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Morphotype disparity in the Precambrian

Rachael Moore (1,4), Joachim Reitner (2), Martin Braiser (3), Phil Donoghue (1), and Bettina Schirrmeister (1)

(1) Palaeobiology, School of Earth Sciences, University of Bristol, UK, (2) Department of Geobiology, Centre for Geosciences, Faculty of Geosciences and Geography, Georg-August-University of Goettingen, Germany, (3) Department of Earth Sciences, University of Oxford, UK, (4) Insitut de Physique du Globe de Paris, France

Prokaryotes have dominated life on Earth for over 2 billion years. Throughout the Precambrian, prokaryotes acted as the major biological impetus for both large and small scale environmental changes. Yet, very little is known about the composition, diversity and evolution of ancient microbial communities due to poor preservation during the Precambrian period. Previous studies of fossils that date to this period relied mainly on light microscopy to identify microfossil morphology and abundance, with limited success. Here we present novel analyses of the microbial remains found in Precambrian stromatolites using Synchrotron Radiation x-Ray Tomographic Microscopy (SRXTM). Microfossils found in samples of three Precambrian deposits, 3.45 Ga Strelley Pool, Australia, 2.1 Ga Gunflint Chert, Canada, and 650 Ma Rasthof Cap Carbonate, Namibia, have been reconstructed in 3D. Based on four scans from each sample, we estimated size and abundance of spheroidal microfossils within those deposits. Our findings show that while cell abundance decreased towards the end of the Precambrian, the biovolume of microfossils within the host rock remained relatively constant. Additionally, both size and disparity increase through time. Constant biovolumes and yet different sizes for these three deposits, point towards a negative correlation of large cell size and cell abundance. This negative correlation indicates that the systems in which these prokaryotes lived may have been biolimited. Both, gas exchange and nutrient uptake in prokaryotes function via diffusion. Therefore, one would expect bacteria to evolve towards an increasing surface to volume ratio. Increased cell sizes, and hence decreased overall surface to volume ratio observed in our data, suggest the influence of other selective factors. Decreased abundance and increased cell size could potentially be associated to changes in nutrient availability and the occurrence of predation. As cells increased in size, more nutrients would be required, which could have a limiting effect on abundance. Additionally, eukaryotes start appearing in the fossil record around 1.6 Ga, with the origin of grazing predators within the Mesoproterozoic. Predation has been suggested to be an important driver for morphological change in bacteria, before. Preservational bias towards larger microfossils, in combination with smaller prokaryotes having been predated on by grazers, this could explain lower appearance of small microfossils in the late Precambrian. Analyses of more localities would be helpful to strengthen conclusions on causes and consequences of microbial size evolution during the Precambrian. Furthermore, analyses of more recently fossilized microbial communities, such as those found in modern stromatolites, could provide valuable information to examine the influence environmental factors have on cell size and abundance. Yet, our results, support earlier hypotheses that suggest a decline in prokaryotic preservation due to the appearance and success of eukaryotes and eukaryotic grazers at the end of the Precambrian.