Spatial distribution of cryoconite granules and microorganisms on Qaanaaq Glacier, Greenland.

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The cryoconite is dark-colored sediment on glacier surface, which consists of mineral particles from surrounding and biogenic organic matter produced by microorganisms living on the glacier. The cryoconite absorbs solar radiation and cause excessive melting of the ice around and beneath it, and sinks down into the ice vertically, forming cryoconite holes. The cryoconite hole provides a stable habitat, which are less frequently washing out to supraglacial meltwater stream for microbial community. Wientjes et al., 2010 shows that visible dark colored band called “dark region” is found every summer in the same position where 20-50 km distanced from the margin of Middle Western Greenland Ice Sheet. This region was covered by ancient dust mainly deposited in Holocene and photosynthesis microorganisms and microbial organic material significantly reduce the albedo. High light absorbency of cryoconite are attributed to humic substance and/or pigmented microorganisms. Cryoconite usually contains substantial amounts of humic substances and pigmented green algae and cyanobacteria grown on the snow and ice surface. According to Uetake et al. 2010, Qaanaaq Glacier in north western Greenland have both these two biologically darkening materials: cyanobacteria dominated cryoconite granules in the middle ablation area and pigmented green algae dominated in the lower ablation area. In order to understand the relationship between cryoconite granules and photosynthesis microorganisms, and the reason for spatial variability of cryoconite granules and growth of dominant cyanobacteria on Qaanaaq Glacier, we will focus on characteristics of cryoconite granules in different altitude and different development stages (6 different diameter). We analyzed carbon and nitrate amounts, and bacterial 16S rRNA gene diversity and potential environmental factors to support cyanobacteria growth.

We found 6 types of photosynthesis microorganisms including green algae (*Ancylonema noldenskioeldii, Mesotaenium berggrenii*, *Chloromonas* sp., *Cylindrocystis brebissonii* and unknown small round green algae) and cyanobacteria (*Oscillatoriaceae*). Altitudinal distribution patterns of green algae and cyanobacteria are clearly different. Green algal specie *Ancylonema noldenskioeldii* is high in QA2, otherwise Oscillatoriaceae cyanobacteria is significantly high in the middle of glacier (QA4). Generally dominant microorganisms in cryoconite granules are *Oscillatoriaceae* cyanobacteria and these cyanobacteria uptake inorganic carbon and produce organic matter in cryoconite granule. Therefore, it seems to be clear relationship between filamentous cyanobacteria biomass and amount of developed cryoconite granules. After analyzing correlation between mass of large cryoconite granules and all photosynthesis microorganisms, only *Oscillatoriaceae* cyanobacteria is correlated with amount of developed granules (coefficient of correlation=0.900, P=0.083). Therefore, whether *Oscillatoriaceae* cyanobacteria growth or not are one of essential process for cryoconite granulation.

Potential environmental factors that control the *Oscillatoriaceae* cyanobacteria growth still have not been clear. However, if we will compare possible factors in both *Oscillatoriaceae* cyanobacteria dominated and non-dominated site, we may be able to identify factors related to their growth.

Among 5 environmental factors (altitude, slope angle, nutrients concentration, amount of mineral, characters of mineral), RDA analysis shows only smaller mineral particles was corresponded to biomass of phototrophs. This result indicates other environmental factors are less important for growth of phototrophs. Previous study suggested that slope angle is proxy for melt water flow and influence microbial communities in GrIS due to surface melt wash out (Stibal et al. 2012), otherwise slope angle in Qaanaaq Glacier are steeper than previous study in Greenland Ice Sheet and all sites are affected equal by melt-water wash out. Mineral particles are known as potential source of phosphate in glacier ecosystem and generally less influenced by melt water and stay longer on same position than chemicals solved in water, in addition we assume hypothesis mineral particles could be base (or foothold) of filamentous cyanobacteria growth.

Reference

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