Stabilization of the coupled oxygen and phosphorus cycles by the evolution of bioturbation

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Animal burrowing and sediment-mixing (bioturbation) began during the run up to the Ediacaran/Cambrian boundary, initiating a transition between the stratified Precambrian6 and more well-mixed Phanerozoic sedimentary records, against the backdrop of a variable global oxygen reservoir probably smaller in size than present. Phosphorus is the longterm limiting nutrient for oxygen production via burial of organic carbon, and its retention (relative to carbon) within organic matter in marine sediments is enhanced by bioturbation. Here we explore the biogeochemical implications of a bioturbation-induced organic phosphorus sink in a simple model. We show that increased bioturbation robustly triggers a net decrease in the size of the global oxygen reservoir—the magnitude of which is contingent upon the prescribed dierence in carbon to phosphorus ratios between bioturbated and laminated sediments. Bioturbation also reduces steady-state marine phosphate levels, but this effect is offset by the decline in iron-adsorbed phosphate burial that results from a decrease in oxygen concentrations. The introduction of oxygen-sensitive bioturbation to dynamical model runs is su-cient to trigger a negative feedback loop: the intensity of bioturbation is limited by the oxygen decrease it initially causes. The onset of this feedback is consistent with redox variations observed during the early Cambrian rise of bioturbation, leading us to suggest that bioturbation helped to regulate early oxygen and phosphorus cycles.

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