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Department of Marine Sciences
Presents a Seminar by

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With a little help of my friends (viruses and arsenic): Living in an anoxic world

The earliest evidence of life on our planet is captured in 3.7 billion-year old fossil stromatolites. These layered carbonate rocks formed through the lithification (precipitation of carbonate mineral) in microbial mats. Today, stromatolites and microbial mats still thrive in extreme environments. Arguably, they are the oldest and most resilient ecosystems we know.

Most contemporary microbial mats and stromatolites are dominated by cyanobacteria. These cyanobacteria "invented" oxygenic photosynthesis that lead to the Great Oxygenation Event 2.3 billion years ago. The lithification of microbial mats is due to the entire community metabolism including viruses, but the cyanobacteria (i.e., photosynthesis) play a critical role. The question arises how stromatolites formed during the first 1.5 billion years of their dominance on Earth, before oxygenic photosynthesis. Ferrous iron, hydrogen and sulfur can serve as electron donor for anoxygenic photosynthesis. However, evidence for this is lacking in the Archean record, and thermodynamic considerations also rule out some of these alternative electron donors.

We found evidence for arsenic metabolism in the 2.72 billion stromatolites (Tumbiana Formation, Pilbara, Western Australia). Submicrometer-size element maps indicated that not iron or sulfur but arsenic cycling was associated with organic carbon. Recently, we discovered a microbial mat system in the southern Atacama Desert that was thriving under early-Earth like conditions. In the permanent absence of oxygen, sulfur and arsenic cycling were coupled to calcium carbonate precipitation. Sulfide and arsenite oxidation were stimulated in the light and sulfate and arsenate reduction were major respiration pathways in these anoxic mats. Thermodynamic calculations show that arsenic cycling is energetically preferred over sulfur when both elements are present. Interestingly, arsenic cycling has a much greater potential to precipitate calcium carbonate, leading to more rapid stromatolite growth.

The distribution of different oxidation states of elements was mapped with a 30-nm resolution using a combination of X-ray fluorescence – XANES (X-ray absorption near-edge structure. The presence of both As(III) and As(V) in close proximity found in the Atacama mats could be the strongest line of evidence for arsenic cycling if also discovered in ancient stromatolites. The PIXL instrument on the Mars Perseverance rover uses a similar technique and perhaps will find evidence of extinct (or extant) arsenic-support life on the Red Planet.

Time & Date: 11:00 am, Friday, October 2, 2020

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