A QUANTITATIVE FRAMEWORK FOR THE INTERPRETATION OF NITROGEN ISOTOPE DATA IN ANCIENT MARINE SEDIMENTARY ROCKS. M. A. Kipp[1,2], E. E. Stüeken[2,3], R. Buick[1,2], and A. Bekker[4]. [1]Department of Earth & Space Sciences and Astrobiology Program, University of Washington, Seattle, WA 98195, [2]NASA Astrobiology Institute – Virtual Planetary Laboratory, Seattle, WA 98195, [3]Department of Earth & Environmental Sciences, University of St. Andrews, St. Andrews, Scotland, UK KY16 9AL, [4]Department of Earth Sciences, University of California, Riverside, CA 92521

Introduction: Nitrogen is an essential nutrient for all life on Earth, and is the proximally limiting nutrient in the modern ocean [1]. Only some groups of Bacteria and Archaea are able to fix N_2 from the atmosphere, leaving the majority of organisms – including all eukaryotes – dependent on a supply of dissolved nitrogen species in the environment. The balance between these two groups of organisms (nitrogen-fixers vs. nitrogen-assimilators) appears to be regulated in the modern ocean by competition-driven feedbacks [1], and results in a system that is phosphorus-limited on geologic timescales, with proximal nitrogen limitation. The nitrogen isotope record suggests that the bioavailability of dissolved nitrogen species, in particular nitrate (NO_3^-), has changed over the course of Earth's history [2]; however, quantitative assessments and linkages to global redox conditions are so far lacking.

Here we consider potential differences in the structure of the marine nitrogen cycle during the Precambrian [2, 3], and model the implications for the prevalence of nitrogen-fixing vs. nitrogen-assimilating organisms, as well as the implications for the sedimentary nitrogen isotope record. We then turn to the Precambrian nitrogen isotope record, and quantitatively assess the prevalence of nitrogen-fixing organisms at different stages in geologic history. We present new nitrogen isotopic data from Paleoproterozoic facies to evaluate the response of the nitrogen cycle to the proposed interval of "oxygen overshoot" [4]. Our results highlight the heterogeneous distribution of fixed nitrogen species in the Precambrian ocean across space and time, and stress the importance of nitrogen fixation for Earth's early biosphere. The evolution of the nitrogen cycle as controlled by redox and productivity changes likely played a significant role in the evolution of microbial ecosystems and the delayed emergence of eukaryotic life.

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