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Upgrades in the framework of nitrogen isotopes interpretation in Archean sedimentary rocks

ALICE PELLERIN[1], MAGALI ADER[2] AND DR. CHRISTOPHE THOMAZO[1,3]

[1]Laboratoire Biogéosciences, UMR CNRS 6282, Université de Bourgogne, France

[2]Université Paris Cité, Institut de Physique du Globe de Paris, CNRS, Paris, France

[3]Institut Universitaire de France (IUF)

Presenting Author: alice.pellerin-lefebvre@u-bourgogne.fr

The nitrogen isotopic signature preserved in sedimentary rocks has become one of the standard tools for investigating redox changes in the ocean associated with the evolution of the biosphere. Indeed, nitrogen is both a nutrient directly limiting biological productivity and a redox tracer taking part in redox-dependent biological pathways. Specifically, it has largely been used to uncover the evolution of the biogeochemical nitrogen cycle and interpreted as showing a rise of oceanic oxidants in the Neoarchean, well before the Great Oxidation Event (GOE), followed by the progressive stabilization of a persistent nitrate reservoir. Yet, the Precambrian $\delta^{15}N$ record does not clearly show significant changes across the GOE (Fig. 1).

Confronting 3 chosen case studies spanning the Archean period (the 3.4 Ga Buck Reef Chert Formation, the 2.68 Ga Serra Sul Formation and the 2.55 Ga Malmani Formation), this communication will highlight the strengths and limits of using sedimentary $\delta^{15}N$ data as an oxygenation tracer, as well as the crucial need for context while interpreting them.

The 3.4 Ga Buck Reef Chert Formation, South Africa, draws attention to possible interactions between the iron and nitrogen cycles in anoxic and ferruginous conditions, which are relevant to most of the Paleoarchean. $\delta^{15}N$ results for this formation invite to carefully consider the meaning of positive nitrogen isotopic signatures in Paleoarchean sediments, which do not necessarily indicate the presence of nitrate.

The extremely positive $\delta^{15}N$ values from the 2.68 Ga Serra Sul Formation, Brazil, together with comparable data from the Pilbara Craton, Australia, may reveal a rise of oceanic oxidants 300 Ma before the GOE. Whether these oceanic redox changes were widespread or rather developed locally/regionally due to specific chemical conditions or depositional configuration will be discussed.

Finally, the $\delta^{15}N$ values close to 0‰ recorded in the 2.5 Ga stromatolitic dolostone of the Malmani Formation, South Africa, invite us to reflect on the reason why, despite the presence of undisputed photosynthetic microbial remains and a $\delta^{13}C_{org}$ signature compatible with the development of an aerobic biosphere, the oxidative part of the nitrogen cycle is not expressed in the sedimentary rock record.