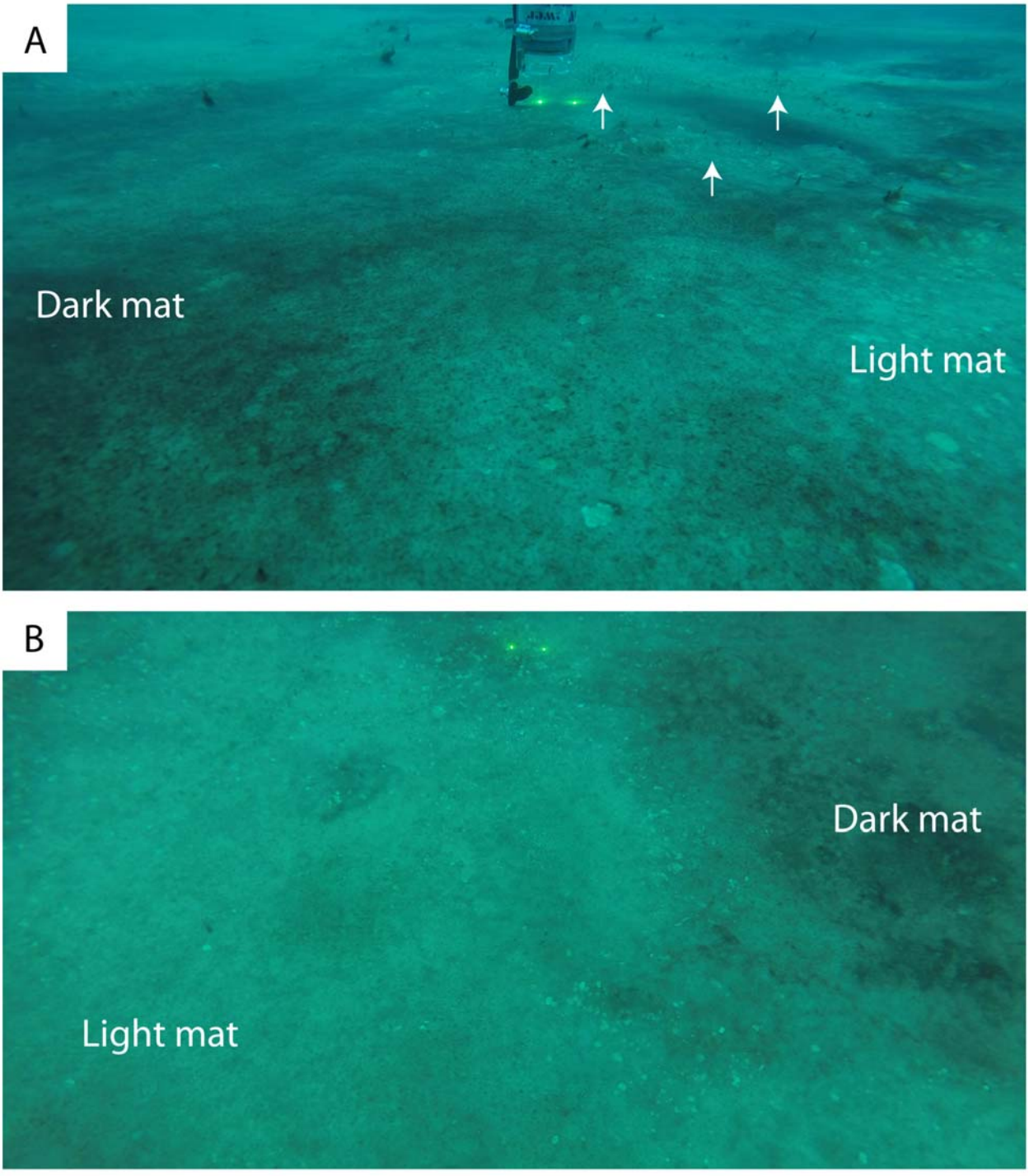
Mackey et al., 2017, Increased mud deposition reduces stromatolite complexity: Geology, doi:10.1130/G38890.1

Supplemental materials

Figure DR1 Oblique view of benthic microbial mats at site 1 from 10.5 m (A) and 10.4 m (B). Dark microbial mats consistent with abundant *Phormidium autumnale* morphotypes (Mackey et al., 2015) have fewer pinnacles than light mat consistent with rare *P. autumnale* morphotypes. Despite apparently greater abundance of pinnacles in light mat (A, white arrows), light mat is not uniformly covered with pinnacles (B). In both images, laser points are spaced by 5 cm.



Drop camera operations and image processing

This study used both oblique and downward-facing images to quantify microbial mat morphology, which required a custom drop camera assembly designed for deployment through a 0.13 m diameter drill hole. A downward-facing drop camera (SeaViewer) with a live surface feed was mounted at the bottom of a PVC pipe and fitted with parallel underwater lasers spaced 5 cm to serve as a scale in images. A second pipe was attached to the top of the drop camera mount with a hinge. This second pipe served as a boom for mounting the oblique drop camera (GoPro HD Hero) and light source (Light and Motion Sola Photo 800). The whole assembly was lowered and raised with the SeaViewer cable when passing through the ice cover and a second line pulled the boom outward once in the water column to obliquely image the benthic microbial mats.

Downward-facing drop camera images were processed to remove lens distortion for quantitative analysis of benthic microbial mats. Images were scaled using 5 cm-spaced lasers and cropped to the center 1 m^2. Remaining lens distortion for each camera was removed in Graphic Converter (https://www.lemkesoft.de/en/products/graphicconverter/) using calibrations images of an underwater target grid. Measurements on the resulting images were made using ImageJ (https://imagej.nih.gov/ij/), and analyses of pinnacle distribution used a nearest neighbor distance plugin (https://icme.hpc.msstate.edu).

Lake Joyce drill hole survey

Benthic mats were documented at 23 GPS-referenced locations in Lake Joyce (Table S1), with the depth logged using an InSitu Rugged TROLL 100 pressure transducer.

Table DR1: Location of drill holes for drop camera observation of benthic microbial mats. Distance was measured from the mouth of the nearest meltwater stream to the drill hole, and the fraction of mat morphologies reflects the proportion of facies at each 1 m^2 location resolved to 10 cm x 10 cm. The number of isolated or webbed pinnacles m^{-2} were counted from downward facing camera images with sufficient resolution. Asterisk denotes a site where 11% of the benthic mat was disrupted within the center of the field of view, requiring renormalization of the mat percent cover and pinnacles m^{-2}.

Site	Lat	Long	Distance (m)	Depth (m)	Fraction prostrate	Fraction Isolated	# Isolated (m^{-2})	Fraction webbed	# Webbed (m^{-2})
1	-77.7160	161.6124	150	10.5	0.85	0.15	-	0.00	-
1	-77.7159	161.6130	132	10.3	0.70	0.30	51	0.00	0
1	-77.7159	161.6127	140	10.4	0.76	0.24	42	0.00	0
1	-77.7160	161.6130	147	10.4	0.89	0.11	35	0.00	0
2	-77.7162	161.6109	187	11.3	0.46	0.54	170	0.00	0
2	-77.7163	161.6110	196	11.6	0.32	0.68	213	0.00	0
2	-77.7161	161.6112	174	11.0	0.23	0.72	205	0.05	18
2	-77.7163	161.6114	186	11.5	0.78	0.22	56	0.00	0
2	-77.7162	161.6119	177	10.9	0.85	0.15	19	0.00	0
3	-77.7166	161.6099	235	12.0	0.11	0.44	-	0.45	-
3	-77.7165	161.6095	236	10.2	0.26	0.62	193	0.12	95
3	-77.7166	161.6097	240	11.9	0.05	0.40	157	0.55	322
4	-77.7172	161.6080	317	10.9	0.29	0.63	-	0.08	-
4	-77.7172	161.6079	326	12.0	0.20	0.33	90	0.47	282
4	-77.7171	161.6079	314	11.0	0.69	0.24	81	0.07	57
4	-77.7172	161.6079	324	12.7	0.19*	0.00*	0*	0.81*	519*
5	-77.7193	161.6066	541	10.0	0.46	0.36	97	0.18	75
5	-77.7193	161.6066	537	10.6	0.19	0.31	65	0.50	327
5	-77.7192	161.6068	534	11.7	0.17	0.00	0	0.83	1072
6	-77.7229	161.6162	902	10.6	0.00	0.44	-	0.56	-
6	-77.7229	161.6163	902	11.8	0.00	0.23	-	0.77	-
6	-77.7229	161.6159	894	11.9	0.01	0.30	-	0.69	-
6	-77.7229	161.6163	895	12.5	0.00	0.29	85	0.71	283

Deployment and recovery of instrumentation through the ice cover

In order to document the sedimentation patterns in four sites across Lake Joyce, we constructed and deployed a self-heating system to deploy and recover sediment traps beneath 4 to 5 m of ice without releasing sediments from the ice cover. 0.25 m Jiffy drill holes were cased by a 0.15 m diameter PVC pipe. The top of the casing pipe was 2.3 m long segment fitted with a Van Stone flange, and subsequent 2.3 and 1.6 m long segments were connected with uncemented

slip-slip fittings. The overall length PVC pipe casing was approximately 1.5 m longer than the thickness of the ice cover, extending below the bottom of the ice.

With the PVC casing pipe in the drill hole, the sediment trap was deployed on a line through the pipe. The trap line was attached to a pipe insert whose bottom was sealed by a PVC cap that fit snugly within the 0.25 m diameter casing pipe and served both to catch any material that fell between the insert and casing pipe and restrict circulation of water. This cap was followed by a 0.10 m diameter PVC pipe insert, which like the casing pipe was made up of 2.3 and 1.6 m long segments connected by slip-slip PVC fittings. The insert was centered in the casing pipe and wrapped by an 8 m length of Arctic Heat Trace (duAlaska, Inc.), with a 2.6 m cold lead. The cold lead was threaded through the center of the top 0.10 m PVC pipe insert. The top of the 0.10 m diameter PVC pipe insert had a fitting to increase the diameter from 0.10 to 0.25 m, and this was in turn secured to the top of the casing pipe with the other half of the Van Stone Flange. The space between the first segment of the insert and the casing pipe was pressurized to displace water, and the whole assembly was tied off to a wood collar, fit with a dust cap, and allowed to freeze in. The pressurized pipe assembly did not require ballast due to the submerged mass of PVC pipe.

The sediment traps were recovered by plugging the Arctic Heat Trace into a field-portable 1 kW generator to melt the space between the 0.25 m diameter PVC pipe casing and the 0.10 m diameter PVC pipe insert. Once the insert was sufficiently melted, it was winched out from the outer pipe casing with a tripod. After each segment or the insert was removed, the winch was connected to the next one below and the pipe segments were separated at their slip-slip fittings. The pipe insert was followed by the sediment trap assembly. After the sediment trap was removed, the Arctic Heat Trace was removed from the pipe insert and re-submerged in the

casing to melt out the outer 0.25 m diameter PVC pipe. It was removed in segments using the winch.

Sediment traps

Sediment traps were deployed at four sites in Lake Joyce to measure annual sediment deposition between December 2014 and December 2015. Each trap consisted of a PVC pipe that was 7 cm in diameter and 63 cm long with floats on the sides, which suspended the trap vertically in the water column above an anchor weight. The line between the anchor weight and the trap had collapsible wings to direct the trap away from the drill hole when lowered under the ice cover. During deployment and recovery, tension on the trap down line held a lid over the trap opening. The trap lid was attached to arms that pivoted on the side of the sediment trap. When the trap reached the lake bottom, the arms fell to the side and the lid slid off of the trap opening. During recovery, the arms were raised by tension on the down line, which also secured the lid on the top of the sediment trap.

The sediment trap itself was deployed through the 0.25 cm diameter pipe casing on a 6 m buoyant polypropylene line tethered to a weight, which kept the lead line off of the benthic microbial mats and sediments. The weight was connected by a 7 m line to a float beneath the ice cover, which in turn was attached to a negatively buoyant line. This down line was attached to the heated pipe insert and was sufficiently long that the pipe insert could be removed without pulling the anchor off of the lake bottom, accounting for probable annual lake level rise and ablation of the pipe insert through the ice cover.

Sediment traps were anchored from 12.5 m to 11.5 m depth and buoyantly suspended in the water column to bring trap openings up to a consistent depth at 10.7 m. The trap mouth was

approximately 5 m deeper than the bottom of the casing pipe. With this depth to descend, traps drifted 0.6 to 1.4 m from the drill hole, as determined by drop camera visual inspection.

When removing the sediment trap, the weighted down line was gently raised until the anchor was approximately 0.5 m above the sediment-water interface and held for more than 18 hours to allow sediment to settle before pulling up the anchor and putting tension on the sediment trap down line to bring up the cap and recover sediment trap. Following sediment trap recovery, water depth was measured using an InSitu Rugged TROLL 100 pressure transducer to determine annual change in lake level. The measured water depth was consistent with the depth at the time of trap deployment.

Lake Joyce sediment processing

Once retrieved, sediment trap contents were kept under refrigeration and returned to UC Davis for analysis. Water from traps was decanted from sediments after settling for more than one week, and the remainder was centrifuged. Sediments were acidified with 2 mL of 1% HCl, centrifuged, and rinsed with DI water. Sediments were subsequently treated with 30 mL of 30% H_2O_2. H_2O_2 treatment was undertaken in a water bath at 80°C for 20 hours, followed by an oven at 60°C until visible bubbling ceased and the sediment could be centrifuged into a pellet. Following H_2O_2 treatment, samples were rinsed with DI water and sieved to divide the sediment into mud ≤63 µm and sand >63 µm. Granules >2 mm diameter were manually separated from the sieved sand. Mud was filtered on 0.40 µm filter paper by vacuum filtration, and both filters and sand were dried for 24 hours at 60°C to determine mass.

Table DR2 Locations of sediment traps deployed over winter at Lake Joyce and total sediment recovered for each size fraction.

Transect site	Latitude	Longitude	Mud (mg cm^{-2})	Sand (mg cm^{-2})	Granules (mg cm^{-2})
Site 2	-77.7163	161.6114	0.88	4.51	0.00
Site 3	-77.7166	161.6097	0.43	2.37	0.00
Site 5	-77.7192	161.6068	0.46	1.62	0.00
Site 6	-77.7229	161.6163	0.46	1.26	1.27