Using nitrogen cycle proxies to determine paleoenvironmental variables

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Nitrogen is primarily controlled by the oxidation state of the environment via a series of biological reactions. As a result, changes in the environmental redox state will be reflected by changes in the nitrogen cycle, which can be evaluated over a wide range of time scales using proxies such as sedimentary δ^{15}N and deep-water N:P ratios.

We have developed a theoretical model illustrating the relationship between sedimentary δ^{15}N values and deep-water O_2 concentration, reflecting the relative contributions of nitrogen fixation, nitrification, and denitrification reactions under various redox conditions. This model can be used to interpret changes in paleo-redox conditions based on the bulk δ^{15}N profiles measured in sedimentary cores, but can also reflect the relative predominance of certain microbially-mediated reactions. We have also evaluated present-day systems and determined that deep-water N:P ratios are not only set by the elemental ratios of the remineralized organic matter but also by the deep-water oxygen concentration and basin surface area. This, combined with the relationship between δ^{15}N and O_2, may allow us to infer historical N:P ratios for any aqueous environment, connecting the oxidation state of the environment to biological productivity and nutrient cycling. Previously reported compound-specific δ^{15}N values measured in sedimentary-derived porphyrins [1-3] provide additional detail regarding paleoceanographic processes and organisms controlling the nitrogen cycle, allowing further interpretation of sedimentary δ^{15}N measurements.

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Decomposition-induced changes in soil organic matter composition

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On a global basis, 470 Gigatons of carbon are contained in boreal forest soils, which is close to 25% of the total carbon present in all the Earth's vegetation and soils. Yet very little is known about the exact nature and decomposition pathways of organic matter in these soils. Objectives of this study were to examine the effects of environmental conditions (vegetation, climate) and disturbance (fire, harvesting) on 1) soil organic matter composition, and 2) decomposition-induced changes in composition from a range of boreal forest and peatland ecosystems typically found in Canada.

Forest floor and peat samples (0-10 cm) obtained from 17 sites located from New Brunswick to British Columbia were incubated for one year at 10°C. Organic matter composition in pre- and post-incubation samples was characterized by solid-state ^{13}C NMR using ramped-cross-polarization (RAMP-CP) on a Bruker Avance 400 spectrometer.

NMR results revealed significant differences among vegetation types regardless of disturbance and climate at the sampling location. The percentage of carbon mineralized during incubation ranged from 1 to 24%. Decomposition-induced changes in carbon chemistry included an overall decrease in carbohydrate concentrations, but significantly differed among vegetation types. In particular, samples from the Jack pine and Douglas fir stands, which had the highest carbon mineralization rates, showed a significantly greater increase in aromatic, phenolic, and carbonyl carbons.