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Metazoan burrowing and organic carbon burial in oxygen depleted sedimentary environments

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Although sub-mm benthic animals (meiofauna) adapted to low oxygen conditions are ubiquitous in modern sediments (Levin, 2003), they leave few recognisable traces so that almost nothing is known about their impact on biogeochemical cycling in the past. New electron imaging techniques have recently identified extensive meiofaunal bioturbation in Pliocene-aged Mediterranean sapropels (Löhr and Kennedy, 2015), a classic anoxic facies. Sapropels are a widely studied model system for anoxic preservation of organic matter (OM), and their record of meiofaunal activity may also be representative of other organic-rich marine sediments. An important question that remains unresolved is to what extent meiofaunal reworking impacts on OM preservation in ancient low-oxygen settings. We study a Pliocene sapropel at high resolution to address this question, combining backscatter electron mapping with stable isotope analysis and RockEval-type pyrolysis to: 1) identify the onset and extent of meiofaunal burrowing and 2) determine the consequences of meiofaunal burrowing for OM composition.
Our imaging analyses identify a clear threshold at which meiofaunal burrowing becomes pervasive, with close to 100% of organic material present within fecal pellets or physically reworked laminae fragments in samples with > 10% TOC. This is preceded by an interval featuring vertically and horizontally discontinous pockets (<500 μm) of meiofaunally bioturbated material embedded in otherwise laminated sediment, implying that short-lived episodes of benthic amelioration and recolonisation occurred well before fully-fledged benthic reworking.
δ13Corg is depleted by 0.6 and 1.5‰ in partially and comprehensively reworked intervals, relative to laminated intervals. C/N and δ15N remain unchanged, so that we attribute the δ13Corg offset to bioturbation leading to selective digestion of a 13C enriched OM component rather than a coincidental shift in OM source. Low δ15N (<-1‰ and petrographic evidence for mass-sedimentation of mat-forming plankton imply selective digestion of 13C-enriched colonial pelagic cyanobacterial (Trichodesmium) biomass.
In contrast, and despite meiofaunal ingestion of close to 100% of OM in the bioturbated intervals, RockEval pyrolysis imply that bulk organic matter quality is not impacted by meiofaunal reworking. Hydrogen index values reach a maximum of 350 mg HC/ g TOC within the laminated interval and remain unchanged through the onset and intesification of bioturbation. Oxygen index remains stable at 50-70 mg CO_2/ g TOC throughout the sapropel. These results indicate that early diagenetic microbial reworking is the primary influence on the quality of organic matter that is ultimately buried in oxygen depleted settings, masking any early post-depositional metazoan modification of the OM. Unlike more oxygen rich settings (e.g. Aller & Aller, 1992), metazoan activity is a minor influence on sapropel OM due to limited oxidant abundance in bottom and porewaters at deposition.

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