The impact of early Paleozoic bioturbation upon phosphorus cycling

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Bioturbation critically shapes not only seafloor ecology and sediment properties but also ocean-wide biogeochemical cycling. In light of strong bioturbation-biogeochemical feedbacks in modern systems, the evolutionary development of the sediment mixed layer likely had important implications for contemporaneous biogeochemical (e.g., C, P, O, S) cycling. Multiple lines of evidence indicate that, following the appearance of the first sediment-penetrative burrows during the Precambrian-Cambrian transition, the development of bioturbation was a protracted process, and that the appearance of intensively and deeply mixed sediments lagged significantly behind relatively early advances in infaunalization. However, the precise biogeochemical impact of early Paleozoic bioturbation has, particularly for the P cycle, remained more poorly resolved, in part because attempts to model C-P-O 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—foremost, formation of carbonate fluorapatite (CFA)—allowing us to explore the impact of both bioturbation and other environmental factors on P cycling. Like previously published modeling exercises [1], we find that increases in bioturbation intensity and depth can be associated with increases in CFA and total P burial. However, we observe that the relationship between bioturbation and both CFA burial and reactive P burial efficiency is a non-linear one; linear increases in bioturbation parameters are, at low intensities and depths of bioturbation, associated with increases in CFA burial and reactive P burial efficiency—whereas, at higher bioturbation intensities and depths, enhancement of P burial by bioturbation is considerably more muted or even reversed. Additionally, in contrast to recently published models [2], rather than operating as a stabilizing feedback, bioturbation appears to enhance the sensitivity of the C-P-O system to perturbation.

[1] Dale *et al.* (2016) *GCA* **189**, 251-268. [2] Boyle *et al.* (in press) *Geobiology*, doi: 10.1111/gbi.12277.