Silica saved our earliest marine cyanobacteria

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Shallow marine environments have hosted photosynthetic microbial ecosystems since at least 3.5 Ga [1]. However, high incident UV radiation levels penetrating the ozoneless Archean atmosphere [2] and toxic iron concentrations in early seawater [3] should have made them inhospitable to life. We examine this issue in experiments with the marine planktonic cyanobacterium *Synechococcus* sp. 7002. Cultures were grown in simulated Archean seawater containing iron and silica concentrations predicted for Archean seawater [4] [5], and subsequently irradiated with UV-C fluxes set conservatively an order of magnitude higher than those predicted for the Archean (ref. 2). We show experimentally that high silica concentrations enabled early phototrophic prokaryotes to overcome these stresses. Silica facilitated the adaptation of early cyanobacteria to ferruginous conditions by reducing toxic levels of bioavailable iron through complexation of Fe(II) in the anoxic water column, and with organically chelated Fe(III) in locally oxygenated littoral zones. We show that the resulting Fe(III)-Si complexes and nanoparticles would have also acted as a 'sunscreen', effectively attenuating high levels of incoming UV-C radiation in the uppermost water column, while allowing the penetration of photosynthetically active radiation. The Fe-buffering capacity and UV protection afforded by these iron-silica complexes suspended in the ancient water column would have facilitated the survival and earliest microbial colonization of littoral and open marine photic zones.

[1] Hoffman et al (1999), *GSA Bulletin* **111**, 1256-1262. [2] Segura et al (2003), *Astrobiology* **3**, 689-708. [3] Swanner et al (2015), *Nature Geosciences* **8**, 126-130. [4] Maliva et al (2005), *GSA Bulletin* **117**, 835-845. [5] Czaja et al (2012) *Geochimica et cosmochimica Acta* **86**, 118-137.