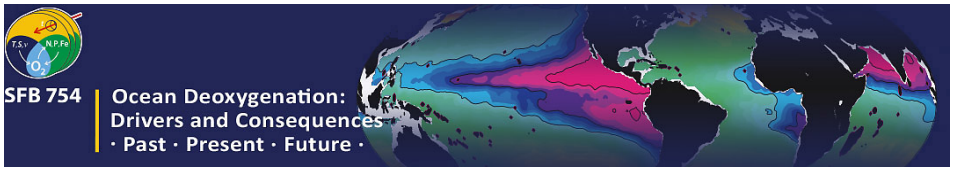

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A quantitative nitrate reconstruction over the last 22,000 years in the intermediate Pacific based on the pore density of the denitrifying foraminifera Bolivina spissa

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Anthropogenic impacts are perturbing the global nitrogen cycle via warming effects and pollutant sources such as chemical fertilizers and burning of fossil fuels. Nitrate is one of the main limiting nutrients in the modern ocean and nitrate fertilization might contribute to the ongoing ocean deoxygenation. The quantitative reconstruction of past reactive nitrogen inventories is indispensable to facilitate future projections for biogeochemical cycling. Benthic foraminifera from oxygen depleted habitats are a rare example of eukaryotes with the ability to perform denitrification. The uptake of nitrate for denitrification is most probably facilitated through the pores within the foraminiferal shell and the pore density can be used as a quantitative proxy for past nitrate concentrations. Here we present the quantitative reconstruction of nitrate concentrations in intermediate water depths of the Peruvian oxygen minimum zone over the last deglaciation using the pore density of *Bolivina spissa*.

Deglacial nitrate concentrations correlate significantly with the downcore stable carbon isotope (δ13C) record which indicates a strong coupling between the carbon and nitrogen cycles over the last deglaciation. The linear correlation between δ13C and nitrate availability remained stable over the last 22,000 years, facilitating the use of δ13C records as a quantitative nitrate proxy. The combination of the pore density record with δ13C records shows an elevated oceanic nitrate inventory of >10% during the Last Glacial Maximum as compared to the Holocene. Our novel proxy approach is consistent with a δ13C-based and δ15N-based 3D ocean biogeochemical model and previous box modeling. The modeling results also indicate that the correlation between δ13C and nitrate, probably facilitated by remineralization, did not differ significantly between the Last Glacial Maximum and the Pre-Industrial Holocene. The coupling of nitrate and δ13C thus provides sound estimates of the spatial nitrate distribution in the intermediate Pacific from the Last Glacial Maximum until the Holocene.

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