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Archean carbonates and oxygen-rich oasis: implications for ancient life on Mars

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Carbonate-rich lakes are considered plausible environments for the origin of life on Earth [1]. Precipitation of carbonate minerals in aqueous environments is stimulated by high alkalinity conditions, frequently driven by autotrophic photosynthesis. However, in the anoxic and dominantly iron-rich (ferruginous) Archean oceans, the precipitation of carbonate minerals would have been largely controlled by dissolved ferrous iron (Fe^{2+}) removal. In this study, iron and phosphorus speciation on samples from shallow and deep facies of the oldest carbonate platform on Earth (2.94 Ga, Red Lake, Canada) seek to constrain the chemistry that favoured carbonate precipitation in the Archean.

Preliminary results suggest a dynamic Fe cycling between ferruginous conditions and short-lived episodes of oxygenated waters that likely developed oxygen-rich oases in protected shallow areas. In turn, oxygen produced by cyanobacterial photosynthesis would have facilitated carbonate precipitation through the oxidative removal of Fe^{2+}. However, little is known about the nutrient (N and P) availability and cycling that led to the emergence and diversification of these photosynthetic organisms. In this regard, we additionally explore the role of P cycling as the limiting factor for primary productivity and remineralisation of organic P by sulfate-reducing bacteria as the primary source of P.

Carbonates are abundant on Earth but scarce on Mars [2]. If carbonate-rich environments might have been cradles of life on Earth, life on Mars could have been limited to the few areas where carbonates have been detected. One of these areas is in the Jezero crater, where the rover Perseverance is searching for signs of ancient life. Like early Earth, a global acidic hydrosphere was likely dominant on early Mars [3]. Whether carbonates on Mars could have a microbial or abiotic origin is a key question in astrobiology. Therefore, the reconstruction of the redox environmental conditions of the oldest carbonate platform on Earth may shed light on the drivers that facilitated carbonate precipitation on Mars.

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[2] Bultel et al. (2019), *J. Geophys. Res. Planets* **124**, 989–1007.

[3] Greenwood & Blake (2006), *Geology* **34**, 953–956.