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Microbial nutrient cycling and physiology in Subglacial Lake Whillans, Antarctica.

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Recent recognition of the widespread nature of liquid water beneath the Antarctic ice sheet has generated international interest in subglacial aquatic environments as functional microbial ecosystems that play a role in global elemental transformations. . 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 bulk liquid water samples from SLW and provide the first direct evidence for active microbial life and elemental cycling in a subglacial lake. Epifluorescent microscopy showed that water collected cleanly from SLW contained ~10^5 cells mL^{-1}. Cellular viability and metabolic activity was measured as (i) cellular ATP concentration, (ii) respiratory electron transport activity, and (iii) cellular incorporation and/or respiration of 14C-bicarbonate, 14C-leucine, 3H-thymidine, and 3H-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, Dark incorporation of 14C-bicarbonate, which we assume to represent chemoautotrophic activity, 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 14C-leucine in SLW water. More conservative estimates of BCD based on 3H-thymidine, and 3H-leucine incorporation rates reveal that chemoautotrophic activity is sufficient to supply between 30% and 150% of BCD. Fluorescence, humification, and freshness indices calculated from EEMS data indicate 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. 14C-dating and 13C 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. Collectively, our data show that SLW is a microbially dominated ecosystem driven by chemoautotrophy that transforms carbon and other key biogeochemical elements beneath the Antarctic ice sheet.