Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24021

Sediment P recycling and effluxes in coastal oceans, the Pearl River Estuary region

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Sediment is an important component of the marine phosphorus (P) cycle. It can either sequestrates the P received from the water column, or recycles it back as dissolved phosphate (PO_4) that can support primary productivity. Understanding sediment P recycling is crucial, especially in coastal oceans where P can be a common limiting nutrient. However, this can be challenging, as coastal environments are often characterized with strong dynamics and spatial heterogeneity. In this study, by using the Pearl River Estuary and its adjacent coastal areas as an example, we will show how sediment P recycling and PO_4 effluxes can be controlled by the balance between oxygen and nitrate levels, organic matter sedimentation, and allochthonous supply of redox-sensitive P-binding iron (Fe) oxides. Our results showed that sediment PO_4 fluxes and P recycling efficiency vary across two orders of magnitude in the region. Upstream, nitrate is surplus in the surface sediment, which can stabilize iron oxides to sequestrate P, preventing PO_4 from releasing into the porewater and the water column. In the offshore open ocean, nitrate is low, but the low organic matter regenerates less PO_4. Moreover, Fe oxides there are still far from being saturated for P-binding, leading to high P sequestration and low PO_4 effluxes. On the contrary, high P recycling and PO_4 effluxes are found at the estuary-ocean junction, where high rates of organic matter remineralization release PO_4, consume nitrate, and lead to the reductive dissolution of Fe-oxides and immobilization of PO_4. Our study reveals the coupled controls of C, N, and Fe cycles on the recycling of P in strongly dynamic and heterogeneous coastal oceans.