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Sedimentary Phosphorus Dynamics in Diverse Marine Environments

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Phosphorus (P) is an essential nutrient for all living organisms. By regulating oceanic primary productivity, changes in P availability can influence organic carbon burial and atmospheric concentrations of carbon dioxide and oxygen (1, 2). Despite the critical role of marine environments in the global P biogeochemical cycle, our understanding of the marine P cycle remains limited. Most existing studies focus on water column measurements, while knowledge of P dynamics in marine sediments is relatively sparse (3).

Upon reaching the sediment-water interface as sinking particulate matter containing various inorganic minerals and organic compounds, P undergoes a range of biotic and abiotic processes that determine its fate. The preservation of buried P depends on several factors, including the chemical structure of P compounds, sediment properties, sedimentation rate, redox conditions, and diagenetic processes (4-6). Existing studies indicate that P occurs in various inorganic and organic forms within marine environments (6, 7). However, most research is based on surface sediments from a limited range of sedimentary environments, restricting our understanding of long-term P dynamics and the processes governing its retention and regeneration during burial.

To address these knowledge gaps, long-term sedimentary cores were collected through the Integrated Ocean Drilling Program (IODP) across diverse marine sedimentary environments, including those with varying compositions (biogenous versus lithogenous), organic material content, oxygen levels, and burial depths. We analyzed P concentrations and binding forms, as well as the processes controlling sediment P dynamics, by integrating geochemical and metagenomic measurements. Through these globally distributed marine sediment cores, we gained crucial insights into the nature of sedimentary P pools and their dynamics within deep-ocean sediments.

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