Significant influence of seawater calcium concentration on marine phosphorus burial

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The marine phosphorus (P) cycle plays a critical role in controlling the extent of global primary productivity and thus atmospheric pO_2 on geologic time scales. Previous work has suggested that marine oxygen level was the key factor shaping the efficiency of P burial and thus the size of the marine biosphere. However, previous attempts to model carbon-phosphorus-oxygen feedbacks have neglected key parameters that could shape the global P cycle. To address this issue, we have developed a new, multi-component reaction-transport diagenetic model that includes the complexity necessary for a full parameterization of marine P burial. We have coupled this diagenetic framework to a global carbon cycle model. Our results indicate that bottom-water oxygen concentrations, organic matter supply and bioturbation have a significant albeit nonlinear influence on marine phosphorus burial. However, in contrast to the traditional view, we find that seawater calcium concentrations have the greatest effect upon P cycling. Increases in seawater calcium concentrations promote the precipitation of carbonate fluorapatite (CFA), the most significant pathway for marine P burial. In light of the considerable variability in seawater [Ca^{2+}] that characterizes the Phanerozoic record, our model results indicate that [Ca^{2+}] directly shaped the secular evolution of global P burial. This suggests previously overlooked strong coupling between Phanerozoic tectonic cycles, the marine P cycle, and atmospheric pO_2. Further, this work provides a mechanistic exploration of previously noted but enigmatic decoupling of atmospheric carbon dioxide and oxygen concentrations.