Relationship of nitrogen isotope fractionation to phytoplankton size and iron availability during the Southern Ocean Iron RElease Experiment (SOIREE)

Karsh, K. L., T. W. Trull, M. J. Lourey, D. M. Sigman

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ABSTRACT: The ^{15}N composition of sediments has been used as a proxy for nitrate utilization in surface waters to assess the role of Southern Ocean export production in glacial/interglacial changes in atmospheric CO_2 concentration. Interpretation has relied on a temporally constant isotope effect (ε) associated with uptake and assimilation of nitrate by phytoplankton. To investigate the reliability of this approach, we examined the relationships between the ^{15}N compositions of dissolved nitrate, bulk and size-fractionated (200, 70, 20, 5, 1 μm) suspended particulate organic nitrogen (PON), and sinking particles obtained from sediment traps during the Southern Ocean iron release experiment (SOIREE). We found variations in phytoplankton nitrogen isotopic compositions with both cell size and iron availability. $\delta^{15}N_{PON}$ increased by >2‰ with increasing size, both within and outside the ironenriched patch. In comparison to unfertilized waters, $\delta^{15}N_{PON}$ within the iron-fertilized patch was a further 3-4‰ higher in those size fractions dominated by large diatoms (20-70, 70-200 μm). We speculate that this iron response might result from (1) variation in ε of nitrate utilization or (2) an iron-stimulated shift from ammoniumba-sed to nitrate-based production. Comparing the $\delta^{15}N$ of the large diatom-dominated size fractions to the $\delta^{15}N$ of nitrate suggests relatively low ε values of 4-5‰, in contrast to estimated values of 7-10‰ from seasonal nitrate depletion and export production. This suggests that higher glacial $\delta^{15}N$ in Southern Ocean sediments could, in part, reflect increases in iron availability, dominant cell size, and possibly growth rates, and these effects must be considered in any quantitative scaling of $\delta^{15}N$ variations, including those of diatom-bound $\delta^{15}N$, to the extent of nitrate utilization.