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The consequences of Quaternary changes in weathering rates for ocean chemistry and isotope geochemistry

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Modern riverine chemistry and discharge is commonly used to estimate the long-term flux to the oceans of the many chemical and isotopic species that have their primary source in the continental crust. Here we suggest that measurements of many modern rivers, only a few thousand years after a glacial period, are not representative of the long-term flux and we quantitatively assess the implications of such a suggestion for key marine geochemical budgets.

The last deglaciation saw a profound change in the weathering regime in many parts of the planet - from intense physical grinding on a relatively cold, dry Earth to stronger chemical weathering on a warmer, wetter Earth. This change was most obvious in the regions formerly covered by large continental ice-sheets, but was by no means restricted to those regions. For example, the supply of sediment to Alpine lakes has been estimated at an order of magnitude higher during the height of the last glaciation than in the Holocene, primarily due to changes assoicated with the retreat of Alpine glaciers. Similarly, sediment supply to the Bengal fan went through an order of magnitude peak in the early Holocene due to a maximum in the intensity of the monsoon. Experimental studies show that these fresh sediments would have undergone a pulse of rapid chemical weathering during the early post-glacial period. Moroever, these same experimental studies have also shown that both radiogenic and stable isotopes in this early chemical weathering pulse would match neither the bulk rock/soil composition nor the long-term weathering flux. Finally, the time constant of the pulse implies that today's rivers still record more rapid weathering, and an unusual isotopic composition, than the long-term equivalents. The implication is that the material supplied by modern rivers to the oceans is not representative of the long-term flux. Many studies corroborate these observations on soils: including investigations of the Pb isotopic composition of the oceans in response to glacial-interglacial cycling, U-Th studies of some large rivers, and stable and radiogenic isotope investigations of rivers and soils.

These findings have major implications for long-standing problems in ocean chemistry. For example, it remains a puzzle that the hydrothermal flux of unradiogenic Sr required to balance the radiogenic flux from the continents, as given by the modern riverine flux, is much greater than is suggested by the extent of alteration of the oceanic crust. Indeed, while there is growing convergence between ocean floor hydrothermal fluid flux estimates based on independent tracer exchanges and simple thermal calculations, estimates based upon the oceanic ^{87}Sr or Mg balances that rely on the quantification of the modern riverine flux are more than an order of magnitude greater. For elements such as Sr and Mg, with long oceanic residence times, modern riverine measured fluxes do not provide approriate estimates of the long-term inputs. These ideas are relevant to many elements, and their isotope systems, with residence times in the oceans that are longer than the time period since the last deglaciation.