Late-Quaternary history of denitrification in the eastern tropical North Pacific: Evidence from sedimentary $^{15}N/^{14}N$ ratios

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Introduction

The eastern tropical North Pacific Ocean (ETNP) contains a pool of oxygen-deficient waters adjacent to the productive Central American Coast (Richards, 1971). In these waters denitrification is the predominant biological respiration process, especially near the continent, where waters with near-zero oxygen concentrations extend from 100 to 800 metres depth (Codispoti, 1973). Cline and Kaplan (1975) have shown that the nitrate in these waters is enriched in ^{15}N due to the preferential loss of $^{14}NO3-$ during denitrification. Saino and Hattori (1987) attributed the high $\delta^{15}N$ values of the suspended POM they have observed in eastern North Pacific to the supply of this ^{15}N-enriched nitrate above the thermocline. Liu and Kaplan (1989) observed that $\delta^{15}N$ values of surface sediments deposited under oxygen-deficient eastern Pacific waters have higher $\delta^{15}N$ values than western Pacific and suggested the use of sedimentary-$\delta^{15}N$ values as a denitrification proxy.

Our study is an attempt to reconstruct the history the ETNP oxygen-deficient water mass using nitrogen isotope measurements on bulk sediments in concert with $\delta^{13}C$ of organic matter, $\delta^{18}O$ and $\delta^{13}C$ of benthic foraminifera, AMS ^{14}C dates, and solid-phase chemical measurements.

Results

Three high quality piston cores were collected from the Mexican continental slope, southwest of Mazatlan, where the the oxygen minimum of the ETNP impinges on the continent. The core were raised from 420 m (within the oxygen minimum), 1018 m (base of the oxygen minimum) and 2025 m (below minimum, in oxygenated deep water) depths. Detail records from all the three cores show an abrupt change from organic carbon-poor glacial age sediments to carbon-rich Holocene deposits. This shift is generally matched by an increase in $\delta^{15}N$ and biogenic opal values. The Holocene sections from the 420 m and 1018 m cores are laminated and the glacial sections in all three cores are homogeneous. Mass accumulation rate calculations confirm that the carbon distribution is not an artifact of dilution by other sedimentary components. The $\delta^{13}C_{organic}$ values and $C_{organic}/N_{total}$ ratios indicate that the organic matter is primarily marine, rather than terrestrial. Despite large changes in carbon, opal and $\delta^{15}N$ values, the epibenthic *Cibicidoides* $\delta^{13}C$ record shows only a modest change between the glacial and Holocene sediments.

Discussion

Today, the ETNP off the Mexican Margin is an area of high upwelling-driven primary production and large water-column biogenic fluxes which results in the development of an intense oxygen-minimum zone and the accumulation of carbon and opal-rich laminated sediments. The heavy $\delta^{15}N$ values of the Holocene sediments (ranging from 9.5 to 10.5 ‰) reflect upwelling of nitrate that is ^{15}N-enriched due to denitrification. The decrease in organic carbon and opal contents, and the lack of laminations in the glacial-age deposits argue for a decrease in productivity and in the supply of organic detritus to the ocean floor resulting in an weaker oxygen minimum. Such a scenario is consistent with the relatively lighter $\delta^{15}N$ values (ranging from 8 to 9 ‰) of glacial-age sediments. However, the almost invariant benthic $\delta^{13}C$ record does not reflect the glacial-interglacial variations in the flux of organic detritus to the ocean floor.

Conclusion

The oxygen-minimum zone of ETNP was probably much reduced in its intensity and extent during the Last Glacial Maximum. Such a reduction is probably a result of the decreased organic production and flux on the adjacent continental margins.

References

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