QUANTITATIVE ASSESSMENT FOR PARTICLE FLUXES: A LINKAGE BETWEEN MODERN OCEANS AND PALEOENVIRONMENTS

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Particle fluxes using sediment traps have been seriously studied for various microfossil groups in the past decade. We have accumulated substantial amounts of information pertinent to properly interpret the past environments. Characterization of productivity signals in present-day particle fluxes can be significant when it is applied to calculate past productivity levels. A match between fidelity productivity signal and good preservation in a given species is a prerequisite for such a conversion Since the majority of biogenic silica production is lost due to dissolution mainly at the sea floor and only a minute fraction can be preserved in the fossil record, such a task cannot always be fulfilled. However, when the productivity signal is in solution-resistant taxa such a conversion can materialize. *Denticulopsis seminae*, a pennate diatom taxon, widely occurs in the high latitude North Pacific. It is clearly a productivity and dominant diatom species with relatively good preservation in the fossil record at least in the northeastern Pacific. Quantitative interpretation of paleoproductivity levels will be demonstrated using the flux information of the productivity tracer species.

DISTRIBUTION OF $\delta^{13}C_{\Sigma CO2}$ AND TRACE METALS IN THE OCEAN: IMPLICATIONS FOR BENTHIC $\delta^{13}C$ AND Cd/Ca RECORDS AS PROXIES FOR INTERMEDIATE-DEPTH NUTRIENT CYCLING AND THE ATMOSPHERE'S PALEOCHEMISTRY

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Continuous accumulation of $^{12}C_{\Sigma CO2}$, Cd and biologically cycled nutrients below the pycnocline stabilizes the deep-ocean (σ_θ >27.7) tracer-nutrient fields, thus leading to monotonic $\delta^{13}C_{\Sigma CO2}$-$PO_4$ and Cd-PO_4 relationships. In the upper ocean ($26.8 < \sigma_\theta < 27.7$), however, these relationships vary as a function of nutrient extraction, Cd- and $\delta^{13}C_{\Sigma CO2}$-cycling in the euphotic layer, vertical exchange, and ocean-atmosphere gas exchange. Data collected during the GEOSECS program in intermediate and deep water outcrop areas shows that PO_4 intercepts (*i.e.*, preformed PO_4) in the tracer-nutrient relationships may vary from ±0 µmol kg^{-1} for the oligotrophic North Atlantic to >1.3 µmol kg^{-1} for the Southern Ocean. That is, while the Cd- and $\delta^{13}C_{\Sigma CO2}$ "clocks" are reset to their starting values before surface waters enter the convection-advection pathway, PO_4 concentrations may vary significantly thus resulting in marked variations of the tracer-nutrient regression slopes. Dominant factors in defining the $\Delta\delta^{13}C : \Delta PO_4$ and $\Delta Cd : \Delta PO_4$ slopes are: (1) efficiency of the marine biota to exhaust nutrients in the surface layer, (2) rate of biotic $^{12}C_{org}$- and Cd-fixation, (3) ^{12}C-distillation from the surface ocean to the atmosphere, and (4) rate and depth at which tracers and nutrients are recycled.

The effects that differential uptake of cadmium and phosphate in polar surface waters may have on their relative distribution throughout the ocean are illustrated with a 13-box model. In this model, the advective component of the surface water source is estuarine in Antarctic waters and anti-estuarine in the North Atlantic. Because of this, the effects of preformed Cd in each of these regions on the Cd-PO_4 pattern are very different. Decreasing the preformed Cd concentration in the North Atlantic has virtually no effect on the Cd distribution elsewhere in the ocean. By contrast, low preformed Cd in Antarctic waters produces a significant alteration to what would otherwise be a simple linear correlation of Cd and PO_4. In this region, more efficient biological uptake of Cd distills a greater fraction of the upwelling flux into Circumpolar Deep Water and leaves Antarctic Intermediate Water depleted relative to phosphate. As a result, there is a "kink" in the deep-water trend of Cd versus PO_4, with the Indo-Pacific having greater Cd/PO_4 ratios than Atlantic deep water. Intermediate waters, especially in the southern hemisphere, are predicted to have lower Cd/PO_4 ratios than deep waters. The distribution of Cd in Circumpolar and Indo-Pacific deep waters is expected to be more uniform than PO_4, and therefore weaker N-S horizontal Cd gradients in these waters should exist.

The observed deviation of the $\delta^{13}C$ - PO_4 regressions at intermediate depths in the "eutrophic" Southern Ocean (slope $\geq$ 1.5, std error=0.09, n=29) from the trend observed in the "oligotrophic" North Atlantic (slope $\leq$ 1.0, std error=0.09, n=83) suggests importance of air-sea exchange perhaps combined with varying rates of carbonate dissolution which adds to the ΣCO_2 pool and tends to steepen the slope at the high-nutrient end of the ocean $\Delta\delta^{13}C : \Delta PO_4$ distribution. Thus even though the mechanics that link $\delta^{13}C$ and Cd to PO_4 are different, in high-nutrient regimes both tracers show similar deviations from the mean-ocean tracer-nutrient relation in a way that they tend to underestimate nutrient concentrations. The observed variation of the $\Delta\delta^{13}C : \Delta PO_4$ and $\Delta Cd : \Delta PO_4$ relations as a function of the ocean's physical and biological regimes inevitably rises concern about the reliability of foraminiferal $\delta^{13}C$ and Cd/Ca ratios, especially at shallow-ocean core sites, as paleoceanographic proxies for reconstructing intermediate-depth nutrient levels and the atmosphere's chemistry.