# The effects of iron solubility and speciation on the survival and growth of cyanobacteria in $Fe^{2}$-organic rich Archean oxygen transition environments

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The bioavailablility of iron in the oceans through time has changed with the evolving redox state of Earth's oceans and atmosphere. Seawater prior to ca. 2.5 Ga was anoxic and ferruginous, with $Fe^{2+}$ reaching concentrations of up to several hundred micromolar during periods of hydrothermally-sourced, deep water upwelling [1]. The appearance of oxygenic photosynthesis, perhaps as early ca. 3.0 Ga [2], created unique challenges for microorganisms, including the production of Fe-potentiated reactive oxygen species. Additionally, dissolved $Fe^{2+}$ itself has been shown to be toxic to cyanobacteria [3]. However, microbial iron uptake is greatly dependent on its solibility and speciation in the water column, where the presence of dissolved organic material plays an important role. Geological evidence implies that organic ligands released into the water column from cell lysis may have been relatively abundant in the Precambrian prior to the evolution of eukaryotic zooplankton [4]. Here we test the effects of iron stress on the marine cyanobacterium *Synechococcus* sp. PCC 7002 under both microoxic (with iron as $Fe^{2+}$), and oxygenic (with iron as $Fe^{3+}$) conditions in the presence of EDTA, citrate and lysed cyanobacterial cells. Our results show that organically complexed $Fe^{3+}$ is also toxic to cyanobacteria, and may have played a role in so-called 'oxygen oases' [5] as a temporary pool of dissolved $Fe^{3+}$-ligand complexes in Archean seawater. By using a variety of quantitative geochemical and microbiological techniques, we can better understand the iron stress mechanisms that may have affected the evolution of early cyanobacteria.

[1] Holland (1984), *Princeton Uni. Press.* [2] Planavsky *et al.*, (2014) *Nat.Geosci.* **7**, 283-286. [3] Swanner *et al.*, (2015) *Nat.Geosci.* **8,** 126-130 [4] Logan *et al.*, (1995), *Nature* 6, 53-56. [5] Kasting (1991), *Global Planet. Change* **5**, 125-131.