Delivery and release of organic carbon associated with iron oxyhydroxides in the Mississippi River-Delta

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Iron oxyhydroxides commonly associate with organic matter in terrestrial environments, but can become reductively dissolved in coastal environments. We examined the organic carbon content of these reducible phases using two carbon-free extraction approaches in Mississippi River suspended particulates and in its adjoining deltaic sediments. Contents of reductively dissolved iron decreased from river to depocenter and with distance from river outfall, and accompanied by similar losses of reductively soluble organic carbon. Both also decreased with depth in coastal cores. The ratios of organic carbon to iron released were less than the 0.22 g-OC g-Fe⁻¹ that represents the approximate sorption limit of iron oxyhydroxides for dissolved organic matter, suggesting that the released organic matter was adsorbed. At these ratios, the solid phase iron and organic carbon are in approximate redox balance, so that import of either oxidant or reductant may not be necessary for metabolism. The reductively soluble organic carbon generally made up <5% of total organic carbon and its loss thus accounted for small fractions of total organic carbon losses during sediment transport and diagenesis. Extrapolation to global scale suggests a greater impact of perhaps 10% of global river delivery of particulate organic carbon in this form.

Hydrogen production from low temperature (55-100°C) water-rock reactions

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Hydrogen (H₂) produced from water-rock reactions at ~150-300°C is known to support thriving microbial communities on Earth (e.g. Lost City hydrothermal vents [1,2]) and similar geochemical process have been suggested to occur on Mars and Europa [3,4]. However, the potential for mafic rocks and minerals to produce enough H₂ to support microbial life at temperatures below 100°C remains a matter of debate (e.g. [4,5]) and is relatively unexplored in the laboratory.

We are conducting laboratory experiments to assess the potential of 12 rock and mineral substrates to produce H₂ when reacted with seawater under anoxic conditions at 55 and 100°C. Time series measurements were obtained for key gaseous and aqueous constituents. Magnetite, hypersthene, fayalite, San Carlos olivine and San Carlos peridotite produce 20-180 nmol H₂/gram mineral at 55°C. The same 5 substrates as well as chromite produce 50-210 nmol H₂/gram mineral at 100°C. In contrast, hortonolite, hedenbergite, augite, enstatite, diopside, and basalt do not produce significant H₂. Our H₂ measurements agree with previously reported results from mineral-water reactions at 30, 50, and 70°C [4,6]. However, previous studies did not conduct an analysis of the mineral products thus the reactions responsible for H₂ gas production are unknown. To address this issue and define the reaction pathways, we are using synchrotron-based µXRF and µXANES investigations to identify Fe-bearing secondary phases and to constrain the partitioning of Fe and the mechanisms of H2 generation as a function of mineral composition and temperature. Investigations into the effect of the starting materials (e.g. surface area of the substrates and substrate and fluid composition) on H2 production are also being undertaken. This work will allow us to constrain the reactions that produce H₂ under low temperature conditions and will provide insight into the potential for water-rock reactions to support microbial life in the deep subsurface and on other planetary bodies.

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