Microbial Nitrogen and Sulfur cycles at the Dune Field, White Sands National Monument (New Mexico)

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Sulfates, including gypsum, have been identified within dunes at the Olympia Undae and Meridiani Planum on Mars [e.g. 1, 3]. The origin of these deposits is still unknown, however, they were likely produced by a combination of hydrothermal processes and/or groundwater upwelling, and later weathered by eolian processes [3, 1]. The White Sands National Monument (WSNM) (New Mexico) contains one of the largest known gypsum dune fields on Earth and has been proposed as a geochemical analog to the gypsum rich dunes on Mars [4]. Our intention is to investigate the dune field (dune slopes and interdune areas) at the WSNM in order to detect different microbial habitats and to assess their ecological characteristics through identification of mineral assemblages, pigments, extractable nitrogen, and functional genes of the microbial communities.

The surfaces of the interdune areas show higher mineral diversity than the dunes. Additionally, most of the microbial mat was found ~ ½ cm beneath the surface at the interdune areas. Nitrogen concentrations from ammonium and nitrates indicate ongoing processes of nitrification in the surface layers of the interdunes. Additionally, the presence of purple non-sulfur bacteria capable of nitrogen fixation and archaea capable of ammonium oxidation (nitrification) implies that microbes do have the capacity to contribute to nitrogen cycling and the detected nitrification. The high groundwater table contributes to minor dissolution and re-precipitation of sulfates at the interdunes. Microbial consortia with andenosine-5'-phosphosulfate reductase enzyme (APS), genes characteristic for green non-sulfur bacteria (CFX) and purple phototrophic bacteria (pufM) detected in the surface layers of the interdune settings have the metabolic capacity to contribute to sulfur cycling through the reduction of sulfate, and the oxidation of sulfide to sulfur and then to sulfate.

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Trace elements in sulfides from Precambrian stromatolites and banded iron-formations

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The evolution of the marine biogeochemical cycles of transition metals (e.g. Ni, Co) has been modulated both by their supply to the oceans, and the evolutionary innovations in microbial metabolisms that utilize (d) these metals through time. For example, ferro-ferric-oxide phases in banded iron-formations (BIFs) appear to record secular decreases in molar Ni/Fe – and thereby declines in aqueous Ni concentrations – beginning around 2.7 Ga [1]. Subsequent major drops in Ni/Fe are coincident with later pO_2 rise recorded by multiple S isotopes at ca. 2.42 Ga [2, 3]. The Ni/Fe data have been used to support a model for severe limitation in aqeuous Ni availability to co-factors of several metalloenzymes central to methanogenesis. Such a 'Ni famine' [1] could have curtailed microbial methane production to the Paleoproterozoic atmosphere and effectively cut off a key O_2 sink. Although BIFs probably record ocean-scale trace metal contents, it is unclear what information they impart on the diversity of microbial communities that would have used Ni or Co and the changes to these communities with changing metal availability. It makes sense now to independently verify the BIF trace metal dataset derived from Fe-oxides [1] and extend such studies to metal sulfide minerals in BIFs as well as stromatolites in a more global sampling of the Precambrian oceans.

If BIF sulfides faithfully record trace metal concentrations in the ancient seawater column, sulfides in stromatolites ought to capture information about the organisms within the microbial stromatolite-building community at time of sedimentation. Furthermore, unlike relatively deep-water sedimentary facies such as BIFs and black shales, stromatolites are (for the most part) considered to be shallow-water sedimentologic features. The 'Ni famine' hypothesis requires suppression of methane production at the global scale. We report our comparative trace metal analyses (Ni & Co vs. Fe) of stromatolitic and BIF sulfides as a means to test the 'Ni famine' hypothesis and to explore its effects to both shelf- and deep-marine environments in the Precambrian.

[1] Konhauser *et al*. (2009) *Nature* **458**, 750–753. [2] Papineau *et al*. (2007) *EPSL* **255**, 188–212. [3] Guo, Q. *et al*. (2009) *Geology* **37**, 399–402.