Bioturbation increases the preserved sulfur isotope fractionation of pyrite

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The term bioturbation refers to a wide range of processes through which biological activity displaces sediment particles and often includes the process of bioirrigation (benthic organisms flushing their burrows with overlying water). Bioturbation also affects the sediment and water column geochemistry because through irrigating to a certain depth, any existing chemical gradient is erased. Moreover, bioturbation drives water advection in and out of sediment, which promotes the movement of molecules that is orders of magnitude faster than the diffusive flux. The onset of bioturbation in the late Neoproterozoic, and its subsequent innovations throughout the Phanerozoic, transformed Earth's surface chemistry and the way the sulfur cycle operates. Therefore, understanding the impact of bioturbation on sedimentary geochemistry and on water column chemistry is key to understanding the link between subsurface carbon and the carbon in the Earth's surface reservoirs.

We present results from a sediment core from salt marsh sediment (North Norfolk, UK) in which we monitored the change over time in both the pore water and the water column chemistry with and without bioirrigating polychaete worms (*Glycera sp*.). In the experiment with worms, there was rapid mixing (in a matter of days) between the water column and pore water. At the same time, our results show that sulfide concentration, alkalinity and pH in the porewater never reached the same concentrations as those in the water column, suggesting that microbial sulfate reduction was still taking place, despite the increased oxygen flux. Further, the difference in $\delta^{34}S$ between pore water sulfide and sulfate was much greater in the presence of bioturbation than in its absence. As a result of infaunal bioirrigation, the continuous flow of isotopically light sulfate from the water column appears to have maximized the fractionation of $\delta^{34}S$ during microbial sulfate reduction. More generally, we suggest that the secular increase in sulfur isotope fractionation observed in pyrite over the Neoproterozoic may have been driven not so much by the recycling of sulfate to the ocean from the onset of sediment reworking by animals, but the introduction of isotopically low sulfate into bioirrigated sediments.