Single Cell and Genomic Characterization of Cyanobacteria in Ancient Environment Analogues

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Cyanobacteria are photosynthetic microorganisms that have greatly changed Earth's geo- and biosphere through their release of oxygen to the environment. In ancient times, they likely inhabited a planet with quite different chemistry from the one we know today. However, growth differences between current, and potential ancient environments are largely uncharacterized. Here we describe phenotypic responses of freshwater cyanobacteria when exposed to potential paleo-environmental conditions on a single cell level, using stable isotope labeling techniques and secondary ion mass spectroscopy (SIMS). We quantified the phenotypic variation of single cells within populations of pure cultures under two distinct growth conditions. In the first condition a modern medium is used for incubation of cells, in the second condition nitrogen and sulfur are limited and the atmosphere exchanged to N2/CO2, to mimic environmental conditions potentially present at the beginning of the Proterozoic eon.
In addition to characterizing phenotypic heterogeneity in these two cases, we also explore the genetic potential of those cyanobacteria inhabiting modern iron-rich hot springs, which may serve as analogues for ancient environments. We are interested in the distribution of strains belonging to the genus Thermosynechococcus across varying geochemical settings, the genomic core within the genus and the genomic adaptations that are specific to high-iron concentrations. The genomic core within Thermosynechococcus is large when compared to the genomic core across different genera of cyanobacteria. Our analysis also shows that strains from high iron environments show no specific genetic adaptation to actively process iron. These results reinforce previous work that demonstrated that Thermosynechococcus are a cosmopolitan group of organisms, which are versatile in the environments which they can inhabit.
Through the characterization of the mechanisms that may have allowed cyanobacteria survival on early Earth, we are hoping to further deepen the understanding of their evolutionary context and the environmental changes they induced.

Keywords: Paleoenvironment, Cyanobacteria