12.740 Paleoceanography
Spring 2008

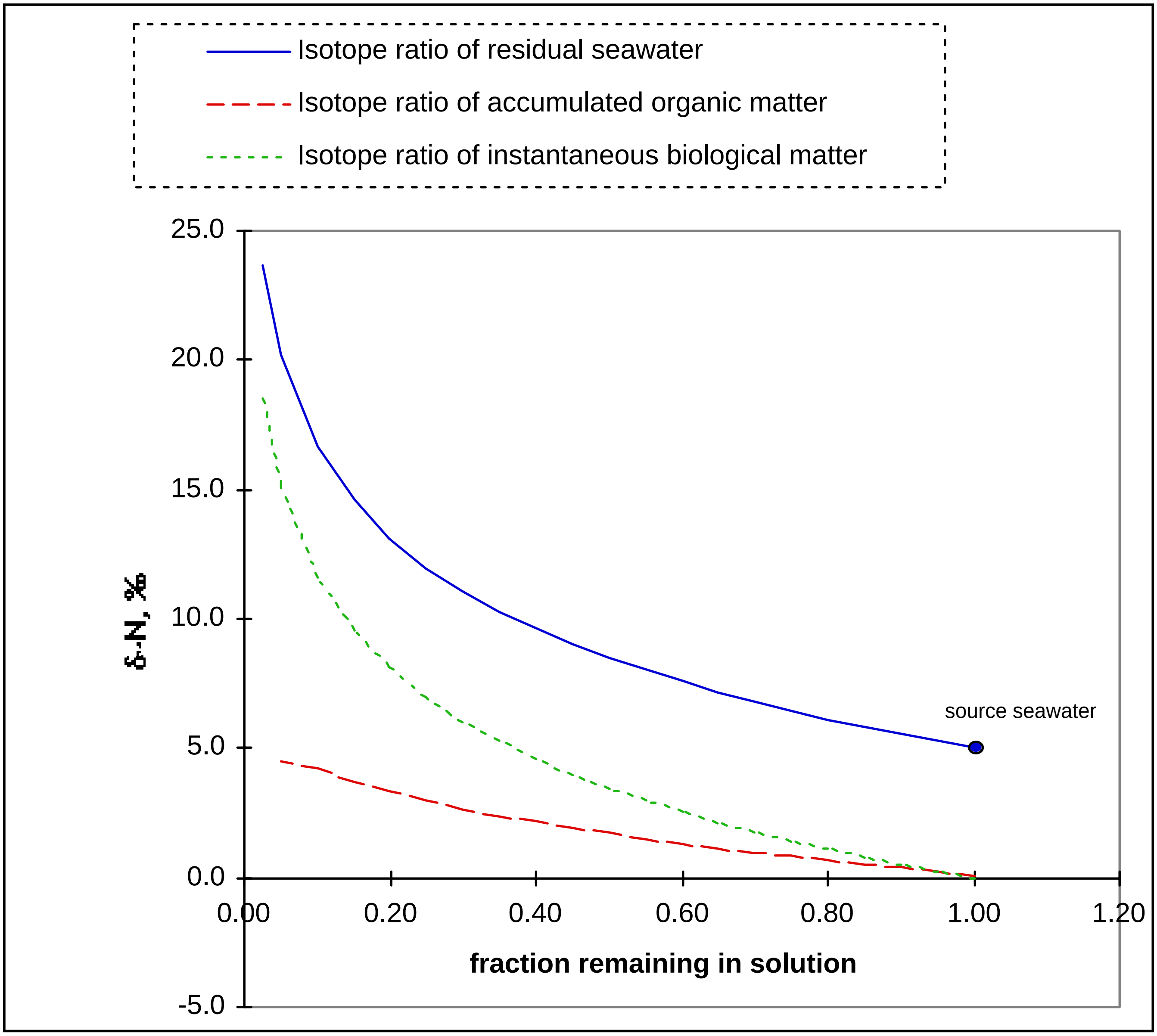
Other Tracers

I. Paleoproductivity and related issues

A. Organic carbon preservation: preserved organic carbon is only 1-2% of new production flux. If the fraction preserved is constant, then the accumulation rate of organic carbon is a measure of changes in new production. BUT…

B. Barium: sinking organic matter is enriched in Ba, with a (roughly) constant Ba:org C ratio. Ba is preserved in sediments as $BaSO_4$ to a much higher extent than organic carbon (up to 40%). Then it might serve as a better-preserved paleoproductivity indicator. Selective extraction of barite (denser than most other mineral phases…) provides a complement to bulk Ba, as well as a carrier phase for other elements (Ra, Sr, etc.)

C. Nitrogen Isotopes and "nutrient utilization efficiency". Phytoplankton preferentially take up $^{14}NO_3^-$ (by about 5‰). Uptake in a closed system proceeds according to Rayleigh distillation, with progressive enrichment of ^{15}N in the photosynthetic product. In a high productivity environment with low nitrogen utilization efficiency, $\delta^{15}N$ of the photosynthetic product is depleted relative to seawater $\delta^{15}N$ by about 5‰. In an oligotrophic environment "what goes up comes down", so the isotopic composition of the integrated photosynthate is the same as in the upwelling NO_3^-. Although there is significant further isotopic shifts on sinking particulate matter and during diagenetic transformation on the seafloor, the bulk organic matter reflects trends in nitrogen utilization in surface waters.



D. Pa/Th: production ratio (atoms) = 24.5 (0.093 activity ratio). Because Th is scavenged more readily by falling particulate matter (res. time 20-60 yrs), Pa (res. time 200-500 yrs) tends to migrate to sites of high productivity, resulting in higher Pa/Th ratios in sediments under high productivity areas. Complication: deep water movements are also a factor; high-production sites within a basin compete with each other.

II. Boron isotope paleo-pH: fractionation of $\delta^{11}B$ due to isotopic fractionation between $B(OH)_3$ and $B(OH)_4^-$

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Source: Honisch et al. (2005).

III. $\delta^{13}C$ of organic matter: paleo p_{CO2} or what?: The Rubisco enzymatic pathway can be limited by available free CO_2 within a cell. As aqueous CO_2 becomes limiting, the isotopic composition of organic matter becomes more limited by transport into the cell, hence shifting the isotopic composition towards that of the free aqueous CO_2. One complication in using bulk organic matter as such a tracer is that different compounds have different $\delta^{13}C$ compositions; this effect can be minimized by using single-compound $\delta^{13}C$. Another complication: there is also a clear cell size/growth rate effect as well as an external aqueous CO_2 effect.

IV. Silica tracers: $\delta^{18}0$, $\delta^{13}C$, $\delta^{15}N$, Ge/Si, $\delta^{30}Si$

V. Isotopic-faunal paleosalinities

VII. Dinoflagellates as biotic tracers

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