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Clear as mud: Molecular insights to landscape patterns of soil carbon in coastal wetlands

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Efficient wetland carbon sequestration supports ecosystem sustainability, can help draw down atmospheric CO_2, and helps offset global change impacts on coastal environments. Characterizing molecular transformations that lead to sequestration (or loss) with fine spatial and temporal resolution can provide insight into landscape patterns of soil carbon distribution. We have explored how a changing biogeochemical environment affects short-term carbon transformations and long-term reactivity of buried organic matter in minerogenic and organic salt marshes using novel geochemical approaches in laboratory and field experiments. Our results demonstrate that the thermodynamic constraint of oxygen limitation affects soil mineralization more than availability of labile carbon inputs. This is consistent with the oxygen priming hypothesis but quantifying the full effect of oxygen availability on decomposition was complicated by oxidation of reduced compounds and potentially substantial lithoautotrophy. Mineral soils were more sensitive to oxygen availability and labile carbon inputs, possibly suggesting greater coupling to root processes compared to organic marshes. Moreover, the composition of carbon inputs had strong effects on mineralization. Adding ^{13}C-glucose stimulated mineralization in both soil types but a greater fraction was respired in mineral soils. Total mineralization rates were slower when soils were treated with ^{13}C-oxalic acid, but the effect of this strong ligand on dissolved inorganic carbon production was comparable or greater than glucose, when normalized to moles of carbon substrate added. This effect was strongest in mineral soils under more oxidizing conditions and potentially suggests a role for abiotic priming. These small-scale processes translate to landscape-scale effects as decreased root inputs and more oxidizing conditions over decades accelerated decomposition and resulted in accumulation of less reactive organic matter in shallow marsh ponds. Yet, even less reactive organic matter that survives transit to deeper, more biogeochemically stable horizons continues to be degraded, turning over at rates (600-10,000 years) that are relevant for modeling ecosystem evolution.