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Factors controlling the ages, character, reactivity, and associated scales of variability of organic carbon transported by rivers to the ocean

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Riverine transport of organic carbon (OC) is a significant flux in the global C budget, representing major terms for both terrestrial losses and marine inputs. Rivers and estuaries are also dynamic systems where the chemical and isotopic character and reactivity of terrestrial OC is modified prior to its export to the ocean margins. However, several major unknowns exist in land-ocean OC fluxes, including: i) the amounts, ages and character of the OC reservoirs mobilized and transported; ii) the scales of variability in these parameters both within and among different systems; iii) the extent of modification of these parameters by microbial and abiotic processes during riverine and estuarine transport. The global C budget currently assumes that riverine flux represents the excess of terrestrial ecosystem net primary production over decomposition. New data, however, show that rivers discharging to the NW Atlantic margin exhibit a broad range in OC ages, from modern to >5,000 yrs B.P., with particulate OC (POC) often being much older than dissolved OC (DOC). Therefore, part of the OC residing in continental reservoirs on 10^3-10^8 year timescales is being remobilized, but the extremely limited dataset precludes quantitative estimates of the transfer of different-aged OC pools from land to the oceans. Mobilization of <~0.05% yr^{-1} of this ancient OC (which may contain both terrestrial and marine fossil material in uplifted sedimentary rocks) could account entirely for present-day riverine fluxes of DOC and POC to the oceans, yet its molecular and isotopic compositions may overlap with those of marine OC, making its detection in the oceans by traditional approaches difficult. Without better constraining the age and reactivity spectra of remobilized OC and the temporal and spatial scales of variability, contributions to present-day global C budgets and as potential atmospheric CO_2 sources cannot be evaluated. We summarize the present global dataset on the ages, character, and reactivity of OC transported by rivers in an attempt to elucidate some of the essential factors controlling watershed-to-coastal ocean OC fluxes, and outline an approach for better constraining these factors in future studies.

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The role of river suspended material on the global carbon cycle

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Chemical weathering of Ca-Mg silicates is the most important mechanism in removing CO_2 from the atmosphere and the ocean on a geological time scale. This mechanism proceeds via the transport of Ca by rivers, both in dissolved and suspended form, to the oceans where it is precipitated as calcium carbonate. One of the most remarkable features of Ca transport to the oceans is its moderating affect on climatic changes; increased temperature and runoff increases Ca transport to the ocean, increasing CO_2 drawdown by $CaCO_3$ precipitation, resulting in lower temperature and runoff through the greenhouse effect [1]. Although it has been demonstrated that the dissolved fluxes have this moderating effect, the significance of the climate moderating effect of the suspended Ca transport has yet to be quantified.

This study presents over 30 years of field evidence from pristine river catchments in Eastern Iceland. An example of observations from one catchement is shown in Fig. 1. The variation of the quantity of Ca transported to the ocean by the Jökulsá á Dal at Brú via suspended material varies by a factor of 100 to 300 times more over the course of each year than that transported in the aqueous phase. Suspended material flux maximizes each summer with increasing temperature and runoff. Such results show unambiguously that the climate moderating effect of suspended Ca flux is more significant than that of the dissolved flux.

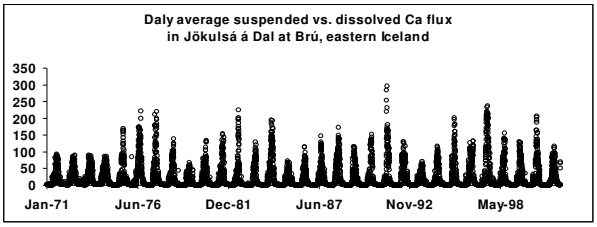

Figure 1. Daily average suspended Ca flux divided by the dissolved Ca flux in Jökulsá á Dal at Brú, eastern Iceland during the last 3 decades.

References

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