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Organic carbon burial and preservation controlled by coupled iron sulfur cycling in euxinic sediments

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In euxinic environments, incorporation of reduced inorganic sulfur into organic matter is an important pathway for long term organic carbon preservation. However, sequestration of reduced sulfur as iron sulfides can compete with organic matter preservation through sulfurisation. High resolution geochemical, petrographic, and electron microprobe analyses were applied to constrain sulfur partitioning between organic matter and iron sulfides in organic and sulfur-rich mudstones from the Kimmeridge Clay (Dorset, UK), Monterey (Santa Barbara, USA), and Whitby Mudstone (North Yorkshire, UK) formations.

In the Kimmeridge Clay and Monterey formations, sulfur is predominantly associated with organic matter, indicated by abundant organic sulfur compounds in pyrolysates and by electron microprobe maps showing sulfur distributed within organic-rich domains under low reactive iron availability. In contrast, in the Grey Shale and Jet Rock members of the Whitby Mudstone formation, sulfur is predominantly sequestered as pyrite, reflected by low abundances of organic sulfur compounds in pyrolysates and by discrete sulfur-rich phases that spatially correlate with iron in electron microprobe maps.

These results indicate that organic carbon burial in euxinic sediments is governed by competition between sulfurisation of organic matter and iron sulfide precipitation. Where reactive iron is abundant, reduced sulfur is preferentially sequestered as pyrite, limiting sulfurisation and diminishing the efficiency of organic carbon preservation. Where reactive iron is limited, sulfurisation proceeds efficiently, enhancing organic carbon preservation and burial. Coupled iron and sulfur cycling therefore provides a mechanistic control on organic carbon sequestration in anoxic depositional systems.