The impact of bioturbation on the coupled cycling of carbon, iron and sulphur in marine sediments

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The emergence of bioturbation during the Cambrian explosion initiated a departure from the transport-limited laminated sediments of the Neoproterozoic. Burrowing fauna stimulated sedimentary transport of solids and solutes in the seafloor through bio-mixing and bio-irrigation, thereby expanding the spatial scale over which biogeochemical reactions occur. The evolution of bioturbation is expected to have affected the coupled biogeochemical cycles of oxygen and sulphur by stimulating re-oxidation of reduced iron sulphide minerals. Currently however, the magnitude and nature of this bioturbation feedback is largely unknown, as it is very difficult to quantify the effect of burrowing fauna under *in situ* conditions over sufficiently long time scales. Ideally, one requires control sites that are exposed to oxygenated overlying water, but display no bioturbation. Yet, marine sediments are either fully oxygenated and bioturbated, or hypoxic/anoxic (e.g. Oxygen Minimum Zones, Black Sea) and unbioturbated.

Here we present data from a salt marsh site (Norfolk, UK), which provides an exceptional opportunity to study bioturbation effects. Neighbouring ponds in this salt marsh show one of two very different regimes of redox cycling (either sulphide-dominated and unbioturbated, or iron-dominated and bioturbated). The two types of ponds are randomly distributed, and no physical factor (e.g. elevation, distance to creek) can explain their spatial pattern, leaving only bioturbation as the possible cause of differentiation. Based on pore water analysis and solid phase speciation, combined with early diagenetic modelling, we show that bioturbation can decrease organic carbon burial up to 40%. Additionally, redox cycling of iron and sulphur is increased by a factor 2-7. These results provide a direct *in situ* demonstration of the strong effects of bioturbation on elemental cycling in marine sediments, revealing how the emergence of bioturbation may have affected geochemical cycling during the early Cambrian.