Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37090

Formation and Transformation of Organic Carbon–Iron Associations Across the Sediment–Water Interface

SILVIA PLACITU[1], NEHA MEHTA[2], LIANE G. BENNING[3,4], VLADIMIR RODDATIS[5], ANJA SCHREIBER[5], MARCIN D SYCZEWSKI[5], MAJID KAZEMIAN[6], LUIS COLOCHO HURTARTE[7] AND **STEEVE BONNEVILLE**[8]

[1]Université Libre de Bruxelles
[2]Sorbonne
[3]GFZ Helmholtz Centre for Geosciences
[4]Freie Universität Berlin
[5]GFZ, Helmholtz Centre for Geosciences
[6]Diamond Light Source
[7]Université de Lausanne
[8]Bgéosys, Departement Géosciences Environnement et Société, Université Libre de Bruxelles (ULB)

Iron and carbon cycles are tightly interconnected in sediments. Globally, over 20% of organic carbon (OC) is associated with reactive iron phases (Fe_R) in freshwater and marine sediments. By reducing the availability of both OC and Fe to microorganisms, the OC-Fe associations are believed to prevent OC mineralization and enhance OC burial over geological times [1, 2]. Yet, the *in-situ* formation and evolution of such associations under natural conditions remains poorly explored. Here, we placed modified passive samplers (peepers) filled with 2-line and 6-line ferrihydrite-coated quartz sands and quartz sands (as a control) across the water-sediment interface in a freshwater mudflat of the Scheldt estuary (Appels - Belgium) for 18 months. We tracked the evolution of the Fe and OC moities at depth, combining bulk geochemistry, thermogravimetry, isotope analyses and spatially-resolved micro-spectroscopy. Fe content declined with depth and exposure time due to microbial Fe reduction, whereas OC progressively accumulated over time, particularly above the sediment-water interface. In 2-line and 6-line ferrihydrite-coated quartz sands (Fe_R-coated sands), early stages were dominated by adsorption yielding low OC:Fe molar ratios (<1) indicative of limited OC stabilization. Over time, coprecipitation became prevalent, leading to higher OC:Fe ratios (>1 and up to 3) in Fe_R-coated sands and even greater values (>3 up to 11) in uncoated quartz sands. Isotopic composition and C/N ratios of the OC moities indicated the binding of riverine and phytoplankton-derived OC. Thermogravimetric and spectroscopic analyses revealed that Fe_R primarily stabilized thermally labile, aliphatic-rich OC enriched (60-70% of the total bound OC) in the sediment. In contrast, at or above the sediment-water interface, up to 45% OC bound consisted of thermally recalcitrant and refractory, aromatic-rich OC with C-XANES features characteristic of black carbon-like compounds. Together, these findings emphasize the contrasted nature and pathways of OC-Fe associations in estuarine sediment and their role in stabilizing OC.

[1] Placitu, van de Velde, Hylén, Hall, Robertson, Eriksson, Leermakers, Mehta & Bonneville (2024) *Journal of Geophysical Research: Biogeosciences*, 129, e2024JG008277.

[2] Placitu, van de Velde, Hylén, Eriksson, Hall & Bonneville (2025) *Biogeosciences*, 22, 8065-8076.