SUBGLACIAL LAKE WHILLANS: A MICROBIAL ECOSYSTEM BENEATH DEEP ANTARCTIC ICE.

Brent C. Christner[1], John C. Priscu[2], Amanda M. Achberger[1], Carlo Barbante[3], Alexander B. Michaud[2], Jill A. Mikucki[4], Andrew C. Mitchell[5], Alicia M. Purcell[4], Mark L. Skidmore[6], Trista J. Vick-Majors[2], and the WISSARD Science Team. [1]Department of Biological Sciences, Louisiana State University, Baton Rouge, LA, USA [xner@lsu.edu], [2]Department of Land Resources and Environmental Science, Montana State University, Bozeman, MT, USA, [3]Institute for the Dynamics of Environmental Processes – CNR, Venice, and Department of Environmental Sciences, University of Venice, Venice, Italy, [4]Department of Microbiology, University of Tennessee, Knoxville, TN, USA, [5]Department of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, UK, [6]Department of Earth Science, Montana State University, Bozeman, MT, USA

Introduction: There is a large liquid water reservoir beneath the Antarctic ice sheet (~10^7 km^3) and ~400 subglacial lakes have been identified in West and East Antarctica. Dark chemosynthetic microbial ecosystems have been proposed to exist at subzero temperatures at the ice sheet bed [1-3], but direct observations are lacking. Here we provide results from the first analysis of water and surficial sediments collected directly from a subglacial lake beneath the West Antarctic ice sheet using microbiologically clean drilling and sampling techniques.

Subglacial Lake Whillans (SLW) lies beneath ~800 m of ice on the lower portion of the Whillans Ice Stream in West Antarctica and is part of an extensive and evolving hydrological system. The subglacial drainage network regulates water transport to the sub-ice coastal margin beyond the grounding line, linking the hydrological system to the sub-ice-ocean cavity beneath the Ross Ice Shelf [4]. The drilling location to access SLW was selected using reflection seismology and ice-penetrating radar data, and corresponded to the region of maximum predicted water column thickness, lowest hydropotential, and largest satellite-measured surface elevation changes.

Results: During January 2013, a hot water drill was used to create a ~0.6 m diameter borehole through the overlying ice sheet into SLW, allowing for direct measurements in the water column and the collection of discrete water and and sediment samples [5]. The ~2.2 m water column of SLW contained metabolically active microorganisms and was derived primarily from glacial ice melt with solute sources from lithogenic weathering and a minor seawater component. The water showed oxygen under-saturation (~2 mg L^{-1}; ~ 17% of air saturation) and N:P molar ratios implied a biologically nitrogen deficient environment, relative to phosphorus [6].

Chemoautotrophic primary production in SLW was adequate to support heterotrophic metabolism in the subglacial ecosystem. The most abundant phylotypes in the SLW water column were most closely related to chemolithoautotrophic species that use reduced nitrogen, iron, or sulfur compounds as energy sources. The profusion of taxa related to bacterial and archaeal nitrifiers in concert with elevated ammonium and $\Delta^{17}O$-NO_3 values in the water column implied that nitrification may be a fundamental chemoautotrophic pathway of new organic carbon production in SLW [6].

Discussion: These new data indicate that environments beneath the world's major ice sheets support viable ecosystems and corroborate previous reports suggesting that subglacial microbial communities can mobilize elements from the lithosphere and influence marine geochemical and biological systems. Given the prevalence of subglacial water in Antarctica, we contend that aquatic microbial ecosystems are common features of the sub-ice environment that exists beneath the Antarctic ice sheet.

Antarctic subglacial lakes have been repeatedly identified as the most promising terrestrial analogs for the habitability of icy worlds beyond earth [7]. The scientific exploration of subglacial lakes also presents similar technological and scientific challenges and shares many of the same concerns about forward contamination as astrobiological studies of other planetary bodies. The sampling and analysis of a sub-ice aquatic environment experiencing long-term isolation from solar energy and atmospheric input not only has broadened our understanding of Earth's biosphere, it has provided new information that will aid in defining the limits and survivability of of life in the sub-ice oceans of Europa, Enceledus, Ganymede, and Titan.

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