 130 | 39 | 345 | 134 | 39 | 332 | 135 | 41 |  |  |  | 39 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **49 ± 8** |
| Clean ice | ALB-1 | 0551878 | 7285946 | 183 | 108 | 59 | 184 | 107 | 58 | 183 | 106 | 58 | 182 | 104 | 57 | 184 | 109 | 59 | 58 |
|  | ALB-2 | 0551878 | 7285946 | 171 | 90 | 53 | 175 | 90 | 51 | 170 | 90 | 53 | 171 | 90 | 53 | 174 | 90 | 52 | 52 |
|  | ALB-3 | 0551878 | 7285946 | 186 | 102 | 55 | 185 | 101 | 55 | 186 | 101 | 54 | 186 | 103 | 55 | 186 | 104 | 56 | 55 |
|  | ALB-35 | 0551703 | 7285413 | 316 | 185 | 59 | 310 | 181 | 58 | 313 | 183 | 58 | 325 | 183 | 56 | 327 | 185 | 57 | 58 |
|  | ALB-42 | 0551752 | 7285525 | 331 | 143 | 43 | 337 | 144 | 43 | 340 | 144 | 42 | 339 | 146 | 43 | 332 | 146 | 44 | 43 |
|  | ALB-47 | 0551681 | 7285613 | 315 | 204 | 65 | 335 | 202 | 60 | 349 | 197 | 56 | 338 | 200 | 59 | 334 | 203 | 61 | 60 |
|  | ALB-50 | 0551681 | 7285613 | 334 | 191 | 57 | 335 | 189 | 56 | 347 | 186 | 54 | 361 | 185 | 51 | 338 | 186 | 55 | 55 |
|  | ALB-62 | 0552059 | 7285700 | 379 | 222 | 59 | 318 | 219 | 69 | 304 | 219 | 72 | 309 | 217 | 70 | 313 | 215 | 69 | 68 |
|  | ALB-67 | 0552141 | 7285611 | 314 | 184 | 59 | 311 | 185 | 59 | 323 | 184 | 57 | 307 | 182 | 59 | 313 | 185 | 59 | 59 |
|  | ALB-68 | 0552141 | 7285611 | 311 | 208 | 67 | 318 | 209 | 66 | 340 | 205 | 60 | 318 | 209 | 66 | 303 | 207 | 68 | 65 |
|  | ALB-71 | 0552318 | 7285716 | 300 | 185 | 62 | 303 | 180 | 59 | 294 | 179 | 61 | 292 | 178 | 61 | 296 | 179 | 60 | 61 |
|  | ALB-72 | 0552318 | 7285716 | 279 | 204 | 73 | 287 | 198 | 69 | 288 | 200 | 69 | 277 | 200 | 72 | 291 | 199 | 68 | 70 |
|  | ALB-76 | 0552292 | 7285836 | 286 | 180 | 63 | 271 | 175 | 65 | 275 | 175 | 64 | 280 | 177 | 63 | 276 | 176 | 64 | 64 |
|  | ALB-77 | 0552292 | 7285836 | 285 | 192 | 67 | 289 | 193 | 67 | 304 | 190 | 63 | 301 | 191 | 63 | 289 | 194 | 67 | 65 |
|  | ALB-78 | 0552292 | 7285836 | 295 | 176 | 60 | 283 | 176 | 62 | 281 | 179 | 64 | 283 | 180 | 64 | 284 | 178 | 63 | 62 |
|  | ALB-80 | 0552292 | 7285836 | 292 | 183 | 63 | 281 | 183 | 65 | 292 | 184 | 63 | 310 | 184 | 59 | 295 | 182 | 62 | 62 |
|  | ALB-95 | 0551972 | 7285813 | 120 | 53 | 44 | 120 | 53 | 44 | 121 | 54 | 45 | 122 | 53 | 43 | 122 | 54 | 44 | 44 |
|  | ALB-98 | 0552035 | 7286025 | 141 | 70 | 50 | 143 | 71 | 50 | 143 | 70 | 49 | 143 | 70 | 49 | 141 | 68 | 48 | 49 |
|  | ALB-107 | 0551878 | 7285946 | 136 | 57 | 42 | 140 | 57 | 41 | 140 | 58 | 41 | 141 | 58 | 41 | 139 | 57 | 41 | 41 |
|  | MIT-14 | 0552441 | 7285291 | 320 | 228 | 71 | 352 | 215 | 61 | 340 | 210 | 62 |  |  |  |  |  |  | 65 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **58 ± 8** |
| Light | ALB-4 | 0551878 | 7285946 | 199 | 83 | 42 | 200 | 84 | 42 | 190 | 83 | 44 | 191 | 80 | 42 | 196 | 77 | 39 | 42 |
| grey | ALB-5 | 0551878 | 7285946 | 195 | 100 | 51 | 190 | 100 | 53 | 194 | 101 | 52 | 201 | 103 | 51 | 201 | 107 | 53 | 52 |
| ice | ALB-6 | 0551878 | 7285946 | 207 | 97 | 47 | 218 | 99 | 45 | 221 | 101 | 46 | 225 | 101 | 45 | 224 | 104 | 46 | 46 |
|  | ALB-37 | 0551762 | 7285494 | 322 | 161 | 50 | 304 | 161 | 53 | 304 | 163 | 54 | 308 | 163 | 53 | 308 | 160 | 52 | 52 |
|  | ALB-38 | 0551762 | 7285494 | 319 | 179 | 56 | 323 | 180 | 56 | 302 | 182 | 60 | 303 | 176 | 58 | 305 | 179 | 59 | 58 |
|  | ALB-39 | 0551762 | 7285494 | 306 | 153 | 50 | 318 | 152 | 48 | 313 | 150 | 48 | 311 | 149 | 48 | 324 | 151 | 47 | 48 |
|  | ALB-40 | 0551762 | 7285494 | 312 | 175 | 56 | 322 | 174 | 54 | 338 | 174 | 51 | 341 | 171 | 50 | 331 | 170 | 51 | 53 |
|  | ALB-41 | 0551752 | 7285525 | 333 | 180 | 54 | 334 | 181 | 54 | 340 | 179 | 53 | 342 | 180 | 53 | 331 | 179 | 54 | 54 |
|  | ALB-46 | 0551681 | 7285613 | 308 | 127 | 41 | 324 | 126 | 39 | 331 | 127 | 38 | 319 | 127 | 40 | 331 | 127 | 38 | 39 |
|  | ALB-52 | 0551690 | 7285639 | 340 | 186 | 55 | 350 | 182 | 52 | 347 | 188 | 54 | 338 | 187 | 55 | 337 | 184 | 55 | 54 |
|  | ALB-64 | 0552059 | 7285700 | 304 | 171 | 56 | 303 | 174 | 57 | 296 | 174 | 59 | 298 | 178 | 60 | 307 | 168 | 55 | 57 |
|  | ALB-86 | 0551766 | 7285796 | 84 | 43 | 51 | 84 | 43 | 51 | 84 | 43 | 51 | 85 | 43 | 51 | 84 | 43 | 51 | 51 |
|  | ALB-89 | 0551766 | 7285796 | 90 | 41 | 46 | 90 | 41 | 46 | 90 | 40 | 44 | 91 | 40 | 44 | 91 | 40 | 44 | 45 |
|  | ALB-93 | 0551972 | 7285813 | 115 | 63 | 55 | 117 | 63 | 54 | 117 | 63 | 54 | 117 | 64 | 55 | 117 | 63 | 54 | 54 |
|  | ALB-97 | 0552035 | 7286025 | 142 | 62 | 44 | 145 | 62 | 43 | 145 | 62 | 43 | 144 | 63 | 44 | 143 | 62 | 43 | 43 |
|  | ALB-99 | 0552035 | 7286025 | 145 | 67 | 46 | 143 | 67 | 47 | 143 | 68 | 48 | 144 | 68 | 47 | 145 | 68 | 47 | 47 |
|  | ALB-114 | 0552166 | 7285960 | 135 | 71 | 53 | 137 | 72 | 53 | 138 | 73 | 53 | 139 | 74 | 53 | 135 | 72 | 53 | 53 |
|  | ALB-118 | 0552266 | 7286120 | 138 | 67 | 49 | 139 | 66 | 47 | 136 | 66 | 49 | 135 | 68 | 50 | 139 | 65 | 47 | 48 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **50 ± 5** |
| Medium | ALB-7 | 0551878 | 7285946 | 225 | 59 | 26 | 225 | 57 | 25 | 215 | 55 | 26 | 217 | 57 | 26 | 217 | 58 | 27 | 26 |
| grey | ALB-8 | 0551878 | 7285946 | 246 | 65 | 26 | 230 | 60 | 26 | 208 | 55 | 26 | 200 | 53 | 27 | 206 | 52 | 25 | 26 |
| ice | ALB-9 | 0551878 | 7285946 | 209 | 65 | 31 | 208 | 63 | 30 | 204 | 64 | 31 | 203 | 64 | 32 | 205 | 63 | 31 | 31 |
|  | ALB-43 | 0551752 | 7285525 | 322 | 148 | 46 | 341 | 153 | 45 | 343 | 148 | 43 | 312 | 151 | 48 | 319 | 150 | 47 | 46 |
|  | ALB-57 | 0551716 | 7285652 | 321 | 125 | 39 | 324 | 124 | 38 | 336 | 124 | 37 | 346 | 126 | 36 | 320 | 126 | 39 | 38 |
|  | ALB-82 | 0552201 | 7285775 | 290 | 156 | 54 | 290 | 152 | 52 | 279 | 155 | 56 | 289 | 154 | 53 | 186 | 156 | 84 | 60 |
|  | ALB-111 | 0552166 | 7285960 | 137 | 56 | 41 | 138 | 57 | 41 | 139 | 57 | 41 | 138 | 55 | 40 | 139 | 56 | 40 | 41 |
|  | ALB-115 | 0552166 | 7285960 | 137 | 63 | 46 | 139 | 63 | 45 | 138 | 63 | 46 | 138 | 62 | 45 | 137 | 62 | 45 | 45 |
|  | ALB-116 | 0552266 | 7286120 | 141 | 38 | 27 | 140 | 39 | 28 | 140 | 39 | 28 | 140 | 40 | 29 | 141 | 39 | 28 | 28 |
|  | ALB-117 | 0552266 | 7286120 | 137 | 47 | 34 | 139 | 46 | 33 | 138 | 46 | 33 | 139 | 46 | 33 | 138 | 46 | 33 | 33 |
|  | ALB-119 | 0552266 | 7286120 | 141 | 48 | 34 | 134 | 49 | 37 | 139 | 49 | 35 | 138 | 49 | 36 | 140 | 50 | 36 | 35 |
|  | ALB-120 | 0552266 | 7286120 | 137 | 67 | 49 | 136 | 70 | 51 | 138 | 66 | 48 | 138 | 67 | 49 | 136 | 69 | 51 | 49 |
|  | ALB-121 | 0552107 | 7286218 | 129 | 33 | 26 | 130 | 33 | 25 | 129 | 33 | 26 | 129 | 34 | 26 | 131 | 33 | 25 | 26 |
|  | ALB-123 | 0552107 | 7286218 | 129 | 40 | 31 | 131 | 40 | 31 | 129 | 39 | 30 | 131 | 40 | 31 | 129 | 39 | 30 | 31 |
|  | ALB-124 | 0552107 | 7286218 | 131 | 34 | 26 | 136 | 36 | 26 | 142 | 34 | 24 | 133 | 34 | 26 | 133 | 34 | 26 | 25 |
|  | ALB-127 | 0552025 | 7286134 | 132 | 32 | 24 | 128 | 33 | 26 | 132 | 31 | 23 | 128 | 32 | 25 | 130 | 31 | 24 | 24 |
|  | ALB-129 | 0552025 | 7286134 | 134 | 37 | 28 | 133 | 37 | 28 | 132 | 37 | 28 | 132 | 37 | 28 | 131 | 37 | 28 | 28 |
|  | ALB-130 | 0552025 | 7286134 | 138 | 32 | 23 | 132 | 32 | 24 | 131 | 32 | 24 | 130 | 31 | 24 | 131 | 31 | 24 | 24 |
|  | ALB-125 | 0552107 | 7286218 | 136 | 43 | 32 | 138 | 43 | 31 | 137 | 42 | 31 | 136 | 42 | 31 | 137 | 42 | 31 | 31 |
|  | MIT-16 | 0552463 | 7285438 | 331 | 126 | 38 | 343 | 127 | 37 | 328 | 128 | 39 | 314 | 127 | 40 | 323 | 128 | 40 | 39 |
|  | MIT-23 | 0551651 | 7285404 | 335 | 127 | 38 | 336 | 130 | 39 | 338 | 129 | 38 | 337 | 130 | 39 | 329 | 131 | 40 | 39 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **35 ± 10** |
| Very | ALB-10 | 0551878 | 7285946 | 207 | 18 | 9 | 207 | 17 | 8 | 209 | 18 | 9 | 210 | 18 | 9 | 202 | 17 | 8 | 9 |
| grey | ALB-11 | 0551878 | 7285946 | 209 | 23 | 11 | 207 | 26 | 13 | 219 | 24 | 11 | 213 | 24 | 11 | 217 | 25 | 12 | 11 |
| ice | ALB-12 | 0551878 | 7285946 | 221 | 21 | 10 | 210 | 21 | 10 | 219 | 21 | 10 | 216 | 21 | 10 | 220 | 22 | 10 | 10 |
|  | ALB-36 | 0551762 | 7285494 | 291 | 102 | 35 | 312 | 105 | 34 | 304 | 104 | 34 | 295 | 104 | 35 | 304 | 103 | 34 | 34 |
|  | ALB-44 | 0551752 | 7285525 | 319 | 126 | 39 | 344 | 146 | 42 | 334 | 124 | 37 | 346 | 125 | 36 | 341 | 125 | 37 | 38 |
|  | ALB-45 | 0551752 | 7285525 | 343 | 99 | 29 | 345 | 99 | 29 | 342 | 99 | 29 | 329 | 100 | 30 | 330 | 100 | 30 | 29 |
|  | ALB-65 | 0552059 | 7285700 | 312 | 129 | 41 | 323 | 129 | 40 | 317 | 130 | 41 | 318 | 131 | 41 | 305 | 128 | 42 | 41 |
|  | ALB-85 | 0552201 | 7285775 | 271 | 102 | 38 | 248 | 104 | 42 | 258 | 102 | 40 | 240 | 103 | 43 | 259 | 103 | 40 | 40 |
|  | ALB-87 | 0551766 | 7285796 | 87 | 36 | 41 | 88 | 36 | 41 | 88 | 35 | 40 | 88 | 35 | 40 | 88 | 35 | 40 | 40 |
|  | ALB-94 | 0551972 | 7285813 | 118 | 31 | 26 | 119 | 31 | 26 | 120 | 31 | 26 | 121 | 32 | 26 | 122 | 32 | 26 | 26 |
|  | ALB-96 | 0552035 | 7286025 | 148 | 55 | 37 | 143 | 54 | 38 | 144 | 55 | 38 | 143 | 56 | 39 | 144 | 55 | 38 | 38 |
|  | ALB-100 | 0552035 | 7286025 | 146 | 46 | 32 | 147 | 46 | 31 | 147 | 46 | 31 | 147 | 47 | 32 | 146 | 47 | 32 | 32 |
|  | ALB-101 | 0551921 | 7286055 | 136 | 12 | 9 | 137 | 12 | 9 | 137 | 12 | 9 | 140 | 12 | 9 | 140 | 12 | 9 | 9 |
|  | ALB-102 | 0551921 | 7286055 | 138 | 42 | 30 | 137 | 43 | 31 | 134 | 42 | 31 | 136 | 42 | 31 | 138 | 41 | 30 | 31 |
|  | ALB-103 | 0551921 | 7286055 | 136 | 15 | 11 | 136 | 15 | 11 | 134 | 15 | 11 | 136 | 15 | 11 | 138 | 16 | 12 | 11 |
|  | ALB-105 | 0551921 | 7286055 | 138 | 57 | 41 | 139 | 57 | 41 | 139 | 56 | 40 | 139 | 55 | 40 | 139 | 56 | 40 | 40 |
|  | ALB-106 | 0551878 | 7285946 | 140 | 44 | 31 | 141 | 44 | 31 | 141 | 44 | 31 | 140 | 44 | 31 | 141 | 44 | 31 | 31 |
|  | ALB-108 | 0551878 | 7285946 | 144 | 50 | 35 | 144 | 49 | 34 | 144 | 50 | 35 | 141 | 51 | 36 | 143 | 52 | 36 | 35 |
|  | ALB-109 | 0551878 | 7285946 | 143 | 31 | 22 | 146 | 30 | 21 | 146 | 30 | 21 | 148 | 30 | 20 | 146 | 30 | 21 | 21 |
|  | ALB-126 | 0552025 | 7286134 | 127 | 17 | 13 | 126 | 17 | 13 | 125 | 17 | 14 | 127 | 18 | 14 | 129 | 16 | 12 | 13 |
|  | ALB-128 | 0552025 | 7286134 | 129 | 15 | 12 | 131 | 16 | 12 | 131 | 15 | 11 | 132 | 15 | 11 | 129 | 14 | 11 | 12 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **26 ± 12** |
| Light | ALB-29 | 0551597 | 7285532 | 155 | 56 | 36 | 164 | 56 | 34 | 167 | 56 | 34 | 167 | 56 | 34 | 167 | 56 | 34 | 34 |
| biofilm | ALB-30 | 0551597 | 7285532 | 160 | 57 | 36 | 163 | 58 | 36 | 164 | 57 | 35 | 165 | 57 | 35 | 165 | 56 | 34 | 35 |
|  | ALB-31 | 0551597 | 7285532 | 166 | 62 | 37 | 165 | 62 | 38 | 164 | 63 | 38 | 164 | 64 | 39 | 164 | 64 | 39 | 38 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **36 ± 2** |
| Dense | ALB-32 | 0551597 | 7285532 | 175 | 39 | 22 | 175 | 39 | 22 | 175 | 39 | 22 | 173 | 40 | 23 | 169 | 40 | 24 | 23 |
| biofilm | ALB-33 | 0551597 | 7285532 | 206 | 26 | 13 | 202 | 27 | 13 | 209 | 26 | 12 | 202 | 26 | 13 | 207 | 26 | 13 | 13 |
|  | ALB-34 | 0551597 | 7285532 | 205 | 42 | 20 | 214 | 42 | 20 | 213 | 44 | 21 | 219 | 43 | 20 | 223 | 43 | 19 | 20 |
|  | MIT-18 | 0552463 | 7285438 | 326 | 75 | 23 | 315 | 72 | 23 | 313 | 71 | 23 | 352 | 78 | 22 | 326 | 76 | 23 | 23 |
|  | MIT-24 | 0551705 | 7285631 | 295 | 58 | 20 | 279 | 58 | 21 | 297 | 56 | 19 | 279 | 55 | 20 | 282 | 54 | 19 | 20 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **20 ± 4** |
| Cryo- | ALB-13 | 0551878 | 7285946 | 206 | 20 | 10 | 211 | 21 | 10 | 212 | 21 | 10 | 208 | 21 | 10 | 208 | 21 | 10 | 10 |
| conite | ALB-14 | 0551878 | 7285946 | 185 | 20 | 11 | 183 | 18 | 10 | 184 | 19 | 10 | 185 | 19 | 10 | 187 | 19 | 10 | 10 |
|  | ALB-15 | 0551878 | 7285946 | 178 | 35 | 20 | 179 | 35 | 20 | 170 | 36 | 21 | 169 | 33 | 20 | 169 | 30 | 18 | 20 |
|  | ALB-61 | 0552059 | 7285700 | 325 | 30 | 9 | 329 | 31 | 9 | 328 | 32 | 10 | 312 | 30 | 10 | 328 | 30 | 9 | 9 |
|  | ALB-63 | 0552059 | 7285700 | 318 | 120 | 38 | 325 | 120 | 37 | 317 | 118 | 37 | 319 | 122 | 38 | 325 | 119 | 37 | 37 |
|  | ALB-73 | 0552318 | 7285716 | 294 | 185 | 63 | 283 | 184 | 65 | 301 | 184 | 61 | 303 | 185 | 61 | 297 | 186 | 63 | 63 |
|  | ALB-88 | 0551766 | 7285796 | 87 | 23 | 26 | 85 | 23 | 27 | 85 | 24 | 28 | 85 | 23 | 27 | 84 | 22 | 26 | 27 |
|  | ALB-91 | 0551972 | 7285813 | 108 | 23 | 21 | 110 | 23 | 21 | 105 | 21 | 20 | 106 | 21 | 20 | 104 | 21 | 20 | 20 |
|  | ALB-104 | 0551921 | 7286055 | 135 | 23 | 17 | 134 | 23 | 17 | 137 | 23 | 17 | 136 | 23 | 17 | 137 | 23 | 17 | 17 |
|  | ALB-110 | 0551878 | 7285946 | 143 | 24 | 17 | 144 | 25 | 17 | 142 | 25 | 18 | 148 | 25 | 17 | 148 | 25 | 17 | 17 |
|  | ALB-122 | 0552107 | 7286218 | 127 | 18 | 14 | 128 | 19 | 15 | 125 | 19 | 15 | 127 | 18 | 14 | 127 | 18 | 14 | 15 |
|  | MIT-21 | 0551741 | 7285782 | 328 | 82 | 25 | 312 | 91 | 29 | 329 | 91 | 28 | 337 | 94 | 28 |  |  |  | 27 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **23 ± 15** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Runoff | ALB-26 | 0551597 | 7285532 | 190 | 55 | 29 | 180 | 54 | 30 | 183 | 54 | 30 | 185 | 54 | 29 | 184 | 53 | 29 | 29 |
|  | ALB-27 | 0551597 | 7285532 | 171 | 44 | 26 | 162 | 43 | 27 | 170 | 44 | 26 | 168 | 43 | 26 | 159 | 43 | 27 | 26 |
|  | ALB-28 | 0551597 | 7285532 | 173 | 57 | 33 | 174 | 57 | 33 | 171 | 56 | 33 | 165 | 58 | 35 | 169 | 58 | 34 | 34 |
| Average |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **30 ± 4** |

Table S2. Aqueous chemical analyses of anions and cations by IC and ICP-MS in all samples.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample no. | NO3-# | NO2-# | Cl-# | SO42-# | B\* | Na\* | Mg\* | Al\* | Si\* | P\* | K\* | Ca\* | Cr\* | Mn\* | Fe\* | Co\* | Ni\* | Cu\* | Zn\* | Sr\* | Cd\* | Ba\* | Pb\* |
| MIT-2 | 104 | ND | 131 | LOD | 2 | 86 | 4 | 1 | 4 | 0 | 20 | 19 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 0 |
| MIT-3 | LOD | ND | 94 | LOD | 1 | 93 | 4 | 1 | 5 | 0 | 6 | 14 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| MIT-4 | LOD | ND | 157 | LOD | 1 | 100 | 5 | 3 | 17 | 1 | 48 | 17 | 0 | 1 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| MIT-5 | LOD | ND | 118 | LOD | 0 | 80 | 10 | 2 | 7 | 0 | 15 | 20 | 0 | 1 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 |
| MIT-6 | LOD | ND | 97 | LOD | 1 | 215 | 38 | 5 | 43 | 10 | 354 | 22 | 0 | 1 | 13 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 |
| MIT-7 | 53 | ND | 458 | 393 | 0 | 134 | 7 | 3 | 24 | 6 | 212 | 19 | 0 | 1 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| MIT-8 | 66 | ND | 225 | 165 | 5 | 207 | 28 | 5 | 97 | 11 | 115 | 30 | 0 | 5 | 7 | 0 | 0 | 1 | 15 | 0 | 0 | 2 | 0 |
| MIT-9 | LOD | ND | 24 | LOD | 0 | 22 | 21 | 7 | 15 | 10 | 42 | 39 | 0 | 2 | 21 | 0 | 0 | 0 | 1 | 1 | 0 | 8 | 0 |
| MIT-10 | LOD | ND | 129 | LOD | 0 | 75 | 10 | 1 | 9 | 1 | 12 | 13 | 0 | 2 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 |
| MIT-11 | LOD | ND | 65 | LOD | 0 | 69 | 28 | 5 | 26 | 0 | 43 | 23 | 0 | 1 | 22 | 0 | 1 | 1 | 3 | 0 | 0 | 1 | 0 |
| MIT-12 | LOD | ND | 744 | 302 | 0 | 498 | 4 | 3 | 16 | 1 | 72 | 11 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| MIT-13 | LOD | ND | 408 | LOD | 0 | 113 | 2 | 3 | 12 | 0 | 12 | 10 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| MIT-14 | 489 | ND | 12 | LOD | 0 | 4 | 2 | 1 | 11 | 0 | 6 | 10 | 0 | 0 | 4 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 0 |
| MIT-15 | LOD | ND | 181 | 106 | 0 | 111 | 8 | 5 | 19 | 7 | 88 | 14 | 0 | 0 | 7 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 |
| MIT-16 | LOD | ND | 24 | LOD | 0 | 13 | 5 | 3 | 8 | 0 | 36 | 13 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| MIT-17 | LOD | ND | 126 | 107 | 0 | 75 | 5 | 7 | 15 | 2 | 43 | 16 | 0 | 0 | 14 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 |
| MIT-18 | LOD | ND | 407 | LOD | 0 | 232 | 18 | 4 | 26 | 1 | 251 | 48 | 0 | 0 | 5 | 0 | 0 | 0 | 6 | 0 | 0 | 1 | 0 |
| MIT-19 | LOD | ND | 291 | LOD | 0 | 148 | 3 | 3 | 22 | 0 | 29 | 18 | 0 | 1 | 4 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 |
| MIT-20 | LOD | ND | 107 | LOD | 0 | 68 | 27 | 5 | 25 | 0 | 42 | 21 | 0 | 1 | 22 | 0 | 1 | 1 | 3 | 0 | 0 | 1 | 0 |
| MIT-21 | LOD | ND | 131 | 108 | 0 | 58 | 29 | 9 | 37 | 2 | 26 | 20 | 0 | 1 | 8 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| MIT-22 | LOD | ND | 336 | LOD | 0 | 211 | 19 | 6 | 36 | 0 | 36 | 15 | 0 | 3 | 24 | 0 | 0 | 1 | 2 | 0 | 0 | 2 | 0 |
| MIT-23 | LOD | ND | 13 | LOD | 0 | 15 | 8 | 8 | 23 | 6 | 41 | 18 | 0 | 1 | 15 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 |
| MIT-24 | 134 | ND | 229 | LOD | 0 | 207 | 19 | 9 | 34 | 3 | 199 | 22 | 0 | 2 | 50 | 0 | 0 | 1 | 4 | 0 | 0 | 2 | 0 |

all values in ppb; determined by #IC, \*ICP-MS; Limit of detection (LOD) for IC: NO3- = 51 ppb, Cl- = 36 ppb, SO42- = 102 ppb, for ICP-MS: < 1 ppb) ND = not detectable;

**Raman spectroscopy**

Individual spherical red or green snow algae and filamentous ice algae as well as mineral grains, all identified with the microscope attached to the Raman system were analyses either at 514 nm or at 785 nm. Chlorophyll was detected in the red and green snow algae samples primarily with the near-infrared Raman laser. Most of the carotenoids detected showed the typical C=C stretching band at 1519 ± 3 cm-1 (Fig S2). For red snow algae cysts, three different peak regions for carotenoids were identified: 1517-1522 cm-1, 1508-1512 cm-1 and 1525-1527 cm-1. The main carotenoid in green snow algae cells also appeared around 1519 cm-1 but additionally a carotenoid band at 1530 cm-1 was detected. The filamentous ice algae cells showed Raman bands at five regions but all were rather weak as the cells were very small and thin: 1525-1524 cm-1, 1520 cm-1, 1515-1516 cm-1,1513 -1508 cm-1 and 1528 cm-1. However, based on the Raman analyses an unambiguous identification and assignment of bands to specific carotenoids could not be done (de Oliveira et al., 2010) and thus below in Table S5a) the organic bands are identified only as compound 1 to 7. In addition, many mineral phases were identified and are listed below in Table S5b.

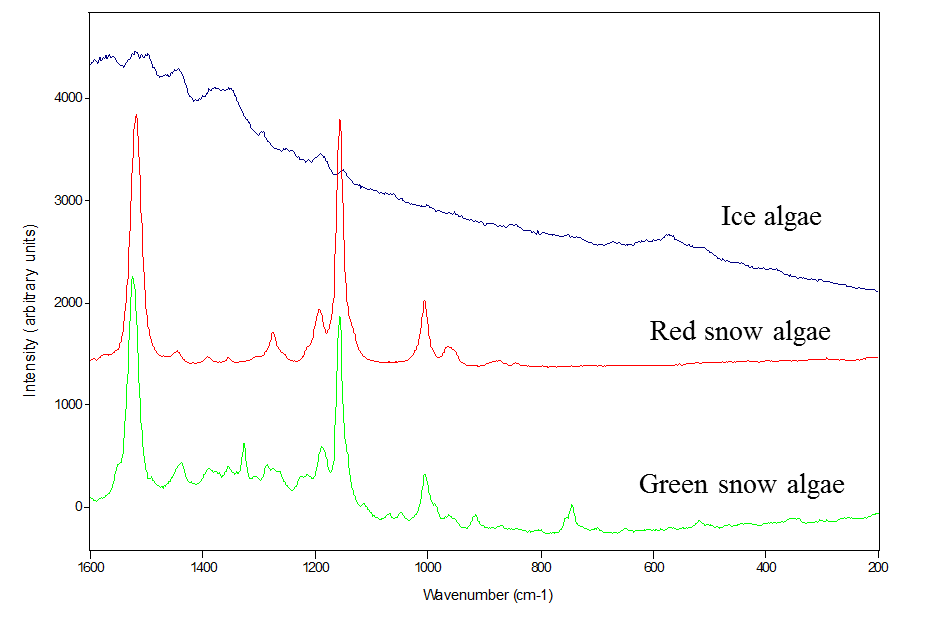


Figure S1. Raman spectra of three different cell types: ice algae (blue), red mature snow algae (red) and young green snow algae (green).

**Table S3a.** Raman spectroscopy analyses of minerals and black carbon in the three samples (in bold shown main peak assignments).

|  |  |  |
| --- | --- | --- |
| Inorganic compounds | Wavenumbers (cm-1) | Sample type |
| Haematite | 640, 410, **292**, 225 | Red snow |
| Limonite | 550, **391**, 297, 245, 202 | Red snow |
| Iron oxide | 686, 460, 335, 261 | Grey ice |
| Feldspar | **508**, **480** | Red snow |
| Microcline | **513**, **474**, 437, 355, 284, 154 | Red snow |
| Zircon | **1005**, 973, 437, **355** | Red snow |
| Quartz | **463**, 205 | Red snow |
| Black carbon | **1618**, **1330** | Red snow, grey ice, biofilm |
| Garnet | 1043 **916**, 861, 635, 556, 502, 480, **350**, 209 | Red snow |
| (Ortho-) Pyroxene | **1000**, **674**, 654, **335**, 229 | Red snow |

**Table S3b.** Raman spectroscopy analyses of organic compounds (in bold shown main peak assignments).

|  |  |  |
| --- | --- | --- |
| Organic compounds | Wavenumbers (cm-1) | Sample category/cell type |
| Compound 1 | **1615, 1567, 1447, 1378, 1359, 1300, 1192, 84**9, 750, **574, 513** | Biofilm/ice algae |
| Compound 2 | **1624, 1571**, 1533, **1506, 1452, 1387, 1350, 1301, 1255, 1199, 850, 579, 511** | Grey ice/snow algae |
| Compound 3 | **1622, 1568, 1509, 1448, 1382, 1359, 1300, 1265, 1194, 853, 576, 513** | Grey ice/snow algae |
| Compound 4 | 1670, 1500, 1410, 1280, 1260, 1222 | Red snow/snow algae |
| Compound 5 | 1444, 1357, 1274, 511 | Red snow/snow algae |
| Compound 6 | 1677, 1601, 1585, 1567, 1558, 1483, 1432, 1426, 1399, 1364, 1305, 1292, 1184, 1118, 1063, 1018, 991, 907, 803, 780, 700, 657, 599 | Red snow/snow algae |
| Compound 7 | 1617, 1325, 1292, 1263 | Red snow/snow algae |

