Low dissolved phosphorus content in the Mesoarchean ocean limited oxygenic photosynthesis

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Oxygenic photosynthesis is the biological pathway of free molecular oxygen (O_2) production, and a growing number of (bio)geochemical studies place the origin of this metabolism to at least the Mesoarchean when shallow-marine "oxygen oases" episodically developed. However, the magnitude and extent of surface ocean oxygen oases and microbial communities inhibiting otherwise anoxic Archean oceans are not well constrained. The rate of O_2 production is thought to be mainly dependent on the bioavailability of nitrogen (N) and phosphorus (P), but the role of dissolved P and its concentration in the Archean oceans remain controversial.

Here, we will present C and N isotope data coupled to water column redox proxies for the ~2.95 Ga Mozaan Group, Pongola Supergroup (South Africa), which records the existence of a Mesoarchean "oxygen oasis" [1-4]. Our data show that oxygenic photosynthetic and Mo-based diazotrophic bacteria coexisted in Pongola Basin surface waters ~2.95 Ga ago, and yet $\delta^{15}N$ values clustering around 0‰ (Air-N_2) are inconsistent with a significant aerobic nitrogen cycle. We thus propose that in contrast to the Neoarchean, dissolved O_2 levels in the Mesoarchean oceans were too low to develop a large and stable nitrate reservoir [2]. Low concentrations of bioavailable phosphorus, rather than nitrogen, seem to have suppressed the growth and expansion of oxygenic photosynthesizers and may explain why pervasive and permanent oxygenation was delayed until the early Paleoproterozoic.

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