Microbial nutrient cycling and physiology in Subglacial Lake Whillans, Antarctica

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. Subglacial Lake Whillans (SLW) lies 800 m beneath the ice surface of Whillans Ice Stream, West Antarctica. Remote sensing data indicate that the lake is situated near the end of a hydrological flow-path and periodically flushes into the sea under the Ross Ice Shelf. We report here on the collection of the first intact water samples from SLW and provide the first direct evidence for active microbial life and carbon cycling in a subglacial water column.

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 and/or respiration of ^{14}C-bicarbonate, ^{14}C-leucine, ^{3}H-thymidine, and ^{3}H-leucine. The fluorescent portion of dissolved organic matter (DOM) in the water column and surficial sediments was analyzed via excitation emission matrix spectroscopy (EEMS).

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. Assuming that the dark incorporation of ^{14}C-bicarbonate is representative of dark carbon fixation, chemoautotrophy provides ~33 ng C L^{-1} d^{-1} to the SLW water column, which meets ~15% of the heterotrophic carbon demand (BCD) estimated from the incorporation and respiration of ^{14}C-leucine in SLW water. More conservative estimates of BCD based on ^{3}H-thymidine, and ^{3}H-leucine incorporation rates suggest that chemoautotrophic activity is sufficient to supply between 30% and 150% of BCD. Fluoresence, humification, and freshness indices calculated from EEMS profiles suggest that DOM in the SLW water column and surficial sediments are the products of microbial activity, and that water column DOM was produced more recently than surficial sediment DOM. $\Delta^{14}C$ and $\delta^{13}C$ characteristics of the particulate organic carbon component of the SLW water column provide further insight into sources of and processes affecting organic matter in subglacial environments.

Taken together, these results show that SLW contains active microbial consortia and have implications for nutrient cycling under Antarctic ice.