

Prokaryote dominated biological pump delayed animal evolution

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Animal evolution requires the atmospheric pO₂ level reached the threshold of 10% present atmospheric level (PAL). Geological and geochemical data indicate that the emergence of animals was coincident with the second rise of atmospheric pO₂ level in Neoproterozoic, i.e. the Neoproterozoic Oxidation Event or NOE. It is proposed that evolution of eukaryotic phytoplanktons might be the major cause of NOE. The earliest eukaryote could be traced back to 1.7 billion years ago (Ga), and the diversity of eukaryote continuously increased. However, biomarker evidence shows that a prokaryote-dominated biological pump might have persisted until the interglacial interval (660-650 Ma) between the Sturtian and Marinoan snowball Earth events.

To explore why the prokaryote-dominated biological pump has protracted and why the increase of atmospheric pO₂ level has been delayed for more than 1 billion years, here we developed a one-dimensional biogeochemical model to simulate how the composition of biological pump would impact atmospheric pO₂ level and marine redox landscape. The modeling result indicates that a prokaryote-dominated biological pump is bound to generate oceanic anoxia and euxinia and low atmospheric pO₂ level, while a eukaryote-prokaryote biological pump that is similar to today is bound to cause oceanic oxidation and to rise atmospheric pO₂ level to the present level. Development of oceanic euxinia in a prokaryote-dominated biological pump would limit the metals (e.g. Mo and Cu) that are essential for eukaryote to fix nitrogen, preventing eukaryote involved into the biological pump. In other word, prokaryote locked the biological pump, i.e. the prokaryote self-locking, resulting in the delay of atmospheric oxygenation and the evolution of animal. The self-locking was not broken until the snowball Earth event devastating the whole biological pump and terminating the oceanic euxinia. In the following recovery from the snowball Earth event, eukayrote out-competed prokaryote and accordingly a modern style eukayrote-prokaryote biological pump was established, leading to the evolution of animals.