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North Atlantic N_2 Fixation during the Pliocene-Pleistocene Transition

MAAYAN YEHUDAI[1], JESSE R FARMER[2], MARIETTA STRAUB[3], RALF SCHIEBEL[4], ALEXANDRA AUDERSET[5], KIRA LAWRENCE[6], DANIEL M. SIGMAN[7], ANJA S STUDER[8], NAZIK OGRETMEN[9], GERALD H. HAUG[4] AND ALFREDO MARTINEZ-GARCIA[4]

[1]Max-Planck Institute for Chemistry
[2]University of Massachusetts Boston
[3]Institute of Radiation Physics, Lausanne University Hospital and University of Lausanne
[4]Max Planck Institute for Chemistry
[5]School of Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton
[6]Lafayette College
[7]Princeton University
[8]University of Basel
[9]Institute of Earth Sciences, Istanbul Technical University

Presenting Author: m.yehudai@mpic.de

N_2 fixation is the primary pathway by which bioavailable nitrogen is added to the oceans. However, the climate and oceanographic drivers of N_2 fixation on orbital timescales are uncertain. Here we investigate the evolution of N_2 fixation throughout the Pliocene-Pleistocene (PP) transition (~3.60 to ~1.97 Ma) with a new N_2 fixation record reconstructed from the analysis of foraminifera-bound $\delta^{15}N$ in the tropical North Atlantic (ODP Site 999). Our results show that, compared to interglacials of the past 160 ka, N_2 fixation was significantly lower throughout the PP transition as reflected by an average of ~2.5 ‰ higher $\delta^{15}N$ values. A possible explanation to the observed higher Plio-Pleistocene $\delta^{15}N$ values could be lower levels of global denitrification that were balanced by lower global N_2 fixation levels. In addition, we observe an increase in the dominance of obliquity and eccentricity frequencies in $\delta^{15}N$ after ~2.7 Ma, coinciding with the intensification of the Northern Hemispheric glaciation and the onset of equatorial upwelling pulses documented during Pleistocene glacial periods in the Eastern Equatorial Atlantic (ODP Site 662; Lawrence et al., 2013) Observed changes in N_2 fixation derived from foraminifera bound $\delta^{15}N$ of the last 160 Ka were explained in previous studies by precession-paced upwelling in the eastern equatorial Atlantic that imported excess P into the oligotrophic Western Tropical Atlantic (*2*). However, precessional cyclicity is not dominant in the new Plio-Pleistocene $\delta^{15}N$ data, which calls for other candidates to explain the $\delta^{15}N$ variations of the early Pleistocene. We propose several mechanisms to explain the early Pleistocene orbitally paced variations in $\delta^{15}N$, including changes in nutrient utilization in the Southern and Equatorial Atlantic, glacial-interglacial sea level changes and global orbitally-paced changes in denitrification.

1. K. T. Lawrence *et al.*, Time-transgressive North Atlantic productivity changes upon Northern Hemisphere glaciation. *Paleoceanography*. **28**, 740–751 (2013).
2. M. Straub *et al.*, Changes in North Atlantic nitrogen fixation controlled by ocean circulation. *Nature*. **501**, 200–203 (2013).