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FROM THE RIVER TO THE SEA: BENTHIC BIOGEOCHEMISTRY IN THE MISSISSIPPI RIVER DELTA

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Biogeochemical cycling in coastal sediments regulates carbon sequestration, greenhouse gas release, and hypoxia through benthic nutrient and metal fluxes. Quantifying the processes that drive these fluxes can be challenging because they occur simultaneously and are strongly coupled. Consequently, dominant organic matter mineralization pathways and carbonate mineral reactions on benthic carbon and alkalinity fluxes remain poorly constrained in river-influenced deltas, requiring the integration of complementary datasets to disentangle their coupled effects on sediment-water exchange.

To address this challenge, we integrated in situ and ex situ datasets from five stations along an offshore transect from the Mississippi River Delta through an early diagenetic reactive transport model. The model resolves aerobic respiration, denitrification, manganese, iron, and sulfate reduction, and methanogenesis, and explicitly simulates carbonate precipitation and dissolution. Measured solute fluxes, depth-resolved porewater profiles, and sulfate reduction rates constrained and validated model simulations, while the influence of organic matter deposition and biologically induced sediment mixing on benthic fluxes was assessed using sensitivity analyses.

Results reveal a systematic shift in pathway dominance along the transect, with aerobic respiration and metal reduction prevailing near the river mouth and sulfate reduction increasing offshore. These patterns are consistent with a synoptic, subregional synthesis of benthic measurements across the Mississippi River delta shelf and slope. The model demonstrates that carbonate formation can regulate sediment-water exchange by attenuating DIC release, modifying total alkalinity fluxes, and controlling iron and manganese mobility through coupled redox and precipitation processes.

These findings suggest that sediments along the land–ocean continuum regulate carbon, metal, and alkalinity fluxes, underscoring the importance of model-integrated datasets in constraining coastal carbon budgets and predicting associated ecosystem responses to climate-driven changes in river inputs.