Insights into organic carbon oxidation potential during fluvial transport from laboratory and field experiments

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Over geologic timescales, the exchange of organic carbon (OC) between the atmosphere, biosphere and geosphere can be a major control on atmospheric carbon dioxide (CO_2) concentrations. The carbon fluxes from the oxidation of rock-derived OC (a CO_2 source) and erosion, transport, and burial of biospheric OC (a potential CO_2 sink) during fluvial transit are approximately the same order of magnitude or larger than those from silicate weathering. Despite field data showing increasing oxidation of OC moving downstream in lowland rivers, it is unclear if losses occur primarily during active fluvial transport, where OC is in continual motion within an aerated river, or during periods of temporary storage in river floodplains which may be anoxic. The unknown location of OC oxidation (i.e., river vs. floodplain) limits our ability to develop mechanistic models capable of predicting OC losses, constrain carbon budgets, and unravel links between climate, tectonics, and erosion. To fill this knowledge gap, we investigated OC oxidation potential in controlled laboratory experiments and a simplified field setting, considering both rock-derived and biospheric OC.

Our experiments simulated fluvial transport without floodplain storage, allowing mixtures of OC-rich and siliciclastic sediment to be transported for distances of ~1000 km in annular flumes. Preliminary experimental results suggest minimal OC oxidation during active river transport, and, to the extent that such experiments represent natural transport through river systems, are consistent with the hypothesis that OC losses occur primarily during floodplain storage rather than fluvial transport. These results are consistent with new field data collected in the Rio Bermejo, Argentina, a lowland river traversing ~1000 km with no tributary inputs, where modern river sediments tend to have higher OC concentrations than both modern pointbar and paleochannel deposits. Together our field data and experiments suggest OC oxidation occurs primarily during sediment storage, and can occur over decadal timescales.