Microbial community structure changes during temporal development of cryoconite holes

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Project overview:

Cryoconite is a matrix of mineral particles and biological material deposited on glacier surfaces by wind and meltwater. Since the cryoconite material is dark coloured, it absorbs sunlight and melts down into the ice, creating a hole (Fig. 1). Cryoconite holes are hotspots of microbial activity on glacier surfaces worldwide.

Figure 1. Cryoconite holes on the surface of Greenland Ice Sheet.

My PhD research focuses on heterotrophic microorganisms from cryoconite holes. The first element of my project assessed the ecology of heterotrophic bacteria from Antarctic and Arctic cryoconite holes, based on cultivation methods. The experiments revealed surprising versatility and broad adaptation for extreme environmental conditions of cryoconite bacteria, and higher resilience of Antarctic bacterial species when compared to the Arctic ones. This detailed analysis of microbial isolates was followed by assessment of biogeochemical processes in cryoconite holes by studies of oxygen and pH dynamics in the cryoconite material. Cryoconite samples were incubated long-term and their oxygen and pH profiles were measured regularly, and subsamples to assess water chemistry changes were collected. My study was first to apply a microsensors method to resolve the oxygen dynamics in glacial ecosystems and to prove the existence of anoxic zones on glaciers surfaces.

Progress:

Previously, my project was largely based on traditional cultivation techniques and biogeochemical analyses. Using funding from the Antarctic Bursary, I extended my PhD project to include the molecular techniques and link the biogeochemistry with the microbial community structure. Specifically, in collaboration with Dr Anne Jungblut from NHM (London), we sequenced the 16S rDNA of microbial communities from the long-term incubations of cryoconite material. This information could be then linked to primary PhD research regarding: (i) metabolic capabilities of microbial isolates, (ii) discovered anoxic niches within the cryoconite holes and (iii) corresponding water chemistry analysis. Building on the previous findings including the growth of isolates both in aerobic and anaerobic conditions, their significant fermentative potential and presence of long-term anoxia in the incubations, my analysis of molecular data focused on the long-term changes in the community structure and the abundance of anaerobes. The 16S rDNA sequencing of community diversity revealed that location is the strongest determinant of microbial populations regardless of other factors such as incubations' time, light/dark regime, depth of sampling or measured water chemistry. Further analysis showed that the

communities varied significantly with time, which was likely caused by long-term anoxic conditions (Fig. 2a). The community was also different depending on light/dark regime (Fig. 2b) and on the sampling depth (Fig. 2c), but the differences were less pronounced. Finally, there was also some clustering of microbial populations depending on the concentration of fermentative products in the pore water (namely acetate). Overall, anoxic conditions caused the shift in the community, which also corresponded to the evidence of anaerobic metabolism. It is the first detailed analysis of anaerobic metabolism and its products comparing the cryoconite material from the Arctic and Antarctica.

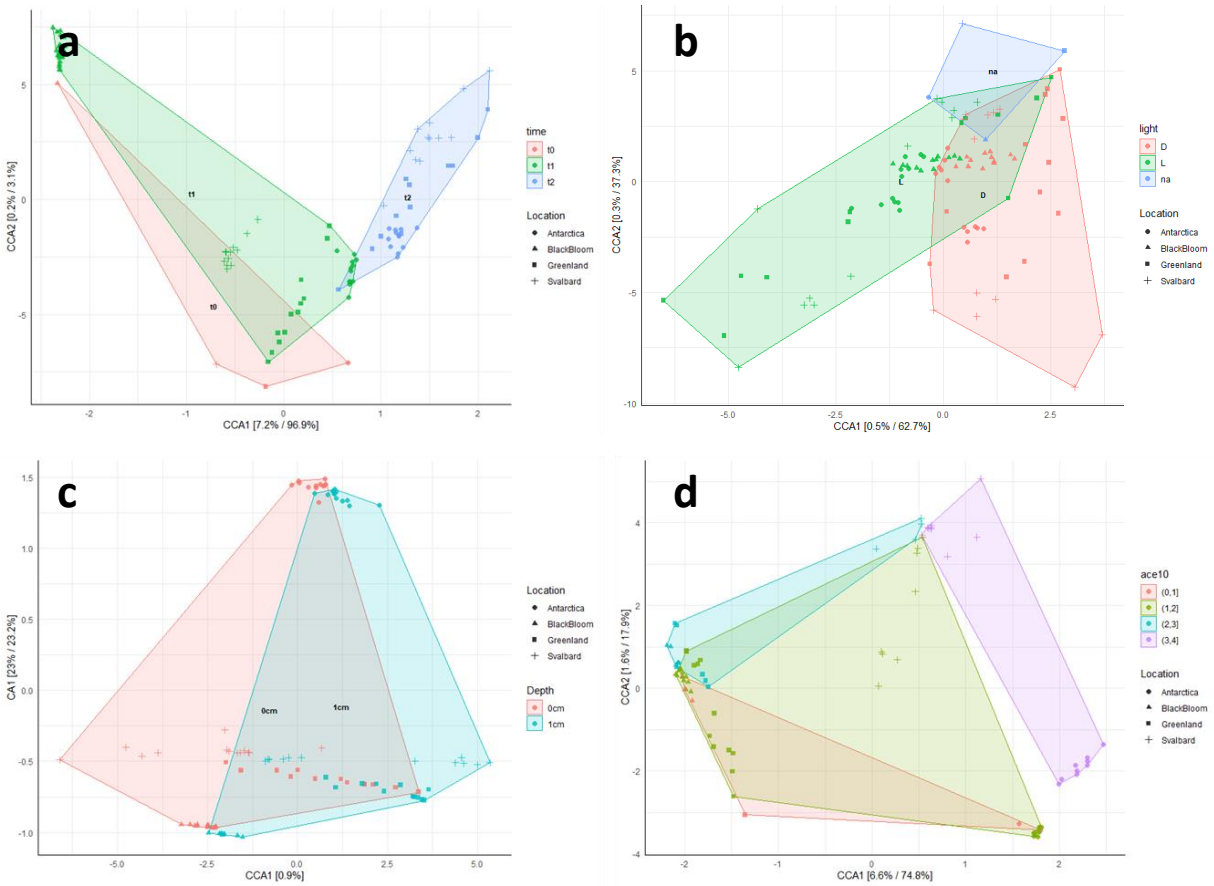

Figure 2. Constrained Correspondence Analysis of microbial diversity – constrained by location. The factors analysed include (a) time, (b) dark/light regime, (c) depth of sampling, (d) fermentation products concentrations in the pore water.

Next steps:

Now, the more in-depth analysis of the abundance of anaerobic microorganisms, specifically fermentative groups and terminal oxidizers such as methanogens and sulphate reducers will be performed. This will allow to determine the potential for anaerobic metabolism in cryoconite holes, generally regarded as well-oxygenated environments. Some additional water chemistry will also be measured to detect the fermentation products in some remaining samples and to link them to the microbial population found in the cryoconite material.