Nitrogen isotope evidence of variable nutrient sources for life over Earth history

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Interpretations of nitrogen cycling on the early Earth are based on our understanding of the modern nitrogen cycle, and on information recorded in the δ15N values of ancient sediments. The nitrogen cycle is driven largely by biological processes, which produce measurable changes in the ratios of N isotopes ([δ15N = ([15N/14N]sample/[15N/14N]air − 1) x 1000, in ‰] in the associated compounds. These nitrogen compounds can be preserved in the rock record, as organic N or as ammonium incorporated into clays. We have assembled a compilation of δ15N data (from extracted organic N and bulk rock N) from well-preserved sediments spanning Earth’s first major rise in global atmospheric oxygen (the Great Oxidation Event, GOE). Our results suggest a change in dominant nitrogen sources for marine primary productivity, from a large pool of deep-water bioavailable ammonium formed in association with the pre-GOE expansion of oxygenic photosynthesis, through ventilation of the surface oceans and widespread nitrate availability during the GOE (1). The individual records, however, indicate spatial segregation of N cycling pathways, suggesting that depositional facies are critical in assessing the distribution of marine nutrient sources even early in Earth history.