BACTERIOHOPANEPOLYOLS ACROSS ENVIRONMENTAL GRADIENTS IN ICE-COVERED LAKES OF THE MCMURDO DRY VALLEYS

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Microbial membrane lipids are commonly used as molecular proxies for evaluating the composition of microbial communities in modern environments and may be applied to the interpretation of geological archives. Diagnostic compound classes include cell wall and interior membrane lipids constituents that are essential to the structural integrity and physiology of cells. Bacteriohopanepolyols (BHPs) are a prime example. To realize the diagnostic potential of these and other lipids, we must first understand their structural diversity, biological sources, and physiological functions. BHPs are pentacyclic triterpenoids that likely serve as sterol surrogates in bacterial cells (Sáenz et al., 2012). Structural variants have been associated with particular types of bacteria or environmental conditions. For example, 2-methylbacteriohopanetetrol (2-MeBHT) was originally proposed as a proxy for cyanobacteria and oxygenic photosynthesis (Summons et al., 1999). However, it is now known that 2-MeBHT is also produced by α -proteobacteria and acidobacteria (Welander et al., 2010). More recently, 2-MeBHT has been associated with stress response to particular environmental conditions such as pH and temperature (Doughty et al., 2009).

Ice-covered lakes of the McMurdo Dry Valleys, Antarctica provide a particular opportunity to identify the sources and physiological function of particular BHP compounds. The lakes contain persistent geochemical gradients with limited physical and biological disturbance due to their isolation and seasonal ice cover. Therefore, benthic microbial mats are able to develop in response to illumination, nutrient, and oxygenation, which vary between lakes.

The lipid assemblages of these microbial communities have not received extensive study and only recently have they been characterized using genomic approaches (e.g. Jungblut et al., 2016). We describe the composition of accumulated organic matter in Lakes Vanda, Fryxell, and Joyce, and in other glacial biomes of the McMurdo Dry Valleys. BHPs are of great interest due to their potential to serve as proxies for bacteria in the geological record. Our results show unprecedented abundances of 2-MeBHPs. While previous studies have identified 2-MeBHT in benthic microbial mats (e.g. Blumenberg et al., 2013), to the best of our knowledge, this is the first study that shows 2-MeBHP amounting to >50% of the total BHP. We propose that the abundance of 2-MeBHP may reflect the unusual seasonal light regime of this polar environment (e.g. Hawes et al., 2016), where shade-adapted cyanobacteria dominate benthic microbial communities.

At 9 m depth in Lake Vanda, benthic microbial mats grow around and under cobbles and boulders. They serve as a particular opportunity to test the influence of irradiance on lipid distribution in an otherwise homogenous environment. *In situ* illumination of the mat was modeled to provide an estimate of incident irradiance at any point on the mat surface, which ranges from 37-150 μmol photons m^{-2} s^{-1} (Mackey, 2016). Cores of the microbial mat structure were sampled across the shading gradient from under an overhang to the open

water. Surface layers were isolated and analyzed for BHPs. Bacteriohopanetetrol (BHT) is a ubiquitous bacterial membrane lipid and is abundant in all samples. 2-methylbacteriohopanetetrol (2-MeBHT) is also abundant and varies in relation to BHT across the shading gradient. The "2-MeBHT ratio" (2-MeBHT/BHT+2-MeBHT) is highest underneath the boulder, at <20% relative irradiance. The 2-MeBHT ratio decreases linearly across the gradient from regions receiving <20% relative irradiance to the open water (100% relative irradiance). These results suggest that BHP methylation at the C-2 position may be a stress response to low irradiance in this unique polar environment. Lake cores confirm that the 2-MeBHT signatures are preserved over time in Antarctica's ice-covered lakes.

By establishing correlations among environmental conditions, microbial community composition, and lipid assemblages in the McMurdo Dry Valleys, our data provide valuable ecological insights as to life in such extreme environments and advance the development of biomarkers that allow us to identify similar environmental stressors in the geological record.

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