

## **Carbon preservation as organo-mineral nanocomposites produced by heterotrophic microbes**

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Of total primary marine productivity, a remarkably small fraction (<0.5%) finds its way into sediments for long-term storage. Against this almost quantitative oxidation of OC, the mechanism(s) responsible for the escape of the small fraction OC into the geologic record seems remarkable and implies very particular mechanisms or circumstances leading to OC preservation. Studies of organically enriched sediment show that the a majority fraction of OC in modern and ancient settings is not present as discrete particles, but rather physically inseparable from their mineral host while scaling with the mineral surface area. We present nanometer resolution images of examples of this fraction from classic black shale deposits revealing organo-clay aggregates with a highly-ordered structure of OC intercalated with particular clay mineral surfaces repeating at scales of tens of nanometers. This raises a fundamental question as to what mechanism can physically reduce  $\mu\text{m}$ -scale organic particles to molecular scales and then intercalate them within nanometer stacks of clay crystallites. Single examples of this amalgamation may not be surprising; rather it is the spatially and temporally widespread occurrence that is so difficult to explain and requires a widespread (ubiquitous) mechanism that is largely unrecognized. Further imaging of these sediments identifies an association with microbial processes, leading to the hypothesis that this class of nanocomposite-stabilized organic carbon results from microbial reprocessing of primary organic carbon particles with specific sub-micron sized clay minerals as a fundamental part of their ecology