5th International Conference on Polar & Alpine Microbiology, Big Sky, MT, USA, 2013

Physiological Ecology of Bacteria in the water column of Subglacial Lake Whillans, Antarctica

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Recent recognition of the widespread nature of liquid water beneath the Antarctic ice sheet has generated new interest in subglacial aquatic environments as microbial habitats. These environments have been hypothesized to contain active ecosystems and encompass stores of organic matter and nutrients of unquantified significance to Earth's biogeochemical cycles. We report here on the collection of the first intact water samples from Subglacial Lake Whillans (SLW), and provide the first direct evidence for active microbial life in a subglacial water column.

SLW lies 800 m beneath the ice surface of Whillans Ice Stream, West Antarctica. Remote sensing data indicate that the lake lies near the end of a hydrological flow-path and periodically flushes into the sea under the Ross Ice Shelf. Epifluorescent microscopy showed that water collected from SLW in clean Niskin bottles contained ~10^5 cells mL^{-1}. Metabolic activity was measured both directly and indirectly by measuring (i) cellular ATP concentration, (ii) respiratory electron transport activity, and (iii) cellular incorporation of ^{14}C-acetate, ^{14}C-bicarbonate, ^{14}C-leucine, ^{3}H-thymidine, and ^{3}H-leucine.

ATP levels (avg +/- SD = 3.7 +/- 0.4 pmol L^{-1}) in the lake samples were significantly ($p<0.05$) greater than levels in drill borehole water and blanks indicating active biosynthesis of this critical metabolic compound. Time series measurements of electron transport system activity and radiolabelled substrate incorporation (except for acetate) were also significantly ($p<0.05$) greater than killed samples. Bacterial growth efficiency (BGE = BP/(BP+BR)) based on ^{14}C-labelled leucine incubations was 0.12, which is relatively low compared to other Antarctic lakes. ^{3}H-leucine incubations amended with combinations of C, N, and P revealed phosphorus limitation of heterotrophic activity in SLW. Taken together, these results show that SLW contains active microbial consortia and have implications for nutrient cycling under Antarctic ice.

Funding provided by NSF-OPP grant 0838933.