Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.28072

Iron oxides prevent acetate from microbial degradation in anoxic marine sediments

YUNRU CHEN[1,2], ANNA HELMS[2], HEIDI TAUBNER[1,3], VERENA B. HEUER[4,5], JENNY WENDT[3,6], RIANNE VAN KAAM[1], LARS ROBBEN[7,8,9], LEA C WUNDER[2], SABINE KASTEN[4,10,11], MATTHIAS ZABEL[1], KAI-UWE HINRICHS[1,3] AND MICHAEL W. FRIEDRICH[1,2]

[1]MARUM – Center for Marine Environmental Sciences, University of Bremen, Germany
[2]Microbial Ecophysiology Group, Faculty of Biology/Chemistry, University of Bremen, Germany
[3]Faculty of Geosciences, University of Bremen, Germany
[4]MARUM – Center for Marine Environmental Sciences, University of Bremen
[5]University of Bremen
[6]MARUM – Center for Marine Environmental Sciences, Germany
[7]Faculty of Biology/Chemistry, Solid State Chemical Crystallography, University of Bremen, Germany
[8]Data Science Center, University of Bremen, Germany
[9]MAPEX – Center for Materials and Processes, University of Bremen, Germany
[10]Faculty of Geosciences, University of Bremen
[11]Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research

Iron oxides have been found to associate with organic matter in various environments via adsorption and co-precipitation, thereby protecting organic matter from microbial degradation [1,2]. However, research on how their association may be influenced by the sedimentary biogeochemical processes in anoxic marine sediments, particularly iron and sulfur redox reactions , remains limited [3]. Here, the interaction between synthesized ferrihydrite (Feh) and ^{13}C-labelled acetate was studied while incubated with surface sediments from Cumberland Bay, South Georgia, Sub-Antarctic, where accelerated glacial melt brings increasing amounts of iron oxides into fjord and coastal sediments. During a 14-day incubation amended with fresh Feh, the remineralization of acetate decreased by 25%, and by 57% when both iron and sulfate reduction were stopped. However, when Feh pre-coated with natural organic matter (NOM) was added, the remineralization of acetate was slowed down by 11%, and by 86% when both iron and sulfate reduction were stopped. The X-ray atomic pair distribution functions showed that NOM-adsorbed Feh has smaller average crystallite sizes compared to acetate-adsorbed Feh. Therefore, the NOM pre-coated Feh may protect more acetate from microbial degradation than the fresh one because of larger surface area for adsorption if no microbial processes are involved. Otherwise, it is more susceptible to microbial iron reduction and iron reduction by microbially-produced sulfide, which can remobilize the adsorbed acetate and make it accessible to microorganisms again. Our results suggested that the role of iron oxides in the sequestration of small organic molecules such as acetate in natural sediments, might be influenced by the nanostructure of the iron oxides and can be counteracted by microbially-mediated processes.

[1] Shields, M. R., Bianchi, T. S., Gélinas, Y., Allison, M. A. & Twilley, R. R. Enhanced terrestrial carbon preservation promoted by reactive iron in deltaic sediments. *Geophys. Res. Lett.* **43**, 1149-1157 (2016).

[2] Lalonde, K., Mucci, A., Ouellet, A. & Gélinas, Y. Preservation of organic matter in sediments promoted by iron. *Nature* **483**, 198-200 (2012).

[3] Chen, Y. et al. Cycling and persistence of iron-bound organic carbon in subseafloor sediments. *Nat. Commun.* **15**, 6370 (2024).