A shifting view of erosion and the carbon cycle

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Mountain building results in high rates of erosion and the interaction of rocks with the atmosphere, water and life. The resulting geochemical transfers may steer the evolution of the global carbon cycle and Earth's long-term climate. For decades, much attention has focused on the weathering of silicate minerals and associated carbon dioxide (CO₂) drawdown, and it is now understood that mountains are places where this reaction is most sensitive to changes in climate. However, the focus on silicate weathering belies a multi-faceted role for mountain building and erosion in the carbon cycle. Erosion also mobilises organic carbon from forests, transferring it to rivers and delivering it to long-lived sedimentary deposits, which results in an additional CO₂ sink. In some mountain belts, exhumation of sedimentary rocks and exposure to the oxygen-rich atmosphere and hydrosphere can release CO₂ by oxidation of rock organic carbon and sulfide minerals. These fluxes remain poorly constrained.

Here we take stock of our current understanding of all of these processes and the magnitude of their fluxes, focusing on insight from modern-river catchments. We find that the net CO₂ budget associated with erosion and weathering appears to be controlled by processes that are not widely considered in conceptual or numerical models, specifically the fluxes from organic carbon burial and oxidation, and sulfuric acid weathering reactions. We suggest that lithology plays a major role in moderating the impact of mountain building on the global carbon cycle, with an orogeny dominated by sedimentary-rocks tending towards CO₂ neutrality, or indeed becoming a CO₂ source to the atmosphere. Over the coming century, erosion-induced changes in CO₂ emissions from sedimentary rocks may result in a previously overlooked positive feedback on anthropogenic climate change.