Widespread export of permafrost-derived organic carbon by the Mackenzie River: A carbon dioxide sink rather than source?

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The soil carbon stock of the northern high latitudes is approximately double the carbon content of the pre-industrial atmosphere, and represents atmospheric carbon dioxide (CO_2) sequestered during the Holocene and Pleistocene [1]. Erosion can mobilise this biospheric organic carbon (OC) and supply it to rivers [2]. If a fraction escapes oxidation during fluvial transport, its delivery to marine sediments in the Arctic Ocean may act as a CO_2 sink over geological timescales. However, the source, flux and fate of particulate OC in major rivers at high latitudes is very poorly constrained. Here we address this issue in the Mackenzie River Basin, the main contributor of clastic sediment to the Arctic Ocean [2]. Collecting sediments across river depth profiles, we measure radiocarbon ($\Delta^{14}C_{org}$), stable isotopes ($\delta^{13}C_{org}$) and element ratios (N/C) to determine the source of bulk particulate OC. Rock-derived OC is an important component (~20%), and we use an end-member mixing analysis to isolate its contribution. After doing so, we find that erosion mobilises significantly aged biospheric OC. The youngest biospheric OC transported by rivers has resided in the basin over several millennia (3-4 ka), while the oldest pool (6-8 ka) corresponds to the age of rapid peatland expansion [1] and suggests widespread erosion of ancient soil- and permafrost-derived OC in this basin. By comparison, large Eurasian Arctic rivers mostly transport dissolved OC which is young (<60 yrs) [3] and so we find that the Mackenzie River dominates the delivery of ancient, soil-derived biospheric OC to the Arctic Ocean. Sediment cores offshore suggest that the ancient terrestrial OC delivered by the Mackenzie River is preserved efficiently in marine sediments [4]. Rather than acting as a CO_2 source, erosion of Arctic soils during high latitude warmth may act to sequester CO_2 over 10^4-10^5 years.

[1] MacDonald *et al* 2006, *Science*, 314; [2] Macdonald *et al* 1998, *Mar.Geol.* **144**; [3] Raymond *et al* 2007, *Global Biogeochem. Cycles*, **21**; [4] Goñi *et al* 2013, *J Geophys. Res. Oceans*, **118**.