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Phosphorus diagenesis in deep-sea sediments: sensitivity to water column conditions and global scale implications

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In this study, the impact of changes in bottom water oxygen and organic matter (OM) input on the burial of phosphorus (P) in deep sea sediments is examined using a reactive transport model. Results show that the burial of key reactive P phases, namely authigenic calcium associated P minerals (Ca-P), organic P (org P) and iron-bound P (Fe-P), responds non-linearly to both water column forcings. High organic matter (OM) flux with either very low or high oxygen favor the formation of authigenic Ca-P, while low oxygen and intermediate to high OM fluxes promote org P burial. Iron-bound P is only preserved in the sediment when oxygen levels are high and OM fluxes low. The conditions for maximum P recycling (or minimum P burial) are low bottom water oxygen concentrations and low OM fluxes to the sediment-water interface (hypoxic, oligotrophic deep-sea settings). The bivariate dependence of P burial on oxygen and OM flux was implemented in an existing box model of the global marine P, oxygen and organic carbon cycles, replacing simple empirical redox functions for P burial. The response of the original and new box model to decreased ocean mixing was then assessed. In the new model, org P instead of authigenic Ca-P is the dominant burial phase of P in deep-sea environments during periods of ocean anoxia. However, reduced ocean mixing leads to a similar response in total P burial and, as a consequence, to similar changes in deep water anoxia and ocean productivity in both models.