

The effects of bioturbation and biogenic structure on S cycling in modern and ancient sediments

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Biogeochemical processes in sediments and the authigenic compositions of sedimentary deposits depend strongly on the specific properties of early diagenetic transport – reaction regimes. Modern marine muds underlying oxygenated water in relatively quiescent, low sedimentation rate regions ($< \sim 4$ cm/yr) are typically extensively bioturbated by communities of active macrobenthos. Such deposits display heterogeneous compositional patterns and complex redox reaction couplings determined by biogenic structure and transport. The marine sedimentary S cycle in particular is strongly influenced by bioturbation activities and time-dependent redox reaction geometry. A primary, long recognized effect of bioturbation on sedimentary S is to increase sediment-water exchange of SO_4^{2-} and the openness of deposits, and thus maximize inherent metabolic isotopic fractionation. The steady and unsteady reoxidation of reduced S associated with bioirrigation, particle reworking, and Fe, Mn-oxidant injection or transient storage further enhances net S isotope fractionation through diffusive refluxing. The 2- and 3-D scaling and dynamics of biogenic reaction patterns associated with burrowing and bioirrigation can be revealed and resolved by a range of imaging optical sensors. Numerical models of such patterns demonstrate some of the relationships between biogeochemical functioning within the seabed, and the spatial and temporal properties of biogenic structures. The tendency in the geologic record for storage of isotopically light S following the rise of bioturbation ~ 550 my ago is a predictable consequence of biogenic diffusion – reaction patterns and is relatively insensitive to seawater SO_4^{2-} concentrations ($> \sim 0.2$ mM). The preserved S/C ratio appears to be largely independent of bioturbation. In contrast, heavy S isotopic compositions can be readily produced in physically reworked, shallow-water deposits, and the preserved S/C minimized despite abundant SO_4^{2-} in oxygenated overlying water.