Mixing the media: soft-sediment versus aquatic bioturbation

N.J. BUTTERFIELD[1]

[1]Department of Earth Sciences, University of Cambridge, Cambridge, UK CB2 3EQ (njb1005@cam.ac.uk)

All motile organisms mix their environments, but the geobiological impact of such processing varies dramatically with organism size, organism behaviour, and the rheological properties of the media in which it occurs. The most obvious agents of such mixing are macroscopic animals in soft sediment, but a comparable phenomenon takes place in water – 'aquatic bioturbation.' As with its soft-sediment counterpart, any substantial processing of water is limited to animals large enough to actively displace the surrounding medium, though the fundamentally more fluid nature of water extends these effects to both smaller body sizes and simpler grades of organization. Notably, aquatic and soft-sediment bioturbation intersect in the case of 'bioirrigation,' where burrowing infauna actively pump water through the system.

Like its soft-sediment counterpart, aquatic bioturbation aerates media otherwise prone to stratification and oxygen depletion, a consequence of both physical ventilation and the repackaging/translocation of biological oxygen demand. Both of these modes are also conspicuously tiered with respect to the sediment-water interface. Even so, the ability of muscular animals to swim free of this surface marks a fundamental departure of expression, potentially exposing the entire ocean system to the effects of bioturbation. With swimming/feeding animals constituting the majority of marine biomass, such forms play a first-order role in both the physical and biogeochemical mixing of the modern oceans. By extension, the progressive aeration of the oceans over the past ~750 million years can be linked to the escalatory evolution of metazoan bioturbators – with localized returns to stratified Proterozoic-like conditions accompanying their top-down collapse during mass extinction events (independently of atmospheric oxygen levels).

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