Origin and evolution of dissolved inorganic phosphate $\delta^{18}O_P$ signatures

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The $^{18}O/^{16}O$ ratio ($\delta^{18}O_P$) of dissolved inorganic phosphate (DIP) has been increasingly applied toward tracing sources and cycling of phosphorus in aquatic, soil and marine environments due to several advances in methods of sampling and analysis over the past decade. Tracing of P along a flow path or mixing line, or tracing the evolution of DIP $\delta^{18}O_P$ within a water mass, requires knowledge of the starting/ source $\delta^{18}O_P$ value, which in the case of wastewater effluent and agricultural runoff, can be determined from direct measurement. For open marine environments and the deep ocean, however, the predominant source of DIP is surface-formed primary organic matter (i.e., biomass) or secondary biomass formed in the water column or pore waters, which have not yet been directly measured. In addition to knowledge of the isotopic composition of source DIP, interpretation of DIP $\delta^{18}O_P$ values has depended on comparisons of measured $\delta^{18}O_P$ values to an equilibrium endpoint , but with no quantitative measure of specific factors promoting equilibrium, or rates of evolution of $\delta^{18}O_P$ toward equilibrium. Furthermore, the equilibrium end point has typically been defined by empirically-derived equations describing the temperature dependence of presumed equilibrium O-isotope exchange between *bioapatite* and water, which could be different from that between *dissolved* phosphate and water. Here we present new data on direct measurement of $\delta^{18}O_P$ values of organically-bound and biomass -PO_4--the source of marine DIP, as well as new controlled laboratory–determined calibrations and rates of dissolved PO_4-water exchange coupled with rates of cellular respiration (*e.g.,* sulfate reduction), to begin to address the above mentioned issues and also further our insights into transformations of marine P based on measurement of $\delta^{18}O_P$ values of DIP.