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Thermal reactivity as a global metric of organic matter persistence in fluvial sediments

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The source and reactivity of organic matter transported by rivers plays a key role in determining the extent to which fluvial systems act as “pipes” or “reactors”, efficiently exporting organic carbon (OC) to be sequestered in downstream reservoirs or rapidly returning carbon to the atmosphere. Numerous studies have highlighted the presence of aged OC in the riverine suspended load, which has been primarily attributed to inputs of stabilized biospheric carbon eroded from mineral soils, as well as petrogenic OC weathered from bedrock, however systematic links between OC age and stability remain unclear, hindering facile prediction of riverine carbon dynamics.

In this study we compare a simple metric for the proportion of refractory organic carbon based on thermal reactivity (residual oxidisable carbon/total organic carbon, ROC/TOC) with its bulk radiocarbon (^{14}C) content (Fraction modern, Fm, of TOC) as a proxy for organic matter persistence in a large suite of sediments from a broad range of fluvial systems. We find striking coherence between these parameters among different watersheds, highlighting (*a*) the integrative nature of fluvial systems and (*b*) overarching controls on organic matter composition during fluvial transport. This coherence persists across systems spanning diverse climate and geomorphic domains. Low ROC/TOC ratios correspond with high Fm values and vice versa, implying that thermal stability serves as a first-order predictor of organic matter persistence in the fluvial domain. In general, we find similar trends to those observed for biospheric OC stabilized by mineral association in soils, while the influence of petrogenic C is evident in some river basins. Watershed-specific variations in slope of the ROC/TOC vs.^{14}C relationship are inferred to reflect modes of soil turnover, erosion, and subsequent sediment storage and transport, as well as bedrock contributions. Overall, the coherence in ^{14}C age-reactivity relationships implies efficient remineralization of mineral-free particulate OC during mobilization and transport through fluvial corridors. While imperfect, we propose that this rapid screening approach combining a simple metric of thermal stability with bulk ^{14}C measurements provides important insights which can inform carbon cycle models and landscape management practices, as well as serving as a guide for in-depth investigations.