2-Methyl hopanoid production and anoxygenic photosynthesis: A model cyanobacteria isolated from a proterozoic ocean analog

T.L. HAMILTON[1], L.M. BIRD[1], K.H. FREEMAN[1] AND J.L. MACALADY[1]

[1]Department of Geosciences and Penn State Astrobiology Research Center (PSARC), University Park, PA 16802 USA (*correspondence tlh42@psu.edu)

Biomarkers recovered from ancient rocks provide invaluable tools to reconstruct early Earth microbial ecosystems as well as providing clues about planetary redox evolution. Bacteriohopanepolyols (BHPs) or hopanoids are membrane lipids produced by many bacteria and are among the most abundant and extractable organic compounds in ancient sedimentary rocks. Cyanobacteria are responsible for oxygenation of the atmosphere and examining their presence in the rock record with specific biomarkers such as 2-methyl BHPs can provide key clues regarding the rise of oxygen on early Earth. However, the lack of a model cyanobacterium capable of producing 2-MeBHPs as well as observations that other bacteria also produce these lipids has hindered our understanding of these biosignatures in ancient rocks. Here we demonstrate hopanoid production and anoxygenic photosynthesis in a cyanobacterium isolated from a Proterozoic ocean analog. We isolated a cyanobacterium that produces 2-MeBHPs from a red phototrophic mat in Little Salt Spring, a karst sinkhole in Florida with low levels of both dissolved oxygen and sulfide. The hopanol content of the phototrophic mat is high and rich in 2-methyl structures which are preserved in the organic-rich bottom sediments. Furthermore, we found the cyanobacterium is capable of primary productivity by anoxygenic photosynthesis. The isolation of a cyanobacteria from an environment with a Proterozoic-ocean chemical composition that produces 2-MeBHPs and is capable of anoyxgenic photosynthesis will greatly improve our understanding of the role of hopanoids in microbial physiology and ecology as well as the deposition of these biomarkers in the rock record.

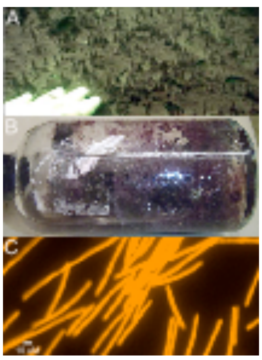

Figure 1. A. Microbial biofilm collected from Little Salt Spring at 9 m water depth at sediment-water interface, human hand for scale**.** B. Culture bottle incubated *in situ* in the Little Salt Spring water column after inoculation with microbial biofilm from the sediment- water interface. C. Autofluorescence of cells due to the presence of phycoerythrin.

Oxygen Minimum-Zone-like conditions from the Early Cambrian of Chengjiang, South China

E.U. HAMMARLUND[1]*, R.R. GAINES[2], CHANGSHI QI[3], AND D.E. CANFIELD[1]

[1]Nordic Center for Earth Evolution (NordCEE) and Institute of Biology, University of Southern Denmark, 5230 Odense M, Denmark (*corr: emma@biology.sdu.dk)
[2]Geology Department, Pomona College, Claremont CA 91711, USA
[3]Yunnan Key Laboratory for Palaeobiology, Yunnan University, Kunming 650091, China

The Cambrian explosion occurred between increases in atmospheric oxygen concentration in the later Neoproterozoic Eon [1, 2] and during the Paleozoic Era [3, 4]. To further constrain chemical conditions in the Early Cambrian ocean, a multi-proxy geochemical approach was applied to two new drill cores through a portion of the Early Cambrian succession of Yunnan, South China. Our results reveal a transition in local ocean chemistry that is captured in both cores. Sulfidic conditions, which were well developed in the lower Yu'anshan Formation (members 1-2), pass through a transitional interval into oxic conditions in the upper part of the Formation (member 4). In member 3, the interval bearing exceptionally-preserved fossils of the Chengjiang biota (~520 Ma), a prominent positive nitrogen isotope excursion occurs in both cores. This $\delta^{15}N$ excursion is noteworthy because it is indicative of extensive denitrification under oxygen-depleted conditions, and suggests that modern oxygen minimum-zone-like conditions were present. Results from Chengjiang suggest that the Cambrian radiation of the animals occurred in a relatively thin layer of shallow oxic waters that was sharply separated from toxic deep waters.

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